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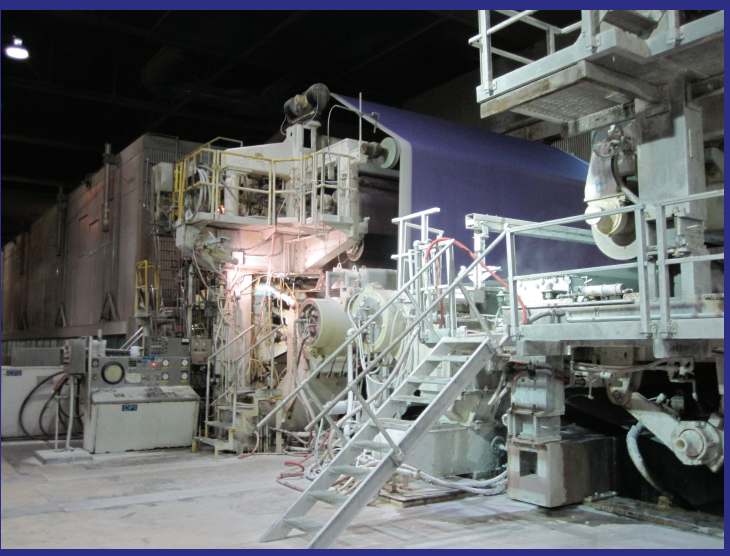
SUSTAINABLE PRINTING



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Skills Victoria/ISS Institute TAFE Fellowship

Fellowship funded by Skills Victoria,
Department of Innovation,
Industry and Regional Development,
Victorian Government

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Published by International Specialised Skills Institute, Melbourne

Extract published on www.issinstitute.org.au

Executive Summary

Printing as a technological process has developed over a very long time, which began centuries before Johannes Gutenberg[1] re-purposed the a screw type olive and wine press of the period to force inked moveable type against paper, a process that could be repeated with accurate predictability. In the next five centuries nothing significant changed in terms of the principles of this process if we leave aside photographic printing and electronic information display for the moment.

What began with a single workshop printing a small number of publications including the now famous bible evolved into a global industry with annual revenue of some US$750 billion.[2]

But the significance of the developing printing industry must be measured in terms beyond money, and with its ability to disseminate information, knowledge and ideas the printing industry has changed the world. It may arguably be the single most significant driver that has facilitated the evolution of thinking and innovation from the dark ages to the digital age over a period of time that can be described as being less than ten average lifetimes.

This progress has also come at a cost and the emergence of carbon accounting as part of the growing environmental corporate responsibility may indicate that we have reached a new waypoint. The practices and processes used by the printing industry over decades, even centuries, that affect the planet and all life on it are now being examined. Logically, what follows such an examination is, at the very least, the identification of the most sustainable traditional practice(s) and at best the development of entirely new paradigms.

Such an examination is indeed taking place, and consequently a great many elements of the printing process have already been modified to become both greener and more sustainable.

There are also, often well-intentioned, changes to existing practices, which create new problems in an effort to resolve old ones.

For example, present European, American and Australian paper recycling practices vary considerably and adopting a best practice standard is complex as many interest groups drive this process and influence legislation.

The Fellow's research focused on two key areas. The first is directly related to his personal creative practice and deals with image permanence of photographic work printed since the days of wet chemical- and darkroom-based printing.

The second area of research investigates sustainable practice in industrial printing from the perspective of a designer. It also includes references to new and emerging technologies, which may change what we define as print in the most fundamental sense.

The key findings as result of the three-week Fellowship program in the USA are divided into four broad categories, as follows:

1. Sustainable Practices in Personal Printing

- Many artists have used variations of Inkjet media and paper that are quite unstable in combination, and these images will not survive for very long periods irrespective of storage and display conditions.
- Museum collections are recognising the imperative to correctly identify substrate and ink/dye combinations to optimise storage and display conservation of prints.
- Cool storage of prints extends the life of the print considerably, but has a significant carbon footprint.
- Rapid, planned, device obsolescence adds to the recycling burden and often results in environmental degradation in third world and developing nations.[3] The new term 'e-waste' has recently been used to describe this particular type of waste. To date Australia has no Federal or State legislation requiring Personal Computer (PC) equipment makers to recycle their products.[4]

- Personal printing devices have poor recyclability.
- Cartridges used in personal printers are generally over packaged and have low reservoir capacity.
- Personal printer cartridges are not easily re-filled by the end user. If that option was more available it would significantly reduced plastic and packaging waste.

2. Medium and Large Volume Printing

The Printing industry Overall

- The printing industry is experiencing major changes in activities and processes, such as slowly being replaced by online systems.
- Ageing workforce (The median age of workers in the printing industry was 42 years in 2008).[5]
- Technologies are very specific to individual workplaces, which makes it difficult in terms of employable skills transfer as, often, printing practitioners are trained in particular hardware/software combinations. As these practitioners frequently lack basic fundamental education there is little skill transferability.
- Poorly managed printing organisations can be a risk factor to the ongoing success of equipment providers and manufacturers because bankruptcy can lead to financial exposure, and multiple bankruptcies could seriously affect even very large manufacturers.
- The packaging industry is looking for ways to address the ageing population by using advanced print technologies to become interactive with consumer devices.[6]

Printing Inks

Soya-based inks are claimed to be more environmentally friendly on the grounds that they are vegetable-based. This is an unfortunate piece of misinformation; in fact, almost all conventional inks used for printing on paper are vegetable based.

The most common base ingredient is linseed oil, and rubber is also used. All types of ink contain roughly similar amounts of petrochemical-derived solvents, and this applies equally to soya-based inks, so they really offer no environmental advantage in their ingredients.

Indeed, far from offering any benefits, they have significant disadvantages; soya oil is mainly produced in the USA, whereas linseed is a European crop. This means the product is unnecessarily transported between continents.

Linseed is an indigenous raw material, with its cultivation providing employment in Britain and Europe.

50 per cent of the USA soya crop is now genetically modified, raising serious questions about its potential to damage the environment.

Soya crops are usually produced under a monocrop farming approach, with significant environmental damage and impact especially in developing countries.

Heavy metals such as barium, copper and zinc can be found in some pigments. They are most often found in metallic inks that are green, orange or opaque yellow. Heavy metals are toxic and sometimes carcinogenic.

3. Sustainable (and Un-sustainable) Practices in De-inking and Recycling Paper

- European newsprint is printed on 100 per cent recovered and recycled paper. This approach to recycling saves greater than 60 per cent of the energy and water compared to fresh fibre.
- Inkjet and Flexographic technologies are least suited to de-inking and thus recycling. Dry toners offer excellent de-inking, better than offset. Liquid toners remain a problem, and are not recommended for high volumes such as direct mail or advertising. Lower brightness paper reduces the requirement for bleaching.

- Best paper for recycling comes from glossy magazines, because of the initial high paper quality.
- There is a need for credible Chain-of-Custody certification on all printed material.
- 'Whole system' best practice needs to be identified, and replicated by all printers.
- Chlorine bleach is still used in conventional wood-pulp papermaking to create 'woodfree' paper, especially in developing nations. It has been recognised for some years that this can be a serious pollutant from paper mills.
- The 'water footprint' of papermaking and paper recycling is considerable.

Wood Pulping Process

Bleaching mechanical pulp[7] is not a major cause for environmental concern since most of the organic material is retained in the pulp. The chemicals used (hydrogen peroxide and sodium dithionite) produce final benign by-products of water and sodium sulfate respectively.

Delignification of chemical pulps releases considerable amounts of organic material into the environment, particularly into rivers or lakes. Pulp mills are almost always located near large waterways.

4. Sustainable Practices in Organic and Printed Electronics

In the span of less than a year, the term 'electronic paper' has largely been pushed to the margin in order to make way for generic trademarks and proprietary eponyms such as Amazon's 'Kindle'[8], Apple's 'iPad'[9] and Sony's 'Reader'[10] to list a few.

Electronic Paper is a subset of Organic and Printed electronics. The acceptance of electrophoretic display technology[11] (where, simply put, dispersed coloured particles are told electronically where to appear) as an important alternative to both paper publishing and conventional display readers has now been proven by both the diversity and quantity of new products on the market.

Driving the acceptance of the e-paper product family over conventional LCD displays are the devices offering a paper-like look, daylight readability, low power consumption,[12] and viewing angle independence.

In addition, electrophoretic display front-plane technology is suitable for use with the new generations of flexible and printed electronic backplanes. Many of these new backplane technologies utilise new materials and processes from conventional semiconductor manufacture. This new generation of technology means that new displays are beginning to emulate the physical flexibility of paper.

The current E Ink display performance is improving rapidly, as is public acceptance of this technology and consequent changes in the marketplace.[13]

The second key area in which organic and printed electronics impact on sustainable printing is in the manufacturing of the printed circuit.[14]

The printing of electronic circuits in the production of digital electronics is now emerging as a strong alternative to the traditional process of manufacturing silicone chips.

Inkjet technology is now making it possible to print digital circuits directly on to a substrate instead of traditional methods. These traditional methods of producing computer chips had always been subtractive in nature ie requiring the use of acid etching processes[15] (a process that requires the use of 'resist', tin-lead that has significant environmental consequences, such as copper bearing wastewater and air pollution from acid fumes).[16]

The key advantage of inkjet printed circuits, from the environmental/sustainability angle is that the printed circuit involves an additive process (no removal waste) where as the traditional silicon chip industry uses a subtractive process (necessitating acids for matter removal).

Table of Contents

Abbreviations/Acronyms

ABS	Australian Bureau of Statistics
ACOR	Australian Council of Recyclers
AIRS	Aerometric Information Retrieval System
AMEE	Avoiding Mass Extinction Engine
ANAT	Australian Network for Art and Technology
ARIGAI	The International Association of Research Organizations for the Information, Media and Graphic Arts Industries
A3P	Australian Plantation Products and Paper Industry Council
BPA	Bisphenol A
CEPI	Confederation of European Paper Industries (EU)
CO_2	Carbon Dioxide
DIA	Design Institute of Australia
ECF	Elemental Chlorine-Free
EPA	Environment Protection Authority (Australia)
EPA (USA)	Environment Protection Authority (USA)
ERPC	The European Recovered Paper Council
EU	European Union
FDA	Food and Drug Administration
GeSI	Global e-Sustainability Initiative (EU)
HAP	Hazardous Air Pollutant
IBSA	Innovation and Business Skills Australia
IMAPS	International Microelectronics and Packaging Society
INGEDE	International Association of the Deinking Industry
INECE	International Network for Environmental Compliance and Enforcement
ISC	Institute for Sustainable Communication (USA)
ISO	International Organization for Standardization
ISS Institute	International Specialised Skills Institute (AUS)
IS&T	Society for Imaging Science and Technology (USA)

