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# EXTENDED PRODUCER RESPONSIBILITY:
## REEXAMINING ITS ROLE IN ENVIRONMENTAL PROGRESS

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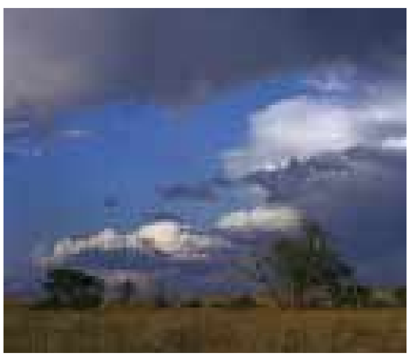






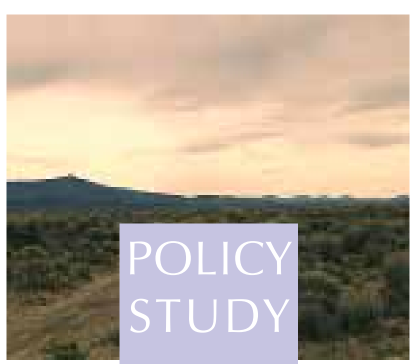


POLICY STUDY 293

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Policy Study No. 293

# Extended Producer Responsibility: Re-examining Its Role in Environmental Progress

By Joel Schwartz and Dana Joel Gattuso

## Executive Summary

Environmental policymakers have increasingly turned their attention to the environmental impacts of products. One concept—extended producer responsibility (EPR)—has captured the hearts of policymakers globally. Variations on this concept have surfaced, but EPR policies generally impose a fee that is paid by manufacturers for targeted products, and establish specific "take-back" goals for each targeted material or product. EPR rests on the idea that if manufacturers pay for the post-consumer impacts of products, they will design them differently to reduce waste. But other opportunities to more fully include environmental values into product-design decisions exist, and their lack of realization should not be deemed "market failure," but rather a natural consequence of the complexity of the design, production, and distribution of good and services, the physical impossibility of vigorously pursuing all values simultaneously, and the continual emergence of new values.

Most proponents of EPR assume that current product-design practices deter efficient resource use and don't adequately mitigate environmental impacts. Yet product-design trends belie this assertion. Manufacturers are moving toward reduced material-use per unit of output, reduced energy use in making and delivering each product, and improved product performance—including environmental performance.

It is not clear that EPR programs accelerate or enhance this process for several reasons. First, the various goals of EPR programs are not necessarily compatible. For example, fees set to reflect recycling costs and thus encourage "design for recyclability" may discourage source reduction and use of lighter and more durable modern materials such as laminates, composites, and plastics. Second, there is no intrinsically right fee level for EPR programs. Packaging fees among European nations vary as much as 35-fold for identical products. Fee setting is generally a political, rather than a scientific or economic exercise. Resulting fees give manufacturers confusing and conflicting signals about which design goals to pursue. To date, EPR has been most frequently applied to packaging and electronics. There is no single model of EPR, so evaluating just a few experiences is at best only suggestive.

What does the record to date show? Germany's celebrated take-back program for packaging has a mixed record, with high costs for performance achieved. Under its Green Dot EPR program, Germany exceeded its waste-recovery targets. But over same time period, with no EPR system in place, the U.S. experienced even greater reductions in total packaging used per unit of output. Canadian packaging manufacturers, who set a voluntary reduction target of 50 percent in packaging sent for disposal, achieved that goal four years ahead of schedule with no EPR and at lower costs than Germany. The Netherlands also had a voluntary approach to packaging reductions under which packaging consumption declined 6 to 15 percent per year initially, dropping to 1.5 percent in later years. Overall reductions in packaging materials were greater in the Netherlands than in Germany.

Effects of mandatory electronics take-back programs are either undocumented or ambiguous. If European Union (EU) EPR directives for electronics steer manufacturers away from plastics, EPR could reverse trends toward more lightweight materials use, increasing shipping costs and energy use. For some electronics products, EPR programs actually generate high costs with minimal or no gains in recycling or other environmental amenities.

Though mandated programs may generate costs with few environmental (or other product-value) gains, some voluntary programs are also emerging. These voluntary programs face several challenges that include: 1) finding mechanisms to attract customer participation; 2) establishing cost-effective collection and return networks for discarded products; 3) identifying markets and uses for returned products and materials; and 4) achieving cooperation where multiple firms are involved.

The performance of voluntary EPR programs depends on program design and the nature of the production and consumption marketplace within which the program operates. Voluntary take-back programs appear to have emerged when one or more of the following characteristics dominate: 1) a high risk of improper disposal and associated liabilities; 2) a high value associated with the discarded product; 3) relatively low-frequency, high-value transactions between a manufacturer and consumer; 4) relatively close or ongoing relationship between the customer and manufacturer; and/or 5) high-end products for which environmental goals may enhance customer loyalty.

The failure of voluntary EPR programs to emerge in some instances is not evidence of market failure. It is an indication that manufacturers anticipate more costs than benefits to their consumers from these programs, and that some barriers (for example, disadvantageous tax treatment for leased rather than purchased products) may inhibit introduction of take-back programs. If benefits from EPR in a particular situation appear likely to accrue, those potential benefits represent an entrepreneurial opportunity that will, over time, attract investment.

Industrial ecology—market-driven innovations to add economic value through investing in environmental improvements to products and manufacturing processes—offers a more comprehensive framework than EPR for achieving environmental benefits. It involves a systematic search by manufacturers for opportunities to reduce environmental impacts as a source for cutting costs or increasing customer benefits.

Four factors are driving the trend toward industrial ecology. First is consumers' increasing concern for nature and environmental values. Second is the emergence of "smart" technologies that make possible new relationships between manufacturers and suppliers and between customers and consumers, and that heighten prospects for replacing production equipment with "knowledge equipment" (for example, use of tractor-mounted computers to allow for highly tailored and efficient fertilizer application). Third is increasing affluence, which is correlated worldwide with increased environmental investment. And fourth is production dynamics, in which companies, having tapped the "low-hanging fruit" of savings available from improving labor productivity and energy efficiency, are now looking for competitive advantage in smaller, dispersed opportunities such as pollution prevention and waste exchanges.

Industrial ecology transcends the common assumption that environmental investments undermine economic performance. But industrial ecology does not rest on the expectation that all waste reduction and pollution prevention will yield bottom-line benefits. Instead, industrial ecology is best understood as a discovery system—a way of organizing information and framing problems.

Mandated EPR programs override this discovery process, forcing creation of take-back schemes within a regulatory framework that prescribes institutional arrangements. Like earlier environmental regulations that prescribed technological responses, such mandates stifle innovative market processes, impose uniform procedures for diverse circumstances, and necessitate the acquisition and reporting of large amounts of implementation and compliance data without guaranteeing tangible environmental benefits.

# Table of Contents

**Part 1**

# Introduction

"Producer responsibility is a philosophy, not a description of a cheap and reliable system."

—*Ib Larsen, Denmark Environmental Protection Agency*

Environmental policymakers, once preoccupied with pollution from production processes, have increasingly turned their attention to environmental impacts of products. The reasons are many:[1]

- Products use natural resources;
- Product use often creates environmental impacts; and
- Discarded products become waste that must be treated in some way—recycled, composted, incinerated, or deposited in landfills.

One concept—Extended Producer Responsibility (EPR)—has captured the hearts of policymakers globally as a solution. Proponents of EPR and its various conceptual cousins argue for "a new generation of pollution prevention policies that focus on product systems instead of production facilities."[2]

## A. Definitions

The term "extended producer responsibility" first surfaced in Sweden in the 1980s.[3] The Paris-based Organization for Economic Cooperation and Development (OECD), which has attempted to advance EPR programs by documenting case studies and developing templates for model programs,[4] defines EPR as:

> *An environmental policy approach where the producers' responsibility, physical and/or financial, for a product is extended to the post-consumer stage of a product's life cycle. . . . Producers accept their responsibility when they design their products to minimize life-cycle impacts and when they accept legal, physical, and/or economic responsibility for the environmental impacts that cannot be eliminated by design.*[5]

Variations of this concept have surfaced. The U.S. President's Council on Sustainable Development, for example, refers to "extended product responsibility."[6] This slight rewording maintains an emphasis on products and their environmental impacts but does not confine responsibilities for managing environmental impacts to producers. Instead, the council proposes that "actors along the product chain share responsibility for the life-cycle environmental impacts of the whole product system."[7] Other expressions of the concept refer to product stewardship, product take-back, or shared product responsibility.

These definitions share two features. First, their focus is intended to be on the life-cycle environmental impact of products. Second, by altering or refining the distribution of liabilities for product maintenance and disposal, they attempt to strengthen feedback loops to product designers to encourage design of products with fewer environmental impacts.

These two features arise from the common assumption that "the design of products and product systems is the most critical step in determining the nature and quantity of resource and energy use and pollution outputs throughout the products' life cycles."[8] Implicit in the appeal for an altered allocation of liabilities for product maintenance and disposal is an assumption that current arrangements result neither in optimal resource use nor in systematic efforts to reduce post-consumer waste impact.

A draft of the 1999 OECD report on EPR is explicit about this assumption. Existing pollution-prevention policies, the document states, "have not been sufficient in creating incentives for producers to address basic choices of materials and product designs which influence life cycle environmental impacts of products. EPR, on the other hand, can create such incentives and influence the reduction of life cycle impacts of products."[9]

## B. EPR Policies and Programs

Many policies and programs, both mandatory and voluntary, potentially fall under the EPR umbrella. A University of Tennessee report on extended product responsibility identifies a variety of such measures, including:[10]

- Mandatory take-back programs with recycling targets;
- Deposit-refund systems;
- Environmental labeling systems;
- "Green" government procurement programs;
- Recycled-content requirements;
- Environmental fees on products;
- Materials-use restrictions, phase-outs, and bans; and
- Voluntary private-sector programs of product leasing, take-back, "green" design consortia, the provision of information and service rather than simply physical product, and so on.

All these programs and policies aim, in various ways, to influence product design. However, the concept of EPR has been most consistently identified with programs that require firms to "take back," recycle, or reuse (either directly, or indirectly by contracting with a third party) their products when discarded by the end user. In essence, these programs rearrange the allocation of rights and responsibilities associated with products as they pass from producer to retailer to final consumer.

Most mandatory EPR programs have two components:

- They impose a fee paid by product manufacturers on targeted products; and
- They establish specific take-back goals for each targeted material or product.

## C. EPR Trends

Product take-back programs have taken root internationally (see Table 1). Over 25 nations have some form of EPR program for packaging—the most celebrated program being Germany's packaging ordinance, which gave rise in 1991 to its privately operated Green Dot program. Nearly two dozen nations, including the

United States, have EPR programs for some batteries. Others are rolling out EPR programs for automobiles, electronic and electrical equipment, appliances, and other products.

**Table 1: Worldwide Extended Producer Responsibility Laws: Selected Sample in 1998**

| Nation | Products | Recycling or Recovery Target |
|---|---|---|
| **Europe** | | |
| ▪ European Union (EU) Directive | Directive on packaging binding on national governments<br>Directive on electronic equipment | 50% minimum recovery by 2001; 25% minimum recycling rate.<br>Recycling targets vary by product type. |
| ▪ Austria | Batteries, refrigerators, packaging | Various materials, 20%-70% recovery. |
| ▪ Belgium | Appliances, batteries, electronics, packaging | Recovery targets by 2000: 95% ferrous, 85% non-ferrous, 20% plastics; 50% total packaging recovery by 1999. |
| ▪ Denmark | Batteries, packaging (voluntary) | 54% overall recovery rate by 2000, with 50%-60% industrial waste. |
| ▪ Finland | Packaging | 82% of packaging recovery. |
| ▪ France | Batteries, packaging | Follows EU directive. |
| ▪ Germany | Batteries, packaging | Various materials 60%-75% recovery. |
| ▪ Greece | Packaging | 25% recovery by 2001. |
| ▪ Ireland | Packaging | Not Available |
| ▪ Italy | Appliances, batteries, packaging | Recover 30,000 appliances a year; follows EU directive for packaging. |
| ▪ Luxembourg | Packaging | 55% recovery. |
| ▪ Netherlands | Appliances, batteries, packaging | Appliance/battery recovery: 90%.<br>Packaging recycling: 65%. |
| ▪ Norway | Appliances, batteries, packaging | Appliances: 80% recovery within 5 years; ni-cad battery pilot: 20,000 households; packaging recovery follows EU directive. |
| ▪ Poland | Packaging | Follows EU directive. |
| ▪ Portugal | Packaging | 25% recovery by 2001; 50% recovery by 2005. |
| ▪ Slovakia | Packaging | Follows EU directive. |
| ▪ Spain | Batteries, packaging | Follows EU directive. |
| ▪ Switzerland | Packaging | Follows EU directive. |
| ▪ United Kingdom | Packaging | Overall target 38%, increasing to 52% by 2001. |
| ▪ Czech Republic | Packaging | Similar to EU directive. |
| ▪ Estonia | Packaging | 60% recovery by 2001. |
| ▪ Slovenia | Packaging | Recycling recovery: 48% by 2000; 78% by 2010. |
| **Asia** | | |
| ▪ China | Packaging | Not Available |
| ▪ Japan | Appliances, packaging | Not Available |
| ▪ South Korea | Packaging | Not Available |
| ▪ Singapore | Packaging (voluntary) | 80% waste reduction through recycling. |
| ▪ Taiwan | Packaging | Not Available |
| **Latin America** | | |
| Brazil | Packaging | Specific manufacturers must set up recycling centers for combustible oils, cosmetics, etc. |

Source: Raymond Communications Inc., www.raymond.com, 1998.

Three European nations—Germany, the Netherlands, and Sweden—have developed comprehensive EPR frameworks. These frameworks impose general requirements for product responsibility on product designers, producers, distributors, and others "to design, produce, distribute, and use products so as to avoid the creation of waste and to recover and manage waste in an environmentally sound manner."[11] Some emerging programs—like Dell's computer take-back program or Nike's "Reuse-a-Shoe" program—are voluntary programs set up by companies. Many programs, however, have resulted from legislation.

In Canada, several provinces have outlined take-back programs for packaging, newspapers, and other products. In the United States, the Environmental Protection Agency (EPA) is coordinating a National Electronic Product Stewardship Initiative to explore options for handling end-of-life electronic products. Several states either considered or enacted EPR policies in the 1990s. Minnesota, for example, proposed legislation that would establish EPR as a general principle from which to develop more specific product policies. In 2000 the state launched a public-private dialogue to identify EPR options. Maine passed EPR legislation targeting mercury-containing products. The U.S. Conference of Mayors, influenced by its Municipal Waste Management Association (MWMA), actively debated in 1999 whether to endorse EPR as a policy priority. Officials of Austin, Texas, suggested introducing EPR programs in the city. In their outreach efforts, the Grass Roots Recycling Network championed EPR as a way to enhance waste-reduction and recycling.

The popularity of EPR as a public policy tool is growing. Some proponents view take-back schemes as necessary to inspire manufacturers to design products that minimize consumer waste or facilitate product recycling. Other proponents advance the more prosaic goal of shifting direct waste-management costs away from taxpayers or waste-service consumers to product manufacturers.

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Mandated EPR programs provoke theoretical questions and face practical limitations to their efficacy as an environmental policy instrument.

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## D. Issues and Challenges

Despite their popularity, mandated EPR programs provoke theoretical questions and face practical limitations to their efficacy as an environmental policy instrument. Voluntary take-back programs, on the other hand, are emerging in specific situations where manufacturers tailor such programs to add value for their customers by reducing costs or improving total product quality.

As a policy idea, EPR has garnered international appeal fairly rapidly, in part because it sounds simple and its central goal—environmentally benign product design—is lofty. But is it good public policy? Addressing this question involves examining layers of other questions, both theoretical and practical. These fall into four categories:

- **General Theory**. As a matter of theory, is there a general case for allocating responsibilities for post-consumer waste at a particular point along the production-consumption chain?
- **The Problem Set**. What are the dimensions of the problem to be addressed? What are trends in resource-use efficiency? What are trends in waste generation and waste management? What are trends

in waste-management costs? Have EPR proponents correctly characterized resource-use and waste-reduction challenges?

- **The Results**. Where EPR programs have been implemented, have they achieved intended outcomes? At what cost have these outcomes been achieved? How do these outcomes compare to baseline trends where no EPR program exists?
- **Alternatives.** What alternatives exist to enhance or accelerate investments in resource efficiency, pollution prevention, waste reduction, and related goals? What are the extent and performance records of these alternatives?

The following sections examine these issues.

**Part 2**

# EPR Theory Revisited

Proponents of EPR view the concept as an extension of a "polluter pays" principle; that is, pollution generators must mitigate or pay for their pollution. Put another way, proponents argue that EPR will "internalize" the costs of "negative externalities," that is, undesirable spillover effects that result from production and consumption. On a more practical level, EPR proponents argue that the current allocation of responsibilities for pollution mitigation and waste management does not result in "environmentally optimal development."[12]

Few would dispute the idea that polluters should be responsible for the pollution they cause. But acknowledging this principle reveals little about the merit of EPR in theory or practice. Three problems cloud EPR theory:

1. Asserting the polluter-pays-principle does not indicate *what pollution is*;
2. The principle does not disclose *who is responsible for what*; and
3. "Responsibility" is itself a broad term that leaves undefined the dimensions or boundaries of the concept of responsibility.

**1. What Is Pollution?** In conventional environmental economics, pollution refers to the residuals from production and consumption that create harmful or unpleasant impacts—for example, harmful air and water emissions, releases of toxins into soils, and so on.[13] The polluter is the generator of these harmful or unpleasant impacts. Under this definition, responsibility for pollution lies with the person or persons who directly generate these impacts. As ownership of a material or product shifts from the resource extractor to the manufacturer to the retailer to the final consumer, responsibility for waste and pollution generated at each stage has generally also shifted.[14] U.K. economist Julian Morris has described this shifting chain of responsibility:

> *The polluter is the party that is most directly responsible for contamination of the environment. Extractors transform deposits into raw materials; industry converts those raw materials into more complex goods; consumers use these goods. At each stage, waste is produced as a by-product and must be disposed of in an appropriate way. . . . Responsibility for waste management falls on the final producers of waste products—whether they are extractors of raw materials, producers of goods, or consumers of those goods.*[15]

EPR theory departs significantly from conventional environmental economics. EPR theory broadens the meaning of "polluter" to include "any person or organization which produces a good that, if disposed of in a certain way, might cause pollution."[16] In some discussions of EPR, the use of resources, distinguished from any harmful residuals or waste associated with that use, is implicitly characterized as pollution.

These new definitions of pollution (and the polluter) are problematic. They blur the distinction between actual and hypothetical pollution, inviting the prospect that “pollution” fees or fines will be assessed even in the absence of any environmental impacts. Such fees may add to the costs of goods without introducing tangible benefits. Moreover, these definitions erode any distinction between resource consumption, the costs of which are typically already incorporated into the prices paid for goods and waste-management services, and pollution externalities, the costs of which are not captured in economic transactions. Thus, the altered definitions of pollution embraced by many EPR proponents may distort, rather than improve, market-pricing signals regarding resource scarcities.

In some discussions of EPR, the actual use of resources, distinguished from any harmful residuals or waste associated with that use, is implicitly characterized as pollution.

**2. Who Is Responsible for What?** Using the more traditional definition of pollution, the polluter-pays principle requires that the person, firm, or organization that most directly generates environmental harms is responsible for their mitigation through prevention, emission control, or clean up. This notion of responsibility underlies virtually all modern environmental management systems and laws. Miners are (in theory) accountable for mining waste; manufacturers are accountable for air, water, and solid-waste emissions that occur during the production process; retailers are responsible for their waste; consumers (through taxes or service fees) are responsible for their sewage, their trash, and other environmental impacts they cause.

Mandated EPR programs depart from this traditional polluter-pays principle, replacing it with a “producer pays principle.” This departure from the traditional polluter-pays-principle has two consequences. First, it diminishes responsibility of others along the production-consumption chain for pollution that they might generate as a result of when and how they use and discard a product. It is not at all clear that the manufacturer ought to be responsible in all circumstances for a product once possession has been transferred to the consumer. A brief mental exercise demonstrates why it is difficult, or even misguided, to apply this assumption as a general precept.

Think of automobiles. On the one hand, manufacturers are responsible (increasingly, through regulations) for producing cars that do not pollute or emit only very small amounts of pollution. But once motorists acquire these cars, they control when and whether to maintain the car in good operating condition, how they drive their cars, and whether to have periodic tests to check that the car is still operating at low emission levels. Asserting that the manufacturer is responsible for the car essentially lifts from the consumer any personal responsibility, which is unlikely to result in good environmental outcomes over the long run.

The departure of EPR programs from the traditional polluter-pays principle has a second consequence: it blurs the distinction between products per se and any pollution that those products might cause. Take the example of packaging. Packaging is not *per se* pollution. Packaging is deliberately produced; it is not a residual of production. It serves many beneficial purposes. Unless it is littered (an act by the consumer not the producer) or discarded into improperly operated disposal facilities, the package does not constitute pollution.

The manufacture of packaging does, of course, require resources. But the use of these resources generally is not “external” to the economic transaction. Packaging is typically owned all along the continuum from production through sale, consumption, and disposal, though who owns the package varies as the package itself changes hands. As ownership shifts, costs to make, ship, store, and, finally, discard packaging are all incorporated into the package price and waste-disposal taxes and/or fees paid for by the end user.

