Environmental Benchmarking of Medium-Sized TVs Sold in North America, Europe and Asia (China)

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Abstract

The environmental benchmarking procedure as developed by the Design for Sustainability Lab of Delft University of Technology and the Environmental Competence Centre of Philips Consumer Electronics has been applied to TVs sold in the market in three continents: North America (USA), Europe and Asia (China). For each region three or four products of different brands have been considered. In total some fifty parameters, which are relevant for the environmental performance, have been measured.

These measurements allow making calculation of life cycle performance of the products (based on the Eco Indicator 95 system).

The results show big differences in all categories; no brand scores consistently best in all focal areas. It will be concluded that although TV's are seemingly a mature product, different design tradition, different supplier base and difference in speed of latest technology make that in practice differences up to 50% in life cycle performance have been found.

Also between products sold in the three regions of the world clear differences were found (although not as big as between best and worst brand performances.) Only partly this observation can be explained by differences in for instance environmental legislation. It will be speculated to what extent the structure of the value chain is responsible.

It will be concluded that environmental benchmarking is a powerful tool to systematically track down design improvements and to check on supplier relationships.

INTRODUCTION

For a number of years, Philips Consumer Electronics and Delft University of Technology's Design for Sustainability Program (DfS) have cooperated in a wide range of (applied) ecodesign related research projects. In 2002 these projects were expanded to include products from other local markets. In the summer of that year a project was completed in cooperation with a Philips production plant in Suzhou, China, and in Fall 2002 another project was completed in cooperation with the Georgia Institute of Technology in Atlanta, Georgia, USA.

Prior to 2002, all projects were conducted in the Netherlands, and focus was on products sold in the European market. In these projects, the Environmental Competence Centre (ECC) at Philips provided products, product data, research facilities, and the business perspective. Staff and students from the Design for Sustainability Programme at the DUT contributed design knowledge, creativity and methodological support where needed. The aim of this ongoing cooperation is to balance and bridge scientific theory and methodology development regarding sustainability issues on the one hand, and corporate practices as they exist in the (manufacturing) industry today on the other.

One of the main research topics that has been particularly helpful in building the bridge between scientific research and implementing it in the business is the collection, and subsequent utilization and interpretation, of environmental

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benchmark data. The environmental benchmark method, explained in more detail in Boks and Stevels [1], is laid out in the Environmental Benchmark flowchart as depicted in Figure 1.

Developed in 1997, the environmental benchmark method emerged at a time when companies in Europe discovered that environmental care included ample opportunity for cost savings and product improvement, extending beyond just end-of-life issues particularly. Saving on resources could be directly related to cost and price reduction. Also, improving environmental performance could enhance brand image and sales.

Environmental benchmarking is based on the assumption that market driven environmental performance means being better than the competition rather than scoring on an absolute scale as most traditional environmental considerations do. The method was more practical than the methods used before, as it focuses on physical parameters which actually can be measured, influenced and easily interpreted by the company itself, as opposed to using life cycle analysis only, which is for company employees and design students difficult to integrate into their day to day practice.

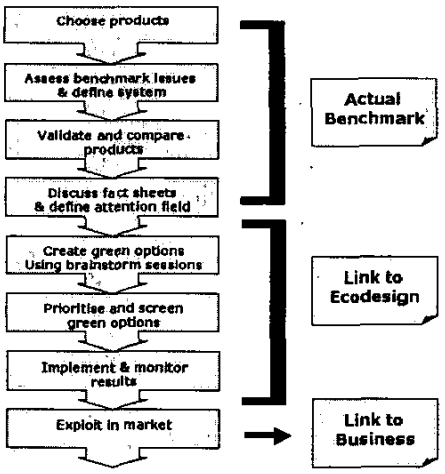

Figure 1: The Environmental Benchmark Method

The environmental benchmark method as recorded in an official Philips document, is laid out in figure 1. The method not only comprises the benchmarking of products; it positions this activity in an integral approach that facilitates the exploitation of the benchmark results. The flowchart explains that there are three main elements: the actual benchmark procedure itself, the link to Ecodesign and the exploitation in the market. The results of the actual benchmark are a basis for creativity later in the process.

