Designed for Recycling, Part 2 Initial Design to Manufactured Book

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Contents

Purpose

The purpose of Part 2 of the overall Designed for Recycling Project is to recommend how physical books could be designed with recyclability at the forefront of the design process, and to investigate efficiencies for reducing waste in the manufacturing and production of books. It will take the data and findings from the now completed 'Design for Recycling Project; Part 1: Life Cycle Assessment' to help identify the key areas that need to be targeted. This Part 2 report lays out, in chronological order, from initial design to manufactured book ideas and practical examples on how a book can be designed to be more recyclable.

The project deliverables are:

- Best practice recommendations to cover
    - Guides and tools
    - Examples and case Studies for the reader
- A definition of 'Waste' for the Book Industry Supply Chain

There will be a separate and subsequent project 'Designed for Recycling Project; Part 3 Manufactured Book to End-of-Life - Addressing Waste Prevention in the Supply Chain'. Part 3 will also look at 'Returns' and how they impact the environment and will be linked with the BIC Ordering Best Practice Project.

Methodology

For Part 2 of the project the Task and Finishing Working Group (T&FWG) agreed a list of topics to research and investigated the various materials that go into the production of a book. Throughout the project, the T&FWG also decided upon smaller pieces of work to research independently such as even workings, fonts, and examples regarding reduced waste foiling options. The T&FWG also solicited help from members of their own organisations to provide data for the final report, as well as reaching out to third party organisations that they were already working with on this topic. This data was then collated and reviewed at the monthly project meetings. The project consultant started writing up the project report as the work progressed, with the T&FWG reviewing each section as it was written.

Waste

One of the deliverables for this project was to provide the reader with a definition of 'waste.' The difficulty is that depending upon where an organization or process sits in the supply chain then waste will have different meanings. The T&FWG agreed upon the following definition of waste:

> ***Waste is something that is discarded as no longer useful or required after completion of a process.***

Below are some examples of waste from four of the main areas in the book industry supply chain:

1. Creation – Content proofs.

2. Production – Make ready copies and run waste‡[1] particularly for lithographic printing‡, binders trim, plates, paper slab, paper core waste, finishing materials, inks, ink cartridges, chemicals, and engineering waste.

3. Distribution – Cartons, binders' bundles, pallet wrap and damaged pallets.

4. Sales – Returns, over stock and re-issue.

Results, examples, and findings

The results of Part 2 of the project revealed that the simplest way to design a book and make it 100% recyclable would be to remove all plastics, and any/all materials from the manufacturing process that impede this. This is not likely to happen for several reasons. People like to see well-designed covers using multiple finishes, they catch the reader's eye, and publishers use them to increase the chances someone will buy the book.

With the above in mind, this report looks at how a book can be designed to be easily recyclable, but also at the materials that are currently used in the manufacturing process and what is being done to make them more recyclable and sustainable. The T&FWG looked at, each of the below processes and a detailed explanation follows in this report:

- Typesetting‡ and sustainable fonts,
- Printing in even workings‡
- Paper,
- Inks,
- Glues/adhesives,
- Laminates,
- Foils and brass-dies,
- Binding styles,
- Special editions.

The main conclusion that the T&FWG came to was that it is complicated to produce a book that does not have an element of it which is difficult to recycle. There are also compromises to be made with the choice of paper and foil designs. It is the balance of all the materials that make up the book that is important and the research into them during the design phase. There are many ways that a book can be designed to be sustainable, but often a compromise must be made, and early in the design process. An example of this would be to remove the cover lamination‡ and use a machine varnish‡ instead, but the varnish would not protect the book in the same way. The book would be more prone to scuffing, marking and water damage that a lamination would reduce and eliminate. One publisher has had success with paperbacks primarily with a lighter colour cover design, varnish offers a plastic free alternative that increases recyclability. Decisions here will depend upon the market and audience that the book is aimed at, and the associated production values.

The use of many different cover finishes influences the recyclability of a book. Should they be used in the first place or could the designer be creative in a different way to provide the desired visual impact. Or do you need to stop the use of foils and

[1] ‡ marks words and phrases that are defined in the glossary at the end of this report.

laminations on the book when they can be removed during the recycling process? The use of a plastic lamination is there to protect the book, so if the book is bought and sits on the shelf for a lifetime is its use a bad thing? Especially as the lamination producers are working hard to reduce the amount of plastic within the lamination. Currently there has been a reduction in plastic in laminates of around 23% depending on the laminate. This figure of 23% comes from the laminate manufactures themselves, as they have reduced the thickness of the laminate. Research is being conducted into other materials to cover books and help protect them.

All the decisions about the production of the book need to be made at the very outset of the book's life with the author, editorial, design, production, and sales departments fully involved. This will ensure that all options are considered, and the author and publisher ultimately agree on the final product. The type of font used in the typesetting also plays into this decision making. Examples are provided later in this report that show how important it is to choose the right one. A balanced approach needs to be taken regarding the materials used in the manufacture of the book. From a cost and waste perspective it is sensible to produce books that fit an even working (explained below in depth), so that paper is not wasted in the printing process. What type of paper is the book being printed on, and the various options around that decision, including should it be virgin or recycled paper. Both virgin and recycled paper have advantages and disadvantages when it comes to their carbon footprint and perceived sustainability.

Choices that can be made when designing a book can be very subjective. The good news is that there is a lot of research going on to either improve the sustainability credentials of the materials that are currently being used in book manufacturing or to try and find alternatives.

Initial Design

So, let us now look in more detail at the design of a book. There are several factors that need to be considered when starting the design of a book – the market for the title, the physical attributes of the book, the content material, the ethical, environmental, and sustainable considerations, the recyclable attributes to encompass in the book, and the target audience. All of these are going to play into the design decisions and need to also be balanced with the sustainability considerations of the author, the publisher, and the printer.

There are very good reasons why certain design decisions are made, but do we challenge these when starting the production of a new book? Take the chapter openers, do they all have to start on a recto‡ (right hand page), or could they simply follow on the next blank page? Do you even need to have a new page, or could the next chapter start a few lines after the previous one finished? All these decisions will have an impact on the extent of the book, and therefore how much paper will be needed to print the title. This should be a consideration at the outset of the production process to make sure the book is as recyclable and sustainable as possible.

An example of this is when Piers Torday began writing his children's book *The Wild Before* about climate change in 2019. He wanted it to draw attention to the contradictory nature of all the sustainability information that is available. He also wanted the book to be as sustainable as possible.

Initial conversations with Hachette Children's Group (HCG) Production Department talked about producing a novelty run of the book using seeded paper‡, but this turned out to be too expensive. The Covid pandemic and supply chain issues with the supply of paper also influenced the materials that could be sourced and used in the production of the book.

The author also wanted the cover design to follow the same distinctive designs of his previous books, but without the use of foils and plastic laminates on the covers. The largest challenge was creating a product that could stand out against the competitors without all the 'bells and whistles'. Finishes such as laminates, varnishes and foils are often used to compliment the cover design and make the book even more eye-catching in stores. Without being able to exploit these benefits, the illustrator Thomas Flintham and designer Samuel Perrett had to maximise the impact of the artwork and the design. This meant that from its inception, utilising colour, contrast, and a clean visual language would be incredibly important. The artwork is graphic and has a rich colour palette, with a fifth colour added to counteract any drawbacks to the uncoated paper stock.

The production department had to research the various stock materials to see what recycled papers they could use to print the book text on, and what alternative cover materials they could use, including the boards for the casebound version. They also had to think about the lamination of the book, and what they could use instead of a plastic laminate to protect the book covers.

The actual manufacturing of the book posed challenges for the printers, Clays. Covers with high levels of ink coverage can cause drying issues during production. The printer would flag this potential risk during pre-flight checks.

The following is a summary of the results and decisions that the production department made in the printing and manufacture of this title.

Example – Piers Torday – *The Wild Before*

For the publication of Piers Torday's *The Wild Before,* HCG Production worked hard to source sustainable materials.

All editions

The text paper was Ensocreamy FSC 65gsm, a standard paper used by the publisher. The text was printed conventionally with mineral oil based cold-set inks.

Hardback

For the hardback edition, the jacket was printed at a UK printer, on a textured Astropack Bianco uncoated 140gsm with no lamination (to avoid plastics), finishes or sealant on the case. The case and endpapers were printed on a recycled Wibalin‡ and paper, which is made from 40% post-consumer waste and 60% post-industrial waste. The chipboard case was also made of recycled materials.

The hardback book cover was printed on a textured 140gsm Astropack Blanco, in 4-colour with a purple pantone vegetable-based ink. Though there will naturally be wear in time along the bottom and hinge of the case, it was felt it was successful enough to proceed with the entire print run. The spine width was 21.5mm, and along with the additional support and robustness from the hardback grey board case, it was felt the

wear and tear will naturally be lessened compared to the risk for a paperback produced in this manner.

Paperback

The paperback was produced with no lamination, varnish or finishes on 270gsm Masterblank Lino.

During the marketing campaign a bookmark was created with a local, London-based printer using seeded paper, which grew wildflowers when planted.

What the publisher and printer might do differently now

If the book were to be produced now the publisher says that they might have done things differently, especially regarding their paper choices. This would have involved a better understanding of the carbon footprint of the stocks they used, which might have resulted in the use of different papers with a lower carbon footprint. This reflects the need to research papers fully, but based on the information available at the time, the decisions made reflected the author's desire for a sustainable book.

The printer involved now collates greenhouse gas emissions for many paper products to inform publishers on the impacts of different choices, alongside starting a supplier engagement program for paper and materials suppliers to offer more sustainable options to publishers. The printer has now expanded their use of vegetable-based inks for colour (cover/jacket) printing and is now researching the benefits of vegetable-based options for conventional text printing.

We know that printers now have a more developed understanding of the key environmental impacts of production gained by studying their organisational greenhouse gas emissions. The findings from this ongoing analysis help to guide how to reduce the impacts of book production. Specifically, this has informed many printers' procurement strategies to source an increased portion of their energy from renewable sources.

Figure 1 Showing the printer paperback cover of Piers Torday's book. Photo courtesy of Lara Hing, Hachette.

