Salvageability by design

Legislative efforts to mandate electronics recycling have begun, and companies are already designing their products to comply

You have sold your house and are packing to move. Cleaning out the basement leaves you with a pile of old electronic appliances—a television set, personal computer, toaster oven, electric shaver, and refrigerator. While some of the equipment still works, it is all out-dated technology. So, you pack up the car and head to the local electronics recycling center.

At the center, a technician plugs each piece of equipment into an electronic scanner that quickly provides a list of materials and components in the product, examines its service record, and does a quality check. The assessment determines that the PC suffered little stress in its lifetime and is therefore in excellent condition for resale to secondary markets. You also learn that the compressor and fans in the refrigerator are functioning well and in demand by the service industry for use as replacement parts. Though the remaining electronics have no market value as used equipment or parts, most of the plastic and metal pieces can be separated and recycled.

This scenario illustrates the kind of "intelligent" electronic products you will be using in the 21st century. They are called intelligent because the products each has an electronic memory to enhance their potential for reuse and recycling at the end of their lives. Through a "green port" installed within each product [see table, right], a recycler can access information provided by the product's manufacturer: the material composition of its parts, the location of hazardous components, and disassembly instructions.

The green port also includes information from service technicians who, over the product's lifetime, have recorded repairs and replacement parts, and from sensors that have monitored equipment use and such operating conditions as maximum voltage and temperature. All this data provides the quality control necessary to ensure the integrity of used products and components as they enter secondary markets.

Keeping track of so much information may seem like a scheme hatched by overzealous recyclers, but it is not. The green port concept is being developed by a consortium of leading European electronic equipment manufacturers who are responding to proposed legislation that will require them to recover and recycle their products when no longer useful.

The concept is only one of several initiatives of electronics firms and their industry associations to implement recycling mandates in a cost-effective manner. Though large-scale recycling of diverse electronic products—from refrigerators to personal computers to stereo equipment—is new, the volume of waste involved is enormous. This year, Germany alone will generate 1.5 million tons of electronic scrap, with consumer goods accounting for about two-thirds of it.

PRODUCER RESPONSIBILITY. Dwindling landfill space, increased waste, and toxic releases from waste disposal facilities have renewed interest in household and commercial trash. In these waste streams, valuable raw materials are being buried and therefore removed from the pool of resources available to future generations. For example, about half (by weight) of the electronic waste stream consists of large household appliances containing over 50 percent ferrous metals. If recovered and reprocessed, these metals could replace the use of virgin ore, saving natural resources and energy.

Historically, product users and municipalities have been responsible for solid waste disposal and recycling. In industrialized nations, however, there is growing recognition that only through fundamental changes in product design can waste prevention and recycling be successful: new products must use less material, last longer, be made of recyclable materials, contain fewer hazardous constituents, and incorporate recycled materials. Design changes such as these require the active involvement and innovation of manufacturers so that product function and quality, as well as business competitiveness, are maintained, while environmental concerns are addressed.

For these reasons, a number of countries, including Germany, Japan, Austria, Italy, Switzerland, France, and the Netherlands, are pursuing the "producer responsibility" principle. This marks a new era of environmental accountability for manufacturers, one that directly impacts core business strategy. Manufacturers are being asked to shoulder more responsibility in reducing the environmental impact of products put on the market and in ultimately disposing of them.

Both Germany and the Netherlands have drafted legislation for waste prevention and recycling objectives for the electronics waste stream [see p. 19]. The legislation, in particular, its product "take-back" requirements, has generated an outcry from industry.

Germany's proposed Electronic Waste Ordinance, for example, will place new obligations on product manufacturers and distributors of electronic equipment to take back used products for recycling. The latest draft of the ordinance, dated Oct. 15, 1992, stipulates that the product chain (retailers, distributors, and manufacturers) must

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The green port

Recycling data			Re-use data	
Manufacturer	Recyclability	Additional functions	Lifetime data	Extension
• Name • Date of production ..	• Materials' names • Purity • Additives • Precious metals • Locations	• Serviceability • Data on power management • Protection against claims for guaranty ..	• Maximum voltage • Maximum temperature • Maximum impact • Operation hours ..	(For future needs)
A	B	C	D	E
GREEN PORT				

Source: "An approach to achieve reusability of electronic modules," L. G. Scheidt and S. Zong, Proceedings of the IEEE International Symposium on Electronics and the Environment

collect and recycle used equipment by establishing a reverse distribution system that is free of charge to product users.

