EXTENDED PRODUCT RESPONSIBILITY:
A NEW PRINCIPLE FOR PRODUCT-ORIENTED POLLUTION PREVENTION

June 1997

Gary A. Davis
Catherine A. Wilt
The University of Tennessee
Center for Clean Products and Clean Technologies

Patricia S. Dillon, The Gordon Institute, Tufts University
Bette K. Fishbein, INFORM, Inc.

Prepared under Cooperative
Agreement with the
United States Environmental Protection Agency
Office of Solid Waste

PREFACE AND ACKNOWLEDGMENTS

Extended Product Responsibility (EPR) has been the focus of the policy research of the Center for Clean Products and Clean Technologies for the past four years. In November 1994 the Center hosted the first U.S. symposium on EPR held in Washington, D.C., which brought together researchers and policy analysts to discuss how EPR, which has emerged in the European context, might apply in the United States. In 1995 the President's Council on Sustainable Development (PCSD) took up the issue and went on to endorse the general principle of Extended Product Responsibility and to recommend adoption of a voluntary system of EPR.

The U.S. Environmental Protection Agency's Office of Solid Waste has been supporting the EPR research of the Center for Clean Products for the past two years and has been cooperating in evaluating and presenting the findings of this research. The focus of this report is on the implementation of EPR by U.S. companies. What has been striking to us and our EPA sponsors from the beginning of this research is the degree to which U.S. companies have been implementing EPR without government mandates. We believe that this finding and the case studies contained in the report are important news for the business community. The report showcases successful applications of EPR by U.S. companies responding to a variety of business drivers, including cost savings, increased customer loyalty, product innovation, and green image building. These case studies are presented to encourage other companies to consider voluntary adoption of EPR as a business strategy.

The case studies in the report were chosen based upon our awareness of company EPR initiatives through literature reports and through the extensive network of contacts of the Center for Clean Products and our collaborators in this project. We have also included other case studies that surfaced through the planning for the President's Council on Sustainable Development workshop mentioned below. We attempted to reflect examples from a variety of industry sectors and which included a variety of methods of implementing EPR. There are undoubtedly more examples that would have merited inclusion in this report, and the exclusion of any example does not imply lack of merit. We will continue to collect information about other examples and will look for opportunities to make additional case studies widely available. We believe that the publication of as many case studies as possible will further the understanding and practice of EPR.

Besides introducing the general principle of EPR to a broader audience, this report briefly highlights a few of the more innovative policy initiatives from other countries. The reader should keep in mind that EPR-based policies are evolving rapidly in Europe and Japan, so that any discussion of these policies will inevitably be a snapshot of the situation at the time the research is done. The Center has prepared detailed discussions of EPR policies in Europe, Canada, and Japan, which will be published separately.

As a way of furthering the ongoing discussion about EPR in the United States, the EPA Office of Solid Waste and the President's Council on Sustainable Development co-sponsored a workshop held in October 1996 that brought together industry representatives with government officials, environmental group representatives, and academic researchers. Many of the companies showcased in this report made brief presentations about their implementation of EPR at the

workshop. A proceedings has been published from that workshop, which is available through the PCSD and the EPA Office of Solid Waste.

EPR is certain to gain more visibility in the coming months. The Organization for Economic Cooperation and Development has been preparing reports on specific EPR issues and will begin conducting a series of international workshops this winter. Major new legislation is taking effect in Europe and Japan, and product systems other than packaging are being impacted. The Center for Clean Products will continue to follow these developments and participate with EPA in evaluating and disseminating information about EPR.

The Center wishes to especially thank Clare Lindsay of EPA's Office of Solid Waste for her leadership and for her support for our research and thoughtful input in the development of this report. Special acknowledgment is also due Jack Barkenbus, Executive Director of the University of Tennessee Energy, Environment and Resources Center, who supported the EPR research by the Center for Clean Products before it could be funded by EPA. Bette Fishbein with INFORM and Patty Dillon of the Gordon Institute at Tufts University were valuable collaborators for this report and also deserve acknowledgment for their ongoing research on EPR policies and the implementation of EPR by U.S. companies. We also want to acknowledge Danielle Droitsch, Richard Thornburg and Christine Dummer, students in the University of Tennessee College of Law who prepared detailed background reports of EPR policies in Europe, Canada, and Japan. Last, but not least, we acknowledge the invaluable assistance of Margaret Goergen, administrative assistant in the Center for Clean Products, who was responsible for document production.

Gary A. Davis, Director
Catherine Wilt, Research Associate
Center for Clean Products and Clean Technologies

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION AND OVERVIEW

1.1 THE GENERAL PRINCIPLE OF EXTENDED PRODUCT RESPONSIBILITY

Extended Product Responsibility ("EPR") is an emerging principle for a new generation of pollution prevention policies that focus on product systems instead of production facilities. The principle of Extended Product Responsibility relies for its implementation upon the life-cycle concept to identify opportunities to prevent pollution and reduce resource and energy use in each stage of the product life cycle (or product chain) through changes in product design and process technology.

Extended Product Responsibility is the principle that the actors along the product chain share responsibility for the life-cycle environmental impacts of the whole product system, including upstream impacts inherent in the selection of materials for the products, impacts from the manufacturer's production process itself, and downstream impacts from the use and disposal of the products. The greater the ability of the actor to influence the life-cycle impacts of the product system, the greater the degree of responsibility for addressing those impacts should be. Producers, for instance, accept their responsibility when they design their products to minimize the life-cycle environmental impacts and when they accept their share of the physical or economic responsibility for the environmental impacts that cannot be eliminated by design.

The principle of Extended Product Responsibility is an outgrowth and modification of the term Extended Producer Responsibility, which has been used to describe the German Packaging Ordinance and other European policies that are discussed briefly in this chapter.[1] In reality, most of the policies for extension of responsibility for product systems do not place the entire onus on the producer, but result in some type of shared responsibility. The German Packaging Ordinance, for instance, is a system of shared responsibility among the retailers of packaged products, the producers of packaging, and consumers. The term Extended Product Responsibility has gained greater acceptance in the United States because it implies shared responsibilities in the product chain, although often the producer is in the best position, both technically and economically, to influence the rest of the product chain in reducing life-cycle environmental impacts.

There are three key attributes of Extended Product Responsibility that are examined in this report: 1) the extension or shifting of responsibility to a life-cycle stage or stages where responsibility currently does not exist or is not well-defined; 2) a product systems approach with a focus on creating feedback to product designers to design cleaner products; and 3) sharing of responsibility for the life-cycle environmental impacts of the product system among links in the product chain in such a way that there is a well-defined locus of responsibility, which may include more than one link.

1.2 THE PRODUCT CHAIN AND THE CURRENT ENVIRONMENTAL RESPONSIBILITY PARADIGM

The product chain is the life cycle of a product. The product chain begins with the extraction of raw materials and progresses through manufacturing of the product to product use and ultimate disposal. The Dutch, for instance, use this product chain or life-cycle concept to talk about Extended Product Responsibility and call the process of implementing EPR "Integrated Chain Management."[2] Throughout the product chain, there are inputs of resources and energy and outputs of pollutants (air, water, solid and hazardous waste), in addition to the production of products of commercial interest.

Over twenty years of environmental regulations have focussed on controlling the pollution outputs from individual firms within the product chain without regard to the linkages to other stages of the product chain. Under this limited view of environmental responsibility, solid waste management, for instance, has been the responsibility of the individual householder or the local government acting on his or her behalf. Traditionally, the producer of the disposable product packaged in multiple layers of non-recyclable packaging has not been viewed as having any responsibility for the product or package when they become waste. As solid waste burdens have increased and tightening disposal regulations have made solid waste management more expensive, the budgets of local governments have been stretched thin, and local taxes have been increased. At the same time, the siting of solid waste facilities has become a major political battleground. Local governments have been saddled with the responsibility for a problem that is not of their own making and about which they can do little on their own to prevent.

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. This is why EPR seeks to create an effective feedback loop to product designers to encourage them to design cleaner products. In addition to determining the impacts of the actual manufacturing process for the product, the choice of materials, for instance, determines the environmental impacts upstream in the extraction and processing of raw materials. Material selection also determines the downstream impacts during the use stage and in the ultimate disposal of the product. The product producer can, at the design step in product development, make a tremendous contribution to minimizing solid waste generation and the impacts of solid waste management.

But when producers design products so as to use less material, to extend product life or to be recyclable, the users of the products and the waste management sector must also share responsibility for sorting, collection, recycling, and proper disposal. Also, users of products must take responsibility for carefully choosing recycled and recyclable products and for generating less waste in the first place by buying less or finding reuse or repair options for products that they no longer use.

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. At the same time, retailers and consumers typically do not take the environment into account in their product selections and in their management of end-of-

life products and packaging. The principle of Extended Product Responsibility seeks to extend responsibility up and down the chain so each actor in the chain has appropriate incentives to be concerned about the life-cycle environmental impacts of the whole product system.

Some producers, driven by a new consumer consciousness of the environmental impacts of product choices and by a desire to reduce environmental costs and avoid more stringent regulations, have picked up on the need for extending their responsibility over the entire product chain, long before any government policies have been developed to mandate them to do so. Very rapidly, the focus for these firms has shifted to cleaner products. Design-for-the-Environment, industrial ecology, life-cycle design, and safe substitutes have become business strategies among a growing number of producers. These producers have voluntarily accepted the extension of their environmental responsibility. The case studies in Chapters 3 - 8 of this report speak to the motivations of these producers and the examples that they have set for the voluntary implementation of the principle of Extended Product Responsibility.

1.3 DEVELOPMENT OF POLICIES FOR EXTENDING PRODUCT RESPONSIBILITY

To implement Extended Product Responsibility fully requires incentives up and down the product chain so that each actor is concerned about and exercises appropriate measures to reduce the life-cycle environmental impacts of the whole product system. Although some producers and distributors have voluntarily accepted greater responsibility, government policies can provide additional incentives. Governments can extend product responsibility through a variety of policy measures, which differ significantly from past pollution prevention policies that have focussed on production facilities.

To date, the implementation of policies that have Extended Product Responsibility as their explicit underpinning has occurred mostly in Western Europe. The most visible such government policy embodying the principle has been the mandatory take-back approach of the German Packaging Ordinance. It should be emphasized, however, that the principle of Extended Product Responsibility embodied in this report is far broader and incorporates many other types of policy measures than the mandatory take-back and rigid recycling goals that are the hallmarks of the German Packaging Ordinance.

Other policies for specific products or specific waste streams that encourage responsibility for the life-cycle environmental impacts of products, both upstream and downstream, have existed for several years. One of the first widely-adopted examples of Extended Product Responsibility is the deposit-refund system for beverage packaging that has been in effect in many countries for more than thirty years. The energy crisis of the 1970s, the hazardous waste crisis of the 1980s, and concerns about solid waste management in the 1990s have engendered EPR-based policies that impact specific product chains, such as energy efficiency labeling for appliances, chemical bans and phase-outs, and packaging recycling initiatives. Other policies related to Extended Product Responsibility include environmental procurement programs, minimum recycled content requirements, advance disposal fees, materials restrictions, product taxes, materials use regulations, and voluntary partnerships with government and others to bring about changes in

product design and end-of-life materials management so as to reduce the life-cycle impacts of products.

1.3.1 Packaging and EPR

Packaging waste has been the major target of EPR in Western Europe. In recent years, the policy initiative that has created the most discussion about the EPR principle is the German Packaging Ordinance of 1991, which is an ambitious program for collecting and recycling consumer product packaging to reduce the demand on scarce disposal capacity in Germany. The Ordinance places initial responsibility on distributors (retailers) of packaged consumer goods to take back the packaging for recycling, but allows retailers to avoid the direct take-back obligation for packaging that is managed by the packaging-producer-funded collection and recycling system, Duales System Deutschland (DSD or Dual System Germany). The DSD was initiated in 1990 as a separate private system (separate from the municipal waste management systems) for collecting and recycling packaging. The system is financed by fees on packaging paid for by packaging producers. Producers who pay the fees to fund the system are entitled to label their packaging with a green dot that tells retailers and consumers that the packaging will be collected and managed by the DSD. The German Packaging Ordinance also requires take back of transport packaging.

The Packaging Ordinance has been very controversial, primarily because it also contains aggressive recycling quotas, which were imposed before adequate recycling capacity existed in Germany. The Ordinance was recently modified, because the overly ambitious recycling targets in the original ordinance could not be met, because of the costs associated with the original plan, and because of the problem of "free riders"— packaging producers whose packaging is collected and managed by DSD but who have not paid any fees. While the take-back obligation was not changed, the amended Ordinance now allows for incineration with energy recovery to satisfy part of the recycling quotas.

Instead of mandating take back, the Netherlands has used a negotiated agreement or "covenant" approach to commit packaging producers, packaging fillers, retailers of consumer products, and waste handlers to EPR. The Packaging covenant was signed in 1991 by an association representing each of the links in the packaging chain and by three ministries in the Dutch government. The covenant contains a general goal of eliminating landfilling of packaging waste by the year 2000.[3] It also contains a source reduction goal, a goal of removing harmful materials from packaging, and packaging reuse and materials recycling goals. The recycling goals do not provide for incineration with energy recovery as a recycling option and instead implement the hierarchy of reuse first, then materials recycling.[4] Life-cycle assessments and market-economic analyses of packaging alternatives have been sponsored by the Dutch government to help steer the packaging chain toward the best alternatives to achieve the goals of the covenant.

France has also followed an EPR approach for packaging waste without the stringent material recycling quotas of Germany and without displacing local governments in the collection of packaging waste. The Waste Act, adopted in 1992, gave producers and distributors three options to accept responsibility for the management of packaging waste from their products. First, firms could organize their own deposit and refund system for packaging waste. Second,

firms could organize their own separate collection and management systems for packaging waste. Third, firms could choose to contribute to a government-approved organization in charge of funding the costs of separate collection and management systems to be operated by local governments.[5] With the encouragement of the government, most producers and distributors have chosen the third option, under which Eco-Emballages, a quasi-governmental company, was founded. Eco-Emballages collects a fee from packaging producers to pay for the sorting of packaging waste that has been collected by the municipalities. The municipalities still are in charge of waste collection.[6] The French program has focussed on avoidance of landfilling and permits incineration with energy recovery as a recycling technology.

In recognition of the potential for market disruptions with divergent packaging waste laws in different countries, the European Union took up the packaging waste issue in 1992 and adopted the Packaging Directive in 1994.[7] Although the Directive incorporates recycling quotas for packaging, which include incineration with energy recovery, it does not incorporate EPR. It is up to the member countries how to provide incentives to the packaging product chain to meet the quotas.

In order to establish a system that meets the quotas of the EU Packaging Directive, the United Kingdom focussed on allocating responsibility for packaging waste explicitly among links in the product chain. After consideration of alternatives ranging from a purely voluntary approach to take-back or deposit-refund schemes, the government adopted a "shared approach" that offers a choice to businesses to comply individually with the program's targets or join VALPAK, a shared product responsibility organization set up by businesses in the packaging chain.[8] The obligation of each individual business sector (described below) to finance the packaging collection and recycling scheme differs depending on their position in the packaging chain as follows:[9]

Packaging raw material manufacturing	6 percent
Packaging converting	11 percent
Packaging/filling	36 percent
Selling (retailing)	47 percent

Japan has also recently begun implementing new legislation on food and beverage packaging waste which requires food and beverage producers and packaging producers to set up systems for recycling packaging materials. The legislation initially applies to cans, glass bottles, and polyethylene terephthalate bottles. Municipalities will collect and sort the packaging, and independent recycling corporations funded by the producers will recycle the packaging.