Typesetting

Typesetting is the process by which the author's text is transformed into the pages for both a physical and e-book. Typesetting can also play its part in the drive to make books more recyclable by reducing waste in the printing process through the reduction of blank pages in a book. Part 1 of this project discovered that books are often returned and then pulped. Alongside this, a publisher will also conduct reviews of the stocks of books that they hold in a warehouse and then complete a stock reduction exercise. In both cases, a lot of paper is being recycled and it would be better not to have the overstocks printed in the first place. Sustainable typesetting and making sure books are set as economically as possible will help with reducing the amount of initial material and energy required as well as saving it from being unnecessarily recycled at the end-of-life.

Fonts

The type of font chosen when designing a book can have a huge impact on the final page extent of a book. A font with a large x-height‡ is going to produce a book of a much longer extent than one with a small x-height. The x-height of a font is the vertical measurement of the letters, in picas‡, as you can see below in the following diagrams (Figures 2 and 3). Picas are the standard measurement of fonts. Here we are looking at how we can design the page to be economical with the extent so as not to waste paper in the manufacturing process by adding large numbers of blank pages at the back of the book.

The Figure 2 shows the same text displayed in the serif font Garamond compared with the 2K/Denmark[2] Sustainable font. Next to it you can see how the increase in x-height has made the sustainable font larger and more readable. Figure 3 shows that you would need to increase Garamond from 12pt to 15.24pt to obtain the same x-height and readability.

Figure 2 Showing a comparison between two fonts, Garamond vs a custom-made Sustainable Serif font.

Figure 3 Showing a comparison in x height between Garamond and custom-made sustainable serif font.

The next two figures 4 and 5 use a sans serif font Arial compared to the Sustainable Sans Serif. In this example the width of the letters between the two fonts has been kept the same, but the Sustainable Sans Serif font has an increased x-height. For the sans serif font Arial to have the same x-height the width of the letters would have to be increased by 13% to make them the same size as the sustainable font thus using more space on the page.

[2] The use of these diagrams and text saving examples are reproduced with the permission of 2K/Denmark.

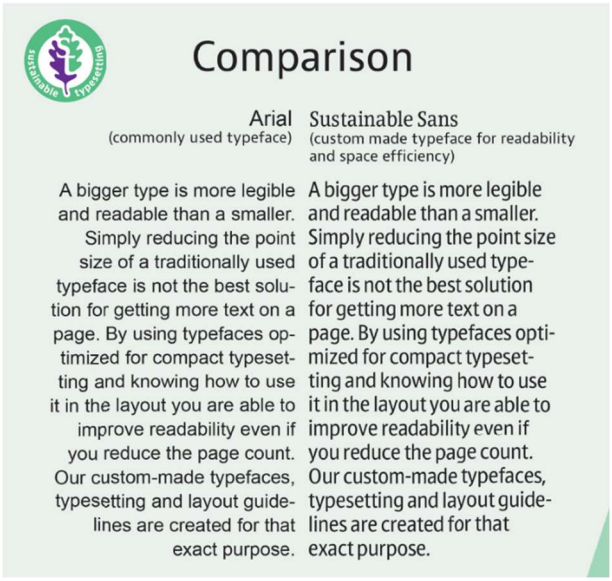


Figure 4 Comparison between Arial Sans Serif font and the custom-made Sustainable Sans Serif font

Figure 5 Showing a comparison in x height between Arial and custom-made Sustainable Sans Serif font.

Example – BIC Designed for Recycling Part 1; Life Cycle Assessment Report

The following is the report generated by 2K/Denmark detailing the difference between the original report written in a single column format in Word, and their double column typeset version. The reason for using the BIC report was to avoid any issues with copyright.

It should be noted that 2K/Denmark claim that by using their sustainable font it should be possible to save up to 20% on the extent of a book. As this report's example was completed using a Word file there was a greater saving on the extent than 2K/Denmark claim is possible with a book. This example is purely illustrative to show what could be possible with the use of a different or sustainable font.

2K/Denmark report using the BIC Word document as an example

Using a sustainable font can have a dramatic effect upon the length of a book. Setting the report from Part 1 of this project reduced the number of pages from 19 to 10.

The comparison of typesetting savings is shown below:

Original file: Single column, Calibri 11 pt, x-height of 1.8 mm – 19 pages, Figure 6

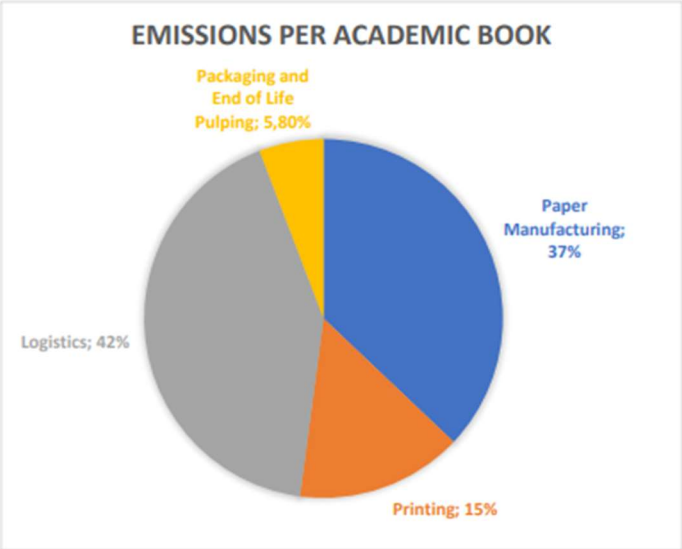
Sustainable Typesetting optimised: Two column, 2K/Denmark Sustainable Sans 11 pt, x-height of 2 mm – 10 pages (9 pages or 48% saved), Figure 7

This is the one 2K/Denmark recommend, as it has the best balance of improved design, layout and x-height while creating almost 50% saving. Two columns create a much more readable design with shortened line lengths resulting in an enhanced readability as well as the increased x-height.

Sustainable Typesetting enhanced**:** Single column, 2K/Denmark Sustainable Sans 12,5p, x-height 2.25 mm - 13 pages (6 pages / 32% saved), Figure 8

This last example is to show the single column application of the sustainable font and typesetting (to give a like-for-like comparison with the original report) and how big the letters could be whilst still saving pages. However, the line lengths are at an absolute maximum here. This clearly illustrates that there are a lot of factors that go into the guidelines on how/when/where to compromise and change layouts etc. for readability purposes.

The original version of the report is downloadable from BIC Green Hub Reports and Guidance - Book Industry Communication. It was not possible to show the full “live” examples of the savings in this report so, the versions created by 2K/Denmark have been loaded to the BIC Green Hub so that the reader can compare them at their leisure and with this report. Taking the original report here is one page of the report containing text, a diagram, and tables.



3.1.1.2 Packaging

The data provided below for packaging is based upon an academic title taking average figures from across the publisher's product range. It has not been easy to gather information in this area. According to one trade publisher that we consulted, for one pallet they use around 168g of pallet wrap.

We know that pallet wrap is an environmental concern for packaging and transportation generally in the industry. There are now biodegradable wraps available, but some shippers are not using them as they degrade down to microplastics, which are known to be even worse for the world's ecosystem. One shipper did say that they are using a thicker, stronger pallet wrap so that they use less of it. This is not ideal, but one way of looking at it, until a permanent solution has been found.

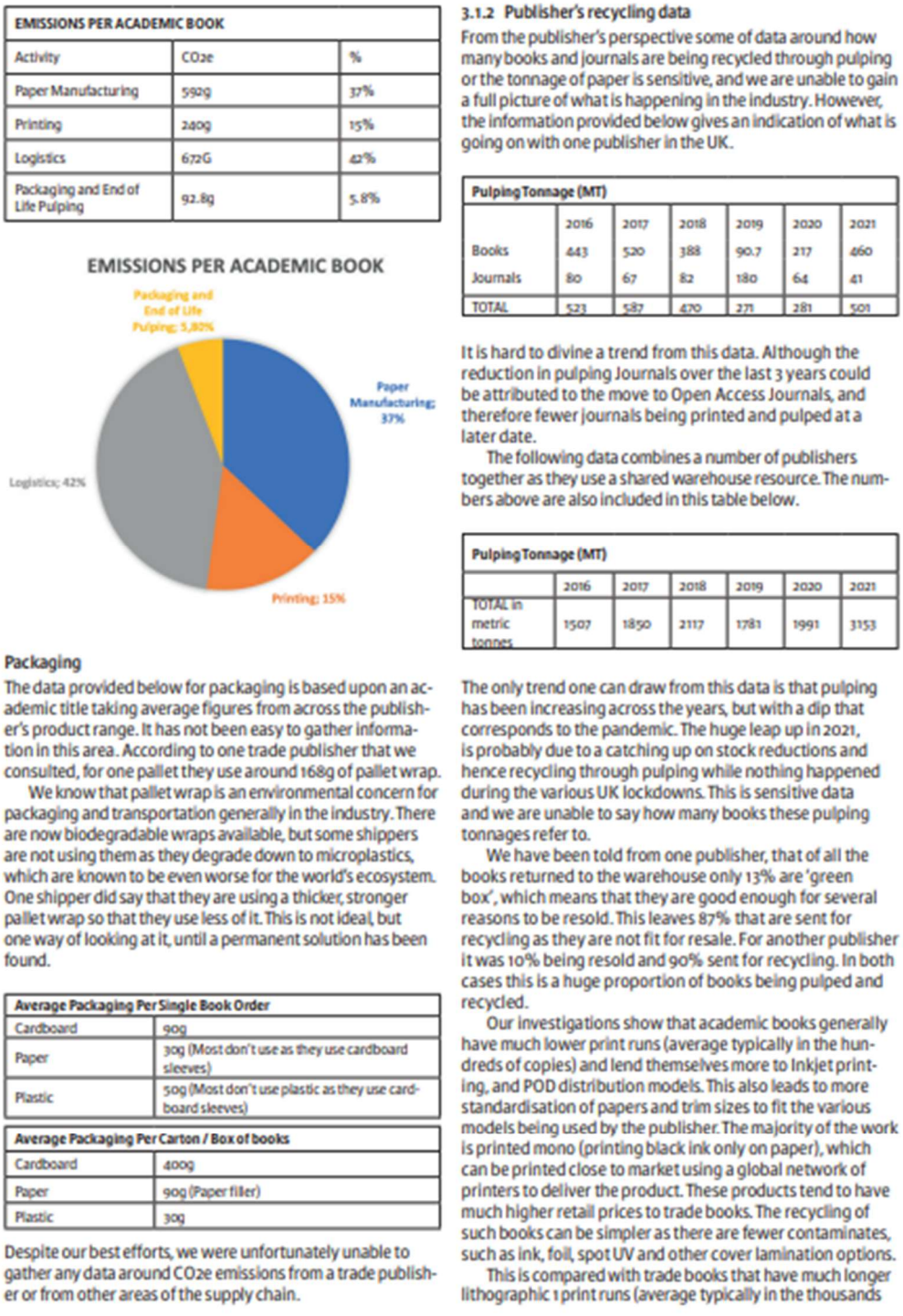
Average Packaging Per Single Book Order	
Cardboard	90g
Paper	30g (Most don't use as they use cardboard sleeves)
Plastic	50g (Most don't use plastic as they use cardboard sleeves)

Average Packaging Per Carton / Box of books	
Cardboard	400g
Paper	90g (Paper filler)
Plastic	30g

Despite our best efforts, we were unfortunately unable to gather any data around CO2e emissions from a trade publisher or from other areas of the supply chain.

