Zeitschrift: Comtec : Informations- und Telekommunikationstechnologie = information and telecommunication technology

Herausgeber: Swisscom

Band: 79 (2001)

Heft: 6

Artikel: Environmental impacts of a mobile phone

Autor: Oiva, Leena / Oppermann, Wilfried / Middendorf, Andreas

DOI: https://doi.org/10.5169/seals-876549

Case Study

Environmental Impacts of a Mobile Phone

For a better understanding of environmental and end-of-life related impacts of cellular phones Nokia Mobile Phones made a case study of a mobile phone. Main outputs of the project were material content estimation, identifying the environmentally relevant components and parts, as well as identification of possible optimisation alternatives in the design and material content of the product according to the identified toxic and recycling potentials. Many tools and methods have been developed to help estimat the environmental impacts of an electronics product. One such tool was tested and is described in this paper with the main results attained by the evaluation.

Nokia is the world's largest mobile phone supplier and a leading supplier of data, video and voice network solutions as well as multimedia terminals. Nokia was among the first companies to sign the Business Charter for Sustainable Development, published by

LEENA OIVA, WILFRIED OPPERMANN,
ANDREAS MIDDENDORF
AND IRINA STOBBE

the International Chamber of Commerce (ICC) in 1991. Nokia Environmental Policy based on the Charter was published in 1994 and commits Nokia to life cycle thinking. Nokia sold world wide 78,5 million mobile phones during the year 1999. According to DataQuest, this was approximately 27% of the total amount of mobile phones sold in the world. Globally, mobile phone user base was put at 480 million at end 1999, which is expected to top 1 billion by the end of 2002. Also by the same date, more phones that can access the Internet will be sold than PCs. The number of cellular phones has increased rapidly during the past years.

One of the Main Environmental Issues

At the same time, thanks to the advanced technologies of miniaturisation and material composition, the material and energy use of each phone has been reduced. However, as material content of the final product is one of the main environmental issues of small electronics appliances, more attention is being focused on it by the producers. With the expanding growth rates and manufacturing amounts, the environmental load of even such small subjects is growing correspondingly. An important tool in developing an understanding on the environmental impacts has been life cycle assessment. Considering environmental issues during the whole life cycle requires large amounts of accurate data, which are today not systematically available. Therefore, many alternatives for making life cycle assessment faster and more usable have been developed world wide. One of these tools has been developed by Fraunhofer IZM in Berlin. In contrast to the conventional LCA approach a simplified environmental evaluation can, with this tool, be done significantly faster.

Background of the study

For a better understanding of environmental and end-of-life related impacts of cellular phones, Nokia Mobile Phones made a case study of a mobile phone. The study was made with the help of the EE (Environmental Engineering) Toolbox developed by the researchers at the Fraunhofer IZM. Main purposes of the project were material content estimation, identification of the environmentally relevant components and parts, as well as identification of possible optimisation potentials in the design and material content of the product. At the beginning of the project in 1998 the mobile phone studied was one of the most advanced handsets on the market. The weight of the product without battery is 90 g. Charger, power consumption and battery were not included in the study. Environmental assessment of an electronics product with the EE Toolbox method is based on material content data of the product in question. The evaluation is based on the environmental properties of the materials in the product. Therefore, some data collection had to be organised in order to access such information.

Data Collection

Since electrical and electronic industry products are mostly combinations of hundreds or even thousands of different components, their material composition is often complex. In many cases, the material composition has been estimated by destructive analysis, by weighing the components and parts individually and doing the best possible assumption on the materials the part contains. As long as the parts are large enough, and especially for the mechanical parts, this is a valid method.

Unfortunately, destructive analysis is expensive, time consuming and inaccurate, often missing small quantities of relevant substances, as is also a chemical analysis of a complex product. Chemical analysis on each component and part would still be needed to detect the full material content. Therefore, to obtain reliable material content data, the information must be acquired directly from the com-

Material	TPI [1/mg]
Cr_2O_3	73.0
Ni	42.5
Ag	37.8
Co	33.7
Pb	20.8
$SnPb_{40}$	9.0
Ferrit	4.6
TBBA	3.0
Cu	1.6
Sn	1.2
Al_2O_3	0.7
Zn	0.6
Acryl	0.6
Liquid Crystal	0.6