Abbreviations/Acronyms

IWA	International Workshop Agreement
LCA	Life Cycle Assessment
lx	Otherwise known as Lux, lx is the SI unit of illuminance and luminous emittance.
MIT	Massachusetts Institute of Technology
MPE	Maximum Permissible Exposure
NAPIM	National Association of Printing Ink Manufacturers (USA)
NAPM	National Association of Paper Merchants (UK)
NIEHS	The National Institute of Environmental Health Sciences (USA)
PACIA	Plastic and Chemicals Institute Australia
PAS	Publicly Available Specification
PEFC	The Programme for the Endorsement of Forest Certification
RH	Relative Humidity
PIAA	Printing Industries Association of Australia
PPISG	Pulp and Paper Industry Strategy Group (AUS)
PRIMIR	The Print Industries Market Information and Research Organization
OPC	Organic Photoconductor
RIT	Rochester Institute of Technology
SGP	Sustainable Green Printing Partnership (USA)
TBC	To be confirmed
TCF	Totally Chlorine-Free
TVOC	Total Volatile Organic Compound
UFP	Ultrafine Particle Emissions
USA	United States of America
UV	Ultraviolet
VFG	Research Organisation for Graphic Arts and Media (Austria)
VKI	Austrian Consumer Organisation
VOC	Volatile Organic Compound

Definitions

ABCD system	In Britain the National Association of Paper Merchants (NAPM) uses a classification system to identify the proportion and source of waste fibre used to make recycled paper. The system uses the letters A to D, with each letter accompanied with a figure indicating the percentage of that source. It is important to understand the differences between these four sources of waste: A: Mill broke B: 'Woodfree' unprinted waste C: 'Woodfree' printed waste D: Mechanical and unsorted waste
Amine	An organic base formed by replacing one or more of the hydrogen atoms of ammonia by organic groups.
Archival terms	The Image Permanence Institute at Rochester Institute of Technology (RIT) has a database of terms used in describing archival properties of images that can be found here: http://www.archivaladvisor.org/shtml/glossary.shtml
Biocides	A chemical agent, such as a pesticide or herbicide, that is capable of destroying living organisms.
Design	Design is problem setting and problem solving. Design is a fundamental economic and business tool. It is embedded in every aspect of commerce and industry and adds high value to any service or product—in business, government, education and training, and the community in general. Reference: 'Sustainable Policies for a Dynamic Future', Carolynne Bourne AM, ISS Institute 2007.
E Ink	E Ink is a specific proprietary type of electronic paper manufactured by E Ink Corporation, founded in 1997 based on research started at the Massachusetts Institute of Technology (MIT) Media Lab. It is currently available commercially in grey-scale only, and is commonly used in mobile devices such as e-Readers and to a lesser extent mobile phones and watches.
e-waste	Typically, waste comprising old electronic goods, especially computers, monitors and peripherals. Of the estimated 8.7 million tonnes of e-waste created annually in the European Union (EU), a massive 6.6 million tonnes is not recycled. In the USA there is very little regulation of e-waste. Less than 20 per cent of USA e-waste is recovered for recycling.[17]
Hardwood	Typically, hardwood trees are deciduous trees that loose their leaves during cold winters (angiosperm). A hardwood tree is often, but not necessarily, a harder and denser wood than softwood.
Innovation	Creating and meeting new needs with new technical and design styles. (New realities of lifestyle). Reference: 'Sustainable Policies for a Dynamic Future', Carolynne Bourne AM, ISS Institute 2007.

Definitions

LCA	The goal of Life cycle assessment (also knows as 'cradle to grave' or 'cradle to cradle' assessment) is to compare the full range of environmental and social damages assignable to products and services, to be able to choose the least burdensome one.
Lignin	A complex oxygen-containing organic compound, a mixture of polymers of poorly known structure. After cellulose, it is the most abundant organic material on Earth, making up one-fourth to one-third of the dry weight of wood, where it is concentrated in the cell walls. Removed from wood pulp in the manufacture of paper, it is used as a binder in particleboard and similar products and as a soil conditioner, a filler in certain plastics, an adhesive ingredient, and a raw material for chemicals including dimethyl sulfoxide and vanillin (synthetic vanilla flavouring).
Mechanical pulp	A method of converting logs or wood chips into paper pulp for use in papermaking, primarily short lifespan paper, such as newsprint, telephone directories, catalogs, 'pulp' magazines, paper towels and tissues. This method is accomplished by mechanical grinding, as opposed to chemical pulping. The purpose of pulping is to reduce wood (or other fibrous raw material) to individual cellulose fibers. A non-fibrous constituent of wood, lignin, binds cellulose fibers together, and is primarily responsible for reducing paper quality and its permanence.
Monocrop	The agricultural practice of growing the same crop year after year on the same land, without crop rotation.
Oilseeds	Oilseeds are a type seed or seed crop grown mainly for oil. Soybeans are the major oilseed produced around the world. The oil content of small grains (eg wheat) is only 1–2 per cent; that of oilseeds ranges from about 20 per cent for Soybeans, to over 40 per cent for Sunflowers and Rapeseed (Canola). The major sources of edible seed oils around the world are soybeans, sunflowers, rapeseed, cotton and peanuts. Seed oils from Flax (linseed) and castor beans are used for industrial purposes. Edible fats and oils are similar in molecular structure; however, fats are solid at room temperature, while oils are liquid.
Recyclability	The potential for a material to be wholly or partly used to make new raw material at the end of its useful life.
Skill deficiency	A skill deficiency is where a demand for labour has not been recognised and training is unavailable in Australian education institutions. This arises where skills are acquired on-the-job, gleaned from published material or from working and/or studying overseas. Reference: 'Directory of Opportunities. Specialised Courses with Italy. Part 1: Veneto Region', ISS Institute, 1991. There may be individuals or individual firms that have these capabilities. However, individuals in the main do not share their capabilities, but rather keep the intellectual property to themselves. Over time these individuals retire and pass away. Firms likewise come and go.
Softwood	Typically, softwood trees are evergreens and are broadly defined as conifers (gymnosperm).

Definitions

Sustainability	The ISS Institute follows the United Nations for Non-Governmental Organisations' definition on sustainability: *"Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".* Reference: http://www.unngosustainability.org/CSD_Definitions%20SD.htm
VOC	Volatile organic compounds (VOCs) are emitted as gases from certain solids or liquids. VOCs include a variety of chemicals, some of which may have short- and long-term adverse health effects. Concentrations of many VOCs are consistently higher indoors (up to ten times higher) than outdoors. Further information can be found on the United States Environmental Protection Agency website: http://www.epa.gov/iaq/voc.html.
Wood free	The term 'wood free' is an oxymoron, as the paper is anything but wood-free. As the name indicates, when originally pulped the 'woody' lignins in the timber are destroyed in a chemical reaction (part of the environmental problem of conventional papermaking), to produce a higher quality paper. If not removed, the lignins—the inflammable part of the wood—cause paper to yellow and become brittle with age (as, for example, old newspapers do). The same process causes pine furniture to change colour over time.

Acknowledgements

Werner Hammerstingl would like to thank the following individuals and organisations who gave generously of their time and their expertise to assist, advise and guide him throughout the Fellowship program.

Awarding Body – International Specialised Skills Institute (ISS Institute)

The International Specialised Skills Institute Inc is an independent, national organisation that for over two decades has worked with Australian governments, industry and education institutions to enable individuals to gain enhanced skills and experience in traditional trades, professions and leading-edge technologies.

At the heart of the Institute are our Fellows. Under the **Overseas Applied Research Fellowship Program** the Fellows travel overseas. Upon their return, they are required to pass on what they have learnt by:

1. Preparing a detailed report for distribution to government departments, industry and educational institutions.
2. Recommending improvements to accredited educational courses.
3. Delivering training activities including workshops, conferences and forums.

Over 180 Australians have received Fellowships, across many industry sectors. In addition, recognised experts from overseas conduct training activities and events. To date, 22 leaders in their field have shared their expertise in Australia.

According to Skills Australia's 'Australian Workforce Futures: A National Workforce Development Strategy 2010':

> Australia requires a highly skilled population to maintain and improve our economic position in the face of increasing global competition, and to have the skills to adapt to the introduction of new technology and rapid change.
>
> International and Australian research indicates we need a deeper level of skills than currently exists in the Australian labour market to lift productivity. We need a workforce in which more people have skills, but also multiple and higher level skills and qualifications. Deepening skills across all occupations is crucial to achieving long-term productivity growth. It also reflects the recent trend for jobs to become more complex and the consequent increased demand for higher level skills. This trend is projected to continue regardless of whether we experience strong or weak economic growth in the future. Future environmental challenges will also create demand for more sustainability related skills across a range of industries and occupations.
>
> *Skills Australia's 'Australian Workforce Futures: A National Workforce Development Strategy 2010', pp. 1-2 http://www.skillsaustralia.gov.au/PDFs_RTFs/WWF_strategy.pdf*

In this context, the Institute works with Fellows, industry and government to identify specific skills in Australia that require enhancing, where accredited courses are not available through Australian higher education institutions or other Registered Training Organisations. The Fellows' overseas experience sees them broadening and deepening their own professional practice, which they then share with their peers, industry and government upon their return. This is the focus of the Institute's work.

For further information on our Fellows and our work see www.issinstitute.org.au.

Acknowledgements

Fellowship Sponsor

The Victorian Government, Skills Victoria is responsible for the administration and coordination of programs for the provision of training and further education, adult community education and employment services in Victoria and is a valued sponsor of the ISS Institute. Hammerstingl would like to thank them for providing funding support for this Fellowship.

Supporters

Hammerstingl would like to acknowledge the following individuals for their support, guidance and assistance during the Fellowship process:

In Australia

- Philip Andersen, Chief Executive Officer, Printing Industries Association of Australia
- Elizabeth Akister, Project Manager/Short Course Coordinator, Swinburne University National Centre for Sustainability (Workplace Mentor)
- Carolynne Bourne, Paul Sumner and Ken Greenhill from the ISS Institute for their support throughout the Fellowship
- Geoff Fitzpatrick, Director National Strategy, Design Institute of Australia
- Brian Gilkes, Director Pharos Editions (Industry Mentor)
- Louise Palmer, Executive Director, Vocational Education and Training, Swinburne University (Report Mentor)
- Chris Pascuzzi, Campus manager Gippsland TAFE Warragul
- Andy Warrington, Creative Director, Avalanche Creative Solutions
- William Winford, Manager Arts Department, Swinburne University TAFE

In the USA

- Peter Laxton, Senior Scientist – Applied Nanotech Inc, Austin, Texas
- Professor Xiaoying Rong, Graphic Communications Department – California Polytechnic Institute, San Luis Obispo, California
- Dr Douglas K Shaffer, Physical scientist, Forensic Document Laboratory – Department of Homeland Security, US Immigration and Customs Enforcement, McLean, Virginia
- Dr Michael McCreary, VP Research and Advanced Development – E Ink Corporation, Boston
- Professor Daniel M Burge – Image Permanence Institute, Rochester Institute of Technology, New York
- Peter Schmitt; Pranav Mistry; Professor Pattie Maes – Massachusetts Institute of Technology (MIT) Media Laboratory, Boston
- Wouter Peddemors, Director, Fibre Line and Technical Services (Mill Project Manager); Glen Johnson, Manager Technical Services – Myllykowski Madison Paper Company, Illinois
- Theresa M Andrews, Conservator of Photographs; Jill Sterret, Director of Collections Conservation (also leads the Media Team) – San Francisco Museum of Modern Art (SFMOMA), San Fancisco
- Professor Marcos Esterman; Professor Sandra Rothenberg – Sustainable Print Systems Laboratory, Rochester Institute of Technology (RIT), New York
- Marc Hamly, Head of Paper Conservation; Judith Keller, Curator of Photography – The J Paul Getty Museum, Los Angeles
- Carol Brewer, Researcher; Henry Wilhelm, Founder and President – Wilhelm Imaging Research, Grinnell, Iowa

In Austria

- Professor Dr Werner Sobotka – Research Organisation for Graphic Arts and Media (VFG), Vienna

In Germany

- Axel Fischer, Public Relations – International Association of the Deinking Industry (INGEDE), Munich

In the UK

- Trevor Lambourne, Operations Manager – Digital Print Centre of Industrial Collaboration, Department of Colour Science, University of Leeds, Leeds
- Rohan Ratnakumar, Project Scientist – DeLaRue Overton Technology Centre, Hampshire

Individuals Involved in the Fellowship Submission

- Louise Palmer, Executive Director, Vocational Education and Training (until March 2010), Swinburne University. Palmer is gratefully acknowledged for her support during the submission process.