However, EPR theorists sometimes present this allocation of costs as inefficient and as evidence of a "market failure" distinct from externalities problems. Rather than suggesting that EPR will internalize "external" costs—in the form of emissions or waste—associated with the consumption of products and packages, this alternative argument suggests that the costs of post-consumer waste are typically borne by the taxpayer/consumer, not the manufacturer. As a result, this cost information is not part of the design decision-making of the manufacturer. In other words, of the many resource costs (such as raw material, processing, shipping, and storage costs) that the manufacturer takes into account in designing products, post-consumer waste costs are not among them. Hence, some EPR theorists argue, manufacturers do not try to minimize these costs by designing for recycling, re-manufacture, composting, or reuse.

This claim has some theoretical merit—it is correct that manufacturers do not typically bear these post-consumer waste costs. But this allocation of responsibilities is not necessarily inefficient. What allocation of responsibilities will "add value" by creating incentives for reduced manufacturing costs (through dematerialization, improved labor productivity, reduced production costs, and so on) and/or improved product and service quality (including but not limited to reduced waste-handling costs) will depend on the product and circumstance.

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Asserting that the manufacturer is responsible for the car essentially lifts from the consumer any personal responsibility, which is unlikely to result in good environmental outcomes over the long run.

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For example, computer manufacturers may increase market share by "adding value" to customers through computer leasing (take-back) programs in several ways. Leasing may allow the user to upgrade more frequently; it may reduce used-equipment storage costs; and it may reduce waste-disposal costs. These benefits may be sufficient to allow manufacturers to recoup the costs of a lease and take-back system. On the other hand, for high-volume, low-cost consumer goods that use few materials per unit, such as many grocery items, a take-back system may add little or no value to the consumer while simply adding to production, distribution, and product-handling costs. In this case, an EPR program may not present an optimal product-ownership arrangement.

**3. What constitutes "responsibility"?** The term "responsibility" implies a duty, burden, or obligation to do something. But that "something" must be specified. In market economies, custom, contracts, tort law, and statutes jointly determine who is responsible for what. Unless contracts specify otherwise, consumers, once a product is in their possession, are generally responsible for a product's disposition–what they do with the product, when they sell it to others, or how they discard it. This arrangement ensures some level of security of possession and some level of stewardship for the product.

Exceptions to this allocation of responsibilities exist, especially in the realm of liability laws relating to accidents or harms resulting from the use of a product. Here, product manufacturers, or even retailers, may be held accountable for these harms and product failures. In contrast to these liability laws, EPR laws do not target harms; they target the mere existence of a product.

EPR programs, which place some part of waste-handling costs in the up-front purchase price of a product, do not internalize an externality. They shift some or all of the costs of waste-handling from a back-end trash fee or tax to an up-front product cost.

Both up-front and back-end fees can, in theory, incorporate the costs of waste management. Neither approach has a theoretical advantage in this regard. But the two approaches have different costs and implications associated with their implementation. The two options may differ in their implementation costs, including:

- Transactions costs: the costs associated with maintaining contracts and reporting and collecting fees;
- “Price-searching” costs: the costs associated with identifying the per unit waste-management costs and apportioning those costs; and
- Dynamic costs: the costs associated with revising unit fees as unit costs change over time.

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In contrast to these liability laws, EPR laws do not target harms; they target the mere existence of a product.

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These relative costs must be weighed against actual, rather than hoped-for marginal benefits in resource efficiency achieved by placing the waste-handling fee up front at the point of product purchase versus a backend waste fee. These issues will be examined later in this study.

EPR programs cannot, then, be justified as a correction of some market failure or, in purely philosophical terms, as consistent with a polluter-pays principle. Instead, EPR programs must be examined empirically: does a shift of waste-handling fees, coupled with mandatory waste-recovery and recycling targets, generate hoped-for benefits (for example, increased resource efficiency beyond baseline competitive market trends) and more efficient waste-management systems? How do these benefits compare with any accompanying increased costs?

Several more basic questions warrant some review before turning to the performance record of mandatory EPR programs.

**Part 3**

# EPR and Environmental Trends

All policy proposals generally rest on a set of assumptions about an identified social, economic, or other challenge—a problem that requires redress, an unmet need, or a persistent injustice. EPR policy proposals are no exception.

## A. Refining the Policy Challenge

Most policy literature on EPR assumes that current product-design practices *are* deterring efficient resource use and do not adequately move toward mitigating environmental impacts. According to EPR proponents, the decisions of retailers and consumers also fail to adequately account for the environmental impacts of their choices.

In a University of Tennessee report on extended product responsibility, for example, its authors state: "because it has not been common for producers to take responsibility for the upstream or downstream environmental impacts of their products, these environmental impacts have rarely entered into their design strategies."[17] An OECD document on EPR uses near-identical language.[18] Others point to a growing waste stream; persistent problems with special wastes such as mercury, cadmium, or lead; and modest recycling levels for some products or materials as evidence of a need for some sort of policy to change consumption and waste-generation patterns.

But these broad-brush claims require some scrutiny and refinement before one can establish solid claims for the need to mandate product-intervention policies such as EPR. And the problem must be placed within the dynamic context of materials-use and product-design trends in order to better understand *what* is happening, *how* product-design choices are made, and the *rate* of changes in resource-use trends.

Addressing several questions will help set the scope of the asserted problem and place it in a temporal context.

- ***What does empirical evidence show regarding trends in product "eco-efficiency" (energy and materials use per unit of output)?*** Identifying these trends will disclose whether claims that resources are inefficiently used and waste is increasing are generally valid. Resource efficiency is, of course, both a relative and a dynamic concept, so a key question is whether trends are moving toward reductions in resource (and energy) use per unit of output. Achievements in resource efficiency and reductions in waste in the absence of EPR may indicate that the traditional allocation of responsibility for end-of-life product costs is not a major deterrent to environmental performance of products.

- ***What are the relative influences of product design, demographic trends, GDP growth, changes in per capita income, and other factors on materials and energy use and environmental impacts?*** Understanding these influences may reveal the importance of macroeconomic and social factors relative to firm-level decisions in overall consumption and resource-use patterns. If macroeconomic or other social factors are significant, policies that reorganize firm-level incentives may have little overall effect on materials use and waste generation.
- ***What are the key environmental impacts of different product categories?*** In a product life cycle, where are impacts most pronounced—upstream, in the manufacturing phase, in transportation and distribution, in use, or at end-of-life? Understanding these differential impacts is relevant to product policy, since program effectiveness in producing optimal environmental benefits requires targeting key impacts at high-impact points along the life-cycle continuum. High-impact targets are likely to vary by product, product category, and location.
- ***What criteria influence product design and process decisions?*** Identifying these influences will help illuminate those policies and market practices that undermine or slow the search for resource efficiencies and environmental impact reductions. Institutional arrangements that place the costs of end-of-life handling on consumers or taxpayers are only one influence on product-design and process decisions—and may vary in their significance from product to product. Other factors, such as relative availability and price of materials, safety and other product performance requirements, tort laws, and so on, may "drive" design decisions more than disposal costs. Hence, a shifting of waste-management costs from the consumer to the manufacturer may have little effect or may diminish other product qualities.

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Most policy literature on EPR takes as a given that current product-design practices *are* deterring efficient resource use and do not adequately move toward mitigating environmental impacts.

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## B. Product Design, Resources, and Impact

Fully addressing the above questions is beyond the scope of this report. However, a few summary comments suggest that product-design trends are moving toward reduced overall environmental impacts per unit of output. Even without directly paying for post-consumer waste-handling costs, other factors are moving manufacturers toward reduced material-use per unit of output, reduced energy use in making and delivering each product, and improved product performance, including environmental performance.

### *1. Trends in Materials Use and Consumption*

Many factors affect materials-use trends and consumption. On the one hand, population growth and increasing wealth tend to push aggregate consumption levels up. On the other hand, technological changes often improve the efficiency with which resources are used, leading to lower energy- and resource-use per unit of output. Likewise, improvements in energy efficiency tend to be accompanied by reductions in pollution per unit of output.

The academic literature that attempts to assess these general trends is too vast to summarize in full. However, the empirical evidence generally supports a few conclusions:

- ***Consumption per unit of economic activity generally declines over time.*** Researchers at Rockefeller University and the University of Texas concluded that, "assessment of consumption per unit of economic activity shows a dematerialization in physical materials of about one-third since 1970."[19]
- ***Consumption of materials per unit of output also declines over time.*** The same university researchers conclude that, "each new material shows improved physical properties per unit quantity, thus leading to a lower intensity of use."[20] They amplify this point by noting that, "with regard to industry, encouraging examples of more efficient materials use exist in many sectors, functions, and products. Firms search for opportunities to economize on materials, just as they seek to economize on energy, labor, land, and other factors of production."[21]
- ***On the other hand, with a few exceptions in particular categories, there are no signs of decline in overall consumption at the level of the individual consumer.*** There is, to date, no evidence of "saturation of individual material wants."[22]

Even without directly paying for post-consumer waste-handling costs, other factors are moving manufacturers toward reduced material use per unit of output.

Eco-efficiency, defined as the amount of material and energy used to produce each product unit, is improving. "This dematerialization means a defined level of consumption is occurring with less resource use, less accompanying waste, and a 'lighter' footprint on the earth."[23] From an environmental standpoint, the gains from eco-efficiencies can be significant. In American forestry, between 1970 and 1993, harvesting and production improvements increased by 27 percent the efficiency of turning logs into useful lumber. An additional 52 million cubic meters of logs would have been needed for lumber in 1993 without these efficiency improvements. Another 23 million cubic meters of logs have been spared by the increasing conversion of wood chips and sawdust—former sawmill wastes—into composite materials that take the place of lumber.[24]

These trends in dematerialization recur across many materials and product types, including automobiles, electronic equipment, and appliances (see Table 2). Packaging, the focus of many early EPR programs, showed dramatic and persistent dematerializing trends in the United States, predating introduction of any up-front fees or take-back programs. For example, without any EPR program in place, materials use for grocery packaging dropped by 26 percent between 1989/90 and 1993/94.[25]

The details that make up this general trend are illuminating:[26]

- Though snack-food consumption jumped 43 percent from 1970 to the late 1980s, snack-food packaging, by weight, decreased 9 percent;
- Plastic milk jugs that weighed 95 grams in the early 1970s weighed 60 grams 20 years later;
- Plastic grocery bags were 2.3 millimeters thick in 1976 and just 0.7 millimeters thick in 1989; and
- Introduction of flexible packaging for frozen foods resulted in a reduction of over 80 percent in both weight and volume of some frozen food packaging.

| Table 2: Average Weight per Appliance Unit Discarded | | | | | |
|---|---|---|---|---|---|
| | 1972 | | 1987 | | % Weight Change/Unit |
| | Avg. Size | Avg. Lb./Unit | Avg. Size | Avg. Lb./Unit | |
| Range | 36 in. | 246 | 30in | 203 | - 17.2 |
| Refrigerator | 7.5–8.4 cu. ft. | 300 | 11.5–14.4 cu. ft. | 374 | 24.7 |
| Freezer | 12.5–16.4 cu. ft. | 380 | 14.5–19.4 cu. ft. | 342 | - 9.9 |
| Washer | 12–lb load | 246 | Std. size | 207 | - 15.6 |
| Dryer | 10–lb load | 191 | Std. size | 151 | - 21.2 |
| Water heater | 38–gal avg. | 169 | 48 gal. avg. | 155 | - 8.3 |
| Dishwasher | Standard size | 137 | Std. size | 143 | 4.1 |
| Microwave | – | – | 1.3 cu. ft. | 80 | – |
| Air conditioner (room) | Standard size | 200 | Std. size | 143 | - 28.5 |

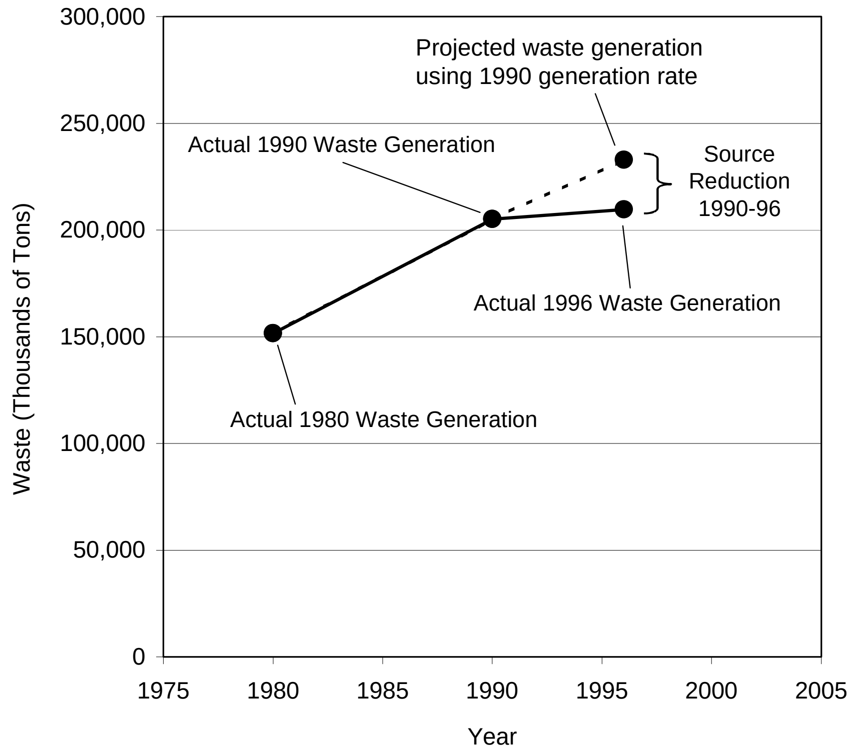
Source: Franklin Associates, *Analysis of Trends in Municipal Solid Waste Generation: 1972–1987* (Prairie Village, Kansas, 1992), pp. 2–4.

Reductions in weight and volume of materials used reflect only part of the environmental improvements caused by these changes in materials use, which often introduce large “spillover” environmental benefits. Reducing juice packaging by 16 percent and label size by 11 percent saved one manufacturer 20,000 pounds of materials, more than 500 truckloads of outgoing freight, 20,000 shipping pallets, 7,000 pounds of stretch wrap, and 250,000 square feet of chilled warehouse space.[27]

Justification of EPR programs has tended to arise from an “end-of-product-life” focus. The persistence of post-consumer wastes and absence, in some cases, of recycling options have been interpreted as a “market failure” to take into account environmental impact in product design. This perspective has two drawbacks. First, it overlooks the substantial source reductions that actually have occurred across virtually all materials and many products. Many of these source reductions, if compared to a baseline, pre-reduction product, have generated waste-avoidance greater than that achievable through recycling, which is generally the main focus of EPR programs. Second, it overlooks the holistic and integrated nature of production and product-design decisions in which small changes in product size or amount of material used can translate into much broader savings in energy, emissions, and so on. There is no guarantee that product-design changes driven by EPR programs will outperform a market-driven, source-reduction dynamic in this regard.

Particularly germane to the discussion of EPR are trends in waste generation, since EPR proponents generally claim that the traditional allocation of responsibilities for waste-handling limits incentives by firms to reduce post-consumer waste. A 1999 report by the U.S. EPA throws into question this assumption (see Figure 1). The report concludes that waste generation grew between 1960 and 1994, largely as a result of increases in gross domestic product (GDP), consumption rates, and population. However, in 1994, “there was a decisive downturn leading to subsequent reductions in the amount of MSW [municipal solid waste] generated.”[28]

**Figure 1: Calculation of Source Reduction in 1996**




Source: Adapted from U.S. EPA, *National Source Reduction Characterization Report for Municipal Solid Waste in the United States,* (Washington, DC, November 1999).

The EPA report attempted to examine the role that source reduction played in this downturn in the growth of MSW. Actual waste generation in 1996 was just below 210 million tons. Using 1990 generation rates, the projected figure for 1996 would have been around 233 million tons. Source reduction explains the difference of 23 million tons.[29] A variety of factors account for this source reduction, according to the EPA report. Over half (58.1 percent) of the reduction comes from yard trimmings and food scraps no longer designated as waste for disposal. But containers and packaging account for 17 percent of the total source reduction, with additional source reduction coming from other non-durable and durable goods (see Table 3).

These source reductions in packaging and other products result from an array of manufacturer and end-user activities, including increases in two-way pallet use; substitution of light-weight, efficient materials; and redesign initiatives toward more efficient products.[30]

While many products have undergone source reduction, others have experienced "source expansion." This expansion, however, appears to be associated with increased use of certain products such as corrugated cardboard for transportation shipping. In this and other instances, "the use of those materials or products is growing faster than the efforts to implement source reduction, thereby outpacing the effects of light-weighting [using more lightweight materials]."[31] In general, however, the source reductions exceed the source expansions resulting in a net decrease in waste-generation rates (see Table 4).

| Table 3: 1996 Source Reduction and Source Expansion Values for Subcategories of MSW (Thousands of Tons) | | |
|---|---|---|
| Waste Stream | Source Reduction/Source Expansion | Percent of Overall MSW Source Reduction |
| Durable Goods | | |
| ▪ Source Reduction | 2,958 | |
| ▪ Source Expansion | (779) | |
| ▪ Net Value | 2,179 | 9.4% |
| Nondurable Goods | | |
| ▪ Source Reduction | 6,314 | |
| ▪ Source Expansion | (2,743) | |
| ▪ Net Value | 3,571 | 15.3% |
| Containers and Packaging | | |
| ▪ Source Reduction | 7,161 | |
| ▪ Source Expansion | (3,159) | |
| ▪ Net Value | 4,002 | 17.2% |
| Other MSW (yard, trimmings, food scraps, and misc. inorganics) | | |
| ▪ Source Reduction | 13,534 | |
| ▪ Source Expansion | 0 | |
| ▪ Net Value | 13,534 | 58.1% |
| Total Source Reduction | 29,967 | |
| Total Source Expansion | (6,681) | |
| Total Net Value | 23,286 | 100% |

Source: U.S. EPA, *National Source Reduction Characterization Report for Municipal Solid Waste in the United States* (Washington, D.C.: November 1999).

| Table 4: 1996 Source Reduction/Expansion Values for Functional Categories | |
|---|---|
| Product: Durables | Source Reduction |
| Miscellaneous | 2,145 |
| Furniture/Furnishings | 388 |
| Major Appliances | 237 |
| Tires | 188 |
| Batteries, Lead Acid | (96) |
| Small Appliances | (258) |
| Carpets/Rugs | (426) |
| Subtotal | 2,179 |

Source: U.S. EPA, *National Source Reduction Characterization Report for Municipal Solid Waste in the United States* (Washington, D.C.: November 1999).

General trends toward eco-efficiency may sometimes be obscured by other factors that drive up total consumption and, hence, waste. Continued increases in total materials use and waste generated result from several factors beyond the direct control of manufacturers. These include population trends, increases in national and per capita wealth, and technology changes that alter consumption patterns.

Population growth can increase materials consumption—more people means greater demand for food, shelter, and other products. However, this relationship is not straightforward. As the U.S. EPA points out in its 1999 report on source reduction, population alone does not account for the rate of growth of consumption (and waste).[32] Economic factors also play a key role.

Up to a point, wealth can increase materials use. As incomes increase, people generally increase their overall consumption. Wealthier economies also generally have greater "individuation" of products—that is, proliferation of choices within individual product categories. In 1960, for example, a typical U.S. grocery store stocked 6,000 items; by the 1990s, GDP and per capita incomes had climbed dramatically, and the number of items in a typical grocery store had jumped to 30,000.[33] Finally, technology may be both a dematerializer and a materializer. By making possible new activities, some technologies drive new forms of consumption.

A growing population, increases in wealth, and technological advances can cause increases in materials-use and waste-generation rates. Improvements in materials efficiency may be partly counterbalanced by increases in total consumption propelled by these factors. While EPR fees may have a small impact on the marginal demand for certain goods, this impact is likely to be trivial relative to other dynamics affecting consumption. Moreover, EPR programs have never been justified in terms of reducing consumption. Rather, their rationale generally rests on the assumption that such programs will improve the environmental performance of products.

### *2. Influences on Product Design and Materials Use*

Numerous factors influence product-design decisions. While these factors vary in their details, they typically fall into three general categories for most products:

- Cost, which includes cost of materials, energy, processing, labor, capital, and distribution;
- Performance criteria, which vary by product type but may include safety, convenience, and functionality from "cradle to grave;" and
- Aesthetics, including product appearance, flavor, texture, etc.

Product-design decisions involve optimizing across many different variables, including subjective consumer tastes. Optimization necessarily involves some compromises—that is, for any individual design criterion, it may be possible to increase the achievement of that individual value, but only at the incremental expense of some other value. The ideal is to achieve a balance among all desired product goals. Moreover, this is a dynamic process: new goals or values surface as consumer preferences broaden or change; new safety goals emerge as more knowledge about products, their constituent parts, and their use develops. There are always untapped possibilities for improving the "value mix" of any product by applying new technologies, new production techniques, new customer relationships, and other new ideas that allow fuller achievement of various product goals. In this sense, many EPR champions are correct: there are always new opportunities to more fully include environmental values into product-design decisions.

This process of dynamic optimization is not a "market failure." It is a natural consequence of complexity, the physical impossibility of "maximizing" all values simultaneously, and the continual emergence of new values.

The central question is whether manufacturers are somehow making the "wrong" optimization decisions by excluding or inadequately attending to some performance values. From the standpoint of a community recycling coordinator or waste manager, some product-design decisions do not maximize recycling or other waste-handling opportunities. But waste managers bring a narrow perspective to the table: their concern is ease of waste-handling, including recycling.[34] The manufacturer has a much broader set of values to consider, including a broader set of environmental values. Trying to drive design decisions, through fees and legislation, toward heightened recycling—or other specified waste-diversion options—may not improve overall resource efficiency, environmental performance, or customer value.