Table 1. Some examples of the numerical TPI scaling of materials. Scale is from 0 (no or small Toxic Potential) to the maximum of 100 TPI.

ponent manufacturer. The original bill of materials of the handset was reduced to one third of the original amount of components to contain only 88 different components. This was done by summarising same types of components with similar packages, and later on by estimating the package type and material content of those components on which no manufacturer information could be obtained. Some suppliers were contacted for detailed material content information on their components. This way, and by doing some estimations, 90% of the product's material content could be acquired. The remaining parts were analysed when necessary. The data obtained were complemented with the database of electronic components and materials developed and maintained by the EE Toolbox. The database contains component information from literature, from free technical sources, from some component manufacturers and from previous non-confidential projects.

Assessment with the EE Toolbox

In order to make one kind of life cycle analysis without years of time and effort, the department of Environmental Engineering at the Fraunhofer Institute for Reliability and Microintegration (IZM) has developed a so-called EE-Toolbox for evaluating environmental impacts of a product. The evaluation model is based on the environmental properties of the materials in the product. Impacts are aggregated in the numerical Toxicity Potential Indicator (TPI), which expresses the possibility of harm to either humans or to the environment when the substances in the product are released freely. Uncontrolled, fine spread release e.g. as dust or through ground water is assumed to be the worst impact case for each substance, even though it might not occur in the real life cycle. Each material in the database is attributed one number which describes the relative worst case ecological impact of the material (table 1). The material weights in each component are multiplied by this evaluation to achieve the component assessment. The impact of a material is subdivided into three classes: human toxicity based on inhalation and carcinogenic risk, toxicity for aquatic systems and other material properties which endanger either humans or ecosystem.

