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# HOUSEHOLD APPLIANCE WASTE MANAGEMENT– EXTERNAL DRIVERS, LEGAL AND SAFETY CONCERNS *

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**Abstract**. *This paper highlights drivers for change and the concerns related to the processing of waste from end-of-life household appliances and similar products. External drivers are emphasized in order to disclose financial motivation for redesigning present procedures and products. Legal requirements, taken as either reactive or proactive, provide a clear framework for further development of environmentally friendly industrial activities. Safety concerns are analyzed in order to raise awareness of health hazards in a steadily developing waste industry. Product end-of-life management and environmentally conscious product design encompasses not only technical details, but also requires insight in legal, health and safety issues.*

**Key Words**: *Household Waste Management, WEEE Waste, Recycling, Environmental Health and Safety*

## INTRODUCTION

Rapid technological development and an ongoing reduction of product lifetime have caused the agglomeration of end-of-life products and consequently, a technological, organizational and legislative reaction to this easily noticeable trend.

The world is facing an ever-growing waste stream from the sector of household appliances, consumer electronics and other products of great consumption, due to the rapidly increasing number of new products of the kind. These products are being disposed of at

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rates higher than ever before because of the increasing speed of technological development and changes in the way consumers interact with them.

According to a European-wide survey (in the framework of the Brite-Euram III program), 6 million tones of waste from electrical and electronic equipment (WEEE) were generated by 1998 [3]. This amounts up to 4% of the entire municipal waste stream in the area. It is expected that the volume of WEEE will increase by at least 3 to 5% yearly in the near future. In spite of ever more stringent regulations, still more than 90% of WEEE is being landfilled (i.e. disposed off without any treatment) or incinerated.

In order to decrease the environmental burden of consumer goods, research activities covering all aspects from design to usage and end-of-life treatment are needed to take all the relevant aspects into account and close the circle of various information during the entire life cycle.

## EXTERNAL DRIVERS

End-of-life strategy for appliances and similar products must balance the positive and negative aspects of three primary goals:

- reducing landfilled waste,
- maximizing recycling, and
- controlling hazardous materials

In spite of a growing trend of environmental awareness, increasing profitability remains the main driving force of any given company. Generally, companies implement those environmental initiatives that reduce operating costs or increase product quality. As a consequence of restrictive legislation on disposal practices, the costs of the disposal of both hazardous and non-hazardous waste have risen over the last couple of decades. A financial benefit can be achieved by generating less waste in general and in particular, by reducing the fraction of hazardous waste. There are many opportunities to reduce costs by studying product end-of-life options and bringing insight into product usage and disposal.

There are increased risks related to introducing new products because of consumer protection and product safety regulations that provide the grounds for possible lawsuits. The responsibility for hazardous material control and occupational safety encourages companies to phase out hazardous substances in their products and processes. Inadequate risk management could be costly for companies, both in terms of finance and the corporate image.

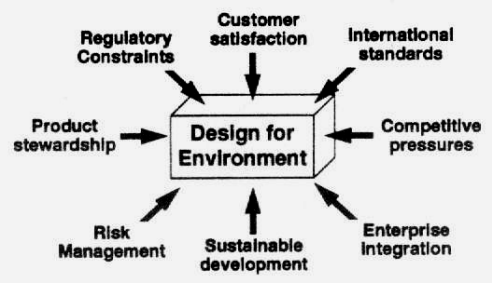


Fig. 1. External Drivers for Environmentally Friendly Design Strategies (J. Fiksel)

Customer pressure is one of the most important drivers for applying environmentally friendly design strategies (Figure 1). Some recent surveys have shown that environmental consciousness is steadily gaining momentum. Although approximately only 25% of the customers demonstrate a strong environmental motivation and will agree to pay higher prices for confirmed environmental improvement, in combination with other improvements, at least 65% of the consumers will be interested in investing in environmentally friendly products [2]. It is expected that improved primary features like performance, energy efficiency, price and safety, accompanied with environmental friendliness would continue to shape the market in favor of environmentally preferable products in the upcoming years. An increasing number of companies realize that the environmental aspect is an issue that could improve the market position of their products.

On the other hand, environmental demands made by industrial customers are powerful drivers for the environmental improvement of the company and its products. In general, an industrial customer is in position to influence a company more than an end-user, by shaping the structure of the environmentally friendly supply chain management. Pressure from industrial customers can have a great influence in introducing environmental improvements to the market and to customers.

## LEGAL CONSTRAINS

Since the late 1970s, the industry is confronted with stricter environmental legislation due to emerging environmental crises. The volume of legislation has increased from this time to constrain further environmental effects [7]. So called "end of pipe" regulations restricted the types of materials that could be discarded, as well as the circumstances for their disposal. A significant portion of this legislation has targeted activities of industrial sectors, has brought high cost penalties, and thus encouraged companies to respond in an environmentally sound manner. Legislation is forcing industry to find alternatives, environmentally improved ways of managing these problems [4].

