Sustainability of the CEWE PHOTOBOOK

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Abstract

Sustainability has become a key indicator in the reception of consumers, not only for companies but also for products. The CEWE PHOTOBOOK is the number one brand product of photo books in Europe with a market share of about 25 %. This paper shall focus on aspects of sustainability of the CEWE PHOTOBOOK with a wide ecological view, including both, aspects of production technologies as well as the product.

The product's total carbon footprint is calculated and discussed, starting with the order process via production by electrophotography, including both liquid and dry toner technologies, and finishing followed by the delivery processes. Further aspects are the product's longevity as well as its fate as waste, discussing both, recycling by de-inking or waste incineration.

For the production process occupational health and safety is of utmost importance. Ozone generation, exhaust of VOC, cleaning methods, and work protection at UV coating or PUR glue binding of the book blocks are to be considered. The total environmental impact of the production process encompasses energy consumption, waste water protection, and full responsibility of production waste streams. Taking care of de-inking problems in recycling paper mills down the waste supply chain is just one example.

1. Introduction

1.1 Sustainability

The three-dimensional framework of sustainability, economical, social, and environmental, deals with the responsibility towards all stakeholders within a company and within society. Whereas economical responsibility is the key driving factor of any business and always has been, it is not enough in today's reception of stakeholders such as customers, shareholders, employees and other members of the society. Taking responsibility for people (social responsibility) and the environment in the course of the economical action has become a necessity.

Sustainability in industry is usually reported at corporate level. The three dimensions of responsibility (economical, social, environmental) are often complemented by statements regarding the management and compliance procedures (corporate government) and contributions to local society (corporate citizenship), e.g. the sustainability reports of CEWE COLOR AG & Co. OHG [1, 2] among many others. However, it is difficult to draw conclusions on single products. Social and environmental aspects are reported for the overall production not focused on a specific product.

Product related reports on the other hand often lack the business perspective. Life cycle assessments are usually reporting aspects of products, e.g. reporting only on greenhouse gas emissions.

This paper shall focus on product responsibility in its wider sense. Dimensions of sustainability shall be applied to the product and its manufacturing process within a company that conducts digital printing as its core production process. In this paper we intend to give a comprehensive view on product sustainability and show solutions CEWE COLOR has implemented. As we consider this a continuous improvement process, the paper shall also trigger the discussion.

1.2 CEWE PHOTOBOOK

The product of choice for this paper is the CEWE PHOTOBOOK. CEWE COLOR AG & Co. OHG was founded in 1961 and has a 50 year history in the photofinishing business. Today, CEWE COLOR is Europe's number one photofinishing company. Detailed information on the company can be found on the website [3]. As recently as 10 years ago, business was the photographic development of still films and printing of photos. Along with the replacement of still cameras for films with digital still cameras, CEWE COLOR invested very early in a variety of solutions for printing digital image capture. A severe transformation process began, which was threefold in its consequences. It started with digital instead of analogue photographic printing (digital exposure of light-sensitive silver halide paper) and continued with the investment in digital printing using electrophotographic print engines and to a lesser extent ink jet print engines. Software, which is the number one unique selling proposition, was developed in-house, adding software development to CEWE COLOR's core competencies. The last and decisive transformation step was to create a brand product and to market it to success.

The CEWE PHOTOBOOK has become the number one photo book in Europe. Starting in 2005 with less than 0.1 Mio copies sold, CEWE COLOR could sell over 4.3 Mio CEWE PHOTOBOOKs in 2010 – with numbers still increasing. The CEWE PHOTOBOOK is composed with award winning software at the customer's home computer. It is ordered mainly online, although delivery is foremost via retail outlets. The reason for this is the dense infrastructure of the photographic market in central Europe and a higher price for mail order delivery.

The average CEWE PHOTOBOOK is an A 4 (letter size) hardcover, weighs about 500 g, consists of 50 pages, and holds 120 photographs. Cover and content are printed with four color (CMYK) electrophotographic print engines of high quality and high speed, e. g. hp Indigo 5000 and 7000 series, Kodak Nexpress 3000 and 3600 series, and Xerox IGen4. These are sheet fed machines with greater A 3 feed and the finishing process starts with format cutting, then glue-binding of the book blocks, three-sided cutting and combining cover and block in the book assembly machine. The cover is a print laminated with an OPP foil and subsequently cut and glued onto the three cardboards. After quality control the CEWE PHOTOBOOK is shrink-packed and put in a corrugated cardboard box for delivery.