The EE Toolbox does not replace a complex LCA but rather complements it for

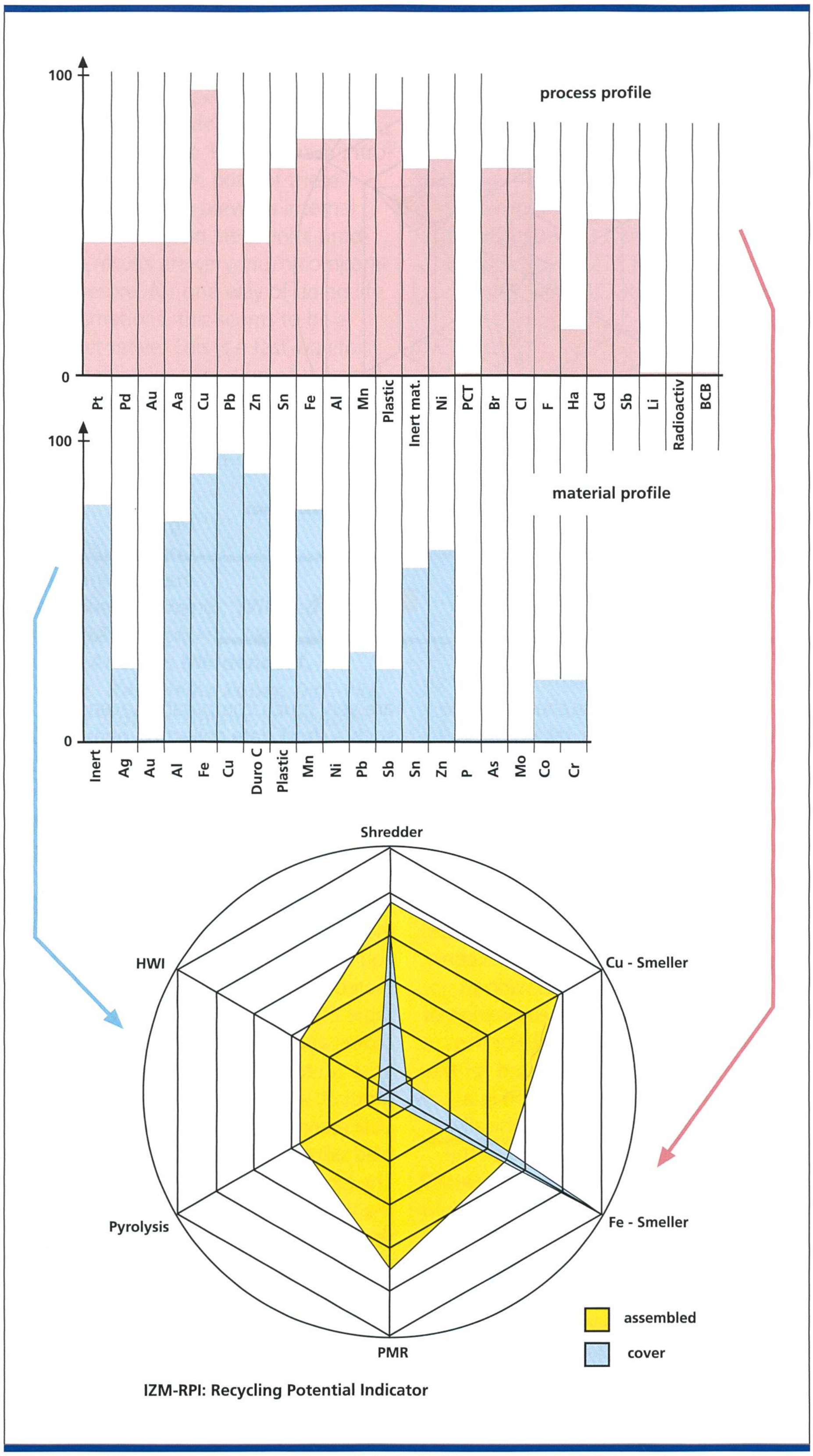

Fig. 1. The principle behind the calculation of the RPI value.

"in the field" use. The toxicity evaluation by definition does not reflect all environmental aspects of a product. Although exact product comparisons might require full LCAs, it is possible to identify where the environmental weak points are to be expected by extrapolating the environmental impact from the material content of the product.

Evaluating the recyclability of products is one of the basic tasks of the companies manufacturing electronic products. More

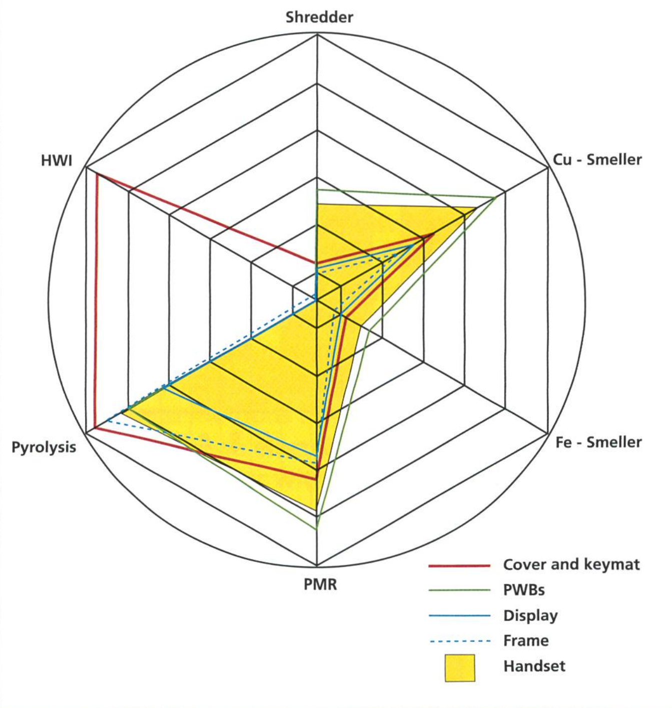

Fig. 2. Compatibility of the main components for different recycling possibilities.

often, the companies are challenged to calculate future costs for taking back their products. Today companies are already looking for technological and logistical ways to limit the recycling costs by appropriate product design. The crucial decisions for recycling are made in the design phase. Furthermore, there are regulations concerning the identification of system-unit covers. The material content of an assembled printed wiring board is suitable for the determination of the optimal recycling strategy. For this the list of materials, as generated for the previous modules, is represented in a product material vector, or graphically expressed as the material profile of the product. For the determination of so-called "process vectors", the required minimum quantities of valuable materials for standard recycling processes and tolerable maximum quantities of interfering or noxious substances were specified. This results in assessed lists of all relevant materials for all investigated processes, the process vectors, that can be graphically represented in material-discrete process profiles. The evaluation method is introduced in figure 1.