Figure 6 A page from the original Word document.

If we now, look at the optimised version from 2K/Denmark (Figure 7), you can see that there is a lot more text on the page. Although it should be noted we are looking at an original document in Word being properly typeset and therefore would expect a greater number of words on the page.



EMISSIONS PER ACADEMIC BOOK		
Activity	CO2e	%
Paper Manufacturing	592g	37%
Printing	240g	15%
Logistics	672G	42%
Packaging and End of Life Pulping	92.8g	5.8%

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3.1.2 Publisher's recycling data

From the publisher's perspective some of data around how many books and journals are being recycled through pulping or the tonnage of paper is sensitive, and we are unable to gain a full picture of what is happening in the industry. However, the information provided below gives an indication of what is going on with one publisher in the UK.

Pulping Tonnage (MT)						
	2016	2017	2018	2019	2020	2021
Books	443	520	388	90.7	217	460
Journals	80	67	82	180	64	41
TOTAL	523	587	470	271	281	501

It is hard to divine a trend from this data. Although the reduction in pulping Journals over the last 3 years could be attributed to the move to Open Access Journals, and therefore fewer journals being printed and pulped at a later date.

The following data combines a number of publishers together as they use a shared warehouse resource. The numbers above are also included in this table below.

Pulping Tonnage (MT)						
	2016	2017	2018	2019	2020	2021
TOTAL in metric tonnes	1507	1850	2117	1781	1991	3153

The only trend one can draw from this data is that pulping has been increasing across the years, but with a dip that corresponds to the pandemic. The huge leap up in 2021, is probably due to a catching up on stock reductions and hence recycling through pulping while nothing happened during the various UK lockdowns. This is sensitive data and we are unable to say how many books these pulping tonnages refer to.

We have been told from one publisher, that of all the books returned to the warehouse only 13% are 'green box', which means that they are good enough for several reasons to be resold. This leaves 87% that are sent for recycling as they are not fit for resale. For another publisher it was 10% being resold and 90% sent for recycling. In both cases this is a huge proportion of books being pulped and recycled.

Our investigations show that academic books generally have much lower print runs (average typically in the hundreds of copies) and lend themselves more to Inkjet printing, and POD distribution models. This also leads to more standardisation of papers and trim sizes to fit the various models being used by the publisher. The majority of the work is printed mono (printing black ink only on paper), which can be printed close to market using a global network of printers to deliver the product. These products tend to have much higher retail prices to trade books. The recycling of such books can be simpler as there are fewer contaminates, such as ink, foil, spot UV and other cover lamination options.

This is compared with trade books that have much longer lithographic [1] print runs (average typically in the thousands

[1] A printing process using the fact that oil and water do not mix, content is etched / burned onto a plate (usually aluminium). Plate is treated so that the image areas are receptive to oil (i.e., ink) and repel water, non-image areas are receptive to water and repel oil therefore the two areas remain separate. Ink is then transferred onto a substrate either onto a blanket for offset printing or directly to the paper.

4

Figure 7 The same page from the Word document now set in the two-column format using the Sustainable Font.

We will now look at a single column version of the 2K/Denmark text (Figure 8) – something that is more akin to the original report. In this case compared with the original there has been a reduction in the space used but not as much as the 2-column optimised version.

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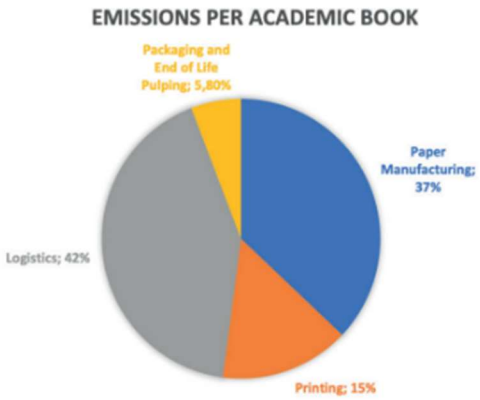

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Plastic	30g

Despite our best efforts, we were unfortunately unable to gather any data around CO2e emissions from a trade publisher or from other areas of the supply chain.

Figure 8 The same page from the Word document set in the one-column format using the sustainable font.

It is reckoned that using the 2K/Denmark sustainable font could save a publisher 10 to 15% on the number of pages in a title. Please use this link to see the complete typeset files provided by 2K/Denmark. [Link to the full 2K Denmark files]

Even workings and trim sizes‡

The book publishing industry knows that it is more financially economical to print books in even workings, that is, in full signatures‡ of paper depending upon a printer's set-up. So, for example, if a printer is printing in signatures of 32 pages that is in 32s, i.e., for a mono book‡ this would require two plates‡ with 16 pages on each plate, one for each side of the sheet of paper. Once printed there will be a sheet of paper with 32 printed pages on it. This sheet would then be folded to make a signature of 32 pages, with each page in numerical order. The following diagram shows the reader both sides of the paper and how the page numbers back-up against each other.

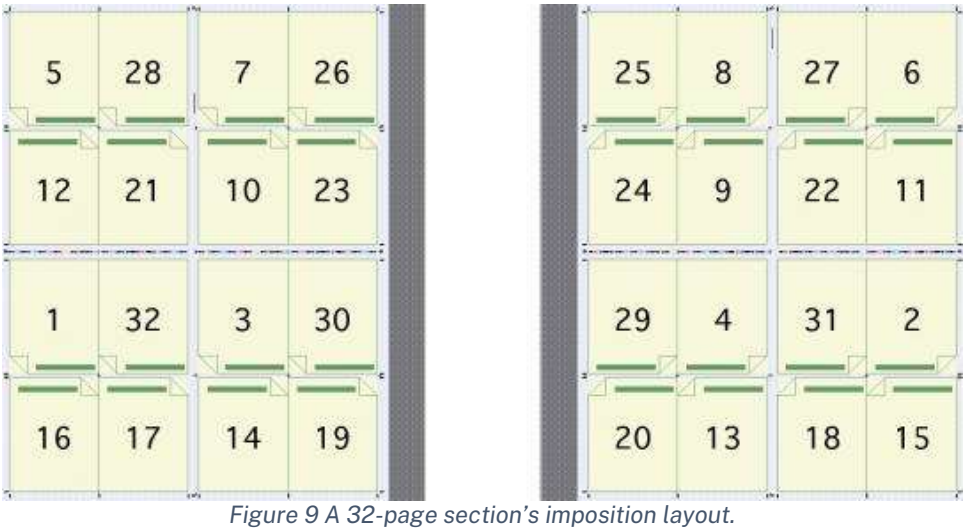


Figure 9 A 32-page section's imposition layout.

In this example, to make an even working, the total number of pages in the book should be exactly divisible by 32. In the past this used to be easier as there was only one technology – lithographic printing‡- to deal with and often this was printing in 32, and 16-page sections or signatures anyway.

Figure 10 Images of folded signatures

Then, with the advent of digital printing, the landscape and technologies changed. Depending on how an inkjet press‡ is set up, books can now be printed in 6s, 8s and 16s, which makes the crossover between technologies more complicated to manage. This can result in the addition of extra blank pages in the back of a book. Some printers have taken the decision to print both lithographic and Inkjet in 16s and therefore it does not matter what the print run is as a title can move easily between the two technologies. This makes it easier for a publisher to typeset their books in even workings, and not have to worry about extra blank pages being added.

Therefore, it is important that every publisher talks to their printer to understand how they are printing books across the various technologies. From there, publishers can make design decisions on how they are going to create the books from the outset.

Printing books to even workings can have a large effect upon the price, amount of paper and the carbon footprint of not just the book, but also the print run and the whole publishing program.

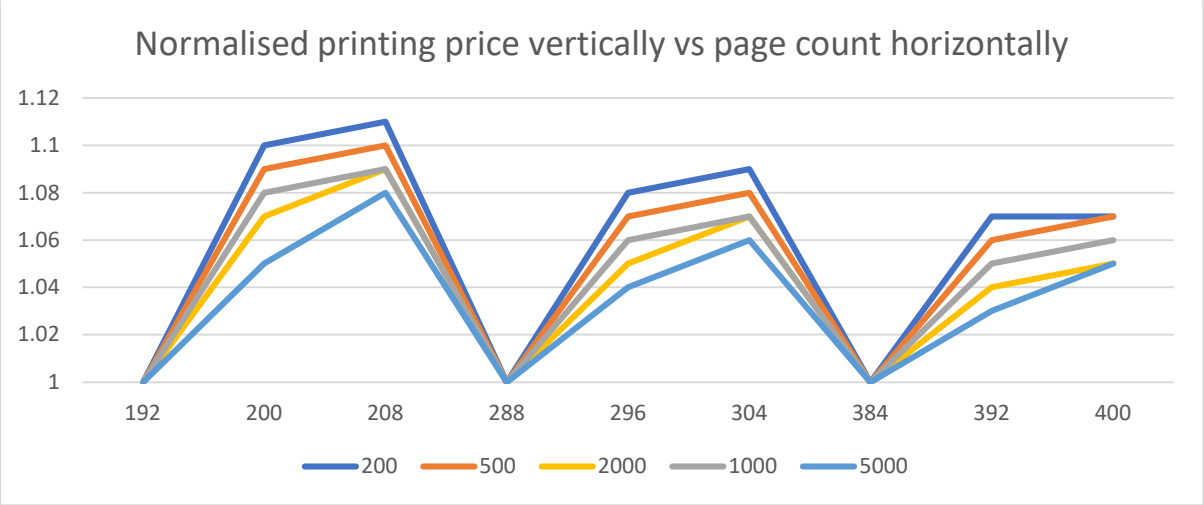
Examples of even workings

In this example the T&FWG took a book with a trim size of 228 x 152 mm (6 x 9 inches) printing in 32 pages for each full signature, a mono (one-colour) paperback. The team also used even working extents of 192, 288 and 384 (i.e., wholly divisible by 32). For all the calculations these even working extents have been normalised to 1 independent of units.