2. Product Sustainability Model

The hypothesis of the underlying product sustainability model states that responsibility has to be accepted in all dimensions (social, economical, environmental) at the owned manufacturing process and additionally up and down the supply chain, not only for materials used but also for processing machines and technologies installed. The CEWE PHOTOBOOK as brand product of CEWE COLOR shall be taken as an example for a digital printing product. It will become evident, that taking full responsibility is a very difficult task, and that the only way to fulfill this requirement is opening up of all members of the supply chain and an open minded communication between these members.

Sustainability aspects are manifold and each aspect has implications for all sustainability dimensions. As an example let us consider the glue-binding of the book-block. Product quality (economical dimension) considerations leave the PUR type glue as the only acceptable possibility to glue the coated quality printing paper. Product safety (economical) has to be secured by assuring that the glue has fully reacted. Using a glue-binding machine with roller application would pose a risk to employees (social dimension). Occupational health and safety issues (social) have to be considered, and therefore CEWE COLOR preferred to install nozzle application machines for reactive glue. Though several measurements at work-place conditions showed concentrations of the carcinogenic MDI component below detection limit in the ambient air, additional extraction systems were installed for double safety. The batch change of the reactive glue must be done with full personal protective equipment. Correct waste disposal of reacted and un-reacted glue and its containers, emission measurements and reduction strategies, and product's end of life assessment are expressions of the environmental dimension. Upcoming low-emission glues are continuously tested for applicability for the CEWE PHOTOBOOK. CEWE COLOR has forged cooperation with machine suppliers and several glue-manufacturers in order to develop the best available technology under sustainability considerations.

3. Sustainability of the CEWE PHOTOBOOK

3.1 Aspects of Product Sustainability

Table 1 shows different aspects of product sustainability in form of a mind map like they are considered for the CEWE PHOTOBOOK at CEWE COLOR. While in chapter 3.1 we will elaborate on the comprehensive view and can only touch upon different aspects, the further subchapters will render some important aspects more precisely.

Total cost of ownership and **product quality** are usually the first issues covered when decisions on production technology have to be taken. Aforementioned electrophotographic digital printing systems offer the best compromise for photographic application. Product quality has to be assured in the production process. CEWE COLOR has developed its own system of process control to take account of the high quality demand of photographic applications. **Customer satisfaction** is determined by product quality but not vice versa. We found that especially the quality of the software with its ease of use is of crucial importance. Customer satisfaction shows in the reclamation rate, and both, rejects from quality control as well as reclamations have direct cost (economical) and waste (environmental) implications.

Table 1. Mind map of product sustainability aspects.

Total cost of ownership	Compli-ance with legislation	Energy consumption	Water consumption
Product quality	Product safety	Carbon footprint	Waste water charac-teristics
Customer satisfaction	Packaging	VOC emissions	Waste at production sites
Materials	Occupatio-nal health and safety	Ozone immissions	Waste at product's end of life
Supply chain logistics	Work-place conditions	Other Immissions (e.g. noise, particulate matter)	Distribution logistics

Compliance with legislation goes without saying. When legislation of business and administration is concerned, usually sufficient know how is with the companies' executives and externally with attorneys or consultants. In Europe, the most complex legislation concerns the environmental area. In order to take responsibility in this area you need to organize intelligence, by co-working within industry associations, with authorities, and with experts along the supply chain. Legislation plays into each of the identified sustainability aspects, like product safety, occupational health and safety, packaging, waste, water, and immissions. Responsibility means not only to comply but to also read across and anticipate conditions or prohibitions for products and the production processes.

Product safety is a good example for legal compliance and responsibility. For the CEWE PHOTOBOOK the main relevant legislation is the new chemical legislation in Europe, REACH [4]. While Annex XVII lays down the restriction of chemicals, special attention must be given to Article 7 on substances in articles and the notification and communication obligation of Articles 32 and 33. The SVHC list [5] is continuously extended and every company should develop a management system to control and comply with the resulting obligations. Severe violations in consumer products have been observed by NGOs [6, 7] and European governments are discussing measures. Additionally, special legislations for food-contact materials and for toys are effective and can easily become relevant. For instance, when CEWE COLOR designs a children's photobook, the toy legislation immediately applies. Besides the CEWE PHOTOBOOK, a lot of other digital print products are produced by the same means, and some of them must be safe for food contact. Thus, CEWE COLOR has requested and was given certificates from the suppliers of digital printing (hp, Kodak, Xerox) that show compliance with food contact regulations. Heavy metals, PAH (poly aromatic hydrocarbons), softeners, flame retardants, and forbidden colorants among many other substance groups have to be accounted for. A

recent example is the omission of tin organic compounds used as catalysts in the polymerization of polyesters.