Previously, legislation had been focused on production processes and the primary industry sector (chemicals, steel, paper, etc) [6]. The solutions were sought through 'end of pipe' remediation through investments in waste processing equipment. At the time, almost no regulation existed for products or the design of products, and only recently the recycling targets for certain categories of products have been imposed. The so-called "end of pipe" legislation had a limited effect on improving environmental conditions.

Scientific efforts have shifted toward elimination of the environmental problems earlier by reducing environmentally relevant material use and rationalizing processing steps (a cleaner production strategy). Modern strategies seek to address the causes instead of the effects, taking the environmental burden into account at the time when the product was designed. End of pipe recuperation was based on the 'polluter pays' principle, but in many cases it was rather difficult to determine who was the original polluter. Recently, the 'polluter pays' principle has been modified into the 'producer pays' principle, thus transferring the burden for many of the activities of modern society on the manufacturers of products that may then be passed on to consumers [4]. In the long run, the whole of society has to bear the burden of environmental improvement and help manage environmental change through environmentally friendly consumption concepts.

The latest developments in environmental regulation target household appliances and similar products. Legislation for extended producer responsibility, or product take-back, requires producers to address the end-of-life stage of their products. The European Union legislation by large require manufacturers to 'take back' electrical and electronic equipment. Many other countries are discussing, preparing or have already enacted take-back legislation, including overseas companies selling products on the European markets. The currently operating Dutch take-back system for large electronic appliances started in January 1999 and for smaller products started in April 2000 [1]. The consumers are obliged to pay a take-back deposit at the stores when they purchase new products. The products are collected at collection points usually managed by the municipalities. In certain cases, there is curbside pick-up for some products. Most products are recycled by local recycling companies, who share the profits or deficits with producers.

Japanese legislation that came into effect in 2001 seeks to achieve the proper disposal of products with a united effort from organizations related to the production, manufacturing, distribution, consumption and disposal of products. The legislation requires the recycling percentages (by weight) for the following products: washing machines (50%), refrigerator (50%), televisions (55%) and air conditioners (60%) [8].

It is necessary to understand "the flow of tangibles and intangibles" in order to prevent any unintended consequences of the legislation and to develop regulation that is better suited to the market forces [5]. Innovative design strategies that mitigate adverse environmental impacts throughout the product life cycle, or that make the product easier to recycle, are steadily more noticeable in all industrial sectors.

## HEALTH AND SAFETY CONCERNS

The waste management of domestic appliances and consumer electronics is a complex and sometimes conflict-related issue. Apart from technical difficulties and significant costs related to collection and disassembly procedures, the fact is that a lot of the obtained materials are rather toxic and harmful to the environment. A fraction of the materials in a waste stream also has a toxic effect on human beings. It is necessary to be aware of, and to investigate, the effects of different materials on health and safety within the disassembly process, and how to manage recycled components and materials on the spot.

In order to facilitate research, some studies suggest that electronic waste be divided into four groups, according to the dominant materials built into the products (i.e. plastics, metals, precious metals and glass).

### Products with a significant plastic content

Appliance plastics consist of many different materials, some of which particularly influence the environment and human health. According to several European and US studies, the amount of plastics in electronic waste amounts up to 23% (second largest amount in household appliances) [3]. There are numerous combinations of different materials, such as stabilizers, flame-retardants and pigments that are used to change the properties of the basic polymeric material. One of the main problems is the treatment of flame-retardants that could be inorganic additives such as aluminum hydroxide, or organic, like

halogens. Halogenated flame retardants are used in plastic housings as protection from the threat of electrical fires.

By recycling plastics containing brominated flame-retardants, and especially if they are being incinerated, there is the risk of generating dioxins and furans. Dioxins and furans can have high potential to bio-accumulate and have a high toxicity. Although toxicity of the majority of the brominated, non-halogen and phosphorous flame-retardants is very low, in the long run the influence could be significant. Beside the acute toxicity brominated flame-retardants can have chronic toxic effects. They have neurotoxic, carcinogenic effects on human beings and negative effects on reproduction.

Waste industry professionals should take special protective measures, design procedures and practices in such a fashion as to avoid the contact between operators and potentially hazardous substances as much as possible, and to enforce the use of protection masks, gloves and other personal protective equipment.

The appliance industry is already in possession of substitutes for certain hazardous materials. However, their quality, price, technical characteristics, industry standards, and testing requirements prevent their wide application.

**Products with a significant metal content**

The recycling of white goods (washing machines, dishwashers, small household appliances and personal computers) usually begins with a volume reduction in large shredder units, or dismantling / disassembly followed by material separation. The main problem is to separate steel, copper and precious metals from hazardous substances - polychlorinated biphenyls (PCBs) and heavy metals. Printed circuit boards contain glass fibers, ceramics, epoxy resins and brominated or chlorinated additives, which are toxic substances, as well as lead or tin solder, and have to be treated very carefully. Separation processes also produces fine metal dust containing iron, copper, aluminum and gold, potentially harmful when inhaled by an operator.