In the first analysis we are looking at printing price vs. page count. As you start to add an extra 8 and then 16 pages to the even worked extents the price inevitably increases. With the first increase of adding 8 pages producing the largest rise in price. The raw data for this analysis is:

	Increasing print run				
Page count	200	500	1000	2000	5000
192	1	1	1	1	1
200	1.1	1.09	1.08	1.07	1.05
208	1.11	1.1	1.09	1.09	1.08
288	1	1	1	1	1
296	1.08	1.07	1.06	1.05	1.04
304	1.09	1.08	1.07	1.07	1.06
384	1	1	1	1	1
392	1.07	1.06	1.05	1.04	1.03
400	1.07	1.07	1.06	1.05	1.05

Graphically this looks like:

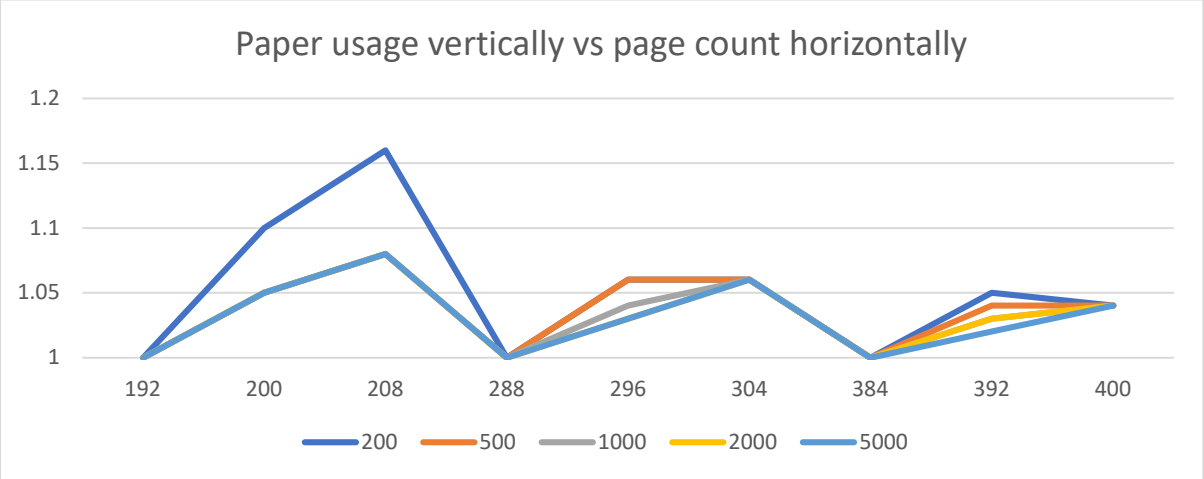


For all the examples used in this section the even working page count (i.e., the page count wholly divisible by the full signature of 32 pages) result has been normalized to 1. There are no units associated with this because all the values would be different for each publisher based on their individual printer contracts. As you can see, each time you start with an even working, the price increases as the extra 8- and 16-page sections are added. Although this becomes less with increasing even workings. The longer print runs are less affected than shorter ones, because more books are being printed and the differences decrease.

In the second analysis we are looking at paper usage vs. page count. Again, the team has used the even working (page count wholly divisible by 32 pages) as a value of 1 independent of units. Here is the raw data:

	Increasing print runs				
Page count	200	500	1000	2000	5000
192	1	1	1	1	1
200	1.1	1.05	1.05	1.05	1.05
208	1.16	1.08	1.08	1.08	1.08
288	1	1	1	1	1
296	1.06	1.06	1.04	1.03	1.03
304	1.06	1.06	1.06	1.06	1.06
384	1	1	1	1	1
392	1.05	1.04	1.03	1.03	1.02
400	1.04	1.04	1.04	1.04	1.04

And graphically this looks like:



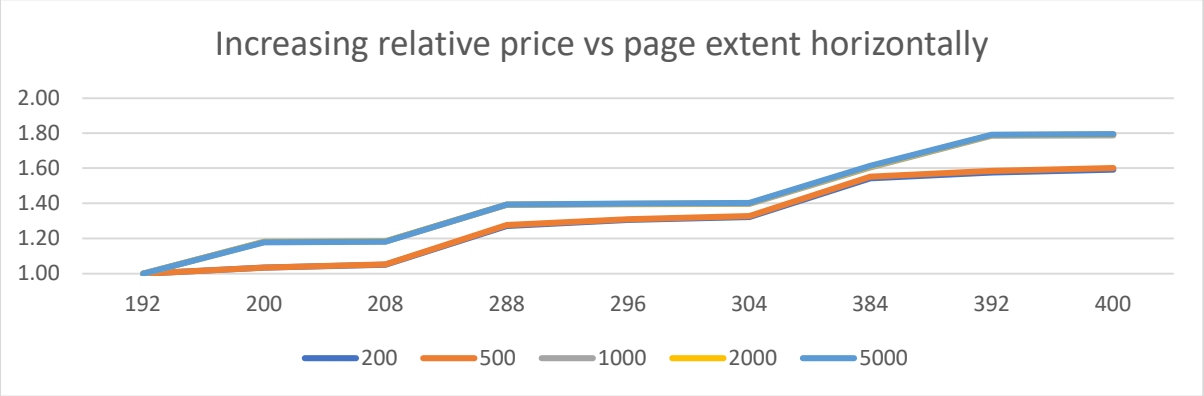
In this case for the shorter extents the amount of paper being added is greater across the print runs. The number of pages added to the shorter extents makes up a greater percentage of all overall extent of the book.

In the third analysis the team looked at the relative price of printing the book vs. the print run. This time the prices for the various print runs have been normalised to 1

independent of units only for an extent of 192 pages. This is to show how the printing price would increase, as it naturally would, as the extent of a book increases.

	Increasing print run				
Page count	200	500	1000	2000	5000
192	1.00	1.00	1.00	1.00	1.00
200	1.03	1.03	1.18	1.18	1.18
208	1.05	1.05	1.18	1.18	1.18
288	1.27	1.28	1.39	1.39	1.39
296	1.30	1.31	1.39	1.40	1.40
304	1.32	1.33	1.40	1.40	1.40
384	1.54	1.55	1.60	1.61	1.61
392	1.58	1.59	1.79	1.79	1.79
400	1.59	1.60	1.79	1.79	1.80

And graphically it looks like:



This shows larger increases for the addition of 8- or 16-page sections to a book. Printers work on a 'just in time' manufacturing workflow with the processes being fully automated as much as possible. The addition of extra pages can result in a disruption to the automated process with the requirement of manual intervention to insert the extra pages into the book block‡. This extra work will cost and slows the progress of a book through the binding line.

So overall it is worth reviewing how a book is printed and making sure it is in even workings. This will save you both money and paper. Another reason for increased costs comes from extra work that might be required at the binding stage.

Example of how to manage the extent of a book

For this example, let us assume that the book is being printed in 32-page signatures.

If during the typesetting of a book it is found to make 321 pages (for example) it will print as 10 signatures of 32 pages, but extra pages will need to be added to the extent so that the printer is able to print the book. In this case it could be an extra 8 or 16 pages

because single pages cannot easily be inserted on their own. Of these extra pages only one of them will be printed on and the rest will be left blank. This is a waste of paper to add to a book.

So, what can be done in this instance? There are several ways this scenario can be rectified such as: reduce the font size of the index (if there is one), alternatively the half-title page could be removed (if there is one in the book).

This extent issue can become more acute when moving between printing technologies e.g., from litho/offset to inkjet printing. To avoid the unnecessary use of superfluous paper BIC recommends talking with the printer to establish the best solution for each title.

Trim sizes

It is important when looking at trim sizes that the publisher and printer have a conversation to establish what the most economical size might be to use. This can vary between printers, and so it is important to have these conversations.

Examples of changing a trim size

A major publisher worked with their printer to look at what was the most economical trim size they could use for one of their book products. Originally it had been decided to produce the books as 297 x 210 mm, but after various conversations this was reduced to 292 x 205 mm This resulted in a saving of 15 Tonnes of paper in the manufacture of these books when comparing print runs of the same length between the two trim sizes. It should be clarified that this is only a saving to the amount of paper used to print the books economically, and not to any waste that would normally be generated in the production process.

The reduction of the use of 15 Tonnes is significant and represented 3.8% of the total paper used by this publisher in a year. Across a whole publishing program this could be a significant saving. It is recognised that smaller publishers would not make the same kind of saving, but savings can nonetheless still be made.

Materials

When considering the materials to use in a printed book the most important thing to do is your RESEARCH into their carbon footprints and sustainability credentials. By materials, we mean everything that is used to manufacture your book e.g., the papers, inks, glues/adhesives, foils, and laminations, plates for text and spot UVs, brass-dies for blocking and embossing covers etc. It is always worth considering these two questions:

- What is the desired look and feel of the book?
- What is the content of the book?

The answers to these 2 important questions, will inform the direction of the research of the materials: Can the sustainability impact of the materials currently and generally in use be improved? Or is a search for new materials that are more sustainable, but still produce the high-quality books required?

If publishing high end, four-colour, graphic books, it is not always going to be desirable to change their feel and look. In some cases, finding similar materials that are more sustainable might simply not be possible just yet. The carbon footprint of the materials

should be investigated, to see if by changing some of them reductions in the overall carbon footprint of the book might be made. A regular review of these decisions should be undertaken to see if anything has changed in the marketplace.

Paper

When it comes to paper, the choice of what to use aesthetically essentially comes down to two areas:

i) Look/feel and
ii) The content that you will be printing in the book.

There are many papers out there, from virgin to recycled stocks, and different organisations and people have different ideas about what they think should be used and when.

This report cannot dictate what type of paper to use. However, it can give facts about papers, advise what to look for in a paper and bust some paper myths. The rest is for organisations and their production departments/teams to decide and will be dependent upon the content being printed, and the type of paper that will best show this off.