Recently, the cooperation between Philips' ECC and DUTs DfS has resulted in two international projects. In these projects, DUT students went overseas to do environmental benchmarking projects in China (summer 2002) and the USA (fall 2002). In both projects, 27" and 28" TV sets were benchmarked by the students. Apart of increasing and disseminating awareness about the importance of environmental benchmarking abroad, an additional benefit of benchmarking projects overseas is the relative ease with which local brands can be included in the benchmark studies. This inclusion was considered upfront to be of great importance, as differences in local legislation, differences in the local supplier base, differences in consumer preferences as well differences in applying the latest technology can be expected to have a significant effect on the design and consequently the environmental performance of products from various brands worldwide. Learning about these differences, and about other brands' solutions, is of great importance to Philips in order to continue improving their products.

ENVIRONMENTAL BENCHMARKING

The environmental benchmark method is split up into five focal areas:

- Energy consumption in various operating modes (and of various subassemblies)
- Material application including metals, plastics weight)
- Packaging and transport including materials, volumes)
- Chemical content including heavy metals, flame retardants, organics)
- Recyclability including disassembly analysis, mechanical treatments)

In addition to checking these five focal areas, a life cycle assessment method is used for the validation of the environmental performance of the benchmarked product. The main idea behind this is to include the life cycle perspective in the final assessment of the product, and also to determine the feasibility of the environmental improvement options that are generated based on the benchmark results.

The actual benchmark consists of four elements: the choice of products, the system definition,

comparison and validation of products, and the review of results. When the actual benchmark is finished the results have to be linked to ecodesign and later to business.

Since its introduction, over 60 environmental benchmarks have been performed and reported on at the Philips ECC, most of them cover the consumer electronics (called "brown goods" in Europe) category. Benchmark reports have contributed to product improvements, cost reductions and general environmental awareness through the organization. But even more can be expected from simultaneous analysis of multiple benchmark reports, especially as regards to the identification of structural underperformance, trend analysis and degrees of freedom for design alternatives. Research on multiple environmental benchmark data analysis has been discussed by Boks and Stevels [2,3].

The current article compares environmental benchmark reports performed in different regions of the world, including analyses of locally manufactured products.

DATA COLLECTION

For this article, three benchmark studies have been compared. These include a 'normal' benchmark study executed at the ECC in Eindhoven, and two similarly conducted benchmark studies in Asia (China) and North America (USA). These were the first two benchmarks executed outside the ECC in Eindhoven.

It is important to first point out that although seemingly different CRT sizes are used in the three regions, in fact a 27" TV in the USA is actually the same size as a 28" TV in Europe and a 29" TV in China. The differences in 'designation' can be explained by the fact that in some cases the measure reflects the visible part of the screen, whereas in other cases the actual screen size is measured.

The Asian benchmark study was executed during an internship for two Dutch students from the DUTs Industrial Design Engineering department in July 2002 in Suzhou, China. After receiving environmental benchmark training at the ECC, their research took place in a Philips production facility with most of the measurement devices already on hand. The 29" TV sets included in the study were at that moment the top-selling television sets in China. They selected the best and second best competitors in the Chinese market, which were both local brands. In addition, a third local brand was chosen, because of its success in the Chinese rural market, its use of different components and because of its software features. All televisions were 29" flat screen sets.

Three months later a similar benchmark study was executed at the Institute of Sustainable Technology and Development at Georgia Institute of Technology (Georgia Tech) in Atlanta, Georgia, by two of the authors of this article. The brand managers of the Philips mainstream television division in North America, also situated in Atlanta, chose two local brands (only sold in the USA) to be benchmarked against the Philips set, which was manufactured in North America (Mexico), sold in the USA and based on global electronic platforms. The collaboration between the initiators of the project and Georgia Tech was positive. On one hand it was very easy to complete benchmarking at the university because of the knowledge and devices already available. On the other hand, Georgia Tech's staff and students got exposure to the environmental benchmarking method, and plans are already made to start future projects with Georgia Tech students.