Consider the case of packaging. In 1990, a former researcher for a packaged goods company compared the costs per ton of some packaging materials with waste-disposal costs (see Table 5).[35] The figures in Table 5 underscore that high materials costs give manufacturers a substantial incentive to reduce the amount of material they use—in short, to "source reduce" through light-weighting or substitution. The U.S. Census Bureau reported that, on average, in 1992 all packaging segments spent about 61 percent of their sales dollar on purchases of raw materials and supplies, including fuel, though this average obscures wide variations among specific package types. Even if manufacturers were to pay some prorated disposal cost for post-consumer discards, these costs would often be a fraction of initial material costs, thereby limiting their influence on design decisions. It is possible, of course, to set fees at levels that would be high enough to stimulate design changes through substitution or further light-weighting. However, setting fees artificially high to achieve some hoped-for outcomes interferes with the value-optimization process by requiring one set of values—say, recyclability—to supersede all other values.

**Table 5: Cost of Packaging Material Creation vs. Disposal**

| | |
|---|---|
| Cost to Landfill | $6 to $140/ton ($30/ton average) |
| Cost of Packaging Material to Food Company | |
| ▪ Toiletries | $6,000/ton |
| ▪ Cosmetics | $800 to $1,800/ton |
| ▪ Pharmaceuticals | $2,500 to $4,000/ton |
| ▪ Meats | $1,400 to $4,000/ton |
| ▪ Microwaveable snacks | $200 to $400/ton |

Source: Alexander Judd, *In Defense of Garbage* (Westport, Connecticut.: Praeger, 1993), p. 81.

Even more relevant to package-design decisions, choices in materials depend not simply on raw material costs but on total costs associated with using that material in relationship to product performance. For example, plastics may have high costs per pound relative to other materials, but because they require substantially less material by weight to create needed packaging characteristics than many alternatives, their use may result in lower total costs. Additionally, their use may generate fewer total environmental impacts relative to many alternatives, including recycled materials in some instances.

Finally, how changes in materials costs—for example, through introduction of EPR fees—affect product-design decisions will also depend on the ratio of materials costs to total product costs. Actual packaging costs as a percentage of total product costs vary widely, from as little as 2 percent or so for some packaged meat products to well over 50 percent for some microwaveable non-meat snacks (see Table 6).[36] Where packaging costs represent a small portion of total delivered product costs, EPR fees on packaging may have little or no effect on design decisions.

**Table 6: Packaging as Percent of Total Product Costs by Category (% of Total Delivered Cost)**

| Product | Percent |
|---|---|
| Household products (cleansers, detergents, etc.) | 10–15% |
| Shelf-stable beverages | 35–45% |
| Canned foods | 10–20% |
| Toiletries | 20–30% |
| Cosmetics | 3–55% |
| Pharmaceuticals | 10% or less |
| Meats | Less than 2% |
| Microwaveable snacks | More than 50% |

Source: Scarlett et al., *Packaging, Recycling, and Solid Waste*.

### *3. EPR Cost Impact*

Costs of processed feedstock[37] vary widely. Take the example of packaging materials (see Table 7), in which material competitiveness is related to the total costs associated with using that material in order to achieve the desired product performance. These costs include energy costs in production and transportation, productivity in handling, tonnage of material required to achieve particular packaging characteristics, and so on. As noted above, however, plastics may have a high cost per pound relative to some other materials, yet a substitution of plastics for more traditional materials may result in lower packaging costs overall.

**Table 7: Packaging Requirements Needed by Various Interested Parties from Production Through Distribution to Consumption**

| ✓ | Manufacturer | Packer | Transport sector | Warehousing (stacking) | Distribution | Consumer |
|---|---|---|---|---|---|---|
| Packaging cost | ✓✓ | ✓✓ | | | ✓✓ | ✓✓ |
| Nature of packaging material | | | | | | |
| ▪ relative to the physical, chemical, and mechanical properties | ✓✓ | ✓✓ | ✓✓ | ✓✓ | ✓✓ | ✓✓ |
| ▪ relative to preserving the quality of the product | | ✓✓ | | ✓✓ | ✓✓ | ✓✓ |
| Feasibility of automatic packaging | | ✓✓ | | | | |
| Good printability (labeling) | | ✓✓ | | | | |
| Information about the product | | | | | ✓✓ | ✓✓ |
| Feasibility of stacking (palletization) | | | ✓✓ | ✓✓ | ✓✓ | |
| Appearance and emotional elements | | | | | ✓✓ | ✓ |
| Ease of handling | | | ✓ | ✓ | ✓ | ✓ |
| Goods coding by means of packaging | ✓ | ✓✓ | ✓✓ | ✓✓ | ✓✓ | ✓✓ |
| Ecological aspects of packaging | ✓✓ | | | | ✓✓ | ✓✓ |

✓✓ major interest
✓ minor interest

Source: Lox, *Packaging and Ecology*, p. 23

EPR programs typically change the feedstock cost to the manufacturer for using one kind of material relative to another. How this change affects the choice of materials or design of the product will depend on:

- What percentage of total costs feedstock costs represent;
- How changes in materials and design will affect other costs such as transportation, handling, and distribution;
- How changes in design will affect product performance; and
- Cost differentials among different material options and how that cost difference affects total product cost.

The outcome will vary for each product. Where thousands of different products exist in a product category (such as packaging), there is simply no way to know in advance how changes in fees will affect design choices. If the fees are high enough and the differential between one material choice and another is high, the fees will likely affect outcomes. Predicting which outcomes will result is not possible, however. EPR programs to date bear out this caveat: there is simply no way to know in advance how changes in fees will affect design choices, and design choices in response to EPR programs show no single, predictable pattern.

#### *4. Environmental Impact*

All products have an environmental impact—in production, sometimes in use, and in disposal. The nature of their impact is complex, and the point of greatest impact varies by product and circumstance. Moreover, comparing impacts requires an examination of the full life cycle of products.

For example, fresh, unpackaged oranges may appear to have less environmental impact than processed, packaged juice for the simple reason that the latter is encased in packaging that uses resources (and generates waste) and because processing oranges requires energy consumption. Upon closer examination, however, assessing the relative impact of fresh oranges versus packaged, processed ones is more complicated. Manufacturers of packaged, frozen orange juice concentrate use highly efficient presses to extract juice from the fresh orange.[38] To make a concentrate that will produce a gallon of juice requires less than half the amount of oranges that a consumer pressing fresh oranges would need to make a gallon of juice. More oranges to accomplish the same consumption goal means a need for more orange orchards, more water, and more agricultural chemicals. Transporting crated oranges to the market takes up more truck volume to deliver the equivalent of a gallon of juice than is required for the frozen, packaged juice, which, in turn, means more trucks and more fuel to get the equivalent amount of juice into the marketplace.

There is simply no way to know in advance how changes in fees will affect design choices, and design choices in response to EPR programs show no single, predictable pattern.

The orange juice tale does not end here. The consumer will generally discard the orange peel, but the orange-juice manufacturer uses the peel for other products, including animal feed, orange extract, and so on.

This orange juice example is meant to be illustrative of environmental complexities; it is not intended to offer a quantitative or definitive life-cycle assessment. Assessing the total environmental impact of a particular product requires detailed analysis of fuel use, impacts of raw material extraction or agricultural operations, air and water emissions, waste generation, and water consumption, among many other variables.

As noted earlier, EPR programs that establish product “take-back” fees or other environmental fees generally base those fees on a single parameter of the product—its recyclability, its toxicity along one dimension, and so on. Manufacturers then have an incentive to reduce the fees by reducing the impact targeted by the fee. However, this response may, or may not, yield a net environmental improvement.

Changes in product design that reduce overall environmental impacts are, of course, possible. But this process generally requires a “big-picture” look at how different design choices will affect product performance, weight, energy use, materials selection, and a host of other factors. EPR mandates can stand in the way of this optimizing process.

## C. Analytic Boundaries and Challenges

Evaluating data that address these questions, and drawing policy conclusions from these data, introduce a subjective dimension.  For example, though trends toward more eco-efficient products are evident, are reductions in environmental impacts and improvements in resource and energy efficiency happening fast enough?  There is no right response to this question.  Whether product changes are judged to be occurring "fast enough" depends on:

- The intensity of harm a product's environmental impacts present;
- The availability of mechanisms to cope with the potential harms;
- The tradeoffs (and costs) that would result from policies intended to accelerate product changes; and
- The economic system's resilience or ability to shift rapidly in response to changes in resource availability relative to demand.

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Entrepreneurial opportunity is possible precisely because prospects always exist to do old tasks better, to satisfy unmet needs, or to identify unfulfilled values.

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Another factor complicates this judgment.  Economic action presents a continual dynamic rather than a set of final endpoints.  Entrepreneurial opportunity is possible precisely because prospects always exist to do old tasks better, to satisfy unmet needs, or to identify unfulfilled values. For environmental performance, this dynamic nature of economic action means that, at any point in time, opportunities to improve energy efficiency, resource efficiency, and reduce environmental impact—in both iterative and revolutionary ways—may be identified.  It is a natural consequence of the dynamic discovery process of markets.

In other words, no product is ever "perfect."  There will always be opportunities for the proverbial better mousetrap, and this includes prospects for improved environmental performance.  Hence, a motivated critic of products will always find areas in which environmental performance appears to be less than is technologically or, at least, theoretically possible.  This prospect for improvement does not, however, demonstrate market failure.

**Part 4**

# EPR Results: Review of Expectations and Implementation Challenges

At a practical level, its proponents advance EPR as a means of improving decisions about resource use. Because EPR programs attempt to incorporate product disposal or recycling costs as an up-front fee, they are expected to change how manufacturers design and market their products. Specifically, these changes might include design for:

- Waste minimization;
- Reuse or recyclability;
- Material conservation;
- Pollution reduction; and
- Lower toxicity.

In addition to these environmental goals, some champions of mandatory EPR systems anticipate that these systems will generate a secure, nonvolatile revenue stream to fund waste-collection, recycling, composting, and waste-disposal programs.

EPR began in Europe as a philosophy about product responsibility. In the United States, its proponents generally focus on more pragmatic concerns. Public works managers, faced with recycling and waste-diversion targets, express frustration that some new packaging and products entering the marketplace make recycling more, not less, difficult. They cite several recent examples:

- The introduction of pigmented polyethylene (HDPE) milk containers, which mingle in the waste stream with the more-traditional "natural" HDPE containers and make separation of those containers into a clean stream more difficult;
- The introduction of polystyrene wrapper labels around glass containers, which they fear may make glass recycling more difficult;
- The introduction of plastic beer bottles, which may supplant easier-to-recycle glass bottles or aluminum cans;
- The trend toward use of more diverse plastic resins in automobiles; and
- The use of multiple plastic resins and heavy metals in electronic equipment, including computers.

Some public works managers see EPR as a potential new revenue stream; most hope that development of an EPR program in the United States will ensure that recyclability moves center stage as a design criterion for manufacturers. They view products primarily from the vantage of their waste-handling attributes. As noted earlier, manufacturers have a different perspective, viewing products in terms of consumer preferences, overall product performance, and overall production and product-delivery costs. This perspective requires juggling multiple goals in a context of both technological and economic constraints. Waste-handling attributes are one of many environmental and other design criteria that manufacturers consider in product design, development, and marketing.

These different criteria make evaluation of EPR complicated, since interested parties have different goals. The local mayor or waste manager is generally seeking lower-cost waste handling; the manufacturer is seeking to anticipate consumer preferences and product-quality requirements while minimizing total resource use per unit of output. Nonetheless, since EPR is typically advanced as a waste-management policy rather than as a materials-management policy, a central question is whether EPR programs are likely to result in efficient waste diversion and recycling. A larger question is whether EPR programs are likely to enhance the overall environmental performance of products.

## A. Packaging

### *1. Goal Tradeoffs*

The various goals for EPR programs are not necessarily compatible. What design responses result from EPR, if any, will depend on the size of the product fee and the criteria used to establish fee levels or take-back targets. Fees set to reflect recycling costs and thus encourage "design for recyclability" may discourage source reduction and materials conservation achieved through use of lightweight, more durable modern materials such as laminates, composites, or plastics.

For example, EPR packaging fees based on recycling costs will typically be higher for composites and laminated products than for single-material glass or paperboard products. The reason is simple: recycling requires the recovery of "clean" streams of uniform materials. Segregating the different materials in a laminated or composite package or product is often difficult and costly. Yet substituting these materials for more traditional glass, metal, and paper packages and products has historically resulted in reductions in material use by both weight and volume (see Table 8), so fees that discourage laminates may, on net, have negative environmental results.

**Table 8: Source Reduction from Composites and Laminates**

| Flexible packaging | Replaced packaging | Reduction weight | Reduction volume |
|---|---|---|---|
| Laminate brick pack | Metal coffee can | 70% | 55% |
| Fabric softener pouch | Bottle | 85% | 84% |
| Diaper bag | Folding carton | 85% | 86% |
| Peelable lid | Metal top | 87% | 50% |
| Instant soup pouch | Metal can | 93% | 97% |
| Frozen food bag, plastic | Waxed-wrap carton | 89% | 83% |

Source: Scarlett et al., "*Packaging, Solid Waste, and Environmental Tradeoffs*."

A 1992 report on green product design by the U.S. Office of Technology Assessment (OTA) cautioned that "what is 'green' depends strongly on context."[39] Product-design choices are often subtle. The OTA report offers an example of potential tradeoffs between materials-use reduction and recyclability. The report describes a modern snack chip bag, which is made up of thin laminated layers of nine lightweight materials, each of which serves a different function in assuring overall product integrity and consumer utility. This multi-layering makes recycling difficult. The package is, however, "much lighter than an equivalent package made of a single [recyclable] material and provides longer shelf life, resulting in less food waste."[40]

How manufacturers respond to EPR fees will depend on the fee levels, product or packaging weight, material composition, and volume, and other consumer-quality variables. However, to the extent that fees push manufacturers out of laminates, composites, and plastics (or other innovative, efficient materials) and into single-material paper, glass, wood, or metal products, materials-reduction opportunities may be foregone or constrained.

There is already some general tension between source reduction and recycling goals through EPR programs, and predicting the outcomes of different EPR fee structures for any given product is nearly impossible, because of the multiple variables that affect product-design decisions. For example, in Germany, clear glass, which is easy to recycle, carries a much lower fee than HDPE (a plastic). But the lower transportation costs incurred by lightweight plastics, their ease-of-handling, lower breakage rate, and better performance of some plastic containers (from the consumer's standpoint), have still resulted in decisions by many manufacturers to use plastic for shampoo bottles, detergents, cleansers, and so on. Some of these choices, driven by EPR fees, have made packaging more, not less, complex. For example, some cleansers, which had been sold in a single-material HDPE container, now are sold in very thin plastic containers held upright with a thin paperboard sleeve.

Since EPR is typically advanced as a waste-management policy rather than as a materials-management policy, a central question is whether EPR programs are likely to result in efficient waste-diversion and recycling.

### *2. Setting Fees*

There is no intrinsically right fee level, a point underscored by the wide variation in packaging and other product fees among existing or proposed EPR programs, even where waste-management technology, wages, and other relevant cost factors are similar. Packaging fees among European nations vary as much as 35-fold for identical products (see Tables 9, 10, and 11).

**Table 9: 1997 Relative Fees for 300ml Plastic Bottle ($ per 1,000 containers)**

| | |
|---|---|
| Austria | $67 |
| Belgium | $10 |
| France | $ 2 |
| Germany | $75 |
| Sweden | $ 8 |

Source: Klaus Draeger, Procter & Gamble

| Table 10: 1997 Relative Fees for 75 ml Glass Bottle ($ per 1,000 bottles) | |
|---|---|
| Austria | $22 |
| Belgium | $ 4 |
| France | < $ 1 |
| Germany | $26 |
| Sweden | $ 2 |

Source: Klaus Draeger, Procter & Gamble

| Table 11: 1997 Relative Fees for Granular Detergent Carton, Size 5 ($ per 1,000 containers) | |
|---|---|
| Austria | $48 |
| Belgium | $ 7 |
| France | $ 4 |
| Germany | $56 |
| Sweden | $14 |

Source: Klaus Draeger, Procter & Gamble

Differing fee structures for EPR programs in Europe result from a combination of political maneuvering, differences in waste-management infrastructure and program goals, and differences in how costs are allocated. In other words, fee-setting is a political process rather than an economic process, which would be pegged to comprehensive assessments of waste-handling costs, or a scientific process, which would determine relative environmental impacts of different products. The result to date has been an explosion of different fees that confuse rather than improve the information about resource scarcities signaled through prices to product and packaging producers.

In other words, fee-setting is a political process rather than an economic process, which would be pegged to comprehensive assessments of waste-handling costs, or a scientific process, which would determine relative environmental impacts of different products.

***Political Maneuvering***. Establishing back-end waste-handling fees is a fairly straightforward process. At the point of waste collection, the recycler has relatively clear information about the average and marginal costs to collect and recycle, compost, or dispose of a given pound or cubic meter of waste. Determining the collection, reprocessing, or disposal costs for individual items or for their various components (such as caps, labels, safety enclosures, and so on) involves a much broader set of loose assumptions. Yet establishing up-front product fees requires making these kinds of item-by-item cost assumptions.

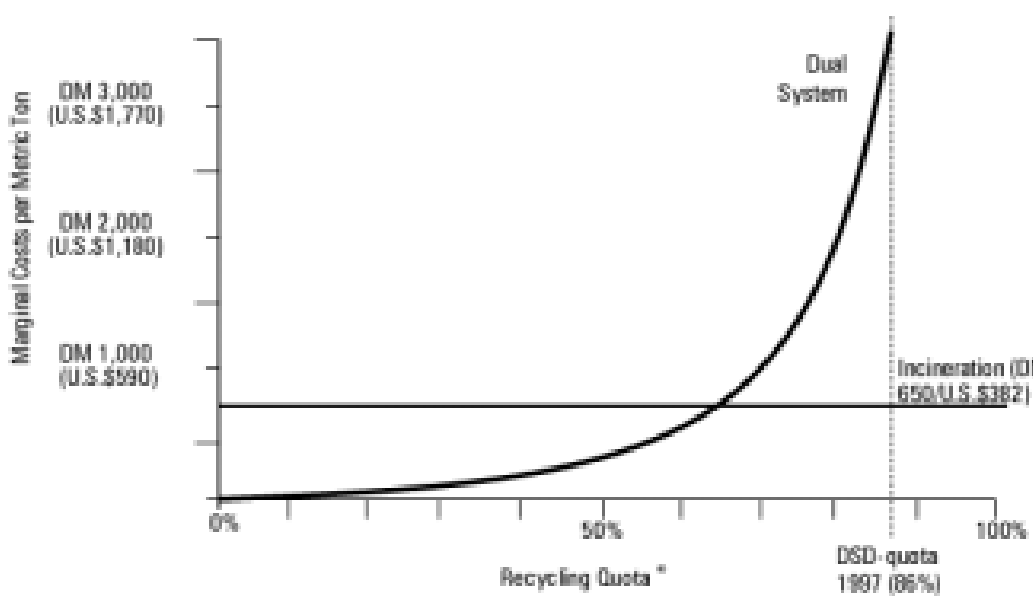
Because determining waste-management and recycling costs on an item-by-item basis involves numerous fairly loose assumptions, fee-setting is often subject to political jockeying. The German experience bears this out. In the mid-1990s, Germany's Duales System Deutschland (DSD), a manufacturer consortium, set up to manage the Green Dot packaging recovery program and sought to raise fees to meet unanticipated costs. The proposed fee for glass changed at least three times over several months, as glass-container producers and fillers pressed for more favorable fees.[41]

***Program Goals.*** Fees also vary depending on program goals. Germany's EPR program for packaging emphasizes recycling and recovery more than waste minimization (source reduction). The DSD sets fees based on estimated costs to recycle or recover materials, with a special surcharge to cover plastics reprocessing costs. The result is costs for plastic containers that are about 20 times higher than the fees for glass containers. Glass and paper-based packaging compose 75 percent of the packaging consumed in Germany by weight, but glass and paper-based packaging fees make up less than 30 percent of fees paid into the DSD system.[42]

These fee variations may approximate the differential recycling costs of the different material types, thereby steering some packaging choices toward materials with lower recycling costs. The net effect is, however, to discourage waste minimization achieved through use of lightweight, efficient plastics, composites, or laminated packaging. Germany's fee system has resulted in some packaging anomalies relative to general trends. For example, in all other European nations, cat litter bags are made entirely of plastic; in Germany, they are made from paper with a plastic reinforcement of less than 5 percent of the package by weight (in order to still qualify as a paper package).[43] There is no obvious environmental benefit from this choice.

Goal details also affect fee structures. Denmark's EPR program for packaging offers reduced fees for packaging with recycled content; France allows waste-to-energy as a recovery option; until recently, Germany required "mechanical recycling"—the direct fabrication of products from recovered materials—to meet recovery targets. Packagers may now meet 40 percent of the plastics recovery target through "feedstock recycling"—the conversion of plastics into their basic chemical elements for reuse.[44] Germany's very high recovery targets also push fees upward, since very high recycling levels require increased processing while generating lower-quality materials (see Figure 2).

**Figure 2: Inefficiency of High Recycling Quotas**




*Based on sales packaging consumption. Source: M. Schroll, "The German Packaging Ordinance," (Bochum, Germany: Institute for Applied Innovation Research, 1998).

***Cost Allocation and Cost-sharing.*** Some of the wide variation in fees seen in EPR programs results from different decisions regarding which costs to allocate to manufacturers and whether costs will be shared among producer/fillers and others in the manufacturing and product distribution chain (see Table 12). In Germany, packaging fees are much higher than in France in part because German producers pay the total estimated waste-collection and handling costs for packaging and an additional fee for plastics that covers reprocessing costs. In France, producers pay the incremental cost associated with expanding recycling programs. Moreover, the French program relies on the existing municipal waste-management infrastructure rather than on a parallel system operated under contract to the producer consortium. In the United Kingdom, waste-handling costs for packaging are spread among raw material manufacturers (6 percent), converters (11 percent), packers/fillers (36 percent), and suppliers (47 percent). Companies that handle less than 50 tons of packaging are exempt, reducing potential participants from an estimated 200,000 to 11,500.[45] The exemption essentially legalized "free riding" by small companies, since larger firms pay for the recovery of small-firm packaging.

