Transitioning Towards Conscious Sustainability Efforts in the Print Industry: An Examination

Donna Razik and Dr. Martin Habekost

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Abstract

The print industry has a reputation for being wasteful, especially within the printing processes, and it uses significant raw materials and energy to produce custom products that often have a limited lifespan. However, paper is one of the most recycled materials, and considerable efforts in R&D and policies push for transition efforts in sustainability across all five stages of a product's environmental life cycle. Life cycle assessments (LCA) are being executed to establish a baseline and comparative analysis of print operational systems' ecological impacts and seek improvements in planning approaches, technologies, and manufacturing. Government and regulatory bodies are implementing new policies such as end producer responsibility (EPR), whereby manufacturers are responsible for the end-of-life and disposal of their packaging. This leads to efforts in the design of recycling and circular economy-focused development strategies. This research paper will highlight many aspects of the initiatives undertaken to make the printing industry more sustainable, environmental frameworks to benchmark with, and ways forward for the industry to make changes starting today.

Introduction

Sustainability is gaining increasing traction in the printing industry. This paper gauges the industry's environmental impact and discusses ways to reduce it. Sustainability is a word often referenced in our industry. It is part of annual corporate objectives, government initiatives, education, and scholarly research. Sustainability in print is explained as printing in an environmentally friendly way. Various opportunities for sustainability are present in the print sector: eco-friendly materials or machinery employed in printing, printing procedures, and the handling of waste and old equipment to minimize the negative impact on the environment.

Toronto Metropolitan University

However, this involves more than just the manufacturing process of print. It should aim to encompass all five critical components of the product's environmental life cycle:

1. Raw material extraction and processing, i.e. petroleum extract for inks, forests for paper, and water.
2. Manufacturing or transforming materials into printed products via file preparation, plate making, printing press operation, and finishing.
3. Distribution of finished printed goods and raw materials globally. Ie. Carbon footprint, carbon emissions.
4. Use - consumer
5. Disposal or end-of-life - recycling, reuse, upcycling of equipment, landfill.

In Figure 1, A product's environmental life cycle stages are shown below.

Figure 1: *The general flow of printed materials through the five stages of a product's environmental life cycle. [Heggie, n.d.]*

Life Cycle Assessment (LCA) tools are used in print to determine ecological implications across each of the life stages. Using quantitative data from inputs and outputs across the stage gates, valuable insights can be analyzed to facilitate manufacturing, material, and process planning decisions toward more environmental approaches in print practices.

The current impact of the printing industry

Before making any improvements, it is necessary to understand where the printing industry currently stands regarding its economic size and environmental impacts. According to Research Reports World, the global commercial print market is estimated to reach 874 billion US Dollars by 2030 [RRW, 2023]. A report from Fortune Business Insights™ projects growth of the global pulp and paper market from 354.39 billion US Dollars in 2022 to 372.70 billion US Dollars in 2029 with

a CAGR of 0.72% in the period from 2022 to 2029 [Global News Wire, 2023]. According to Duplo International [Duplo International, n.d.], four billion kilograms or four million metric tons of ink are used worldwide yearly. To produce this amount of printing inks, 800 million kilograms or 800,000 metric tons of pigment are required.

The Esko Packaging Trend report [Esko, 2024] states that the global packaging sector accounts for 40% of the world's plastic consumption. The same report also states that the manufacturing of single-use plastic equals 12% of the energy consumption within the industrialized economy.

The Ellen McArthur Foundation, in their 2014 report, states that even though paper and cardboard have high recycling collection rates, they suffer from quality loss and ink contamination during the reverse cycle. This amounts to an annual value loss of 32 billion US Dollars.

One should also remember the ecological pressure humankind places on the planet. According to Duplo International [Duplo International, n.d.], the global population is expected to reach 9.7 billion by 2050. In the same report, the United Nations states, "...to maintain our current lifestyles, we may require as many as three planets' worth of resources".

These statistics deliver a message of doom and gloom, which could lead to the conclusion that it is all too late to make impactful changes toward the betterment of our planet. Everyone must do their part; sustainability is no longer just a buzzword. The following paragraph will discuss the foundations and frameworks of sustainability and how they can be applied to the print industry.

Sustainability in the print industry

Before discussing any sustainability initiatives in the printing industry, one needs to look at the pillars of sustainability shown in Figure 2.