1.3.2 Take-Back Approaches for Other Products

Take-back approaches are also being implemented in Europe for other product systems, including automobiles and electronics goods. Many of the same countries who were leaders in applying EPR to packaging have also been leaders for other products. German legislative proposals on automobiles and electronic goods have led to similar proposals in other countries and by the European Union. In some cases, take back and increased recycling goals are being implemented through negotiated agreements with the affected product chain without passage of legislation.

Automobile take-back and increased recycling are being implemented in Germany, the Netherlands, Sweden, and France. The European Union has also issued a draft directive. The draft German Scrap Car Rule, first proposed on the heels of the Packaging Ordinance, was recently supplanted by a "voluntary pledge" in which the automobile producers agreed to take back end-of-life vehicles without any cost to the final owner. The "voluntary pledge" also commits to an increase in recycling so that the amount of automobile shredder residue for disposal is reduced from the present average of 25 percent by weight of the car to a maximum of 15 percent by weight by the year 2002, decreasing to a maximum of 5 percent by weight by 2015.[10] The pledge does allow the use of incineration with energy recovery as a reduction option.

In contrast to the German Packaging Ordinance, the German automobile take-back program does not set up a new organization to collect and manage end-of-life vehicles, instead relying on and upgrading the existing recycling infrastructure. The Dutch, on the other hand, in setting up a covenant for take back of automobiles, created a new organization to pay for the collection and recycling through a fee on new automobiles.

The European Commission has recently developed a draft directive on end-of-life vehicle waste that is under review. The new draft directive, dated July 31, 1996, incorporates a free take-back requirement, minimum recycling and recovery quotas (85 percent of the weight recycled by 2002, with 95 percent for new models; 95 percent of the weight recycled by 2015 for all models, without counting incineration with energy recovery), and restrictions on certain materials (lead, mercury, cadmium, hexavalent chromium, and PVC).

There have been several legislative proposals for mandatory take back for electronic goods and a resulting scramble for development of voluntary agreements. In 1992 the German government introduced the "Ordinance on the Avoidance, Reduction and Salvage of Waste from Used Electrical and Electronic Equipment." The draft ordinance did not include specific recovery or recycling targets for products, but it did require manufacturers to design more recyclable products and either establish reverse logistics systems for their recovery or finance a private system for the collection, sorting, disassembly, and recovery of used equipment.[11] Since the introduction of the draft ordinance, discussions have been underway between the German Environment Ministry and electronics manufacturers on developing a voluntary framework for the recycling of electronic and electrical products. Similar legislative proposals have been made in Sweden and Austria, and voluntary agreements are being negotiated in the Netherlands, Denmark, and France.[12]

1.3.3 Comprehensive Legislative Frameworks for EPR

Recently, three Western European governments have begun the process of developing a comprehensive framework for Extended Product Responsibility: Germany, the Netherlands, and Sweden. The German Eco-Cycle Waste Act of 1994 imposes a general "product responsibility" on product designers, producers, distributors and users 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. Elements of Extended Product Responsibility listed in the framework legislation include development and manufacture of products which can be reused or have a long life, use of secondary materials for production, labeling of dangerous materials in

order to ensure safe waste management, labeling of products as to their reuse and recyclability, and the obligation to take back products after their useful lives. The Act also permits the recovery of wastes based on the "highest value" basis, which allows burning for energy recovery in some instances. The Act does not necessarily represent a complete life-cycle framework for Extended Product Responsibility, since it does not explicitly extend responsibility to include other stages of the product life cycle, such as raw material extraction, transportation impacts, and energy use.

The Netherlands, which has previously implemented take-back approaches through covenants with producers, developed a comprehensive product policy that was approved by the Parliament in late 1993 and which embodies the Extended Product Responsibility principle. It aims to encourage each link in the product chain to take greater environmental responsibility primarily by requiring the distribution of life-cycle assessment information all along the product chain and, ultimately, to the consumer. The driver for development of cleaner products will ultimately come from the marketplace under the Dutch product policy.

The Swedish government adopted the Eco-Cycle Law, effective January 1, 1994, which also embodies the principle of Extended Product Responsibility. It calls for more efficient use of resources in production, recovery, and re-use of waste. The bill identifies packaging as one of the areas to which the principle of EPR may be applied and identifies other product categories, including electronics and electrical appliances, automobiles, tires, and plastics. The bill, much like the German Eco-Cycle Act and the Dutch Product Policy, must be implemented by specific ordinances that contain the details of how Extended Product Responsibility is to be applied.

1.3.4 EPR in the OECD

Following adoption of comprehensive frameworks for EPR in European countries, the Organization for Economic Cooperation and Development (OECD) has become more involved in elucidating the principle and promoting its application. At the International Waste Minimization Workshop in March 1995, Extended Producer Responsibility was adopted as both a basic principle and key strategy for waste minimization. Further, members of the Pollution Prevention and Control Group and the Waste Management Policy Group expressed considerable interest in continued analysis of Extended Producer Responsibility as a tool for waste minimization contributing to a strong product policy.

To this end, the OECD is in the process of completing three phases of research on Extended Producer Responsibility. Phase 1 consisted of a report, published in March 1996, cataloging EPR programs in OECD countries.[13] Phase 2, portions of which are still underway, consists of several study themes, including case studies of trade implications, methods for analysis of cost-effectiveness of Extended Producer Responsibility methods, and legal issues affecting Extended Producer Responsibility implementation. Phase 3, to be completed in 1999, will consist of a series of workshops involving different stakeholders. These workshops will encourage dialogue on more fully defining Extended Producer Responsibility and recommending policy approaches to implement Extended Producer Responsibility programs. The specific goals of these workshops will be:

- To propose policy options aimed at minimizing pollution, wastes and natural resource consumption throughout the life cycle of the product.
- Suggest efficient and equitable means to prevent producers from transferring the costs for dealing with pollutants and wastes of product systems to other links in the product chain that are least capable of preventing these external costs.
- Help promote the application of the Polluter Pays Principle by developing proposals to ensure that the private sector is responsible for efforts to reduce environmental effects from both use and discarding of their products and to use recovered resources, recycling, and reclaimed materials in so doing.[14]

1.4 TOWARD A BROADER VISION OF EPR POLICIES

The purpose of the policy discussion in this chapter is not to advocate the adoption of any specific Extended Product Responsibility policies in the United States, but to show the development of these policies throughout the world and their potential influence on the situation in the United States. It is unlikely that any one policy option will result in widespread implementation of Extended Product Responsibility or will be appropriate for the conditions (political and economic) in every country. As discussed in Chapter 2, the federal government in the United States and several state governments already have policies in place that encourage Extended Product Responsibility, at least indirectly. Policy makers at all levels are struggling with the appropriate mix of policies and are experimenting with innovative voluntary approaches with willing partners in the producer community.

Many of these new policy options, being voluntary or market-driven, encourage a more cooperative, outcome-oriented relationship among government and the actors along the product chain than traditional command-and-control regulations. These options also allow more flexibility for producers in achieving environmental goals, encouraging innovation, since they do not necessarily prescribe technologies.

The President's Council on Sustainable Development recently concluded "that sharing responsibility for environmental effects would transform the marketplace into one driven by:

- More efficient use of resources.
- Cleaner products and technologies.
- More efficient and more competitive manufacturing.
- Safer storage, shipping, and handling of materials.
- Improved relations between communities and companies.
- Improved recycling and recovery.
- Responsible consumer choices."[15]

With this potential, Extended Product Responsibility can be a key principle that leads from facility-oriented pollution prevention to environmentally and economically sustainable production and consumption.

ENDNOTES

1. The phrase "Extended Producer Responsibility" was first used by Thomas Lindhqvist, Lund University, Department of Industrial Environmental Economics. See proceedings, *Extended Producer Responsibility as a Strategy for Cleaner Products.* 1992. Invitational Expert Seminar, Department of Industrial Environmental Economics, Lund University, Sweden, May 4-5.

2. *Integrated Substance Chain Management.* 1991. Dutch Ministry for Housing, Physical Planning, and the Environment.

3. *Inventory of Product Policy Instruments.* 1993. Institute for Environmental Studies, Free University. Amsterdam. November.

4. *Packaging Covenant*. 1991. Ministry of Housing, Physical Planning, and the Environment. The Netherlands. June 6.

5. *Inventory of Product Policy Instruments: Case Study France*. 1993. Centre International de Recherche sur l'Environment et le Développement (CIRED). Paris. October.

6. Demetrakakes, P. 1993. "European Packaging Laws: A Pandora's Box." *Packaging*. February.

7. *European Parliament and Council Directive on Packaging and Packaging Waste.* 94/62/EC.

8. *The Producer Responsibility Obligations (Packaging Waste) Regulation: A Consultation Paper.* 1996. UK Department of the Environment. July, § 1.12, 1.24.

9. *The Producer Responsibility Obligations (Packaging Waste) Regulation: A Consultation Paper.* 1996. Department of the Environment. July, § 4.2 - 4.5.

10. "Voluntary Pledge Regarding the Environmentally Compatible Management of End-of-Life Vehicles Within the Concept of the Ecocycle Act." 1996. VDA Press Release. February 21.

11. Dillon, Patricia. 1994. "Electronics Recycling Legislation in Europe and Its Implications for U.S. Public Policy. *In Extended Product Responsibility: A New Principle for New Generation of Pollution Prevention* (C. Wilt and G. Davis, eds). University of Tennessee Center for Clean Products and Clean Technologies.

12. Davis, John Bremer. 1996. "Product Stewardship and the Coming Age of Takeback. What Your Company Can Learn from the Electronic Industry's Experience." *Business and the Environment*. Cutter Information Corporation. p. 13-32.

13. Organisation for Economic Co-Operation and Development. *Pollution Prevention and Control. Extended Producer Responsibility in the OECD Area*. Phase 1 Report. 1996. OECD Environment Monographs, No. 114. Paris. OECD/GD(96)48.

14. Organisation for Economic Co-Operation and Development, Environmental Policy Committee, Group on Pollution Prevention and Control. 1996. *Extended Producer Responsibility*, ENV/EPOC/PPC(96)5, May 13-14.

15. *Sustainable America: A New Consensus*. 1996. President's Council on Sustainable Development. p. 39.

CHAPTER 2

EXTENDED PRODUCT RESPONSIBILITY IN THE UNITED STATES

2.1 HISTORICAL CONTEXT

Although the U.S. has no comprehensive Extended Product Responsibility law or policy, there are laws and policies at the federal level that indirectly embody the principle and have been applied to particular environmental problems. In the 1970s, an energy crisis stimulated programs, such as mandatory energy efficiency labeling for appliances, to increase consumer awareness of energy consumption and to promote products that conserve electricity. Hazardous waste problems became apparent in the 1980s, leading to product and materials policies such as chemical bans and phase-outs. The 1990s have given rise to increased concerns about solid waste generation and disposal, especially as many landfills near capacity and new sites face stiff public opposition. This concern over solid waste has led to increased interest in engaging product producers in the process of reducing and managing the wastes created by their products.

Recently, increased demand from consumers for "green products" has caused many companies to reevaluate their products' design, production, recyclability, and disposal. Some states and the federal government have responded to public pressure with new legislation or voluntary programs aimed at altering consumer and producer behavior. These pressures have combined with the regulatory initiatives in Western Europe, which directly affect U.S. exporters, to heighten awareness of EPR and its implications in the U.S. Furthermore, as companies begin to take more responsibility for the life cycle of their products, they are discovering business advantages, including reduced environmental costs and liabilities and reduced raw materials costs. This heightened awareness of EPR in the U.S. led to the President's Council on Sustainable Development recommendation that EPR be implemented in the U.S. through a voluntary program and, in one specific case, caused one industry to support federal legislation facilitating a producer-sponsored take-back and recycling program.

2.2 RECENT EPR INITIATIVES ON THE FEDERAL LEVEL

2.2.1 President's Council on Sustainable Development

In 1993 The President's Council on Sustainable Development (PCSD) was created to advise the President on integrating the environmental, economic, and social goals of the nation so that the needs of the present can be met without compromising the ability of future generations to meet their own needs. The PCSD was composed of leaders from government, business, environmental, civil rights, labor, and Native American organizations. One of the major policy recommendations of the PCSD is that the nation should "adopt a voluntary system that ensures responsibility for the environmental effects throughout a product's life cycle by all those involved in the life cycle."[1]

Specifically, the PCSD recommended in 1996 that the President should appoint a Product Responsibility Panel to facilitate voluntary, multi-stakeholder models of shared product responsibility through demonstration projects. The Product Responsibility Panel would include representatives from all sectors; the demonstrations would help identify means of conducting effective monitoring, evaluation, and analysis of the project's progress and possible links with other sustainable development initiatives. It would also help coordinate sound economic and environmental analyses to assist in transferring the lessons from local demonstration projects to regional and national policies. The panel would have a balanced representation of stakeholders with interests in the life cycle of a product, including its supply, procurement, consumption, and disposal.

The PCSD further recommended that, following evaluation of the demonstration projects, the federal government, private companies, and individuals should voluntarily adopt practices and policies that have been successfully demonstrated to carry out EPR on a regional and national scale. After the demonstrations, the Product Responsibility Panel would also recommend any legislative changes needed to remove barriers to extending product responsibility. Finally, the PCSD recommended that the procurement policies of federal, state, local, and tribal governments should reflect preferences for resulting cost-effective, environmentally superior products.[2]

In October 1996, the PCSD and EPA co-sponsored a workshop on EPR in Washington, D.C., at the White House Conference Center. Workshop participants included over 85 persons from numerous businesses, trade associations, environmental groups, states, universities, and the federal government.

A major goal of the workshop was to showcase some of the business initiatives already underway in the U.S. that illustrate EPR in action. U.S. companies are beginning to embrace the principle of EPR for a variety of reasons: some are responding to mandates abroad; some wish to forestall similar mandates in the U.S.; some are striving to meet corporate goals to "green" their products; and some recognize that products can be valuable assets even at the end of their useful life. Other goals of the workshop were to: 1) enhance understanding of the principles of EPR; 2) demonstrate the various models, actors and industry sectors implementing EPR through presentation of case studies; 3) determine how best to educate the business community, government, environmental organizations, and other non-governmental organizations about the benefits and challenges of EPR; and 4) encourage greater implementation of EPR.

The workshop program included introductory presentations on the concept of EPR and the drivers and obstacles facing businesses and other organizations interested in EPR. Eleven companies, including many of those represented in this report, presented case studies on how they are implementing EPR to reduce the life-cycle environmental impacts of their products. Some of the presentations included partners (such as suppliers, product users, trade associations) in the product life cycle who are helping to make EPR successful. Industry sectors represented in the case studies included the automobile, forest products, consumer products, building cleaning and maintenance, plastics, telecommunications, office equipment, battery, and carpeting industries. In total, more than 30 companies and industry associations participated in the workshop.

