



Sustainability Case Study

Plastic Books

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Summary

The authors of this book chose to publish the first edition on plastic, not paper, to make a point about sustainable design in a dramatic way. It certainly captures attention. But does a cold analysis support the idea that replacing paper by plastic for books is a sustainable development?

This resource is divided into two sections: a handout to be used with students in the classroom and an example assessment. There is also an associated lecture presentation.

Referenced websites were accessed at the time of the first publication date.

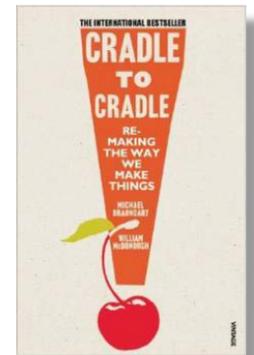
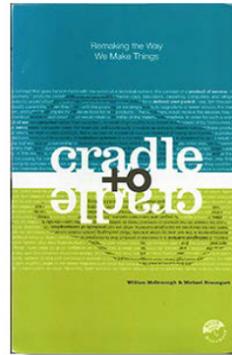
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Plastic Books-- Handout

The proposal

The influential book “Cradle to Cradle” by William McDonough and Michael Braungart makes the case that “waste” is a design failure; well-designed products should be reusable or usable in another way at end of first life. To make their point, the first edition of their book was printed on plastic rather than paper. The authors say: “This book is not a tree. It does not use any wood pulp or cotton but is made from plastic resins and inorganic fillers. It is...a product that can circulate infinitely in industrial cycles. The use of an alternative material expresses our intention to evolve away from the use of wood fibers for paper”.



“Cradle to Cradle” (a) plastic edition (left); (b) paper edition (right)

Is this a good idea? Analyze the proposal that printing books on plastic is more sustainable than printing them on paper.

Initial facts

- *Cradle to Cradle* is printed in China and is sold primarily in Europe and the US.
- The plastic edition weighs 562 grams and costs \$27.
- The paper edition weighs 157 grams and costs \$19.
- The paper is ordinary wood-fiber paper.
- The “plastic” of the plastic edition is proprietary.

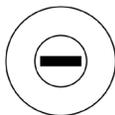
This resource follows the five-step method, which is simply explained below and explained in detail elsewhere.

- What is the prime objective? What is its scale and timing? What is the functional unit?
- Who are the stakeholders and what are their concerns?
- What facts will be needed to enable a rational discussion of the proposal?
- What, in your judgment, is the impact of these facts on Natural, Manufactured, and Social Capitals?
- Is the proposal a sustainable development? Could the objective be better met in other ways?

Where can Granta EduPack help with Fact Finding?



The **Materials data-table** has records for paper, unfilled and filled polymers. They include data for price, embodied energy, carbon and water footprints and recycle fraction. The “Science notes” give background about recycling of plastics and paper.



The **Regulations data-table (Level 3 Sustainability)** identifies government incentives and restrictions that relate to packaging, waste and the use of chemicals.



The **Eco Audit Tool** allows a fast comparison of the carbon footprint and embodied energy of the plastic and paper editions of the book.

Plastic Books-- Example of Assessment

The number of the sections corresponds to that of the 5 steps of the analysis. Granta EduPack databases help with fact-finding in ways described in the handout for this case study.

Step 1: the objective, size, time scale, and functional unit

- **Objective:** reduce environmental impact of book publishing by printing all books on plastic instead of paper
- **Size scale:** A lot of books are published each year. If all of them are printed on plastic instead of paper there will be implications of supply for both. We will need to research this in the Fact-finding step
- **Time scale:** unclear, but if the will existed, a reasonable time frame for publishers to set up alternative printing facilities might be 10 years
- **Functional unit:** 1000 years



Comment: This initial vagueness is not unusual. Make a best-guess and move on, noting issues for research in the fact-finding step.

Step 2: stakeholders and their concerns

Anyone involved in the chain from writing the book to production of the plastic, to the printing, marketing, distribution, sales and book consumption is a stakeholder.



Table 1: Stakeholders

Stakeholders	Concerns
Authors	Reaching a wide readership; making (in this case) an ethical point
Publishers	Impact on costs, sales, and margins
Printers	Disruption of production
Distributors, retailers	Weight, shipping cost, book price, impact on sales
Book readers	Good eco-feeling; but weight, feel, and price may be unattractive to some
Paper providers/recyclers	Probably insignificant*
Plastic providers/recyclers	Probably insignificant*
Libraries	Weight, durability, storage-space
Forest industries	Loss of a market for wood pulp but probably insignificant
Environmentalists	Are the authors' claims justified? Is plastic better and recycled more than paper?

