Preface

Debates about environmental protection often become highly charged and passionate. The recycling debate is no exception. Over the past decade, at times headlines have heralded that "trash is treasure"; at other times, they have proclaimed that "recycling is garbage."

We think the debate misses the fundamental issue. Antagonists in this debate really are not debating the merits or demerits of recycling. Indeed, our own research demonstrates that without question recycling many products and materials can generate both environmental and economic benefits. The participants in the debate are really disagreeing over public policy; its role in shaping decisions about resource use; and the likely outcomes of various policies that would intervene in the marketplace to reduce virgin material use and divert materials from disposal facilities.

As recycling has gained political visibility, many proposals have been advanced—and quite a few have been enacted—to regulate or tax certain products, packages, or virgin materials. Proponents of these policies seem to want to accomplish four goals: reduce solid waste disposal (waste diversion); reduce associated pollution from producing goods; reduce consumption of virgin materials; and generate revenues to cross-subsidize nondisposal waste-handling activities (or even other municipal services). Recycling is often viewed as a potential means to these goals.

But whether forcing or stimulating recycling—through mandates or taxes—actually would result in more efficient resource use has seldom been systematically analyzed. It is to this task that we turn, and the job is a prodigious one. So many variables—devilish details—determine what mix of production inputs yield the most efficient outcomes in terms of resource use and conservation.

Recognizing this complexity, our goals were to identify the relevant complexities and provide a quantitative analysis that, while based on a somewhat "stylized" world, might at least provide some generalized sense of likely outcomes. The uncertainty inherent in the assumptions and variables means that one should not be taken in by the illusion of monetary precision. Our report does not present life-cycle analysis and does not attempt to quantify or place a dollar value on air or water emissions. We do take into account all resource use, however, including energy consumption and usage of landfill space.

The omission of quantified values for air and water emissions is, to our mind, not a fatal flaw. Recycling is not consistently correlated with reductions in either air or water emissions. Any policies to reduce such emissions will need to target directly the emissions themselves, through regulations or pollution charges, to achieve emission reductions. Such regulations or pollution charges become part of the costs manufacturers consider in making choices among different raw material and energy inputs in the production process.

In those instances where recycling does substantially reduce pollution, its overall cost-effectiveness may improve when air and water pollution are regulated relative to a situation in which air and water pollution are unregulated. But we believe pollution reduction is best achieved directly, through pollution policy, and not through recycling per se, since the relationship between recycling and pollution abatement is highly variable, nonlinear, and sometimes even negative. Consequently, we view our primary task as exploring the more direct question of how policies that intervene in the marketplace to force recycling affect overall resource use. A secondary task was to examine certain policies—Germany's “Green Dot” system and Florida's (now expired) advance disposal fee policy.

We hope our discussion provides some useful information and observations about public policies and economic decisionmaking. We hope the report is not used to claim that recycling is “good” or “bad,” a line of debate that we believe is misleading.

About the Authors

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Packaging, Recycling, and Solid Waste

by Lynn Scarlett, Richard McCann, Robern Anex, and Alexander Volokh

Executive Summary

During the past decade, over forty states quickly adopted waste-diversion or recycling laws, responding to public concern about resource conservation. On the other hand, early attempts to encourage recycling by increasing demand for recyclables received a more mixed reception: only two states--Oregon and California--passed recycled content mandates for products other than newsprint. One state--Florida--passed (and then allowed to sunset) an advance disposal fee on packaging. The federal government failed to pass any national "demand-side" policies in the early 1990s. But when scrap values for recyclables fell in the mid-1990s, the press for policies intended to stimulate demand for recyclables resurfaced.

Proponents of these "demand-side" laws typically want to accomplish one of four goals: waste diversion; reduction in pollution from producing goods; reduction in consumption of virgin materials; or revenue generation to pay for recycling or other waste-management programs. Recycling is basically a means for achieving one of the first three goals, not an end in itself.

Yet policies proposed to achieve these ends surfaced with little understanding of the effect these policies might have on waste-diversion, resource use, recycling, and product manufacturing. This study helps fill that knowledge gap by exploring the cost-effectiveness of these policies as a means to achieving specific levels of waste diversion and reduction in use of virgin materials. We look at four different policies:

* recycled content mandates, which mandate that a proportion of recycled materials be used in packaging;
* virgin materials taxes, which assess a tax on the use of material inputs based on the implied disposal costs for those materials;

* advance disposal fees, which assess a charge on the final product based on the implied disposal cost for the associated packaging; and
* manufacturers' responsibility, which requires manufacturers to implement waste collection and material recovery systems for their packaging and generally combines required recovery rates with packaging fees.

Our study evaluated these policies at a national level, with cost estimates provided for glass, steel, three types of plastic, and paperboard. In each case, policies were evaluated in relationship to specified recycled content (or waste-reduction) levels in order to provide a metric for comparison.

Our analysis summarizes the direct production costs, if packaging manufacturers had to bear the entire waste and recycled material collection, processing, and production costs and the social costs, which include both the direct production costs and the savings in reduced waste-disposal costs. The analysis ignores implementation costs by government agencies and other information-gathering and reporting costs incurred by manufacturers to comply with these policies, which could be substantial. The study also necessarily provides only a snapshot picture; changing technologies and changing economic circumstances would alter the results of our analysis. Finally, we do not try to put a price tag on air emissions or other emissions associated with different product processes. However, our study does look at total energy use and total resource use, including "use" of landfill space.

What is the bottom line? Our analysis shows that, under best-case conditions, there are net benefits to society at low or modest levels of recycled content for almost all materials. However, as content rises and conditions become less favorable, costs rise, creating net societal losses. The wide variation in outcomes reflects the large variations in waste-disposal costs across locations and by program design, as well as the large variations in material-specific production processes. *Net costs (and benefits) are for levels of recycled content, not for the policy mandates per se.*

The benefits at lower content levels are not surprising--many packaging manufacturers have used recycled-content materials at these levels without government intervention. Our findings suggest that the marketplace likely is producing efficient levels of recycling and that attempts to force specific levels of recycling--either directly through recycled-content mandates or indirectly through various taxes and fees--will not uniformly generate hoped-for benefits.

Even where benefits are predicted, our results do not indicate that a given level of recycled content is achievable or beneficial for each manufacturer and every product, which suggests that mandates and fees tied to recycling levels are not likely to be environmentally beneficial. Some manufacturers will be able to achieve economic (and environmental) benefits at much higher levels of recycled content; others may experience net costs even at very low levels of recycled content. The benefits we estimate are total societal benefits, using average production and disposal costs at a high level of aggregation.

Our analysis also demonstrates that some mandated recycled content levels would simply not be achievable on a steady-state basis due to physical limits on recycled material use (especially in worst-case scenarios). These limits result from production losses, spoilage and breakage during collection and processing, constraints on "capturing" all postconsumer recyclables, and so on. In these cases, only a reduction in package use would achieve the intended standards. In worst-case scenarios sustainable content levels top out between 26 and 37 percent, with higher levels achievable under best-case circumstances.

In examining virgin materials taxes and advance disposal fees, we are not predicting that the fee levels identified will result in the associated recycled-content levels; rather, we are predicting that waste-disposal rates will fall to a level equivalent to that of the recycled-content policy.

To achieve specified waste-diversion rates from 10 percent to over 50 percent (depending on the material), our analysis shows that virgin materials taxes would range from a low of $16 per ton for glass (under best-case conditions) and a high of $136 per ton (under worst-case conditions) for containerboard (see Table 1).

Table 1

Virgin Material Tax Ranges	
Glass	$16-$39 per ton
Containerboard	$19-$136 per ton
Steel	$20-$40 per ton
HDPE	$0.006-$0.023 per pound
PET	$0.015-$0.059 per pound

LDPE	$0.006-$0.023 per pound

Advance disposal fees (ADFs) intended to incorporate disposal costs of individual packages "up front" at the point of packaging purchase would range from fractions of a cent to two cents per package (see Table 2). On the other hand, ADFs designed actually to increase consumption of recycled materials would need to be set at substantially higher levels, especially in instances where the price of the package is only a very small percentage of total product price.

Table 2

ADFs (Pegged to Disposal Costs)	
Glass	$14-$45/ton ($0.01-$0.02/virgin pkg)
Containerboard	$31-$56/ton (under $0.01/virgin pkg)
Steel	$24-$55/ton (under $0.02/virgin pkg)
HDPE	$0.016-$0.031/lb ($0.001-$0.002/virgin pkg)
PET	$0.014-$0.031/lb ($0.001-$0.002/virgin pkg)
LDPE	$0.016-$0.031/lb ($0.001-$0.002/virgin pkg)

Policies that establish manufacturers' responsibility typically require that product manufacturers achieve particular recycling rates and impose packaging fees pegged to recycling costs. The cost (or benefit) of manufacturers' responsibility is the difference between the cost of production using virgin materials and the cost of producing at the target recycled content level, plus the waste-handling cost. Our analysis shows these costs ranging from almost zero (for containerboard under best-case conditions) to over $440 per ton (for PET under worst-case conditions). (See Table 3).

Table 3

Manufacturers Responsibility: Cost Ranges	
Glass	$75-$203 per ton
Containerboard	$1-$166 per ton
Steel	$50-$109 per ton
HDPE	$0.015-$0.161 per pound
PET	$0.044-$0.221 per pound
LDPE	$0.019-$0.164 per pound

We supplement our quantitative analysis with two brief case studies: one of Germany's experience with its Green Dot program; the other of Florida's experiment with advance disposal fees on packaging. One key finding from this case-study analysis sheds some doubt on the effectiveness of Germany's program in promoting packaging source reduction.

Though Germany's program was accompanied by declines in packaging per product unit, overall reductions in Germany were not very different from the United States, which had no up front packaging fees. A basket of typical U.S. goods went from over 2,750 pounds per gross production unit in 1989 to approximately 2,100 pounds in 1993-94. In Europe, including Germany, packaging materials use went from just over 2,500 pounds per gross production unit to just under 2,100--only marginally better than U.S. material efficiencies.

Experience to date with packaging take-back policies suggests that the low-value, high-volume, decentralized, heterogeneous nature of consumer packaging transactions are ill-suited to establishment of efficient and effective product stewardship programs. These attributes especially characterize the U.S. packaging marketplace in which billions of products change hands annually, products move across large geographical distances, and waste-disposal systems (and needs) vary substantially.