CEWE COLOR conducts a full **materials** balance [1, 2]. Paper is by far the highest volume and sustainability aspects to paper are widely known throughout industry and consumers. CEWE COLOR is continuously checking the possibility of using recycled paper for its brand product. Until now, due to the specks and the slightly reduced whiteness, quality requirements do not allow the use of recycled paper. To maximize sustainability although fresh fibers are needed, the paper for the CEWE PHOTOBOOK comes from sustainable forestry. CEWE COLOR has achieved the FSC® certification for all of its production and sales subsidiaries in 2010 and 2011 and uses FSC paper in the production of all digital print products. FSC is the best established and the most ambitious forest and supply chain certification scheme in Europe.

The cardboard **packaging** of the CEWE PHOTOBOOK is composed 100 % from recycled fibers. As packaging ends up as waste immediately when the product arrives at the consumer, national take-back regulations apply, in line with the European packaging directive [8]. For a typical CEWE PHOTOBOOK packaging is about 20 % of the total weight, with 100 g of cardboard packaging and 3 g of plastic from the shrink foil. Currently two programs are in operation, one to reduce total weight of packaging, the other to replace the plastic foil with a bio-degradable foil or a foil from renewable sources.

All logistical considerations (supply chain and product delivery) are dealt within the carbon footprint calculation (3.4 and 3.5), as well as energy consumption. Waste considerations are summarized in chapter 3.6.

Water consumption and waste water characteristics do not play a big part in digital printing. Rather, photographic processing is a water intensive production method. Over 5 % of the CEWE PHOTOBOOKs are made of photographic paper. The examination of this process is out of focus for this paper although it is the second core technology of CEWE COLOR, see [1-3]. Water is extremely well regulated in the European environmental legislation. Every manufacturer has to show that water or soil pollution can be fully excluded at production.

3.2 Occupational Health and Safety (OHS)

Work-place conditions summarize the efforts of a company to improve the working conditions of its employees. Professional trainings, ergonometric evaluations, health and sports offers, and pension schemes are part of the social strategy of CEWE COLOR [2]. While most of these are optional, **OHS** is compulsory. OHS deals mainly with physical and chemical hazards and the measures for working safely.

To advance working conditions, air conditioning and sufficient ventilation improve ambient air at the presses and in the whole print and finishing room. Work place measurements of VOC and ozone were conducted at the presses, MDI (methylene diphenylene diisocyanate) was determined at the glue-binding machines, and acrylates were measured at the UV coating equipment. At glue-binding machines and UV-coating equipment, additional exhausts have been installed for chemical vapor removal.

Still, hazardous substances are used in digital printing. The wide use of isopropanol is seen critically, and CEWE COLOR is currently conducting tests in cooperation with the machine suppliers to omit this substance.

3.3 VOC Emissions, Ozone Immissions, and other Immissions (e.g. Noise, Particulate Matter)

VOC emission in digital printing comes primarily from liquid toner technology, whereas **ozone immission** is an intrinsic problem of all electrophotographic machinery. The presses used at CEWE COLOR are equipped with activated carbon filters which very effectively reduce ozone emissions. The maximum concentration measured was 10 ppb, which is tenfold below limitation [9]. According to German (and European) law, VOCs (volatile organic compounds) have to be balanced under certain conditions and reduction measures have to be undertaken [10]. The balance at CEWE COLOR has shown that 3 % of the liquid toner oil evaporates. According to legislation [10], additional measures are to be installed when the VOC emission is above 20 %. The liquid toner oil mainly consists of C_{11}- to C_{13}- aliphatic hydrocarbons as VOCs. Aromatic hydrocarbons which are much more dangerous were not found. The ambient air concentrations of the VOCs are at 22 ppm which is 20fold below limitation [11]. Per CEWE PHOTOBOOK the VOC emission is 0.7 to 0.8 g when printed with liquid toner technology.

The VOC balancing was done by two different approaches. Firstly, the consumption of oil from all oil containing articles was balanced for the time period (26.9 t, year 2009) in the main photobook production at CEWE COLOR's biggest production site in Oldenburg and subtracted with the disposed amount (26.0 t). The balance showed 900 kg. The number of CEWE PHOTOBOOKs produced in this hall in this time period was 1.3 Mio, which gives 0.7 g per photobook. The second approach was the determination of the C_{11}- to C_{13}- aliphatic hydrocarbon concentration at two different times, one showed 26 mg/m^3, the other 27 mg/m^3. Multiplied with the air flow, the emission was at 312 g/h and 324 g/h, respectively. The production rate was approximately 400 photobooks per hour, resulting in 0.8 g VOC per photobook.