Australian Organisations in the Printing and Sustainability Industry Impacted by this Fellowship

Federal Government

- Australian Council for Private Education and Training
- Department of Innovation, Industry and Regional Development (DIIRD), Australian Government
- Department of the Environment, Water, Heritage and the Arts, Australian Government
- Environmental Protection Authority (EPA)
- Innovation and Business Skills Australia (IBSA)
- Sustainability Victoria, Victorian Government

State Government

- Registered Training Organisations (RTOs)
- Technical and Further Training (TAFE) organisations

Industry

- Design Institute of Australia (DIA)
- Printing Industries Association of Australia (PIAA)

Professional Associations

- Australian Network for Art and Technology (ANAT)
- Education and Training
- Plastic and Chemicals Institute Australia (PACIA)
- Swinburne Institute of Technology

Community

- Community in general

About the Fellow

Name: Werner Hammerstingl

Employment

- Teacher and Coordinator in Multimedia (Design), Swinburne University (TAFE), Melbourne

Qualifications

- Bachelor of Education (Arts and Crafts), Melbourne College of Advanced Education, 1981
- Graduate Diploma in Fine Arts, Phillip Institute of Technology, 1982
- Master of Visual Art (by Research), The University of Melbourne, 1994
- Certificate IV in Assessment and Workplace Training , Swinburne University (TAFE), 2004
- Diploma of Sustainability, Swinburne University (TAFE), 2009

Werner Hammerstingl has 40 years experience in the creative industries. This includes photography, visual art, graphic design, set design, video and sound, multimedia design and industrial styling. His work has been exhibited in some 300 National and International solo and group exhibitions. Hammerstingl worked in secondary education for three years, post secondary for some 25 years and considers teaching his key practice. For the last nine years he has been with Swinburne University (TAFE) as Teacher and Coordinator in Multimedia (Design).

Possibly because of this diverse background, which has always straddled some combination of art/design and teaching, when asked by a member of the ISS Institute team what he considered to be lacking in his own skill range and possibly, more broadly, in the teaching of post secondary Design and Multimedia, the Fellow pointed to a knowledge deficiency in sustainable printing practices, both at a single user level as well as in the broader fields of industrial application.

Aims of the Fellowship Program

The aims of the Fellowship program can be outlined as follows:

1. To have a comprehensive understanding of best practice in printing for the purpose of creating a cultural artifact with optimum Image permanence.
2. To understand how such an artifact can best be displayed and stored to ensure its durability.
3. To become skilled in identifying sustainable activities and process in the printing industry and its supply chains.
4. To appraise the likely impact of new and emerging technologies on the printing industry.
5. To formulate a response in the education sector to trends in the printing industry.

The Australian Context

Australia is presently undergoing a fundamental awareness shift in understanding and implementation of sustainable practice. Terms such as 'carbon footprint' and 'greener practice' are encountered frequently and strategies are already underway, such as the Australian Government's Green Office Initiative is already entering its ninth year.

It is also now possible to study sustainability in Australia. The number of institutions that are offering courses in this, now officially recognised, discipline is growing rapidly.[18]

Creative fields of practice ranging from the graphic arts to photography and digital imaging have been impacted by the rapid transition from an analog to a mostly digital workflow, but have not yet met the challenges of sustainable practice in a proactive manner.

This lack of focus on sustainable practice is also embedded in current education programs directed at future practitioners in the field that, in general, will still have a printed output as the final result of their creative innovation. New content related to alternatives to print, convergent viewing technologies and the archival qualities of print receive just a small percentage of content focus in these programs. On a larger scale yet again the printing industry as a whole and its approximately 5,000 printing establishments,[19] is still undergoing a difficult period of adjustment towards a growing demand for a greener product, workflow and practice.[20]

The Sustainable Green Print (SGB) initiative, which is built around the ISO14001 framework is a very good step,[21] and will help the industry build greener practices around waste management, recycling, energy and water usage as well as emissions.

The Fellow believes that future apprentices who are entering the print trade as well as students in Graphic Arts and related fields should have the opportunity, and indeed the requirement, to study these issues in the course of their training.

New paradigms of how visual information can reach its audience are emerging rapidly and while Australia's position amongst this rapidly changing world is not unique, regrettably, neither is its history of innovation in this area.

At the time of drafting this report there is no published opportunity to study Sustainable Printing Practice in fields such as fine art and design in Australia. There is also no evidence that studies are available that are geared to developing and testing industry-specific, applied work procedures and tools for environmental and emerging sustainability issues in the graphic arts industry. This includes methodologies that can quantify, follow-up, evaluate, manage, improve and communicate the environmental performance of activities in the graphic arts supply chain and in printed products.[22]

A great deal of printing occurs in another context altogether, namely in the home, the studio and the office. Usually this involves small volume devices such as inkjet and laser printers.

There are numerous opportunities to make personal printing a greener activity and because of this, an investigation into how the current practices, devices and consumables can be made to benefit the environment without loss experiential or technical of quality.

Most will agree that the concept of the paperless office, which has been talked about for some 40 years, has not produced the economies or efficiencies originally quoted as possible.

Because of this the Fellow believes it quite urgent to explore ways in which environmental benefits can be achieved in this area, followed by embedding this core knowledge of sustainable technologies, workflows and practices in education programs especially in VET.

The Australian Context

William McDonough in his book *Cradle to Cradle*[23] points out that we can no longer afford to act without regard to downstream consequences. In this broad context any reduction of paper usage, be it produced from sustainably grown plantation timber or recycled from the 'urban forest' not only reduces carbon production,[24] but more importantly, given Australia's status as the driest inhabited continent on the planet (http://www.about-australia.com/facts/), reduces water usage. It is worth noting that each ream of A4 paper uses the equivalent of a single person's maximum recommended daily water usage of 150 litres.[25]

The Australian Printing Industries Association (PIAA) is already heavily involved in the promotion of Sustainable Printing practices. This means that the need for greener practice is recognised at this level and some printers are already discovering that substantial positioning as a green enterprise has provided very profitable consequences. In this context the Fellow's research will hopefully discover new developments that can augment the Australian printing industries very substantial initiative to become more sustainable.

The big lag is in the area of personal and office printing, where staff and individuals usually base their workflow and general printing habits on inherited and observed practices. Neither education in general, nor vocational training has up to now included sustainable printing in their curricula. The Fellow intends to make a positive contribution towards new strategies that infuse sustainable printing in curricula. As we learned with recycling, the first essential step in behaviour change is awareness.

SWOT Analysis – Sustainable Printing

Strengths

- Improved awareness of best possible practice.
- Creative practitioners become more aware of greener alternatives in printing their work.
- Extends the relevance of vocational training in the graphic art, multimedia and photography.
- Transforms present 'ad hoc' practice into more sustainable and cost effective solutions in printed media.
- Cultural, attitudinal, behavioural adaptation of more sustainable printing practices will give Australia a competitive advantage.
- Feeds into education rollout of sustainability awareness.
- Can be rolled out as short course delivered content.
- Increasing public awareness and demand for greener practices and products.

Weaknesses

- Research value may be short lived as this area is undergoing rapid change.
- Lack of knowledge where best practice may be found.
- Insufficient time for extensive preliminary research.
- Lack of local research and development.
- Lack of local awareness of ISO 14001.
- Embedded falsehoods about the green value of particular practices masquerading as facts.

Opportunities

- ISO 14001 mandates corrective action addressing unsustainable practices.
- Research should provide the opportunity to recognise elements of technology, materials and processes presently used that are unsustainable under ISO 14000 environmental management standards and recommend appropriate changes.
- To create and become known for best practice in Asia Pacific region.

Threats

- Long-term entrenched attitudes may make it difficult to take action towards adaptation of the recommendations resulting from this Fellowship.
- Industry is focused on continuous growth.
- Confidentiality issues with new technologies.
- Industry may choose compliance over quality-based leadership and initiative.
- Implementation may be deemed too financially costly.

Identifying the Skills Deficiencies

How can present day printing practices be modified or replaced to become more sustainable without loss in quality?

Surfaces, inks, applications and environmental factors affect our choice of print technology. This Fellowship enabled an exploration of how these choices can be mapped against a new factor in the equation – the question of sustainability.

1. Surfaces Used for Printing

The aim was to learn key issues about the range, availability, cost and production factors that affect the choice and use of paper, plastics and textiles and other substrates in printing.

Questions relating to this area of the Fellowship investigation are:

- What are best practice considerations in choosing surfaces for printing?
- When considering which pulp is most appropriate, what are the advantages and disadvantages of synthetic paper versus natural fiber?
- Do media and surfaces impact on the archival qualities of inks and if so, how and how much?
- How do choices in surfaces affect such factors as colour, thickness, recycling ability, texture?
- What are the key sustainability issues arising from the surfaces used for printing?
- Are there emerging technologies that might change the answers to the previous questions?

2. Inks and Delivery Systems Used for Printing

The aim was to learn key issues about the range, availability, cost and production factors that affect the choice and use of inks, toners and other media and other substrate in printing.

Questions relating to this area:

- What are the best practice considerations in choosing particular inks and toners for printing?
- How do inks or toners affect colour, cost, recycling ability?
- How do inks and toners affect durability and archival qualities?
- What are the key sustainability issues related to inks, toners and delivery systems?
- What are the emerging technologies that might change the answers to the previous questions?

3. The Impact of Environmental Factors on Print

Questions relating to this area:

- How does UV light/radiation, humidity and other factors affect various combinations of surfaces and inks?
- Which combinations are particularly useful in difficult external environments, such as outdoor banners and waterproof prints (including books)?
- Which storage systems and conditions are particularly suitable for print preservation purposes?
- What insights and outcomes for future research and development have emerged in recent 'forced aging' testing experiments?

4. The Applications of Sustainable Printing

Questions relating to this area:

- What archival solutions exist specifically for the production of digital artwork in areas such as creative photography and printmaking, which then result in print outcomes?

- How can we achieve 'cradle to cradle' solutions in sustainable printing?
- What are the key issues that stand in the way of 'cradle to cradle' solutions?
- What are the emerging best practice solutions in environmentally responsible and sustainable publishing applications with regard to volume printing?

A new skill resulting from these deficiencies will include the ability to advise on best practice printing solutions suited to a variety of applications and workflows.

Why the Deficiencies Need to be Addressed

Australia could and should follow New Zealand's lead and brand itself as a country that makes green and sustainable printing practices a clear and central mandate.[26]

Carbon reduction targets are only part of the reason why the printing industry is beginning to seek greener practices. There are clear health and environmental risks[27] and costs associated with the papermaking, ink production and printing Industries and any reduction in these areas can be chalked up as positive initiatives in the global process of moving to a more sustainable future.