**Table 12: EPR Cost-allocation Schemes for Packaging**

| | Producer Responsibility | | Items Recovered | |
|---|---|---|---|---|
| Nation (EPR program) | Incremental | Total Cost | Selected | All |
| Austria (ARA) | | X | | X |
| Belgium (FostPlus) | | X | X | |
| France (Eco-Emballages) | X | | X | |
| Germany (DSD) | | X | | X |
| Sweden (REPA) | X | | X | |

Source: K. Draeger, "Ist Der Grüne Punkt Zu Teuer?," June 10, 1997.

### *3. Fee Transactions Costs*

Establishing fees and ensuring their payment by targeted firms is an information-intensive undertaking. Packaging consultant Victor Bell notes that:

> *[I]n most cases, the cost of data collection and report preparation far exceeds the cost of the fees themselves…For example, a large personal-care company, which manufactures and distributes its products globally, will spend millions of dollars creating and maintaining its environmental packaging database, which is necessary to complete all country reporting requirements. Additionally, it is spending thousands of dollars to complete each country report…[O]ne company is spending more than [$1,000] each month in preparing its monthly reports to Svensk Glasatervinning in Sweden for their glass bottles and paying less than $200 in fees per month.*[46]

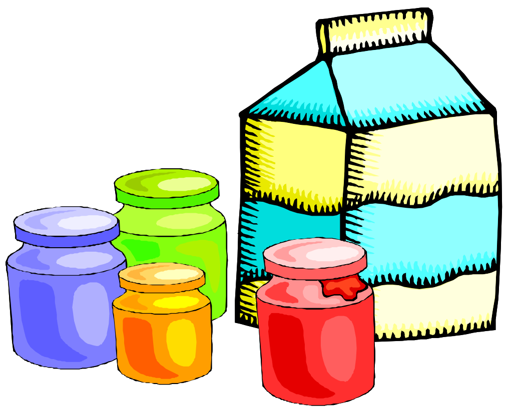
At least 30 nations now require environmental packaging reports, often for the purposes of setting EPR fees and monitoring changes in packaging design on a national level. As Bell points out:

> *[T]he data requirements are constantly changing, making the database requirements for multinational companies increasingly difficult. For example, in the EU alone the same piece of paperboard can be defined as "paper" in France, "composite" in Germany, "aluminum" in Spain, and "other" in Belgium.*[47]

Criteria for determining packaging fees vary widely, with the result that reporting requirements also vary, and the cumulative list of required data elements is extensive (see Figure 3).

While firms to date have the broadest experience with EPR programs that target packaging, mandatory EPR programs—whether for electronic equipment, automobiles, or appliances—have data-reporting requirements to determine what fees must be paid or to track program compliance. How significant data-reporting costs are will depend on program complexity and numbers and types of program participants.

**Figure 3: International Data Reporting Requirements for Packaging**



- Weight of the package
- Shelf area
- Declared weight
- Declared volume
- Product to package ratio
- Empty -space ratio
- Specific material type
  - Resin type
- Fiber content
- Rigid
- Heavy metal content
- Nation of origin
- Packaging Category
  - Primary
  - Sales unit
  - Transport
  - Service
- Packaging element
  - Cap, carton, etc.
- Percentage of recycled material
  - Postconsumer
  - Preconsumer
  - Industry scrap
- Data on recyclability
- Percent composition by component

For example:

| | |
|---|---|
| - Fiber | 84.5% |
| - Aluminum film | 5.8% |
| - Acetate film | 3.8% |
| - Ink | 1.4% |
| - Glue for aluminum | 0.7% |
| - Glue for acetate | 3.8% |
| - Carton glue | 0.3% |

Source: V. Bell, "How Manufacturers Are Responding to Extended Producer Responsibility Programs and How These Programs Can be Made More Effective," paper presented at OECD Workshop on Extended Product Responsibility (Washington, D.C.: December 1–3, 1998), p. 1.

## B. Electronics

EPR regulations for electrical and electronic products are as complex as EPR packaging laws, creating big gaps in compatibility between what regulators want and what may yield high-performing products and improvements in environmental performance. In addition to carrying potentially high monetary costs that are ultimately passed down to the consumer, mandatory electronic EPR requirements trigger numerous environmental tradeoffs. They can also compromise consumer safety and product reliability.

The most far-reaching proposal to regulate the life of electronic products is the EU's pending Waste Electrical and Electronic Equipment (WEEE) directive, which holds the manufacturer responsible for the product from cradle to grave. The WEEE program, would require all manufacturers and importers of the 15-member states to pay for (through a surcharge on the price of the product) and implement take-back collections, product recovery or treatment, and the recycling or "environmentally sound disposal" of products' components. To meet the recycling provision, different products would have to meet specific recycling targets. By 2006, large household appliances would have to meet a recycling rate, as defined by weight, of 75 percent; small household appliances, such as electronics and sound equipment, toys, tools, and any equipment containing cathode ray tubes (CRTs), would have to meet a target of 60 percent.[48]

WEEE would apply to all electrical and electronic goods for both household and business use, including everything from toasters to refrigerators, portable radios to stereo sound systems, cell phones to personal computers.[49] Manufacturers' financial obligation would extend to old, as well as new, products, applying retroactively to products previously manufactured.[50] As with most EPR programs, its proponents reason that if manufacturers are held responsible for the end-life of the product, they will design products that can be more easily disassembled and will use materials that can be more easily recycled.[51]

The WEEE directive would also require that certain substances be segregated from the recycling stream and treated separately. In addition, as part of a separate companion directive to WEEE called the Restriction of the Use of Certain Hazardous Substances (ROS), these same materials would be phased out of the manufacturing process altogether. The ban would apply specifically to lead, mercury, cadmium, hexavalent chromium, and certain brominated flame retardants.

### *1. Environmental Tradeoffs*

The EU's proposed WEEE regulations on electrical and electronic waste present numerous environmental tradeoffs that have not been adequately considered or assessed by the EU in preparation of WEEE. Moreover, the European Commission has not considered the findings of risk assessments conducted by its own officials and scientists.

***The Recycling Process.*** The collection of end-of-life products and the recovery and recycling process will generate air and water emissions and solid waste. This is particularly true for products containing cathode ray tubes (CRTs), such as televisions and computer monitors, because they require greater amounts of energy to process.[52]

A report commissioned by the United Kingdom's Department of Trade and Industry (DTI) on the projected impact of WEEE compared emissions from increased recycling and reuse with current waste-management practices in the United Kingdom. While some products showed a decline in emissions following recycling, as one would expect, other products surprisingly showed an increase. For example, recycling and reusing one ton of waste from television sets would actually increase carbon dioxide emissions by 29 percent, from 331 kilograms to 427 kilograms, and increase acidic air pollutant emissions by 18 percent. Similarly, recycling a ton of waste from a refrigerator would generate an 11 percent increase in hazardous waste, from 84 to 93 kilograms (185 to 205 pounds).[53] It is crucial that these environmental costs be considered and weighed against the environmental benefits of recycling requirements (benefits are discussed in a later section.)

***Banning Materials.*** The ROS directive to ban various metals (mercury, lead, cadmium, and hexavalent chromium) and brominated flame retardants (polybrominated biphenyls—PBBs and polybrominated diphenyl ethers—PBDEs) in the production of electrical and electronic equipment could have a negative impact on the environment. Little is known about potential substitutes. Those that are known are far less effective and present environmental and health risks of their own (for the latter, see the following subsection). As Orgalime, a consortium of European mechanical, electrical, electronic, and metalworking industries**,** commented in its response to the ROS directive, "Substitutes have been identified for only a small number of the [materials to be banned]. There is no way to ascertain the safety, reliability, and environmental improvements associated with substitutes until they are identified. Requiring substitution before there has been an adequate evaluation of the risks associated with alternatives may result in use of materials and processes that increase environmental impact."[54]

For example, the lead in solders, which is used to attach microchips to circuit boards and in the production of other electronics, is one of the heavy metals targeted for phase-out, yet there are few known substitutes. Moreover, those that are considered the most-viable alternatives have notable environmental impacts.

Because known substitutes require temperatures to be 25 percent higher than lead in order to melt properly for usage, they consume far more energy than lead-based solders.[55] The European Commission's own scientific committee rejected Denmark's ban on lead last spring, stating that the Danish authority had failed to consider the negative impacts on human health and the environment that could result from substitutes for lead. The committee also determined that the Danish authority had failed to perform a risk assessment or base its ban on scientific evidence.[56]

The EU's failure to consider substitutes and their effects could be a direct violation of the international Technical Barriers to Trade (TBT) agreement, which requires that all potential alternatives be taken into consideration and that all less restrictive approaches that achieve the same objective be considered.[57]

Nor does the directive consider the environmental benefits of the materials slated for phase-out. One example is brominated flame retardants (BFRs). Plastic components used in electrical equipment such as TVs and computer monitors are typically treated with BFRs to prevent fires. Proponents of the ban maintain mandatory restrictions on BFR usage are necessary because the materials emit hazardous organic compounds, such as dibenzodioxins and furans, during recycling or incineration.

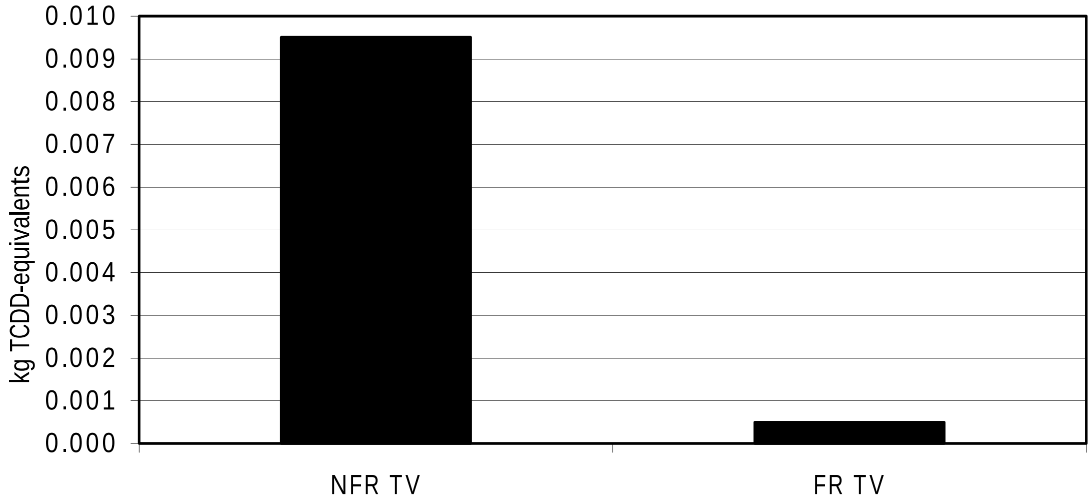
However, recent studies show that the use of these same BFRs actually reduces emissions of dioxins and furans because of their effectiveness in preventing fires, a significant performance benefit of these substances.

One study conducted by the Swedish National Testing and Research Institute (SNTRI) found that in Europe, where one of the most effective brominated flame retardants—DecaBDE—is rarely used in the production of TV sets, there are on average 165 TV fires per million TVs each year. In the United States, where DecaBDE is widely used, there are 5 per million.[58] The study also compared the energy use and emissions generated through the typical product life cycle of non-flame-retarded TVs with flame-retarded TVs. While the results are preliminary, researchers found the emissions of dibenzodioxins and furans, as well as polycyclic aromatic hydrocarbons, to be dramatically higher for TVs that were not flame-retarded. This effect resulted from the significantly higher probability of fire.[59] (See Figures 4 and 5.)

While more research is being conducted on the benefits of these flame retardants and the risks that would surface from phasing them out, research is also being conducted to determine the health risks of using these substances. So far, the scientific evidence suggests that they pose little risk. A series of recent studies conducted by German scientists at the GfA [Gesellschaft fuer Arbeitsplatz] Laboratory and the University of Erlangen reveal that recycling plastics treated with the retardant decabromodiphenylether (DecaBDE) did not produce detectable amounts of dioxins or furans and, therefore, did not present a health risk. The studies also showed that plastics containing DecaBDE could be recycled five times and still meet the requirements of Germany's ordinance on dioxin and furan emissions, the harshest of such restrictions in the world.[60] The findings are consistent with the preliminary results from the EU's own four-year risk assessment on the impact of PBDEs, which shows no scientific basis for the ban.[61]

The dearth of scientific evidence for these regulations has prompted Germany, Europe's most aggressive regulator of product waste and supporter of extended producer responsibility, to vehemently oppose the EU's directive on binding recycling targets and the substance ban, calling it an "excessively prescriptive and restrictive system."[62] Such strong opposition from Germany, the least likely nation to oppose EPR legislation, has stirred EU officials to acknowledge the need for more science. Yet instead of withdrawing the ban for lack of evidence, the European Union has proposed that the phase-out be extended to the year 2008, so that new scientific evidence can be reviewed. At the same time, they are advancing their proposal for complete "substitution" by 2008. Furthermore, they have not applied these findings to the directive's provision to separate components treated with BFRs.

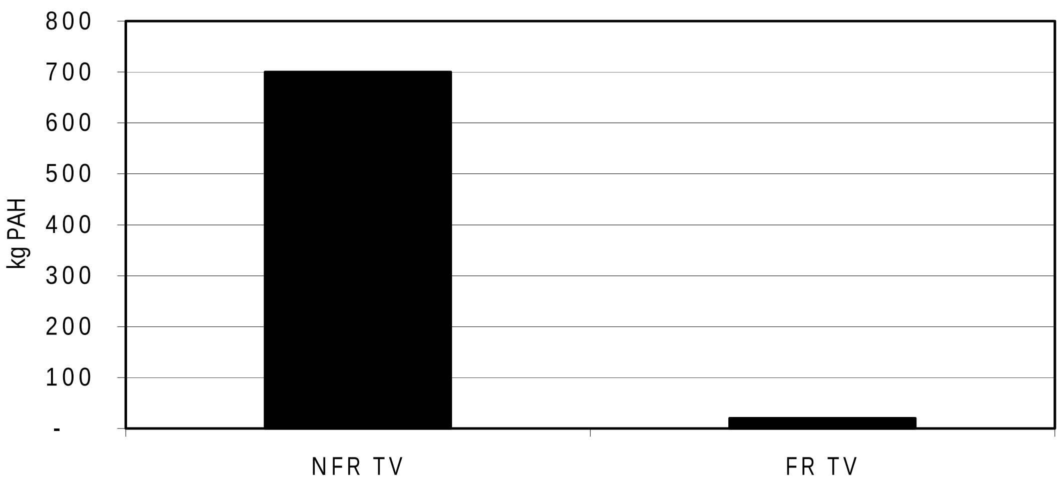
**Figure 4: Emissions of Polychlorinated Dibenzodioxins and Furans**




Note: The emission of TCDD (tetrachloro-dibenzo-dioxin) equivalents to the air for $10^6$ TV sets over their 10-year life cycle for non-flame-retarded (NFR) and flame-retarded (FR) TVs. The TCDD equivalents represent a weighted sum of both polychlorinated-dibenzo-dioxins and -furans.

Source: M. Simonson and H. Stripple, *LCA Study of Flame Retardants in TV Enclosures*, SP Swedish National Testing and Research Institute (Boras, Sweden: February 2, 2000).

**Figure 5: Emissions of Polycyclic Aromatic Hydrocarbons (PAH)**




Note: The emission of PAH to the air for $10^6$ TV sets over their 10-year life cycle for non-flame-retarded (NFR) and flame-retarded (FR) TVs.

Source: M. Simonson and H. Stripple, *LCA Study of Flame Retardants in TV Enclosures*, SP Swedish National Testing and Research Institute (Boras, Sweden: February 2, 2000).

***Separating Materials from the Recycling Stream.*** Some of WEEE's requirements for the special treatment of waste (including separation of certain liquids and materials from the recycling process) could be less environmentally sound than current methods that use the chemical makeup of these materials in the recycling process. Supporters of the WEEE requirements argue that, in addition to increasing dioxin emissions in the recycling process, these materials prevent plastics from being recycled effectively. But practitioners have found this not to be the case. Some member nations, including the United Kingdom, have suggested that the removal of these materials could fail to meet the "best practicable environmental option" (BPEO).[63] The BPEO is a procedure that a number of nations apply, requiring waste management firms to adopt the option with the most benefit or least damage to the environment at an acceptable cost.

Concerning brominated flame retardants (BFRs), the WEEE directive goes even further than the ROS directive on substance bans in that it covers many different types of BFRs, not just PBBs and PBDEs.[64] But by doing so, the directive overlooks the growing body of evidence showing that BFRs are extremely resistant and stable during plastics-recycling processes, particularly compared to known substitutes.

One such study performed by a Japanese manufacturer of plastics, Techno Polymer, compared the recyclability of the halogenated flame retardant called brominated epoxy oligomer, with non-halogenated retardants. The study looked specifically at two effects that are crucial in the recycling process of plastics—the retardant's tolerance of extreme heat and its resistance to chemical breakdown. For both effects evaluated in the study, the brominated retardant maintained its physical properties, while the non-halogenated retardant showed significantly lower resistance when subjected to these effects. The report concluded, "Among the commercially available plastics suitable for business machines, only [the flame retardants treated with] brominated epoxy oligomer show flawless recyclability in terms of keeping the original performance after the thermal history and accelerated hydrolysis testing."[65]

### *2. Health and Public Safety Risks*

Even more critical than their impact on the environment are the potential consequences these regulations would have on public health and safety. The proposed ban of brominated flame retardants by 2008 poses a potentially high threat to human safety, given their dramatic effectiveness in fire prevention described above. The Swedish National Testing and Research Institute (STRI) found that in Europe, where the use of the halogenated flame retardants has already been severely restricted through regulations, at least 16 people die each year from TV fires, based on conservative estimates. In the United States, where BFRs are typically used in the production of TVs, there is no record of casualties from TV fires.[66]

### *3. Product Reliability*

The WEEE regulations would also present unattractive tradeoffs in product reliability. In addition to the obvious deterrents such regulations would have on innovations and improvements in product design, regulations would also end current design methods that optimize product performance. For example, under WEEE's recycling mandates, electrical products would have to meet the recycling target of 60 percent by the year 2006. This requirement would discourage the use of plastic components in production, which are more durable and lighter than the metal components the WEEE directive favors. Consumers would therefore be forced to use heavier, less durable products. This requirement would also have a long-term negative effect on the environment, since these products' life cycles would be shortened, increasing product waste.[67]

**Part 5**

# EPR Benefits: A Reality Check

Proponents of EPR list a variety of hoped-for product-design benefits. However, most programs base EPR fees on resource recovery and recycling costs and couple these fees with recovery targets for specific products or materials. Success is then evaluated in terms of whether these targets are met.

This sort of program evaluation is incomplete. Assessing whether mandatory EPR programs "work" requires looking at three different measures. First, one needs to assess in absolute terms whether EPR waste-recovery and waste-reduction targets have been achieved. Second, one needs to compare these effects with recycling and waste-minimization trends in places that do not have mandated EPR programs. Third, one needs to examine opportunity costs—what benefits might have been foregone by investing in EPR programs. For example, EPR programs may generate increased recycling rates for packaging but reduce overall investments in waste-reduction or other product innovations.

As there is no single model of EPR, evaluating a few experiences that are applied to one set of products is at best only suggestive. EPR systems, as implemented around the globe, share no common set of goals, no uniform regulatory structure, and no comparable pricing schemes. Nonetheless, a look at several EPR programs for packaging and electronics, which have the longest track record, is useful for examining the benefits of mandatory EPR programs.

## A. Packaging

Targeting packaging for EPR raises some difficult challenges for a number of reasons. First, there are large numbers of potential participants that make very heterogeneous products. Second, the value of each individual packaging transaction is small (even miniscule). Third, potential health and safety impacts from mishandling of waste may exist but are small, limiting any harm-reduction benefits that might accompany an EPR program. Finally, the pre-EPR manufacturer sensitivity to price and consumer-preference signals is high as manufacturers make product-design choices, so that spontaneous waste-reducing benefits are already significant. These characteristics all point to potentially high transaction costs with limited expected results.

Germany's Green Dot program has the longest track record, dating back to 1991. Germany had one explicit and one implicit goal in establishing its EPR program: minimized waste and increased recycling.

***Absolute Benefits***. Germany did see some decline in packaging waste. Outer (secondary) packaging was virtually eliminated but made up a small fraction of total packaging. Looking at a typical set of grocery products, packaging dropped from 2,500 pounds per gross production unit to just under 2,100 pounds, a 14 percent reduction between the outset of the program and 1994.[68]

An examination of materials-use trends that compares packages included within the DSD program and those not covered by take-back requirements further clouds the oft-claimed picture of success attributed to the DSD program. Reductions in packaging material consumption show little difference between those packages covered by DSD and those outside its scope.

Germany's program also increased recycling, achieving an overall packaging recycling rate of around 78 percent by year-end 1996 (see Table 13). DSD officials report the achievement of recycling and recovery targets for each material (see Table 14).

EPR programs may generate increased recycling rates for packaging but reduce overall investments in waste-reduction or other product innovations.

**Table 13: DSD Packaging Trends (Thousands of Tons)**

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|
| Total DSD packaging | 7,575 | 7,322 | 6,995 | 6,943 | 6,880 | 6,786 |
| Recovery quantity | 920 | 3,945 | 4,574 | 4,918 | 5,323 | |
| Recovery rate ( %) | 12.6 | 56.4 | 65.9 | 71.5 | 78.4 | |

Source: A. Troge, "Comparison of Cost-efficiency of Packaging Recovery Systems in Germany and the Netherlands," short version of diploma of P. Axt, translation from German (Bayreuth, Germany: University of Bayreuth, 1999).