Figure 2: *The three pillars of sustainability [The Brundtland Report, 1987]*

The three pillars of sustainability are a ladder against what is known as the triple bottom line. The environmental aspects of the planet cover climate change, greenhouse gas emissions, energy usage, natural resource use, pollution prevention, and environmental management. The economic elements or profit include cost savings, economic growth, innovation, capital efficiency, and risk management. The social aspects of people are considered in terms of community, education, diversity, and safety.

A printing company's mission and vision should incorporate result objectives that seek to consider and respond to the three pillars of sustainability.

Even though Figure 1 shows a product's environmental life cycle as a form of circularity, there is a more expanded way to show the multiple aspects and components that go into production processes. The Ellen McArthur Foundation [2014] made a butterfly diagram that shows an industrial system that is restorative by design. This framework has been defined as the circular economy.

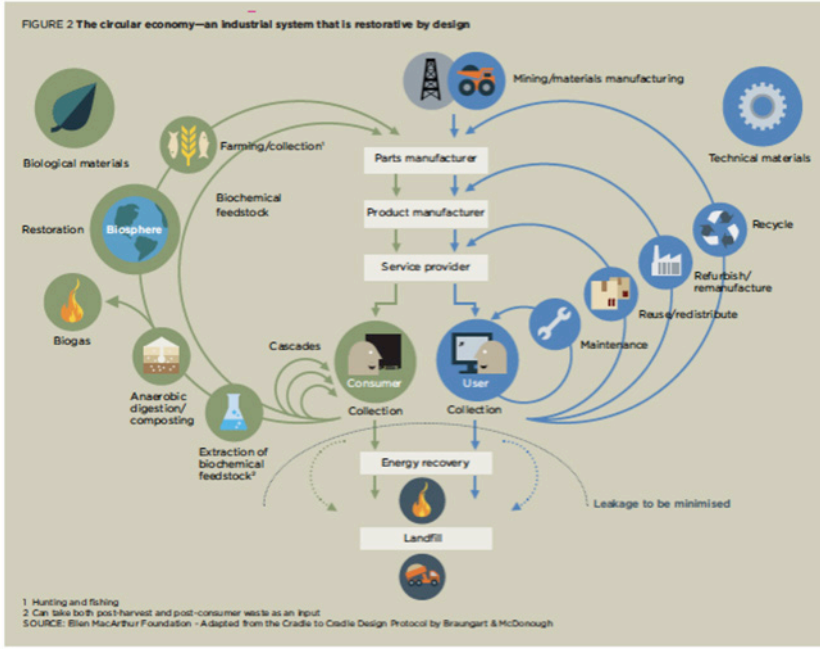

Figure 3: *Butterfly diagram of the circular economy according to the Ellen McArthur Foundation [Ellen McArthur, 2014]*

This diagram highlights several value-creation opportunities, including:

- Distinguishing between biological and technical flows of materials to allow biodegradable materials to be separated, reused effectively, and returned as nutrients to the soil when appropriate, as shown on the technical side of the diagram, gaining greater value from innovating through the inner loops, where a higher percentage of the original embedded value in terms of labour and energy is retained
- designing products to be more durable, easier to repair, and upgradeable so they can stay in circulation and cycle through different loops for longer

Although many steps have already been taken, the printing industry still has a long way to go before its production processes are changed to be more sustainable. The following section will examine examples of the print industry's efforts towards environmental improvements.

Steps taken towards increased sustainability

Changes in the paper industry

The printing industry and its affiliated industries have done much to be more sustainable. Paper is a renewable material when it is produced from wood sourced from sustainably managed forests. Healthy forests act as carbon traps, binding CO2 from the atmosphere and mitigating climate change. Reforestation and recycling efforts ensure a circular infrastructure for the pulp and paper industry. Forestry certification programs such as SFI and FSC trace the chain of custody for the paper used. Corrugated cardboard can be reused up to 25 times. Using recycled paper can save, on average, up to 60% of energy and water. [UPM, 2024].

One industry-wide example of a balanced global materials flow between production and point of use is the global secondary fibre stream for paper and cardboard production. This fibre stream is used in Asia to make packaging materials for export products because recovered fibres are less expensive than virgin fibres [Ellen McArthur, 2014].