Green washing is a term often heard in reference to the printing industry, as many operators are trying to cash in on the growing public sentiment of wanting to support sustainable activities. The ISO certification processes mitigate this, but the ISO system administrators appear to be falling behind in their ability to react to, or anticipate, rapidly changing scientific and environmental circumstances.[28]

The International Experience

Destinations

The J Paul Getty Museum, Los Angeles, California

- Contact: Marc Hamly, Head of Paper Conservation
  Tour of conservation and storage facilities for paper and digital media
- Contact: Judith Keller, Curator of Photography
  Discussed curatorial issues regarding photographic prints

Wilhelm Imaging Research Institute, Grinnell, Iowa

- Contact: Henry Wilhelm, Founder and President
- Contact: Carol Brewer, Researcher
  Discussed photo imaging and storage

San Francisco Museum of Modern Art (SFMOMA), San Francisco, California

- Contact: Jill Sterret, Director of Collections Conservation (also leads the Media Team)
  Tour of conservation area
- Contact: Theresa M Andrews, Conservator of Photographs
  Discussed collecting and storing digital prints and digital media

The Media Lab, Massachusetts Institute of Technology, Boston, Massachusetts

- Contact: Professor Marcos Esterman, Sustainable Print Systems Laboratory
  Discussed product and process development in print technology
- Contact: Peter Schmitt (Assistant to William Mitchell, Director of Media lab who was away ill)
  Discussed the Media lab and sustainable design
- Contact: Pranav Mistry and Professor Pattie Maes
  Discussed wearable hybrid communication technology (sixth sense) and media convergence

E Ink Corporation, Boston, Massechusetts

- Contact: Dr Michael McCreary, VicePresident, Research and Advanced Development
  Discussed the future of electronic ink-based technology, and electronic paper

Rochester Institute of Technology, Rochester, New York

- Contact: Professor Sandra Rothenberg
  Discussed corporate environmental strategy and management
- Contact: Glen Johnson, Manager Technical Services
  Discussed papermaking
- Contact: Professor Daniel M Burge, Image Permanence Institute
  Discussed Image Permanence

California Polytechnic, San Luis Obisbo, California

- Contact: Professor Xiaoying Rong, Graphic Communications Department
  Discussed offset versus Indigo printing

NIP 25/Digital Fabrication 2009 – Conference in Kentucky, USA

NIP 25 was sponsored by the Society for Imaging Science and Technology (IS&T) and Digital Fabrication 2009 was sponsored by the Imaging Society of Japan. The Fellow met the folowing contacts here:

- Contact: Dr Douglas K Shaffer, Physical scientist, Forensic Document Laboratory, Department of Homeland Security, US Immigration and Customs Enforcement, McLean, Virginia

  Discussed media and device Identification
- Contact: Peter Laxton, Senior Scientist, Applied Nanotech Inc, Austin, Texas

  Discussed nanoparticle inks and pastes for printed electronics
- Contact: Professor Dr Werner Sobotka, VFG (Research Organisation for Graphic Arts and Media), Vienna, Austria
- Contact: Axel Fischer, Public Relations, INGEDE, Munich, Germany
- Contact: Trevor Lambourne, Operations manager, Digital Print Centre of Industrial Collaboration, Department of Colour Science, University of Leeds, UK
- Contact: Rohan Ratnakumar, Project Scientist, DeLaRue Overton Technology Centre, Hampshire, UK

Myllykowski Madison Paper Company, Alsip, Illinois, USA

- Wouter Peddemors, Director, Fiber Line and Technical Services, (Mill Project Manager)

  Discussed paper recyclability and de-inking

Outcomes: Best Practice in Image and Electronic Media Permanence

The J Paul Getty Museum, Los Angeles, California, conservation and storage facilities for paper and digital media (detail).

The J Paul Getty Museum collection houses its most sensitive and important works in dark, humidity controlled cold storage. This type of storage will greatly improve the survival of important cultural artifacts in photo-media but has a significant carbon footprint.

It is interesting to note that the collection is deemed so important that the City of Los Angeles assigned the Getty museum the same status as hospitals in terms of access to emergency power supply.

According to Mark Hamly, one of the key issues in relation to sustainable practice in printing of what we might call cultural artifacts is the identification of media and process used to make a print. In general that is the primary determinant of conservation and curatorial considerations. Mark kindly gave the Fellow a copy of a book on this topic[29] by his friend and colleague Martin C Jürgens, recently published by the Getty Foundation. This book, which Jürgens stated took him ten years to research and write, is an exhaustive treatment of the topic of identification and preservation of the digital print. It will make the task of the conservator easier, especially when combined with an accurately filled Photograph Information Record (see Attachment 7). Mark Hamly explained that this document was the result of widespread collaboration[30] and a writable version of this document (without copyright) is freely available online.[31]

Identification of Support (Substrate), Processes and Other Variables

The value of accelerated ageing tests on various combinations of inks and substrates in order to gain insights into the life expectancy of prints that are exposed to normal environmental and display conditions.

As far as image stability and durability are concerned, the following emerge (at the present time) as best practice choices for artists using digital print media:

- image forming substance is within surface of the media
- image forming substance is pigment-based
- media is made up of one layer.

Best practice factors that influence image stability and durability are as follows:

Image Stability

- Limit print exposure to light and UV radiation.
- Ensure lowest practical temperature as this limits both colourant fading and yellowing of coating or support.
- Avoid print exposure to liquid and relative humidity to inhibit colourant fading or bleeding and yellowing of coating or support.
- Aim for pure air quality as this also impacts on colourant fading and yellowing of coating or support.
- Avoid storage materials coming directly in contact with image as this also has a bearing on colourant fading and yellowing of coating or support.
- Do not mismatch ink and media (inkjet only) as it is likely to result in colourant fading.

Individual Printing Using Inkjet Technology

- Many photo media artists are now using Inkjet-based processes as a replacement for earlier darkroom-based processes, which resulted in either silver gelatin or traditional chromogenic prints.
- The printers and cartridges are to be rated against the criteria of recyclability.
- The digital file that replaces the traditional ‘transparency’ or ‘negative’ requires close attention in terms of version control and media life. Many storage media have short lifecycles and are susceptible to physical damage.

Key Findings on Preservation Issues

- The Department of Homeland Security has developed a forensic knowledge base for identifying the materials used by inkjet and laser printers. Its scientists can identify a print and match its inks and paper as well as device against manufacturer. Sharing the knowledge with conservators would result in considerable savings.
- Institutions are beginning to compliment new acquisitions with a Photograph Information Record to obtain essential information detailing the materials and techniques used in the creation of photographic works and their history. This allows institutions and individuals to better catalogue, interpret, and care for their photographs. Colour prints using inks or dyes tend to be less stable compared to black and white images.[32]
- Numerous factors can deteriorate and even destroy photographic prints. Some examples include:
  – High temperature and high Relative Humidity (RH)
  – Air pollution and dirt
  – Light exposure
  – Biological threats such as fungi and insects
  – Residual processing chemicals
  – Base and emulsion deterioration
  – Handling and usage
  – Improper storage and enclosures.

Three Signs of Age that Affect Colour Photography

1. Dark fading occurs regardless of the procedures taken to preserve a photograph and it is unavoidable. This is instigated by temperature and RH. Cyan dyes will typically fade more quickly, which will make the image appear overly red in colour.
2. Light fading occurs when materials are exposed to light, such as while on display. The intensity of the light source and UV rays will affect the rate of change and fade. Magenta dyes will typically fade the quickest.
3. Highlight staining occurs with older colour photographic papers, and is a yellowing of the border and highlight areas of a photograph.

Storage

As a general rule, the life of colour photographs is directly impacted by the temperature of the storage facility; the colder the storage, the longer the photographs last. Frost-free refrigeration, more commonly known as cold storage (below freezing) is one of the most effective ways to bring a halt to developing damage of colour photographic materials. Selecting this type of storage environment is costly and requires special training to remove and return items. Also, as Marc Hamly, Head of Paper Conservation at the Getty Conservation Institute pointed out, cold storage has in itself a significant carbon footprint and is thus not very sustainable.

Cool storage (above freezing) is more common and less costly, and requires that the temperature is consistently between 10 and 15 degrees Celsius at 30–40 per cent relative humidity with special attention to dew point to eliminate concerns for condensation. General dark storage in light tight enclosures and storage boxes is always advised for individual items. When materials are exposed to light during handling, usage, or display, light sources should be UV-filtered and intensity kept at minimum. In storage areas, 200 to 400 lx is recommended.

Handling

Large differences in handling behaviour were seen between inkjet papers. Some papers showed cracks in the image-accepting layers before buckling occurred; others only had buckling in the paper support and/or were actually torn during the testing. The severity of damage varied considerably amongst samples and is probably more important than the wedge diameter at which a given sample first exhibited cracking or buckling.

The most severe brittleness was found in the inkjet fine art papers and some glossy inkjet papers intended for photo printing.

Some digital prints can be significantly more sensitive to cracking than traditional chromogenic prints.[33]

Overall Conclusion

Identification of inkjet prints (substrate, ink and printing device) provide considerable support for the correct, or optimum, handling, storage and display decisions required for collections, both private and public. A standardised identification system is presently being trialed in the USA. See Attachment 7 for details of this system.

Colour prints, not electronic files, are the best way to ensure that digital images will be preserved for future generations. Many options, including traditional photographic prints, are now available for producing colour prints from digital images. When properly stored, dye-based inkjet and dye diffusion thermal transfer prints have stability comparable to that of traditional photographic prints. Pigment-based inkjet and colour electrophotographic prints are even more stable. All technologies may be vulnerable to damage from light, air pollution, and improper handling. Understanding the differences between available technologies and proper storage of the resulting prints is the key to long lasting colour prints.[34]

Outcomes: Industrial Printing and Sustainability

The printing and publishing industry is facing a period of unprecedented challenges and change. This industry needs to look at system level modeling with the aim of reducing unnecessary production, such as junk mail, improving product quality and durability (high impact print), and developing entirely new business models that include diversification and developing larger market share of reduced output markets (a larger slice of a smaller cake). Only sustainable businesses will survive this change.

The arrival of portable electronic readers has already impacted significantly on book sales. It will do the same to magazines, newspapers, and catalogues. It should be noted that both print and digital media are prodigious users of electricity and that each have a very large carbon footprint.[35]

Total supply chain analysis[36] is central to identifying and comparing carbon footprints, as well as overall sustainability values for a workflow or product. Standards and specifications for carbon footprinting such as ISO 14040, ISO 14064 and PAS 2050 do now exist, and open standards-based Web 2.0 platforms like AMEE[37] are now available that enable accurate carbon footprinting, like-for-like comparisons and large-scale supply chain analysis.

Key issues that emerged:

- The environmental impact of the printing industry and its supply chain.
- The lack of print industry specific legislation in Australia.
- The lack of leadership in identifying ‘whole system’ best practice.

Outcomes: Best Practice in De-inking and Paper Recycling

Historically, recyclability had little priority when designing a print product. In the last two years it has become more important, and the Fellow expects this trend to continue at an ever-increasing rate.