The third benchmark research was, like all other environmental benchmarks, executed at the ECC in Eindhoven, including a Philips set and its three best commercial competitors. It was executed in September 2002. In Europe widescreen TV-sets are becoming the standard, because of that there was no European benchmark of a conventional 28" TV set available at the ECC. Of course this contains a problem in comparing the three benchmarks; the widescreen tube is almost 17 percent smaller (figure 2).

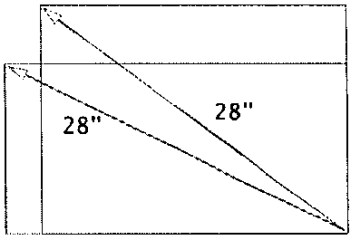

Figure 2: Widescreen Versus Conventional Screen

Based on the fact that both TV sets have the same functionality for the user the difference in the size of the tube and the consequences of that are neglected in the results, but if relevant, used in the explanation of the results.

The main difference between the selected TVs is that they are not all flat screens. The European and Asian televisions were flat screens, the televisions in the USA were not. Other differences are the power source in the contingents, for the USA 110 Volts and 60 Hz, for Europe and China: 220 V and 50Hz. There is also a difference in the antenna signal in the three regions, in the USA it is NTSC, in Europe and China PAL PLUS.

RESULTS

In this section, the differences in the results between the three regions are considered. Classification by the aforementioned five focal areas is used, as is validation using a life cycle analysis.

Energy consumption

Although the usage behavior of consumers in Europe, Asia and the USA is not the same, it is important to determine a uniform usage profile to enable comparison of the energy consumption. For this reason the usage profile in Table 1 was chosen. This model assumes televisions are always in stand-by or on-mode, and never in off-mode.

Table 1: Average User Behavior Modeled in This Study

User behaviour pattern:	hours/wk
On mode	35
Standby mode	133
Off mode	0

For correct energy measurement the benchmark manual mandates that the brightness and contrast should be calibrated with a color analyzer. As there was no color analyzer in China, the research was done with the setting from the manufacturer. If not all manufacturers use the same factory settings, comparing them might show a significant deviation from actual energy consumption. Before energy measurements were made, the TV sets were warmed up for 30 minutes before the energy consumption was measured using a power analyzer. The energy consumption was expressed in kilowatt-hour/ year, using the described behavior pattern. The results are shown in Figure 3.

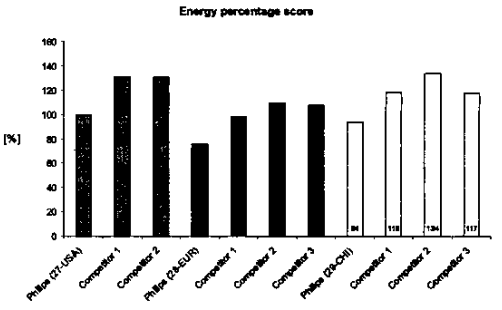

Figure 3: Differences in Energy Use

There is a significant difference in energy use between the continents. The average of the USA, European and Asian televisions is respectively 121, 98 and 116 kWh/year. These differences can be attributed to sizable difference in the energy use in stand-by mode. In the USA, for example, the Philips set uses 0.6 watts whereas the other brands use 7.7 and 6.8 watts respectively, in stand-by mode.

In Europe and Asia all televisions have a power switch, but in the USA only one of the local brands does, whereas the Philips set and the other local brand do not have one. If consumers want to turn off their televisions they have to pull out the plug.

Research of one of the authors of this article has proved that in on-mode a 28" widescreen TV-set uses approximately 5 percent more energy than a 28" conventional TV-set. This means the performances of the European TV sets on the field of energy-use are even better than can be seen from the results. The success of widescreen television proves that for consumers the advantages of widescreen television are of more importance than saving energy.

Additional explanations for the differences in energy consumption could be:

- In Europe the Philips product was benchmarked against global brands whereas in the USA and Asia it was benchmarked against local brands. It may be that global brands spend more time on design for environment and are better connected to IC suppliers to get latest chip sets and therefore may use less energy.
- In Asia, televisions are designed with higher criteria for printed wiring boards, because of less stable power supplies in for example

China, which may cause Chinese televisions to use more energy.

- As antenna signals differ in the various regions, this could lead to differences in energy use between the systems.