In lieu of direct recovery of products from customers, the German ordinance provides another option. Distributors and manufacturers may establish and finance a private collection and recycling system, but certain conditions must be met. The system must be accessible to customers, result in a high level of product returns, and cost consumers nothing. Following collection, electronic scrap may be processed for reuse or material recycling.

Europeans are hotly debating the efficacy of mandatory product take-back obligations, some of which are being applied to such diverse products as packaging, electronics, automobiles, and batteries. But in Germany and the Netherlands, the most aggressive countries on this front, the take-back obligations are temporarily stalled. Industry and government officials there are awaiting further results from the first experiments with product take-back, which involve product packaging, before going ahead with any formal ordinance.

The European Union is also grappling with an electronics recycling policy as part of its priority waste stream project; it began formal discussions on this issue early this year. To complicate matters, any European Union directive must balance the bold take-back proposals of Germany and the Netherlands with countries like France, which prefers to let market forces predominate.

Regardless, it is fairly certain that product recovery and the recycling of electronic products will be a reality across Europe by 1996. Diverting electronics from the waste stream will be the ultimate goal. The points of negotiation will be the mechanisms needed to achieve this goal: in particular, the role of industry in recovery and recycling operations and financing strategies. For example, will industry be solely responsible for administering and financing product take-back systems, or will requirements be flexible enough to allow market-driven strategies to emerge with industry assistance and financial subsidies as needed? In focusing on these questions, the debates surrounding the proposed take-back requirements in Germany and the Netherlands offer some possible answers.

WHO PAYS. The financing of product take-back has generated much debate because the mandate represents a radical departure from business as usual by placing financial responsibility for the end of a product's life on the manufacturer. Dutch and German environment ministries insist that consumer product prices include recovery and recycling costs.

The industry estimates that this approach will increase product prices by 5–8 percent. For example, the collection and sorting of refrigerators cost approximately Dfl 60 today (US $35). Consumers, however, would pay approximately Dfl 110 (US $65) after value-added tax and trade margins, if recycling costs were internalized in the product price.

Paying recycling costs at the time of product purchase also presents a challenge to any industry that sells long-lived products. How does an industry predict the costs of recovery and recycling in five, 10, or 20 years? What technologies will be available and at what cost? What markets will be available for parts resale and secondary materials? One solution proposed by the Dutch appliance industry, Vlehan (Society of Suppliers of Electrical Domestic Appliances), is to use the recycling fees paid today to finance the disposal of appliances discarded today.

The European Association of Consumer Electronics Manufacturers and its national counterparts argue that take-back legislation burdens producers unduly, while neglecting the role and financial obligations of other sectors /such as suppliers, consumers, and local authorities) in generating electronic wastes and future recycling activities. In addition, a cost-effective recycling system must embrace existing municipal collection networks and utilize existing financing through municipal tax revenues.

Another alternative is to directly charge consumers for disposal of used goods. Such charges, however, are deemed unacceptable by the environment ministries because they are potential deterrents to consumers who may opt to avoid the charges by illegally disposing of products. Additionally, strategies that shift the responsiblity for collection and recycling away from manufacturers would lessen the pressure on industry to undertake fundamental changes in product design.

Regardless of who wins the financing debate, however, one thing is certain. Consumers will ultimately pay.

DIVERSE SOLUTIONS. The German and Dutch ordinances apply to a broad range of products. The German one, for example, covers all electrical and electronic devices from household, office, and commercial establishments, ranging from stereos and toaster ovens to large household appliances, PCs, and medical equipment.

These products are diverse. From a materials standpoint, the composition of a refrigerator is quite different from that of a telephone or a television set [Fig.1]. Markets and customers for these products are equally diverse, as are their reuse potential and the value of used materials and components contained within them.