Amongst other factors, the printing process itself is crucial for the re-use of a printed product—flexo, UV, inkjet, and liquid toners as well as some adhesives can be challenges for the production of recycled graphic paper. Some print material can indeed spoil the de-inking process at concentrations as low as ten per cent of the total.[38] With rising environmental awareness, paper recycling becomes a more and more important issue in the marketing of printers and, accordingly, also in the development of a printer. But very little is known about coherences. During the recycling process, the ink is separated from the paper fibers dissolved in water, and then it has to be removed from the aqueous suspension. This is why current inkjet inks are almost impossible to de-ink.

Field-testing of de-inkability has been done for the last decade but without any rating system to evaluate a particular printed product. The European Recovered Paper Council (ERPC) adopted a scoring system for de-inkability in 2008. This system is based on the evaluation of de-inkability against the International Association of the Deinking Industry's (INGEDE's) Method 11, a laboratory procedure that has been developed to evaluate and compare the challenge a printed product presents for a paper-recycling mill.

In 2009, INGEDE began to establish a certificate confirming the de-inkability of a printed product, serving frequent requests of both the authorities and printing industry as well as the printer manufacturers and marketers. The certificate has already been accepted by the Austrian Consumer Organisation (VKI) who was the first to include de-inkability into the criteria for their eco-label for printed products.

The underlying procedure for de-inkability testing is INGEDE Method 11. Occasionally discussion occurs as to whether it is relevant for all de-inking processes, not only in Europe but also in the USA. The procedure allows a solid assessment under standard conditions but is not meant to simulate every detail of a de-inking plant.

The Research Organisation for Graphic Arts and Media (VFG) in Vienna, Austria, is working on an overall rating system for digital printing.

A range of parameters is used to form a sustainability number on a scale up to 100. A rating of 100 would describe a system that is completely sustainable.

A rating between 60 and 99 describes a range of essentially environmentally friendly and sustainable systems.

Different parameters are rated for the number 100, like de-inkability,[39] paper quality, FSC or the Programme for the Endorsement of Forest Certification (PEFC) paper profiles, energy consumption, CO_2 output, Volatile Organic Compound (VOC) figures, toner, inks, used chemicals, percentage of waste paper in production, air pollution, archival quality.

All factors are rated according their importance for the complete environmental process, and de-inking and paper are more important as an example of energy consumption.

Beside the number system, there are factors such as toxic and carcinogenic substances or lack of de-inkability, which prevent a system from being rated at all.

This rating system will be applied to the following Digital Printing Systems:

- Electrophotographic systems
- Magnetographic systems
- Inkjet Printers

- Dry and Liquid toner technology using:
  - dry toner
  - aqueous (water) based inks
  - pigmented inks
  - solid inks
  - solvent based inks.

In addition to all materials used in the production of toner, inks, paper and any other necessary chemicals.

Health, Safety and Environmental Criteria

Overall Considerations:

- Recycling capacity concerning the construction of the digital printing unit.
- Avoiding fixed connections.
- Recycled materials should be used in manufacturing whenever feasible.
- Mainframes, accessories, and replacement parts should be designed to be re-manufactured or recycled. System modularity can enable upgrades and extend useful life.
- Any plastic used should be free of halogen polymers—using definitions ISO 11469:2000 and ISO 1043 part 1–4. Batteries and accumulators used should be free of heavy metal components like lead, cadmium and mercury.

Paper Used

The printing system has to be able to print on paper produced from 100 per cent recycled pulp and paper that is FSC or PEFC certified.

Organic Photoconductor Drums[40]

- Must be free of selenium, lead, mercury or cadmium and used drums have to be taken back by the producer.
- Should be recyclable and should be rotated for extended life.

Requirements for Toner and Inks

- The design of toner and ink modules and cartridges should be outlined for recycling or to enable re-use. Important facts to note are that toner or ink modules for different colours are separately changeable.
- Containers for dry ink should be recyclable.
- Toner and ink modules are to be refillable or can be consolidated.

Components to be Excluded Under the Rating System

Toner or inks must be free of components listed in guideline 67/5487EWG, as listed below. See Attachment 6 for rating system.

- R40 (suspicion of being carcinogenic)
- R45 (carcinogenic)
- R46 (creates mutagen effects)
- R49 (carcinogenic through breathing)

- R60 (can affect reproduction)
- R61 (can affect pregnancy)
- R62 (can affect the child during breast-feeding).
- R68 (irreversible damage)
- AMES test[41] has to be negative.
- Toner or ink must be de-inkable (see de-inking).
- Free of mercury, lead, cadmium or chrome VI components.
- Free of azoic-dyes and pigments which can release amines.
- List of the chemical substances are listed in guideline 2002/61 EC (or TRGS 614).
- Special user manual for toner and inks has to be included.
- Biocides in inks have to fulfill the requirements of EC guideline 1048/2205 Emissions.
- TVOC (Total Volatile Organic Compounds).
- Single component evaluation for benzene, polystyrene, ozone and dust.

Outcomes: Paper Making and Recycling

Recycling of paper has a strong relationship to its de-inkability and it in turn has clear and troubling links to certain processes and inks:

- Indigo printers are really threatening the recycling industry because the inks used are not yet able to be removed.
- The high paper quality used for many magazines is not easily recyclable.
- Optical whitening is often totally unnecessary and difficult to recycle.
- Vegetable dyes are difficult to de-ink.

Bleaching with chlorine produces large amounts of organochlorine compounds, including dioxins. Increased public awareness of environmental issues (as evidenced by the formation of organisations such as Greenpeace and the others that followed) has influenced the pulping industry and governments to address the release of these materials into the environment—the amount of dioxin released has been reduced by replacing some or all of the chlorine with chlorine dioxide. The use of elemental chlorine has declined significantly and as of 2005 was used to bleach 19–20 per cent of all craft pulp. Elemental chlorine-free (ECF) pulping using chlorine dioxide is now the dominant technology worldwide (with the exception of Finland and Sweden), accounting for seven per cent of bleached craft pulp globally.

The promise of complete removal of chlorine chemistry from bleaching processes to give a totally chlorine-free (TCF) process, which peaked in the mid-1990s, did not become reality. The economic disadvantages of TCF, the lack of strict government regulation and consumer demand meant that EFC has not been replaced by TCF. As of 2005 only five to six per cent of bleached craft pulp is made using TCF sequences, mainly in Finland and Sweden. This pulp and paper goes to the German market, where regulations and consumer demand for TCF pulp and paper makes it viable.

A study based on Environmental Protection Authority (EPA) data demonstrated that TCF processes reduce the amount of chlorinated material released into the environment, relative to ECF bleaching processes that do not use oxygen delignification. The same study concluded, *"Studies of effluents from mills that use oxygen delignification and extended delignification to produce ECF and TCF pulps suggest that the environmental effects of these processes are low and similar."*[42] The energy needed to produce the bleaching chemicals for an ECF process not using oxygen delignification is about twice that needed for ECF with oxygen delignification or ECF processes.

It should also be noted that the revived concern shown by the Food and Drug Administration (FDA) with regard to BPA[43] should be of concern here as recycled newsprint and carbonless copy paper (ie receipts) can and does wind up as food containers, such as pizza boxes, thus exposing the unsuspecting to BPA.[44]

Further concern should be shown in regard to BPA in paper disposal/recycling as dangers have been highlighted when it is recycled into toilet paper[45] and when it is turned into landfill.

Outcomes: Ink and Toner

The image is intended to convey a sense of the vast broad acre planting of soy and corn. America alone plants approx. 87 Million Acres of Corn (70% of which is Genetically modified) and 72 Million acres of Soy (93% of which is Genetically modified). Source: USDA.

Both toners and inks are potentially dangerous and it sometimes takes decades to identify this. Office-style printers using toner cartridges should be used only in self contained and well-ventilated areas to mitigate effects on the respiratory system from Maximum Permissible Exposure (MPE) printer emissions.[46]

BPA is a preferred colour developer in thermal paper and in carbonless copy paper and general environmental exposure to it has been identified as being of potential serious risk to health.[47]

Soya-based inks are frequently cited as 'green inks', which is not necessarily correct if a Life Cycle Assessment (LCA) is applied.[48]

Specialist Inks such as those used in currency printing often require the use of dangerous and toxic chemicals to assist in cleaning as well as curing and hardening.[49]

The 1994 Vegetable Ink Printing Act of Congress[50] exerted a powerful influence on the industry. The bill mandated that printers with government contracts use vegetable oil-based inks instead of volatile petroleum-based inks whenever possible.[51] The main concerns were due to the hazardous effects of using crude oil as the ink base, as was done for most of the history of printing inks up to that time. Emissions from VOCs and emissions of Hazardous Air Pollutants (HAPs) had to be controlled. Printing inks also had to be developed to make the de-inking and recycling of paper easier. Printers wanted inks that stuck to paper, and recyclers wanted inks that could be easily removed.

Conventional screen printing inks contain solvents, which are a key cause of air pollution creating harmful pollutants like ground-level ozone.[52]

The alternative UV ink is exposed to intense Ultraviolet light for instantaneous curing and is frequently suggested to be environment friendly but UV curing inks are very difficult to de-ink.[53]

Outcomes: Future Technologies

The printing industry is acknowledging the inevitable impact of E Ink and organic and printed electronics on its future direction.

The 'sixth sense' device is in all likelihood just the beginning of a new paradigm in which the concepts of print, information technology and media convergence are merging into entirely new forms.

The next stage of print will be driven by E Ink-based technology such as electronic readers. Such tablet-style readers are already available on the market for less than $500 for a full colour display. Grayscale devices will drop in cost and will become the standard for many.

This will eventually displace most of the extant book, magazine and newspaper printing.

There is also potential for electronic engineering companies to collaborate with electronics print workshops in the same way that advertising agencies work alongside conventional printing companies. The engineering companies design the print work and have different products manufactured rapidly, even in small quantities.

Equipment and materials for the production of printable electronics are under development particularly in Europe, the Far East and the United States of America.

Additive manufacturing or printing electronics offer significant environmental benefits compared to the traditional subtractive processes. Only the required materials are added leaving no need for corrosive chemicals.[54]

Knowledge Transfer: Applying the Outcomes

The following activities are recommended in order to transfer the knowledge gained during the Overseas Fellowship journey:

Industry Seminar

Type of Activity: Group brainstorming session/think-tank

Aim of Activity: Create awareness and brainstorm concepts for progressing sustainable printing in Australia

Intended outcome: Formation of a working group would further explore how these learnings may be adopted and scaled to the Australian Research and Education sector.

Target Audience: Sustainability consultants, designers, print educators and government

Timeframe of Activity: Date to be determined after publication of report

Location: To be determined, but could be at any TAFE institution with printing education and suitable facilities. Swinburne University (TAFE) may be prepared to host such an event.

Government Seminar

Type of Activity: Presentation

Aim of Activity: To provide an insight into the learnings obtained from the USA trip and how the learnings may be adapted to the Australian industry.

Target Audience: Both printing educators and practitioners to be invited

Location: TBC

Timeframe of Activity: One half day, with follow-up sessions based on response to initial seminar

Location: TBC

Short Course

Type of Activity: Short course

Aim of Activity: Create awareness and understanding of key issues involved in sustainable printing in Australia.

Target Audience: Targeted to design students, designers, printers, educators and government

Timeframe of Activity: TBC

Location: TBC

Recommendations

Currently Australia does not have legislation that prescribes sustainable printing protocols. The following recommendations are made to address this obvious deficiency.