Comment: Stakeholder concerns highlight facts that need research in the Fact-finding stage. What is the relative eco-impact of paper and plastic? Does plastic really recycle forever? What are the cost implications of the proposed change? Will readers accept plastic books?

Step 3: fact finding

Materials. About 2.2 million new book titles are published, world-wide, each year¹. If the average weight of a plastic book is 500 grams and the average print-run is 3000 we are talking of 7 billion (7x10⁹) books, requiring 3 million tonnes of plastic per year. Paper books weigh about 3 times less than plastic so the reduction in paper consumption is about 1 million tonnes.



The “plastic” of the plastic edition is proprietary. A little detective work² suggests that it is probably a calcium carbonate filled polypropylene. The global production of paper (2012) was 400 million tonnes³ in 2012; that for plastic was 280 million tonnes of which 45 million tonnes is polypropylene. Thus the increased demand for polypropylene created by a total switch to plastic books would consume about 6.7% of current global production. The reduction in paper consumption is about 0.07%.

The conclusion: there is no cause for concern that a global switch from paper to plastic for books would face problems of supply.

Energy, Carbon footprint and Environment. Table 2 shows that the embodied energy and carbon footprint of paper and 40% CaCO₃ filled polypropylene are almost the same as that of paper, both in the virgin and recycled condition. But the plastic book weighs three times more than the paper one, so the energy and carbon per plastic book is much higher.

Table 2. Embodied energy and carbon footprint for virgin and recycled materials (data from CES EduPack 2016)

	Embodied energy, virgin (MJ/kg)	Carbon footprint, virgin (kg/kg)	Embodied energy, recycled (MJ/kg)	Carbon footprint, recycled (kg/kg)
40% CaCO ₃ filled polyolefin	55	2.4	17	0.86
Paper	52	1.2	22	1.1

An eco-audit for 1000 books is shown in Figure 2. The green bars show data for the paper edition, the yellow bars are for the plastic edition. Both the material use and the transport stage have higher carbon footprint and cost for the plastic edition.

The eco-audit assumes air freight from China to Europe by air freight; if the transport is by sea freight all three fall by more than a factor of about 10 as shown.

1 <http://www.worldometers.info/books/> For comparison, 56 million newspapers are sold world-wide each day. Newspapers have a useful life of 24 hours; books last for weeks, months or years.

2 Based on estimate of density, resistance to water, color and feel of the book itself, and the information contained in <http://www.wired.com/2013/02/stone-paper-notebook/> and <http://www.treehugger.com/green-architecture/yupo-synthetic-paper.html>

3 <http://www.paperonweb.com/A1006.htm>

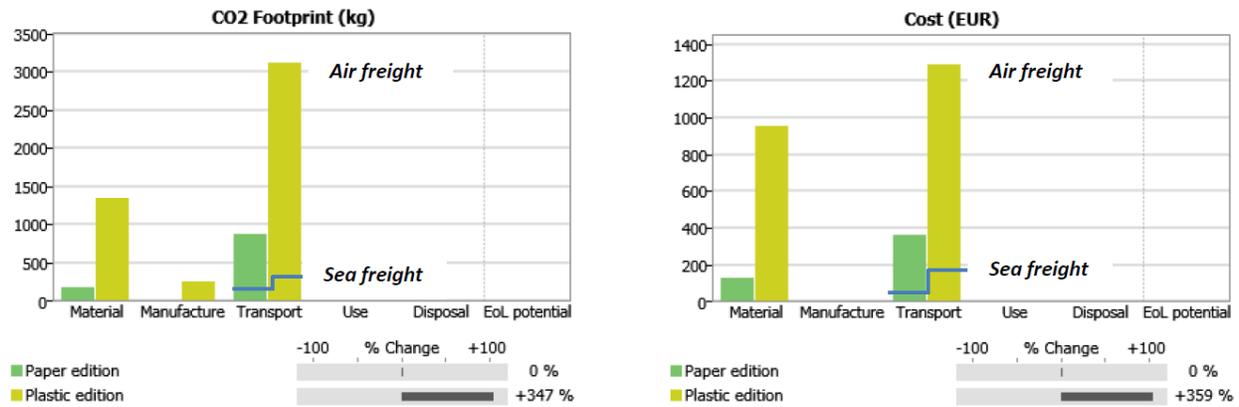


Figure 2: A comparison of the carbon footprint and cost of paper and plastic books for 1000 units. (charts from CES EduPack 2016)