Results of the Evaluation

Material Content Estimation

The main output of the case study was detailed material content evaluation of the product. Compared to previous studies on electronics products, the results are very much comparable, even with such a short data collection phase of 2 months. Material contents of the handset were estimated according to the material data gathered. The overall values show that 56% consists of plastics, 25% metal compounds and 16% ceramics. The remaining 3% contains other non-metallic elements and materials such as liquid crystal. The material contents estimated are presented more precisely in table 2. In comparison, the weight of the covers and other mechanical parts comprise up to 54% of the weight of the product, approx. 5% is the weight of the LCD assembly, and the rest is the assembled printed wiring board.
The largest single contribution (29%) to the weight of the product results from the plastic covers, made of ABS PC. The group ceramics summarises glass and ceramics, which can be found in the LCD, printed wiring boards, semiconductors and resistors. Copper compounds comprise 15% of the whole weight of the product, which shows the importance of this metal for the electronics industry. Other important metals in the product are iron, nickel, silver and zinc, which altogether total 6% of the weight of the product. Both nickel and zinc are used for iron, nickel in the alloy and zinc for protection against corrosion. Zinc can also be found in brass as an alloying element. The amount of silver is relatively high in this product due to a silver coating of one inner part. SnPb on the surface of component terminals, as well as in the solder itself, has been estimated to comprise 1% of the weight of the product. Flame retardants in the PWB and component housing also add up to 1 w-%. Materials with single contributions under 1% have a total contribution of 3% for the whole product.

Toxic Potential Indicator Evaluation

Previous experience was confirmed in this case, as some materials with small amounts have a significant contribution to the total TPI. The absolute TPI for the product is ca. 120 000 TPI and the TPI normalised with the product weight is ca. 1,3 (TPI/mg). As can be seen in table 3, copper compounds make the largest contribution of 45% to the total TPI due to the weight of the copper in the product. The evaluation system gives nickel a high TPI ranking, and despite the low concentration of nickel in the product, it adds up to 20% of the whole product's TPI amount. The same can be seen with silver compounds, which comprise 17% of the total TPI.
The high ranking of the above materials is due to their allergenic feature or toxicity in aquatic environment if exposed freely. It is clear that these materials cannot easily be eliminated from the electronics appliances. Although uncontrolled exposure of these metals does not happen during the normal use of a phone, the results point out that the recycling of these metals must have a high priority when considering the end-of-life treatment of the products.

Recycling Potential Indicator Evaluation

End-of-life treatment alternatives were estimated separately for the whole product and its subassemblies. In figure 2, the compatibility of the main parts of the product for different recycling alternatives is illustrated. Precious metal refining (PMR) and copper smelter are the optimal options for the assembled PWB and also for the complete product. Pyrolysis is a possible thermal treatment for electronic scrap, because of the good destruction of dioxins. Unfortunately it is at the moment economically unreasonable. Household waste incineration (HWI) and landfill are not acceptable for electronics waste because of the presence of heavy metals.

TPI values	% of the TPI value
Cu & its compounds	45 %
Ni & its compounds	20 %
Ag & its compounds	17 %
SnPb	4 %
Flame retardants	4 %
Epoxy	2 %
$BaTiO_3$	2 %
E-Glass	1 %
Cr_2O_3	1 %
$FeNi_{29}Co_{17}$	1 %
Co & its compounds	1 %
< 1% contribution to the TPI value e.g.: Al & its oxides Ferrite, Zn & its compounds, Mn & its oxides, LC	

Table 3. Toxic Potential Indicator (TPI) evaluation of a mobile phone.

Material	Content Weight %
ABS-PC	29%
Ceramics	16%
Cu & its compounds	15%
Silicon plastics	10%
Epoxy	9%
Other plastics	8%
Fe	3%
PPS	2%
Flame retardants	1%
Ni & its compounds	1%
Zn & its compounds	1%
Ag & its compounds	1%
< 1% of the weight e.g. Al, Sn, Pb, Au, Pd, Mn, Cr_2O_3, LC	

Table 2. Estimated material content of a mobile phone.

Literature

[1] A. Middendorf, N.F. Nissen, H. Griese, J. Müller, H. Pötter, H. Reichl, I. Stobbe, (2000). "EE-Toolbox – A Modular Assessment System for the Environmental Optimization of Electronics". Proceedings of the 2000 IEEE International Symposium on Electronics and the Environment, San Francisco, May 8–10, 2000.