Our study attempts to shed some light on the complexity of decisions about resource use and packaging. Our quantitative analysis shows net social benefits from some recycled content for most materials under best-case scenarios. The levels at which net benefits occur appear to be fairly consistent with levels being achieved in the aggregate through market transactions. As technologies change, opportunities for resource-conserving recycling may increase, but our study suggests that there is no one-size-fits-all formula in the resource-conservation process.

The Reason Foundation study can be obtained by contacting Mike Alissi at 310-391-2245 (Price: $30.00).

Chapter 1

Introduction

THE WASTE MANAGEMENT PROBLEM

Solid waste management practices in the United States underwent a sea change in the early 1990s. Federal, state, and local rules now prescribe a host of collection and disposal practices; and the waste industry now offers a variety of integrated collection and disposal services, including recycling, composting, and special waste handling.

By 1995, 41 states had enacted goals or mandates regarding waste diversion, recycling, and source reduction (see Table 1-1). These goals ranged from a modest 20 percent in Maryland to an ambitious 70 percent in Rhode Island, with target dates for achieving these goals starting as early as 1994 in some states and extending to 2002 in others.[1] Overall, by 1996 the nation had achieved a waste-diversion rate of around 26 percent.[2]

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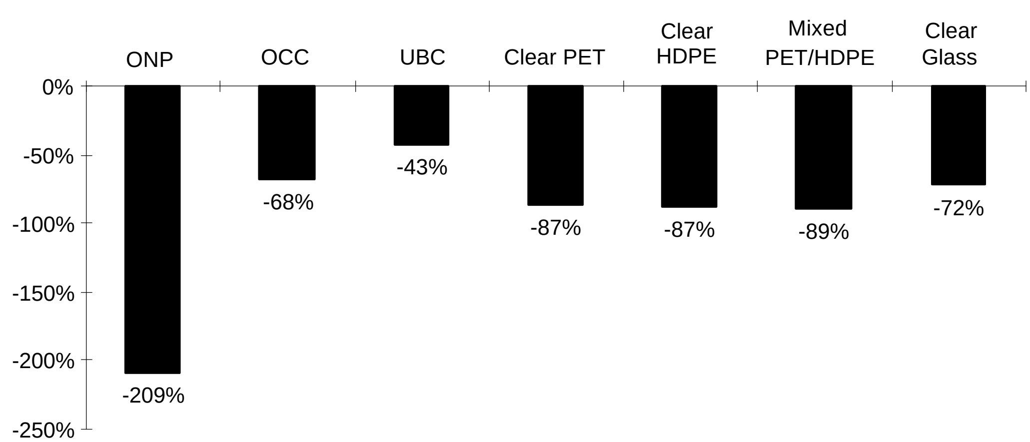
1 Twenty states require some sort of integrated waste management plan; seven states and the District of Columbia mandate some source separation of recyclables; the remaining states require some mix of recycling or waste diversion goals.

2 See Winston Porter, *Recycling in America* (Leesburg, Va.: Waste Policy Center, January 1996), p. 7.

Table 1-1: State Recycling or Diversion Goals

State	Recycling/Reduction Goal	Diversion Rate 1994	Diversion Rate 1993	Mandatory Recycling
AL	25%	15%	10% - 15%	No
AK	N/A	1%		No
AZ	N/A	N/A	7% (excl.	N/A
AR	40% - 2000	25.4%	25.4%	No
CA	50% - 2000	25%	25%	Yes
CO	N/A	N/A	N/A	N/A
CT	50% - 2000	23%	21%	Yes
DE	N/A	41%	28%	No
DC	45% - 1996	28%	30%	Yes, not enforced
FL	30%	40%	36%	Yes
GA	25% - 1996	16%	12%	Yes
HI	50% - 2000	17%	17%	Yes
ID	25%	17%		No
IL	25% - 2000	26% - 27%	19.2%	Yes
IN	50% - 2001	19%	19%	No
IA	50% - 2000	28%	14.4% - 16.9%	Yes
KS	N/A	6% - 8%	5% - 7%	N/A
KY	25% - 1997	10% - 15%	10% - 15%	No
LA	25%	10% - 15%	10%	No
ME	50%	33%	30%	No
MD	20%	28%	26%	Yes
MA	56% - 2000	31%	32%	Yes
MI	20% - 30% - 2005	25%	26%	No
MN	Urb. 45%, rur. 30% - 1996	42%	44%	Yes
MS	25% - 1996	> 12%	11%	No
MO	40% - 1998	17.3%	17.3%	No
MT	25% - 1996	7%	5%	No
NE	50% - 2002	15%	19%	No
NV	25%	18%	17%	No
NH	40% - 2000	20% - 25%	17%	Yes
NJ	60% - 1995	52%	41%	Yes
NM	50% - 2000	11.8%	10.2%	No
NY	50% - 1997	38%	28%	No
NC	40% - 2001	21%	20% (10% reduction	Yes

Figure 1-1: Percentage Change in Processor Prices for Selected Recycled Materials (1/90 to 1/92)



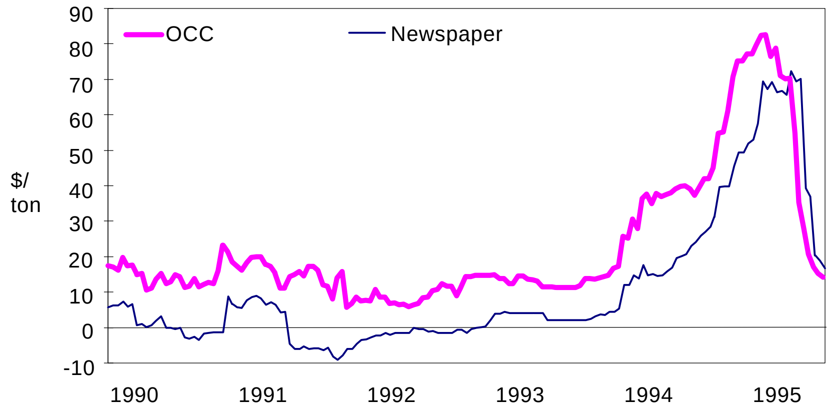
Source: *Plastics News*

Table 1-1: State Recycling or Diversion Goals

State	Recycling/Reduction Goal	Diversion Rate 1994	Diversion Rate 1993 at landfill)	Mandatory Recycling
ND	40% - 2000	20%	18%	No
OH	25%	32%	32%	No
OK	N/A	10% - 12%	10%	N/A
OR	50% - 2000	30%	30% - 40%	Yes
PA	25% - 1997	23%	20%	Yes
RI	70%	25%	24%	Yes
SC	30% - 1997	17%	16%	No
SD	70%	12%	10% - 25%	No
TN	25% - 1995	6.2%	5% (excl.	No
TX	40% - 1994	12%	14%	No
UT	N/A	16%	15%	N/A
VT	40% - 2000	25% - 35%	> 25%	No
WA	25% - 1995	33%	24%	Yes
WV	50% - 1995	38.5%	38%	No
WI	N/A	50%	28%	Yes
WY	N/A	3%	5%	No

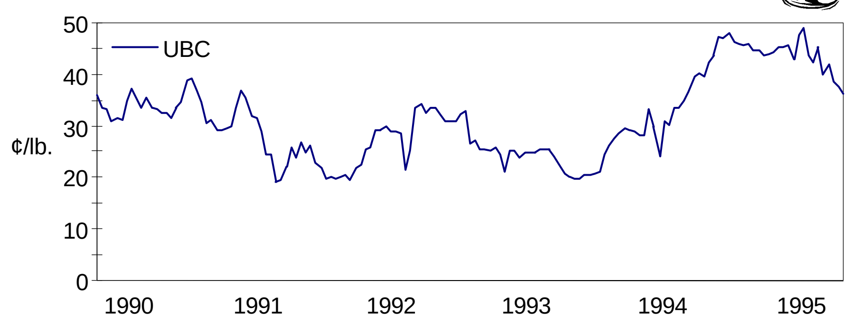
Source: Raymond Communications, *State Recycling Laws Update: Year-end Edition 1996*, 6429 Auburn Av., Riverdale, MD 20737, 301-345-4237. Used with permission. Some numbers are from the Delaware Solid Waste Authority and the Connecticut Department of Environmental Protection. Rates exclude industrial sludge and auto bodies, but include composting. These numbers have a significant margin of error, as different states define recycling differently and keep track of their rates differently.

Figure 1-2: Processor Prices for Old Newspaper and Old Corrugated Cardboard



Source: *Plastics News*.

Figure 1-3: Processor Prices for Used Beverage Cans



Source: *Plastics News*.

These diversion goals translated into a rapid introduction of curbside and other recycling programs. The result in the early 1990s was a dramatic increase in supplies of secondary (recycled) materials into the marketplace. Thrust into the marketplace in the midst of an economic slowdown, these supplies resulted in some supply/demand imbalances and, hence, falling scrap prices through the early 1990s (see Figure 1-1). However, scrap values are historically highly volatile in any event (see Figures 1-2 through 1-5).[3]

"Regulation," as economist Murray Wiedenbaum has quipped, "begets regulation." The rapid changes in waste management practices prompted by waste-diversion requirements sparked a series of follow-on laws or proposals to regulate use of secondary materials, to develop funding sources for increasingly complex (and sometimes costly) waste management programs, and to influence materials-use and packaging decisions by consumers and producers.

These policy proposals have received varying levels of scrutiny. Because of their potential impacts on materials-use and waste-handling decisions, these policy proposals warrant further assessment.

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3 By 1994 scrap prices for many secondary materials began climbing rapidly, but by mid-1995 they had begun to fall, sometimes dramatically. By mid-1996, prices for some grades of paper had reached levels similar to those experienced in the early 1990s.