Other immissions (e.g. noise, particulate matter) can arise from digital presses. However, particulate matter and noise are well controlled with all presses used at CEWE COLOR. The main sources of noise are three-side cutters and milling units of the glue-binding machines, both in the finishing section. The units are efficiently housed in so that noise level is well controlled.

3.4 Carbon Footprint

The carbon footprint calculation for the CEWE PHOTOBOOK shown below (Table 1) is in accordance with the calculation methods of the Greenhouse Gas Protocol [12]. The Carbon Dioxide emission (CO_2e) balance of CEWE COLOR for 2009 [1] and 2010 [2] is found in the sustainability reports.

The **scope 1 emissions**, resulting from heating with natural gas and company owned cars, are broken down to the photobook level via the share of production volume. In 2010 the scope 1 emission per CEWE PHOTOBOOK was 186 g, derived from the emission per photograph as calculated from [2].

For **scope 2 emissions** (purchased electrical power) two calculation approaches are shown. The top down approach takes the company-wide numbers and attributes CO_2e to photobook level

via share of production volume. The bottom up approach calculates scope 2 via energy consumption and the CEWE COLOR averaged emission factor of 401 g CO_2e / kWh for 2010.

From the top down approach the scope 2 emission in 2010 was 414 g per CEWE PHOTOBOOK, calculated from 3.45 g per photograph [2]. This includes all electrical power consumed; a break down to process steps is not applicable. However, from energy flux analysis we know, that 50 % of electrical power usage is due to cooling units of air-conditioning and ventilation (15 %), illumination (15 %), compressed air production (5 %), and installed IT in server rooms (15 %). Pure production steps then account for 207 g scope 2 CO_2e per photobook.

Energy consumption and scope 2 emissions from the bottom up approach are shown in table 2, together with materials weight when applicable.

Table 2. Scope 2 emissions from the bottom up approach.

Production step	Weight [g/ photo-book]	Energy [kWh/ photobook]	CO_2e [g/ photobook]
Printing [1)]	284	0.25 to 0.3	100 to 120
Cover printing [2)]	167	0.03	12
Cover finishing		0.03	12
Block finishing [3)]	46	0.085	34
Book finishing		0.045	18
Packing [4)]	103	0.03	12
Total [5)]	600	0.47 to 0.52	188 to 208

1) Book-pages on 200g/m^2-high quality paper.
2) Cover printed on thinner paper, then laminated, then glued on 1.300g/m^2 card-board.
3) Comprising guillotine cutting, glue-binding with the addition of book end paper, three-side cutting and stacking.
4) Comprising shrink-packing (3 g) and final packing in corrugated cardboard (100 g).
5) Total weight includes colorants and glue (10 g in all).

The main consumer of energy at CEWE PHOTOBOOK production with 60 % to 63 % is printing. There is no significant difference between liquid and dry toner. The numbers of the bottom up and the top down approach match quite well.

The main **scope 3 emission** sources in 2010 were supply chain logistics (375 g per photobook) and delivery logistics (780 g per photobook). Other scope 3 sources like employee commuting or waste disposal logistics accounted for less than 5 % of scope 3 emissions [2].

3.5 Discussion of Carbon Footprint

Table 3 shows the carbon footprint left by a digital printing company like CEWE COLOR together with those of paper manufacturing [13] and transportation.

CEWE COLOR's direct emissions (scope 1 and scope 2) account for 23 % of the total carbon footprint, 5 % for digital printing alone. While paper manufacturing contributes 32 %, the emissions due to transportation are biggest (45 %). The supply of materials is in accordance with the ton-mileage calculation approach of the GHG Protocol [12], but emissions from transportation to the customer are higher than would be expected from [12]. The reason is that CEWE COLOR subcontracts the pick-up and delivery of photo orders from and to the customer with car fleets. This is faster and more convenient, but more inefficient than truck transport in terms of carbon dioxide emissions. Accordingly, it is CEWE COLOR's ambition to reduce the transport emissions [1, 2]. The mail orders in Germany are delivered by the carbon neutral program GOGREEN of the Deutsche Post / DHL.

Table 3. Carbon Footprint of CEWE PHOTOBOOK from supplier to customer.