Paper type

Ideally publishers/organisations should already be using paper stocks that come from certified responsible sources such as FSC (Forest Stewardship Council), PEFC (Programme for the Endorsement of Forest Certification) and SFI (Sustainable Forest Initiative). When starting the decision process about the production of a book, appropriate paper will be chosen based on its weight, opacity, brightness, and surface finish (matt, smooth or gloss), from the ones currently in use. Once a choice of the "type" of paper has been made, sustainability research can begin and should include: looking for papers that have the same properties as the preferred "type," but with a lower carbon footprint, more recycled content, or 100% recycled paper. However, the decision to change should be based on maintaining the look and feel and being the best paper for the content being printed on it. The printers and mills should have data sheets for all the papers that they produce or purchase. It is a good idea to ask the printers and mills if they will share this data. We are all in this together and all areas of the industry are working hard to be more sustainable.

Paper Profiles/CEPI statements

For paper and boards, printers may be collating carbon footprint statements for individual products and/or suppliers every year. These are most commonly in the form of Paper Profiles or CEPI (Confederation of European Paper Industries) statements measured in emissions per tonne of paper produced. One printer has told us that they have product-specific measurements for paper covering over 90% of their purchased volume.

Weight of paper and carbon emissions

Based on data from T&FWG members, the production of paper is the largest source of emissions within a printer's carbon footprint therefore, it is the most important area towards meeting any emissions reduction targets. If consistency is essential, then consider keeping the same paper but changing its base weight‡ to a lower value. The

base weight of a paper is either expressed as gsm (grammes per square metre) (UK and Europe) or lbs (weight in lbs of 500 sheets) (USA) depending on location or both if it is an international conversation. Look at a pack of home printer paper - the weight of the paper is displayed on the packaging. This is generally something like 75 or 80 gsm. Different weights are available and changing this is what we are talking about here when we talk about reducing the weight of the paper to change the carbon emissions.

When it comes to the carbon footprint of a paper there are several factors to consider, such as:

- How energy efficient the mills producing the pulp are.
- Are the mills using renewable energy sources?
- How are the mills processing the water that they use in their plants? Is it recycled and released back into the rivers again, or recycled to be used in the mill?
- Recycled paper - a lot of energy is required to produce this, particularly as the pulp needs to be de-inked to make it usable for making paper again.

Based upon the findings of your research a decision can be made to change the paper or not. This is going to be different for all publishers based on how they buy paper. For a large publisher who manages the buying and supply of paper this is going to be easier than for a smaller publisher. For smaller publishers who use a printer's stock, it is a good idea to talk to printers about your publishing program, what the production aims are, and work with them to buy more sustainable papers. Publishers and printers can work together to consolidate the number of papers that they use. There is much greater collaboration in the industry now, and these are the types of conversations that are generally happening across the board.

Consolidating paper types

In recent years, new machinery investments have enabled considerable reductions in paper wastage with the ability to splice reels‡ without stopping the press. This means, if printing on a printing press that uses reels of paper, as the current reel is coming to its end, then the next reel automatically replaces the old one, splicing the two together without the need to stop the printing press. These reduced levels of paper waste are however only achievable if common reel sizes‡ are used. Printers print books that utilise the same paper roll size, independent of the publisher, organising their print schedules to maximise the use of a particular paper before changing the paper reel size on the printing press. Consolidating different paper types would achieve shared benefits in costs and help publishers and printers achieve their sustainability goals. A publisher might use, say 30 different types of paper, but do they need to use this many? When in fact there might only be a requirement for different 10 papers. By consolidating the number of papers, a publisher will save money as they can buy the ones they do use in greater bulk. Similarly, for a printer, they can reduce the number of papers that they must stock and increase their bulk buying.

Print runs - overs and unders

For every job, an allowance is made by the printer for over and under production varying by run length and format. When planning to print a book printers will allow, in their calculations, to print more books than required. This is because during the whole production process at the various set-up stages they will use some of the printed material to make sure the machinery is optimised for those particular books' production.

These small reductions eat away at the total number of books that will be produced during the print run. The final number of books may vary from the actual number of books requested on the print order form. The term over and under refers to the final number of books printed compared to the actual number requested. Printers generally work to tolerances of +/-5% for mono books and +/- 10% for colour books. If there is a shortage of printed copies exceeding the agreed tolerance, customers have the option to makeup the shortage by going back on press. These can be extremely short run lengths (less than 100 copies), requiring an overproportionate amount of paper for startup procedures, energy consumption and time for the press to get up to speed, especially when using unique trim sizes.

Whether or not a shortage is made-up depends on the discretion of the customer and is determined on a case-by-case basis; not all shortages will be put back onto press if they are deemed to be insignificant. Increasing the agreed tolerances between publishers and printers for certain work would bring co-benefits in reducing energy consumption, paper waste as well as the costs of production, storage and pulping excess stock.

Virgin v. Recycled

There is a big debate around whether to use virgin or recycled paper. Again, only the publisher, can decide what is best for their content and USP. The efficiency of the paper mill, how it sources its power and what pulp it is using to make the paper will have a wide-ranging impact on the CO_2e of the paper as the following two examples show.

Example of paper comparison looking at energy and CO_2e

This example looks at three papers (two virgin and one recycled) with similar attributes, produced at three different mills with different levels of efficiency. How efficient the mill is and if it is using renewable or fossil fuels as its energy source will have a direct effect upon the CO_2e of the paper produced. In the example below a Paper A produced in the most efficient mill with renewable energy has a carbon footprint that is much lower than the other two. This is just one example and shows how important it is to look at all aspects of the paper.

Even if it were in BIC's remit to do so, it is not possible to provide a price guide for these papers as that varies depending upon whether the publisher buys their own paper or uses that provided by their printer. Although it has been noted that recycled paper can often cost more than virgin paper. There is also a limited supply of quality recycled paper in the market for book printing.

	Attributes	**Current Mill efficiency**	**Mill's Energy Source**	**CO_2e**
Paper A – virgin	Weight: 60 gsm Brightness: 73.5iso Opacity: 92%	Upgraded mill, most efficiency improvements made	Renewable	97 Kg/ton
Paper B – virgin	Weight: 60 gsm Brightness: 73.5iso Opacity: 93%	Some upgrades completed, more to do	Renewable	320 Kg/ton
Paper C – recycled	Weight: 60 gsm Brightness: 72iso Opacity: 92%	Large investment coming to move away from fossil fuels	Fossil fuel	1010 Kg/ton

Some myths and facts about paper

Myths and facts	Answer
Is it bad to cut down trees to make paper?	In an FSC environment, the trees are grown as a crop and replanted. Also, the trees are often primarily cut down for the timber industry and the paper mills use the parts of the tree that are not suitable for timber. Therefore, it is a secondary use to make paper. It should be reported that although the forests are managed responsibly there is a lack of information about the biodiversity in plantations.
Is recycled paper 100% recycled fibre?	No, not all as recycled paper needs a small amount of virgin fibre to have long enough fibres to make it into paper.
Does recycled paper use less water in its manufacture than virgin paper?	Yes, it does, but water is not consumed in the process. The water used in the manufacturing process is cleaned and recycled either to be reused by the mill or cleaned and let back out into the river.
Are European forests shrinking?	No, European forests have been growing by over 1,500 football pitches every day.
Myth - Paper is bad for the environment.	Paper Is highly recycled and naturally sustainable.
Myth - Paper production is a major cause of global greenhouse gas emissions.	Most of the energy used in paper production is renewable and carbon intensity is surprisingly low
Myth – Paper wastes precious resources.	The paper industry supports a circular economy.
Fact – The paper recycling rate in Europe was 70.5% in 2022, keeping fibres in the loop longer and extending the benefits of their renewable origin.	This is approaching the practical maximum recycling rate of 78%
Fact – Paper is recycled on average 3.5 times a year in Europe. Paper cannot be recycled indefinitely as fibres get too short and worn out and therefore can no longer be used in creating new paper. Hence, virgin fibres from trees are needed to continue the cycle. These new fibres come from renewable, sustainably managed forests and continue the loop.	
Fact - Recycled and virgin fibre are complementary	Both recycled and virgin fibre have benefits. When compared to the manufacture of virgin fibre, production of recycled pulp generally requires less energy consumption depending upon the efficiency of the mill it is produced in and has lower emissions to air. Yet virgin fibre

	production typically uses more renewable energy and creates less solid waste. However, because virgin and recycled fibres are interdependent, it is very difficult to reliably compare their environmental attributes. In practice, recycled fibre would not exist if virgin fibre were not sustainably harvested and societal demands for paper and board products could not be met without both. Fibre can be recycled several times, yet not indefinitely. Therefore, there is a continuous need to feed the inflow of recovered fibre with paper products made of virgin pulp.
Paper power	Paper is fundamental to a circular economy and has the benefit that it is based on wood fibres which are renewable, recyclable, and sustainable. 62% of European pulp and paper mills' energy consumption comes from renewable sources and 96% of on-site electricity production is through efficient combined heat and power (CHP)‡ units. The European paper industry has achieved (between 1991 and 2020) substantial reductions in energy and water consumption (Cepi's Key Statistics), as well as emissions to air and water, despite a 45% increase in production.

Myths and facts supplied and published with permission of Two Sides, https://twosides.info/

Inks

Printers use a range of inks for different production routes. The types of inks used on a specific title would be at the discretion of the printer determined by machine specification, press loads, paper/board, finishing requirement and capacity at a certain point. The flexibility to allocate jobs to certain machines based on capacity allows the printer to optimise the production process; minimising time on press, energy usage from additional machinery adjustments and materials wastage. The most common types of inks used for a printer are oil-based, UV and digital inks:

- Oil-based: Use mineral or vegetable oils as the vehicle for the ink. Oil-based inks can be coldset drying by a mixture of oxidation and absorption into the paper or heatset drying, whereby the printed pages run through a series of dryers to evaporate solvents and set the ink.
- UV: UV inks dry through a reaction to ultraviolet light, emitted by one or more lamps incorporated into the printing press. There are no vegetable or mineral oils

in UV curing inks, containing polymers and monomers with photo initiators for the curing process.
- Digital: Synthetic water-based inks containing neither vegetable nor mineral oils.