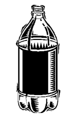
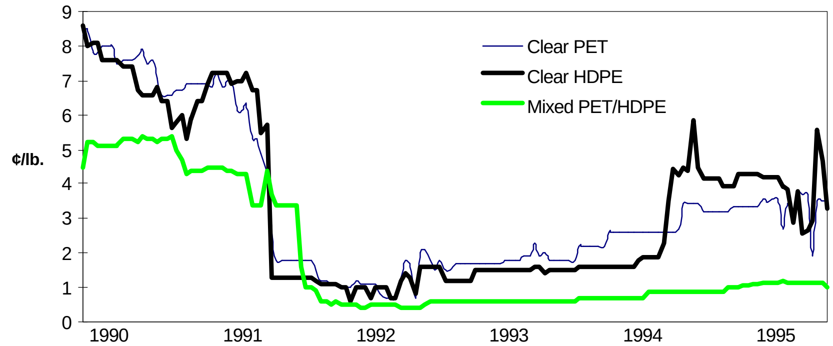
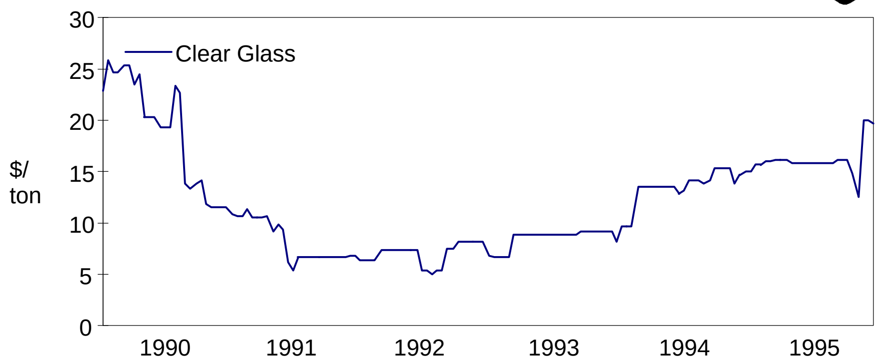


Figure 1-4: Processor Prices for Clear PET, Clear HDPE, and Mixed PET/HDPE



Source: *Plastics News.*

Figure 1-5: Processor Prices for Clear Glass



Source: *Plastics News.*

A series of questions remain unresolved or only incompletely answered in relationship to these solid waste and materials-use policies. Specifically,

- What is the goal (or set of goals) to which these proposals are directed?
- How effective are these proposals in meeting these goals?
- What are the comparative costs of these proposals?

This paper offers background information with which to better understand both the goals and potential cost-effectiveness of several policy options. Using that background information, the paper develops an economic model for understanding the effects of these policies on resource use and efficiency in terms of production, consumption, reuse, and disposal.[4]

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4 In neoclassical economics, economic efficiency is generally defined in terms of the notion of "Pareto optimality." The concept, as summarized in lay terms by economist Thomas Sowell, conceives of an optimal performance by an economy "as representing the satisfaction of the diverse sets of preferences to such an extent that no one could be made any better off (by his own standards) without making someone else worse off (by his own different standards)." See Sowell, *Knowledge and Decisions* (New York: Basic Books, 1980), p. 72. Economic efficiency must be understood as a relational concept between means (resources) and ends (the multitude of values and preferences that individuals seek to satisfy, including environmental values).

POLICY BACKGROUND

In 1993 alone, some 1,200 waste management bills were proposed among state legislators in the United States; of these, nearly 300 targeted packaging.[5] This pace slowed only slightly in 1994. During the Resource Conservation and Recovery Act reauthorization proceedings in 1991–1992, several proposals for national-level solid waste, packaging, and materials-use legislation surfaced, though none was enacted.

A number of states have moved from concept to practice, implementing materials-use regulations or fees relating to solid waste issues (see Table 1-2). Florida, for example, enacted an “advance disposal fee” that, until the law sunset in 1995, imposed a tax on some packaging.[6] California and Oregon enacted legislation that combines a *pot pourri* of regulatory options directed at some packaging. California's Rigid Plastic Packaging Container Act (SB 235) requires that targeted packages be 10 percent source-reduced; reusable five times; achieve 25 percent recycling rates; or contain 25 percent recycled content. The law covers carbonated beverages and food, personal care, household cleaning agent, and auto fluid packaging. SB 66 in Oregon sets forth similar mandates.[7] By 1995, thirteen states mandated recycled content in newsprint (another 15 had voluntary newsprint recycled-content goals). By 1996 some 25 states had approved tax credits for recycling investments. And, at the local level, an estimated 2,800 communities use some form of variable-rate user fee at the household level to encourage waste reduction and diversion.[8]

Outside the United States, Germany and France have enacted packaging laws frequently cited as potential models for the United States.[9] These laws require that manufacturers take some (or all) responsibility for ensuring that specified amounts of packaging are diverted from the waste stream. Though they vary in detail, the concepts of “manufacturer's responsibility” or “packaging stewardship” rest on common assumptions about how waste diversion should be funded. These policy models, though often distinguished from materials-use regulations and pricing policies, essentially offer a hybrid policy that combines diversion (or recycling) targets with some sort of fee structure imposed at the product manufacturer level.

Table 1-2: Programs

State[a]	Recycled-content Mandate[a]	State Tax Credit[a]	Heavy Metal Bans[a]	Purchasing Preference[a]	Variable Rates[b]
AK				All	
AR		Tax Credit		All	
AZ	newsprint	Tax Credit		Paper	
CA	fiberglass glass containers	Tax Credit		All	

5 Raymond Communications, *State Recycling Laws Update*, Year-end 1994 edition (Riverdale, MD: Raymond Communications).

6 Effective on October 1, 1993, the Florida law placed a 1-cent fee on packaging, but exempted packaging materials that had reached a 50 percent recycling rate. The fee was levied at the wholesale level, and applied only to bottles, cans, jars, and beverage containers. The law required that consumers see the tax on their purchase receipts as a separate line-item.

7 The Oregon law mandates recycled content in specified plastic packaging. The law applies to all rigid plastic containers from 8 ounces to 5 gallons, unless they contain drugs, medical devices, medical food or infant formula; are destined for shipment out of state; are tamper-resistant; are 10 percent source reduced; or are non-beverage food containers. ORS § 459A.660(5). These containers must attain, in the aggregate, a 25 percent recycling rate; or containers must be composed of at least 25 percent post-consumer plastic resin content; or the container must be reused five times. § 459A.655. A modifying law, SB 1009, delayed enforcement until January 1996, rather than the originally specified July 1995. § 459A.660(1). Since the aggregate rigid plastic container rate in Oregon is above 25 percent, the law has not been enforced. Enforcement may not begin until a year after the Oregon Department of Environmental Quality determines that the recycling rate has fallen below 25 percent. § 459A.660(7).

8 Estimate from Lisa Skumatz, Skumatz Economic Research Associates, Seattle, WA. September 1995, personal communication.

9 Outside of Europe, Canada also considered enacting a “manufacturer's responsibility” law. However, by mid-1996 only Manitoba had moved forward with the idea, and it applied narrowly only to some beverage containers.

Table 1-2: Programs

State[a]	Recycled-content Mandate[a]	State Tax Credit[a]	Heavy Metal Bans[a]	Purchasing Preference[a]	Variable Rates[b]
	newsprint, trash bags, rigid plastic containers 8 oz, 5 gallons				
CO		Tax Credit		Plastics & Paper	
CT	newsprint, phonebooks		✓	All	
DC	paper packaging, newsprint - 40% recycled content				
DE		Tax Credits, Tax Incentive		All	
FL	newsprint	Sales Tax Credit	✓	`	
GA		Tax Credit	✓	Paper	
HI				All, glass for hwy const.	
ID		Income Tax Credit			
IL	newsprint	Property Tax Abatement	✓	All	
IA			✓	Paper, Oil, Tires	✓
IN				All	
KS		Sales Tax Credit		Paper	
KY	newsprint	Sales Tax Credit			
LA		Tax Credit		All	
MA				All	
ME		Tax Credit	✓	Paper	
MD	newsprint, phonebook	Sales Tax Credit	✓	All	
MN		Tax Credit	✓		✓
MO	newsprint		✓	All	
MT		Tax Credit			
NV		Property Tax Exemption		All	
NC	newsprint	Special Property Tax Exemption			
ND				All	
NH			✓	Paper prods containing >10% noncellulose mat.	
NJ		Tax Credit	✓	All	
NM		Investment Tax Credit		All	
NY			✓	All	
OK		Sales Tax Credit, Income Tax Credit		Paper	
OR	newsprint, phone books, rigid plastics	Tax Credit		All	
PA			✓	All (constr. mat.)	
RI	newsprint		✓	All	
SC		Tax Credit		All	
TN				Paper	
TX	newsprint	Tax Credit		All	
UT		Tax Credit		Paper	
VA		Income Tax Credit	✓	Paper	
VT			✓	All	
WA		Tax Credit	✓	Paper, Compost	✓
WV	newsprint			Paper	
WI	newsprint, rigid plastic - retail containers 8 oz.+	Sales Tax Credit	✓	Paper	✓

a Raymond Communications, *State Recycling Laws Update: Year-end Edition 1996*.
b Lisa Skumatz, SERA Associates, Seattle, WA.

Most of these regulatory proposals fall into several basic categories: pricing mechanisms, regulations regarding materials usage, information reporting requirements, and bans (see Table 1-3).[10] Each category comprises an

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10 Other schemes for categorizing these policies have been used. Franklin Associates, for example, divides policies into educational (labeling/coding, procurement guidelines, public awareness campaigns, for example), market-driven (front-end fees, solid

array of specific options that vary in detail; and some specific options—like the "manufacturer's responsibility model"—are a hybrid of fees and materials-use regulations, as noted earlier.[11]

Each of these policy options translates into near-infinite variations. For example, recycled content requirements may be accompanied by proposals for tradeable credits, or they may be proposed as part of a series of regulatory options that also include source reduction or product reuse requirements. Fee options may be accompanied by creation of a trust fund that specifies how fee revenues will be spent. Or fee options may combine with recycled-content regulations that exempt some items from the charge if they meet some other legislated criteria. And they may be applied at any point along the production-consumption-disposal continuum. "Reverse fee" options, such as tax credits, material-use subsidies, or R&D subsidies also conceptually belong among the pricing-policy options.

Though these policy instruments vary in their particulars, they are, essentially, variations on the four themes of pricing, regulations, information, and bans. Whether a pricing mechanism, a regulation, an information requirement, or a ban, all of these policies may have impacts on materials flows and production/consumption costs. Actual economic and environmental impacts of each policy instrument will depend on the "devilish details" that turn each policy concept into a concrete legislative proposal. They also depend on how the policy instrument affects decisions at each step in the packaging life cycle (see Figure 1-6).

