

Design for Volume Reduction

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ABSTRACT

Traditionally packaging design-for-sustainability (DfS) strongly focuses on resource conservation and material recycling. The type and amount of materials used has been the driver in design. For consumer electronics (CE) products this weight-based approach is too limited; a volume-based approach is needed. As this paper will show, from an environmental perspective (as well as from an economical perspective) transportation of goods from factories to the final retail outlets is about twice as important as the materials used in the packaging. Due to the low density of packed CE goods volume is the limiting factor in determining the number of products per shipment, as will be demonstrated using data from approximately 100 products. Hence design for volume reduction is an approach of major importance in packaging design for sustainability.

INTRODUCTION

Ever since the growing attention for the environmental impact of products, packaging has been one of the areas receiving a lot of attention, both from scientists, companies and environmental lobby groups. Packaging is often discarded quickly after purchasing a product, especially packaging of durable goods, such as consumer electronics (CE) products. This quick discarding makes the environmental impact of packaging very tangible to the consumer, thus giving packaging a negative environmental image. This feeling with the general public is reflected by the attention of researchers and legislators. The attention of academia is demonstrated by the fact that in the 1970s and 1980s when Life Cycle Assessment (LCA) methodology was developed, approximately 40% of the studies published were concerned with packaging materials (Knoepfel, 1994). Attention from legislators started showing in the late 1980s. In 1991 several European countries introduced environmental packaging legislation, of which the German one, resulting in the Green Dot system, is the best known.

The above demonstrates packaging has been receiving a lot of environmental attention. However, a closer look will show that the current focus is entirely on the production and end-of-life phase of the packaging. This focus is caused strongly by the EU packaging legislation, which resulted from the many legislative initiatives by member states in the early 1990s. With the introduction of the 'Directive on Packaging and Packaging Waste' the European Union set targets for recycling (European Union, 1994). The first article of

the directive clearly reflects the focus on the production and end-of-life phase of the packaging: *'... this Directive lays down measures aimed, as a first priority, at preventing the production of packaging waste and, as additional fundamental principles, at reusing packaging, at recycling and other forms of recovering packaging waste and, hence, at reducing the final disposal of such waste.'*

Although, at a later point, the directive does state that the entire life cycle should be considered, in all its other guidelines it focuses on material reduction and packaging recovery. Yet, for packaging of CE products, where cushioning is involved, the use phase of the packaging is a significant part of the environmental impact of the packaging. This use phase is the transportation of the packed product from its point of assembly, through the distribution chain, all the way to the consumer's home. The packaging volume is of significant influence here.

The importance of volume is based on two important facts. First, the environmental impact of transporting packed CE goods is roughly between 1 and 2 times the environmental impact of the production and end-of-life phase of the packaging. Second, the impact of the transportation is strongly influenced by the number of products that fit into one shipment. As will be demonstrated later on, this factor is determined solely by the volume of packages, not by their weight. Thus far this factor has been ignored in environmental assessments of packaging. As Table 1 shows, suppliers of cushioning materials do not mention volume efficiency as an environmentally important factor. Their environmental claims are mainly production and recycling related. Judging from Corporate Social Responsibility Reports from major CE manufacturers, these companies often do recognize volume as a relevant factor, but never as a major one.

Elaborating the first point, that transportation is important, LCA case studies done within Delft University of Technology and Royal Philips Electronics (Thijsse, 2001; Wever, 2003; van Es, 2005) have shown for several types of products that the ratio between the environmental impact of the Bill-of-Materials (BOM) and the environmental impact of transportation is approximately between 1:1 and 1:2 depending on the type of packaging materials used, the mode of transportation used, and the transportation distance. Thijsse (2001) compared the environmental impact of packaging and transportation (factory to shop) of four CE products (an audio system, portable audio, a 28" TV and a VCR). She found an average ratio of 1:2,8. An similar analysis for costs showed a average ratio of 1:1,2. Wever (2003) looked at a molded fiber cushioning for a VCR. For this cushion its material impact and its contribution to the transport volume were studied in a LCA. The resulting ratio between material and transportation found here was approximately 1:10.