Production Step	CO_2e [g/ photobook]	Per-cen-tage
Paper manufacturing [1)]	830	32 %
Supply of materials, transport (scope 3)	375	15 %
scope 1 (heating, company cars)	186	7 %
scope 2: digital printing	132	5 %
scope 2: other production steps	76	3 %
scope 2: indirect (IT, air-con, illumination, …)	206	8 %
Transportation to customer, product delivery (scope 3)	780	30 %
Total	2585	

1) Production waste at CEWE COLOR due to cut-off has been accounted for. Carbon footprints of papers (1.518 kg CO_2e/kg – 671 g per photobook) are courtesy of the suppliers, cardboard (0.75 kg CO_2e/kg – 109 g per photobook), and packaging (0.50 kg CO_2e/kg – 50 g per photobook) are estimates [13].

The total amount of CO_2e is 5.2 kg/kg photobook, cradle to customer. This can be compared to the 2.0 kg CO_2e /kg photobook found in a complex Finnish study [14], which also examined a photobook of 500 g. Percentages match roughly: 44 % of CO_2 emissions were due to paper manufacturing, 21 % to the printing phase, and 20 % to customer delivery. The deviation cannot be fully clarified here; the main differences are the much lower emission factor for electrical power and the much lower transport assumptions made in [14]. Nevertheless, the numbers in this paper have been made transparent, and they are based on the accounting principles of the Greenhouse Gas Protocol Initiative [12].

We did not consider the CEWE PHOTOBOOK's fate as waste, the grave phase, in the above comparison. In Germany and other environmentally progressive European countries, landfill is not an option. Paper, cardboard, and packaging wastes are primarily recycled. In case of incineration of the CEWE PHOTOBOOK, emissions as calculated from the carbon content lead to 514 g CO_2e, the packaging to another 127 g CO_2e.

3.6 Waste considerations

Waste at production: CEWE COLOR's materials balance shows that 74 % of the materials are product and 26 % waste [1, 2]. The waste/product ratio of 0.35 would imply 210 g of waste per photobook. At CEWE PHOTOBOOK production, the highest amount of waste is paper cut-off. For the circa DIN A 4 size cut from greater A 3 (320 mm x 460 mm) sheets, the book-block-paper

cut-off alone adds up to 98 g. Process control material, cleaning material for imaging drums and transfer devices, and adjustment routine material add to the waste. There is additional waste volume from rejects of quality control and adjustment procedures of the finishing machines. 210 g waste per photobook requires improvement.

Product's end-of-life: In contrast to other print products a CEWE PHOTOBOOK is designed to be a long-lasting collection of memories. However, all products are perishable, and product design should always include the waste phase. Paper products are usually recycled in central Europe. Thus, photobooks and other print products should be recyclable.

De-Inking: There is an ongoing discussion about de-inkability in the digital printing industry. Especially liquid toner and water based ink jet technologies do not seem to de-ink well [15 – 17] at standard de-inking plants in Europe. A lot of research effort was initiated recently to overcome the observed difficulties of de-inking liquid toner print waste [18, 19] and ink jet waste [20]. Double-sided UV-coating or double-sided lamination as used for gloss-finishing are not de-inkable at all [15, 16]. The de-inking of liquid toner print was studied in model experiments by INGEDE [15, 16] and it was found that they did not de-ink well. Additionally, a batch of offset paper waste with a fraction of 3 % of liquid toner print waste was de-inked in a big de-inking plant in Germany and the resulting product showed specks that were undesirable [17]. In order to avoid cases like that, production waste from CEWE COLOR's liquid toner printing is indicated and possible difficulties are communicated down the supply chain, via the waste disposal company to the de-inking company. In consequence de-inked pulp from liquid toner printing may not be suitable for high-end recycled graphic paper but rather for packaging material. The main responsibility for the waste producer lies in the full and open communication of the possible difficulties.

4. Conclusion

An approach to sustainability of the CEWE PHOTOBOOK was attempted in this paper. All dimensions of sustainability, economical, social, and environmental, were applied at product level. Products have to yield a profit of course but they just as well have to be socially and environmentally acceptable. Sustainability should be taken into account in product design at research level and along the whole supply chain.

In order to strengthen and continuously improve sustainability of a product open communication is necessary. This includes addressing disadvantages and problems of technologies and materials used.

CEWE COLOR continuously tries to improve its digital print products and to assume responsibility. With sustainability reports CEWE COLOR wants to contribute to the discussion by openly communicating about sustainability and by actively considering the interests of all stakeholders.

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