Government

Recycling

There appears to be a difference in opinion between the printing industry's view of recovered paper as a raw material and developing public policy,[55] which often views it as waste.[56] If recycling is to continue to move forward, this needs to be addressed.[57]

Europe is the world leader in recycling paper with a rate of 64.5 per cent. The paper industry has been a driving force in achieving that rate and is part of a new industry initiative to push it even higher, to 66 per cent by the close of 2010.[58] Australia's paper recycling is often reported in misleading ways because agencies, such as the Australian Bureau of Statistics (ABS), report that more than 90 per cent of households recycle paper and cardboard without including what that translates to in terms of actual percentage of paper recovery.[59]

Furthermore, Australian industry has not, to this writer's knowledge, been examined in terms of its paper recycling for the last 20 years[60] and the figures provided by the recycling industry tells only part of the story.[61]

Industry

Industry needs to actively move towards a green printing protocol and work together with academia, the EPA and other stakeholders to progressively move to greener practices. This involves far more than simply reducing the industry carbon footprint.

The Fellow could not obtain Australian statistics on VOC emissions but the latest available figures on VOC emissions in the USA (by industry sector) show that the printing industry ranks at number five (with 101,537 short tons per year), pulp and paper at number seven (with 96,875 short tons per year). As the EPA (USA) lists organic chemicals, rubber/plastics, and fabricated metal separately on its Aerometric Information Retrieval System (AIRS) database, it could be argued that combining the input from these areas with the above mentioned pulp, paper and printing emissions, the printing industry overall may well rate as the number one VOC polluter. Arguably, the Australian situation may be somewhat different, but the industry should be strongly motivated to reduce its VOC footprint.

Professional Associations

The Design Institute of Australia (DIA) and similar bodies should focus on promoting greater awareness amongst designers in how to meaningfully influence the evolution towards truly green practices (as opposed to green washing practices).

The relevant industry bodies have a role to educate businesses that alternatives to traditional printing should be explored. Businesses often use colour inkjet printers alongside black and white laser printers and only use a single recycling container. A combination of the highly recyclable black and white laser prints and the poorly recyclable Inkjet prints might make the total container unrecyclable due to de-inking problems.

Education and Training

All courses leading to a qualification in graphic design should now include a strong sustainability focus. In the first instance it would seem appropriate to avoid prescribing specific practices to students—equipping them with a framework for analysing existing activities and conventions, and accessing the latest research as part of the course projects. This would include protocols where design students are challenged to explore communication strategies that offer alternatives to print.

Recommendations

Community

The community at large needs to become active participants in demanding improved recycling and lowering unnecessary communication and packaging.

ISS Institute

Support a rollout of education and awareness initiatives that popularise best green practice in printing and the printing industry supply chain.

Further Skills Deficiencies

More research is needed into how optimum paper recycling can be achieved. The EU leads in this area with Austria and Germany in particular recognised as being at the forefront.[62] There are some local initiatives that can be held up as examples of best practice,[63] such as the Kiama Municipal Council and the Deutsche Bank Place at 126 Phillip Street Sydney.[64]

References

Endnotes

[1] The invention of printing, using moveable type is attributed to 'Johannes Gensfleisch zur Laden zum Gutenberg' and its dating varies between 1439 and 1454

[2] RIMIR/NPES recently published a series of three reports entitled 'The World-Wide Market for Print 2006-2011'. UK's Pira International conducted the research. The first report identified and profiled 51 country markets that essentially account for 99% of the global print market. The second report explored those markets and identified the markets for printing equipment, paper and supplies. The final report rolls up the findings from the first two phases, identifies and profiles eleven key emerging or developing markets, and provides a global forecast as well as forecasts for each print market including forecasts for equipment, paper and consumables markets through 2011. According to the study, the global print market is forecast to grow by 18% to US$721 billion by 2011, with fastest growth in developing/emerging countries. http://www.primir.org/Files/GlobalPrintPR.pdf

[3] http://www.greenpeace.org/international/campaigns/toxics/electronics/where-does-e-waste-end-up

[4] At a conference in May 2009, State and federal governments recognised the need for a national, regulated computer e-waste system, something Australian Information Industry Association lobbied for over five years. *"The ministers have made a strong commitment to this direction."* Ministers are yet to agree on regulations. http://www.itnews.com.au/News/145765,ministers-agree-to-national-e-waste-regulation.aspx

[5] IBSA's Environment Scan 2010, Innovation and Business Skills Australia 2010, Page 11

http://www.ibsa.org.au/Portals/ibsa.org.au/docs/Research%20&%20Discussion%20Papers/Sectoral%20report%20-%20Printing%2026%20Feb%2010.pdf

[6] Packaging for an ageing population: http://www.pca.org.au/uploads/00499.pdf pages 6-7

[7] The production of mechanical pulp (also called groundwood) results in little removal of lignin content, and consequently produces paper that is not of as high a quality as other pulping methods that remove significant amounts of lignin. The advantages of mechanical pulping are its high pulp yield (100 pounds of wood can generate as much as 95 pounds of pulp), its low cost, and the paper it produces has several desirable printing qualities, such as high ink absorbency, compressibility, opacity, and bulk. Disadvantages, however, include low strength, low permanence, and a tendency to yellow with time (primarily caused by high levels of lignin). Paper made with mechanical pulps also contain shives, or incompletely ground fiber bundles.

Mechanical pulps are primarily used in newsprint, as well as papers used in telephone directories, catalogs, 'pulp' magazines, and paper towels and tissues.

See http://printwiki.org/Mechanical_Pulping

[8] http://www.amazon.com/Kindle-Amazons-Original-Wireless-generation/dp/B000FI73MA

[9] http://www.apple.com/au/ipad/

[10] http://ebookstore.sony.com/reader/

[11] http://people.ccmr.cornell.edu/~cober/mse542/page2/files/Herz Electrophoretics.pdf

References

[12] Compared to 12" LCD Display a similar sized Elnk display uses 36 times less power.

Electronic Paper Comes of Age Dr Michael McCreary VP Research and Advanced Development E Ink Corporation Digital Fabrication 2009 Louisville, KY NIP 25 / Digital Fabrication 2009 Society for Imaging Science and Technology September 22, 2009, page 10 (please see attachment).

[13] IDC, the world's leading technology media, research and events company (http://www.idc.com.au/about/default.asp), estimates about 2.5 million e-readers were sold in 2009, and that number is expected to double to 5.1 million this year.

http://seattletimes.nwsource.com/html/businesstechnology/2011695150_btereaders26.html

[14] While the writer could no access any recent statistics of the financial value of the printed circuit industry, the following snapshot of the US industry ten years ago can be used as a guide to the growth pattern in this industry:

"In the late 1990s, more than 1,300 US facilities shipped printed circuit boards worth $9.1 billion. By 2000, the value of shipments had increased to more than $12 billion. The total number of industry employees grew steadily throughout the late 1990s, rising from 72,282 in 1997 to 84,018 in 2000".

Read more: http://www.referenceforbusiness.com/industries/Electronic-Equipment-Components/Printed-Circuit-Boards.html#ixzz0m4FXytKN

[15] The foil surface of the substrate is degreased. The panels pass through a vacuum chamber where a layer of positive photoresist material is pressed firmly onto the entire surface of the foil. A positive photoresist material is a polymer that has the property of becoming more soluble when exposed to ultraviolet light. The vacuum ensures that no air bubbles are trapped between the foil and the photoresist. The printed circuit pattern mask is laid on top of the photoresist and the panels are exposed to an intense ultraviolet light. Because the mask is clear in the areas of the printed circuit pattern, the photoresist in those areas is irradiated and becomes very soluble.

The mask is removed, and the surface of the panels is sprayed with an alkaline developer that dissolves the irradiated photoresist in the areas of the printed circuit pattern, leaving the copper foil exposed on the surface of the substrate.

The panels are then electroplated with copper. The foil on the surface of the substrate acts as the cathode in this process, and the copper is plated in the exposed foil areas to a thickness of about 0.001-0.002 inches (0.025-0.050 mm). The areas still covered with photoresist cannot act as a cathode and are not plated. Tin-lead or another protective coating is plated on top of the copper plating to prevent the copper from oxidizing and as a resist for the next manufacturing step.

The photoresist is stripped from the boards with a solvent to expose the substrate's copper foil between the plated printed circuit pattern. The boards are sprayed with an acid solution, which eats away the copper foil. The copper plating on the printed circuit pattern is protected by the tin-lead coating and is unaffected by the acid.

http://www.answers.com/topic/circuit-board

[16] http://www.inece.org/mmcourse/chapt7.pdf

[17] http://www.greenpeace.org/international/news/e-waste-toxic-not-in-our-backyard210208

[18] http://www.educaedu.com.au/sustainable-development

[19] IBSA's Environment Scan 2010, Page 4

http://www.ibsa.org.au/Portals/ibsa.org.au/docs/Research%20&%20Discussion%20Papers/Sectoral%20report%20-%20Printing%2026%20Feb%2010.pdf

[20] ibid, page 1

[21] http://www.proprint.com.au/News/148952,sustainable-green-print-program-launched.aspx

[22] Maria Enroth *Developing tools for sustainability management in the graphic arts industry*, PhD Dissertation, Royal Institute of Technology, Stockholm 2006

[23] William, McDonough; Michael Braungart *Cradle to Cradle: Remaking the Way We Make Things* (2002). North Point Press

[24] According to The Public Recycling Officials of Pennsylvania, for every ton [907 kg] of paper that is recycled, the following are saved:

- 17 trees
- 275 pounds [125 kg] of sulfur
- 350 pounds [159 kg] of limestone
- 9,000 pounds [4,082 kg] of steam
- 60,000 gallons [22,7125 liters] of water
- 225 kilowatt hours
- 3.3 cubic yards [2.5 m^2] of landfill space

Please note: measures described in vertical brackets [ ] are conversions calculated by the author

http://www.all-recycling-facts.com/recycling-statistics.html

[25] http://www.avoka.com/blog/?tag=climate-change. The same site also provides a rather useful eForm benefits calculator (http://www.avoka.com/flash/formcalc/formCalc6.html).

[26] According to the latest ShapeNZ nationwide poll there is equal support (39% each) for the Prime Minister's aspirational goal for the country to become carbon neutral and the National Party's recently announced policy to cut greenhouse gas emissions to 50% of 1990 levels by 2050.

http://www.nzbcsd.org.nz/story.asp?StoryID=788

[27] For example ultrafine particle (UFP) emissions from laser printing systems (http://arstechnica.com/science/news/2007/07/laser-printers-pollute-office-air.ars).

[28] This fact is acknowledged by ISO itself: An IWA is an ISO document produced through workshop meeting(s) and not through the technical committee process.

Any interested party can propose an IWA and can participate in developing one. An ISO member body will be assigned to organise and run the workshop meeting(s) resulting in the IWA. Market players and other stakeholders directly participate in IWA and do not have to go through a national delegation. An IWA can be produced on any subject.

An IWA can be developed swiftly (published in less than 12 months) to address a rapidly emerging market need or public policy requirement.

The ISO brand can give international recognition and credibility to your organisation's work.

IWAs can be used as precursors to International Standards. The process for developing an IWA is detailed here: http://www.iso.org/iso/tmb_iwa.pdf.