Material	Production				use			end-of-life						
	Number of companies	Contains recycled content	Limited use of material	Eco-friendly production	Volume efficient in storage	Is a light weight solution	volume efficient in use	Packaging is reuseable	Material is recyclable	Material will be recycled	Material is CFK free	Material is biodegradable	Energy recovery	Volume efficient waste
Frequency	22	4	9	2	4	6	0	5	21	8	4	3	2	1
EPS foam	6	0	5	1	0	5	0	0	6	3	3	0	0	0
EPP foam	1	0	0	1	0	1	0	1	1	0	0	0	0	0
EPE foam	1	0	0	0	0	0	0	0	1	1	0	0	0	0
Polyether	1	0	0	0	0	0	0	0	1	1	0	0	0	0
Polyester	1	0	0	0	0	0	0	0	1	1	0	0	0	0
Neopolene	1	0	0	0	0	0	0	0	1	1	0	0	0	0
Foam in place	2	0	1	0	0	0	0	0	2	1	1	0	1	1
Paper based	4	3	0	0	2	0	0	1	4	0	0	2	0	0
Air cushions	1	0	1	0	0	0	0	1	1	0	0	0	1	0
Korrvu	3	1	2	0	2	0	0	2	3	0	0	0	0	0
Starch foam	1	0	0	0	0	0	0	0	0	0	0	1	0	0

Table 1 Environmental claims made by European protective packaging suppliers in their brochures, or on their web sites. The data was collected in October 2004. The table shows the strong focus on prevention of packaging waste and recycling.

This high ratio is caused by the fact that just the cushion was taken into account, not the cardboard box. Furthermore the design of the cushion was far less volume efficient than is possible with molded fiber nowadays.

Van Es (2005) studied several packages for electric shavers. These packages included clamshell tamperproof packages. In this analysis only the transportation from the factory in the Netherlands to the distribution centre in North America was included. Here a ratio material / transportation of 1:1 was found. The relatively low impact of transportation is caused here by the exclusion of the transport from the distribution center to the final retail outlets. This transportation would be by truck, which is both economically and environmentally more costly than sea transport.

Hence a strategy aiming at minimizing the transportation impact seems more justified than aiming to minimize packaging waste. To see how packaging design influences the impact of transportation, a closer examination of used modes of transportation is required. For CE companies the most relevant modes of transportation are container ships, trucks and airplanes. Standard 40 feet sea containers (ISO container 1AA as described in ISO 668 and ISO 1496) have a minimum internal volume of 65.70 cubic

meters with a maximum payload of approximately 28,000 kg. Both values show small fluctuations as only the outside dimensions and the total weight of container and cargo are stringently determined by the standard. Therefore the specific construction of the container can influence the internal dimensions and the weight. These values result in a breakeven density of 390 to 430 grams per dm^3 . If packaging has a higher density the weight limit determines the maximum container load. If the density is lower, volume is the limiting factor. The same calculation can be made for trucks. As trucks vary more in design, the breakeven density also varies more, namely from 190 to 350 grams per dm^3 . For air cargo the breakeven point is 167 gram per dm^3 . If the density is lower the carrier will calculate a fictitious volume-weight based on this density, and charge likewise. These breakeven densities can be compared to the densities of packed consumer electronics products. Figure 1 shows the densities of 97 CE products and the breakeven densities of several modes of transport. Most packages have densities lower than the breakeven densities of the modes of transportation. Hence the number of products in a shipment is limited by their volume, and not by their weight.

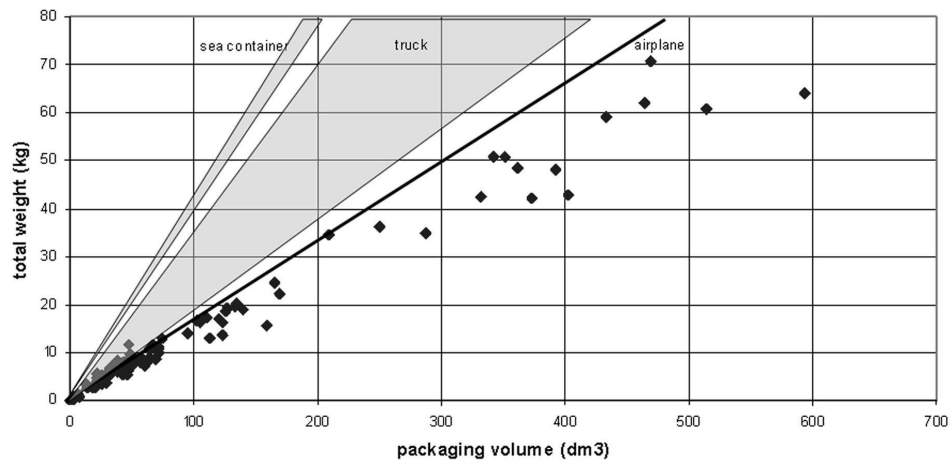


Fig. 1: Breakeven densities of the most important modes of transport and the product from the data set.

Based on this finding design for volume reduction is a sound DfS strategy for packaging of CE goods. However, pursuing *Design for Volume Reduction* requires insights into required functionalities of the packaging and knowledge on alternative fulfillments of these functionalities.