[2] Nokia and the Environment brochure (1999).

[3] Nokia Mobile Phones' Environmental Affairs and Fraunhofer IZM, Department Environmental Engineering (1999). Confidential report on the environmental assessment of a Nokia mobile phone.

Conclusions

There are two primary ways of use for the material content information of the product, reports to external and internal stakeholders, and information to make decisions on actions. The approach introduced above helps in both of these cases. Compared to previous internal and public studies on electronics products, the results are very much comparable. Therefore, for one way of doing life cycle estimations, this seems to be a good alternative. This is a fast way for getting a reliable estimation of the product material content and some advice on the issues to concentrate on without having to organise time-costing data collection or analysis. 8

Leena Oiva, *Dipl.-Ing.;* ***Wilfried Oppermann,*** *Dipl.-Ing., Nokia Mobile Phones;* ***Andreas Middendorf,*** *Dipl.-Ing.;* ***Karl-Heinz Zuber,*** *Dipl.-Ing,* ***Dr. Irina Stobbe,*** *Fraunhofer Institute for Reliability and Microintegration, Stuttgart*

Zusammenfassung

Umwelteinflüsse von Mobiltelefonen

Nokia Mobile Phones hat in einer Fallstudie untersucht, wie sich Mobiltelefone und ihre Entsorgung auf die Umwelt auswirken. Hierbei hat sie ihr Hauptaugenmerk auf die materielle Zusammensetzung der Geräte und ihre umweltrelevanten Komponenten und Teile gerichtet und die Frage zu beantworten versucht, wie sich Design und Zusammensetzung angesichts der ermittelten toxischen und Wiederverwendungspotentiale optimieren lassen. Es wurden zahlreiche Werkzeuge und Methoden zur Beurteilung der Umwelteinflüsse elektronischer Produkte entwickelt. Ein solches Werkzeug wurde getestet. Was hierbei herausgekommen ist, lesen Sie in diesem Artikel.

Neuer Weltrekord für optische Übertragung von Signalen

Derzeit purzeln die Weltrekorde in der optischen Nachrichtentechnik. Einen grossen Sprung nach vorn machten die Labors von NEC, die mit DWDM-Übertragung (Dense Wavelength Division Multiplexing) fast 11 Tbit/s über eine Entfernung von 117 km schafften. Das Signal wurde auf 273 Kanäle aufgeteilt, von denen jeder 40 Gbit/s übernahm.

NEC Corp.
7-1, Shiba 5-chome
Minato-ku
Tokyo 108-01
Japan
Tel. +81-3-3454 1111
Fax +81-3-3798 1510

LCD weiter auf Wachstumskurs

Nach einer kürzlich abgeschlossenen Studie von Stanford Resources Inc. wird der Markt für flache LCD-Monitore kontinuierlich weiter wachsen – nicht sehr heftig, aber immerhin um 40% in den nächsten sechs Jahren. Nachdem die ersten PC-Monitore jetzt bei den grossen Discount-Märkten die Preisschwelle von 1000 DM unterschritten haben, dürften sich vermehrt dafür auch Privatkunden interessieren. Nicht jeder braucht einen 17-Zoll- oder gar 19-Zoll-Monitor: Wer auch mit kleineren Bilddiagonalen hinkommt und keine extrem hohen Auflösungen braucht, könnte sich den Umstieg auf ein solches «Schmuckstück» bald überlegen.

Weiter Fragezeichen hinter Mobilfunkentwicklung

Die Ende März in den USA abgehaltene CTIA Wireless Show 2001 (CTIA steht für Cellular Telecommunications and Internet Association) liess nicht klar erkennen, wohin sich Industrie und Netzanbieter bewegen wollen. Auch in den USA stand GPRS (General Packet Radio Service) im Zentrum, das als eine Art Zwischenstandard GSM und UMTS überbrückt. Die grossen Anbieter sind aber mit der Vorbereitung von UMTS finanziell an die Grenze des Möglichen gegangen. So ist die Neigung nicht sehr gross, übertrieben viel Geld in einen Standard zu stecken, der sich möglicherweise in drei Jahren wieder tot läuft.