**Table 14: 1996 DSD Recovery (Tons by Material)**

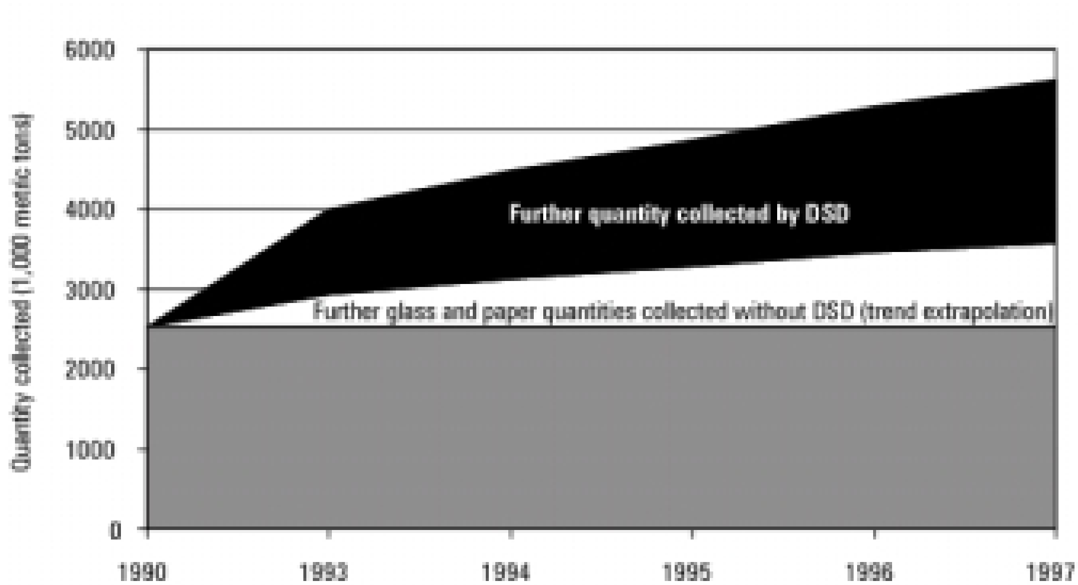
| | Recovered Quantity | Actual Recovery | Regulatory Requirement |
|---|---|---|---|
| Paper/paperboard | 1,318,641 | 94% | 64% |
| Glass | 2,686,639 | 85% | 72% |
| Plastic | 534,953 | 68% | 64% |
| Tin plate | 301,789 | 81% | 72% |
| Aluminum | 35,926 | 79% | 64% |
| Laminates | 444,753 | 79% | 64% |

Source: A. Troge, "Comparison of Cost-efficiency of Packaging Recovery Systems in Germany and the Netherlands," short version of diploma of P. Axt, translation from German (Bayreuth, Germany: University of Bayreuth, 1999).

By 1998, 6.2 million tons of used sales packaging were collected from Green Dot containers, a slight climb from the previous year. Of this amount, 5.6 million was recovered for recycling. Targets were achieved for all materials.[69] These levels of recycling very likely exceed levels that would have been achieved by market trends. However, only a portion of the total amount of recycling can be attributed to the EPR program. German economist Marcus Schroll estimates that without the DSD program, recycling would have increased from the 1990 baseline of 2.5 million tons to around 3.6 million tons (see Figure 6). The DSD program has, thus, resulted in about 2 million tons of additional recycling.[70]

***Cross-national Comparisons***. In absolute terms, the German program has achieved, even exceeded, its waste-recovery targets. However, these reductions in waste and increases in recycling need to be put into perspective. Cross-national comparisons are instructive.

**Figure 6: What Would Have Happened Without DSD?**



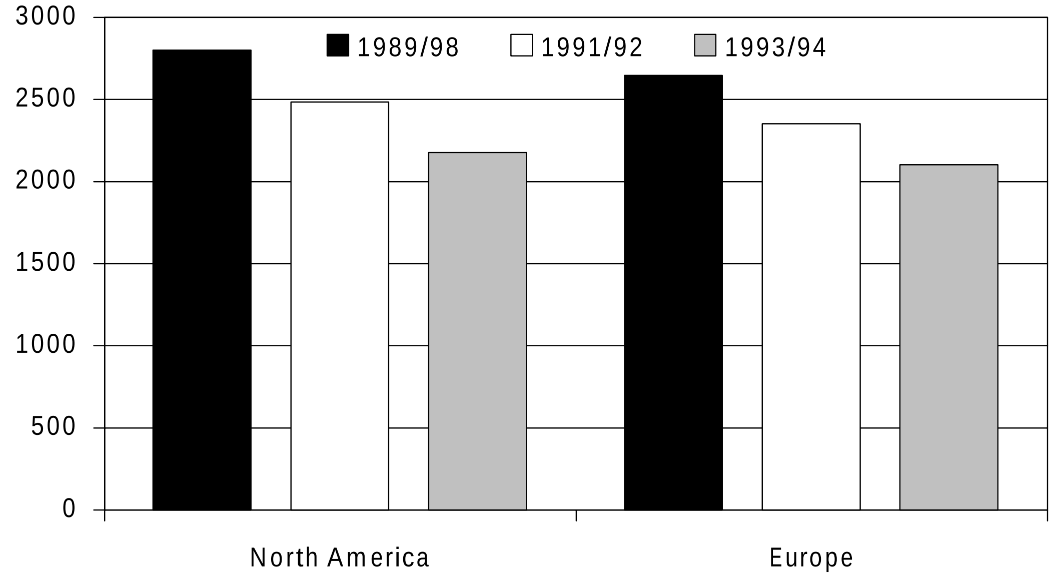

Source: Schroll, "The German Packaging Ordinance."

Over the same time period, and with no EPR system in place, the same basket of grocery items in the United States experienced a reduction from 2,750 pounds per gross production unit to 2,100 pounds, nearly a 26 percent drop (See Figure 7). A 1999 analysis of waste-generation changes in the United States shows a reduction in projected rates of waste generation (before any recycling) of 23 million tons between 1990 and 1996, with 17 percent of this reduction coming from packaging.[71]

In 1988, Canadian packaging manufacturers voluntarily set as a target a 50 percent reduction in packaging sent for disposal by 2000, with interim reduction goals of 20 percent by 1992 (over the 1988 baseline) and 35 percent by 1996. In January 1998, the Canadian Council of Ministers of the Environment announced that Canada's manufacturers had exceeded the year 2000 goal four years ahead of schedule. Data from 1996 showed disposal reductions (by weight) in packaging of 56 percent (from 5.41 million tons in 1988 to 2.64 million tons in 1996). These reductions were achieved despite an 11 percent increase in population.[72]

The Netherlands initially followed a similar approach, using a voluntary agreement rather than take-back mandates and packaging fees (though they later modified their approach to comply with the 1994 Packaging Directive of the European Union). Packaging consumption in the Netherlands declined upon implementation of the voluntary agreement 6 to 15 percent per year in the initial years, dropping to 1.5 percent by 1996. Recovery quotas in the Netherlands climbed modestly over this time (from 31 percent recovery in 1991 to 47 percent in 1992), indicating that reductions were occurring primarily through waste-prevention.[73] Overall, reductions in packaging consumption were stronger in the Netherlands than in Germany (see Figure 8), a possible indication of waste-reduction opportunity costs in Germany resulting from fees pegged to recycling costs.

**Figure 7: Material Use Per Production Unit (in Pounds)**



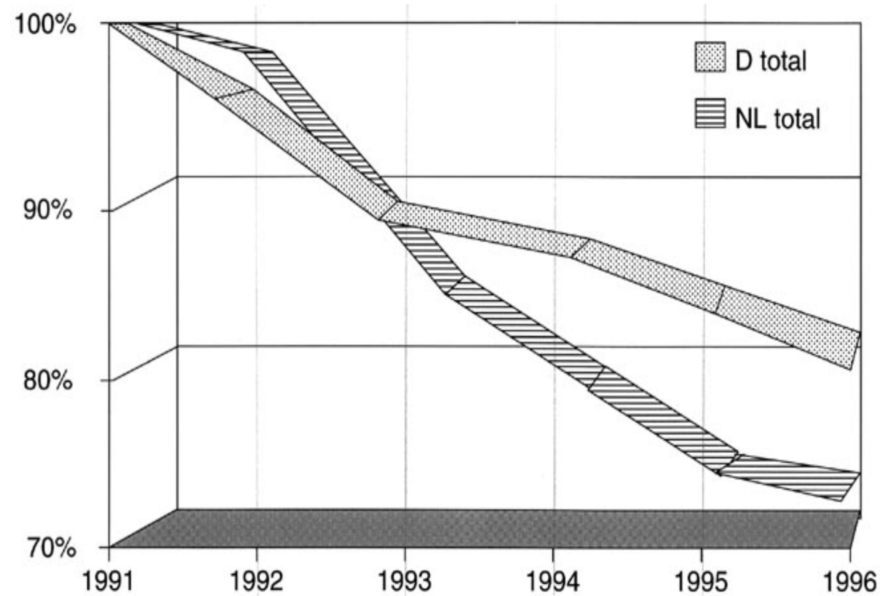

Source: Scarlett et al., *Packaging, Recycling, and Solid Waste*.

In other words, the drop in packaging was actually as steep in the two-year period before EPR implementation as it was in the four-year period just after EPR implementation.

***Market-process Comparisons.*** A snapshot picture of reductions in packaging waste in Germany during the EPR period ignores the materials-reduction dynamics that had occurred prior to implementation of EPR. Using a 1990–1991 base case, packaging material per task equivalent went from 117 in 1988 to 100 in 1990; then fell to 80 in 1993–1994, and then, to 76 in 1995 (see Figure 9). In other words, the drop in packaging was actually as steep in the two-year period before EPR implementation as it was in the four-year period just after EPR implementation.

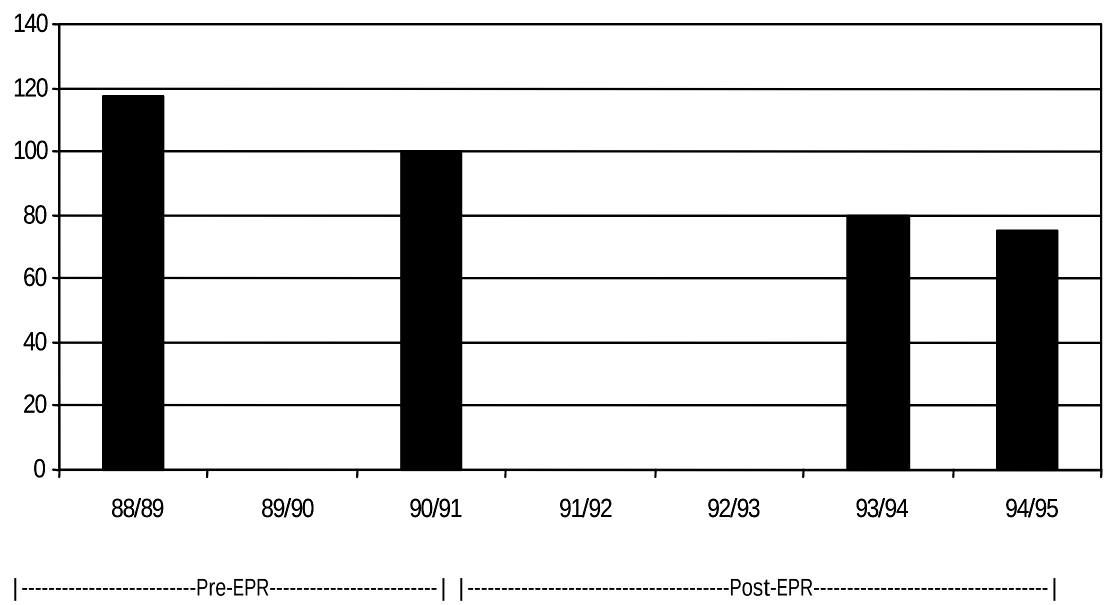
Individual product dynamics also show significant materials-use reductions before implementation of Germany's Green Dot program. These reductions are constant and usually incremental. Anticipation of the new program by producers cannot fully explain these reductions, since light-weighting and substitution toward more efficient materials predates discussion of take-back programs (see Figure 10). Nonetheless, in the years just prior to implementation of Germany's program, reductions were especially dramatic. For example, soap packaging declined by 35 percent on a task-equivalent basis; detergent carton packaging per task dropped 27 percent.[74] Over a variety of packaging types in the decade prior to implementation of the German EPR system, substantial reductions occurred in packaging (by weight) per product unit (see Figure 11).

**Figure 8: Development of Packaging Consumption (Adjusted to Economic Cycle)**



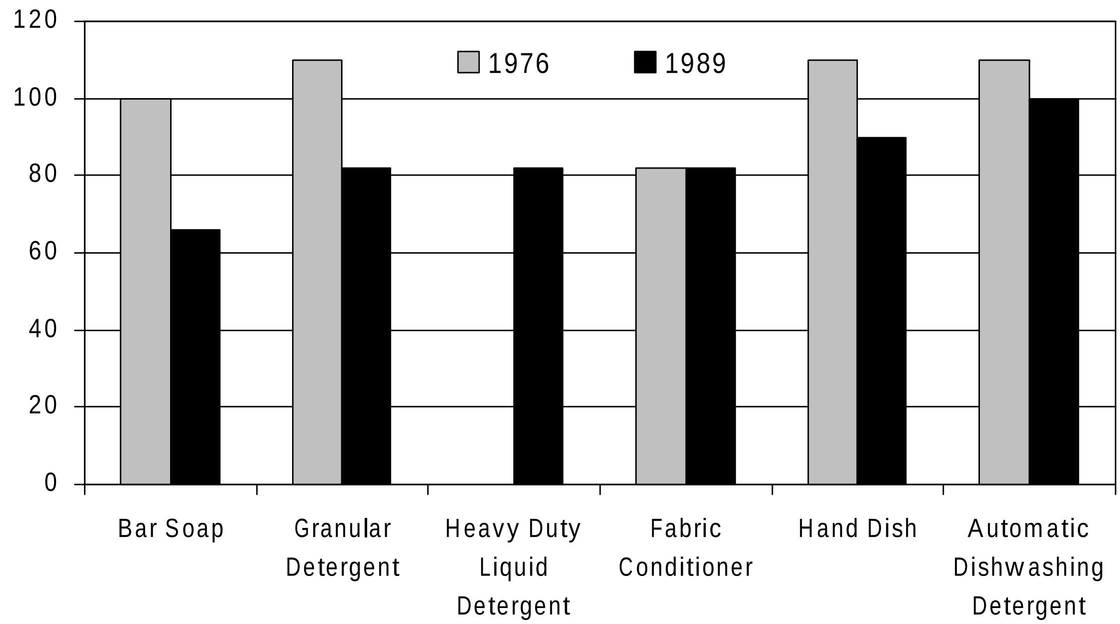

Source: Troge, "Comparison of Cost-efficiency of Packaging Systems."

**Figure 9: Relative Packaging Material Consumption Per Job Equivalent**



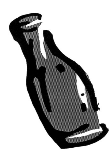
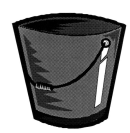

Source: Klaus Draeger, Procter & Gamble.

**Figure 10: Reduction of Packaging Material before Packaging Ordinance**




Source : M. Schroll, *The Challenge of the German Industry in Solid Waste Management: The Example of Packaging* (Bochum, Germany: Institute for Applied Innovation Research, 1998).

**Figure 11: Changes in Typical Container Weights Over Time**


| | | | |
|---|---|---|---|
| 0.33-liter soda can | 1-liter glass bottle | 150-gram plastic tub | 4-liter fabric softener container |
| 1950 = 80g | 1972 = 570g | 1970 = 11g | 1970 = 300g |
| 1992 = 33g | 1992 = 350g | 1985 = 5 g | 1985 = 100g |

Source: Klaus Draeger, Procter & Gamble.

## B. Electronics

Benefits from mandatory electronics take-back programs are undocumented or ambiguous. Because legislated EPR for electronic goods is a relatively new practice compared to packaging and some other products, little empirical evidence is available to examine how mandated EPR works compared with conventional ways of handling discards.

***Identifying the Problem.*** EPR laws are largely aimed at reducing the amount of waste that ends up in landfills or incinerators. For electrical and electronic products, waste-diversion is the main goal, since landfill space in Europe is limited, particularly compared with the United States.

However, the amount of waste generated from end-of-life electric and electronic products, while growing, is small. Collectively, it accounts for less than 1 percent of Europe's total solid-waste stream, or 4 percent of the EU MSW stream.[75] Furthermore, 90 percent of electronic end-of-life waste is comprised of large household appliances, large information technology (IT) products, and TVs. Yet these represent just a small portion of all the electric and electronic products manufactured in or imported into Europe that would be subject to the WEEE directive. Some of the regulations apply to electronics that don't end up in the waste stream at all, such as mainframe computers, servers, terminals, and central storage systems used by businesses.[76]

The amount of waste generated from end-of-life electric and electronic products, while growing, is small—less than 1 percent of Europe's total solid-waste stream.

***Shifting Costs and Their Effects on Incentives.*** Even if it were determined that the total waste stream's 1 percent of electronic goods should be reduced to the degree the EU is proposing, would the WEEE's mandates on EPR be effective in reducing that waste? Would manufacturers' cradle-to-grave responsibility persuade them to make easily recyclable goods? In the case of the EU's 2000 WEEE proposal, the answer is no. Traditionally, the theory behind "producer responsibility" is to shift costs from the consumer/taxpayer to the manufacturer to improve the waste characteristics of the product.

Yet the EU directive will likely not change design incentives substantially for several reasons. First, the largest costs in the whole product-recovery process lie in collection and transportation of the end-of-life products, not in product disassembly and recycling.[77] There is little a manufacturer can do in product design or production to control these costs. Indeed, pegging WEEE fees to recycling costs may steer manufacturers toward use of more easily recyclable, but heavy materials such as metals, and away from lighter-weight plastics. This reversal of previous light-weighting trends could actually increase shipping costs and transportation fuel use.

Second, cost shifting for historical waste cannot affect manufacturing design for these products. In five years, manufacturers will be responsible for products they manufactured some 20 years ago, long before the requirements even surfaced. There is nothing manufacturers can do to improve the recyclability of such products.[78]

***Measuring the Eco-efficiency of Take-back Requirements.*** Incentives aside (and incentives driving product design are moot in the event the European Union enacts a third WEEE directive, mandating specifications for design), an important cost-benefit consideration is the environmental gains of the take-back requirements, relative to cost. Ab Stevels, Eco-design Senior Advisor of Philips Consumer Electronics in the Netherlands and on the faculty of industry design at the Delft University of Technology, has devised a method for calculating the eco-efficiency of take-back mandates, where "eco-efficiency" is the environmental gain of the recycling of materials, over the cost of recycling; the higher the eco-efficiency, the greater is the environmental gain of recycling, relative to recycling costs.[79] He has applied the method to a number of different consumer electronic products and their materials to compare eco-efficiency among different products. He bases his calculations on current take-back behavior from pilot projects in Eindhoven, The Netherlands, recycling technologies employed by recyclers in various European countries, and on transaction costs.

He finds that eco-efficiency initially increases with increasing expenditures, but then begins to fall, indicating that at some point additional money spent will not yield additional environmental gains. Because the point of maximum eco-gain will vary depending on the product and its material characteristics, policy decisions should aim for the maximum point of the eco-efficiency curve.

In comparing eco-efficiency levels, he found it more useful and revealing to consider products' material characteristics, rather than just simply comparing products. For example, in calculating the eco-efficiency of TVs, he found a big difference depending on whether or not the TVs were old or new and, if new, whether or not they included or excluded plastic recycling. Table 15 shows his results.

**Table 15: Eco-efficiency of Old and New Televisions**

| | Material Recycling Efficiency (%) | Recycling Cost (US$/kg) | Eco-efficiency |
|---|---|---|---|
| Old TV | 68 | .47 | 1.45 |
| New TV (incl. plastic recycling) | 90 | .20 | 4.50 |
| New TV (excl. plastic recycling) | 75 | .30 | 2.50 |

Source: A. Stevels, *Eco-efficiency of Take-back Systems of Electronic Products*, OECD Workshop, "Extended and Shared Responsibility for Products" (Washington, D.C., 1999).

The table shows the dramatic change in both recycling efficiency and cost when treating new TVs. Even in situations where the plastic in TVs is not recycled—for example, in the presence of flame retardants—the eco-efficiency is still higher than for old TVs.

In comparing different products, Stevels found big differences in eco-efficiency levels. Again, emphasis was placed on the materials of the products, rather than the products themselves. Table 16 shows the results of products high in glass content (new TVs), precious metals (portable phones), non-precious metals (VCRs), and plastic (audio machines).

**Table 16: Eco-efficiency of Materials in Electronic Products**

| | Material Recycling Efficiency (%) | Recycling Cost (US$/kg) | Eco-efficiency |
|---|---|---|---|
| Glass Dominated (TV) | 90 | .20 | 4.50 |
| Precious Metal Dominated (portable phones) | 9 | 2.50 | N.A. |
| Metal Dominated (VCR) | 53 | .21 | 2.50 |
| Plastic Dominated (Audio Machine) | 30 | .46 | .65 |

Source: Stevels, *Eco-efficiency of Take-back Systems of Electronic Products*, 1999.

Table 16 shows products composed largely of glass, such as (newer) TVs, yield the highest eco-efficiency, while plastic-dominated products, such as audio machines, have relatively low recycling efficiency rates and high costs per kilogram, yielding the lowest eco-efficiency levels.