A recent Drupa article [Drupa, 2023] discussed alternatives to paper made from wood cellulose. These are the alternatives from the article:

- Paper made of grass:
  - Saving 99% water and 97% energy
  - 25% less CO2 is produced
  - Grass paper can be recycled entirely

- Paper from apple fibres:
  - Introduced in Bolzano in 2007
  - Made from apple pomace
  - Makes uncoated paper for high-quality prints and packaging
  - Unbleached, slightly creamy hue
  - Needs to be mixed with cellulose to become high-quality printing material
- Paper from bamboo:
  - Fastest-growing wood on earth (up to 70 cm/day)
  - Fibres are processed together with sugarcane bagasse
  - Slightly greenish and bluish
  - High amounts of water are needed for its production
- Paper made from limestone:
  - 80% stone meal and a small amount of polyethylene
  - It can be used for screen, offset, and digital printing
- Paper from hemp fibres
  - Only in 2021, a company from Bavaria succeeded in making a paper from 100% hemp fibres.
  - Made from hemp pulp mixed with chalk, potato starch, and water
- Paper from silphia fibre
  - A waste product in bioenergy production
  - Substitute for cellulose
  - Only 35% of the cellulose can be saved
  - It can be recycled like conventional paper
  - Used mainly for corrugated board and packaging materials

From this list, one can see that not all alternatives are a 100% replacement for paper made from wood cellulose. These alternatives show that it is possible to manufacture paper from other sources that can be used in the printing industry. Since many of these alternatives are recent developments, producing paper from alternative sources in the quantities the printing industry needs has not yet been feasible.

Changes in the ink industry

The printing ink industry has also taken steps to reduce its environmental footprint. The inks' mineral oil content has been reduced or replaced with vegetable oils. A recent WAN-IFRA study [WAN-IFRA, 2023] describes the successful implementation of mineral-oil-free web offset inks at six European printing companies. The trials have been so successful that the companies involved want to continue using these inks. Adjustments to the operation parameters of the printing press had to be made. Still, the adjustments were mild and were similar to switching ink suppliers or switching to a new line of ink from the current supplier.

Sheetfed offset inks used to require heavy-metal-based driers, usually cobalt and manganese-based, for the freshly printed ink film to dry through oxidation. Reformulation efforts replaced the cobalt-based driers, making these inks more sustainable and less damaging to the environment. The VOC content of printing inks was also reduced to lessen the environmental impact.

Researchers at Colorado State University developed inks from algae [EcoEnclose, 2022]. The ink is currently available only in black. Although these alternatives are an advancement to petroleum-based inks with high levels of VOCs (volatile organic compounds), vegetable inks also pose environmental questions, as they are manufactured from soy derivatives, contributing to deforestation. Sustainability initiatives are not black and white, bad versus good choices; they are about efforts towards continuous improvement, reductions, alternatives, and betterment across the print life cycle.

Sustainable sources of energy

A print company uses heavy machinery that requires significant electricity to keep the machines running. A print company's environmental footprint can be reduced in many ways. A small step is to install light sensors across the facility to reduce the amount of electricity consumed to only times of use. The installation of solar panels on the roof of a print company, together with battery storage, enables a print company to produce some of its own required electricity. The storage capacity allows electricity storage when solar panels produce more than is consumed. Another option is to buy electricity from a provider that uses wind energy. Using this option will make the operation of a print company more sustainable.

Other options

Many printers use SFI- and FSC-certified substrates, ensuring that the paper comes from sustainably managed forests that are regularly replanted. Print businesses in North America can join the Sustainable Green Printing Partnership (SGP)[SGP, n.d.]. Print companies that joined this program decreased waste, reduced energy use and greenhouse gas emissions, and improved worker safety. Of course, there is the ISO 14001. As it states on the ISO's website:

> ISO 14001 offers a structured approach for businesses to address these pressing concerns. By adopting this standard, organizations signal a commitment to regulatory compliance and ongoing environmental improvement. This proactive approach to environmental management can result in tangible benefits, such as reduced waste, energy conservation, and cost savings.

Furthermore, it enhances an organization's reputation, fosters stakeholder trust, and often constitutes a critical step for engaging in global trade and supply chains. ISO 14001 stands as a testament to an organization's dedication to a sustainable future, blending environmental responsibility with strategic business growth. [ISO, 2021].

The type of print process used also influences the environmental footprint. Using UV-LED curable inks over traditional UV-curable inks reduces the energy used to cure the ink film. Digital print processes provide savings because no make-ready and no printing plates are needed. Workflow automation and connectivity have improved efficiencies in imposition, error reduction, increased production output, and overall optimization of print operations. Some digital press manufacturers recover plastic-based components and ship them back to their manufacturing site to manufacture new components [Ellen McArthur, 2014].