Table 1-3: Policy Options: Waste Management and Materials Use

Pricing Mechanisms	Virgin Materials Tax Manufacturer Fee Advance Disposal Fee • Container Deposit/Refund • Packaging Nonrefundable Fees Household Waste Charges • Flat-Rate User Fees • Variable-Rate User Fees Disposal Surcharges Material Use Subsidies Tax Credits R&D Subsidies
Regulations	Recycled Content Standards • Product • Material Source Reduction Standards Product Reuse Standards Waste/Packaging Liability Mandates • "Responsible-Entity" Requirements • Packaging Stewardship Requirements
Information-Reporting	Eco-Label Regulations Eco-Label Guidelines Toxics Use Reporting
Bans	Packaging Bans Material-Use Bans Landfill/Disposal Bans

Source: Reason Foundation survey, 1994.

Defining Evaluation Criteria

A. The Question of Goals

Evaluating the efficacy of any public policy requires that one have a clear sense of the goal (or goals) toward which a policy is directed.[12] This initial assessment of goals requires:

- ranking goals from high-order to derivative or secondary goals; and

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waste charges, taxes, deposits, subsidies, tradeable credits, for example), and restrictive laws (bans and regulations, procurement regulations, and negative public opinion measures).

11 Non-regulatory proposals to stimulate markets for recyclables have also been proposed or implemented. For example, the Federal Trade Commission issued guidelines regarding acceptable advertising claims with respect to the environmental attributes of products and packages. The State of Washington created its Clean Washington Center, which provides research and technical assistance regarding recycling market opportunities. Many other states also have programs that assist in the financing of facilities that process or use recyclables. Some states also offer tax credits and other incentives to build such facilities.

12 There are at least six points at which packaging has some potential environmental effects: 1) during raw material harvesting and mining; 2) during packaging production and filling; 3) during cleaning/processing of multi-trip and recycled packages; 4) as litter;

- evaluating the coherence of articulated goals in terms of available information.

In recycling debates, policy goals have not always been clearly delineated. However, it appears that proponents of recycling laws and related policies want to accomplish four goals:

- *Reduce solid waste disposal (waste diversion);*
- *Reduce the associated pollution from producing goods;*
- *Reduce consumption of virgin materials; and*
- *Generate revenues to cross-subsidize non-disposal waste-management activities, or even other municipal services.*[13]

Recycling may accomplish these four goals at the same time. However, these goals are not perfectly congruent with each other if one examines them closely. The first two goals involve what are basically local impacts. Few would argue that a "unit" of air emissions in rural Canada, for example, has the same detrimental value as the same air emission in Los Angeles. The same principle holds true for solid waste disposal. Constraints on disposal capacity are local and largely dependent upon land values and differential handling and transportation costs. Likewise, pollution effects from disposal are local in nature and will vary by geography, ecological characteristics of the site, human proximity, and disposal technologies.

Thus, for the first two impacts, no single national (or even statewide) "value" for waste diversion or pollution abatement can be established. The attempt to do so will result in distortions of resource use away from efficient levels. Appropriate disposal rates will depend on local conditions.

On the other hand, virgin materials are traded in national and global markets due to their fungibility. Their scarcity value may or may not be adequately reflected in market prices. However, the production and consumption of virgin materials do not necessarily lead to higher solid waste and pollution impacts relative to use of secondary materials.[14]
And total resource impacts from virgin and secondary-materials use (in terms of labor, capital, raw materials, and energy) will vary across materials and locations.

Finally, the desire to create another municipal revenue stream may be understandable but can only be analyzed in the context of all available revenues and local government spending patterns.

Another caveat is in order. Many recycling and materials-use policies have been advanced as mechanisms to "create markets" for recyclables.[15] While this intent lies behind much recycling policy activity, it must be viewed as a derivative rather than a fundamental goal. It derives from first-order

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5) during disposal treatment; and 6) during transportation. See *Packaging and Ecology* (Surrey, U.K.: Pira International, 1992). Frans Lox lists these and several additional points of environmental impact, p. 77.

13 At least three of these goals are set forth by Susan Birmingham of the Public Interest Research Group in her 1993 comments to the Recycling Advisory Council (RAC). Among other goals, Birmingham identifies reduction in use of virgin materials to preserve resources, the elimination of unsafe disposal, and more-efficient waste handling as possible outcomes of recycling market development policies.

14 Several studies have suggested that, in general, total environmental impacts from use of recyclables will be lower than impacts of products made from virgin materials. See, for example, John Schall, "Does the Solid Waste Management Hierarchy Make Sense?", Working Paper No. 1, Program on Solid Waste Policy, Yale University, New Haven, Conn., 1992. This argument, however, suffers from two shortcomings. First, actual comparative impacts will depend on the specific product and the particular amounts of recycled content used. The relationship between use of recycled content and reductions in energy use, for example, is not always linear and may sometimes even resemble an inverted bell curve—that is, energy use associated with recycled content may decline up to certain levels of recycled content, after which energy use again begins to climb. Second, at issue is not a comparison of a particular virgin material with its secondary material counterpart. A more appropriate comparison is between a product containing recycled content and those made from all other available substitutes. For example, a package made from 100 percent recycled aluminum may actually require more energy consumption (with associated air emissions) than one made from non-recycled plastic resins.

goals regarding pollution or waste reduction and resource conservation. Recycling is presumed to be a means to one or more of these more fundamental ends. If recycling serves these fundamental ends, enhancing market development becomes an indirect mechanism for mitigating pollution, reducing waste, and conserving resources.

For analytical purposes, therefore, it is appropriate to examine solid waste and recycling policies in terms of one or more first-order goals. To do otherwise would be to ignore the underlying fundamentals that prompted the initial establishment of waste-diversion goals. In short, the fundamental issue is not whether a policy creates markets for recyclables, but whether it results in waste diversion, pollution abatement, or resource conservation, and at what cost the policy achieves one or several of these goals.

One principle of effective policymaking is that unless multiple goals are exactly coincident with each other, accomplishing each goal requires implementing a separate policy instrument for each goal. As it turns out, the four goals posited above are not fully coincident. Maximizing one goal, such as reducing solid waste disposal, may lead to diminishing another goal, especially after reaching a certain saturation point. For example, maximizing waste reduction might, at some saturation point, result in increased air pollution. (Consider that waste-to-energy incineration may maximize post-consumption waste reduction; total reliance on incineration may, however, increase air emissions over some mix of alternative production, consumption, and waste-handling options).[16]

One must consider these trade-offs in evaluating policies to achieve each of the above policy goals. An economic optimization analysis of multiple objectives must either define a policy instrument for each type of activity under the control of an economic decision-maker, or such analysis must focus on a single goal, while defining other goals as constraints on the final outcome. That is, the other goals define trade-offs to be considered.[17]

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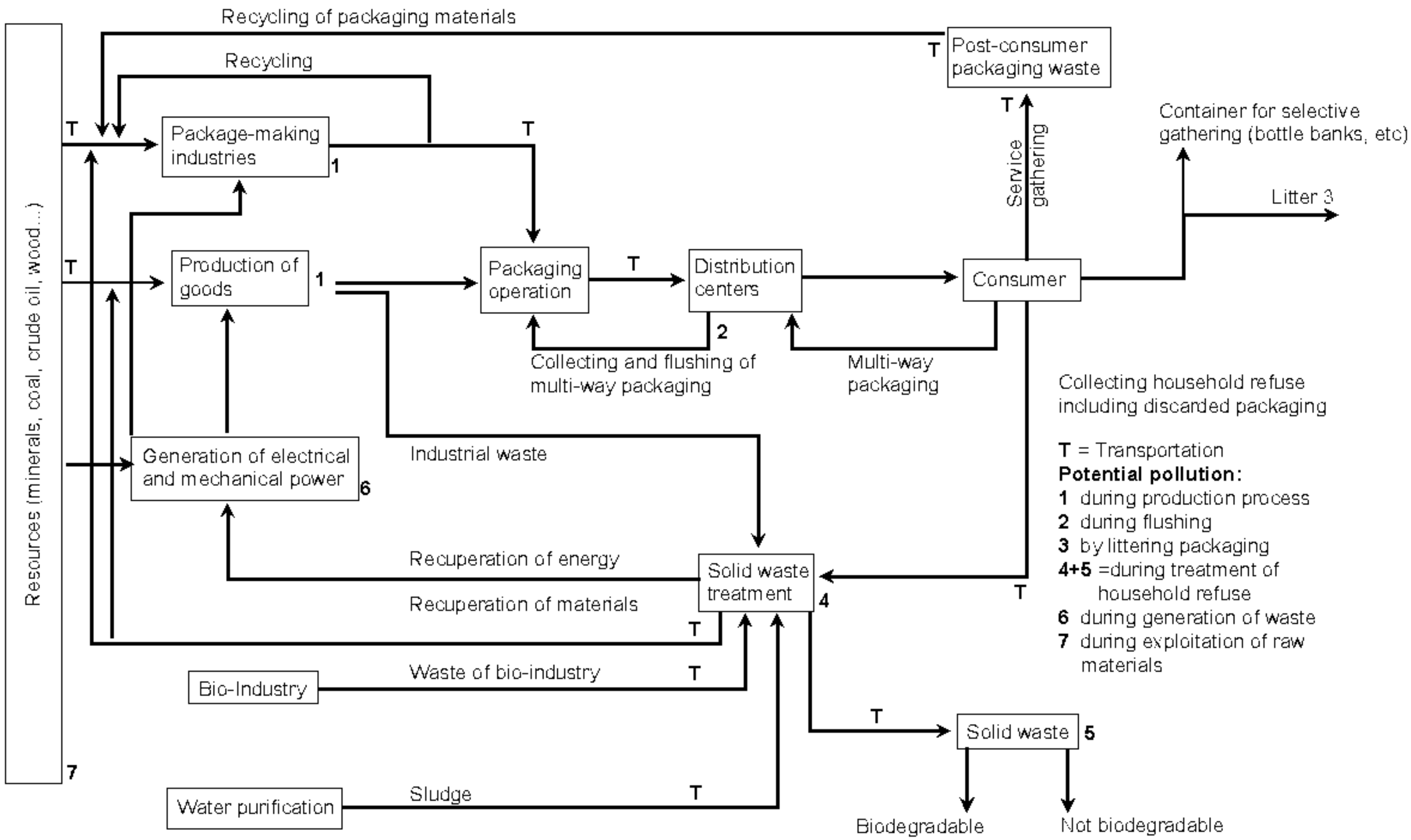
15 For example, the Recycling Advisory Council's Market Development Committee identifies increased demand for recyclables as one rationale for minimum recycled content standards and recycling utilization rates in its 1993 “Market Structure Policy Options Briefing Book” (Washington, D.C.: National Recycling Coalition, 1993).