Finally, Stevels observes that eco-efficiency levels vary enormously from nation to nation, due primarily to variances in costs, market availability for processing secondary materials, and processing outcomes. Table 17 compares eco-efficiency levels for Italy, the Netherlands, and Sweden.

**Table 17: Eco-efficiency in Italy, the Netherlands, and Sweden**

| | Material Recycling Efficiency (%) | Cost (US$/kg) | Eco-efficiency (US$/kg) |
|---|---|---|---|
| Italy | 56 | 1.16 | .48 |
| The Netherlands | 68 | .47 | 1.44 |
| Sweden (with screen glass recycling) | 55 | .75 | .74 |
| Sweden (without screen glass recycling) | 20 | .75 | .26 |

Source: Stevels, *Eco-efficiency of Take-back Systems of Electronic Products*, 1999.

Stevels concludes that because of these vast differences in efficiency rates and cost, "it will be problematic to come to recycling targets which are uniform throughout Europe."

***Unsubstantiated Risks from Materials Tapped for Phase-out.*** Concerning the ROS directive to ban certain substances, including mercury, lead, cadmium, hexavalent chromium, and the brominated flame retardants (BFRs) PBBs and PBDEs**,** net benefits have not been determined**.** Put another way, the stated risks from human exposure to these substances are unsubstantiated.

Concerning BFRs, numerous studies—including the German study referenced earlier on electronics' environmental tradeoffs, research conducted by the U.S. National Toxicology Program,[80] and studies commissioned by the Association of Plastics Manufacturers in Europe[81]—show no discernable risk from recycling plastics treated with these substances. Even the European Union's "Memorandum on Scientific Evaluation," which is intended to provide justification for the directive's regulations, notes that data from municipal waste incinerators in the Netherlands failed to "show any significant relationship between dioxin formation and the bromine content of the waste." The memorandum continues, "further research is necessary."[82] As alluded to earlier, the European Union's preliminary results from its own risk assessments show no need to ban the substances. The memorandum indicates that any potential risks can be handled by standard practices in the industry.

Similarly, the European Commission's memorandum fails to substantiate risks to human health from these substances, mainly because human exposure levels are well within accepted levels of safety. For example, the European Commission uses research conducted by the World Health Organization (WHO), which establishes acceptable exposure levels, or "tolerable weekly intake" (TWI) levels, for these substances, including cadmium, lead, and mercury. For all three materials, the European Commission's data on daily exposure show that humans are well within the WHO's TWI levels.[83]

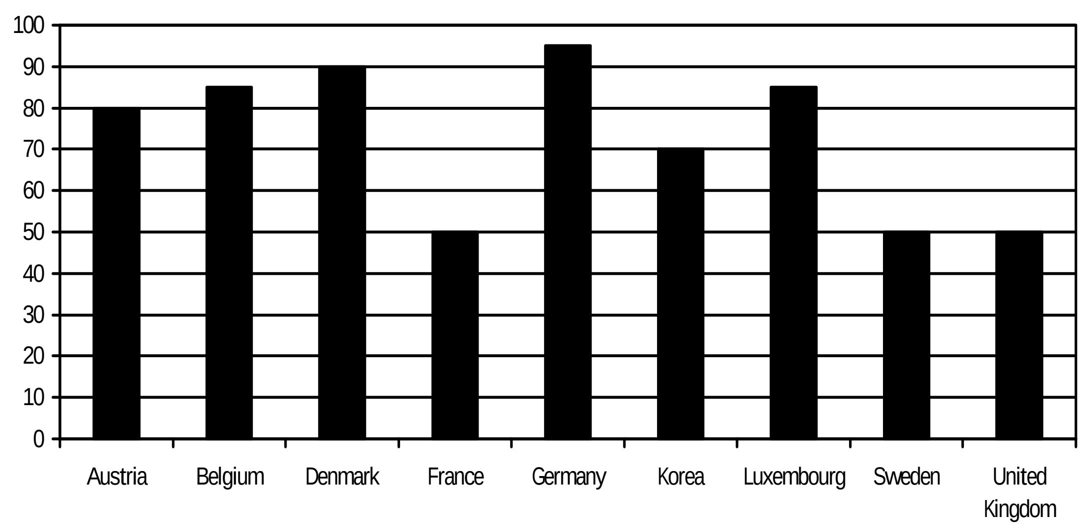
## C. The Limiting Factors

While mandatory EPR systems have generally been successful in increasing material recovery and recycling rates, their overall environmental impact is more ambiguous. For example, they appear to have had only limited effects on overall source reduction. Several factors limit their effectiveness. First, fees are typically passed on to consumers, softening the role that fees might otherwise play in inducing manufacturers to redesign products to reduce costs. Second, with the proliferation of different fees associated with different programs, manufacturers designing products for international markets face no clear price signal. Packaging analyst Victor Bell points out that "since there is such a variance in the methods of calculating packaging fees in each nation, making decisions regarding material substitutions that reduce the weight or volume of packaging is almost impossible."[84]

Bell offers several examples. In Germany, switching from a 50-milliliter glass container to a 50-milliliter polyethylene terephthalate (PET) container will increase fees as much as 132 Deutsche Marks (DM; about $72 in 1998) per 1,000 containers, but will have no impact on fees in France. Fees for laminated paper send even more confusing messages. In Sweden, France, and the United Kingdom, a package is considered laminated if fiber content is 50 percent or less. In Germany, it's considered laminated if fiber content is less than 95 percent (see Figure 12).

Third, fee structures change frequently in some programs. Belgium, which introduced EPR "eco-taxes" for a variety of products (batteries, disposable cameras, and packaging, for example), amended its law 17 times between July 1993 and 1998.[85]

**Figure 12: Amount of Fiber Required by the Major Countries for a Paperboard Carton to be Classified as Paper (in Percentages)**




Source: Bell, "How Manufacturers Are Responding."

Finally, all products must meet a variety of design goals. Notes German economist Eric Staudt, "measures concerning the design of sales packaging are oriented first and foremost towards the requirements of the packaging contents, the buyer, [retail] trade, and the packaging costs."[86] The EPR fees and take-back requirements are, therefore, only one of many considerations that manufacturers take into account when designing products. At the margin, the fees have some influence on packaging decisions, but product performance and total (rather than solid waste) costs dominate design decisions.

**Part 6**

# The Matter of Costs

Any program that sets mandatory product recovery targets and enforces compliance will likely achieve those targets. However, at least as important as the achievement of stated targets is the cost to achieve those results.

## A. Packaging—The Case of Germany

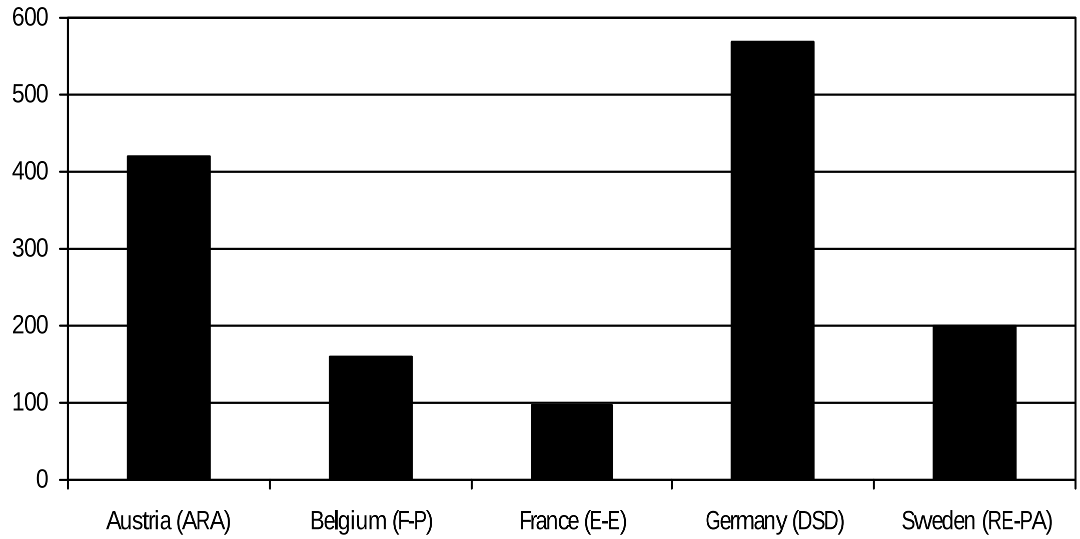
Architects of Germany's EPR program acknowledge its high cost relative to other waste-management programs. The costs per metric ton to collect, recover, and recycle packaging waste under the Green Dot program exceeds $500.[87] Marginal costs of the program rise significantly for recovery rates above 65 percent of packaging. Germany's program costs are substantially higher than integrated waste-management program costs in the United States that are achieving 30 percent diversion of the total waste stream, with an aggregate national diversion rate for packaging of around 40 percent.[88] While program costs vary widely, many U.S. programs operate recycling and waste diversion programs for well under $150 per ton of material recycled. These U.S. figures, like the German figures, represent total collection, recycling, and disposal costs.

Germany's program costs are also higher than program costs in other European nations that also operate some sort of extended (or shared) producer responsibility program (see Figure 13). However, a direct comparison using EPR program costs is misleading, since reported EPR costs in some nations represent only a portion of total waste-management costs. For example, some nations, like France, require that manufacturers pay only the incremental additional costs of recycling through their EPR program. The remainder of waste management costs in municipally operated or contracted programs is covered through taxes or residential service fees.

Several full-cost comparisons between Germany's EPR program and other more market-driven, voluntary programs exist. One comparison of Germany's Green Dot program with the "packaging covenant" program in the Netherlands concluded that 1996 diversion costs in Germany were around 719 ECU (European Currency Units; about $573 in 1996) per ton; in the Netherlands diversion costs were 174 ECUs (about $139) per ton. Adjusting the German costs to reflect different local labor and other costs in the Netherlands, Germany's program required 639 ECUs (about $511) per ton.[89] Even with 1998 projected reductions in Germany's program costs, the "efficiency ratio would still be one to three" for the Dutch system contrasted with the German system.[90] While costs in the Netherlands are much lower than in Germany, packaging recovery rates, at over 75 percent, are much higher than Germany's 50-percent recovery of packaging. However, source reduction has been significantly greater in the Netherlands—where the waste-management program does not specifically favor recycling—than in Germany.

**Figure 13: Recovery Scheme Cost**

**Estimated Cost in $/ton Diverted from Final Disposal** Source: Klaus Draeger, Procter & Gamble




Any program that sets mandatory product recovery targets and enforces compliance will likely achieve those targets.

Looking at Germany's program costs is instructive, because it helps illuminate some of the implementation factors that affect costs. If the policy challenge is how to design a least-cost EPR program, understanding these implementation issues is useful. For example, the chief operating officer of Germany's Duales System Deutschland, Wolfram Bruck, points to four regulatory-design elements that pushed Germany's costs upward:[91]

- Short lead time for participants to prepare for full program implementation;
- Noncompetitive award of collection and recycling contracts;
- Very high recovery targets; and
- A parallel collection system operating alongside existing waste-management collection systems rather than being integrated into those systems (as in France).

Other analysts of the German program point to additional implementation issues that affect both the efficacy and efficiency of the German EPR model. Klaus Draeger of Procter & Gamble points to the importance of how costs are allocated (who pays for what), whether and how "free rider" problems are addressed, and how fees are structured.

Uniform fees for all packages, for example, are easier (that is, less costly) to develop and administer than fees that vary by material, weight, and volume. However, they are less effective as a means of steering design choices in some predetermined direction. Cost-allocation among multiple entities (as in the United Kingdom) reduces the cost burden on any particular participant, but substantially increases tracking and reporting costs; shared cost structures also reduce the impact fees might have on product design, since each participant pays only some fraction of the total. Free-rider problems (among both consumers who place non-licensed materials into collection containers and manufacturers who fail to pay fees for products they introduce into the market) can result in contaminated waste streams and higher costs to participating firms. On the other hand, reducing free-rider problems generates enforcement costs—the more extensive the enforcement effort, the higher the administration costs.

## B. Electronics

For electronics, the costs of the EU WEEE program, which would be passed down to the consumer in the form of higher prices, would likely be significant. Typically, the cost of collecting and recovering an electrical or electronic product ranges from 5 to 15 percent of the product's manufacturing cost.[92] State pilot programs to collect and recycle electronic equipment in the United States have cost anywhere from $0.17 to $0.50 per pound (see Table 18)

**Table 18: Costs of Collecting and Recycling Used Electronics**

| Program | Lbs. Collected | Cost / Lb. |
|---|---|---|
| California | 61,600 | $0.29 |
| Illinois (1) | 23,341 | $0.35 |
| Massachusetts (2) | 7,448 | $0.44 |
| Minnesota (3) | 552,000 | $0.50 |
| NewJersey (4) | 232,866 | $0.17 |
| NewYork (5) | 2,372 | $0.19 |

(1) Average for the Chicago suburbs of Naperville and Wheaton in first program year.

(2) First program year for the community of Somerville, Massachussetts.

(3) Multiple types of collections across Hennepin County in the Minneapolis area.

(4) Multiple communities; multiple collection types.

(5) First program year.

Source: EPA, *Resource Recycling* (Washington, D.C., May 1999).

The European Union puts the price tag for collecting and recovering electrical and electronic products from households alone between $516 million and $930 million a year for the 15 member states, which EU officials estimate will increase the average price of items between 1 and 3 percent.[93] Orgalime**,** which calculates the financial impact of *all* aspects of the WEEE and ROS directives, puts the total cost as high as $59 billion: $7 billion for all take-back requirements, $14 billion for development of new technologies to comply with the regulations, and $38 billion for historical waste requirements**.**[94] The largest manufacturing companies might be able to absorb some of the cost—particularly if they form a cartel, as some analysts speculate could happen.[95] However, the heaviest financial burden likely will fall on small businesses, importers, and other producers who don't have the resources or infrastructure to establish take-back programs of the magnitude that the directive would require.

## C. Efficacy and Efficiency—The Bigger Picture

What we've discussed so far are all implementation details. The broader issue is whether mandatory EPR programs represent sound public policy.

Though the waste-reduction rationale for current EPR take-back programs may be laudable, these mandated programs may increase, rather than reduce, transaction costs associated with managing household and commercial waste and may limit innovations in a product's overall and environmental performance.

Three implementation features of take-back systems create new monitoring and enforcement requirements in the delivery of waste-management services: free-rider problems, "price-searching" problems (that is, the difficulty of ascertaining costs due to lack of research data), and contract management and licensing oversight.

***Free-rider Problems.*** The free-rider problem is a consequence of offering consumers "free" waste disposal service through manufacturer-funded programs: they have an incentive to place non-program items in the designated containers. The problem is most acute where separate municipal and EPR systems operate, as in Germany's Green Dot program. Ironically, the Green Dot program, justified as a way of eliminating market externalities, actually creates them. It creates a "public goods" problem where, under the former ownership arrangement in which responsibility for packaging handling and disposal transferred with the sale of the item, consumers were responsible for their own waste. Waste was, in effect, a cost internalized to the consumer, either through trash disposal fees or taxes. Under the take-back program, waste disposal costs, embedded in product prices, appear free to consumers. Moreover, access to manufacturer-funded collection systems invites overuse of the system.

For manufacturers, the free-rider problem is a consequence of creating a waste-collection system in which it is difficult for either the consumer or the waste hauler to distinguish whether waste-collection fees have been paid for any product or package. Nor do haulers have an incentive to make such a distinction, unless they face penalties for collecting non-program waste. Manufacturers therefore have an incentive either to underreport the amount of EPR products they place into the market (and thus pay lower fees), or not to pay any fees at all. Enforcement efforts can minimize these problems—but at a cost.

***Price-searching Problems.*** Price-searching problems result from two gaps in data. First, information about location-specific waste-management costs are either unavailable or must be aggregated into an "average" cost. Second, since waste-collection and -disposal systems collect aggregated mixes of discards, information about the specific disaggregated costs of handling a single item may be sparse. This latter problem is more acute for small, dispersed, heterogeneous discards such as packaging and less difficult for appliances, automobiles, and larger disposal items. The price-searching problem generates significant prospects for arbitrary and discriminatory fee structures, which, in turn, give rise to politicking over fee setting.

## D. Summary

The discussion above shows that EPR cannot be justified on either practical or theoretical grounds. However, there may be circumstances in which product "leasing" arrangements, including product "take-back" or product stewardship programs will generate environmental value and consumer value. In these cases, they are likely to emerge spontaneously through market forces as manufacturers compete to provide services that their customers value.

**Part 7**

# The Rise of Voluntary EPR Programs

Heightened concerns about waste and other environmental impacts, especially of consumer products, have prompted a search for new institutional relationships within firms, among firms, and between firms and customers, that:

- Create incentives for companies to deliberately incorporate waste-minimization values into product design decisions;
- Motivate firms to reduce the overall environmental impact of their production processes and products; and
- Motivate consumers to generate less waste and reduce their environmental "footprint."

As firms compete to add value for their customers, EPR has emerged voluntarily in some settings, for some materials, and within some industries. These voluntary EPR arrangements are situated among a whole complex of other institutional innovations that share the common goal of reducing the environmental impacts of manufacturing processes and products. What distinguishes voluntary EPR arrangements from these other experiments in industrial ecology is one central feature—the reallocation from the end user to the manufacturer of some or all responsibility for products at the end of their useful life span.

In a 1998 informal survey of emerging institutional arrangements intended to enhance environmental responsibility, Reason Public Policy Institute identified three different categories of voluntary programs that embody features of EPR. These include:

- Take-back and product-leasing programs;
- Private-sector "green design," recycling, and remanufacturing consortia; and
- Producer-leveraging agreements with their private-sector suppliers.

## A. Three Voluntary Program Models

***Take-back and Product Leasing.*** Voluntary take-back programs in many ways mirror those created through legislation or public-private negotiated agreements. Individual companies or specific industries set up mechanisms to recover products, either directly by the manufacturer or through a designated collection network. Costs are borne either by an individual firm, when acting independently, or through a fee system established collectively by the sponsoring industry. In the United States, only one example of the latter approach—an industry-wide take-back scheme—exists to date: the Rechargeable Battery Recycling

Corporation (RBRC), established by the rechargeable battery industry. Several pilot industry-wide programs also have been tried, such as a windshield take-back pilot sponsored by the U.S. Council for Automotive Research (USCAR).

Other programs have been established by individual businesses independent of other firms operating in the same industry. These include:

- Nike's Reuse-a-Shoe program;
- The computer recovery programs of IBM, Dell, and Hewlett Packard;
- Hewlett Packard's toner cartridge return program;
- Several brand-name clothing return programs;
- A number of returnable transport packaging programs;
- Saturn's bumper-fascia return program;
- A furniture manufacturer retrieval program for foam shipping material; and
- Several returnable camera programs.

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As firms compete to add value for their customers, EPR has emerged voluntarily in some settings, for some materials, and within some industries.

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***Private-sector Green Design, Recycling, and Remanufacturing Consortia.*** Where manufacturers within an industry share common environmental challenges, especially relating to product reuse, recycling, and disposal, many collaborative research efforts have been undertaken. Well known in this realm are efforts by trade associations such as the American Forest and Paper Association, the Steel Institute, and the American Plastics Council. However, some industries have moved beyond the traditional joint research efforts that occur under the rubric of trade associations to embark on direct, industry-funded research into reuse and recycling on a partnership basis. Most notable of these efforts is the Vehicle Recycling Development Center (VRDC), established in 1994 as a partnership of the American auto manufacturers, who also collaborate with the Automotive Recyclers Association, the American Plastics Council, and the Institute for Scrap Recycling Industries. The primary goals of VRDC include: 1) finding ways to recycle automobile "fluff"—the 25 percent or so of a scrapped automobile that can't be recycled; and 2) finding ways to more cost-effectively disassemble cars, including removal of fluids.

***Producer-leveraging Agreements with Private-sector Suppliers.*** Most manufacturers are not fully vertically integrated, meaning that they purchase parts and other production inputs from outside suppliers. These relationships are often stable and involve large transactions, giving the manufacturer substantial "leverage" over the private-sector supplier regarding the environmental characteristics of supplier inputs. Through this leverage, firms invest in product redesign to meet company recycling, waste reduction, toxin reduction, and other environmental goals. Such "green partnerships" between manufacturers and suppliers are among the most common forms of voluntary extended (or shared) producer responsibility programs. Notable examples include, but are not limited to:

- Dell's establishment of Environmental and Recyclability Design Guidelines for all input suppliers;

- Hewlett Packard's "Controlled Materials List," in which suppliers must avoid 154 pre-identified hazardous wastes;
- DuPont's Emerald Environmental Services, which works with DuPont clients to implement waste-recovery programs;
- Bell Atlantic's coordination with Westvaco, a supplier of billing envelopes, to work with paper manufacturers in creating an envelope of 100 percent recycled content, of which half is made from recycled phone books, diverting 575 tons of waste from landfills.

## B. Voluntary Program Possibilities

Voluntary program challenges vary by program type but generally include 1) finding mechanisms to attract customer participation, 2) establishing cost-effective collection and return networks, 3) identifying markets and uses for returned items, and 4) achieving cooperation where multiple firms are involved.

***Customer Participation.*** Some programs use incentives—such as Nike's $5 rebate on returned shoes—to generate customer participation. Other programs involve direct economic benefits to consumers—as in the case of Dell's computer leasing and take-back program—that stimulate consumer cooperation. Others use a social services approach, such as LensCrafters's eyeglasses return program, which works with local nonprofit Lions Clubs to generate consumer responsiveness.

Customer participation is a critical issue for take-back programs. For manufacturer-supplier leveraged agreements, the pre-existing relationships, the economic incentives suppliers have to meet the needs of their manufacturing customers, and the relatively small universe of suppliers that some companies interact with make customer participation less of an issue for these agreements.