Recognizing the diversity among electronic products, the Dutch environment ministry divided the electronics industry into five branches; the most significant are office equipment, large domestic appliances (including TV sets), and consumer electronics. The ministry is requiring each branch to develop a plan to implement take-back and recycling requirements, tailored to the circumstances and challenges of its own products and markets. Industry plans must address how products will be collected, who will be responsible for collection and recycling, and how the system will be financed. The plans are to be developed by trade associations that represent manufacturers in each industry sector, in consultation with other stakeholders in the electronics chain.

According to Vlehan representative J.

Draft of German and Dutch electronics legislation

According to the German electronic waste ordinance, wastes should be avoided and reduced by:

- Manufacturing equipment and components from materials that are environmentally acceptable and recyclable.
- Designing products that are easy to repair and dismantle.
- Setting up collection systems for used equipment that are "easily accessible to end-users and ensure a high level of returns".
- Salvaging and finding new applications for used equipment and components.
- Assigning used equipment and components that cannot be recycled to appropriate waste disposal facilities.

For the purposes of the ordinance, electronic products include household and commercial products such as office equipment (personal computers, fax machines, and telephones); television sets; large and small domestic appliances; entertainment electronics; laboratory and medical equipment; measurement, control, and automation equipment; and data processing and telecommunications equipment.

The Netherlands' objectives for the electronic waste stream are:

- Prevention—achieve as much quantitative prevention as possible by reducing materials use and increasing the product's useful life.
- Recovery—achieve 100 percent differentiated collection by the year 2000 for optimal product and materials reuse.
- Product reuse—achieve as much re-use as possible of collected equipment.
- Materials reuse—for waste remaining after product reuse, by the year 2000 achieve

90 percent materials reuse for white goods (refrigerators, washing machines, boilers, dishwashers).

70 percent materials reuse for brown goods (television sets, videos, computers, telephones) and other domestic appliances (sewing machines, vacuum cleaners, coffee makers).

95 percent material reuse of metals in metal-grade applications.

30 percent material reuse of plastics in high-grade applications.

- Processing of residues—incineration with energy recovery is preferred.

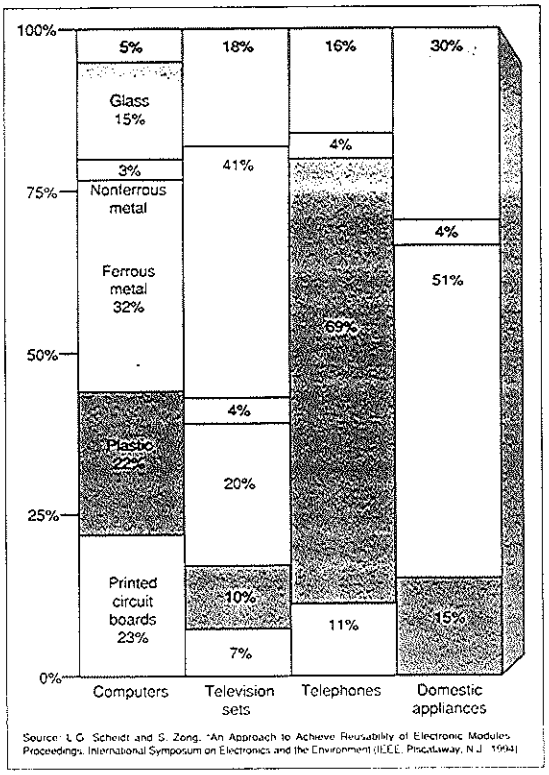
Source: German Federal Ministry of the Environment, Nature Conservation and Reactor Safety, "Ordinance on the Avoidance, Reduction and Salvage of Waste from Used Electrical and Electronic Equipment (Electronic Waste Ordinance)," draft, Oct. 1[illegible] and Bureau B&G, "Analysedocument Projekt Wit En Bruingoed," Rotterdam, May 1993.

van der Burg, the large domestic appliance industry for which he is negotiating has proposed to the ministry that Vlehan establish and administer a collection and recycling system on behalf of manufacturers and importers. The take-back system would utilize existing infrastructure for appliance collection [Fig. 2].