Reuse and recycling. The premise of the authors is that plastic can be recycled an “infinite” number of times. Data for recycling rates don’t support this. About 65% of paper is recycled; recycled paper forms 33% of the ⁴pulp for paper production (US Environmental Protection Agency). By contrast only about 9% of plastic is recycled in the US (US Environmental Protection Agency⁵); globally it is less. Further, the processing and properties of polymers are sensitive to contamination; unless the plastic books are separated from all other plastic waste, the recycled materials will be unusable.

Regulation. There is much legislation that relates to waste. Landfill taxes (standard rate in UK now £80 per tonne) discourage sending paper or plastic to landfill. The European Commission Waste Management Directive sets binding targets for waste management. The US Resource Conservation and Recovery Act does much the same thing.

Economics. The retail price of a book is, very roughly, 10 times the production cost because of overheads, advertising, cost of holding stock, delivery charges and margin. The cost estimator built into the Eco-audit tool can give information about the difference in production cost of the plastic and the paper edition (Figure 2). The plastic edition is predicted to cost 3.6 times more per book more than the paper edition.

Society. Will authors, publishers and the reading public accept plastic books? Plastic books feel different; you can’t fold the corner of the page down; they are heavy; and they cost more than paper books. Paper books have survived for hundreds of years – some for thousands; what guarantee is there that plastic books will be as durable? For all these reasons you might expect stakeholders to oppose the change. But the only way to find out is to ask them.

Comment: Fact-finding in this case study has proved simple; the information we need is easily retrieved from the Sustainability database or from a web search. What is missing here (but should, if possible, be included in a longer project) is direct contact with stakeholders both before and after fact-finding to explore their reactions and inputs.

4 <http://www.epa.gov/osw/consERVE/materials/paper/faqs.htm>

5 <http://www.epa.gov/osw/consERVE/materials/plastics.htm>

Step 4: forming a judgment



What, then, is the likely impact of wide use of electric cars on the three Capitals? These are questions for debate, informed by the data generated by the Fact-finding step. Here is one view for discussion, summarized in Figure 3.

Natural Capital. Is the objective (a more environmentally-designed product) achieved? The plastic book has higher embodied energy and carbon footprint of both material and of transport than the paper book. The plastic draws on a non-renewable resource (oil or gas) for its initial creation. No evidence is provided that the plastic can be recycled without loss of quality – a conclusion supported by the low recycling rates.

Pulp for paper for books and newsprint is generally derived from sustainable forests. Paper can be (and is) recycled to a book-quality product at least once before the fiber-length becomes too short.

The evidence suggests that natural capital is better conserved by using paper, not plastic, for books.

Manufactured Capital. It might be argued that the production of plastic books is a new technology and that, given time, the process will become cheaper. But the higher price of the plastic book is at least partly caused by its weight – transport costs will always be higher than for the paper book.

The evidence suggests that – on a purely economic basis – manufactured capital is better conserved by printing on paper, not plastic.

Human Capital. Does the change of material bring benefits or satisfaction to readers? Book producers and sellers are unlikely to welcome a development that increases the cost of their product unless it increases both market share and margin of profit. Market share and acceptance of higher price depends on the value the reader attaches to having a plastic (and waterproof) book rather than a paper one. The plastic book feels different; it (at present) has a certain novelty and it carries an aura of innovation. But the much greater weight, the stiffer paper and higher price may, in the long term, prove a dis-incentive, perhaps excepting those who like to read in the bath.

The evidence here is inconclusive – market research is needed to establish reader’s preferences. But there is no compelling reason to think that human capital gains from a switch from paper to plastic.

Step 5: reflection

To be fair to McDonough and Braungart, printing their book on plastic was (almost certainly) to make a point: that everyday objects can be redesigned to allow the materials they contain to be reused. And, to a degree, it works: the plastic book makes the reader think. But to express their “intention to evolve away from the use of wood fibers for paper” is a statement without a reasoned basis to justify the environmental benefits.



The final conclusion: plastic books have novelty value, but their contribution to natural, manufactured and human capital is negative or neutral. Better stick with paper.

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Document Information

This case study is part of a set of teaching resources to help introduce students to materials, processes and rational selections.

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