***Collection Networks.*** Our survey showed nearly as many different collection networks as there were programs, but these networks fall into several categories, including 1) contracting with professional shippers using prepaid shipping labels, 2) direct return to retail outlets where they are reshipped to the manufacturer, 3) use of nonprofit service organizations as collection centers, and 4) use of a manufacturer-operated return network.

Under the first category are those such as Hewlett Packard's (HP) toner cartridge take-back program. HP supplies all customers with prepaid United Parcel Service (UPS) shipping labels. Large customers also receive free of charge bulk-shipping containers for multiple cartridges. UPS picks up returnable cartridges either directly from the customer, or the customer can take the cartridge to Mail Boxes Etc., a private mailing service, where UPS will pick up the cartridge. UPS now has over 200 clients that use its Asset Recovery Service (ARS) to provide for efficient, prepaid return of items from the user back to the manufacturer. Some of these ARS programs have no environmental dimension; others, like the HP program, are specifically designed with environmental goals in mind. The UPS program allows companies with take-back programs to take advantage of a pre-existing, highly efficient shipping network. However, such prepaid shipping programs appear most feasible only where the returned product has high reuse, remanufacturing, or recycling value, as can be the case for photographic equipment or some selected electronic supplies and equipment.

Under the second category are numerous programs such as Nike's Reuse-a-Shoe program and the Ecolog outdoor clothing program. Use of retail outlets appears feasible primarily when the manufacturer has a preexisting, decentralized, and substantial network of retail outlets or distributors that provide broad customer access across market areas. The LensCrafters "Gift of Sight" program uses a combination of its over 700 retail outlets and the nonprofit Lions Club International to provide a product-return network.

Under the final category are several product-leasing programs, including some returnable pallet programs. Chep USA ships products in a variety of returnable containers and pallets, each marked with a bar code for tracking purposes. Chep provides participating customers with computer software to allow for tracking and return of container inventory.

Manufacturing research consortia such as the VRDC typically work with existing infrastructure, including auto retailers, auto scrap dealers and dismantlers, to identify key issues and research applications. Since no real product take-back occurs, the collection issue is not relevant.

***Identifying Markets and Uses.*** All voluntary take-back programs in our informal survey actively invested in and developed end uses for returned products, including reuse, remanufacturing, and recycling. In most instances, the take-back programs generated some up-front product redesign. These redesign efforts vary but typically include one or several of the following features:

- Increased product simplicity for easier material separation and reduction in contaminants in the recycled products;
- Greater ease of disassembly, through use of modular parts, elimination of glues or welding; reduction in number of parts, etc.; and
- Increased durability of parts designated for reuse.

In each of these three categories are several examples. These include Ecolog's outdoor clothing, with all parts made of a single, highly recyclable polyester; Dell's use of modular computer components, reduction in number of materials used, and reduction in use of welding; and Xerox's switch from plastic to more expensive, but more durable copy machine parts that facilitate reuse.

In numerous cases, manufacturers conduct materials research to create marketable and high-quality end uses for recycled materials. Nike has developed its Nike Grind, made of recycled shoe parts that it licenses for use by makers and installers of athletic surfaces. Saturn developed processes to remove paint from bumpers and recycle the bumper fascia materials into new car parts.

***Achieving Industry Cooperation.*** Most voluntary efforts operate through the actions of individual firms, so the issue of coordination and cooperation is not relevant. However, the several examples of industry-wide take-back or joint research efforts reveal several features of the cooperative efforts. In the case of the RBRC, cooperation was, in effect, facilitated as the industry faced a common legislative challenge—specifically, the designation of nickel-cadmium batteries as a hazardous waste. This challenge helped coalesce the industry to move toward common action and provided an impetus for the 200 participating companies to pay licensing fees to use the RBRC "Charge Up to Recycle!" logo.

The other major industry-wide effort, involving American automobile makers, did not result from specific legislation. Instead, it arose from their growing common interest in recycling the 25 percent of auto materials typically not recycled in traditional scrap operations. The transaction costs to achieve coordination were limited because of the small number of companies involved.

## C. Challenges and Barriers

Voluntary EPR programs are emerging within a larger market context. Sustainability of these programs hinges on cost-effectiveness and efficacy in achieving a combination of product-quality goals. All programs surveyed placed a premium on integrating economic concerns with environmental goals. For example, a key to recycling automobile fluids is the ability to remove fluids quickly, reducing labor costs. VRDC set a goal of reducing disassembly time for a single auto from 45 minutes to 20 minutes in order to improve the economics of disassembly. The "white goods" industry has likewise focused on improved, cost-effective means for removing chlorotrifluoromethane (CFC) refrigerants before recycling.

But cost-effectiveness can be influenced by non-market factors. In the case of returnable shipping pallets, tax laws can deter the use of returnables. For example, many states exempt non-returnable shipping pallets from sales taxes but require payment of sales tax on returnable, leased containers. This differential taxation creates an economic hurdle that can be difficult for suppliers of returnable, leased pallets to overcome.

Many states exempt non-returnable shipping pallets from sales taxes but require payment of sales tax on returnable, leased containers.

Uneven enforcement of regulations can also affect incentives for firms to establish take-back or other programs to enhance environmental performance. For example, U.S. federal law requires removal of hazardous materials from appliances before recycling of scrap metal. However, this requirement is unevenly enforced. According to the Appliance Recycling Centers of America, only one regional EPA office enforces against intentional venting by scrap yards of CFCs. Appliances, on average, weigh 150 pounds; current scrap values garner recyclers about $3 per appliance (at $40 per ton, which is a high value in today's markets). Costs of hazardous waste removal are not offset by scrap prices, thereby requiring that a fee be charged for this service. But with widespread non-enforcement of the removal policies, neither manufacturers, end users, nor others have any incentive to pay removal fees.

In several cases, public-private partnerships have created incentives for participation in take-back programs. Indiana's Department of Environmental Management, working with the Indiana Drycleaning and Laundry Association, established a 5-Star Environmental Recognition Program for drycleaners. The program is a flexible labeling program, with five tiers of actions and options that drycleaners can undertake; the more of these tiered actions undertaken, the greater number of stars awarded. Levels two and above include the establishment by the participating drycleaner of a take-back program for hangers and drycleaning bags.

Each product and industry faces a series of specific "devilish details" that influence what institutional arrangements will add both environmental and economic value. Each industry also faces its own specific set of barriers and challenges that can only be hinted at in a general overview.

## D. Voluntary Electronics Programs

Volunteer programs that address end-of-life products are taking off in the electronics industry as well. Manufacturers are running their own programs—in some cases, operating their own recycling plants—to reduce different products' environmental impacts from cradle to grave. Most programs include some or all of the following elements:[96]

- Designing products for easy and quick disassembly and recyclability of parts;
- Designing products that eliminate or reduce substances of environmental concern;
- Designing products that can more easily be upgraded to reduce the generation of waste;
- Reducing waste and emissions in the manufacturing process;
- Manufacturing products that improve energy efficiency;
- Arranging for the product's collection at its end-life; and
- Enabling the product's recovery—via reuse or recycling.

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Manufacturers are running their own programs to reduce different products' environmental impact from cradle to grave.

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These efforts are taking hold for a several reasons. Some producers claim they are introducing these programs to address environmental concerns. Some say they are responding to consumer pressure. Some point to a growing market demand and opportunity to add market share by implementing take-back programs. Some are attempting to preempt any regulatory action that might constrain the flexibility with which they are able to implement such programs. All of these efforts benefit from (and could not occur without) markets and infrastructure for reusing and recycling electronics.

Growing interest in recycling has given birth to a secondary market of firms that handle the recovery, reuse, and recycling of many electronic products, especially computers.[97] Within North America, there are an estimated 300 "de-manufacturing" facilities for electronics alone.[98] Such a large network of plants that specialize in asset recovery enables all parties involved to benefit from economies of scale resulting from high volume. For items that can be reused, these firms typically refurbish the products and sell or donate them. For items that can't be reused, firms separate those parts with value for resale, including hard drives, chips, precious metals, and even non-precious metals.[99] What remains is then recycled. For the many products that contain lead, such as TV and computer monitors, the firms extract the material and sell them to smelters or exporters where markets to recycle the lead and glass are emerging.

A necessary component of successful recycling programs is consumer awareness. Most manufacturers that run programs give a lot of attention to educating the consumer on where and how one can return used products. The Electronics Industries Alliance (EIA), a consortium of electronic and high-tech associations and companies, has established a nationwide consumer education campaign called the Consumer Education Initiative (CEI) to help users identify what options are available to them for discarding used equipment. Through a Web site, consumers can locate nearby schools, "de-manufacturers," and other local or national programs that collect and recover electronic products. The initiative's objective is "to lessen the environmental impacts of our products throughout their entire life cycle, from design to end-of-life."[100]

The following provides a summary of a few other successful private recovery programs in the electronics industry:

***HP's Product Stewardship Program.*** This report has already made several references to HP's initiative for recycling printer cartridges. The company's pioneering efforts in this area, as well as its sophisticated computer recycling operation, have made the corporation a leader in the voluntary recovery movement. HP launched its stewardship program as far back as 1992 as an attempt "to prevent or minimize any negative impacts to human health and safety, or to the ecosystem, that may occur at any point in the life of an HP product—from when it is designed until when it is no longer used."[101]

In the design process, HP builds its computers for easy disassembly and recyclability, using a foam chassis to reduce the number of parts used and material identification codes to make sorting easier. HP also uses fewer raw materials.

HP was the first corporation to create its own "tear it down" effort to accompany its successful "build it up" operation. Called Product Recycling Solutions (PRS), the recycling plant processes 3.5 to 4 million pounds a month of end-of-life HP equipment, collected both from internal facilities and from corporate customers. Components with value—such as circuit boards, chips, and precious metals found in some of the older computers, as well as the reusable parts including the hard drive, mouse, and speakers—are separated out for reuse or sale. The rest is recycled fully; no waste is sent to landfills.

***IBM.*** "Big Blue" is also thinking green. In November 2000, IBM started a recovery program primarily targeted at personal and small business users, the segment of the PC user population that typically gets overlooked in computer recycling programs. Unlike some other computer manufacturers operating similar programs, IBM charges a fee to have the equipment shipped to a recycling firm, but also unlike some other programs, IBM does not require a new purchase as a condition for returning used equipment. The company also will take any brand of computer or parts, not just IBM-manufactured ones. Once computers are sent to the recovery plant, they are either recycled or donated to a nonprofit organization in need, such as a job training or family service center.

***Sony.*** HP and IBM represent the "high-end" of the electronics industry, where recycling efforts can actually yield profits if implemented properly due to the relative value of computer materials and components. Products manufactured by Sony, however, such as hand-held radios, TVs, and computer monitors, are extremely expensive to recover. This is largely because the process is labor-intensive. A Walkman, for example, is composed of numerous tiny, low-value parts, requiring a costly effort to separate these materials that yield little return. Similarly, TVs and computer monitors contain lots of lead in the glass and the cathode ray tubes (CRTs) that make it challenging to handle safely.

In spite of these hurdles, Sony Corporation has created a take-back program for batteries and computer monitors, the latter through Sony Deutschland, its European manufacturing branch. Unlike the WEEE legislation's premise that the producer is ultimately responsible for end-of-life products, Sony believes the user should play a role. To this effect, Sony designs and builds products that can be easily recycled and works with third-party recyclers to handle the process. Consumers or localities also must do their part, paying to send the product to Sony or drop it off at one of the numerous recycling centers.

Sony also maintains that while it is not in the recycling business, it is willing to help make recycling as cost-effective as possible where it is able to do so. By encouraging the growth of recycling centers and buying recovered products and materials from these centers, Sony is able to ensure that its products are recycled at the lowest possible cost. Sony takes advantage of the recyclers' high volumes and resulting economies of scale. One such example is International Metals Reclamation Company, Inc. (INMETCO), which has worked under contract with Sony to collect its returned nickel-cadmium batteries. INMETCO captures the cadmium and sells it to manufacturers of nickel-cadmium batteries for reuse, thus preventing the material from ending up in the waste stream. In another venture, Sony has joined with Corning Glass to build a glass manufacturing plant that will recycle the glass from Sony TVs and PC monitors.[102]

The success of these efforts has enabled Sony to subsidize some of recycling collection costs. Most recently, Sony has joined forces with the state of Minnesota, turning what was a three-month pilot project—over which time consumers returned close to 700 tons of electronic products—into a five-year commitment. Specifically, Sony will encourage consumers to return end-of-life Sony products to numerous recycling centers throughout the state at no cost to the user.[103] Sony is also taking steps to extend the program nationwide in five years.[104]

## E. Voluntary Programs—Summary and Outlook

The effectiveness of voluntary EPR programs in advancing environmental goals depends on a number of factors. These include, but are not necessarily limited to:

- Ability to overcome interfirm, intrafirm, and other coordination barriers (thereby reducing private enforcement costs);
- Success in motivating "green design," waste reduction, reuse, recycling, and remanufacturing;
- Success in motivating "green" consumption and waste-handling choices;
- Scope and intensity of unintended (negative) consequences associated with the program; and
- Financial sustainability.

How these programs perform is both a function of the particular program design and the nature of the production and consumption marketplace within which the programs operate. A number of factors appear to influence the likelihood that voluntary EPR programs will emerge, what particular form these programs will take, and whether they will be efficient and effective over time. The incidence and form of these programs appears to be affected by the following:

- Number of affected products within a target category;
- Frequency of product transactions;
- Degree of product homogeneity within a product category;
- Size and scope of a product-distribution network;
- Degree of harm (liability) associated with product mishandling in use and disposal;
- Nature of existing discards-handling infrastructure;
- Number of affected manufacturers within an industry;
- Availability of consumer incentives/disincentives for appropriate product use and disposal or recycling;
- Sensitivity of current materials use to price and consumer preferences; and
- Nature and type of design tradeoffs within a product category.

To date, voluntary take-back programs appear to have emerged in circumstances where there are one or several of the following characteristics:

- High risk of improper disposal and associated liabilities;
- High value associated with the discarded product;
- Relatively low-frequency, high-value transactions between a manufacturer and a consumer;

- Relatively close or ongoing relationship between the customer and manufacturer; and/or
- Specialty or high-end products for which environmental or other social goals may enhance customer loyalty.

In the absence of any of these qualities, environmental stewardship is taking different forms through environmental certification initiatives, firm-specific life cycle analysis in product development, source reduction, and so on.

Take-back programs are less likely to emerge spontaneously in the marketplace (and are likely to be inefficient) in cases where there are:

- Many high-volume, low-value transactions;
- High levels of product heterogeneity (e.g., packaging and electronics);
- High degrees of centralization of product manufacturing with wide geographic distribution of the product; or
- Pre-existing safe, efficient, waste-handling or product management infrastructure (for example, U.S. auto scrap markets).

Their lack of emergence is not evidence of market failure. It is an indication that manufacturers anticipate more costs than benefits to their consumers from these programs, or that barriers exist (for example, disadvantageous tax treatment for leased rather than purchased products) that inhibit introduction of take-back programs. If benefits from EPR in a particular situation appear likely to accrue, those potential benefits represent an entrepreneurial opportunity that will, over time, likely attract investment by firms.

The variety of institutional arrangements that are emerging suggests that environmental progress involves not only technological innovation but also institutional innovations that link production and consumption choices to the environmental impacts associated with those choices. A competitive market context helps foster this institutional discovery process and allows firms and industries to tailor their environmental responses in ways that match the industry profile.

Part 8

# Industrial Ecology: A Broader Perspective on Environmental Stewardship

The ongoing search for ways to do more with less is intrinsic to companies' goals of cutting costs and providing greater value to customers. Resource use is a cost of production, and manufacturers in competitive markets continuously seek ways to reduce costs while still providing high-performance goods and services. Thus, at least for resources that are owned and traded, eighteenth century philosopher Adam Smith's "invisible hand" sometimes has a green thumb.

## A. The Advent of Industrial Ecology

Four factors are converging to accelerate and magnify the current trend toward dematerialization. These trends are also giving rise to an era of "industrial ecology," which combines the goals of producers and consumers with environmental values. Environmental benefits that were once the inadvertent outcome of a search for bottom-line benefits now sometimes result from a deliberate strategic focus by manufacturers on reducing environmental impacts of their activities. Industrial ecology offers a strategy to focus a firm's search for ways to cut costs or provide greater value to customers.

Before turning to the factors that are propelling industrial ecology, the term "industrial ecology" itself requires further explanation. As a business strategy, industrial ecology is the deliberate incorporation of environmental values into process and product-design decisions. It involves a systematic search for opportunities to reduce negative environmental impact while cutting costs or increasing customer benefits. As a business strategy, it is best viewed as a discovery tool, not as a set of particular practices, measurement tools, or institutional arrangements.

This approach to industrial ecology is not, as the more technocratic approach to industrial ecology has suggested, simply a set of methodologies for quantifying materials and energy use and tracking their associated environmental impacts. Indeed, viewing industrial ecology as the practice of comprehensively measuring materials flows and impacts may actually limit rather than enhance its utility as a business strategy, since data generation, analysis, and dissemination are costly. *Some* data on materials and energy use and their concomitant environmental impacts are a prerequisite to designing products and selecting manufacturing processes or service-delivery options. But attempting to quantify all input and output, while interesting as an academic exercise, is too cumbersome a process to be a useful decision-making tool for private firms.

Nor is industrial ecology, as used here, a decision-making strategy for centralizing production and product choices under a single authority, as one view of industrial ecology suggests. Eco-efficiency analyst Robert Ayres has argued that industrial ecology requires such a holistic perspective that its utility in reducing environmental impacts from production and consumption activities requires central planning. This perspective on industrial ecology assumes that "total knowledge" by a single coordinating decision-maker is possible and that determining some best resource allocation is also possible.

A more dynamic and contextual view of resources and environmental impacts suggests that even approximating these conditions is not possible. Similar emissions will have different environmental impacts under different conditions; resource scarcities will vary by time, place, and circumstance. The sheer complexity of materials and emission-flow patterns requires that, for analytic purposes, these patterns be simplified by aggregating data and drawing time and location boundaries around the analytical universe. Such simplified models may serve a heuristic function—i.e. they may generally indicate and prompt interest in areas of greater and lesser environmental impact. But they can't offer the contextual and dynamic information relevant to optimizing resource and energy use for a specific function at a particular location.

At least for resources that are owned and traded, eighteenth century philosopher Adam Smith's "invisible hand" sometimes has a green thumb.

Industrial ecology, then, is better understood as an organizing construct—a way of focusing the search by firms to add value, through cost cutting or increasing customer benefits. Firms face infinite opportunities to enhance resource productivity and add customer value; there are always new prospects for creating the proverbial "better mousetrap." Industrial ecology provides a focus for that search.

But industrial ecology does not presume that pollution-prevention always "pays," as some environmental economists have proposed. As in any economic pursuit, there may be diminishing returns from reducing waste or emissions below some threshold. It presents, instead, an articulation of a new "problem set" around which firms may seek economic opportunity.

## B. Four Converging Trends

So why are we seeing the emergence of this new "problem set" as firms move into the twenty-first century? Four converging trends help explain the rise of industrial ecology.

### *1. The Nature Culture*

First is the emergence of a "nature culture," especially in wealthier nations. At its loftiest, protecting "Mother Earth" has, for some, filled a spiritual void, becoming a sort of secular religion. On a less metaphysical plane, as human artifice has created a world of "the artificial"—man-made chemicals, fabrics, homes, and conveyances, nature becomes scarcer. That scarcity raises its value relative to other attributes that humans pursue. For these and other reasons, "nature" has become an aesthetic metric. Natural fibers, wild landscapes, and organic foods have come increasingly to exemplify what's beautiful or desirable.

To acknowledge an emerging "nature culture" should not be mistaken for assuming the emergence of a "Green Consumer" juggernaut. Most consumer surveys show that only a small fraction of consumers—less than 10 percent—will pay a premium for "low environmental impact" goods and services.[105] Instead, the "nature culture" has put environmentalism on the radar screen and in the "value mix" of producers and consumers.

### 2. "Smart" Technologies

A second trend—new technological possibilities—contributes to the rise of industrial ecology. Technology has, of course, changed steadily since the industrial revolution. It is useful to divide these technological changes into three eras.

***The Era of Mechanics.*** First came the "era of mechanics" in the late 1800s. For industrialists, the primary focus was on making large numbers of goods available at low cost. Labor was a key limitation, not the Earth's carrying capacity; productivity, not job-protection or safety preoccupied the minds of industry captains. Their central production challenge focused on designing machinery for mass production to make low-cost goods available to large numbers of people. They blended and welded together large masses of metals into machinery that consumed, per unit of output, large amounts of low-cost energy and cheap, abundant resources.

In this era, the natural environment was mainly a resource to tap into. Health and safety considerations, though not entirely overlooked, played a role secondary to revving up the industrial engine. Conservation, with occasional exceptions, occurred not as a deliberate attempt to shepherd the Earth's resources but as the inadvertent byproduct of a competitive drive to improve mass-production efficiencies.

***The Era of Chemistry and Physics.*** The Twentieth Century was the "era of chemistry and physics." Having mastered the art of mass production, industrial leaders turned their attention to product refinement and greater product quality. The imperative of improving production efficiency persisted into this new era. A new breed of industrialists entered the scene—scientists and engineers—who harnessed scientific knowledge to improve product and process performance. Chemistry made possible new materials, pharmaceuticals, brighter and whiter paper, new inks, better photographic techniques; the list of triumphs in the form of more convenient, better, and safer products is endless.[106]

This was an era of increasing wealth, which brought with it greater attention by consumers, workers, and society at large to matters of health and safety. As basic needs such as food and shelter were more broadly met, the relative importance of other values such as convenience or safety grew.