Consumers would be allowed to take used appliances to retail outlets or to municipal collection centers at no charge. (Consumers might also exercise market-driven options such as selling the appliance to a second-hand shop.) The retailer would then have the option of turning appliances over to municipal collection centers in exchange for a bonus, equivalent to US $5, or of using existing networks to recycle the product. Third-party recyclers, under contract with Vlehan, would collect the discarded goods from municipal depots, which would be reimbursed for their expenses, for recycling.

In the Netherlands, as well as in Germany, the ministries would most likely provide more flexibility on product recovery to manufacturers involved in business-to- business transactions. For example, the draft German ordinance states that manufacturers of certain commercial and industrial equipment (that is, laboratory and medical equipment and large commercial items such as data processing and communications equipment) "shall be free to determine the terms governing the nature and place of [product] return."

On the basis of early discussions with the Netherlands environment ministry, Hans

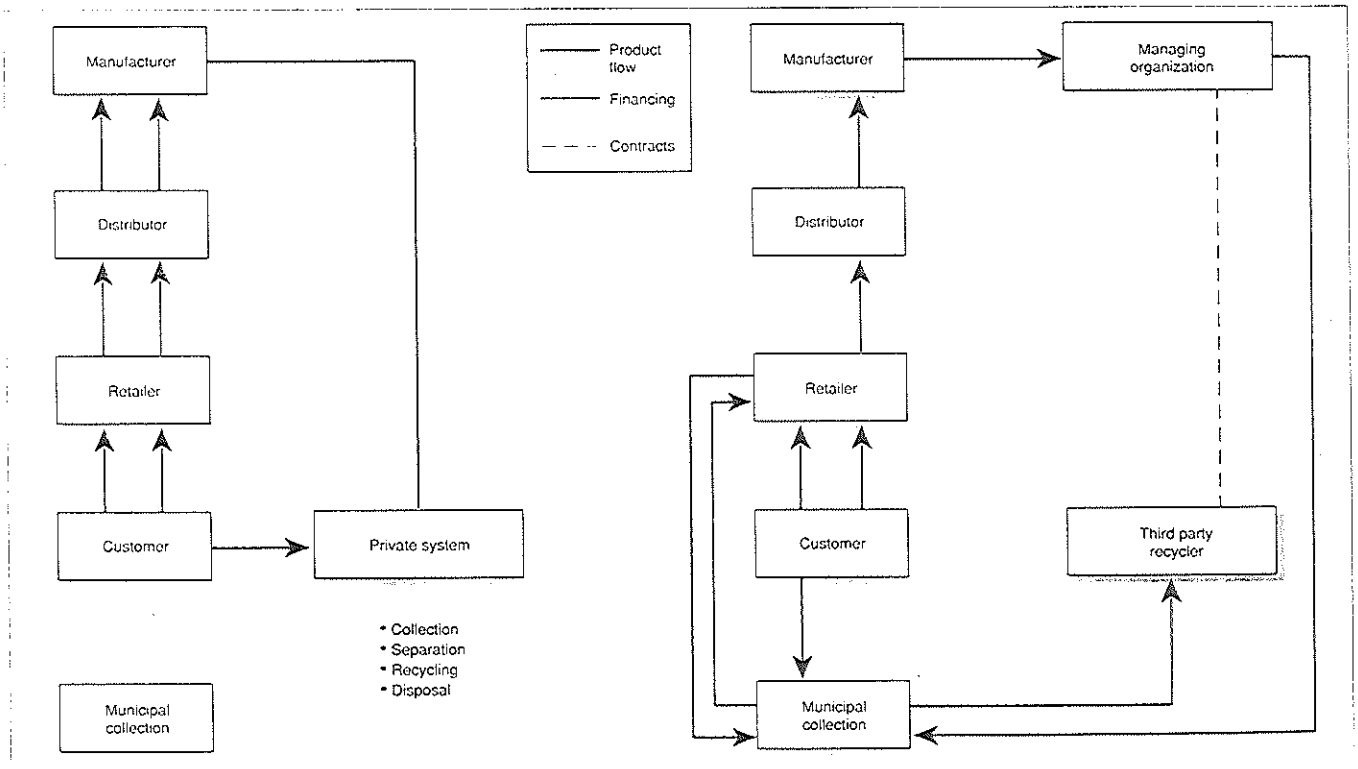


Source: L.G. Scheidt and S. Zong, "An Approach to Achieve Reusability of Electronic Modules," Proceedings, International Symposium on Electronics and the Environment (IEEE, Piscataway, N.J., 1994)