PACKAGING FUNCTIONALITIES

Packaging for Consumer Electronics (CE) products has to fulfill multiple functions. Traditionally these functions were all distribution related (e.g. protection, facilitating handling). To protect the packed product, cushions are added (=volume). For the design of these cushions several factors are important, such as the fragility of the product, the expected roughness of the distribution environment and the characteristics of the packaging material. Many handbooks describe how to go about this engineering task (e.g. McKinlay, 1998)

Nowadays however, due to commoditization of CE products (Spector, 2005, p. 65-66, 185), the sales functions of the packaging have become more important, and as a response to this commoditization, the added value packaging can provide through the unpacking experience has become important as well.

The importance of sales functions is a result of the changed retail situation of CE products. So-called 'Category Killers' have entered the market, and they are gaining market share. Category killers are budget shops with a wide selection of products within a limited segment, such as Best Buy, and Circuit City in the US, MediaMarkt and Saturn in Europe. Furthermore hypermarkets such as Wal-Mart in the US and Carrefour in France have also begun to sell CE products in their stores. The display of goods in these types of retail environment is different from the traditional mom-and-pop store that displays unpacked products in locked showcases. Category killers and hypermarkets sell packed products from the shelf, with only a limited amount of sales assistants available. Hence the product has to sell itself; or rather the packaging has to sell it (Wever, *et al.* 2006, Underhill, 1999 p. 32, Marzano, 2005, p.368, Imhoff, 2005, p. 33-34, 38-39). Furthermore, the directly accessible products, combined with the relatively low number of shop assistants, raises the chances of pilferage. Therefore packaging has to be big enough to make it difficult to smuggle a product out of the store. The package also has to be tamperproof, meaning it should not be possible to open the package without the use of tools, to prevent people from taking the product out of the package in the store.

When products become commoditized price becomes a dominant factor in product choice. Hence margins for the manufacturer decrease. To counter this development a brand needs to have added value. Pine and Gilmore (1999, p.16) propose that companies create experiences instead of mere products; "*Manufacturers must explicitly design their goods to enhance the user's experience as well - essentially experientializing the goods - even when customers pursue less adventurous activities. Automakers do this*

when they focus on enhancing the driving experience. (...) What changes could an appliance manufacturer make to its white goods that would enhance the washing experience, the drying experience, and the cooking experience? (...) If you as a manufacturer start thinking in these terms - inging your things - you'll soon be surrounding your goods with services that add value to the activity of using them and then perhaps surrounding those services with experiences that make using them more memorable. (...) Any good can be -ing-ed." Within the CE field brands like Apple and Bang & Olufsen work very strongly with this strategy. For packaging, experientializing means creating an unpacking experience for your product. The importance of the unpacking experience for CE products is expressed by Marzano in his book on 80 years of Philips design (2005, p.373): *"(...), the new Philips marketing strategy involved offering experiences rather than just products. It was important to communicate the emotional dimension of what was inside the box, and this obviously had to be achieved through the packaging."* One example of a packaging that was redesigned with the unpacking experience in mind is the new package for the Senseo coffee maker (www.maxsbd.nl).

As the above shows, three types of functionalities may have an influence in the volume of a packaging for a CE product; distribution, sales and experience functionalities. For most products each of these functions will have to be fulfilled to some extent. Sales and experience together form the marketing functionalities of the packaging. These marketing functionalities often clash with optimization from an economic and environmental point of view, as they often result in a much more voluminous package as would be required from a pure protection point of view.

It is important to make sure that a product gets a packaging with the required mix of functionalities (distribution, sales, experience), as a mismatch automatically results in a sub-optimal design.

A useful way of determining the dominant functionality of a packaging is to ask the following question (either about the packaging of the previous product generation, or a concept design for a new product): *"Why isn't the packaging smaller?"* Here there are four groups of answers. The first group relates to *"otherwise the product gets damaged"*. This answer indicates a distribution-packaging. The second group of answers relate to *"otherwise the shelf performance would go down"*. This answer indicates a sales-packaging. The third group relates to *"otherwise it wouldn't look nice"*. This answer indicates an experience-packaging, where feel-good is most important. The fourth and final group relates to *"we had no time/money so we took a design from a related product or previous generation, and adapted it"*. This answer is a red-flag for sub-optimal designs,

as new product generations in the CE market often are more robust and smaller than the previous product. Hence, maintaining the previous packaging leads to a very unfavorable volume-index. However, this type of design re-use is quite frequent in the CE market. Based on the answer on the question posed above the mix of the three types of functionalities (distribution oriented, sales oriented and experience oriented) can be determined. This mix can be represented in a triangular graph (Wever and Del Castillo, 2006), as in Figure 2. A design team, consisting of product managers, sales managers and packaging engineers, should also be able to score the direct commercial competitor products. Hence the relative position to these products in the graph can be discussed, presenting arguments either why a packaging may be more voluminous, or why it should be less voluminous, than the competition.