Materials-use reduction occurred, and this conservation was not trivial. For example, the climb up the clean fuel ladder from residential wood burning, to coal burning, to natural gas is estimated to have reduced residential emissions of sulfur dioxide by 75 percent.[107] Some deliberate efforts to improve safety and reduce environmental impacts took shape. Pittsburgh steel mills were built with indoor ventilators. Cities began introducing air pollution laws—by 1956, at least 82 local jurisdictions had crafted air-pollution-control programs.[108] But the environmental benefits from conservation were usually unintended and often unnoticed byproducts of the search for bottom-line efficiencies and lighter, newer, better materials. Industries, at this time, generally viewed environmental issues as a constraint, not an opportunity. Both the mindset and language of regulatory compliance rather than environmental excellence predominated.

***The Era of Biology.*** Finally, the dawn of a new century has also ushered in a third era: "the era of biology." Borrowing from the language of biology, industry participants in this era have begun to think about "feedback loops," that is, learning from each cycle of a process and integrating that knowledge into future design and production decisions. If wielding large amounts of resources characterized the era of mechanics, and manipulating molecules characterized the age of chemistry, this new era is characterized increasingly by knowledge-based production and knowledge-intensive products. Emphasis on individualized service, convenience, performance, and enhanced leisure continue, but environmental values, health, and safety are becoming integral to product and process design.

New information technologies are making possible new relationships between manufacturers and suppliers and between producers and consumers. Information technologies are also taking the place of physical equipment in many cases. Farmers, for example, are using tractor-mounted computers to apply fertilizers more efficiently; computer-controlled automobiles allow for constant information feedback to enhance efficiency.

#### *3. A Time of Wealth*

A third trend—increasing wealth—is reinforcing the rise of industrial ecology. Economist Don Coursey and others have shown that peoples' environmental values become stronger with increasing wealth.

People's environmental values become stronger with increasing wealth.

#### *4. Production Dynamics*

On the practical side, many firms have plucked the low-hanging fruit of savings available from improving energy efficiency and labor productivity. So the search for competitive advantage is turning to smaller, dispersed opportunities to add value. Pollution-prevention, remanufacturing, and recycling all present potential opportunities for reducing costs.

Put together, the nature culture, the rise of "smart" technologies, increased wealth, and productivity challenges have combined to create a comfortable context for industrial ecology.

## C. Industrial Ecology as a Discovery Process

As a business strategy, industrial ecology represents a discovery process. This discovery process occurs along two dimensions: technological and institutional. The first of these, technological discovery, is well understood as a value-adding activity. The latter, institutional discovery, is less well understood and more often overlooked.

#### *1. Technological Discovery*

Industrial ecology strategies within firms and among farmers are inspiring a dynamic search for technologies that reduce environmental impacts. Some examples are:

- In the Netherlands, Dutch farmers have developed a closed-loop system to grow flowers in water and rock wool (an inorganic growing medium manufactured from ground rock). The process lowers the need for pesticides and fertilizers, which recirculate through the water. The process also lowers risk of disease and narrows the variation in growing conditions, thereby improving the consistency and quality of the flowers. The process has one added benefit: it involves growing the flowers on platforms, which facilitates curing, handling, and shipping, thus lowering labor costs.
- Hitachi, using an industrial-ecology strategy, sought to facilitate recycling and remanufacturing of household appliances. For example, it developed a six-screw washing machine, which substantially simplified disassembly and recycling. The new technology also cut manufacturing costs by reducing production time by 33 percent and reducing the total number of parts. For the customer, the washing machine required less servicing and was more reliable than earlier models.
- U.S. farmers, farm chemical suppliers, and equipment manufacturers have jointly worked to develop "precision agriculture" as a way of increasing yields while more efficiently using farm chemicals, water, and other production inputs. Precision agriculture brings together many disciplines and many technologies: site sensors, global positioning satellites, geographic information systems, rate-variable fertilizer equipment, and computers. The organizing construct behind precision agriculture is to find ways to increase yields, reduce environmental impacts, and remain cost competitive. Though precision agriculture is in its early stages of application, initial efforts show potential for optimizing soil and crop treatment to generate more uniformly high yields while reducing pollution runoff. In selected circumstances, it is proving to be cost-effective.

### *2. Institutional Discovery*

As a business tool, industrial ecology often unleashes an institutional discovery process, generating new organizational structures within firms, new relationships between firms and their customers, and new relationships among firms. Voluntary EPR programs fit within this institutional discovery process.

#### a) Sample New Firm-Customer Relationships

- Interface Flooring, Inc., developed a carpet-leasing system in which commercial customers lease carpet tiles that can be replaced tile by tile as they wear out, thus reducing waste.
- Dell Computer initiated a computer-leasing program that allows users to receive frequent upgrades: it uses modular computer components to facilitate upgrading, disassembly, and reuse, and older computers can be returned to Dell after a specified time—for example, two years. Companies thus avoid storage and disposal costs for their used computers.
- "Servicizing"—the provision of ecological information and service in addition to simply product—is emerging as an important tool of industrial ecology. For example, chemical firms provide special assistance to users to help them reduce total chemical consumption.

#### b) Sample New Relationships between Firms and Suppliers

- Saturn has worked with its suppliers to develop "green purchasing guidelines." As part of this process, Saturn redesigned its payment structure to paint suppliers, introducing a system of payments for specific amounts of "paint coverage" rather than total paint volume. The fee structure stimulated efforts to improve the efficiency of paint application and reduce waste.

c) New Relationships among Firms

- In Kalundborg, Denmark, a number of firms have created a literal "verge"—a coming-together in which the wastes of one firm became the usable materials or energies for another. In what has come to be called an "industrial eco-park," a power plant, a chemical plant, an enzyme plant, a cement plant, an oil refinery, a wall-board factory, fisheries, and farms all developed integrated waste exchanges. For example, the power plant sells steam to the enzyme plant and refinery, fly ash to the cement company, surplus heat to the city in which the plant is located, and high-sulfur gas to the sulfuric acid plant. Pollutants from its smokestacks are sold as "gunk" to the wallboard plant. The oil refinery sells wastewater to be used as cooling water in other plants. The cement plant sells low-grade or off-spec cement to the wallboard plant. The Kalundborg industrial eco-park evolved as a spontaneous discovery process rather than as a result of regulations. One successful waste exchange led to other exchanges as firms began deliberately to pursue such opportunities.

There is, of course, an interface between institutional and technological discovery processes. Precision agriculture involves both new technologies and new relationships between farmers and farm-chemical suppliers. DuPont's micromanufacturing system is another new concept in action. DuPont created a "microfactory" capable of synthesizing 18,000 pounds per year of a single industrial chemical. It generates the chemical starting materials on site, which allows for on-demand production, and eliminates the storage and transportation of hazardous chemicals, since no toxic chemicals enter or leave the site. The microfactory concept merged new technologies with new organizational design within DuPont.

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Interface Flooring developed a carpet leasing system in which commercial customers lease carpet tiles that can be replaced tile by tile as they wear out, thus reducing waste.

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## D. Challenges for Industrial Ecology

Industrial ecology is a strategy with which firms can identify new opportunities to add value—through cost cutting and/or enhanced customer benefits. It is a conceptual framework, not a specific set of techniques, technologies, or institutional arrangements.

***Defining the Problem.*** The first challenge for industrial ecologists within a firm is to define the nature of the problem. "Design-for-environment" is a mantra insufficient to determine opportunities for product, process, purchasing, or marketing innovations. Procter & Gamble, for example, spent several years just building a database of information and a set of metrics that would allow them to evaluate where their primary environmental impacts were—the first step to launching any design or process changes. Industrial ecology strategies require that managers specify what they want people (employees or suppliers, for example) to do. It requires that they set guidelines or goals for where they want products or production processes to be at the end of the work effort.

***"Shared Creation" and Collaboration.*** Industrial ecology faces what MIT research associate Michael Schrage calls "shared creation" and collaboration problems.[109] Firms need to better link their environmental, health, and safety teams with their engineers and their marketing teams. Suppliers and producers need to collaborate in creating supply-chain specs, since suppliers have local knowledge regarding both limits on what is possible and opportunities for change. In some instances, industrial ecology requires collaboration with the communities in which a firm is located. Such collaboration can help firms identify which environmental effects are perceived as most critical to those facing potential exposure to those effects.

***Coordination.*** Collaboration also implies a need for coordination. Leasing programs or product take-back programs, for example, may require establishing product-collection networks or coordinating with existing shipping systems to retrieve products from customers for refurbishing or recycling.

***Cross-fertilization.*** Economist Steven Postrel notes that integrating diverse teams within a firm often brings together people with very different specialized knowledge—an engineer with a technical or scientific background may have a very different knowledge set and vocabulary than a marketing team, for example.[110] Both specialization and cross-fertilization offer important benefits. The challenge for managers of industrial ecology efforts is to determine how far to push a knowledge curve toward cross-fertilization. Pushing that curve toward cross-fertilization is not costless; hence how far to move away from organizational structures set up to reflect knowledge-specialization in order to achieve the integrating goals of industrial ecology is not self-evident and will vary by firm and circumstance.

***Politics.*** Twenty-first century dynamism and complexity are nested within nineteenth and twentieth century regulatory structures. Thirty years ago, a permit-driven regulatory approach prevailed in the American environmental policy battle. Market discovery processes lost out to a legalistic framework. That framework focused on permits and compliance rather than on environmental results. Its orientation toward prescriptive technologies demonstrated a basic suspicion of spontaneous technological evolution. The “default” position within the framework was one of punishment, and not incentives or cooperation.

This regulatory framework poses problems for industrial ecology. Its prescriptive technological mandates have slowed the search for new technological options and impeded firms from adopting the more holistic values-optimizing perspective of industrial ecology.

Medium-specific (e.g., air, water, and land) regulations reinforced a tendency toward specialization without cross-fertilization—both within firms and among regulators. Prospects for optimizing results across multiple impact variables were thus diminished.

The emphasis on permits rather than results within the old regulatory framework probably slowed the development of metrics to measure actual environmental impacts or assess tradeoffs. That framework also slowed the development of metrics and methodologies to establish equivalencies among different emission sources that would allow for effluent and air-emission trading. For example, when a Minnesota brewing company wanted to develop an effluent-trading program to offset some of its effluent with pollution runoff coming from nearby farms, methods for establishing equivalencies between the two sources of pollution were nonexistent.

Finally, the emphasis on “end-of-the-pipe” clean-up over the past 30 years diverted attention away from up-front pollution prevention and waste reduction. While the regulations generally did not prohibit pollution prevention, they steered resources within firms toward complying with permit requirements by installing mandated end-of-the-pipe equipment. When one chemical firm in New Jersey, through an innovative facility-wide permitting process, was able to break out of the old requirements to regulate every individual emission source, it was able to modernize the plant and eliminate several hundred emission sources altogether. This endeavor would not have been possible had the firm been required to get new permits for each process change undertaken in the modernization.

## E. Summary

Industrial ecology efforts are transcending the oft-held assumption that environmental-performance investments undermine economic performance. But industrial ecology does not rest on a simple-minded assumption in the opposite direction, i.e., an assumption that all waste-reduction and pollution-prevention efforts will yield bottom-line economic benefits.

Instead, industrial ecology is best understood as a discovery tool—a way of organizing information and defining new problem sets. To paraphrase from Bertrand Russell, it is a way of hanging a question mark on things long taken for granted. Industrial ecology creates a framework within which firms may ask, “can we do things differently?”

Part 9

# Conclusion: EPR, Industrial Ecology, and Markets as a Discovery Process

Twenty-first century environmentalism will increasingly gravitate toward decision processes that routinely blend environmental considerations into product-design and manufacturing decisions. Moving toward this "industrial ecology" involves experimentation in product development and new technologies as well as in organizational strategy and institutional design. As consumers press for continued environmental protection, firms competing in the marketplace are stepping up their efforts to add environmental value for their customers through new products, new services, and new organizational arrangements. Markets are thus serving as a discovery process in which part of the search for adding value involves experimenting with new manufacturer-supplier-customer relationships. Different arrangements are emerging for different products, depending on product and marketplace characteristics. EPR is one possible institutional arrangement for advancing industrial ecology, but it will not add value for all products in all circumstances.

Mandated EPR programs override the discovery process, forcing the creation of take-back schemes into a regulatory framework that prescribes institutional arrangements. Like earlier environmental regulations that prescribed technological responses, such mandates stifle innovative market processes, impose uniform procedures for diverse circumstances, and, because they are mandatory, necessitate the acquisition and reporting of large amounts of implementation and compliance data.

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# Endnotes

1 Portions of this study are taken from or are an adaptation of L. Scarlett, “Extended Producer Responsibility,” Center for the Study of American Business (St. Louis, November 1999).

2 University of Tennessee, Center for Clean Products and Clean Technologies, *Extended Product Responsibility: A New Principle for Product-oriented Pollution Prevention*, prepared for U.S. EPA (Washington, D.C., June 1997).

3 T. Lindhquist, “EPR as a Strategy for Cleaner Products,” presented at Invitational Expert Seminar, Trolleholm Castle, Sweden, May 45, 1992. The term first appeared in 1988 in a report to the Swedish Environmental Protection Agency, “About a Waste-Conscious Product Development,” Swedish EPA Report 3488, (Solna, Sweden, May 1988).

4 The OECD held four workshops between 1997 and 1999 on “extended producer responsibility,” or “product take-back.” The major focus of these workshops was how to implement such programs. Their literature accepts as relatively undisputed the philosophical merits of the concept. See, for example, OECD Environment Directorate, Environment Policy Committee, *Extended and Shared Producer Responsibility: Phase 2 Framework Report* (Paris, France: OECD, 5–6 November 1997). That report states, “When properly undertaken, EPR’s strength lies in its ability to simultaneously operationalise life-cycle thinking, the waste-minimisation hierarchy, and the Polluter Pays Principle” (p. 6).

5 OECD, Working Party on Pollution Prevention, *Guidance Manual for Governments: Extended Producer Responsibility*, draft document (Paris, France: OECD, November 4, 1999).

6 President’s Council on Sustainable Development, “Eco-Efficiency Task Force Report,” (Washington, D.C., 1996), on the Web at clinton2.nara.gov/PCSD/Publications/TF_Reports/eco-top.html

7 University of Tennessee, *Extended Product Responsibility*.

8 Ibid, p. 12.

9 OECD, *Guidance Manual for Governments*, p. 12.

10 University of Tennessee, *Extended Product Responsibility*, pp. 1–3.

11 Ibid.

12 Lindhquist, “EPR as a Strategy for Cleaner Products.” Lindhquist writes that EPR requires manufacturers of products to “bear a degree of responsibility for the environmental impacts of their products throughout the products’ life cycles, including upstream impacts inherent in the selection of materials for the products, impacts from the manufacturers’ production process itself, and downstream impacts from the use and disposal of the products.”

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14 Liability laws modify this general case in some circumstances.

15 J. Morris, “Extended Producer Responsibility: Objectives, Incentives and the Impact on Trade,” paper presented at the OECD Workshop on Extended Producer Responsibility (Helsinki, Finland, May 11–13, 1998), p. 1.

16 Ibid.

17 University of Tennessee, *Extended Product Responsibility*, pp. 1–3.

18 OECD, *Guidance Manual for Governments: Extended Producer Responsibility*, p. 13.

19 I. Wernick et al., “Materialization and Dematerialization: Measures and Trends,” in *Technology and the Environment* (Washington, D.C.: National Academy of Sciences, 1997), available on the Web at phe.rockefeller.edu/Daedalus/Demat/

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21 Ibid.

22 Ibid.

[23] L. Scarlett, "Doing More with Less," in *Earth Report 2000*, ed. R. Bailey (New York: McGraw-Hill, 2000), p. 47.

[24] I. Wernick et al., "Searching for Leverage to Conserve Forests: The Industrial Ecology of Wood Products in the United States," *Journal of Industrial Ecology*, vol. 1, no. 3 (Summer 1997), pp. 125-145, available on the Web at phe.rockefeller.edu/forests/

[25] L. Scarlett, "Product Take-Back Systems: Mandates Reconsidered," (Center for the Study of American Business: St. Louis, 1999).

[26] The data in this paragraph all come from Scarlett, "Doing More with Less," pp. 53–55.

[27] L. Scarlett, "Packaging, Solid Waste, and Environmental Trade-offs," *Illahee: Journal of the Northwest Environment* (Spring 1994).

[28] U.S. EPA, *National Source Reduction Characterization Report for Municipal Solid Waste in the United States*, (Washington, D.C., November 1999), available on the Web at www.epa.gov/epaoswer/non-hw/reduce/r99034.pdf.

[29] Ibid.

[30] Ibid.

[31] Ibid.

[32] U.S, EPA, *National Source Reduction Report*, section 2.2.

[33] L. Scarlett, et al., *Packaging, Recycling, and Solid Waste*, Policy Study No. 223 (Los Angeles: Reason Foundation, 1997), p. 29.

[34] In *Packaging and Ecology*, Frans Lox explains how a waste manager's perspective may overlook environmental effects that a broader perspective would incorporate. Bulk packaging, for example, can reduce the amount of packaging waste per unit of delivered product. However, using the example of cream, Lox points out that the amount of cream delivered must be consumed within approximately one week, otherwise it will spoil and need to be discarded. If a consumer will use 250 milliliters (one-fourth of a liter, or a bit more than 8 ounces) of cream in a week, then a 1-liter "bulk" package will result in 750 milliliters of wasted cream. In terms of cost and overall resource use, this waste (which the solid waste manager will not see), is far greater than the incremental additional waste produced by using four 250-milliliter containers rather than a l-liter container. See Fans Lox, *Packaging and Ecology* (Surrey, U.K.: Pira International, 1992).

[35] A. Judd, *In Defense of Garbage* (Westport, Connecticut: Praeger, 1993), p. 81.

[36] Scarlett et al., *Packaging, Recycling, and Solid Waste*, p. 29.

[37] "Processed feedstock" means processed materials that are then used as starting materials for additional production steps on the way to generating the final product.

[38] H. E. Teasley, Jr., Coca-Cola Foods, personal communication with L. Scarlett, 1991.

[39] Office of Technology Assessment, *Green Products by Design* (Washington, D.C.: U.S. Government Printing Office, 1992).

[40] Ibid.

[41] Scarlett et al.., *Packaging, Recycling, and Solid Wast*e, p. 83.

[42] A. Schmidt and K. J. Suchard, seminar proceedings, "Managing the Rising Cost of 'Producer Responsibility' for Packaged Products," Panel III, Questions and Answers (Brussels, Belgium: EUROPEN, 1996).

[43] U. Denison, Duales System Deutschland, seminar proceedings, "Managing the Rising Cost of 'Producer Responsibility' for Packaged Products," Panel III, questions and answers.

[44] Duales System Deutschland, *Mass Flow Verification Report: 1998* (Cologne, Germany, May 1999).

[45] D. Perchard, "Understanding System Differences," seminar proceedings: "Managing the Rising Cost of 'Producer Responsibility' for Packaged Product."

[46] V. Bell, "How Manufacturers Are Responding to Extended Producer Responsibility Programs and How These Programs Can be Made More Effective," paper presented at OECD Workshop on Extended Product Responsibility (Washington, D.C.: December 1–3, 1998), p. 1.

[47] Ibid, p. 2.

[48] Commission of the European Communities, "Proposal for a Directive of the European Parliament and of the Council on Waste Electrical and Electronic Equipment, and Proposal for a Directive on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment" (Brussels, June 13, 2000).

[49] Defined as "equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer, and measurement of such currents and fields." It includes "…all components and subassemblies which are part of the product as well as consumables." Ibid.

[50] Specifically, manufacturers would be financially responsible for historical waste, beginning five years after the directive enters force.

[51] To ensure this outcome, a separate directive is expected to be proposed in 2002 that mandates the actual design of the products and the materials used.

[52] United Kingdom, Department of Trade and Industry (DTI), *Proposed EC Directive on Waste Electrical and Electronic Equipment; Proposed EC Directive on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment*, consultation paper (London, August 11, 2000), p. 53.

[53] Ibid.

[54] Orgalime, *Detailed Position of Orgalime's Electrical & Electronic Liaison Committee in Cooperation with European Sector Committees* (Brussels, Belgium**,** September 5, 2000), Annex II.

[55] *Ibid*, p. 28. See also DTI, "Lead-free Soldering: Update 2000" (London, 2000).

[56] European Commission (EC), Scientific Committee on Toxicity, Ecotoxicity and the Environment (CSTEE), "Opinion on Lead—Danish Notification 98/595/DK" (Brussels, May 5, 2000).

[57] For more on this, see R. Hunter and M. L. Torres, "Hunton & Williams Memorandum," *Analysis of Scientific Justification of ROS Directive's Substances Restrictions* (Brussels, January 18, 2001) , p. 8.

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[65] Techno Polymer Co., Ltd., *A Practical Study to Compare Recyclability between Non-halogen PC/ABS (HIPS) Alloy and FR-BAS Flame Retarded by Brominated Epoxy Oligomer* (Yokkaichi, Japan: Recycle System & Business Planning, June 2000).

[66] Simonson, "LCA Study of Flame Retardants in TV Enclosures," p. 11.

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[77] Orgalime, *Detailed Position*, p. 4.

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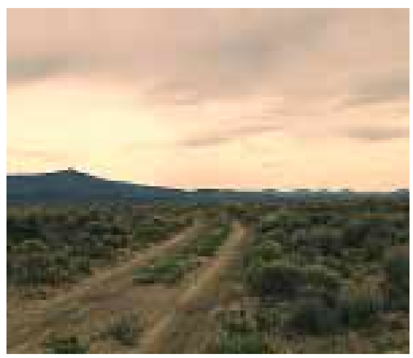


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