[29] *The Digital Print* Identification and Preservation Martin C. Jürgens, The Getty Conservation Institute, Los Angeles, 2009

References

[30] This form is endorsed by: The American Institute for Conservation and its Photographic Materials Group. It is used by The Art Institute of Chicago; Atelier de Restauration et de Conservation des Photographies de la Ville de Paris; George Eastman House, Rochester, New York; High Museum of Art, Atlanta; J Paul Getty Museum, Los Angeles; Los Angeles County Museum of Art; The Metropolitan Museum of Art, New York; Milwaukee Art Museum; Museum of Fine Arts, Boston; The Museum of Fine Arts, Houston; The Museum of Modern Art, New York; National Gallery of Art, Washington, DC; National Gallery of Australia, Canberra; The National Gallery of Canada, Ottawa; The New York Public Library; Philadelphia Museum of Art; Rijksmuseum, Amsterdam; San Francisco Museum of Modern Art.

[31] http://www.conservation-us.org/PIR

[32] Experimentation with creating photographs that mirrored the colours of real life began as early as 1861. Each process may require different methods of preservation.

Colour photographic materials are impermanent and are by nature unstable. Chromogenic colour photographs, for example, are composed of yellow, magenta, and cyan organic dyes; which fade at different rates. Even when in dark storage and enclosed in the proper archival materials, deterioration is unavoidable. However, when given the proper preservation care, fading, colour shifting, and discolouration can be delayed.

[33] *Brittleness of Digital Reflection Prints* Eugene Salesin, Daniel Burge, Peter Adelstein and James Reilly; Image Permanence Institute, Rochester Institute of Technology, Rochester, NY, USA

[34] http://www.imagepermanenceinstitute.org/shtml_sub/consumerguide.pdf

[35] According to the Department of Energy, the US papermaking industry used more than 75 billion kilowatt hours of electricity in 2006. That's the fourth largest industrial use of electricity in the country. However, US data centers and servers consumed over 60 billion-kilowatt hours of electricity during the same year, and that does not include the energy consumed by client computers or networks. In fact, recent analysis by Gartner Research indicates that datacenter energy consumption is expected to double by 2010, and its growth is unsustainable. This is one of the factors spurring investment in Green IT.

[36] Also known and refered to as 'Cradle to Grave' or 'Cradle to Cradle' analysis.

http://www.businessdictionary.com/definition/cradle-to-grave.html

[37] AMEE (http://www.amee.com) has been named one of the UK's *"20 fastest-growing clean-and-cool companies"* for 2010 in a competition initiated by the UK's Technology Strategy Board.

[38] This problem is especially evident when recycling water based, pigment based inkjet prints.

B Carre and L Magnin *Digital prints: a survey of deinkability behaviours* published by 7th Research Forum on Recycling, Quebec, Canada 2004

[39] Not yet deemed a proper work but progressively being used in the recycling industry.

[40] 'OPC' stands for organic photoconductor. The term 'organic' indicates that the photoreceptor's coating was manufactured from carbon-based chemical compounds -- specifically, photo-conductive polymers synthesized from raw materials, that are obtained by refining fossil fuels such as petroleum. OPC drums are generally considered the most 'environmentally friendly' photoreceptors available today -- primarily because their designers and manufacturers consciously utilize nonhazardous raw materials.

In fact, all materials must pass strict material safety tests before they can be used in OPC manufacturing. This ensures that OPC drums are, in fact, environmentally friendly alternatives to more hazardous photoreceptors such as arsenic triselenide (As2Se3) and selenium tellurium (SeTe) drums.

http://www.doc-imaging.com/opc_drums.htm

[41] http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/A/AmesTest.html

[42] Duke University, Environmental Defense Fund sponsored by Johnson & Johnson, McDonald's,The Prudential Insurance Company of America and Time Inc.

White paper #5 : Environmental Comparison Of Bleached Kraft Pulp Manufacturing Technologies, December 19, 1995, page 44

http://www.edf.org/documents/1626_WP5.pdf

[43] http://www.nytimes.com/2010/01/16/health/16plastic.html?th&emc=th

[44] Sharon Begley When Studies Collide – Rethinking the evidence *on BPA* in Newsweek

http://www.newsweek.com/2009/06/19/when-studies-collide.html

[45] M Gehring, D Vogel, L Tennhardt, D Weltin & B Bilitewski Bisphenol A contamination of wastepaper, cellulose and recycled paper products http://library.witpress.com/pages/PaperInfo.asp?PaperID=14382

[46] Fraunhofer-Gesellschaft (2008, December 3). Particulate Emissions From Laser Printers. *ScienceDaily*. Retrieved February 6, 2010, from http://www.sciencedaily.com/releases/2008/12/081202115330.htm

[47] http://www.niehs.nih.gov/news/media/questions/sya-bpa.cfm

[48] According to the US Department of Agriculture America had 75.7 million acres (about the size of Italy) of Soybean plantation in 2008 (http://www.ers.usda.gov/News/SoyBeanCoverage.htm). 92% of soybean acreage in the US is planted with genetically-modified soybeans. Soybean production is a major source of deforestation in the Amazon basin in Brazil resulting in the release of carbon into the atmosphere and contributing to global warming. The European commission warns of global consequences in this 2006 alert: http://ec.europa.eu/environment/integration/research/newsalert/pdf/39na3.pdf.

[49] For example, Securency International notified environmental authorities about the leak at Note Printing Australia four days after it occurred on New Year's Day.

An estimated 25,000 litres of methyl ethyl ketone spilt from a burst hose. http://hume-leader.whereilive.com.au/news/story/craigieburn-spill-reported-late-to-epa/

[50] http://rs9.loc.gov/cgi-bin/query/z?c103:H.R.+1595:

[51] The specifics are important here as it is only a partial conversion to as can be seen from the specific entry in the act on

VEGETABLE-BASED INKS-

(1) IN GENERAL- Notwithstanding any other law, beginning on the date that is 180 days after the date of enactment of this Act, all lithographic printing performed or procured by a Federal agency that uses oil in its ink shall use the maximum amount of vegetable oil that is technologically feasible and results in printing costs that are cost-competitive with printing using petroleum-based inks.

(2) MINIMUM PERCENTAGES- Except as provided in paragraph (3), in no event shall a Federal agency use any ink that contains less than the following percentages of vegetable oil in its ink used for lithographic printing:

(A) In the case of news inks, 40%.

(B) In the case of sheet-fed inks, 20%.

(C) In the case of forms inks, 20%.

(D) In the case of heat-set inks, 10%.

[52] http://www.screen-printing-advisor.com/screenprintingink.html

[53] http://sciencelinks.jp/j-east/article/200513/000020051305A0565990.php

[54] The Vicinics consortium in Finland recognises that: to commercialise this emerging technology it is vital to perform a comprehensive environmental evaluation throughout the materials, components, manufacturing processes and product life cycles. Transparent environmental information reporting is critical for successful products. Therefore the environmental study of ink-jet printable electronics started simultaneously with process and material development in a project researching printable electronics under the Vicinics consortium. Vicinics is an international industrial- academic consortium including participants from ICT and paper industry. Environmental demands are becoming more and more product life cycle oriented and so we have taken a wristband, a technology demonstrator manufactured using ink-jet printing, as a test subject for the study.

The study started with the gathering of environmental information on the compiled band life cycle scenario. The information was structured by MET- matrix (material, energy, toxicity) for the preliminary assessment of the band life cycle with the combination of complementary ecodesign tools. In fact, the assessment is a continuous iterative process, as the quality of information improves in parallel with the development of the band, and since the applicability of different ecodesign tools is evaluated concurrently. Finally, the results of the assessment were used to form environmental performance indicators which can help designers make sustainable decisions without complete knowledge about environmental terms, and this is why indicators were selected as the ecodesign approach. In order to construct indicators, environmental impacts and requirements must first be identified and evaluated, and then assigned to the properties of the product. As a result, the most significant environmental aspects of the product were evaluated and translated to the first list of corresponding ecodesign indicators with adequate use and update instructions. See http://www.imaps.org/jmep/jmep.asp – 2009

[55] Matthew Benns 'It's cheaper to bury than recycle: council' The Sydney Morning Herald, March 21, 2010

http://www.smh.com.au/environment/its-cheaper-to-bury-than-recycle-councils-20100320-qn71.html

Also:

"Kerbside recycling is widely hailed as a suburban success story. Yet it only tackles part of the problem. A huge amount of recyclable materials are still ending up in landfill, much of it generated at work or when we're just out and about.

Take waste at the office. According to research from the Paper Recycling Action Group of Australia, 9 out of every ten sheets of office paper are thrown away. This creates the ridiculous situation of recycled toilet paper manufacturers having to import used white paper".

Source: http://www.abc.net.au/science/features/recyclingreality/default.htm

[56] Australia collects and recycles substantial proportions of the newsprint and packaging paper and board consumed in Australia. Overall, in 2007-08, Australia recycled or exported around 2.5 million tonnes of waste paper and paper board — a recovery ratio of around 64 per cent (the recovery rate for newspapers is over 77 per cent).

Australia's strong performance in relation to recycling relies upon good household collection systems that do not contaminate recovered paper with other materials.

In 2004, the global collection was 177 million tonnes, which represented a 50 per cent recovery rate of paper produced. Western Europe, Belgium, Germany and the Netherlands have the highest recovery rates, representing 70-80 per cent of their paper production.

Pulp and Paper Industry Strategy Group Issues paper, 2009, page 29

http://www.innovation.gov.au/Section/Industry/Documents/Final_PPISG_Issues_Paper.pdf

[57] World Top Ten Paper Recycling Countries

(Tonnes) Per 1,000 People

Switzerland	167.36
Sweden	164.61
Austria	157.77
Netherlands	155.30
USA	144.14
Germany	140.55
Finland	134.80
Japan	116.55
Norway	98.26
France	93.62

Source: http://www.mapsofworld.com/world-top-ten/world-top-ten-paper-recycling-countries.html

[58] http://www.cepi.org/Content/Default.asp?PageID=53

[59] ABS: WASTE AND RECYCLING PRACTICES OF HOUSEHOLDS

http://www.abs.gov.au/AUSSTATS/ABS@.NSF/a9ca4374ed453c6bca2570dd007ce0a4/501F93E63FF1B6C5CA2573D200106169?opendocument

Compared with 1996, paper products (including cardboard and newspapers) were the most commonly recycled material in Australia (graph 2.2). In the Australian Capital Territory, about 99% of households recycled paper, 97% in Victoria and 93% in New South Wales. Paper recycling was lowest in the Northern Territory (74%) but has nearly doubled since 1996 (39%). Significant increases in paper recycling were also noted in Tasmania (63% in 1996 to 86% in 2006), Victoria (77% to 97%) and Western Australia (68% to 85%).

[60] Australian Government Productivity Commission, Interim Report on Paper Recycling (http://www.pc.gov.au/ic/inquiry/02paper), 15 May 1990: Nearly 2.8 million tonnes of paper products are consumed annually in Australia. About one-third of this is recovered and recycled (page 17). It should be noted that this interim report was commissioned by Paul Keating in 1989 and (to this writers knowledge) no further enquiry or federal report on office/industry paper recycling in Australia has been commissioned since.

References

[61] For example, the Australian Plantations Products and Paper Industry Council website (http://www.a3p.asn.au/keyissues/recycling.html) states: More than 1.6 million tonnes of waste paper is collected each year, most of which is used in making paper. Collecting this paper saves the cities and towns we live in about $80 million per year in reduced rubbish disposal costs.