16 *Data Summary of Municipal Solid Waste Management Alternatives*, SRI International, Menlo Park, Ca., October 1992, prepared for National Renewable Energy Laboratory, Golden, Co.

17 Past work typically has assessed at least two of the four goals listed above. Not surprisingly, these analyses have usually found that a single policy instrument was not optimal and that optimal policy required at least as many instruments as there are goals. For example, a typical policy approach is to seek reductions in solid waste disposal and virgin materials consumption through increased recycled material use. In theory, a product tax might, for example, reduce disposal rates if it is identical to a locally optimal waste-end disposal fee. However, the reduced product usage will be distributed proportionately among virgin and recycled materials unless the latter materials are subsidized. Thus, while overall waste may be reduced, virgin material use will not be reduced without a direct virgin material tax. This example is not meant to support the case for such a tax; rather the example illustrates the difficulty of achieving two different goals with a single policy instrument.

Figure 1-6: Pattern of the Packaging Life-Cycle and of the Potential Interactions with the Environment



Source: Frans Lox, *Packaging and Ecology*, p. 73.

Our primary focus here is on waste-diversion, as that is the goal most directly related to current decisions regarding appropriate waste-management and recycling policies. Two of the other three posited goals—pollution abatement and revenue enhancement—clearly encompass concerns that go far beyond waste management and recycling activities. The fourth goal—reduction in the use of virgin materials—will be examined here as it relates to waste-reduction issues and efficient resource allocation.[18]

B. Economic Analysis: Prospects and Problems

Fundamentally, debates about solid waste, recycling, and packaging take place along two separate dimensions: matters of solid waste management and matters of resource management. The former raises traditional questions about pollution, safety, and costs of alternative waste-handling approaches. The latter dimension raises questions about the production and consumption of goods.

Though pollution and safety questions involve matters of science, technology, and risk, questions about the efficient production, consumption, and disposal of goods are largely economic ones. Economist Haynes Goddard notes that the solid waste problem “is not primarily one requiring just technical or engineering approaches such as landfill and incineration, but that fundamentally it is economic in nature.” Thus, continues Goddard, “the market and price system should be employed to help identify the proper balance among the various management alternatives of source reduction, recycling, incineration and landfill.”[19]

As Goddard notes, there are sigificant limitations to using empirical cost-benefit analysis “to determine the optimal material throughput in the economy and the relative emphasis that is to be placed on various options.”[20] The number of variables relevant to understanding materials flows (production and consumption decisions) and how they change over time in relationship to regulations or politically determined fees and taxes defy modeling capabilities. Nonetheless, developing a framework for understanding these economic interactions—and quantifying some aspects of those relationships in a snapshot (single-point-in-time) form—can help us better understand the potential effectiveness and costs of different policy options. At a minimum, such an exercise can give us a more clearly defined view of the policy problem.[21]

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18 Allen Miedema, et al. wrote in a 1976 U.S. EPA report that high rates of natural resource disposal are not “a theoretically sound basis for discriminatory waste reduction policies, unless it is assumed that natural resources are underpriced.” See Miedema, et al., *The Case for Virgin Material Charges: A Theoretical and Empirical Evaluation in the Paper Industry*, prepared for the Office of Solid Waste Management Programs, U.S. Environmental Protection Agency, January 1976, p. 17. Miedema, et al. go on to argue that, at least for bulk paper, the “true social cost” is about 15 percent higher than their market prices. That conclusion is not transferable to present circumstances, since tax and other policies that affect paper prices have undergone significant changes in the intervening years.

19 Goddard's comment does not suggest that engineering and technology are unimportant in terms of “how” disposal service ought to be provided. However, technology and engineering are simply tools; they cannot tell us “what” services to provide or in what combination they ought to be provided at a given location. Determining what services to provide is largely a function of “values”—what services people wish to purchase—and “price.” Moreover, when waste management is viewed as part of the larger picture of resource production and consumption decisions, the issues are also primarily economic. It is in this sense that Goddard calls the solid waste problem primarily an economic one.

20 Goddard, “The Benefits and Costs of Alternative Solid Waste Management Policies,” p. 4.

21 Some critics contend that economics are irrelevant when considering some values. For example, a panelist at a National Recycling Council symposium on recycling market development commented: “You cannot put a cost or value on reducing litter; it is a quality-of-life issue. No one can put an economic value on clean water and clean air....There are other values to be considered beyond economic values....” See Recycling Advisory Council, RAC Market Development Committee, “Industry and Interest Group Panel Discussion on Recycling Market Development Policy Options,” Sept. 20–21, 1993, Symposium Proceedings (Washington, D.C.: National Recycling Coalition), p. 22. But this statement misconstrues what economic analysis is. That some values are not currently expressed in economic transactions should not be misconstrued to imply that pursuit of these values has no “cost.” Pursuit of all values has a cost in the sense that their pursuit requires time, personal commitment, resources, capital, or all of these inputs. A cost of an activity is the opportunities forgone by devoting resources, time, or capital to that activity. In this sense, pursuit of all values has a cost and therefore can be understood in economic terms. As economist Thomas Sowell points out, “the most widespread misunderstanding of economics is that it applies solely to financial transactions. Frequently, this leads to statements that 'there are noneconomic values' to consider.” Sowell replies that “there are, of course, noneconomic values.” Indeed, he continues, “there are only noneconomic values. Economics is not a value itself but merely a method of trading off one value against another.” See *Knowledge and Decisions*, 1990.

C. Cost Impacts: Relevant Criteria

Materials use and disposal policies have potentially different cost impacts across four dimensions: waste management costs; product and packaging production and distribution costs; consumer utility; and transactions costs. These combined costs will determine the relative cost impacts of the different policies on overall economic activity and consumer "welfare."

1. Waste Management Costs

Several factors are important in understanding potential waste management costs associated with different materials use and disposal policies.[22]

First, these costs are location-specific. Waste management costs are a function of land values, demographics, service quality, program design, and other variables unique to specific locations or regions.

Second, these costs are not fixed. The costs of various waste management options will vary over time, and adding increased amounts of material to a program may result in costs that either increase, decrease, or remain the same.[23]

Third, increases (or decreases) will not necessarily be linear. For example, recycling costs may resemble an inverted bell curve, with high per ton costs experienced at very low levels of recycling, a drop in costs as more households and materials are included in a collection program, and a rise in costs after a program moves beyond capturing those materials that are relatively easy to collect and process.

Fourth, "avoided costs"—those costs avoided by diverting waste away from disposal facilities—represent real potential savings, but these costs are often misapplied. Avoided costs cannot be determined by taking a current landfill (or incinerator) tip fee and multiplying it by the tonnage diverted through recycling, composting, or waste reduction, then deducting that amount from out-of-pocket recycling costs. The avoided disposal costs should, instead, be determined by estimating the amount of time the landfill "life" will be extended as a consequence of the diversion program. The extension in essence represents a delay in expenditures on new capacity.

Avoided costs are appropriately calculated by determining the difference in current landfill costs versus expected costs of new capacity, and calculating the net present value of the future savings that result from delaying the onset of higher disposal costs. Using this methodology, avoided costs will be higher for landfills near the end of their useful life, but will diminish for landfills that have many years of remaining capacity.

Fifth, capital and operating costs for waste-management systems will not capture total costs to individuals associated with the environmental impacts of these systems. For example, to the extent that incinerators emit air pollutants into an air basin, these pollutants represent a "cost" to affected

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22 Assessing waste management costs involves a host of conceptual and practical pitfalls. There is no "one way" to measure costs. Costs can be evaluated in terms of average costs per ton or per household (or other unit) served. Such costs, which divide total costs by total tonnage (or number of households served) give a static picture of costs that has limited utility for understanding how incremental additions of material to the system will affect costs. Marginal cost analysis attempts to assess this dynamic. Yet a third cost measure may also be appropriate: incremental cost analysis. Such analysis examines the incremental cost of adding an additional program component to a waste management system. For example, incremental cost assessment assesses the costs of adding, say, a recycling program to one that previously had provided only trash collection and disposal. There is a second, practical problem in understanding waste management costs. Many publicly owned and operated waste management programs do not use activity-based accounting. Waste management costs may be spread among different departments (for example, sanitation, fleet maintenance, legal services). Reported sanitation department figures may thus represent only a portion of total waste management costs. This public-sector accounting phenomenon can make cost assessments difficult.

23 See, for example, Solid Waste Association of North America, *Integrated Municipal Solid Waste Management (IMSWM): Six Case Studies of System Costs and Energy Use* (Silver Springs, MD: SWANA, November 1995).

individuals in the surrounding community—costs that are not reflected in the direct monetary production costs of operating the incinerator.

To the extent that these external costs are not part of the "price" picture that users pay to use waste facilities, the user, in effect, is not paying the full cost associated with use of the facility and may, therefore, have an economic incentive to "buy" more waste disposal services than would be the case if the total external costs were absorbed by the user.[24]

While these external costs are important to recognize, two points warrant brief mention. First, external costs associated with handling discards (whether through recycling, landfilling, or other options) are likely to be small relative to external costs associated with many other production and consumption activities.[25] Second, to the extent that such external impacts exist, their remedy lies in directly mitigating such effects rather than using recycling and waste-diversion rules as an indirect, proxy mechanism through which to reduce these environmental impacts.

2. Transaction Costs

Transactions costs refer to costs associated with maintaining and enforcing different decision-making arrangements. For waste-disposal and materials-use policies, these can include costs of monitoring and enforcing regulatory compliance. Transaction costs also include information-gathering costs necessary to implement a particular policy.