The use of oil-based, UV or digital inks is not likely to significantly impact the recyclability of process waste generated in production or the recyclability, biodegradability, or compost ability of a finished product due to the low levels of contamination. When a book with ink is sent into the pulping process, any non-paper materials, such as finishes, are filtered out during the pulping process and incinerated for energy.

Most printers have manufacturing guidelines to limit issues during the production process, for instance, maximum ink densities on different types of board to minimise drying issues exceeding these thresholds will flag in the printer's pre-flight checks.

Plates

Plates are vital to the lithographic/offset printing process and are purchased from third parties by printers. To begin with a printer's imposition software‡ will determine, from the publisher's PDF files, where to place the pages on a plate so that when it is folded to make a signature all the pages will appear in order. The PDF image is then burnt onto the plate using either a photomechanical or photochemical process. Four plates are needed when printing a colour book and only one is required for a mono book. During the printing process ink is attracted to the areas with the image. The ink is then transferred from the plate to what is known as a 'blanket' and from the blanket to the paper the book is being printed on.

The most used plates that are currently used for lithographic/offset printing are made of 100% virgin aluminum. They need to be made from virgin material to be able to perform correctly on press. It is therefore currently not possible to have plates with recycled content, but this could change in the future. It should be noted that different materials are also used in the gravure‡, flexo‡ and letterpress‡ printing to transfer the image onto the paper.

There are currently no direct/supplier measurements available for the carbon footprint to produce plates. The production of plates is currently measured using a European sector average for producing a tonne of aluminium, in total about 10% of scope 3 emissions for an example printer.

The same set of plates would be used for a single run however sometimes a new set of plates are required as the image can wear during printing. A new set of plates would be needed for any reprints. Plate sizes are determined by the machine (not by customer trim size), however new plates may need to be produced if a change in the order means the job is allocated to a different machine or the print quantity is a high volume as plates wear during the print process and image quality reduces as run length increases. The good news is that all plates are recycled, due to their level of purity, into engine parts. This is a good revenue stream for a printer and constitutes roughly 1% of their total waste left over from the manufacturing process by volume.

Brass-Dies

Brass-dies are used in the foil-blocking process to press/imprint the foil on to the cover of a book. They can also be used to make an indentation in the cover, without the use of foil, and this is known as blind blocking.

Figure 11a Evolution of foil artwork to create the brass-die. Figure 11b metal brass-die. Photo courtesy of Lisa Faratro, CPI

Brass-dies as they used to be known or 'brasses' in the UK and 'dies' in the USA are now made of copper, magnesium, and brass. All brass-dies currently used by T&FWG members are created from virgin material, containing no recycled content. At the end of their useful life, brass-dies are sent for recycling, making up less than 1% of total waste volume based on an example printer.

There are currently no direct/supplier measurements available for the carbon footprint of the production of brass-dies. The production of brass-dies is currently measured using European sector averages, in total at less than 1% of scope 3 emissions for an example printer.

Brass-dies can generally be used for the complete print run and for reprints. Multiple sets of blocks are sometimes used on a single job to run on multiple machines or as a backup. Brass-dies are kept at the discretion of the printer, who may have a time limit on how long they are prepared to keep them for depending upon space and workflow.

Foils

Foils are used on covers as a way of enhancing the cover design, or with a Wibalin cover blocking the author and title of the book. The project team reached out to a foil supplier for their comments on the make-up and recyclability of foils.

Figure 12a, b, c Foil as it comes on a roll. Photos courtesy of Lisa Faratro, CPI and Tom Scatchard, Clays

Figure 13 Waste roll of foil after use. Photo courtesy of Tom Scatchard, Clays

Foil stamping – foils are transferred to paper or board with heat and pressure using engraved metal dies. There are two main types of foil blocking methods used in book printing: hot foil stamping and cold foil printing:

Hot foil stamping: foil is transferred to a substrate using heat and pressure
Cold foil printing: foil is bonded to an ink, with no need for heat or dies

Foil consists of different layers:

1) A carrier layer, usually made of plastic (PET – polyethylene terephthalate)
2) A release coat, which allows the foil to separate from the carrier layer when heat or pressure is applied
3) Lacquer and dye, to give the foil the colour, but is translucent to show the aluminium layer below.
4) Aluminium (present only in metallic foil) to give the shiny effect
5) Adhesive: Used to bond the foil to a substrate. Different adhesives are used for different substrates that the foil is being bonded to.

A list of questions was distributed by members of the T&FWG to key foil suppliers with regards to the sustainability implications of foil. The responses have been summarised below:

- Recycled content varies by the type of foil – some metallised foils contain a percentage of recycled aluminium.
- The transferred materials are plastic free, the carrier currently uses PET. Leftover carrier film is normally sent for heat recovery at a power station,

previously using fossil fuels. PET carrier film has a high thermal load and can directly replace coal and/or gas. An initiative is underway to reclaim the waste PET carrier film for recycling.

- Alternative products to foil marketed as 'plastic free' may still use PET at some point in the upstream supply chain and may only be plastic free on the finished product, like transfer foil.
- Books printed with foils are 100% recyclable and compostable‡, assuming all other materials on the product e.g., laminates, meet the same qualities and are similarly recyclable.
- Foil jumbos‡ arrive at the printers on metal stillages so no packaging is used for transportation, Metal stillages are used repeatedly for transporting foils. Foil is sent out to customers, i.e., printers on pallets and/or on cardboard packaging. Apart from tape, no plastic is used to transport any foils. Cardboard and plastic tape must be used to secure the foil in transportation.
- Foils for hot stamping are generally produced in standard thicknesses (12 microns ranking from 8 to 10). A particular supplier has reduced the thickness of the PET carrier by up to 50%, varying between different types of foil.
- The width of foil rolls is standardised to reduce waste in the manufacturing process. Waste management initiatives follow the waste hierarchy, prioritising reducing waste e.g., through reducing the thickness of the carrier film, reusing leftover material when possible and recycling into new materials e.g., PET recycling scheme. Any opportunities to reduce waste through new product development are discussed with customers from the outset.
- Carbon footprint measurements for foil may only be available directly from the foil supplier for confidentiality reasons.
- Waste rolls of foil after use (shown in Figure 10) are difficult to recycle due to the combination of the aluminium foil attached to the plastic carrier film. Waste rolls of foil are currently sent for incineration to generate energy.

Design impact on foil usage

Foil usage is relative to both the area that has foil on it and the imposition used by the printer and whether any spacing within the design (called steps) can be utilised to reduce any wastage.

Firstly, foil is provided in rolls (like reels of paper, see photos above) which are cut down from larger reels called jumbos. The foil width used is decided by the printer and is related to the imposition used per job. In the example below we are showing a standard UK B format cover.

Both covers have the same amount of foil visually on them – 96cm^2 but the amount of foil actually used to create the image is different due to slight alterations with design. The below calculation is based on a cover being produced imposed as one copy per sheet of paper (one up).

Figure 14 courtesy of CPI

This B format cover utilizes 233 cm^2 of foil in its creation, therefore wasting 137cm^2 of foil for every book cover meaning more foil goes into the recycling than is shown on the book itself.

Figure 15 courtesy of CPI

This utilizes 113cm^2 of foil in its creation therefore wasting just 17cm^2 of foil (17%).

Most A and B format books in the UK are imposed 4 or 8 covers onto a sheet of paper (4 up or 8 up) depending upon size of press and the finishing equipment so the below now demonstrates how the imposition also influences the foil usage.

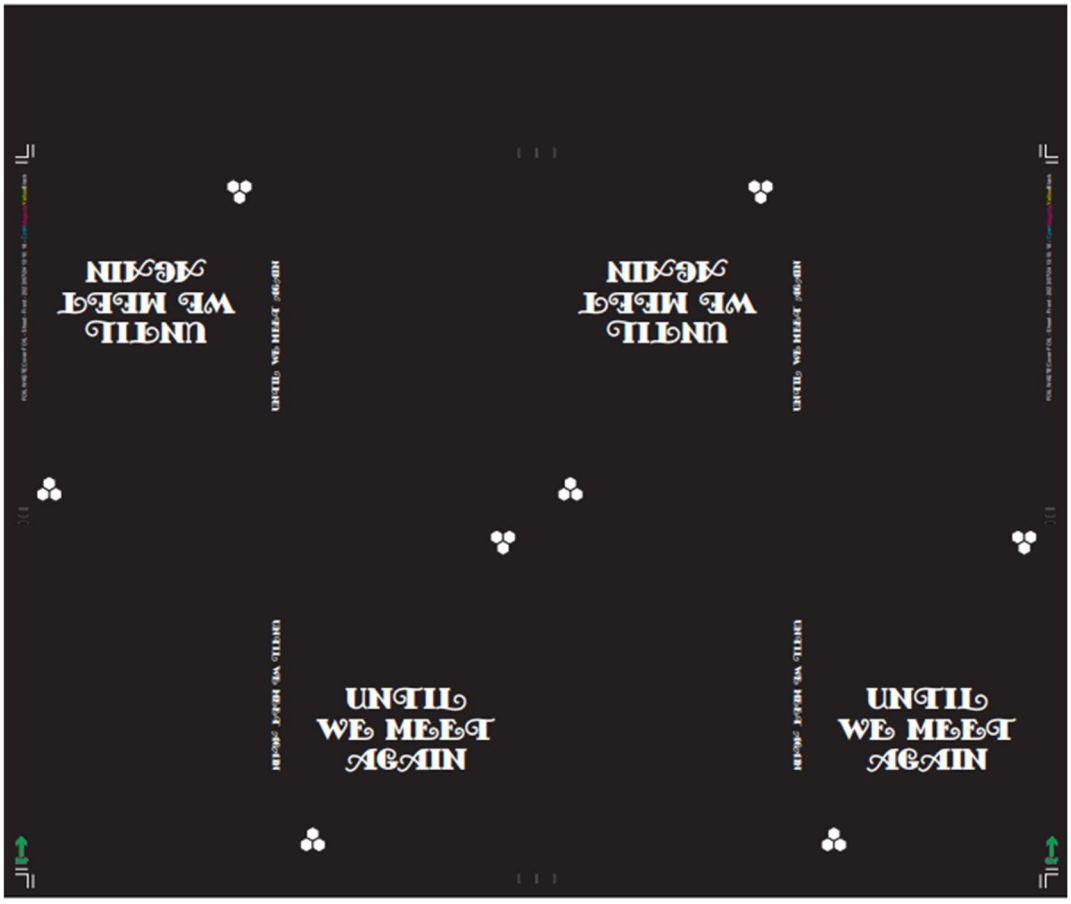


Figure 16 courtesy of CPI

Imposed this uses even more foil 464cm^2 therefore wasting 368cm^2 of foil for every cover which is almost 4 times the amount of foil that is visually on the cover. Altering this design very slightly by **moving the foil on the diagonal corners of the front cover,** reduces the wastage considerably when hot stamping. Hot stamping machines have the ability to pull the foil at different lengths allowing the operator to optimise the foil by 'stepping' areas of foil required into the next area of foil available. This would mean 220cm^2 of foil used thereby showing how a small amendment to design can dramatically reduce foil wastage.