Paper makes up between 10% and 15% of the rubbish that is taken from houses to the rubbish tip. Rubbish from houses makes up just under half of the total rubbish produced in Australia. The other half of the rubbish comes mainly from building sites but also from offices, shops and factories. Surveys suggest that waste paper makes up less than one-tenth of the total rubbish going to Australian rubbish tips.

Does Australia recycle as much paper as other countries?

Most fibre used to make paper in Australia is recycled [but not necessarily in Australia: "Take waste at the office. According to research from the Paper Recycling Action Group of Australia, 9 out of every ten sheets of office paper are thrown away. This creates the ridiculous situation of recycled toilet paper manufacturers having to import used white paper!
ABC (http://www.abc.net.au/science/features/recyclingreality/default.htm) W.H.]. Fibre from recycled paper currently makes up approximately half of total production, and this figure has increased significantly in recent years because of major investments made by the industry.

Australia is a world leader in recycling newspapers. Australia recovers for recycling more than 70% of newsprint. In contrast, the average recycling rate in Western Europe and the US is approximately 50%. In Europe, the large numbers of people living in small areas make it cheaper and easier to collect waste paper.

[62] http://ec.europa.eu/environment/etap/pdfs/jan07_eu_paper_recycling.pdf

[63] Kiama Municipal Council 'Walks the Talk' & Increases its Own Recycling by 50%

http://www.papertopaper.com.au/site/news.php?pID=94&articleID=23such

[64] Recycling figures for the property for 2006/2007 put the level of diversion of waste from land fill at an overall average for the year of 79% per month. This outstanding result is the greatest level of waste diversion for Investa Property Group, owners and managers of the building, across their Australian portfolio.

Paper makes up 42% of the building's waste. It takes a lot less energy to produce new office paper from old office paper rather than producing it from virgin pulp. However, without 'at source' separation from other contaminating waste, a lot of paper that is recycled would be 'down cycled' to cardboard or other lower grade paper products.

The Paper To Paper bin, which sits neatly under each of the 3000 desks within the Deutsche Bank Place building, makes it easy to separate waste paper where it is created. Waste paper slips easily into the lower section of the unit, protected from other contaminating waste which is collected in the top compartment.

According to General Manager of 126 Phillip St, Kerry Wade the unique Paper To Paper at source separation waste bin is a key driver in the impressive recycling results within the building, with 100% of the 250 tonnes of used office paper from the property diverted back to the production of clean paper each year.

http://www.papertopaper.com.au/site/news.php?pID=94&articleID=30

Bibliography

Books

McDonough, William and Braungart, Michael. *Cradle to Cradle: Remaking the Way We Make Things*, North Point Press, 2002

Jürgens, Martin C. *The Digital Print* Identification and Preservation The Getty Conservation Institute, Los Angeles, 2009

Wilhelm, Henry and Brower, Carol *The Permanence and Care of Color Photographs: Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures* Wilhelm Research Institute 1993

Government Acts

Mr DURBIN (for himself, Mr. LEACH, Mr. PENNY, and Mr. BEREUTER) *Vegetable Ink Printing Act of 1993*, the Senate and House of Representatives of the United States of America in Congress assembled, 1993 http://rs9.loc.gov/cgi-bin/query/z?c103:H.R.+1595:

Papers and Articles

Author(s) not cited] *Deutsche Bank Place at 126 Phillip Street Great Team Work Creates a New Sustainability Benchmark* Paper to Paper International Pty Ltd 4.10.2007 http://www.papertopaper.com.au/site/news.php?pID=94&articleID=30

[Author(s) not cited] *Kiama Council with Innovative New Waste Minimisation System* Paper to Paper International Pty Ltd 13.9.2007 http://www.papertopaper.com.au/site/news.php?pID=94&articleID=23such

[Author(s) not cited] *Pulp and Paper Industry Strategy Group Issues paper,* Commonwealth of Australia 2009 http://www.innovation.gov.au/Section/Industry/Documents/Final_PPISG_Issues_Paper.pdf

[Author(s) not cited] *Recycling Reality - Features - The Lab - Australian Broadcasting Corporation's Gateway to Science* February 2, 2006 http://www.abc.net.au/cgi-bin/common/printfriendly.pl?/science/features/recyclingreality/default.htm

[Author(s) not cited] Sustainable Green Print program launched, Jul 1, 2009 http://www.proprint.com.au/News/148952,sustainable-green-print-program-launched.aspx

[Author(s) not cited] *Waste and Recycling Practices of Households* Australian Bureau of Statistics 1301.0 - Year Book Australia, 2008 http://www.abs.gov.au/AUSSTATS/ABS@.NSF/a9ca4374ed453c6bca2570dd007ce0a4/501F93E63FF1B6C5CA2573D200106169?opendocument

[Author(s) not cited] *Where does e-waste end up?* http://www.greenpeace.org/international/campaigns/toxics/electronics/where-does-e-waste-end-up

[Author(s) not cited] White paper #5 : *Environmental Comparison Of Bleached Kraft Pulp Manufacturing Technologies* Duke University, Environmental Defense Fund sponsored by Johnson & Johnson, McDonald's,The Prudential Insurance Company of America and Time Inc., December 19, 1995, http://www.edf.org/documents/1626_WP5.pdf

References

[Author(s) not cited] *Why Screen Printing Ink Industry Should Turn Environment Friendly* Screen Printing, 2008 http://www.screen-printing-advisor.com/screenprintingink.html

[Author(s) not cited] *Where does e-waste end up?* http://www.greenpeace.org/international/campaigns/toxics/electronics/where-does-e-waste-end-up

[Author(s) not cited] *Where does all the e-waste go?* February 21, 2008 http://www.greenpeace.org/international/en/news/features/e-waste-toxic-not-in-our-backyard210208/

[Author(s) not cited] Particulate Emissions From Laser Printers. Fraunhofer-Gesellschaft (2008, December 3). ScienceDaily. Retrieved February 6, 2010, from http://www.sciencedaily.com/releases/2008/12/081202115330.htm

[Author(s) not cited] *Key Issues: Sustainability and Environment, Paper Recycling* Australian Plantations Products and Paper Industry Council [ND] http://www.a3p.asn.au/keyissues/recycling.html

[Author(s) not cited] IBSA Environment Scan 2010, Innovation and Business Skills Australia 2010 http://www.ibsa.org.au/Portals/ibsa.org.au/docs/Research%20&%20Discussion%20Papers/Sectoral%20report%20-%20Printing%2026%20Feb%2010.pdf

Begley, Sharon *When Studies Collide: Rethinking the evidence on BPA. Newsweek*, June 20, 2009 http://www.newsweek.com/2009/06/19/when-studies-collide.html

Benns, Matthew *It's cheaper to bury than recycle: council* The Sydney Morning Herald, March 21, 2010 http://www.smh.com.au/environment/its-cheaper-to-bury-than-recycle-councils-20100320-qn71.html

Bucher, John and Shelby, Mike *Since You Asked - Bisphenol A (BPA) Questions and Answers about Bisphenol A.* The National Toxicology Program (NTP) is an interagency program of the US Department of Health and Human Services, 2009 http://www.niehs.nih.gov/news/media/questions/sya-bpa.cfm

Carre, B and Magnin, L. *Digital prints: a survey of deinkability behaviours* published by 7th Research Forum on Recycling , Quebec, Canada 2004 http://www.ingede.de/ingindxe/pdf/2005-dpp-article-digital-print-deinking-carre.pdf

Coleman, Graeme *New Zealanders want country to become global leader on climate change, back Labour and National policies* New Zealand Business Council for Sustainable Development, 10 Jul 2007 http://www.nzbcsd.org.nz/story.asp?StoryID=788

Enroth, Maria *Developing tools for sustainability management in the graphic arts industry*, PhD Dissertation, Royal Institute of Technology, Stockholm 2006

Frost, Prudence *Background paper for the workshop 'Packaging your world: protect, preserve, contain, inform'*. Packaging Council of Australia, June 2005 http://www.pca.org.au/uploads/00499.pdf

Gallagher, Dan *Can e-readers compete with newcomer iPad?* The Seattle Times, April 24, 2010 http://seattletimes.nwsource.com/html/businesstechnology/2011695150_btereaders26.html

Gehring, M, Vogel, D, Tennhardt, L, Weltin, D, and Bilitewski, B. Bisphenol *A contamination of wastepaper, cellulose and recycled paper products* http://library.witpress.com/pages/PaperInfo.asp?PaperID=14382

References

Grady, Denise *FDA Concerned About Substance in Food Packaging* New York Times, January 15, 2010 http://www.nytimes.com/2010/01/16/health/16plastic.html?th&emc=th

Herz, Erik *Electrophoretic Display Technology: The beginnings, the improvements, and a future in flexible electronics* May 19, 2006, MSE 542 Materials Science and Engineering Cornell University, Ithaca, NY http://people.ccmr.cornell.edu/~cober/mse542/page2/files/Herz%20Electrophoretics.pdf

Kunnari, Esa *Environmental Performance Evaluation of Printed Electronics in Parallel with a Prototype Development* Tampere University of Technology, Institute of Electronics, Finland, 2007 http://www.imaps.org/abstracts/system/new/abstract_preview.asp?abstract=07imaps064

Makoto, Wakatsuki *Deinking Agent for Used Paper Printed with UV Curable Ink*, Japan TAPPI Journal, Vol 59, No 7, 2005 http://sciencelinks.jp/j-east/article/200513/000020051305A0565990.php

Morton D C et al. *Soybean Production Impacts Climate and Deforestation in the Amazon* 'Science for Environment policy': European Commission DG Environment News Alert Service,19 October 2006 http://ec.europa.eu/environment/integration/research/newsalert/pdf/39na3.pdf

Parker, M L, Mauldon, R G, Chapman, D R. *Interim Report on Paper Recycling*, Industry Commission, Commonwealth of Australia, 1990 http://www.pc.gov.au/ic/inquiry/02paper/02paper.pdf

Ringman-Beck, Jori, Leberle, Ulrich, Ashmead, Sophy Recycling Confederation of European Paper Industries (CEPI), Brussels [ND] http://www.cepi.org/Content/Default.asp?PageID=53

Salesin, Eugene, Burge, Daniel, Adelstein, Peter and Reilly, James *Brittleness of Digital Reflection Prints* Image Permanence Institute, Rochester Institute of Technology, Rochester, NY, USA. 2009

Winterford, Brett *Ministers agree to national e-waste regulation* May 22, 2009 http://www.itnews.com.au/News/145765,ministers-agree-to-national-e-waste-regulation.aspx

Attachments

Index to Attachments (See CD)

1. Environmental Rating Scale for Evaluation Sustainability of Digital Printing Systems, *Research Organisation for Graphic Arts and Media*, 2009

2. *Electronic Paper Comes of Age,* Dr Michael McCreary, 2009. Reprinted with permission.

3. Assessment of Print Product Recyclability – Deinkability Scorecard, *European Recovered Paper Council,* 2008

4. *European Declaration on Paper Recycling 2006 – 2010*. Reprinted with permission.

5. Sustainable Design Checklist. Public document.

6. *Deinkability Certification for Public Procurement and Marketing of Printed Products*, Axel Fisher, 2009. Reprinted with permission.

7. *Photograph Information Record*, The JP Getty Museum et al, 2009. Public document.