Among the findings of the workshop were that EPR is actively being implemented in the U.S., and is bringing about significant changes in products and their associated environmental impacts. In many cases, changes are occurring at multiple stages in product life cycles: upstream, during manufacturing; during product use; and at the end of the product's useful life. Though EPR is not yet a standard way of doing business in the U.S., the participants agreed that the idea must spread to more products and players in this country.[3]

2.2.2 Mercury-Containing and Rechargeable Battery Management Act

The Mercury-Containing and Rechargeable Battery Management Act signed by the President on May 13, 1996, helped usher in a voluntary, national take-back system for nickel-cadmium rechargeable batteries. The primary purpose of this law, which was actively sought by the rechargeable battery industry, is to facilitate a national take-back program paid for and carried out by the rechargeable nickel-cadmium battery and rechargeable products industries to collect and recycle these batteries. The law paves the way for the national collection and recycling of these batteries by making a new regulation immediately applicable nationwide that eases what would otherwise be more onerous regulatory requirements for collection and recycling of these batteries. The Act also requires uniform national labeling of nickel-cadmium and other rechargeable batteries and sets uniform battery removeability design requirements for rechargeable products containing these batteries. Chapter 6 describes the battery take-back and recycling system in detail.

2.3 POLICIES ON THE FEDERAL LEVEL THAT EMBODY THE EPR PRINCIPLE

Following is a brief description of types of policies that embody the principle of EPR which have been implemented or are under consideration at the federal level in the U.S. Such policies tend to encourage EPR directly, if not explicitly, when they deal with environmental impacts beyond those associated with an individual manufacturing facility in the product chain.

- **Partnering Agreements** - Pollution prevention goals and measures agreed to among the federal government and other stakeholders in the product chain, such as the EPA WasteWi$e Program and the EPA Green Lights Program.
- **Voluntary Product Environmental Information Approaches** - Voluntary approaches in which producers provide information on the significant environmental attributes of products so that purchasers can reflect environmental preferences in their purchasing decisions. The EPA Energy Star Program is an example of such a program.
- **Government Procurement of Recycled-Content Products and Environmentally Preferable Products and Materials** - In addition to price and quality, government purchasing is directed at products that contain recycled content or are considered "environmentally preferable." Executive Order 12873 (1993) requires Federal agencies to purchase recycled content and other "environmentally preferable" products. EPA identifies recycled content products and provides guidance on purchasing them. EPA also provides general guidance on purchasing "environmentally preferable" products.

- **Mandatory Disclosure of Environmental Information** - Requirements that producers or distributors provide information about the environmental attributes of a product. One example includes appliance energy efficiency labeling, required by the Energy, Policy and Conservation Act of 1976, which, together with minimum efficiency standards, has been very successful in encouraging manufacturers to increase energy efficiency of large appliances.
- **Mandatory Labeling of Product Contents** - Labeling that provides the user with information about the product contents, which can take two forms: 1) a simple listing of product ingredients; or 2) statements concerning the potential environmental or health impacts of those ingredients. For instance, the Consumer Product Safety Act requires certain products to contain statements of potential health and safety impacts.
- **Materials Regulations/Prohibitions** - Regulations on material use, such as bans of toxic chemicals. An example is the Toxic Substances Control Act, which allows EPA to restrict or prohibit material production, distribution, use, and disposal.

2.4 POLICIES ON THE STATE LEVEL THAT EMBODY THE EPR PRINCIPLE

Following is a brief description of additional types of policies that embody the principle of EPR and which have been implemented or are under consideration at the state level in the U.S.

- **Deposit-Refund Systems** - Mandatory systems in which a deposit is charged to the purchaser at the time of purchase to encourage the return of the product (or packaging) at the end of its useful life, at which time the deposit is refunded. These have been implemented for beverage containers in ten states.
- **Product Taxes to Fund Waste Management Systems** - Taxes that are used to shift economic responsibility for waste management to the producer and consumer of the product that generates the waste, often called advance disposal fees. Examples include taxes on new automobile tires or batteries which are used to fund recycling or disposal systems. More than half the states have advance disposal fees for tires, for instance.
- **Mandatory Product Take Back** - A few states require retailers of lead-acid batteries to accept spent batteries from anyone who brings one in.
- **Waste Disposal Bans** - Most states ban landfilling of certain products or materials, which can lead to increased producer efforts to collect and recycle them. State bans on disposal of nickel-cadmium batteries, for instance, led to the industry-wide take-back and recycling program described in Chapter 6.

2.5 VOLUNTARY EPR INITIATIVES BY PRODUCERS

Several voluntary EPR initiatives have been created by producers in the U.S. Following are some general categories of these programs.

- **Corporate or Industry-Wide Product Stewardship Programs** - Voluntary measures that generally deal with the downstream environmental and safety aspects of product use. An example is the chemical industry's Responsible Care Program, announced by the Chemical Manufacturers Association (CMA) in 1988. This program outlines a standard method for CMA member companies to develop principles, practices, and obligations regarding environmental, health, and safety responsibilities in the management of chemicals.[4] Responsible Care has six elements: 1) Guiding Principles - a statement of the philosophy and commitment by all member companies; 2) Codes of Management Practices in specific areas of chemical manufacturing, transporting, and handling; 3) Public Advisory Panels - leaders from the environmental and health and safety fields who assist the industry in identifying and developing programs and actions that are responsive to public concerns; 4) Member Self-Evaluations - reports, measurements, and other demonstrations of program implementation that document progress toward improved environmental, health, and safety performance in the management of chemicals; 5) Executive Leadership Groups - senior industry representatives who periodically review the Codes of Management Practices being developed, discuss progress on implementing existing codes, and identify areas where assistance from CMA or other companies is needed; and 6) Obligation of Membership - member companies are obligated by the bylaws to ascribe to the Guiding Principles, to participate in the development of the Codes and programs, and to make good-faith efforts to implement the program elements of the Responsible Care initiative.
- **Voluntary Take-Back or Buy-Back Programs** - The producer voluntarily takes back or buys back products or waste materials for recycling or proper management in order to mitigate downstream environmental impacts from product use and to recover valuable materials. The Case Studies dealing with the electronics industry (Hewlett-Packard, Compaq, and Nortel - Chapter 3; Xerox - Chapter 7), the automotive industry (Ford and Saturn - Chapter 5), and the rechargeable battery industry (Chapter 6), provide examples of voluntary take-back or buy-back programs. Others include a new carpet recycling program at BASF which allows customers to send nylon carpet back after its useful life so it can be recycled into other products;[5] a program initiated by New Jersey Bell in 1993 to accept old telephones and answering machines at selected department stores throughout the state, which pays for itself through recovery of valuable materials;[6] and a program by some kayak manufacturers, such as Perception, Inc., to accept used or damaged boats made from a recyclable linear polyethylene to be recycled into seats and bracing components for new kayaks.[7]
- **Leasing Systems** - Voluntary systems in which ownership of durable materials and products is never transferred down the product chain. Instead, the function of the materials or products is leased to the user, at least theoretically encouraging the producer to close material loops and extend product life. An example is a carpet leasing program developed by Interface Flooring Systems in which Interface retains ownership of the commercial carpet, charging a lease fee for installing and maintaining it, replacing worn portions and whole sections when necessary, and recycling the carpet when replaced.[8]

- **Life-Cycle Management Programs** - These include environmental management and auditing programs which are extensions of internal environmental management systems extended upstream (to provide assistance to suppliers) and downstream (to provide assistance to product users in improving their environmental performance). They also include Design-for-the-Environment (DfE) Programs and the use of tools like life-cycle assessment (LCA) to improve the life-cycle environmental performance of a product, often in partnership with suppliers or other stages of the life cycle. The Case Study of the electronics industry (Chapter 3) discusses DfE programs and extended environmental management programs used by Hewlett-Packard, for instance. The Case Study of the automotive industry (Chapter 5) discusses Ford's efforts to incorporate recycled plastics in new car parts. The Rochester Midland Case Study (Chapter 8) highlights an innovative partnership between a cleaning products supplier, a building maintenance company, building owner, and occupants to reformulate cleaning products and reduce impacts of their use. Other examples include IBM's design-for-disassembly program[9] and the supplier accreditation program conducted by The Body Shop, which rates its suppliers based upon their environmental management programs, their waste generation, recycling efforts, and emissions.[10]
- **Partnerships for Recycling and Waste Management** - Companies in the product chain are pooling their resources to create partnerships for recycling and waste management. These may involve separate corporations with membership by many members of the product chain. Rechargeable battery producers, for instance, joined together to form the Rechargeable Battery Recycling Corporation (discussed in detail in Chapter 6), which administers a collection and recycling program and a license and fee system to fund the collection and recycling program. These partnerships may involve cooperative product development. For example, two U.S. textile companies, Martin Color-Fi, Inc. and Starenseir, collaborated to develop a woven fabric called "NatureTex 100," made entirely from post-consumer recycled plastic beverage bottles. These partnerships may also involve life-cycle partnerships, or partnerships among different links in the product chain. For example, photographic film manufacturers have assisted their photographic chemical customers in meeting wastewater discharge standards for precious metals (silver) by including the waste collection and recovery services of Safety-Kleen as part of their overall service to customers, such as minilabs in retail stores, thereby recovering valuable silver for reuse.[11] United Parcel Service (UPS) has partnered with producers of consumer goods, such as Canon, to facilitate the take back of products for recycling by offering an "Authorized Return Service" (ARS) which provides a preprinted label shipped inside the package when a company sends out new stock or products that can be used by the customer as a mailing label to ship the item back for recycling.[12]

2.6 FACTORS ENCOURAGING VOLUNTARY ADOPTION OF EPR

As discussed with the specific Case Studies in Chapters 3 through 8, there are several factors which have encouraged companies in the U.S. to voluntarily adopt EPR. These include (not necessarily in order of importance):

- **Cost Savings** - Even if not created for cost savings, many of the voluntary take-back and recycling initiatives reported on in the Case Studies have been sustained by cost savings. Some companies in the electronics industry, notably, have discovered that they can make money by recovering and reusing valuable components and recycling high-priced metals. Even with plastic materials, some automotive companies have found significant cost savings in recycling.
- **Environmental Stewardship** - All of the companies discussed have adopted environmental stewardship as a corporate ethic. They see EPR initiatives as a proactive way of demonstrating their commitment to this corporate ethic.
- **Product Innovation** - Many of the companies studied found that extending responsibility to additional stages of the life cycle resulted in product innovations that either saved money through more efficient manufacturing or allowed cost savings in materials use. For instance, the focus on end-of-life management for refrigerators and computers led the producers to reduce the number of parts and the number of materials used in the products, resulting in cost savings in manufacturing. The focus on design-for-disassembly to facilitate recycling also led to faster and cheaper assembly during manufacturing.
- **Customer Satisfaction and Loyalty** - Consumer products producers, particularly some computer manufacturers, see product upgrades and take-back and recycling programs as a means to increase customer satisfaction and loyalty. If a computer is readily upgradeable, it is more likely that the customer will remain loyal to the brand over the long term. And if the nagging problem of what to do with an obsolete computer is solved by the producer, the customer is more likely to consider purchasing a new computer from the same company. Similarly, materials suppliers can increase customer satisfaction and loyalty by helping solve their customers' materials recycling headaches.
- **"Green Marketing"** - All of the companies discussed in the case studies produce products that are sold to consumers who are increasingly concerned about the environmental performance of the products they purchase. One reason that most of the case studies involve recycling is that this is the most visible and frequently reported on environmental attribute of products today. Recycling has become an ingrained value in our society, and most of the companies studied have ambitious corporate goals to increase recycling.
- **Take-Back Mandates in the U.S. or Abroad -** Many U.S. companies discussed in the case studies in this report are responding, at least partly, to mandates in the U.S. or abroad. This calls into question exactly what "voluntary" means in the context of these initiatives. In the rechargeable battery case, for instance, two states had already required take back and recycling of nickel-cadmium batteries, so the nationwide program created by the battery industry can be seen as one that sought to avoid inconsistent regulations from state to state. In both the electronics and automotive cases, the German take-back proposals have encouraged some U.S. manufacturers, who also do business in Europe, to demonstrate progress in end-of-life management with the intent to avoid the threat of such mandates in the U.S.

- **Existing Facility-Based Environmental Regulations and Environmental Liabilities** - As existing facility-based environmental regulations restrict waste disposal options, and environmental liabilities make use and disposal of hazardous substances a potential financial disaster, companies have discovered that EPR may be the most effective and economically efficient means to comply with regulations and avoid liabilities. Some of the DfE and recycling programs reported on in the case studies were motivated, in part, by potential bans on disposal of substances contained in the products. Automotive companies, for instance, have instituted restrictions on hazardous substances in materials and components supplied to them by their suppliers. Through the application of EPR, many companies have redesigned products to eliminate hazardous substances, instead of spending money to treat and dispose of hazardous waste.

ENDNOTES

1. *Sustainable America: A New Consensus*. 1996. President's Council on Sustainable Development. February, p. 40.

2. *Sustainable America: A New Consensus*. 1996. President's Council on Sustainable Development.

3. President's Council on Sustainable Development. 1997. Proceedings of the Workshop on Extended Product Responsibility, October 21-22, 1996. The White House Conference Center, Washington, DC.

4. McKenzie, C.J. 1991. "Environmental Investment." (Citing CMA, "Responsible Care: A Public Commitment." 1990. CMA brochure.)

5. "Next-Generation Environmental Management: What Will It Look Like?" 1994. *Business and the Environment*. Cutter Information Corp., 1994, WL 2504960. April 1.

6. "New Jersey Bell Recycles Telephone Equipment Swapped for New Service." 1993. *Business and the Environment*. Cutter Information Corp., 1993, WL 2736177. June 1.

7. "Kayak Manufacturers Start Programs to Recycle Used Boats." 1992. *Business and the Environment*. Cutter Information Corp., 1992, WL 2645107. August 1.

8. "Extended Producer Responsibility: A New Principle for a New Generation of Pollution Prevention." 1995. Proceedings of The Symposium on Extended Producer Responsibility, November 14-15, 1994, Washington, DC. Edited by Catherine A. Wilt and Gary A. Davis.

9. "Computer Makers, Plastics Council to Work Jointly on Recycling." 1993. *Business and the Environment.* Cutter Information Corp., 1993, WL 2736180. June 1.

10. "Greening the Supply Chain: What's Working." 1993. *Business and the Environment.* Cutter Information Corp., 1993, WL 2736264. February 1.

11. "Safety-Kleen Launches Photochemical Recovery Service in US." 1994. *Business and the Environment*. Cutter Information Corp., 1994, WL 2505104. November 1.

12. "Product Takeback Update: Manufacturers Are Acting in Anticipation of Legislation." 1994. *Business and the Environment.* Cutter Information Corp., 1994, WL 2504996. February 1.

CHAPTER 3

EXTENDED PRODUCT RESPONSIBILITY IN THE ELECTRONICS INDUSTRY

Case Study Prepared by:
Patricia S. Dillon
The Gordon Institute, Tufts University

3.1 INTRODUCTION

Electronics firms are subject to a proliferation of international environmental policies and standards that go beyond traditional concerns about manufacturing process wastes and releases to impact corporate management practices, product design and marketability, and post-consumer product disposal. Their suppliers and customers are increasingly sensitive to environmental issues such as energy efficiency, material use (e.g., recycled content, ozone-depleting substances concerns), and environmentally-sound product disposal and recycling, motivating electronic firms to manufacture and supply appropriate products and services.

The market for electronic products is highly competitive. As demonstrated in these case studies, extended product responsibility (EPR) presents opportunities for companies to lower the cost of doing business for themselves as well as their customers, and increase customer satisfaction by offering products and services that meet the environmental performance needs of their customers. Indeed, global competitiveness today hinges on delivering products that meet customers' price and performance preferences, while improving the life-cycle environmental performance of products.