Figure 17 courtesy of CPI

This imposed B format cover shows the lowest wastage of foil because the gap between foil image is the same height as the foil coverage therefore the roll of foil can be "stepped" (i.e., the roll of foil can travel at a different timing to the press itself to help reduce wastage). This requires skilled operators to minimise wastage but certainly should be reviewed when designing covers and utilizing the knowledge in printer production departments, i.e., foil designs should be kept as 'condensed' as possible to reduce wastage.

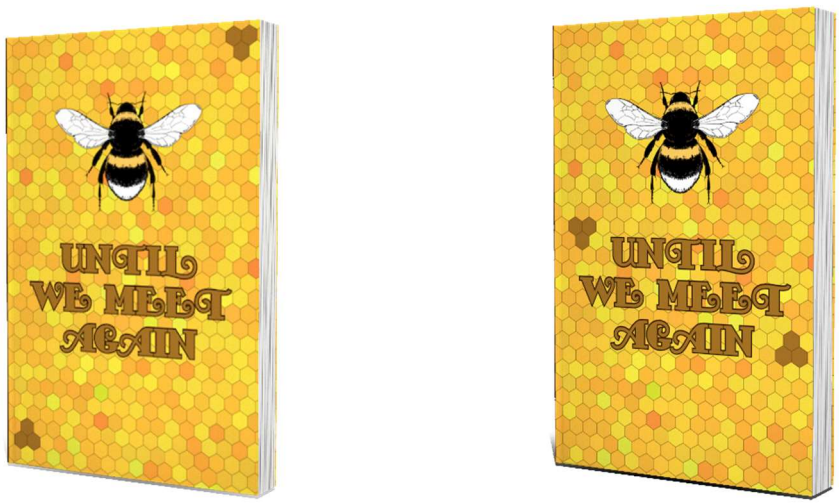


Figure 18A on the left and Figure 18B on the right courtesy of CPI

This is how the actual books might look if the covers had been produced and blocked for real. These images have been generated by CPI eMotion for this report. Figure 18A uses 464cm2 of foil, Figure 18B uses 220 cm2 of foil.

Glues/Adhesives

The basic purpose of 'glues' in the book binding process is to glue the text pages together to make the book block. They are also used to glue the cover to the book block to make either a paperback or hardback book.

There are four basic types of glues that can be used in the printing industry for the manufacture of books; they are hot-melt, solvent-based, water-based, and animal-based.

A list of questions was distributed by members of the T&FWG to a key glue supplier with regards to the sustainability implications of glue. The responses have been summarised below:

- Most glues do not contain any recycled content,
- Glue on books is generally not recyclable and is screened out without contaminating fibre when repulping/reclaiming fibre, often the non-paper material including adhesive is used for energy,
- The transport and packaging of glues varies with grades, larger volumes are in pallet boxes (cardboard), with individual boxes or bags in paper/cardboard, and film,
- Glue manufacturers often visit their relevant printer sites and other sites when required to check glue lines and thickness to ensure no over gluing. During site visits they may suggest options to balance the current glue application against the best option for each unique circumstance,

There are many glue formulations that have had LCA (Life Cycle Analysis) statements completed as well as suppliers that have external sustainability assessments such as Ecovadis. Printers can be contacted to find out more about their glue supplier credentials.

Laminates

When we talk about laminates the word plastic comes to mind, and therefore the assumption is made that it is something bad to have in a book. Is this really the case and what are the alternatives that could be used instead? Firstly, let us understand the main purpose of a laminate. It is there to decorate the product and for protection, therefore may not be considered as single use. Secondly, we can start asking questions with regards to laminates, such as what is being done to make them more environmentally friendly, what alternatives are there, and how desirable it is to protect the book(s) in question.

The project research looked at the current plastic laminates in the marketplace, their properties, applications, and what is being done to improve the perception and attributes. The team also looked at alternative materials that are not plastic based, and future developments in this field. It is important in this field to know when talking about 'plastic' if it is derived from a petroleum/fossil-fuel or a bio-based‡ material.

What is film lamination?

There are two types of film lamination – thermal and wet. Both types of laminations are made from Biaxially Oriented Polypropylene (BOPP)‡.

Thermal lamination film‡

Construction is BOPP/EVA (Ethylene vinyl acetate). During the application process the EVA is activated and then bonded to the printed cover. From feedback from T&FWG suppliers, thermal gloss and matt films are 22 microns thick, and soft-touch and anti-scratch 30 microns.

Wet lamination film‡

Construction is BOPP/Wet acrylic. These films are typically about 12 to 13 microns thick.

Lamination sustainability information

The team created a list of questions regarding the sustainability implications of different laminate materials to their respective printers and suppliers. The responses have been summarised below:

- Most laminate materials do not contain any recycled plastic content, there are some products available containing 30% post-consumer recycled (PCR)‡ content with ongoing research to increase this to 50%. Recycled content laminates can be more expensive than standard options, and can carry limitations with the supply of recycled plastic,
- No specific data is currently available on the carbon footprint data of laminate products,
- Laminates containing 30% bio-based content are available sourced from 2nd generation feedstock (e.g., waste vegetable cooking oils) with ongoing development to increase this to 50%,
- Other alternatives are cellulose acetate‡ (wood pulp) and bio-degradable‡ and compostable. Wet laminate versions are non-plastic, whereas thermal versions use EVA (contains plastic) as the adhesive applied to the laminate film. Wet acetate options can be used with a bio-degradable adhesive; however, they are

only available in gloss or matt. Compared to BOPP, acetate has a higher scratch resistance,

- PLA‡ (polyacetic acid) laminates are currently only an option for wet lamination for gloss as it has a lower melting temperature (matt & thermal versions are in R&D). The PLA material is made from cornstarch and is compostable, but not bio-degradable in other environments,
- BOPP and PET‡ laminate materials are commonly recycled plastics however suppliers advise customers to consult their waste management contractors,
- For a printer, any process waste with laminate would not prevent recycling the paper. During the pulping process, non-paper components of a book would be filtered off and burnt for energy,
- For an end-consumer, whether a finished book with laminate is recyclable depends on the available facilities, and the other materials the book would be disposed of with. Acceptable contamination levels depend on the country - https://www.aticelca.it/1/riciclabilita-della-carta/,
- Since January 2023, the EU has been following new packaging requirements where final packaging must state which materials are being used and information given on how to arrange disposal (just for packaging). For example, laminated paper boxes are allowed to be recycled with paper if the lamination part does not exceed 5% of the total weight of the packaging,
- Application temperatures for laminates vary between machines and substrates, which may not reflect the laminate manufacturer's specifications. Application temperatures should be considered against processing times to give a more complete indication of the carbon footprint during the application stage,
- Technological developments have enabled reducing the thickness of laminate films, in some cases by up to 23% without affecting the properties of the film. Most of the work in this area is around process optimization rather than reducing the film specifications,
- One of the primary issues identified was around availability and access to greenhouse gas emissions data from manufacturing and applying different laminate products. These processes should be included as part of a printer's emissions, specific data for laminates would enable identifying opportunities to reduce and feed through this data into design and production teams.

Alternative print finishes

Aqueous coatings

These are applied to covers and jackets during the printing process, and dry instantly. They are a fast, affordable, and sustainable option, but they provide no protection against water damage. They are available in neutral, gloss, matt, silk, and soft touch finishes, and are used to provide some protection from set-off‡ and help reduce marking the page.

Biofilms

Biofilms are derived from biological/renewable sources such as cellulose acetate from wood pulp or Poly acetate from starches as alternatives for fossil-fuel based plastic laminates. Bio-based materials are not necessarily biodegradable or recyclable as a separate product in commonly available waste streams. When applied to a book cover, biofilms would not significantly disrupt the recyclability of a book.

Litho machine varnishes and seals

These are used to prevent set-off and marking particularly on uncoated products where drying is more difficult. They can change the finished feel of the page depending upon the finish used (neutral, matt or gloss). As they are fossil-fuel based, varnishes may carry a higher carbon footprint than aqueous coatings.

Conclusions

Although the best protective laminates are made of plastic there are many positives to using them in books. The term 'plastic' is often used to refer to single use, throwaway items ultimately disposed in the natural environment with prolonged issues during degradation. Whilst the majority of the plastic used for laminate is fossil-fuel based, laminates arguably face these issues to a lesser degree. Laminate provides a protective and decorative function for books, adding to the overall longevity and value of the product. They are only a small percentage of the overall make-up of a book. They can be removed from the pulp as part of the recycling process. If a book is being kept for a long time, be that on someone's bookshelves or in a library, then that is a good thing. If going forwards fewer books are pulped for whatever reason, then this issue becomes less of a bad sustainability factor.

There is also a lot of work going on in the production of plastic laminates to reduce their environmental impact. Laminates which are being produced as thinner films with a 23% reduction in their plastic content must be a good thing**.** This is also being done without the reduction in quality to the protective properties of the film.

Currently the alternatives to plastic laminates do not give the same protection, which is a problem for the longevity of a book. One alternative, cellulose acetate could be a replacement, but it comes at a cost. Although figures are not available for the carbon footprints of laminates, the only thing possible is to look at the journeys made by laminates from raw materials to roll of laminate delivered to the printer.