Packaging & Transport

To compare different packaging solutions for the TVs, the environmental benchmark method uses the following 'packaging equation' (PE).

$$PE = \frac{\text{Packaging weight}}{\text{Product weight}} \times \frac{\text{Packaging volume}}{\text{Product volume}} \times \text{Nr. of materials}$$

This equation compares the weight and the volume of the packaging with that of the product. These two figures are multiplied by the amount of materials used in the packaging. The number of materials is relevant for recycling issues. In order to compare the different television sets, the score of the Philips product in the USA was set at 100 percent. Results are shown in Figure 4. (It should be noted that the lower the PE value, the better)

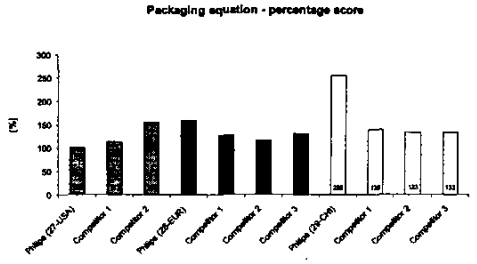

Figure 4: Packaging Equation Percentage Score

Although there are some big differences in the packaging scores within regions, for example the Philips in the USA scores 55 percent better than the product which scores worst on this field, the differences between the averages of the three regions seem to be too small to draw any conclusion. A striking finding, however, is the poor Philips score in Asia. This is because of its relatively large and heavy box. Possible explanations for this are:

- The transport conditions in China are as such much worse than in Europe and Asia;
- Quality image in China;
- Retailers use already small flaws for an excuse to send TVs back to the manufacturer

Material application

Every TV in every benchmark is completely disassembled; every part is separated and weighed. In this way detailed information is obtained about how much of each material is used by the various manufacturers for the various applications. In Figure 5, some interesting differences between the weight percentages of the TV sets in the three continents can be observed (Philips USA = 100). The averages of the USA, Europe and Asia are respectively, 35, 41 and 47 kilograms.

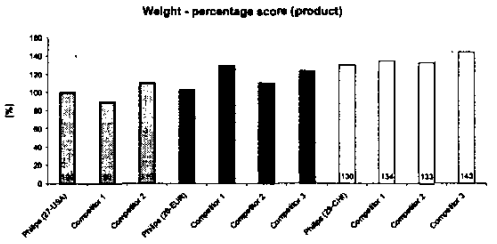

Figure 5: Weight-Percentage Score

The large differences in weight can be explained mainly by the CRTs. One of the TV sets in the USA has the lightest CRT (24 kilograms), the heaviest CRT is a Chinese, it weighs exactly 13 kilograms more. Part of the difference can be explained by the fact that the Chinese televisions are flat screen TVs and the American is not.

A CRT of a widescreen television uses 20 till 25 percent more glass than a conventional television. If we would scale the amount of glass of the widescreens to the amount of glass of the conventional TV sets, the European would have the lightest CRTs.

Apart from the difference in the weight of the CRTs, there are also interesting differences in the weight of the encasing, as shown in figure 6. The most remarkable thing is the weight of the lightest TV set in the USA.

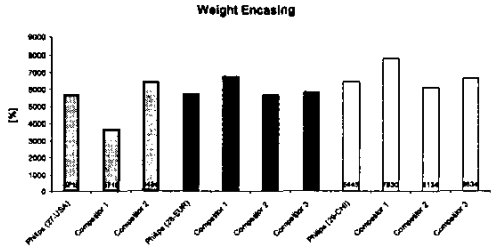

Figure 6: The Weight of the Encasing

Further research has to point out why it is possible for the designers of this TV to use almost 2 kilograms of plastic less than the second lightest

encasing. Maybe the encasing is less strong, but the question is whether it is strong enough for its purpose.

Recyclability

To calculate these figures we take all materials of the television. We assume 90% of the ferrous material is recycled, therefore we multiply the amount of Ferro fraction in the television by 0.9. Equivalent factors for percent-recyclability are multiplied with totals for aluminum (80%), copper (95%), glass (61%) and paper (31%), to yield the total amount of materials – from a weight perspective - that can be recycled. The Philips in the USA is set at 100%, which gives the results as shown in figure 7.