This chapter highlights the voluntary EPR activities of three electronics companies, Compaq Computer Corporation, Hewlett-Packard Company, and Northern Telecom. Each of the companies has developed a systematic approach to the life-cycle management of its products across the corporation, building on efforts in the 1980s to control and reduce manufacturing emissions and waste. These cases illustrate the breadth and quality of EPR programs in the industry, including design for environment, product take back, and new customer-supplier partnerships, as well as the drivers of change. In many respects, these programs are in their infancy, but represent the leading edge of product life-cycle management. Given technological innovation, competitive trends in the industry, and international policy developments, we can only expect continued progress.

3.2 DESIGN FOR ENVIRONMENT AT COMPAQ COMPUTER CORPORATION

"We believe that striving for exemplary environmental performance is essential to sustaining market leadership."

1994 Summary Annual Report

Compaq Computer Corporation believes that environmental responsibility begins with product design and manufacturing, and continues to the end of the product's useful life. This philosophy evolved over time, beginning with a traditional focus on manufacturing concerns and the prevention of wastes and emissions in the 1980s. With a goal to eliminate the use of chlorofluorocarbons (CFCs), Compaq began to take a step back in the product life cycle to alter the process design. This was not enough. In 1992, Compaq began to push further back in the product life cycle to influence product design.[1]

Compaq Computer Corporation, headquartered in Houston, Texas, is the world's largest supplier of desktop, servers, and portable personal computers to commercial and residential markets. Compaq sells its products in more than 100 countries, mostly through its network of dealers, distributors, and value-added resellers. Founded in 1982, Compaq now operates manufacturing facilities in five countries and employs 17,000 people world-wide. In 1995, sales reached almost $15 billion.

World-wide competitive pressures have led Compaq to redefine the boundary of its product life cycle. In earlier years, Compaq considered its job done when the product left manufacturing and was sold in the marketplace. The introduction of a 3-year warranty extended Compaq ownership concerns through service and support. With the advent of "take-back" legislation in Europe, Compaq's view of the product life cycle was stretched all the way to the end of its product's life.

This paradigm shift created a new mandate for design. The ability to cost-effectively service and repair the product, as well as recycle the product at end of life, became an integral part of the competitiveness equation.

Product life-cycle management at Compaq is market driven. For this reason, Compaq is not developing complex life-cycle analysis tools to identify environmental impact. Rather, customer needs, expectations and regulatory trends are translated into product, process or service features. The personal computer industry is also a high-volume, low-margin business. Therefore, Compaq must pay particular attention to costs.

3.2.1 Compaq's Design for Environment (DfE) Program at a Glance

At Compaq, product design occurs within an established product development process, beginning with product definition and moving through product manufacture. Early on, the environmental organization within Conpaq realized that in order to influence product design, it had to work within the system. As a result, an engineer from Compaq's engineering design

organization was brought onto the environmental staff to spearhead the development of environmental design guidelines that fit within Compaq's design culture. Rather than dictate a set of design guidelines, the environmental staffs' strategy was to create a forum for the discussion of environment in design, and then leverage the expertise of cross-functional design teams to develop design guidelines.

Compaq's initial efforts to change design practices focused on plastics. The polymer guideline, which was released in 1993, provides recommendations on selection of plastics, including preferred polymers, and other design considerations to improve recyclability: for example, consolidation of material types in a product and the use of flame retardants and plastics identification markings. The polymer guideline was later published as a corporate specification.

In 1994, Compaq completed a comprehensive environmental design guideline. Rather than focus its efforts on a single product, Compaq's approach has been to implement the program across all product lines. As discussed below, these design efforts have resulted in the introduction of new product lines with environmental features.

The design guide promotes the adoption of a life-cycle perspective in the design of products, and specifically addresses the following issues:

- Material Selection, focusing on Recyclability.
- Design for Disassembly.
- Packaging Materials.
- Energy Conservation.
- Design for Reuse and Upgradeability.

Table 3-1 highlights some design parameters within each category.

Cross-functional design teams, which include representatives from engineering, packaging, purchasing, finance and marketing, apply the design guidelines within their jurisdiction. For example, the mechanical engineering team applies the polymer standard in establishing hardware product specifications; the printed circuit board designers consider upgradeability issues; packaging engineers incorporate packaging standards; and the service organization provides feedback on design features impacting serviceability (e.g., use of thumb screws, the need for special tools to disassemble).

Compaq finds synergy between DfE and other priority design objectives, namely design for manufacturability and design for serviceability. For example, fewer parts simplifies manufacturing, while facilitating recycling. Similarly, easy disassembly facilitates the servicing, upgrading, and recycling of equipment as well.

Table 3-1: Sample Design Guidelines

C **Packaging**
- Minimum 35% recycled content
- No heavy metals in packaging inks
- 100% Kraft paperboard, no bleach
- Use of recyclable materials only

C **Plastics**
- Use only recyclable thermoplastics
- Consolidate plastic types
- Use ISO markings to identify resin type and exact blend
- No paint finishes
- Labels: molded in or use same resin type as housing

C **Disassembly and Recycling**
- Use of standard screw heads
- Design modular components
- Minimize number of parts

C **Energy Conservation**
- Comply with Energy Star standards

C **Design for Reuse**
- User upgradeability
- Use of industry standard architecture

3.2.2 EPR Results

Examples of Compaq's efforts to reduce environmental impact throughout the life cycle of its products include:

- Eliminating ozone-depleting substances from manufacturing processes. Compaq accomplished this in 1993, years ahead of the schedule established by the Montreal Protocol.
- Minimizing waste generation and energy use in manufacturing. To help further waste reduction and energy conservation progress, in 1993 Compaq established a world-wide environmental performance measure that quantifies pounds of by-product and energy consumed per PC produced. From 1993 to 1994, the manufacturing by-products were reduced 34 percent per unit worldwide.[2] At their manufacturing site in Houston, Compaq reduced electricity use per PC manufactured by 34 percent in 1994 compared to 1993.[3] Regarding wastes, Compaq's ultimate goal is the total elimination of waste in all manufacturing processes.[4]

- Reducing energy consumption of its products. According to EPA projections, with the power management features activated on the desktops and monitors Compaq shipped in 1995 alone, the estimated worldwide energy savings could be as much as $60 million dollars. It could also reduce CO_2 pollution equal to the emissions from 150,000 automobiles.
- Designing products for upgrades and recycling. Compaq's efforts increase the likelihood of resource conservation through product life extension and recycling, as discussed further below.

Through these initiatives, Compaq demonstrates that products can have reduced environmental impact, while achieving business objectives, such as reduced costs for Compaq and its customers and increased competitiveness.

Easy Upgradeability

One of the most promising "reuse and recycling" opportunities can be found in upgradeable products. Product upgrade features help avoid early obsolescence and increase the product life by facilitating the replacement of electronic components, while avoiding the unnecessary disposal of mechanical parts, such as the plastic housing, power supply and metal chassis, which do not impact product functionality.

For example, a customer who purchased a 486/33 MHZ computer with 4 megabytes of RAM will have trouble running Windows 95. Rather than discarding the old computer and buying a new Pentium-based computer, a user can attain similar results by upgrading the microprocessor to a Pentium and adding additional RAM. The added bonus — the upgrade is a fraction of the cost of a new computer.

While any PC can be upgraded if you have the technical knowledge and are willing to replace the motherboard or manually de-solder the microprocessor chip,[5] Compaq's designs are truly "upgradeable" by the average user without the use of specialized tools and the risk of damaging the computer. This is accomplished through the use of alternative technologies for mounting components and easily accessible subassemblies. In Compaq's recent ProLinea® and Deskpro® models, a user can easily upgrade the entire motherboard, the microprocessor, or the memory and easily access the hard drive and expansion slots to replace or add new features.

One technology that enables easy upgrades is the ZIF (zero insertion force) socket that holds the microprocessor in place on the motherboard. This socket replaces the traditional solder mounting, which is considered a semi-permanent connection technology. The ZIF socket uses a tension bar to hold the microprocessor and force a connection. This technology allows the user to easily remove and replace the old microprocessor and install updated or faster technology, simply by unlatching and relatching the bar.

From an environmental vantage point, upgradeable products conserve resources. For the most part, however, this is not critical to the purchasing decisions of customers, who are concerned predominantly about costs and product features. For Compaq and its customers, the upgradeable PC is important from another angle. It lowers the lifetime cost of computer

ownership, a growing concern to customers as technological obsolescence occurs at an ever increasing rate. In this regard, Compaq's marketing literature extols the virtues of its upgradeable product:

> "Needs change, goals change, and people change. The good news is, a Deskpro computer can change every bit as quickly. It opens without any special tools. The system board slides out, making it easy to upgrade the processor or add extra RAM. The PCI expansion slots are easily accessed. And the drive cage swings out to make hard drive upgrades painless.....With the task of upgrading a PC reduced to minutes, you can allocate your time to more lucrative pursuits."[6]

Upgradeable products also lower the costs of servicing products, for those customers who do not want to do it themselves. While upgradeability has several advantages, both environmental and economic, it does have its limitations. The biggest limitation is technological change. If the basic architecture of the computer or its components changes, for example, upgrades might not be an option. So, for a computer coming on the market today with upgrade features, it is unclear how long the current technology will be compatible with future generations.

Design for Recycling

The design of products to facilitate recycling at the end of life is a major focus of Compaq's environmental design efforts. These efforts focus largely on plastics, currently the most difficult wastestream to recycle at the end of a PC's life, including:

- Removal of flame retardants that contain polybrominated biphenyls, dioxins and cadmium from plastics, many of which are restricted substances in Europe.
- Reduction in the number of plastic types to favor two polymer compositions, ABS and polycarbonate, which now make up 90 percent of all plastic used at Compaq.
- Use of detailed markings on plastic to identify resin type, manufacturer and exact blend, which facilitates the reuse of these plastics in high grade applications and prevents future downcycling.

In addition, due to efforts to design upgradeable products, Compaq computers are easier to disassemble. Components such as microprocessors, hard drives and memory are also pulled out easily and undamaged, which facilitates resale and reuse opportunities.

3.2.3 Compaq's Experience with Product and Packaging Recovery

Recognizing its responsibility to help manage the end of life of its products, Compaq has initiated several programs over the past four years to recover and recycle its products, product components, and packaging. Although well-intentioned, these programs have been limited by low customer participation rates, illustrating that EPR sometimes needs more than a willing producer to make a difference.

Battery Take Back

In 1992, Compaq initiated the first U.S.-wide take-back program for portable rechargeable battery packs, in response to a patchwork of state battery laws. The program is user friendly and provided at no cost to customers. The customer calls a toll-free number and provides the product name and serial number. A pre-addressed, postage-paid mailer is sent to the customer. Using the mailer, the customer sends the battery directly to a reclamation facility approved by Compaq. Compaq incurs all program costs (about $5 per pound of batteries processed) including the 800 number, mailers, postage, and processing fees.

The market response to Compaq's battery recycling program has been limited, according to Walt Rosenberg, Corporate Environmental Manager, although there was a 17 percent increase in participation between 1993 and 1994.[7] About 1,000 to 2,000 batteries are recycled each month, representing less than ten percent of Compaq products on the market. The program is advertised via inserts in new Compaq portable products and periodically in product advertisements. Program information is available from the dedicated Battery Return Program hotline, information software supplied with new Compaq products, the toll-free Compaq Customer Support Center, and authorized Compaq dealers.

Equipment Recycling

Compaq offers product recycling in selected markets. In Switzerland, Compaq participates in an industry-established system, while in Germany, where the take-back concept first gained notoriety, Compaq offers a recycling service through independent contractors. Customers pay approximately $25 to $30 for this recovery and recycling service, which is consistent with the current economics of electronics recycling in Europe.

In its four years of experience with product take back, Compaq reports insignificant customer response. In Germany and Switzerland combined, approximately five systems are recovered each month. Customers are inclined to sell or give away their used equipment, or store it indefinitely.

In the U.S., Compaq is receiving more and more inquiries about environmental issues, including requests for product recovery, particularly from major accounts concerned about long-term liability. Upon request, Compaq has assisted these customers in equipment disposition. Compaq also recycles excess production materials and operates a factory store, where product returns and excess equipment are offered for resale.

Logistical constraints make large scale equipment recovery from end-use customers particularly unattractive and costly for Compaq (and ultimately the customer). The major costs associated with equipment recovery and recycling for Compaq, as well as other electronics manufacturers, is in deinstallation and reverse logistics (that is, moving products from the end user site back to the manufacturer). The majority of Compaq equipment is distributed, installed, serviced, deinstalled, and even leased through third parties. With the exception of product under warranty, Compaq typically does not receive used or leased equipment back from customers.

Compaq's experience with battery take back and product recovery in Europe indicates a low value placed on such services by customers. The top priorities of customers remain cost, quality, and serviceability. Given the cost of reverse logistics, it will generally be more cost-effective for most Compaq customers to utilize existing channels for recycling their used equipment (e.g., third party electronic recyclers and used equipment brokers) rather than turning to Compaq for this service.

Packaging Pilot

In 1994 Compaq initiated a pilot program for the recovery of foam inserts used to package network servers. Customers were provided with a postage-paid mailer to return the foam insert. Upon return, foam inserts were inspected and designated for reuse or recycling. Again, the results were disappointing. Of the 5,000 units targeted, only two foam inserts were returned by customers, indicating that recycling foam inserts is not a priority of customers or they have another outlet for recycling.

3.2.4 Supplier Management

Compaq purchases some components and subassemblies for integration into its final products. To control the quality of inputs, and thus the quality of Compaq products, the company instituted a "world-class" supplier process. Compaq evaluates vendors along seven dimensions including quality, capability, responsiveness, and price. Environmental issues are included in the evaluation and vendor approval process.

Compaq requires suppliers to certify that they do not use CFCs or HCFCs in their products or processes and that they have not been excluded from federal government procurement for environmental reasons. This certification helps ensure that Compaq's products will not be shut out of markets due to vendor practices. Compaq also conducts site surveys as part of the supplier management program. Prospective suppliers are evaluated and graded (on a scale of zero to four) on aspects of their operations, such as order processing, quality inspection process, calibration, and environmental programs. To be awarded a contract with Compaq, a vendor must receive a minimum score, representing the sum of all activities evaluated.

The evaluation of environmental programs specifically examines and rates a vendor's environmental, health, and safety compliance record; environmental policy and commitment to address environmental issues; waste minimization program; and self-evaluation program (i.e., audit program). As an example, if there was "no evidence" of a waste minimization program, a supplier receives zero points. In contrast, a company that has developed waste minimization objectives and metrics and has integrated these objectives into its business plans receives the highest score, or four points.

The process is used to inform suppliers of Compaq's expectations and to help suppliers improve their programs if needed. Suppliers with low scores are given the opportunity to develop new programs and raise their scores. As a result of this program, for example, several companies stopped using CFCs in order to meet Compaq's requirements. Although many of its suppliers meet Compaq's minimum expectations, they strive to continually improve their scores.

3.3 PRODUCT STEWARDSHIP AT HEWLETT-PACKARD COMPANY

To provide products and services that are environmentally responsible throughout their life cycles and to conduct business operations worldwide in an environmentally responsible manner.