Material	Description	Pros	Cons
BOPP	• Thermoplastic polymer that comes in gloss, matt, anti-scratch, and soft-touch finishes	• Does not affect recyclability of a book when pulped* • More PCW (Post Consumer Waste) and PCR (Post Consumer Recycled Waste) options coming to market (reduction in virgin plastic) • Provides good protection from scuffing and water resistant	• Usually requires petroleum to manufacture polypropylene

Aqueous coatings	• Applied during the printing process and dry instantly. They come in neutral, gloss, matt, and soft-touch finishes	• Easily recycled • Easily applied in printing process • Dry quickly • Sustainable option	• Offers no protection
Biofilms	• Cellulose derived acetate from tree pulp • Applied with a non-toxic ~~PVA~~ glue	• Does not affect recyclability of a book when pulped* • Bio-based – from a renewable resource	• Not all biofilms are biodegradable, need to check the film that is being used on your books
Litho machine varnishes	• Used to protect the page from set-off and marking particularly on uncoated products where drying is more difficult	• Does not affect recyclability of a book when pulped* • Protects the page from marking and set-off	• Offers little or no protection • Hydrocarbon based so come with a higher carbon footprint, so would be better to use an aqueous film

*Due to the low levels of contamination, these finishes would be unlikely to affect the recyclability of a book. In the pulping process non-paper components would be filtered out.

Bindings

The most common bindings used in book manufacture are used to create paperback and hardback books. Printers utilise several methods in the binding process be that:

- Perfect bound - where individual pages are held together with glue and stuck to the spine of the paperback cover, or
- Notched binding - where the individual signatures of the book have notches cut in them so when all the signatures are gathered in the book block the glue can penetrate all the pages to hold the book together.
- Sewn binding - The signatures can also be sewn together using thread that is made of cotton with a very small percentage of plastic. The thread would be removed during the recycling pulping process.

When recycling books that are manufactured using glue to keep them together the glue is a small part of the whole make-up of the book, and this is filtered/removed in the recycling process. The same is the case for books that are sewn.

Wire-O binding

Wire-O binding is the type of binding used for things like notebooks, maps, and titles where you want the pages to either lay flat or turn over on themselves. The actual spiral can be made from a metal coil coated in plastic or fully plastic. They are useful way of

keeping the pages together for the product they are being used for, but difficult to recycle. The coil needs to be separated from the pages of the book in the first instance. They are not environmentally friendly as they are made from plastic. It is not evident how you can recycle the coils once they have been separated out.

The use of Wire-O binding is a design choice that is made in the initial stages of the book or products design. In some cases, publishers are actively removing this type of binding from their existing books or choosing not to use it going forwards.

Packaging

As part of this project the T&FWG have not researched packaging to any depth. The topic has come up in discussions and research, but it was decided that packaging was best dealt with under Part 3 of this project – Manufactured Book to End-of-Life. This current report looks at the design and manufacture of a book to the point of the production of the finished physical book. At the end of the binding line, be that automated or not, books can then be gathered in shrink wrapped bundles or put into cartons. Hence with several options available this project stops at a manufactured book.

Editions

Publishers are producing more sets of editions for niche markets. This is where a publisher will use the same text from the book but will binding it in different ways. They will design a different cover for each edition depending on the target audience. They will employ the use of coloured and/or printed endpapers. Endpapers are attached to both ends of the book block and are used to fix the hardback cover to the book.

In the past and even today books can have gold sprayed onto the edges of the paper. This was done to prevent moisture being absorbed by the pages as gold is an inert metal. This is done when the book block is closed prior to binding. It is now possible with modern technology and printing presses designed to do this work to print an image on to the edges of the paper. This technique is being used a lot more with editions as a decorative feature.

All these additions require further production processes, with more materials, chemicals, energy, greenhouse gas emissions and waste. In some cases, printers are producing up to 14 different editions of the same book at once.

Summary

So, in summary here are the highlights from this report:

- Waste – a definition of waste has been provided,
- Initial design – This section talks about what to look for and how to start thinking about the design of a book from its conception. An example using Piers Torday's book *The Wild Before* shows how making changes to the materials used can impact the both the design and sustainability/recyclability of a book,
- Typesetting and sustainable fonts – This section talks about the importance of choosing the right font from the being for the book that is being produced. It then provides an example using the sustainable fonts design by 2K/Denmark and how these fonts save space and increase readability of a book,

- Printing in even workings – this section talks about working with your printer to understand how books are printed. This understanding can then be applied to the extent of the book and savings made by printing to even workings and not adding unnecessary pages to the book's extent.
- Paper – this section provides ways to review papers and things to look for with sustainable papers. There is also an example showing the relationship between mill efficiency, energy source and corresponding paper carbon footprint. The section also provides a table of myths associated with paper.
- Inks – this section reviews the various ink options available to printers and explains the differences.
- Glues/adhesives – this section reviews the various glues/adhesives options available to printers and explains the differences.
- Laminates – this section looks at the various options that are available on the market. As laminates are plastic based it also talks about the work and research in this area to reduce the carbon footprint and impact that laminates have upon books.
- Foils and brass-dies – this section looks at the options available to publishers and printers. It also has an example on how the design of foil stamping/blocking area can have upon the amount of foil that is used in the process compared to the waste generated.
- Binding styles – the various binding styes are reviewed to show how recyclable they are.
- Packaging – this area will be looked at in Part3 of this project – Manufactured Book to End-of-Life.
- Special editions – the impact of having multiple editions is explored in this section regarding the extra waste generated.

As sustainability rightly remains at the top of an organisation's and people's mind there are going to be sustainability, environmental and recyclability advances in both materials and manufacturing processes. This is also true for the book industry supply chain. So, although this report has provided the reader with many ideas and suggestions of how they might do things differently when designing books, the work does not stop there. Organisations need to keep reviewing and researching the materials and processes that they use and employ in the supply chain. This will help enable them to stay up to date with any advances in the sustainability and recyclability of materials and then apply them to their own processes.

Glossary

- Acetate: Cellulose laminate made from wood pulp.
- Base height: The height of a letter from the imaginary line that the letter sits on
- Biaxially oriented polypropylene (BOPP): Thermoplastic polymer – malleable at certain temperatures and returns to a solid form when cooled down
- Bio-based: Made from biomass e.g., wood pulp, typically from renewable resources
- Bio-degradable: Capable of decomposing into natural elements aided by biological processes. There is no set timeframe for a material to biodegrade, meaning this is sometimes used to mean over 100 years.
- Book block: A book block is a collection of pages, usually in the form of folded signatures, that are not yet bound with the cover.
- Closed loop recycling: The process of recycling material back into the same product

- Combined heat and power (CHP): Electrical generator with equipment for recovering heat
- Compostable: Capable of decomposing into natural elements in home or industrial composting (with specific temperature and humidity requirements)
- Digital lamination: Similar to thermal laminate films with another bonding additive for the silicons and waxes within certain types of inks
- Elemental chlorine (EC): Elemental Chlorine bleaching is the traditional method for bleaching pulp, using chlorine gas (elemental chlorine). This process produces significant amounts of toxic chemical compounds called dioxins and furans.
- Elemental chlorine free (ECF): Elemental Chlorine Free bleaching technique uses chlorine dioxide and e.g., hydrogen peroxide as bleaching agents. Oxygen delignification is often used prior to ECF bleaching, as this reduces the amount of bleaching chemicals required.
- Even working: A group of consecutive pages will be printed on a single sheet in such a way that when the sheet is mechanically folded and cut, the pages will be in the correct order for binding.
- Flexo: form of rotary printing in which ink is applied to various surfaces by means of flexible rubber (or other elastomeric) printing plates
- Foil jumbos: large roll of foil used in book manufacture
- Gravure: a printing process that uses an etched or engraved plate
- Imposition software: The software is used to layout a book's pages so that when printed they appear in the correct order.
- Inkjet press: A digital printing press that uses printing inks.
- Lamination: Is the application of a thin plastic film to protect the cover of a book from scuffing and general wear and tear.
- Letter press:
- Lithographic: Lithography/Lithographic and offset printing, or litho printing for short, is where the image of the content you want to produce is placed on a plate which is then covered in ink and used for printing.
- Machine varnish: Machine Varnish is a virtually invisible coating that is applied to the printed item immediately after the ink is put on the paper.
- Mass balance: Tracks the amount of recycled or bio-based content through the value chain
- Material safety data sheets (MSDS): Provides information on controlled substances required under the REACH regulation
- Mechanical recycling: Includes processes such as grinding, melting, and granulating
- Mono book: A book that is printed on one colour black
- Open loop recycling: The process of recycling material back into other products
- Picas: The unit of measurement used in typesetting.
- Plates: Printing plates that are used to transfer the ink to the paper.
- Polyethylene terephthalate (PET) and rPET are types of polyester films used to laminate book covers
- Polyacetic acid (PLA): Starch-based polymer
- Post consumer recycled (PCR): Waste recovered after the intended use by an end-consumer
- Post industrial recycled (PIR): Waste recovered from an industrial process before use by an end-consumer
- Process chlorine free (PCF): Process Chlorine Free indicates that fibres are recycled and treated/bleached using totally chlorine-free compounds.

Recovered fibre cannot be considered totally chlorine free, because the previous bleaching method of the fibres is not known.

- Pulp bleaching (PB): Pulp bleaching is the process where wood pulp fibres are chemically treated before papermaking to remove lignin and resins. Pulp bleaching results in white and clean paper products.
- Recto: Right hand page of a book.
- Reel: A reel of paper used on a printing press instead of sheets of paper
- Reel sizes: The size of the reel. These are dependent on what size of reel the printing press can manage
- Run waste: waste generated in the manufacturing process, such as off cuts of paper created during the trimming process
- Seeded paper: Paper that has plant seeds in its structure, so it can be planted, and the seeds will grow.
- Set-off: Ink transferring from one page to an adjacent page
- Signatures: A Signature is a configuration printers use to layout book pages on a press sheet so that after folding they are in the correct order.
- Technical data sheet (TDS): Lists specifications of a material such as thickness and grammage
- Thermal lamination: Uses heat and pressure to bond a laminate film to a substrate with adhesives
- Total chlorine free (TCF): Totally chlorine free bleaching technique uses oxygen delignification in combination with hydrogen peroxide or ozone as the main bleaching agents.
- Trim size: The actual size of the printed pages in a book.
- Typesetting: Typesetting is the process by which the pages of a book are laid out for printing.
- Verso: Left hand page of a book.
- Wet lamination: Films treated on both sides with solvent-based, UV or special hot-melt adhesives
- Wibalin: A type of material that is used to cover hardback books and can look like cloth or leather.
- X-height: the distance between the baseline and the mean line of lowercase letters in a typeface

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