All of the mentioned substances have different effects on human health. Polychlorinated biphenyls are immunosuppressive could act as tumor promoters. Aluminum is considered relatively harmless, but potentially dangerous for irritating the metabolism. Chromium is, when in contact with skin, very caustic and could cause ulcers.

**Products with a significant precious metal content**

The proper dismantling of rare metal-dominated products (mobile phones, components of personal computers, handheld devices, etc.) is becoming ever more important both due to the valuable material content as well as from a health and safety perspective.

The main hazardous substances on printed circuit boards are batteries, capacitors and lead solder. Substitution for lead can be applied under high temperature and upcoming European legislation would require it whenever possible.

Operators should be careful while removing hazardous substances such as tin, cadmium, nickel, lithium and mercury. Those substances, if not properly handled, could disperse into the environment, causing contamination and damage to human health:

Lead is toxic both to the central and peripheral nervous systems, inducing behavioral problems and negative effects on intelligence.

Cadmium has harmful effects on kidneys, other organs, and induces skeletal demineralization. Nickel produces short and long-term effects to the endocrine and immune system, skin and eyes.

Mercury in sufficient concentration could cause the severe disruption of any tissue it comes in contact with.

**Products with a significant glass content**

Computer monitors and television sets are typical glass-dominated products. The tube of a television set accounts for approximately 50% of a device, and must be divided into screen glass and conical glass. Screen glass consists of barium and strontium, while conical glass contains mainly lead. The presence of heavy metals and hazardous substances in glass make it virtually impossible for reuse. The fluorescent tube should be removed under special hygienic surroundings to avoid any contact with skin. When removing barium, the inhalation of dust should be avoided. Protection for the face and the neck is necessary. Hands and arteries have to be covered with special gloves, while protective attire should cover the body.

The waste processing industry is a fast growing industrial sector, and a growing waste stream brings about new concerns. Comprehensive information, communication and a flow of knowledge is required to manage newly recognized health risks while sustaining environmentally friendly activities.

## CONCLUSIONS

There are very few approaches currently widely known, that enable a systematic integration of the post-consumer concerns into all the relevant phases of product development, in a comprehensive manner. Product end-of-life management should incorporate not only technical details and techniques, but also insight into legal, financial, health and safety issues. There are numerous external drivers and a growing legislative pressure on the industry to shift toward environmentally friendly concepts.

As for end-of-life treatment of household appliances, consumer electronics and similar products, certain common safety and health requirements for all four abovementioned groups (categorized by their predominant material content) could be recognized as follows:

- Specific identification technologies are needed for the extraction of the substances in a safe manner. Logistics and the collection process should be designed to guarantee that the products and substances are collected properly.
- The recycling of electrical devices is becoming steadily more valuable due to the scarcity of raw materials, but the presence of hazardous substances that contaminate the environment and damage human health is an accompanying problem that should be addressed by the transfer of knowledge, communication development and continuing education.
- A special care is needed to protect disassembly plant workers from being contaminated by hazardous substances and from external injuries. The consumers of goods containing secondary raw materials have to be protected as well. Therefore, safety and health aspects should be one of the most important issues within the recycling industry.

Research organizations, manufacturers, logistic experts, recyclers and landfill managements should exchange information and knowledge to find strategies and practical solutions for one of the fundamental problems of environmental protection – regulating the industrial waste stream by quality and quantity in a financially effective and safe manner.

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# TRETMAN OSTATAKA ELEKTRICNIH APARATA – MOTIVACIONI FAKTORI, ZAKONSKI I BEZBEDNOSNI ASPEKTI

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*U radu se analiziraju ekonomski, zakonski i bezbednosni okviri za razvoj optimalnog tretmana ostataka aparata bele tehnike po isteku upotrebne vrednosti. Naglašeni su ekonomski motivacioni faktori za reinženjering postojećih procedura i proizvoda, dok razvoj legislative u ovoj oblasti predstavlja jasan okvir za budući razvoj ekološki podobnih industrijskih aktivnosti. Zdravstveni rizici u industriji prerade otpada u odgovarajućem sektoru su sistematizovani u cilju širenja saznanja o mogućim implikacijama određenih tehnoloških aktivnosti. Tretman industrijskog otpada i projektovanje ekološki podobnih proizvoda ne obuhvata samo tehnička rešenja, već zahtevaj uvid u pravna, zdravstvena i bezbednosna pitanja iz domena upravljanja sekundarnim materijalima.*

Kljucne reči: *Upravljanje otpadom, elektronski i električni otpad, recikliranje električnih aparata, zaštita na radu u industriji otpada*