Corporate Environmental Policy, 1992

Hewlett-Packard Company's (HP) environmental philosophy took a significant stride in 1992 with the launch of its product stewardship program. The company made a commitment to move beyond the factory and an emphasis on the manufacturing process to embrace a new life-cycle philosophy. The life-cycle approach broadened HP's concerns to encompass product design, packaging, distribution, use and disposal, in addition to traditional manufacturing issues. Most importantly, the life-cycle approach allows HP's business units to identify and address emerging global product legislation and market expectations. HP's product stewardship program was triggered by a desire to stay ahead of legislative developments and voluntary programs such as German take back and U.S. Energy Star requirements, and to respond to an increase in the number of customers seeking more environmentally-sound products.[8]

Hewlett-Packard Company (HP) designs, manufactures and services communications, measurement, and computation equipment. Computer products and services, from personal computers to workstations, printers and network systems, account for 80 percent of HP's business. Other major product lines include electronics test equipment, medical diagnostic systems, laboratory instrumentation, and electronic components. In 1995, HP posted net revenues of over $30 billion and employed over 100,000 people world-wide. The company operates 60 manufacturing sites throughout North and South America, Europe, Australia and Asia. Its products are in use in over 120 countries.

At the root of its life-cycle approach is design — this is, design to minimize adverse health, safety, and environmental impacts from the manufacture, use, and disposal of its products. This focus on product design is critical to achieving environmental improvement, given the rate of new product introductions. More than half of HP's 1995 orders were for products introduced in the previous two years.[9] To address this issue, HP has developed Design-for-Environment guidelines that encourage the development of new products that incorporate energy-saving features and recyclable materials, and that reduce waste generation in manufacturing processes.

Hewlett-Packard's product stewardship efforts extend beyond product design. To influence the inputs to its products and processes, HP developed its supplier "E" process, which adds environmental issues to vendor management along side traditional concerns such as quality, delivery, and cost. At the end of product life, Hewlett-Packard engages in selected collection of products from customers for processing at recycling centers in the U.S. and Europe.

3.3.1 Product Stewardship: From Concept to Implementation

Hewlett-Packard's product stewardship program was designed to accommodate the needs of a highly decentralized company, where business units operate in an environment characterized by intense competition and rapid technological change. Furthermore, it is a global marketplace. Hewlett-Packard operates 60 manufacturing sites world-wide, deals with more than 10,000 suppliers, and sells products in 120 countries.

To address these needs, HP's corporate environmental management function was tasked with the following mission:

> *"In partnership with HP's geographic organizations and other corporate functions, provide a strong facilitation platform to the HP businesses and be proactive in elevating awareness and leveraging product stewardship solutions for improved business results."*

As a result, Hewlett-Packard developed a global product stewardship network and management process that provides business units with support, tools and information, as well as autonomy, to develop responses that meet the demands of their product lines and customers.

Each of HP's product lines has a product steward who champions the program and coordinates efforts to identify, evaluate and respond to any market forces that could impact that product line. The product stewards create cross-functional teams, as needed, to deliberate issues and weigh all aspects of design — from cost and performance to environmental impact. Ultimately, the success of Hewlett-Packard's product stewardship program rests with product line management, since it is up to them, with the assistance of the product stewards, to act upon relevant information.

Hewlett-Packard established an on-line information system to help business managers and product stewards world-wide stay abreast of environmental issues and informed decision making. The database contains current and proposed legislative requirements, market developments, and Hewlett-Packard's Design-for-Environment (DfE) guidelines. Product stewards can access documents on subjects such as batteries, ecolabels, packaging, energy, and product take back. The information is organized by geographic regions, as well as topics, and is accessible using a keyword search feature.

A global product stewardship council, comprised of senior level business managers from each of HP's major businesses, oversees company-wide implementation of the program. The council initiates projects to address company-wide issues and program needs. For example, teams have been created to address European product take back, battery legislation, lead in electronics assemblies, and plastics procurement and recycling. Resulting recommendations are communicated to the product stewardship network for appropriate follow-up action by the product line.

In mid-1995, four years after the initiation of its product stewardship program, Hewlett-Packard put one of its last key processes, the business self-assessment, in place. The self-assessment procedure is designed to promote the further integration of product stewardship into

the mainstream of HP's business by ensuring the involvement of senior business managers. Essentially a self-audit using Quality Management System (QMS)-type questions, the procedure helps business managers verify that their businesses and products are positioned appropriately to address emerging market forces, such as customer expectations, legislative requirements, voluntary standards, and competitor initiatives.

The self-assessment also measures internal deployment of product stewardship programs, including HP DfE guidelines, the supplier "E" process (see below), and appropriate awareness-building and communication vehicles. Feedback from initial application of the self-assessment procedure has also identified opportunities to improve support services for product stewards: for example, providing more comprehensive summaries of legislation and eco-labels on the company-wide on-line information system.[10]

Supplier "E" Process

> *"Although HP does not intend to dictate how suppliers should comply with or meet environmental requirements, HP will favor, whenever possible, suppliers who demonstrate the best Technology, Quality, Responsiveness, Delivery, Cost and Environmental (TQRDC-E) performance."*[11]

In support of HP's product stewardship program, HP's procurement organization established environmental criteria to inform suppliers about HP's environmental performance expectations. As a result, HP's supplier performance metrics, TQRDC-E, now include "E" for environment along with technology, quality, responsiveness, delivery, and cost criteria. Supplier "E" criteria have been developed on two levels: global and commodity specific.

HP suppliers on a world-wide basis are expected to meet three global "E" criteria:

1. Establish an environmental policy, endorsed by top management, that commits the company to continuous environmental improvement.
2. Develop an implementation plan with well-defined metrics that supports the environmental policy.
3. Eliminate ozone-depleting substances from operations and products.

HP further suggests that environmental improvement policies cover manufacturing processes, information and labeling, recycling and reuse, power consumption reduction, packaging, and disposal in the brochure that it distributes to suppliers.[12]

Suppliers are rated on a scale of zero to four for each "E" criteria, and a total score is calculated based on the sum of the weighted score for each criteria. Similar scores are derived for each TQRDC-E metric. A supplier's overall score is the average score for the six metrics. HP uses a supplier's overall rating to compare it to other suppliers of the same commodity when making sourcing decisions. Equally important, the rating system provides a tool for communicating environmental expectations and performance with suppliers. For example, HP credits the Ozone Depleting Substances (ODS) supplier "E" criteria with bringing "tremendous supplier compliance."[13]

In addition to the global "E" criteria, commodity-specific "E" criteria have been established to promote the development of environmentally responsible materials and processes, including plastic resins, CRT monitors, power sources, and contract manufacturing. Implementation of the commodity-specific "E" criteria for plastic resin (see Table 3-2), in conjunction with resin recyclers and suppliers, resulted in the launch in 1995 of the first HP DeskJet printer manufactured with recycled plastics.

Table 3.2: HP's Plastic Resin Commodity Specific "E" Criteria

E1: Recycling
1. Program to take back post-consumer plastics from HP for formulation of recycled resin.
2. Offers minimum 25 percent recycled-content plastic resin.
3. Program to make available HP requested recycled resin, if not commercially available.
4. Offers recycled plastic resin at parity or lower prices compared to comparable virgin grades.

E2: Environmental Awareness
1. Aware of and in compliance with country-specific requirements (e.g., PBB, PBDEs).
2. Informs HP about potential bans on plastic additives and offers alternative solutions.
3. New product developments reflect existing and emerging worldwide environmental, recycling, health, and safety requirements.
4. Participates in industry organizations and is abreast of worldwide environmental and legislative trends affecting manufacturing and product use.

E3: Waste Reduction
1. Program to help HP reduce amount of material used in applications.
2. Processes to reduce and responsibly dispose of production wastes.
3. Minimize, reuse, or recycle packaging materials.
4. Programs/plans to offer environmentally sound disposal solutions for non-recyclable materials (e.g., mixed or contaminated plastics).

Source: Choong, Hsia. 1996. "Procurement of Environmentally Responsible Material," IEEE International Symposium on Electronics and the Environment. May.

Product Stewardship at the Business Level

The Computer Products Organization (CPO) first tested product stewardship practices within HP beginning in 1992, and developed the prototypes of several tools now in use company-wide (e.g., DfE guidelines, on-line information system, supplier performance criteria). As the producer of HP's widely-recognized and high-volume LaserJet and InkJet printers and personal computers, CPO was a good place to start. CPO was subject to a proliferation of emerging "green" market forces: customers were increasingly asking about environmental features and the environmental impact of HP products, including energy efficiency, packaging, recyclability, and the use of ozone-depleting substances; ecolabels and voluntary standards were driving competitors to introduce new products; and European take-back requirements were pushing

product stewardship.[14] Since CPO manufactured high-volume products, focusing on these products presented HP with its greatest opportunity to reduce environmental impact.

CPO developed a set of metrics to help drive product stewardship improvements and to provide management with a mechanism to review and measure progress. The metrics shown in Table 3-3 were chosen based on customer inquiries, government initiatives, proposed ecolabel criteria, and end-of-life handling considerations. For products, consumables and packaging, CPO chose to focus on energy efficiency and reducing its contribution to the wastestream.

Table 3-3: CPO Performance Metrics

I. Product, Consumables, and Packaging

Material Conservation and Waste Reduction
- Mass (kg)
- Projected % remanufacture or reuse
- Projected % recycled

Energy Efficiency
- Normal operating mode (watts)
- "Sleep" mode (watts)
- Off mode (watts)

Design for Environment
- Variety/number of materials
- Plastics marked (yes/no)
- Disassembly time (minutes)
- Recycled material content (%)
- Number of materials requiring special handling

II. Manufacturing Process

SARA 313 emissions (kg/yr)
Hazardous waste generated (kg/yr)
Hazardous waste reused/recycled (%)
Solid waste generated (kg/yr)
Solid waste reused/recycled

Source: Korpalski, T. 1994. IEEE Proceedings. May.

Product lines select specific objectives for improvement and set goals. Results are measured as a percentage improvement above the baseline year. The next section discusses results for one product, the Vectra personal computer.

3.3.2 Product Stewardship Results

Improving Product Environmental Performance Through Design

Table 3-4 provides some environmental improvement results for HP's Vectra series of personal computers, accomplished over the past five years. Most of the Vectra PCs meet U.S. Energy Star requirements and are easier to disassemble and recycle than previous models due to the use of fewer materials, parts, and screws. Indeed, it takes a recycler only four minutes to break down the computer into its component parts. In addition, the product mass was reduced by 46 percent, while the manuals were cut by over 60 percent.

Table 3-4: Environmental Improvements for HP Vectra Personal Computers

Metric	**Improvement**
Number of parts	1,650 to 350
Weight	13 kg to 7 kg
Number of screws (to module level)	4
Time to disassemble (to module level)	4 minutes
Number of materials (housing and chassis)	2 (pure plastic and steel)
Energy efficiency	All 486s and most Pentiums meet Energy Star requirements
Batteries	No heavy metals No batteries in some models
Flame retardants (housing and chassis)	No brominated flame retardants (PBB/PBDE)
Packaging	75% recycled corrugated EPS Foam No heavy metals in inks
Manuals	400 pages to 150 pages 50% recycled content Recycling compatible binding No heavy metals in inks

Source: Korpalski, T. 1996. "The Role of the 'Product Steward" in Advancing Design for Environment in Hewlett-Packard's Computer Products Organization, IEEE International Symposium on Electronics and the Environment. May.

Other environmental attributes in the Vectra model, as well as most current HP personal computer products, include:

- All but the smallest plastic parts carry markings that identify the type of plastic, making the plastic easier to recycle. HP uses the standards developed by the International Standards Organization (ISO).

- The elimination of poly-brominated diphenyl ethers (PBDEs) as a flame retardant in the plastic housings and keyboards, which may emit dioxins when burned.
- Batteries do not contain heavy metals.[15]

A tribute to its environmental performance, HP's Vectra VL series carries the comprehensive German Blue Angel environmental label for PCs. The German Blue Angel is granted only to PCs that meet or exceed 65 requirements in a broad range of environmental and safety categories. Product recycling is an important aspect in PC Blue Angel certification. Numerous criteria focus on some aspect of recycling, from material selection and identification markings to the use of screws to facilitate recycling. Furthermore, Blue Angel certification requires the manufacturer to provide a written commitment ensuring the recovery and recycling of the product at end of life at no cost to the customer. Other PC Blue Angel criteria cover, for example, expandability/upgradeability, batteries, and energy consumption.

Energy Consumption

HP offers more than 100 product models that meet or exceed U.S. EPA Energy Star criteria, including 100 percent of its printers, plotters, facsimiles, 486-based PCs, and PC display monitors. For HP's customers, this translates into reduced energy use and costs. For the environment, this means a reduction in fuel use and power plant emissions.

Given the proliferation of Energy Star products on the market, the logo is not a market differentiator for HP, although the absence of the logo is seen as a competitive disadvantage. For example, President Clinton signed an Executive Order in 1993 requiring federal agencies to purchase only computers and printers that meet Energy Star requirements. According to Cliff Bast, HP's corporate product stewardship manager, the structure of the Energy Star program is a good one: "it was not designed to pull in elite products only, but to get maximum amount of participation, and therefore, maximum environmental benefit." This is in contrast to the German Blue Angel, which establishes multiple stringent standards in an "all or nothing," resource-intensive certification process.

A New "Packaging" Concept Reduces Waste

One innovative solution developed in HP's workstation division requires 30 percent less packaging because protective packaging is built into the product itself, instead of being wrapped around it. The new HP Packaging Assembly Concept (PAC) replaces the metal chassis with expanded polypropylene (EPP) foam. The foam chassis cushions sensitive electronic parts during shipping, while reducing the number of mechanical parts needed to hold parts in position. The foam chassis has an added benefit of reducing product development time, since prototypes require less preparation and assembly time with the easy to mold foam.

Hewlett-Packard's chemical analysis business adopted the innovative E-PAC technology in its new 1100 Series HPLC systems. This new packaging design resulted in major costs savings in assembly and disassembly, since fewer parts and no assembly tools are needed. For example, the new product design resulted in:

- 70 percent reduction in mechanical housing parts.
- 95 percent reduction in screw joints.
- 70 percent reduction in assembly time.
- 90 percent reduction in product disassembly time compared to previous models.

EPP foam can also be 100 percent recycled into source material polypropylene.[16]

Asset Management and Recycling

Managing the end of life of electronic equipment provides multiple business opportunities for Hewlet-Packard, from improved customer service and sourcing of spare parts to new revenue streams in some cases. The company's two equipment recovery operations in the U.S. are strategically located within the HP organization to reflect their mission. The Hardware Recycling Organization (HRO) is part of the Support Materials Organization (SMO), which is responsible for worldwide distribution and repair service material. In contrast, the home of the asset management group servicing the Technical Computer Business Unit, also known as Alternative Inventory Solution, is within the marketing group.

The primary mission of the HRO, located in California, is to process useful service parts through the disassembly and refurbishment of HP and non-HP excess equipment and parts. HRO also serves as one of HP's recycling hubs. Equipment and parts that are not suitable for service are routed to environmentally-responsible, non-competitive recovery channels.

Salvaging parts from used equipment allows HP to improve its service levels; in particular, it increases parts availability while lowering costs. Indeed, the origins of the HRO operation lie here. In 1987, HP found it difficult and expensive to obtain new service parts for some printers. In its search for solutions, the service organization found tear down of used equipment and subsequent refurbishment of parts to be a cheaper and more reliable source of service parts. HRO could fill an order for spare parts in two weeks time, in comparison to over six months for new parts. HRO now stocks the service supply pipeline, resulting in an immediate turn around for service parts. Stocking service parts using the HRO organization also frees up HP's manufacturing capacity, allowing production units to concentrate on manufacturing new products. In addition, for some older technologies that are no longer in production, recovery of service parts from used equipment is the only option, and therefore, is vital to keeping equipment in service.