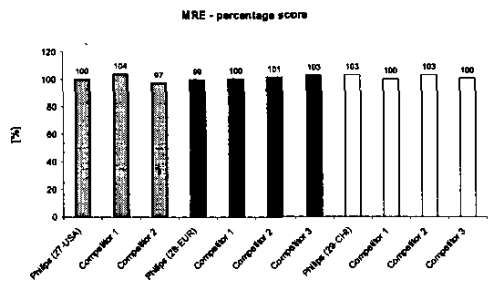

Figure 7: Weight-based Recyclability percentage score

It is concluded that the differences between the televisions on material recycling efficiency are minimal.

This is completely in line with findings in European practice. For years designers worked on Design for Disassembly and Design for Recycling while realizing very few improvements. Many more results can be gained by better organization of the recycling system, not on recycling quotes but on recycling costs. A better recycling system organization includes leverage of scale towards recyclers and getting better prices from material processors, for example because of better economics of scale.

The environmental benchmarking report also checks on disassembly time. This is done by counting the amount of screws, snaps and solder connections that have to be opened to separate the materials. These figures are multiplied by the standard time needed to break these connections. The averages of the time for the Europe and Asia are respectively: 358 and 660 seconds. An average for the USA is not meaningful because of the large differences within this region. In the USA the three televisions will take approximately 180, 194 and 794 seconds to separate. The differences in disassembly time can mainly be explained by the amount of screws: one of the American TVs scores best with 19 screws, a television in China performs worst with 107 screws.

Chemical contents

There are flame-retardants in the encasing of all benchmarked televisions in the USA, which make the plastics in these televisions very hard to recycle. No flame retardants were found in European and Asian TVs.

All manufacturers use PVC in their products, but some of them use PVCs in their packaging. In fact the amounts are very small, some only use PVCs in their twist-ties, but they are very easy to replace by non-PVC twist-ties.

Life cycle analysis

As already stated, in the environmental benchmark method life cycle analysis is used to summarize and validate the results of the five focal areas.

What can be learned from the life cycle analysis is that energy use is the main issue, and real improvements for environment should be made on energy use on televisions.

The averages of North America, Europe and Asia are respectively: 4030, 3650 and 4300 millipoints, according to the Eco Indicator 95 method. The differences can mainly be explained because of the differences in energy use between the regions.

CONCLUSIONS

We have provided a comparison of environmental benchmark studies devoted to mapping the environmental performance of 27"-29" television sets of a variety of international and local brands. In total some fifty parameters, which are relevant for the environmental performance, have been measured. These include the following focal areas:

- Energy consumption in various modes (and of various subassemblies)
- Material application (metals, plastics weight)
- Packaging and transport (materials, volumes)
- Chemical content (heavy metal, flame retardants, organics)
- Recyclability (disassembly analysis, mechanical treatments)

Considering the focal area of energy consumption, the European benchmarked televisions score significantly better, and an explanation for this

could be the governmental regulations. By improving energy consumption, manufacturers can potentially score much better in life cycle assessments, because with TV sets the energy use is very dominant in life cycle analysis. Some manufacturers could easily improve their performance on energy use by improving their stand-by modes; others already have but can make further improvements in on-mode.

Although not much can be said in relation to any differences between the regions in the field of packaging, much can be learned from the differences within the regions. The difference is big enough for Philips to reconsider its packaging designs.

Considering the focal area of weight, televisions from the USA score significantly better than competitors in other regions. The differences on the areas of the CRTs and the encasing can be very large.

On the focal area of recyclability the total amount of materials that can be recycled does not differ significantly, but interesting differences can be found in the disassembly time. A further analysis

of these data will give rise to interesting cost savings.

Also, between products sold in the three regions of the world, clear differences were found (although not as large as between best and worst brand performances). We have provided speculations about factors that contribute to this.

The current study shows an example of how environmental benchmarking is a powerful tool for systematically tracking down differences in design solutions preferred by competing brands. We have also demonstrated how this knowledge can be used to identify where to focus product improvement and environmental redesign efforts.

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