In general, such costs will vary depending on regulatory complexity. Regulatory complexity will, in turn, depend on such factors as:

- **Frequency of adjustment.** How frequently will the regulatory standard or fee be adjusted to reflect changing circumstances or information?
- **Scope of application.** To what universe of products, materials, or companies will the regulation or fee apply?
- **Price-searching problems.** In setting fees/taxes, how available is information about the actual costs of a targeted service, good, or environmental impact? Is the information available in the aggregate but not in a form that differentiates among locations, materials, or other relevant variables?[26]
- **Calculation problems.** Is price information available from market transactions?[27]
- **Information feedback mechanisms.** Does the regulation accommodate feedback information about regulatory impacts and supply/demand distortions and adjust to take into account this information?
- **Accountability.** What mechanisms, if any, does the policy include to link decisions with consequences for those decisions, thereby creating some degree of self-monitoring and adjustment?
- **Structure of markets.** What is the company/firm concentration, the number of collection points, and the availability of relevant audit information in the regulated industry(ies)?
- **Time frame.** What is the length of time for transitioning to the new regulatory regime?

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24 See, for example, John Schall, "Does the Hierarchy Make Sense?"

25 Ibid.

26 For example, one may know the costs to collect a trash container full of garbage; one may not, in any meaningful sense, be able to disaggregate those costs to establish costs to collect (and dispose) of a single discarded razor, or frozen food package, or used tissue.

27 For example, a policy that attempts to internalize costs of air emissions associated with the production of a good will have to "guess" at what value to place on a unit of air emissions. For the most part, air emissions are not traded in the marketplace; hence how much people value an incremental reduction in air emissions relative to some other good is not known.

- **Regulatory clarity.** Is the regulation clear and unambiguous, resulting in ease of interpretation? Is it selective or universal in its scope of application?

3. Consumer Costs

Consumer costs associated with proposed policy measures have both quantitative and qualitative components. Costs include direct "pocketbook" costs, such as any increases in prices paid for goods and services that might occur upon implementation of solid waste or materials-use policies. In addition, costs include any reductions in consumer "utility." For example, reductions in consumer convenience, product safety, or product performance all represent "costs," though these reductions may not show up directly in consumer expenditures[28] (See sidebar: Consumer Attitudes). As it is difficult to quantify reductions in consumer utility, these costs will be discussed only anecdotally in this report.

4. Production/Distribution Costs

Production and distribution costs affected by resource-use policies include a broad array of variables. For packaging, these costs include material costs and how different policies might affect feedstock costs. These costs also include labor, impacts on speed of production, costs of fuel used for shipment of goods and for production, capital costs, and R&D costs. Some proposed packaging policies can affect labeling costs, shipping costs, and costs associated with shelf space and advertising. Though packaging may appear to the consumer or policymaker as a simple set of different container technologies, decisions about packaging forms, material usage, and product distribution involve a complex set of interrelated decisions (see Figure 1-7).

Consumer Attitudes

In a 1992 survey of female shoppers, AcuPoll Research asked the following question:

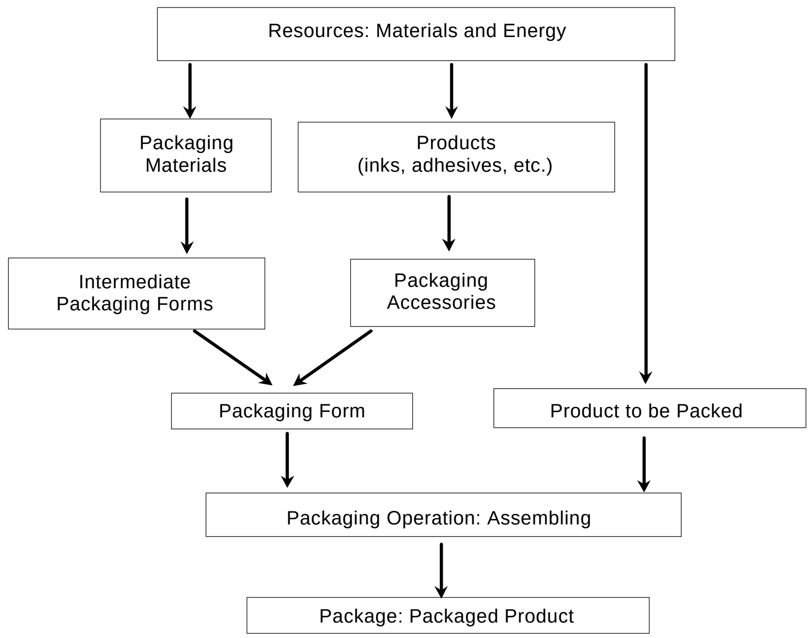
"The packaging of foods and drinks can provide many benefits. How do you rate the importance of each of the benefits listed below?" (0 = Not important; 10 = Very important)

- Keeping product in good condition up to time you buy it: 9.2
- Keeping remaining product in good condition after package has been opened: 9.2
- Has nutritional info on package: 8.8
- Easy to reclose: 8.5
- Provides "enough" packaging, but not more: 8.4
- Easy to open: 8.1
- Made with recyclable materials: 7.4
- Right size for freezer, cupboard, etc.: 7.4
- Made with recycled materials: 7.2

Source: Richard Lawrence, "Trends in Packaged Goods Innovations," presented at *Packaging Magazine's* 1993 Packaging Forecast & Planning Seminar, Sept. 22, 1992.

28 What consumers value may not coincide perfectly with the goals of a particular solid waste/materials use policy. Polling of consumer attitudes toward packaging shows that while "recyclability" and "recycled content" do rank relatively high among consumer values, other product attributes rank still higher. Any compromise of these other values to achieve recyclability or recycled content would, therefore, represent a "cost" to consumers in terms of reduced utility.

Figure 1-7: Sequence of Packaging Concepts



Source: Frans Lox, *Packaging and Ecology*, p. 5.

Transaction Costs:

The Relevance of Market Structures

STRUCTURE OF PACKAGING INDUSTRY

Most analyses of regulatory costs focus primarily on production costs and the impacts that regulations might have on consumption. These impacts are central to understanding the cost implications of different regulatory options, but they exclude transaction costs of regulations. Yet these costs can be significant.[29]

Transaction costs will vary widely depending on the implementation details of specific regulatory concepts. In the case of laws targeting packaging and solid waste, the structure of the packaging industry, consumption patterns, and the structure and composition of sales will affect transactions costs and the feasibility (and cost) of implementing different policy options.

A. Industry Concentration

Total sales in the packaging industry reached around $75–$80 billion in 1995.[30] Unlike many other U.S. manufacturing industries, the packaging industry is not highly concentrated. Instead, production for most packaging sectors is decentralized across many firms, with a high degree of competition among firms within each packaging sector. *The Rauch Guide to the U.S. Packaging Industry* reports that "estimates for 1989 indicate that only 50 companies had sales of domestically produced packaging of over $200 million and their aggregate sales accounted for only 57.7 percent of total industry shipments."[31] Fewer than a dozen firms had sales over $1 billion.

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29 Several assessments of costs of Superfund regulations, for example, suggest that in some instances transaction costs—primarily in the form of litigation—can actually dwarf site clean-up costs. See, for example, Jan Paul Acton and Lloyd Dixon, *Superfund and Transaction Costs: The Experience of Insurers and Very Large Industrial Firms* (Santa Monica, Calif.: RAND Corporation, 1992).

30 See *1996 Packaging Sourcebook* (Philadelphia: North American Publishing Company, 1996), presented by *Packaging, Printing and Converting* and *Packaging Technology & Engineering*.

31 *The Rauch Guide to the U.S. Packaging Industry* (Bridgewater, N.J.: Rauch Associates, Inc., 1990), p. 12. The Rauch Guide notes that some packaging segments—molded pulp packaging, milk and beverage cartons, liquid-tight containers, and metal cans—are more concentrated, with the top four firms producing over 65 percent of shipments. Other segments, however, are particularly decentralized, with the top four firms accounting for 35 percent or less of total shipments. These include producers of pallets and skids, rigid paperboard boxes, converted flexible packaging, folding cartons, plastic containers, corrugated containers, textile bags, and most wooden containers.

Competition continues to characterize the packaging industry of the 1990s, though concentration varies by industry, and some consolidation is occurring.[32] In the glass industry, for example, the top three companies control around 90 percent of the market. However, at the other end of the spectrum, 10 companies control about 40 percent of the flexible packaging market, with over 2,500 companies composing the rest of the market.[33]

In addition to firm decentralization, the industry is also characterized by geographical decentralization of manufacturing plants, to economize on shipping distances. Even those firms that dominate a particular packaging market tend to have a large number of widely dispersed plants. *The Rauch Guide* reported, for example, that 70 percent of paperboard containers (excluding food containers) and half of metal cans were shipped less than 100 miles in the 1980s.

The plastics industry is especially decentralized. Approximately 50 resin manufacturers, with 250 distributors, operated in the United States in the early 1990s.[34] These resin manufacturers supply feedstock to several hundred plastic container manufacturers, who in turn supply containers for over 6,000 product manufacturers (see Figure 2-1).

B. Industry Competition

The packaging industry is also characterized by a high degree of competition among different packaging materials (see Figure 2-2). In 1993, corrugated paper led the packaging market with 30 percent of total sales; metal cans held 18 percent of total sales; plastic-flexible held 15 percent of the market; folding-paper cartons made up 12 percent of the market; plastic bottles and glass containers each held 8 percent of the market respectively; and paper-flexible packaging held 5 percent of the market.[35] *The Rauch Guide* summarizes this structure by noting that "packaging is produced by a group of diverse manufacturing segments employing different raw materials and manufacturing processes and offering a variety of seemingly unrelated products—metal cans, glass bottles, paperboard boxes, plastic film, and wooden pallets among others. The common factor uniting these segments is their market."[36]

The $75–$80 billion industry translates into production of billions of individual packaging units. Approximately 200 billion units of rigid containers of metal, glass, and plastics are produced each year.[37]

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32 The 1995 edition of *Market Share Reporter* estimates that the top seven companies in the packaging industry together held 44 percent of market share, with the top producer holding less than 10 percent of market share.

33 See *Wall Street Transcript Digest*, June 26, 1996. Note that evaluating industry competition depends on how one defines a specific industry. For example, using a somewhat different set of boundaries, *Paper, Film & Foil Converter* reports that "950 flexible-packaging facilities exist in the U.S., representing 380 to 420 companies, and providing 84,000 people with work." Both of these sources, however, confirm that a large number of firms participate in the flexible packaging market.

34 For a detailed description of plastics production and consumption patterns see Ernst & Young, *Rigid Plastic Packaging Container Act*.