The HRO facility processes 9,000 tons of equipment annually with a total "recycling" rate of over 99 percent (including some incineration with energy recovery). Less than one percent of product goes to landfill. Sixty percent of the equipment processed at the facility comes from HP divisions (e.g., internal equipment, excess inventory), while deinstallation from customer sites and HP's service organization account for 25 percent and 15 percent, respectively.

At the facility, incoming product lots are weighed and unpacked. Product numbers are entered into a computer system and any service parts identified. The products are then routed to either disassembly for removal of service parts or reclamation. Equipment that is not utilized for service is diverted to non-competitive recovery channels, including component resale and

material recycling. Of the equipment processed, the disposition of products breaks down as follows:

- 70 percent reclamation, which includes pulling integrated circuits and material recycling of precious metals, plastics, nonferrous metals, and CRT glass.
- 18 percent resale of components and parts, such as disc drives, fans, and motors.
- 12 percent recovery of parts for use in HP's service organization. Service parts designated for recovery include, for example: electronic assemblies, boards, drives, and monitors.

In the past, the HRO program was passive; the program waited for equipment to come to it. This is changing into a more active program that deliberately pulls products from markets into the HP recycling system in order to recover valuable service parts. For example, in late 1994, HP's marketing department initiated a tradeup program for LaserJets with a dual goal. An obvious goal was to increase the sale of new LaserJets; an additional driver was to increase the supply of spare parts to the service organization and to lower service costs. HP will also buy back equipment with needed service parts, although the company offers no formal product take-back program.

The biggest problem materials for the recycling organization are plastics and cathode ray tubes. HP is beginning to find solutions for plastics, now that the company is looking at plastics recycling from a financial perspective. One year ago, HP was sorting all plastics, despite a lack of markets for the material. The company then shifted its focus to recover only those plastics that were in market demand, and in particular, plastics that were in demand by HP. HRO started with ABS, which represents 12 percent of the wastestream. HP worked closely with a resin supplier to develop a recycling solution and infrastructure, which allows closed-loop recycling of ABS. (See discussion in *Plastics Recycling Project* section.) Using the ABS model, HP plans on tackling other plastics, in particular, polystyrene and polycarbonate, which together with ABS, account for 80 percent of the recoverable plastics stream.

For HP's HRO organization, the bottom line is that the recovery of service parts is very profitable, while the unit strives to break even on its recycling activities. Historically, the largest revenue generators have been chip recovery, precious metals and resale of disk drives, fans, and motors. However, these markets are volatile (as demonstrated by the plummet in the DRAM market in mid-1996), impacting the economics of electronics recycling. In addition, CRTs and plastics recycle are financial drains, although ABS recycling is reaching a break even to slightly positive cash flow.

The HP Technical Computer Business Unit (TCBU), which manufactures workstations and other high-end computer systems, operates its own recycling organization from its headquarters in Massachusetts. Like the HRO organization, this recycling operation, also known as Alternative Inventory Solutions (AIS), has strategic importance to the company. The program:

- Provides alternative sources of equipment and service parts to HP.
- Ensures that equipment does not enter the gray market.

- Recovers maximum value from equipment, without damaging new product sales.
- Ensures proper disposal of equipment.

A workstation, or Unix server, has greater value when it enters the marketplace and when it leaves the marketplace, compared to a PC or printer. For this reason, HP is able to recoup "significant" savings and revenues (after expenses) from this operation. Over 70 percent of the equipment and subassemblies processed by AIS is returned to HP for reuse or resale, while only 30 percent goes to third parties for recycling. Reuse and resale opportunities include, for example:

- Product remanufacture, where systems are upgraded to incorporate design changes or features introduced since the product's inception (e.g., CPU board upgrade). These systems are tested to ensure that they meet HP quality standards.
- Recovery and refurbishment of service parts for HP internal use (e.g., boards, disc drives, cables).
- Sale of commodity items (e.g., disc drives, monitors, integrated circuits) to secondary markets.

HP is trying to increase its sale of remanufactured equipment. Such equipment may fill an existing customer's expansion needs or target new markets. New markets are targeted for strategic purposes. For example, HP seeks entry into new geographic and vertical markets, where potential customers may not be able to afford the latest technology (e.g., developing countries, educational institutions). Used product sales create current revenue streams, while increasing HP's presence in the market and competitive edge for future sales of new products. Used equipment also is offered for sale to HP partners, such as software developers, to create goodwill and strengthen alliances. Whether reselling equipment or parts, however, HP is careful not to compete with new product sales or HP's service organization.

Plastics Recycling Project

Finding solutions for the plastics wastestream from scrapped products is a priority for HP, with preference given to recycling. At the same time, HP product groups are looking towards meeting the expectations of an increasingly environmentally-sensitive customer base. Merging these two objectives, HP is working with its suppliers, its recycling organization, and its printer division to qualify recycled content plastic in HP product, thereby creating a market for the output generated by the recycling organization and improving the environmental profile of its products.

In July 1995, HP introduced its first recycled-content product to the U.S. market, the DeskJet 850C InkJet printer. The printer's outer cover contains up to 25 percent recycled-content ABS, a combination of post-consumer and post-process wastes.[17] This was a major milestone for HP's product stewardship program; the company was able to demonstrate and qualify 25 percent recycled-content in a high-quality, cosmetic application. Meeting extremely tight color controls for this light-colored part was the biggest technical challenge overcome in the project. As a result, in 1995 more than 1.1 million pounds of recycled plastic were used in the DeskJet 850 printer series. When the recycled-content is incorporated into the entire 850C platform, HP estimates a diversion of six million pounds of plastic from the wastestream annually.

Access to a consistent supply of recycled resin, in terms of quality, quantity and cost, is a major issue. When HP embarked on this project, recycled plastic resin for this application was not even commercially available. HP research and development staff, design engineers, and procurement managers worked closely with resin manufacturers and injection molders to co-develop and qualify a usable recycled product and identify a reliable and steady source of pre-consumer and post-consumer scrap. In addition to meeting engineering specifications for color and performance, the recycled-content resin had to meet "parity" cost criteria.

Other HP product lines are exploring the use of recycled-content in plastic parts, although uncertainty in recycled-resin supply makes designers hesitant to specify recycled-content in new products and undergo costly and time consuming qualification and certification processes. With a projected increase in demand for recycled resin, one of the significant challenges ahead for manufacturers such as HP, the information technology industry in general and its resin suppliers, is building up the supply of recycled resin. For example, HP has difficulty getting their printers back from customers due to their long life and secondary market value. Building an effective plastics recycling infrastructure will require coordinated efforts among manufacturers, recyclers and resin suppliers to ensure product designs that facilitate plastics recycling, effective product recovery channels and improvement in plastics identification, sorting, and recycling technologies.

Toner Cartridge Recycling

Over the life of a printer, a customer may go through 50 or more print cartridges, amounting to a wastestream of cartridges and packaging that exceeds that of the printer itself. To facilitate recycling these "consumables," Hewlett-Packard has offered customers a program for returning toner cartridges for recycling. For LaserJet toner cartridges, customers return used cartridges in the original packaging using a pre-paid UPS label that is provided with the product inserts.

Cartridges are disassembled and over 98 percent of the cartridge by weight is recycled or used in the manufacture of new cartridges. As an example, the following is a breakdown for one cartridge model:

- 37 percent reuse of parts, such as screws, springs, clips, magnetic roller, and corona assembly.
- 38 percent parts remolded for use in new cartridges, including plastic housings.
- 24 percent materials recycled (e.g., some plastic parts and electronic assemblies) and sold to alternative markets for use in new products.
- 1 percent landfill disposal, including seals, foams, and adhesive labels.[18]

Since the program's inception in 1991, approximately 13 million cartridges have been recycled, at no cost to the customer. A similar return program is offered for InkJet printer cartridges through U.S. dealer networks, although reuse and recycling opportunities are limited by product technology.

Looking Towards the Future

To guide its environmental improvement efforts, in 1995 HP's InkJet Business Unit undertook a comprehensive life-cycle assessment (LCA) of its highest volume print cartridge. The LCA measured environmental impact in four categories: greenhouse effect, atmospheric acidification, natural resource depletion, and nutrification potential. Some expected and some interesting results emerged:

- Energy consumption of the cartridge during printing was very small compared to other life-cycle stages.
- A packaging change implemented in 1994 reduced by 15 percent the environmental impact in each of three categories. The packaging change led to a 35 percent reduction in packaging mass, doubling of shipping efficiency, and significant savings in manufacturing costs.
- Ocean shipping of cartridges from their manufacturing location in Singapore to the European market, instead of air transport, significantly reduces environmental impact, a change which has subsequently been implemented. Ocean shipping, combined with the packaging change, reduces resource depletion by more than one-third, and both global warming and acidification by about one-fourth.
- Paper use in printing and the energy consumed when the printer is idle, together account for almost 95 percent of all environmental impacts.

In addition to the changes in packaging and shipping already made, these LCA results establish clear priorities for future product stewardship efforts in the InkJet business. Possible improvements include, for example, double-sided print capabilities using hardware or software solutions, and a printer design that turns itself off after a specified period of non-use.[19] Cost savings in paper and energy consumption for customers clearly make these win/win proposals, demonstrating that environment and business objectives go hand in hand.

3.4 PRODUCT LIFE-CYCLE MANAGEMENT AT NORTEL

Nortel sees sound environmental management as a key contributor to customer and shareholder value. The company continually seeks to exceed mere compliance and to minimize resource consumption, waste and adverse environmental impact, limited only by technological and economic viability.

Nortel's Corporate Environmental Policy

In 1992, Nortel initiated its Product Life-Cycle Management (PLCM) program which commits the company to factoring resource efficiency into all stages of the product life cycle. Similar to the programs of Compaq Computer and Hewlett-Packard, Nortel's PLCM program addresses supplier management, builds environmental improvement into the design phase of new products, and provides alternative solutions to product disposition. PLCM at Nortel also means reevaluating traditional manufacturing processes and technologies to design new, more efficient, as well as less toxic, products and processes.[20]

Nortel (Northern Telecom), headquartered in Mississauga, Canada, is a leading global manufacturer of telecommunications equipment. The company provides equipment, services and network solutions for information, entertainment, and communications networks operated by telephone companies, corporations, governments, and other institutions worldwide. Major products include central office switches, private branch exchanges (PBXs), and wireless communications. Nortel operates in more than 90 countries, and employs over 60,000 people. Celebrating its centennial in 1995, Nortel reported revenues of U.S. $10.7 billion, of which 60 percent were earned in North America.

Nortel's approach to environmental management has evolved over time. Starting with end-of-pipe solutions and compliance in the 1980s, Nortel developed fundamental programs to address discrete sources of pollution for the protection of air, land, and water resources. Nortel is now moving towards more systematic and comprehensive approaches to addressing environmental issues. For example, the company adopted an Environmental Management System (EMS) standard, and with the PLCM program, it is actively moving beyond manufacturing operations to address the life-cycle environmental impacts of products.

Nortel is convinced that environmental excellence is excellent business. The company realized this first with chlorofluorocarbon elimination. Nortel saved four times its one million dollar initial investment over three years. Similarly, a business case on investment in environmentally-related programs developed in 1995 to support the pursuit of Nortel's environmental targets (see below) revealed an impressive 1:4 ratio of investment to return.

With its PLCM program, Nortel believes it can save money for customers and for the company, increase customer loyalty, and create value for their customers. This case addresses how efficient use of resources, such as reusable packaging, longer life products and asset recycling, saves money for Nortel and customers, while reducing environmental impacts. Nortel also believes that a segment of the marketplace will choose environmentally-preferable products.

Indeed, some large telephone operating companies, such as British Telecom and Telia Telecom, are querying suppliers about the use of hazardous materials in products and product recyclability.

3.4.1 Product Life-Cycle Management: From Design to End of Life

Nortel approaches its product life-cycle management program strategically. Consistent with corporate operating principles, the program aims to create customer value. Customer value takes many shapes, including: lower lifetime costs of products through resource efficiency; partnerships with customers to improve their environmental performance; and value-added recycling of products at the end of life. PLCM also strengthens strategic alliances with suppliers, which are of growing importance to Nortel's overall business strategy.

In support of its philosophy, Nortel created a new position, Corporate Director of Business Development in Environmental Affairs, to guide and stimulate PLCM efforts throughout the company. The mandate for this position is to improve the environmental performance of the corporation through changes in all stages of the product life cycle — design, supply management, manufacturing, marketing, distribution, and product disposal. Activities underway include, for example:

- Working upstream with suppliers to redefine responsibilities and requirements.
- Redesigning products to eliminate toxics and improve resource efficiency.
- Improving manufacturing operations through energy efficiency and research into the use of VOC-free fluxes and lead-free solders.
- Implementing packaging improvements that minimize wastes.
- Reducing environmental impacts at product end of life through recycling initiatives.

Nortel is also developing guidance and tools to help product and system designers integrate environmental considerations into systems of the future. In 1995, design guidelines were made available on-line to design engineers. Development of a set of PLCM standards for new product design is underway. Like any Nortel standard, compliance with these standards will be required as part of the product development process.

Over the next several years, Nortel will develop and phase in PLCM standards as the company acquires the necessary knowledge and experience to establish appropriate standards. Standards are currently proposed for:

- Life-cycle analysis, or eco-profiles.
- Hazardous material use (e.g., eliminating use of lead in manufacturing, brominated flame retardants in plastics, chromate metal finishes).
- Product packaging (e.g., volume reduction, reusable designs).
- Manufacturing emissions (e.g., reducing VOC emissions which account for 50 percent of hazardous air emissions at Nortel sites).
- Material reuse and recyclability (e.g., material selection, design for disassembly).
- Product take back.

The first series of standards will include eco-profiles, manufacturing emissions, and hazardous material use.

The eco-profile standard will assist Nortel staff in developing the necessary knowledge base to establish future standards. The eco-profile standard will require design engineers to characterize the product, identifying environmental issues and potential solutions throughout the life cycle, from technology, market and regulatory perspectives. Introduction of the eco-profile standard will occur over three years, starting with consumer products and followed by commercial equipment (e.g., PBX, Norstar) and infrastructure (e.g., switching, cellular) equipment. Information derived from the eco-profiles will serve as a management tool to establish Nortel PLCM standards and will help focus Nortel's research and development efforts. Eco-profiles might also be used in marketing and customer communications.

Measuring and communicating environmental performance is a priority for Nortel, and a requirement of their corporate EMS. The company is currently working toward four measurable targets for the year 2000, with 1993 as the baseline year:

- 50 percent reduction in total pollutant releases to the environment (land, air, and water).
- 50 percent reduction in solid non-hazardous waste.
- 30 percent reduction in paper purchases.
- 10 percent improvement in energy efficiency.

While these initial targets focus mostly on Nortel operations, additional product-related targets will be established over the next several years.

3.4.2 Results

Nortel's PLCM results demonstrate that environmental objectives are supportive of business objectives. To lower product costs, Nortel strives to root out inefficiencies and waste in the design, delivery, and use of its products. Energy efficiency is a major target. Study after study conducted by Nortel identifies energy efficiency as a major leverage point for environmental improvement of products and processes. More energy-efficient products translate directly into lower costs for customers, since energy is a major cost of operating telecommunications equipment.

Over the years, Nortel has made significant progress in reducing the environmental impact of manufacturing processes, including the elimination of CFCs and reductions of VOC releases. Under the PLCM program, improvements in manufacturing continue; for example, in 1996 Nortel's Research Triangle Park facility installed a new VOC-free process technology, developed by Nortel's own process development teams. Research and testing are also underway on lead-free solders and alternative circuit board coatings. Nortel's PLCM program, however, moves beyond manufacturing. Below are highlights of some of Nortel's initiatives to improve other aspects of the product life cycle.