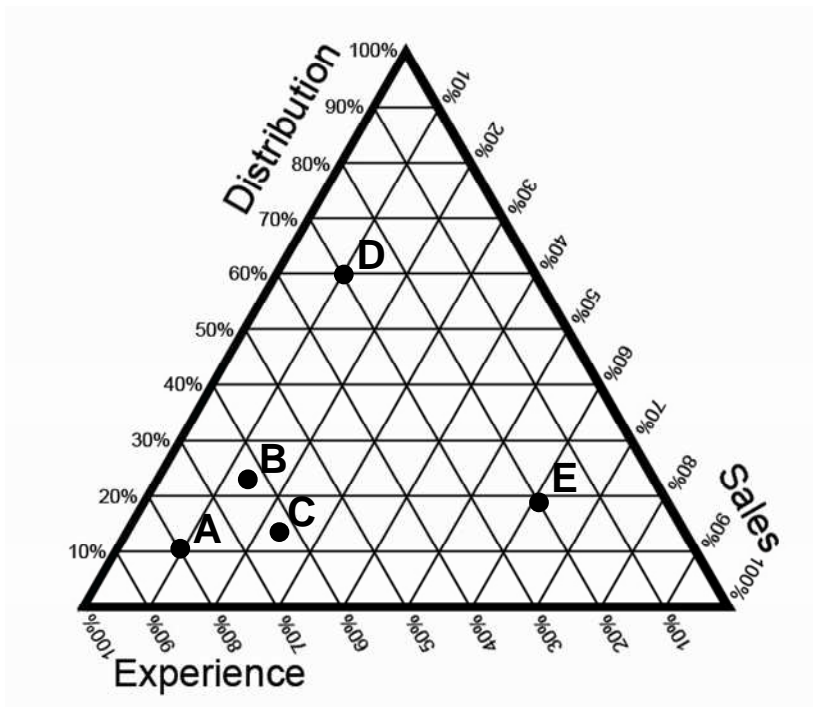


Fig. 2: A triangular graph, representing the mix of the three types of packaging functionalities; distribution, sales and experience.

Here products A, B and C could form a realistic market segment, where it can be argued that differences should be minor, but that the focus of packaging C would be more on front-face area, where a packaging A would have the strongest focus on high quality and original presentation of the product, both on the outside of the package as on the inside. Other positions in the triangle would justify other measures. Packaging E would be

strongly focused on front face area, and have high finishes on the outside, but a rather plain inside of the package. Packaging D would be more like the classic, efficient brown cardboard box, but with some attention to experience (mainly printing, and not additional materials or volume).

OPTIMIZATION STRATEGIES

In each corner of the triangle different optimization strategies are open to the designer. In the distribution corner designers might consider:

- selection of more volume efficient cushion materials. The volume added to a product by applying cushions depends of course on the thickness of the cushion, which in turn is determined by the cushioning characteristics. Some cushioning materials need more thickness than others to provide the same level of protection. Molded fiber is one example of a material that is very volume efficient when applied properly (see also Wever and Twede, 2007)
- optimizing the damage rate. From an economical perspective it is well acknowledged that no transport damage at all is a sign of over-packing (e.g. McKinlay, 1998, p.12). This is also true from an environmental perspective, although the optimum may be at a different damage rate than the economical optimum.
- product redesign, so that its fragility is reduced (e.g. Nielsen, 1994). (Another interesting solution here is making sure that the product can be transported in any orientation. LCD-TVs for instance mostly have to be transported upright, which often results in a in efficient use of the height of sea containers, as there is just too little room for a extra layer of products)

In optimization of marketing functionalities the priority should still be on volume minimization, hence marketing functionalities should preferably be fulfilled through upgrading finishes (printing). If this is deemed insufficient more and/or higher quality materials may be utilized, and only as a last resort should the volume be increased. This goes for both sales-packaging and experience-packaging.

Sales dominated packaging may for instance be optimized by reducing the third dimension (the one perpendicular to the front facing area). Experience packaging may for instance be optimized by using high quality materials and finishes, thus resulting in a small jewel box, in stead of a big bulky package. If sales and/or experience functionalities still require a relatively big package design, than splitting the long-distance distribution phase and the retailing phase may be an option. In this case one applies bulk packaging long distance, and repacks the products into their final sales package close to market (Twede, *et al.* 2000, Boks *et al.* 2003).

NOTE

This paper describes the base of an ongoing PhD project, which will continue to explore the characteristics of the different packaging functionalities as well as to investigate the savings potential of different optimization strategies (see also Wever, De Vries, Boezeman, Roskan and Uythoven, 2007; Del Castillo and Wever, 2007)

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