Government policy environmental initiatives, such as end producer responsibility (EPR) for packaging brand owners, extend the physical and financial responsibility of a product's post-consumer stage of the life cycle back to the owner. This leads to efforts in the design of recycling and circular economy-focused development strategies from the start of a product's initiation.

Where to start?

A baseline needs to be established before one starts making their operation more sustainable. This can be done through the life cycle assessment of a process or by using the carbon footprint calculator provided for free by Printing United Alliance [Printing United Alliance, n.d.]. The carbon footprint calculator is an Excel spreadsheet that collects information and calculates the carbon footprint as it is. Once changes regarding the operation are made, the spreadsheet needs to be filled out again, and it is possible to see the impact the shift in manufacturing made.

Figure 4 shows a general life cycle assessment (LCA) and the general procedure for conducting this type of assessment.

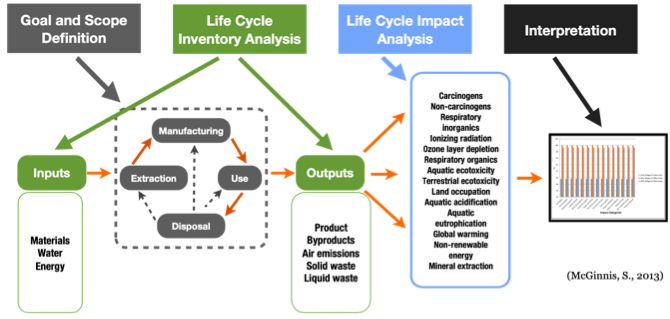

Figure 4: *Life cycle assessment according to Fitzpatrick et al. [Fitzpatrick, 2012]*

LCA is a formal, quantitative method for assessing the environmental impacts of a product, process, or system. Why an LCA? Because collecting the data and the results can improve decision-making and the performance of sustainability targets.

1. **Goal and Scope definition:**
   Define the goals, scope, and boundaries
2. **Life Cycle Inventory Analysis:**
   Develop and list a detailed inventory, including all inputs and outputs within the scope defined in Phase 1
3. **Life Cycle Impact Analysis:**
   Translate inventory outputs to potential environmental impacts using the best science and analysis available
4. **Interpretation:**
   Interpret the results analyzed through phases 1, 2, and 3.

The current straight-line economy needs to be transformed into a circular economy, which lessens its impact on the environment. Figure 5 provides a good explanation of a circular economy.

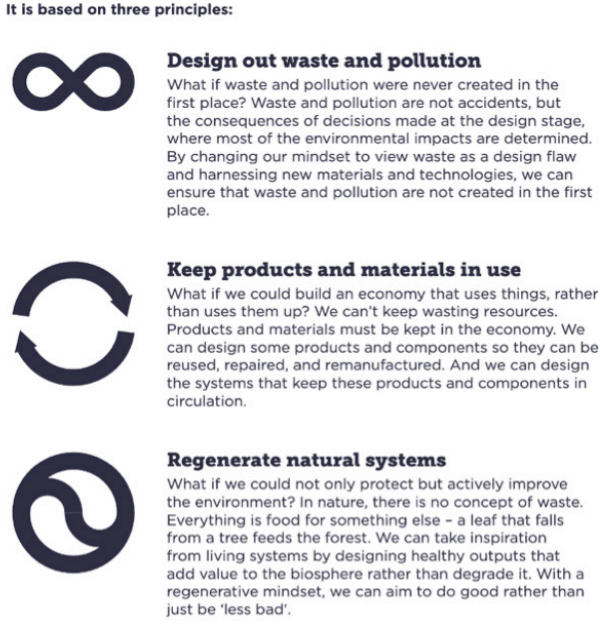

Figure 5: *Circular economy according to the Ellen McArthur Foundation [Ellen McArthur, 2014]*

The circular economy is often misunderstood, leading to various misconceptions:

1. Focus on Waste Utilization: Contrary to common belief, the circular economy is more than just about better waste management. It emphasizes eliminating waste through innovative design rather than finding new uses for existing waste.
2. Recycling Isn't Enough: While recycling plays a role, the core of the circular economy involves maintaining products, components, and materials at their highest value for as long as possible through strategies like reuse, repair, refurbishment, and remanufacturing.
3. Beyond Efficiency: Unlike traditional sustainability efforts focusing on efficiency, the circular economy aims for systemic change, creating a new industrial system rather than merely optimizing the current linear model.
4. Distinct from Sustainability: The circular economy isn't just a rebranding of sustainability; it proposes a fundamentally different approach to industry, focusing on redesigning processes from the outset rather than mitigating existing impacts.
5. Waste-to-Energy Isn't Ideal: While some view waste-to-energy solutions like incineration as valuable, they need to align with the principles of a well-designed circular system. Such methods often perpetuate the need for continuous waste generation and fail to create high-value processes.