Supply Management and Chemical Use Reduction

Nortel is investigating new business opportunities in supply management to help the environment and lower costs. In an effort designed to reduce chemical use, Nortel is embarking on an innovative business strategy with its chemical suppliers. In a pilot project at one of Nortel's Ottawa, Ontario sites, Nortel is initiating a new business relationship with its main chemical supplier. Under this new relationship both Nortel and its chemical supplier will have a joint incentive to reduce chemical use.

The hallmark of such a relationship is a change in the once competitive nature of the manufacturer/supplier relationship. Instead of the supplier seeking profit by encouraging Nortel to use more chemicals, under a "shared savings" relationship, Nortel and its chemical supplier will work together to minimize chemical use. In its long-term contract, Nortel purchases the services of the supplier for a fixed fee, rather than purchasing the chemicals themselves. Thus Nortel removes the financial incentive of the supplier to sell more chemicals. In this new relationship, the supplier is responsible not only for supplying the needed chemicals, but also for providing services such as chemical process expertise and chemical management, storage, and disposal. As a result, the supplier has the incentive to help Nortel minimize chemical use by introducing innovations, searching for alternatives to hazardous chemicals, suggesting more efficient chemical processes, and delivering only the quantity of chemicals needed.

Such a supply management relationship allows Nortel to concentrate on what it knows best — network solutions in the telecommunications industry — while leaving the chemicals to the experts. The ultimate impact is reduced chemical use and costs and increased quality in products and processes due to the leveraging of outside expertise. By inviting suppliers into such long-term business relationships, Nortel is developing an innovative solution that helps the environment and makes good business sense.

Extending Product Life Through Design

Nortel has adopted a modular product philosophy for its new Vista line of telephones, called Power Touch, in the U.S. The new model allows the customer to upgrade the unit without buying a new one and scrapping the old one. The principle driver behind the design was to create "user value" by leveraging the customer's initial investment through a flexible and upgradeable design. The new model is designed in two parts — a standard base with basic telephony features and an upgradeable slide-in module that can add features such as caller ID, call waiting, a larger screen size, or a better graphics display. The base holds its design for a longer period of time, while the module can be replaced to provide the latest features at half the cost of replacing the telephone. This new design minimizes product obsolescence and reduces the volume of product headed for recycling or disposal.

Long-life products are not new to the telecommunications industry, where equipment is typically in the field for 15 to 20 years. Nortel's Meridian office systems introduced in 1970s were "backwards compatible," which meant that even in the 1990s a customer can easily upgrade and expand to provide enhanced communication capabilities without replacing the entire system.

While the Meridian system was unique at the time, the architecture of new systems is increasingly modular in design to enhance upgradeability and expansion and to allow "plug 'n play" with any manufacturers' equipment.

New Packaging Concept to Reduce Waste

For Nortel, packaging was an obvious and early target for waste reduction, as legislation worldwide focused attention on this wastestream and disposal costs skyrocketed. Nortel established a North American packaging council in 1995, and expanded this effort to a world-wide packaging council in 1996, to promote returnable and recyclable packaging, and to assist Nortel sites in achieving the corporate target for reduction of non-hazardous solid waste.

As a result, packaging changes are springing up throughout Nortel, leading to significant cost savings and a 10 to 15 percent reduction in packaging volume. For example:

- Standardization and redesign of distribution packaging saves approximately $5 million annually. These savings were achieved by standardizing, and thus reducing the number of packaging configurations. The resulting reduction in the number of box configurations led to a greater reuse of boxes, the need for less storage space and sorting, and fewer boxes purchased.
- Shipping switching products in assembled mode, rather than packaging and shipping components separately for on-site assembly, saves an additional $5 million annually. The "plugs in place" shipping method requires less packaging and reduces installation time.
- Nortel designed a new "clamshell" packaging system for shipping circuit boards that eliminates cardboard and foam waste, and is reusable. The packaging is also designed to improve handling and storage for customers. The clear plastic allows customers to scan product bar codes without opening the packaging and risking damage to the product. The nesting and stacking feature of the clamshell design saves space on the production floor.

Asset Recycling

Nortel operates three recycling facilities in North America and one in the United Kingdom with a mission "to provide entrepreneurial solutions and services for the valued recovery of materials and surplus assets while demonstrating environmental leadership." To accomplish this mission, the reclamation operation provides Nortel divisions and customers with a full range of asset disposal and recycling services, such as equipment testing and refurbishing, resale of useable components, and recovery of precious and non-precious metals and plastics. The operation has a good profit margin: approximately 85 to 90 percent of the revenues are returned to business units, and even customers where applicable, while 10 to 15 percent cover operating costs.

Nortel's reclamation operations date back to the 1970s, when they opened a facility in Barrie, Ontario to provide an equipment recycling service to Bell Canada, a major customer. The facility primarily processed metal-based product, particularly copper, to achieve maximum separation and recovery value for Bell Canada. The origin of Nortel's U.S. reclamation facility in Durham, North Carolina was quite different; it started in 1990 as a central collection and disposal point for Nortel surplus assets such as desks and other non-telecom office equipment. Today,

however, the Durham facility handles mostly telecommunications equipment, and is the central return point for Nortel products coming back from the field.

In the U.S. and Canada, the reclamation operation processes 50 million pounds of equipment annually, including central office switches, private branch exchanges, and cable and components from excess and obsolete inventory. About 50 percent of the equipment processed is Nortel's own equipment and excess and obsolete inventory. Trade-ins and removal from customer sites account for the other 50 percent, although Nortel is actively trying to expand services to commercial customers and suppliers. In the United Kingdom, for example, Nortel negotiated with British Telecom to take back some older varieties of PBX equipment for reuse and recycling. In addition, Nortel is working with other European distributors to develop tailored Product Take Back (PTB) services to suit distributor and market conditions.

Over 90 percent of the equipment processed at the facilities (by weight) is recovered for reuse or recycling. Product and component reuse and resale (e.g., circuit boards, memory chips, line cards) account for approximately 50 percent of revenues, playing a greater role today than in the past. Three years ago at the Barrie, Ontario facility over three-quarters of the equipment was electro-mechanical or copper-based cable, which was granulated or shredded to recover metals. In contrast, today more than half of the equipment is processed for reuse and resale. There are two reasons for this. First, the value in the recovery of raw materials is declining due to a reduction in the precious metals content of the products processed at the facility. Second, technology is moving at a faster pace, which results in a greater rate of equipment turn over. While the equipment might be obsolete by some customers' standards, it may still be functional or contain reusable parts.

The amount of material going to landfill has decreased from ten percent to four percent over the past several years as a result of a zero landfill program aimed at reducing solid waste disposal costs. (The goal for 1998 is only two percent to landfill.) The zero landfill program identified alternative disposal options and reuse opportunities for materials going to landfills. One wastestream targeted was pallets. The solution in this case was to route the pallets back to the business units for reuse, rather than disposing of them. In addition to saving landfill costs, this program saves the business units approximately $70 on the purchase of each new pallet (after inspection and redistribution costs). As a result of the zero landfill program, disposal costs at the Durham facility were reduced approximately 90 percent from 1992 to 1994.

3.5 CONCLUSIONS

The companies highlighted in this case study are just a few of the many electronics companies undertaking EPR initiatives. Similar activities are underway at Xerox Corporation (see Chapter 7 of this report), IBM, Lucent Technologies (formerly AT&T), Digital Equipment, and Dell Computer, to name a few. Common elements among these companies are a focus on product design for environment, supplier management, and improved asset management and recycling. As illustrated in this case study, the design and implementation of EPR programs is uniquely suited to each company and its culture and operating norms, although each company is working towards integration of EPR program elements into the business units.

Table 3-5 provides an overview of EPR initiatives underway in the electronics industry. There are good business reasons for undertaking such initiatives. Indeed, the companies interviewed for this study each emphasized that "if it doesn't make economic sense, it is not going to happen." The examples highlighted in this case demonstrate the convergence of environmental and business performance objectives, for example:

- Upgradeable designs can slow product obsolescence, increase customer loyalty, lower cost of product ownership, and improve product serviceability.
- Designing products with reuse and recycling in mind can lead to lower manufacturing costs and improved manufacturability due to parts consolidation and reduction in material variety.
- Energy efficient products reduce operating costs.
- Extending product life through asset management strategies can improve the service function, lower disposal costs, create new revenue streams, and introduce products to new markets.

Table 3-5: EPR Initiatives in the Electronics Industry

More Efficient Use of Energy and Material Resources
- Greater or same functionality using less materials (by weight).
- Reduced power consumption through Energy Star products.
- Reusable transport packaging.
- Reduction in packaging materials.
- Selling functionality or service instead of products (e.g., call answering service).

Pollution Prevention
- Elimination of CFCs in manufacturing operations.
- Lead-free solders.
- VOC-free fluxes.
- Removal of brominated flame retardants from plastics.
- Removal of heavy metals from packaging materials.

Reuse and Recycling
- Reusable transport packaging.
- Recycled content in packaging and products.
- Product design for recycling (e.g., reduced material variety, use of recyclable materials, plastics identification).
- Equipment demanufacturing, component reuse, and materials reclamation.
- Rechargeable battery recycling.

Extending the Useful Life of Products
- Improved asset management, including product redeployment, remanufacture, equipment conversion, and recycling.
- Product design for upgrades, expansio, and serviceability.
- Recovery of service parts from used equipment.
- Lease-based programs.

Successful implementation of most of these initiatives, however, is highly contextual, subject to myriad product and market variables that must be sorted out on a company-by-company, product-by-product basis. This is particularly true for product recovery and recycling, where product technology, configuration, components, and material composition influence end-of-life opportunities and value. The economics of product recycling is determined further by recycling markets (and their volatility) and recovery infrastructure.

This is just the beginning of EPR in the electronics industry. The companies highlighted in this study are in the early stages of program implementation. We can fully expect continued progress as more and more companies and business units within these companies realize the economic advantages of EPR programs and begin to focus their creativity and competitive spirit on eco-efficiency throughout the product life cycle. The challenge for public policy will be in monitoring these developments and recognizing where economic incentives are absent and government intervention is needed.

ENDNOTES

1. David Lear, Environmental Program Manager, Compaq Computer Corporation, February 1, 1996, Houston, TX; Walt Rosenberg, Corporate Environmental Manager, Compaq Computer Corporation, February 1, 1996, Houston, TX; Julie Vickers, Environmental Marketing Manager, Compaq Computer Corporation, February 1, 1996, Houston, TX; and Rob Nixon, Director, Consumer Quality, Compaq Computer Corporation, February 1, 1996, Houston, TX. Personal Communication to Patricia Dillon, Tufts University.

2. Compaq 1994-1995 Environmental Report.

3. Compaq 1995-1996 Environmental Report.

4. Compaq 1994-1995 Environmental Report.

5. PC Magazine 1996 Computer Buyer's Guide.

6. Compaq Deskpro product literature, 1995.

7. Compaq 1995-1996 Environmental Report.

8. Cliff Bast, Manager, Product/Process Stewardship, Environmental Management, January 17, 1996, Palo Alto, CA; Tom Korpalski, Environmental Programs Manager, Computer Products Organization, January 17, 1996 and February 1, 1996, Palo Alto, CA; Rene St. Denis, Reclaim Program Manager, Hardware Recycling, Support Materials Organization, January 16, 1996, Roseville, CA; and Becky Willis, Marketing Worldwide Alternative Inventory Solutions, Workstation Division, January 24, 1996, Chelmsford, MA. Personal Communication to Patricia Dillon, Tufts University.

9. Hewlett-Packard Company 1995 Annual Report.

10. Bast, Cliff. 1996. "Hewlett-Packard's Self Assessment Procedure for Product Stewardship." *IEEE International Symposium on Electronics and the Environment.* May.

11. "Procuring Environmentally Responsible Material" (revised). 1995. HP internal memo from corporate procurement to manufacturing, material, and purchasing managers. October.

12. "Procuring Environmentally Responsible Material." 1995. Hewlett-Packard brochure.

13. Maxie, Eddie. 1994. "Supplier Performance and the Environment." *IEEE International Symposium on Electronics and the Environment.* May. Also, Choong, Hsia. 1996. "Procurement of Environmentally Responsible Material." *IEEE International Symposium on Electronics and the Environment.* May.

14. Korpalski, Tom. 1994. "Pragmatic Use of Priority Life Cycle Assessment Elements to Help Drive Product Stewardship." *IEEE International Symposium on Electronics and the Environment.* May.

15. *Hewlett-Packard's Commitment to the Environment*. 1994. Hewlett-Packard Co. November.

16. Huber, Ludwig and Manfred Berndt. 1996. "Squaring Technical Performance with Environmental Needs." *Today's Chemist at Work*. March.

17. Since HP currently cannot guarantee an adequate supply of recycled resin to manufacture this printer line, the company labels the product as containing "up to 25 percent recycled-content."

18. McGavis, Dennis. 1994. "The Energy Bucket and a Not-So-Drop-in-the-Bucket Portion of the Waste Stream, Consumables." *IEEE International Conference on Electronics and the Environment.* May.

19. Pollock, Doug and Remi Coulon. 1996. "Life Cycle Assessment of an InkJet Print Cartridge." *IEEE International Conference on Electronics and the Environment.* May.

20. Murray Hamilton, Director, Business Development, Environmental Affairs, Nortel, January 19, 1996; Ed Parker, General Manager, Materials Recycling, Nortel, January 18, 1996; and Elizabeth Rose, Vice President, Employee Satisfaction and Environment, Nortel, February 8, 1996. Personal Communication to Patricia Dillon, Tufts University.

CHAPTER 4

THE FRIGIDAIRE COMPANY'S PROGRAM FOR RECYCLABLE PRODUCT DEVELOPMENT OF REFRIGERATORS

Case Study Prepared By:
Catherine A. Wilt
University of Tennessee
Center for Clean Products and Clean Technologies

"Our goal is to become the leader in environmentally sound technology."

Lief Johannsen, Electrolux Environmental Mission Statement

4.1 INTRODUCTION

The appliance industry has long been the focus of environmental concerns and pressures. Household appliances consume 12 percent of the energy and 34 percent of the electricity used in American households.[1] Lack of recycling infrastructure led to illegal dumping of appliances (also known as white goods), and hazardous constituents in older appliances, such as mercury and PCB-contaminated capacitors, created a perception of appliances as a problem waste. Concerns about the shrinking ozone layer have required manufacturers to look for adequate substitutes for ozone depleting substances. Appliances comprise one percent of the municipal wastestream in the U.S., with approximately eight million used appliances discarded annually. While the current recycling rate for appliances is around 62 percent (by weight), many appliances still wind up in landfills, where they take up valuable space. These issues and others have spurred 16 states in the U.S. to ban appliances from landfill disposal,[2] and several countries in the European Union to mandate take back, disassembly, and recycling of used appliances.

In light of environmental regulations and public pressure, many major manufacturers in the appliance industry are moving towards voluntary EPR. Manufacturers realize that even in the U.S. they may ultimately share responsibility for the disassembly and recycling of their products. In order to make product recycling simpler for the existing recycling infrastructure, manufacturers are working on making appliances more recyclable. According to Frigidaire Company President Hans Backman, the "industry will now aggressively design products up front for environmental considerations, including design for disassembly and recyclability — environmental concern will be become a product design specification."[3] Frigidaire is including environmental considerations in product development as it moves towards the year 2000.