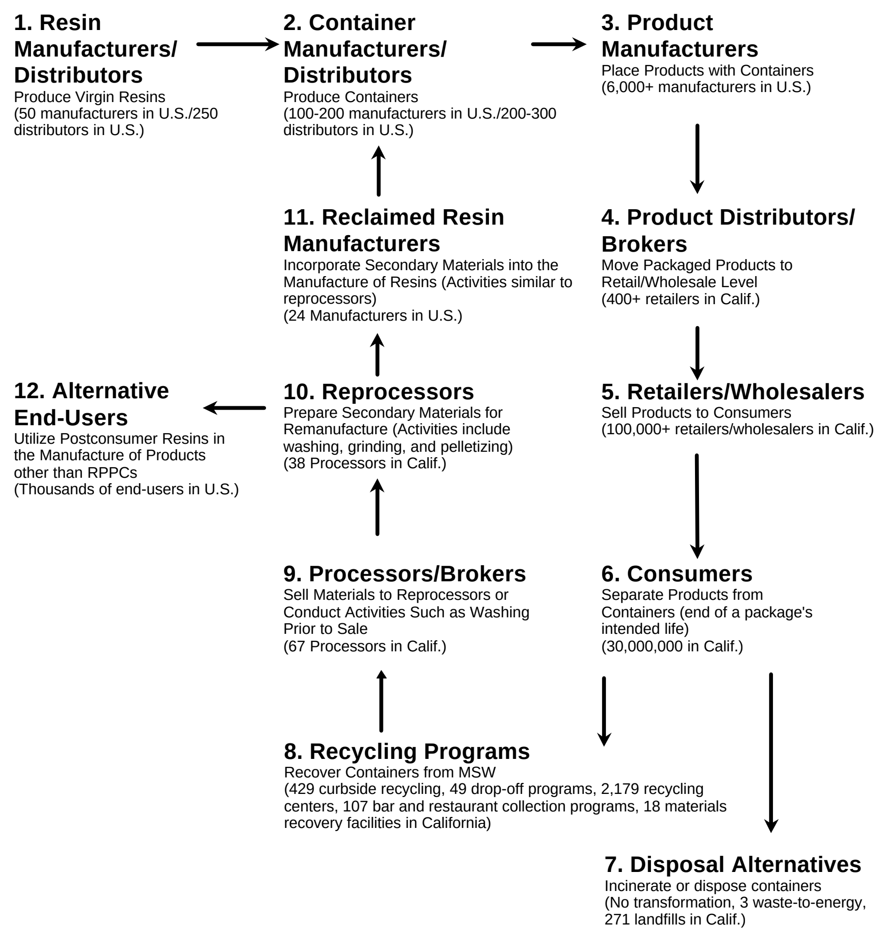
35 See *Market Share Reporter*, 5th edition, 1995.

36 *The Rauch Guide*, p. 4.

37 See, for example, *Packaging Week*, June 3, 1992.

Figure 2-1: Flow of Rigid Plastic Packaging Containers

(California Example)



Source: *Conceptual Plan to Implement the Rigid Plastic Packaging Container Act,* Ernst and Young, March 31, 1994, p. D-2.

C. Feedstock Costs Relative to Total Shipments

The U.S. Census Bureau reported that, on average, in 1992 all packaging segments spent about 61 percent of their sales dollar on purchases of raw materials and supplies, including fuel (see Table 2-1).[38] However, this average obscures wide variations among specific package types, with raw material costs ranging from 39 to 73 percent of total shipment value. Moreover, packaging costs per unit also vary as a function of how packages are distributed (see Figure 2-3).

Costs of processed packaging materials vary widely (see Tables 2-2 and 2-3), with material competitiveness related to the total costs associated with using that material. These total costs include energy costs in production and transportation, productivity in handling, tonnage of material required to achieve particular packaging characteristics, and so on. For example, plastics may have a high cost per

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38 *The Rauch Guide*, pp. 23–24.

pound relative to some other materials, but because they require much less material by weight to create needed packaging characteristics compared with glass or paper, a substitution of plastics for more traditional materials may result in lower packaging costs.

In the short term, demand for materials is relatively inelastic, since most materials are only imperfect substitutes for existing materials. As a result, switching to new materials may require significant changes across production, filling, and labeling equipment, as well as changes in warehousing and transportation. Small changes in feedstock costs are usually insufficient to warrant a material switch.

D. Summary: Industry Structure and Transaction Costs

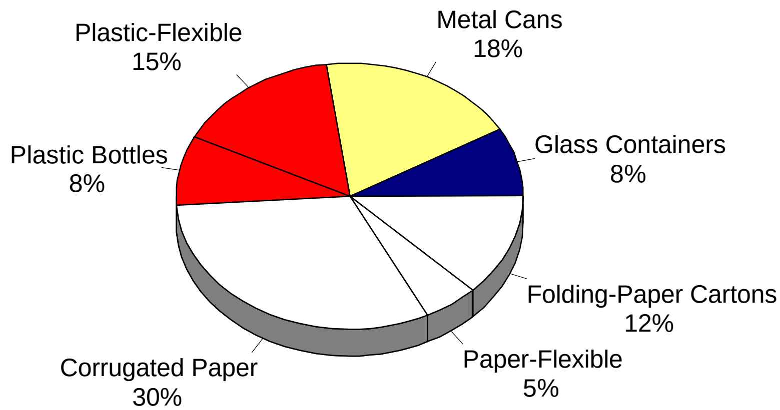
The highly competitive and decentralized nature of the packaging industry poses difficult challenges for regulatory efforts that attempt to micromanage resource-use decisions. For example, the State of California has faced this sort of challenge in attempting to implement its Rigid Plastic Packaging Container law. The California Integrated Waste Management Board staff have indicated that a review of the SIC Code shows approximately 10,000 users of rigid plastic containers in California. Of these, only around 260 actually had provided information by late 1995—individually or through collective reports of industry consortia—relevant to assessing compliance with the law.

Table 2-1: Employment and Expenditures in Selected Packaging Segments, 1992

	# of Employees	Value of Shipments ($Million)	Sales per Employee	Materials (% of Sales)	Payroll (% of Sales)
Paperboard Containers and Boxes	198,800	$32,571.2	$163,839	62.0%	17.5%
• Corrugated and Solid Fiber Boxes	111,700	19,789.9	177,170	66.1	16.5
• Folding Paperboard Boxes	52,700	7,932.7	150,526	54.9	20.0
• Sanitary Food Containers	15,400	2,490.8	161,740	57.5	15.5
• Fiber Cans, Drums & Similar Products	12,400	1,922.1	155,008	59.2	17.5
• Setup Paperboard Boxes	6,600	435.7	66,015	45.3	29.7
Metal Cans and Shipping Containers	39,500	13,246.0	335,341	71.7	11.0
• Metal Cans	32,300	12,112.2	374,991	72.6	10.4
• Metal Barrels, Drums, and Pails	7,200	1,133.8	157,472	61.2	17.7
Glass Containers	32,300	4,859.6	150,452	39.2	21.7
Plastic Bottles	32,700	4,458.2	136,336	51.7	17.5
Plastic, Laminated, and Coated Bags	38,700	5,708.2	147,499	50.3	17.3
Uncoated Paper and Multiwall Bags	18,600	2,846.0	153,011	64.1	15.4
Wood Containers	40,000	2,930.6	73,265	55.2	21.8
• Nailed Wood Boxes and Shock	5,900	444.0	72,254	57.6	22.8
• Wood Pallets and Skids	28,700	2,143.3	74,679	55.2	21.0
• Other Wood Containers	5,400	343.3	63,574	51.8	26.0
Textile Bags	11,900	778.5	65,420	57.0	23.9
Cordage and Twine	6,700	672.7	100,403	48.3	20.6
Total or Average	**419,200**	**$68,071.0**	**$162,383**	**60.2%**	**16.7%**
Total or Average (1987)	**414,100**	**$55,796.4**	**$134,741**	**59.7%**	**17.1%**

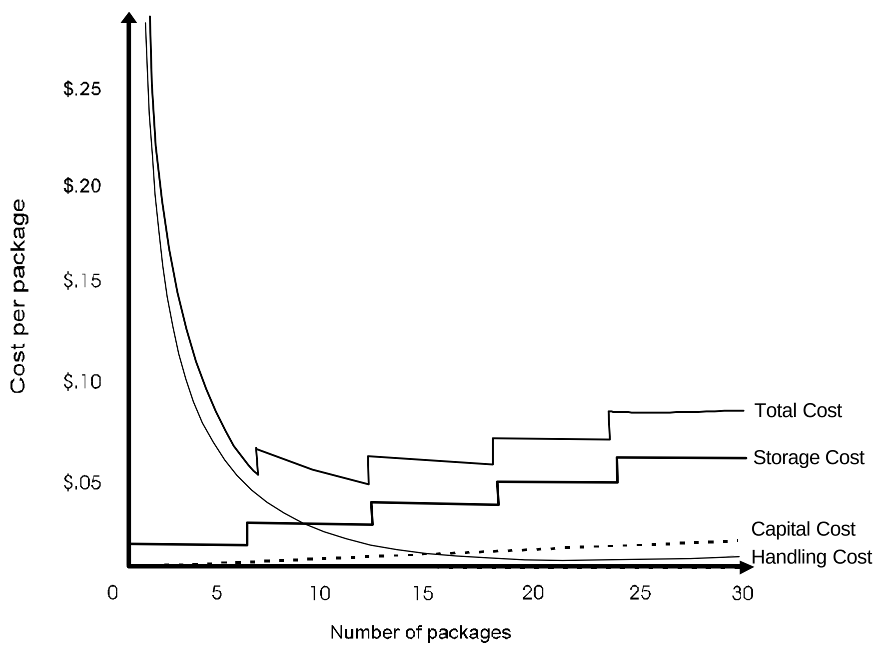
Source: U.S. Census Bureau.

Figure 2-2: Packaging Market Sales by Type of Package



Source: *Market Share Reporter*, 5th Edition, 1995.

Figure 2-3: Cost Price Structures of Packaging as a Function of Unit Sizes



Source: Frans Lox, Packaging and Ecology, p. 21.
Original costs are in Belgian francs.
Conversion to U.S. $ uses 1992 exchange rate of 32 BeF = $1.