[1] The material composition of these products will, in part, determine their recyclability and associated costs. The high ferrous metal content in refrigerators and PCs is favorable, while the plastic content of telephones presents challenges for cost-effective recycling. The cathode-ray tubes in television sets, which contain hazardous leaded glass, are also a technical challenge for recycling.

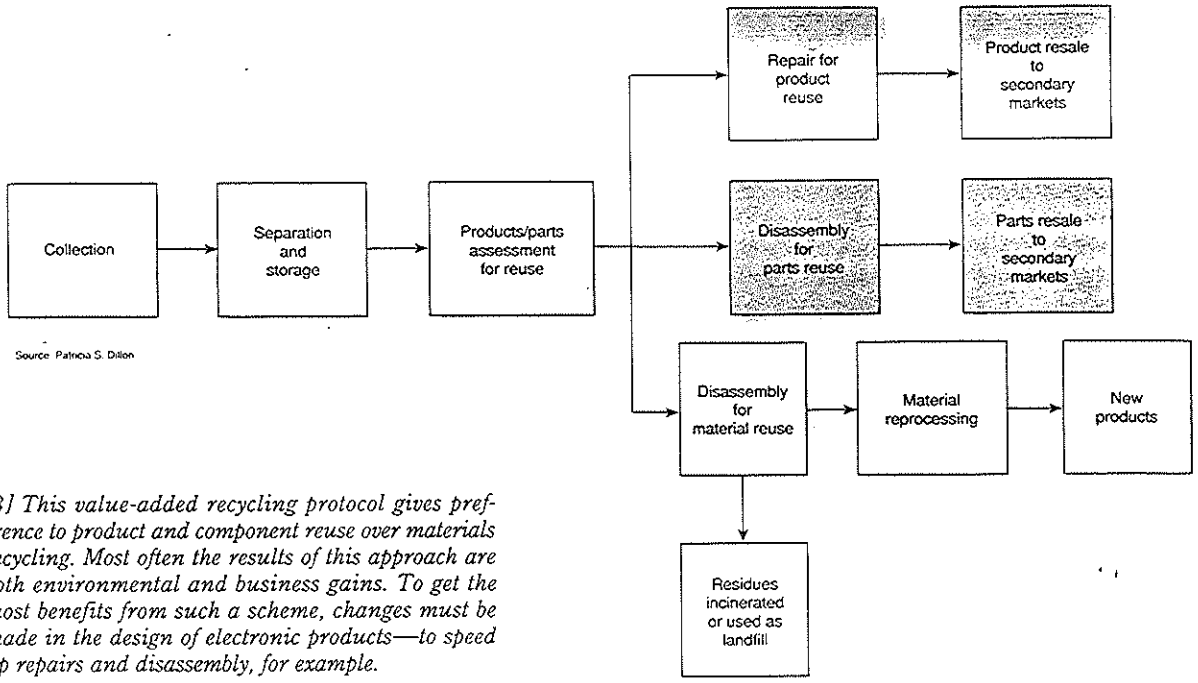
Iserief, an environmental programs strategist at Digital Equipment Corp.'s product recycling center in Nijmegen, believes that two systems for the recovery of office equipment will emerge in his country. For residential customers, a private collection system will probably be established by industry, along the lines of the appliance industry proposal. For business-to-business transactions, companies will most likely recover products directly from customers, who will take advantage of existing customer-supplier relations, service agreements, and trade-in policies.