4.2 FRIGIDAIRE COMPANY — BACKGROUND

The first refrigerator under the name of Frigidaire was sold in 1918. Since then, Frigidaire has been a pioneer in appliance manufacturing in North America; among Frigidaire's inventions are the electric self-contained refrigerator, the home food freezer, the room air conditioner, the window air conditioner, the vertical pump agitator washer, and the refrigerator-freezer combination.[4] In 1979, Frigidaire was purchased by White Consolidated Industries (WCI), which owned several other appliance lines, such as Gibson, Kelvinator, White-Westinghouse, and Philco. WCI had registered sales of $2.06 billion annually, with 76 percent of total sales from their Home Products Division.[5]

In April, 1986, WCI was acquired by AB Electrolux of Sweden, making Electrolux the largest global manufacturer of appliances. In the resulting restructuring, the WCI Major Appliance Group was renamed the Frigidaire Company.[6] Frigidaire produces five product brands in the U.S.: Frigidaire, Gibson, Kelvinator, Tappan and White-Westinghouse, at ten manufacturing facilities in North America.

4.3 BACKGROUND OF DECISION TO IMPLEMENT EPR

Frigidaire's parent company, Electrolux AB, has emerged as a leader in environmental product development. The company's Environmental Mission Statement from is expressed as follows:

> Our goal is to be the leader in environmentally sound technology. The fact that we sell about 40 million units per year in white goods alone means that we have to have commitment to the environment. But it also offers an opportunity to exert an influence and make a positive contribution. Reduced consumption of resources and systems for recovery and recycling will help to alleviate the problem of waste and increase the potential for conservation of valuable raw materials.[7]

Electrolux is committed to minimizing the impacts of refrigerators and freezers on the environment, while seeking to meet the highest safety and efficiency requirements throughout the entire life cycle of the products.[8] In Sweden, Electrolux is a signatory of the ICC Charter on the Environment, and operates a take-back and recycling program for its scrapped products in Stockholm as part of its environmental commitment.[9] In 1994 Electrolux completed the transition from chlorine-free R134a to cyclopentane as a foam blowing agent in refrigerators and freezers for the European market, as well as shifting from R134a to isobutane as a refrigerant. Their department of Research and Innovation is working on completing life-cycle assessments and guidelines for "environmentally-friendly" product development. A number of products, including white goods, vacuum cleaners, and chain saws have already been analyzed from a life-cycle perspective. Electrolux is also producing a new type of vacuum panel for thermal insulation in refrigerators. The panels are totally recyclable, and the insulating properties of the panels enable a reduction of energy consumption of up to 18 percent.[10]

While the environmental stewardship mission of its parent company has created an impetus for greater product responsibility for Frigidaire, federal and state legislative initiatives have also driven Frigidaire to action. Improvements in energy efficiency are required of the industry under U.S. Department of Energy standards set by the 1987 National Appliance Energy Conservation Act and the 1992 Energy Policy Act. Under these energy standards, manufacturers were to make efficiency improvements of 32 percent over 1990 efficiencies, with additional requirements of another 25 percent reduction set for 1998.[11] State initiatives, such as landfill bans and advance disposal fees on white goods, have also prompted Frigidaire to improve the recyclability of refrigerators. Table 4-1 describes state bans and fees for white goods.

Table 4-1: State Policies on White Goods

State	Landfill Disposal Ban	Advance Disposal Fee
California	T	
Florida	T	
Hawaii	T	
Illinois	T	
Louisiana	T	
Maine	T	$5, on retail sale
Massachusetts	T	
Minnesota	T	
Missouri	T	
Nebraska	T	
North Carolina	T	$10 w/CFCs; $5 otherwise
Oregon	T	
South Carolina	T	$2, on wholesale
South Dakota	T	
Vermont	T	
Wisconsin	T	

Sources: Steutville, 1995.

Guided by Electrolux's vision statement, the Frigidaire Company has adopted environmental policies and plans to drive progress in product development, processes, and workplace issues. Product evaluation teams are established with cross-functional representation and participation from several departments, including engineering, marketing, quality, and purchasing. All new product lines are evaluated for environmental factors including recyclability, materials usage, energy usage, and environmental impact. The Company considers these factors to be an important aspect of good business.[12]

Frigidaire has set a goal of having a more recyclable product line by the end of the 1990s. This is to be accomplished through enhancing the recyclability of existing products and design for recycling of future products, without sacrificing performance or increasing manufacturing costs. Enhancing the recyclability of existing products will entail recyclability assessment, materials consolidation, and labeling. A second phase will involve better interaction with suppliers and

recyclers to: 1) use more recycled products in refrigerators; and 2) find future uses for the materials in disposed products.[13] This case study describes activities to date under the Frigidaire program, changes in the product, and future plans. Specific environmental initiatives at the Refrigeration Products Plant at Greenville, Michigan, are highlighted, followed by discussion of company-wide activities.

4.4 CURRENT STATUS OF PROGRAM

Changes in public and environmental perceptions of appliances have led to many technological advances in appliance design and manufacturing. Appliances are being designed to be CFC-free, more energy-efficient, more recyclable, and less noisy.

4.4.1 Refrigerator Recyclability Assessment and Improvement

In keeping with industry trends, in the Spring of 1994, Frigidaire began a Refrigerator Recyclability Assessment at its Refrigeration Products Plant in Greenville, Michigan, with a goal of developing a more recyclable refrigerator.

Product Teardown

First, teardown of a refrigerator was performed to determine how long it would take a two-person team to disassemble a common refrigerator model. The teardown was accomplished manually with hand tools and a power saw. The goal was strictly to assess recyclability of a refrigerator; when and if disassembly of appliances is done on a large-scale in the U.S., it could be accomplished through a combination of automated and manual disassembly, as is done by Electrolux in Europe. The team took approximately 32 minutes to tear down the majority of the unit, with exception of the liner-foam-cabinet sandwich, which required quite a bit more time to take apart.

Several conclusions were drawn from the teardown:

- While all the metals could easily be identified, not all plastics could be identified.
- Too many types of plastics were being used.
- The liner-foam-cabinet sandwich required the most time to disassemble, and comprised most of the units' mass.[14]

Materials Consolidation

Based upon findings from the teardown, Frigidaire decided to consolidate several of the plastics used in their refrigerators. Frigidaire consolidated three types of clear plastic that were being used in the clear portions of the refrigerator, such as the bins, containers, drawers, and shelves. The three plastics, polymethyl methacrylate, clear acrylonitrile/butadiene/styrene, and polyester, came from three different suppliers. Rather than using one of the existing plastics exclusively, Frigidaire decided to use a polycarbonate that achieved the "water clear" look

desired for interior bins, etc. The change in materials resulted in improved part quality, as well as achieving a ten percent reduction in materials price due to purchasing a larger volume of material from one supplier as opposed to three.[15]

Parts Reduction

Frigidaire had great success with parts reductions in the handle and trim of their refrigerator doors. Based on results from the refrigerator teardown, Frigidaire felt that a substantial reduction in the number of parts in the handle assembly could be accomplished without decreasing performance or aesthetics. The design change resulted in a reduction of 58 parts to 20 parts. The new handle is also more recyclable because it is made out of a fewer number of plastics. Further, the parts reduction substantially reduced the assembly labor, time, and space requirements, as seen in Table 4-2. Implementation of the parts reduction resulted in materials savings of 77 percent, and a labor savings of 64 percent.[16]

Table 4-2: Comparison of Original vs. New Refrigerator Handle Assembly

Side-by-Side Refrigerator	Old	New	Difference
Number of parts	58	20	38
Labor (# of people)	17	4	13
Assembly time (min.)	8.1	1.9	6.2
Assembly space (sq. ft.)	425	100	325

Source: Paul Nash, Frigidaire.

4.4.2 Conversion to Organic Powder Paint

In late 1994, Frigidaire decided to replace the existing high-solids paint system. The company believed it could obtain a better finish and more corrosion protection through switching to an organic powder system, while also realizing significant environmental advantages in elimination of solvents.[17] Powder paints are powdered resins which are applied to a substrate (in this case, a refrigerator or freezer) and heated to fuse the resin into a uniform, continuous film. Results of the new powder paint line include:

- Film thickness in the 1.5 - 1.7 mil-range.
- Transfer efficiency in the range of 95 - 98 percent, compared to 70 percent with the high-solids system.
- Line speed of 24 ft/min.[18]

There have been multiple benefits from the conversion. The switch to the powder paint formulation removed the use of caprolactum in refrigerator and freezer paints. Further, the elimination of solvent borne painting operations has reduced annual factory emissions by more than 2.2 million pounds.[19] The new powder paint lines have been installed for refrigerator doors at the Greenville, Michigan and Anderson, South Carolina facilities, as well as in five other Frigidaire manufacturing facilities.[20]

4.4.3 Packaging Program

Frigidaire has also instituted a Returnable Reusable Container (RRC) program. The RRC goal was to have 80 percent of internal packaging be returnable and reusable. This goal was accomplished in cooperation with suppliers and transporters. Concentrating on replacing wooden pallets, paper dunnage and corrugated cardboard, Frigidaire purchased reusable polyethylene pallets, dunnage and containers, marked for use with specific suppliers. The empty containers are back hauled by suppliers upon making deliveries. At the Greenville facility alone, the RRC program has complete participation of eligible suppliers, and saved over $3 million since 1994.[21] Company-wide, the Frigidaire RRC is the largest packaging reduction program in the industry, with estimated environmental savings of 10,431 cubic yards of landfill space annually.

4.4.4 Plastics Marking

The increased use of plastics in appliances has complicated appliance recycling, much as it has for other durable products, such as automobiles. As plastics use increases, so does the amount of shredder residue, or "fluff," that is generated when appliances are shredded. To combat these problems, manufacturers have been looking for potential solutions to make plastics more recognizable, separable, and recyclable.

As early as 1992, Frigidaire began to mark plastic parts by resin type to aid in recycling of plastic parts. Using the ISO 1043 system, Frigidaire began labeling all plastic parts and packaging in an effort to enhance their future identification and the disassembly process of discarded major appliances. Polymer and filler contents for all plastic parts with an approximate weight greater than four ounces are marked.[22] A primary concern in development of the plastics labeling initiative was to mark parts in an easily accessible location without hindering the performance and aesthetics of the part. The system developed by Frigidaire to accomplish this has become the industry standard.[23]

Frigidaire also has an active voluntary program to eliminate polyvinyl chloride (PVC) in several product lines. Interest in reducing PVC is primarily due to an initiative from Electrolux to remove PVC from all European product lines. Currently Frigidaire is working with Dow to test polyethylene gaskets as an alternative to PVC gaskets in refrigerator door seals.

4.5 OTHER FRIGIDAIRE INITIATIVES

Frigidaire is also working towards a second phase which translates their product recyclability improvements into product recycling; in this way, Frigidaire can ensure that the materials from disposed products can be reprocessed and resold for future use. While Frigidaire is not directly involved in take back of used appliances, the company is working with its suppliers, processors and manufacturers, as well as with representatives of consumers, dismantlers, and shredders to assist in developing a more recyclable product. In particular, as more plastics are used in appliance manufacture, Frigidaire is working to better develop the plastics recycling infrastructure.

As part of their commitment to product recycling, Frigidaire is a member of the Major Appliance Resource Management Alliance, or MARMA. Created in 1995, MARMA is a coalition of the Association of Home Appliance Manufacturers, the American Plastics Council, the Institute of Scrap Recycling Industries, the American Iron and Steel Institute, and representatives of the individual North American appliance manufacturers. MARMA's mission is to actively promote environmentally sound and sustainable management of material streams generated from the disposition of major home appliances. This mission is to be accomplished by:

- The promotion of the effective collaboration of organizations actively engaged in the material supply, appliance design and manufacturing, and resource management (including recycling).
- Identification and implementation of projects that: 1) acheive short- and long-term improvements in the management of materials generated by the disposition of appliances; and 2) assure the long-term viability of existing and evolving recycling infrastructures.
- Development of a system so that members can effectively collect and communiciate critical information needed to efficiently manage the materials available in major appliances and serve as a basis for sustainable appliance resource conservation policies, laws, and regulations.[24]

4.6 CONCLUSIONS

The appliance industry in the U.S. is beginning to move towards designing major appliances with less environmental impact. While past improvements have been based on state and federal government mandates, the industry is voluntarily implementing policies and design changes to make appliances easier to disassemble and recycle and more energy efficient. Much of this trend within the appliance industry is predicated on the increasingly global nature of the appliance industry and changes that are being required in European and Asian markets.

The Frigidaire Company is actively working to make its refrigerators more recyclable by enhancing the ease of disassembly, reducing parts and material used, and using materials that are more readily recycled. Frigidaire is not considering, at present, take back of used appliances. Recent studies have shown that over 60 percent of the overall product weight of appliances is currently recycled in the U.S. Given these rates of recovery through the traditional recycling infrastructure, Frigidaire feels there is no need to actively consider industry take back of appliances in the U.S. Instead, Frigidaire is concentrating on working with other industry members and trade associations to increase the recovery potential of plastics in major appliances. This is being pursued by working with plastics suppliers to help drive up plastic recycling rates and develop more efficient plastics recovery technologies.

ENDNOTES

1. Davis, Dan. 1994. "The Environmental Era." *Appliance*. June.

2. "Turning White to Green: Appliance Recycling Spins Toward 21st Century." 1994. Phoenix. ISRI. Fall.

3. Davis, Dan. 1994. "The Environmental Era." *Appliance*. June.

4. *History of White Consolidated Industries*. 1996. Frigidaire Release.

5. *History of White Consolidated Industries*. 1996. Frigidaire Release.

6. *Frigidaire History and Home Appliance Firsts*. 1994. Frigidaire Release.

7. Johannsen, Lief. "The Electrolux Group and the Environment."

8. "Domotechnica: The World's Fair of Appliances." 1993. *Appliance Manufacturer*. April

9. "Domotechnica: The World's Fair of Appliances." 1993. *Appliance Manufacturer*. April.

10. "The Group's Environmental Activities." 1995. Electrolux AB. http://www.electrolux.se/elt4.html. June 16.

11. *CFC Phaseout: An Environmental Balancing Act*. 1994. Environmental and Energy Study Institute.

12. *Frigidaire Company Environmental Activities For Appliance Magazine Environmental Roundup*. Internal Communication.

13. Nash, Paul. "Recyclable Product Development of Refrigerators."

14. Nash, Paul. "Recyclable Product Development of Refrigerators."

15. Nash, Paul. "Recyclable Product Development of Refrigerators."

16. Paul Nash, Frigidaire. February 29, 1996. Personal Communication to Catherine Wilt, University of Tennessee, Center for Clean Product and Clean Technologies.

17. "A Cool Conversion." 1996. *Appliance*. Appliance Focus. February. http:/www.appliance.com/app/powder.cool.htm.

18. "A Cool Conversion." 1996. *Appliance*. Appliance Focus. February. http:/www.appliance.com/app/powder.cool.htm.

19. *Frigidaire Company Environmental Activities For Appliance Magazine Environmental Roundup*. Internal Communication.

20. *Frigidaire Company Environmental Activities For Appliance Magazine Environmental Roundup*. Internal Communication.

21. Internal Communication, February 25, 1996.

22. Internal Communication, March 10, 1994.

23. Paul Nash, Frigidaire. July, 1996. Personal Communication to Catherine Wilt, University of Tennessee Center for Clean Products and Clean Technologies.

24. "Major Appliance Resource Management Alliance Forms." 1995. AHAM press release. February 15.