According to Parletta [Parletta, 2019], "80% of people respect companies and brands that adopt eco-friendly practices". This notion is also reflected in a survey published by Inkbot Design in 2022 [Inkbot, 2022]. The results are shown in Figure 6.

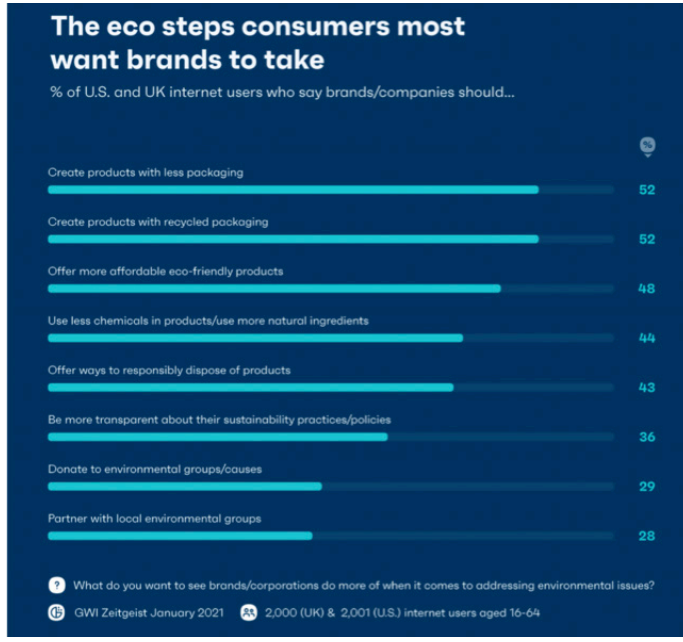

Figure 6: *Results from a study published by Inkbot Design [Inkbot, 2022]*

Industry collaboration

Industry Collaboration is necessary for a sustainable future:

1. Re-examinations of current practices
2. Accelerate advancement through collaboration
3. Spread innovation - Net Zero Objectives
4. Consumer consciousness and awareness

A new way of sustainable thinking in the printing industry must take hold. Not as individual contributors but as a higher degree of collaboration involving all industry partners working towards common goals to create environmental advancement in the print industry.

The World Economic Forum [weforum.org, 2023] pleads with industries to achieve sustainability goals by "pooling resources, knowledge, people and strategies." Organizations can collectively improve supplier performance, leading to higher industry standards. By sharing information, they tap into a vast knowledge bank, accelerating the pace of change within the industry.

Pursuing net-zero objectives through collaborative efforts encounters obstacles from competition concerns and regulatory limitations. Businesses fear violating competition laws or appearing to do so, hindering their cooperation. Regulators must discern between collusive behaviour and legitimate sustainability-driven collaboration by offering guidance to advance sustainability initiatives such as net-zero goals. Harmonized approaches across borders are necessary to address complexities effectively.

Addressing the depletion of natural resources necessitates a unified endeavour. Businesses must embrace collaborative strategies to ensure long-term sustainability. Governments should explore regulatory frameworks and incentive mechanisms to promote collaboration toward net-zero targets. Businesses must reframe their perception of collaboration as an opportunity rather than a liability, taking decisive actions to maximize net-zero potentials.

Conclusion

Sustainability is not a checkbox or a quick solution. It is an iterative process to advance decisions, processes, and infrastructure towards areas that have less environmental impact over time. The first step for any organization is to establish a baseline by building a process map of your operations with all the inputs and outputs contributing to your business. Track your energy consumption, analyze your disposals, and determine whether equipment always has to be on. Ensure that your evaluation is comprehensive. By following the life cycle assessment framework, you can attempt to quantify the environmental impact of a product

across each stage of its life to find areas of improvement. Can you consider a full circular economy framework? Areas to be mindful of are trade-offs. What impacts might result from a shift from one area of the life cycle to another? An example of this could be to consider a change to a higher recycled content paper; however, this may result in production speed impacts on the press, causing more waste and potential risk to overall quality.

Prepare an internal circular economy pitch for organizational buy-in. Consider collaboration with suppliers or even colleagues to consider partnered opportunities for change.

As scholars, we recognize the importance of education, research, and awareness for our next generation of leaders, who will continue to work toward future innovations and a more sustainable industry.

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