DESIGN FOR RECYCLING. While the logistics and financing of product recovery are being argued, companies are anticipating product take-back requirements by positioning themselves and their products for recycling. Partnerships among manufacturers, industrial customers, and recyclers are



Source: J. Ertel, "Current Technologies for the Valorization of PCB's and Electronic Waste," Proceedings, International Symposium on Electronics and the Environment (IEEE, Piscataway, N.J., 1994)

[2]: To comply with product take-back legislation, manufacturers may establish either a reverse distribution system in conjunction with retail establishments or a separate industry-funded collection system [left flow chart]. A take-back system proposed in the Netherlands would be managed by industry [right flow chart], with consumers returning products to retail establishments or using existing municipal collection sites.



Source: Patricia S. Dillon

[3] This value-added recycling protocol gives preference to product and component reuse over materials recycling. Most often the results of this approach are both environmental and business gains. To get the most benefits from such a scheme, changes must be made in the design of electronic products—to speed up repairs and disassembly, for example.

emerging to develop recycling technologies and pilot processes for discarded equipment.

For example, three European manufacturers of TV sets have teamed up with a glass manufacturer to recycle picture tubes, while the German postal and telephone giant, Deutsche Telecom, has formed a consortium with manufacturers to recycle telephones.

Meanwhile, Siemens-Nixdorf and Digital Equipment have established company-operated recycling facilities in Germany and the Netherlands, respectively. In order to reap maximum savings, Digital set up a value-added protocol as a guide for making recycling decisions [Fig. 3]. At its facility, Digital recovers and performs partial disassembly of products into component parts. In partnership with Digital, firms specializing in recycling provide their services for glass, metals, and printed-circuit boards.

But even as industry seeks to implement cost-effective recycling, it must confront some daunting obstacles. Electronic products entering the waste stream today were not designed with recycling in mind. A lack of information about their composition, material variety, purity of recyclates, and hazardous constituents presents hurdles to their being successfully recycled, particularly plastics.

In the future, cost-effective recycling will require product design changes that reduce disassembly time and increase the reuse and recyclability of components. The expected changes will include product simplification, standardization of components and product configuration, and modular designs, especially with components for reuse. Also required will be standardization of material types, easily detachable parts, and reduction in the number of pieces requiring disassembly. Moreover, components in products will have to be easily accessible, and the number of material types cut to reduce sorting. Through such approaches, the European Association of Consumer Electronics Manufacturers predicts savings in recycling costs of almost 40 percent.

Such initiatives are already under way. At Sony Europe, for example, new TV set designs incorporate more snap-together parts and fewer screws to speed product disassembly, as well as fewer material types to reduce the amount of sorting required for recycling. In the design of its new Eco-PC, Siemens AG in Germany reduced the number of parts in its computer by two-thirds, so that disassembly took a quarter of the time needed for previous models.

Despite its apparent flaws, product take-back obligations in Europe are having a positive impact on product design and the development of a recycling infrastructure. Product take-back legislation is stretching the imaginations of companies and compelling them to consider new options for design and product disposal. Moreover, the impact on product design transcends national boundaries. U.S. manufacturers, too, are responding to the mandates in order to remain competitive in European markets.

Throughout Europe, most probably several scenarios for product recovery and recycling will evolve over the next several years, including industry pool organizations (such as the one proposed by the Dutch appliance industry) and company-operated product recycling facilities. The United States and other countries that lag behind others in the development of national product recovery and recycling strategies should learn from the grand take-back experiment in Europe. In the meantime, they can encourage market-driven approaches to product recovery and recycling.

TO PRobe Further. The conference records of the IEEE International Symposia on Electronics and the Environment (1993 and 1994) provide technical, managerial, and policy papers on product design, recycling, and end-of-life management of electronic products. At the May 1994 conference, several papers focused on international policy developments in electronics recycling and industry's response. A.J. Clegg and D.J. Williams present the results of an international survey of electronics firms and how they are preparing for expected product take-back legislation. J. Ertel discusses the state-of-the-art in electronics recycling in Germany. L. Scheidt and S. Zong present the "green port" concept in their paper, "An Approach to Achieve Reusability of Electronic Modules."

Draft legislation and supporting documentation is available through the environment ministry in the country of interest, although the information may be available only in the native language. Industry associations such as the European Association of Consumer Electronics Manufacturers and German Electrical and Electronic Manufacturers' Association (ZVEI) have prepared discussion papers to contribute to legislative debates. ◆

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