The California experience points to a more general problem. Where production regulations target highly decentralized industries, enforcement and other transaction costs will necessarily be significant. While regulatory mandates have been reasonably enforceable—though not necessarily efficient—in concentrated industries like that of auto manufacturing or oil refining, such mandates have proven much more challenging to enforce on industries with thousands of producers, of which the packaging industry is one example.

Attempts to regulate packaging producers to require certain product inputs face several different kinds of implementation problems, including:

- high potential levels of noncompliance resulting from an inability either: 1) to identify all relevant manufacturers; or 2) to deploy sufficient enforcement personnel to monitor regulated firms on a frequent basis; and
- high "information-searching" costs to determine regulatory criteria, since large intra-industry variations are likely to exist.

These implementation problems are likely to generate high transaction costs associated with information-gathering and reporting, compliance-monitoring, and enforcement.

Table 2-2: Packaging Material Costs (1992)

Material	$/lb.
HDPE	.35
LDPE	.36
PET	.35
PS	.45
EVOH or EVAL	2.40
Paper—wrapper stock	.65
Paper—bleached stock	.50
Paperboard—SBS	.44
Paperboard—recycled	.27
Paperboard—uncoated	.22
Paperboard—other	.28
Aluminum ingot	.60
Aluminum—metal foil	1.00
Aluminum sheet	1.10
Steel sheet (8 to 10 mil.)	.40
Glass	.16

Source: Reason Foundation survey, 1994.

Table 2-3: Costs—Packaging Laminates, Sheets, Films (1992)

Material	$/1000 sq. in. (MSI)
Corrugated board	.200 - .350[a]
Paperboard	.150 - .290[a]
Aluminum foil	.050 - .072
Plastic films (HDPE, LDPE, LLDPE)	.022 - .037
PVC, PVDC plastic films	.030 - .150
Steel tinplate	$1.000

[a] Depending on specifications   Source: Reason Foundation survey, 1994.

STRUCTURE OF PACKAGING CONSUMPTION

In 1995, the packaging industry shipped billions of packaging units valued at over $70 billion. *The Rauch Guide* pointed out that "as almost all manufactured products are packaged and shipped, the packaging industry has almost every other industry as a customer."[39] Paper and paperboard packaging is used by over 75 percent of all manufacturing industries. By contrast, some packaging types such as metal and glass containers are more narrowly concentrated among consumer nondurable products.

A. Consumption Trends

Per capita consumption of containers is both highly dynamic—that is, consumption patterns change relatively rapidly over short periods of time—and also very diverse (see Figures 2-4 and 2-5). For example, though population climbed 10.5 percent between 1985 and 1989, consumption of plastic bottles climbed over 200 percent during that same time frame. Fiber can consumption, by contrast, fell some 60 percent. Trends in rigid packaging consumption between 1981 and 1991 underscore the dynamism of packaging markets, with plastic container consumption representing just 13 percent of total market share in 1981 and jumping to over 26 percent by 1991; the share of glass in this market dropped from a 1981 share of 28.9 percent to under 20 percent by 1991, but began to climb again in the 1990s. The fall in steel packaging was even more dramatic, falling from almost a quarter of the market in 1981 to under 10 percent by 1991.[40]

These changes in consumption patterns resulted in an overall decline in per capita consumption of packaging by weight to approximately 560 pounds per capita (see Table 2-4).[41]

B. Packaged Product Manufacturing Profiles

End users, like producers, are highly decentralized: In the 1980s, the top 100 of all package users accounted for only 38 percent of total expenditures, according to the *Rauch Guide*. Expenditures on packaging are also highly decentralized by product category, with foods industry purchasing accounting for about one-half of total packaging purchases (see Figure 2-6).

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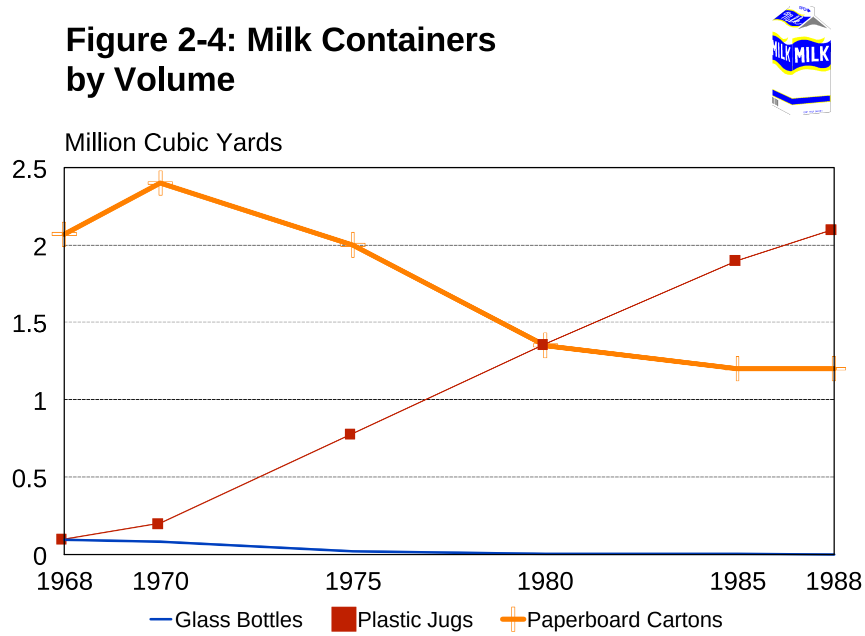
39 *The Rauch Guide*, p. 5.

40 Several trends have influenced the changing composition in packaging over the past decade. These include: 1) accelerated product-distribution cycles with an accompanying decline in shelf-life requirements; 2) high-acid foods with no heat processing; 3) hot-filling; and 4) use of hot-filled and retorted packaging (filled at temperatures above 250 degrees Fahrenheit). About half of all packages in the mid-'80s were filled at ambient temperatures; the remainder were hot-filled at temperatures varying from 148 degrees (for pasteurization) to over 250 degrees. See *Packaging Encyclopedia Yearbook 1985*. Frans Lox points out that the decline in shelf-life requirements has been made possible by shipping efficiencies that have made food supplies less dependent on harvest time and location of origin. (*Packaging and Ecology*, p. 12). Another important trend is the use of coextrusion, which is the simultaneous extrusion of two or more polymers from two or more extruders through one die system. The result is a multilayered film. The process permits the manufacture of extremely thin layers of very high value (expensive) copolymers combined with layers of less expensive polymers to provide greater packaging bulk.

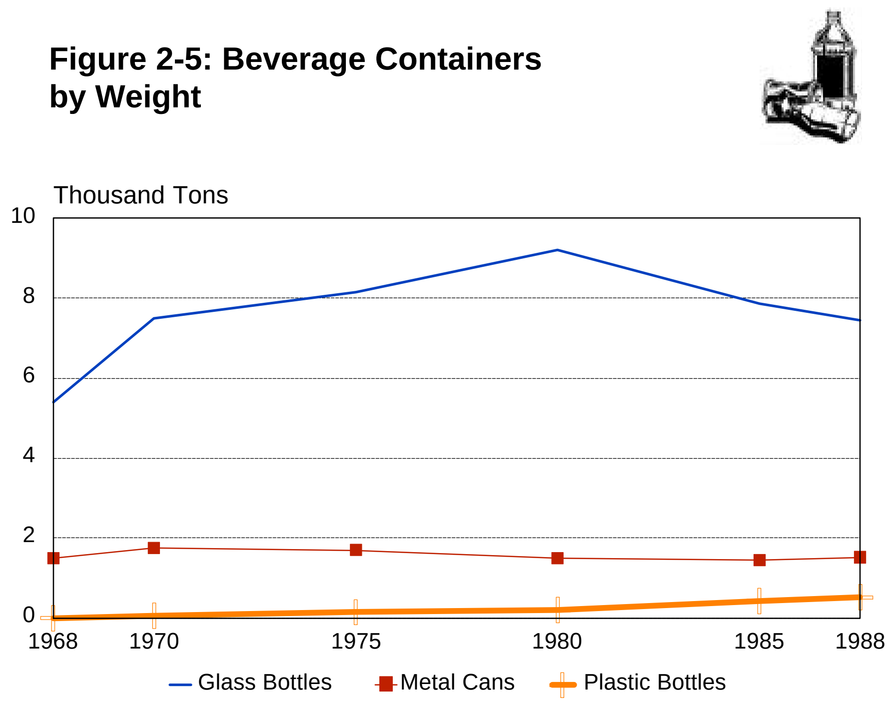
41 *The Rauch Guide*, p. 8. Note that one cost of relatively static regulations is their inability to anticipate changing consumption patterns. Two adverse consequences can result: 1) the regulations may actually impede introduction of new packaging materials; or 2) regulatory costs can increase as adjustments are made to accommodate the ever-changing universe of packaging. Note, for example, that a polycarbonate milk container may eventually replace HDPE as the preferred milk package. Such a change would dramatically alter the availability of post-consumer HDPE feedstock in the recycling stream.

Figure 2-4: Milk Containers by Volume



Source: Franklin Associates, "Materials Technology: Packaging Design and the Environment," prepared for U.S. Office of Technology Assessment, April 1991.

Figure 2-5: Beverage Containers by Weight



Source: Franklin Associates, "Materials Technology: Packaging Design and the Environment," prepared for U.S. Office of Technology Assessment, April 1991.

While rule-of-thumb industry figures estimate that a package typically represents 10 percent of total product cost, this figure is highly misleading. Actual packaging costs as a percentage of total product costs vary widely, from as little as 2 percent or so for some packaged meat products to well over 50 percent for some microwaveable non-meat snacks (see Table 2-5).[42]

Table 2-4: U.S. Per Capita Consumption of Containers: 1985/1989

	1985	1989	% Change
Paperboard	1,065	1,264	18.7
Metal Cans	419	463	9.5
Closures	338	361	6.8
Soft Drink Cans	137	183	33.6
Glass Bottles	170	167	-3.0
Beer Cans	150	147	-2.0
Plastic Bottles	76	158	208.0
Cigarette Pkgs.	115	111	-3.6
Milk Cartons	63	55	-14.5
Fibre Cans	32	20	-60.0
Liquor/Wine	20	16	-25.0
Aerosol	10	12	20.0
Tubes (metal/plastic)	8	7	-14.0
Population (millions)	237	249	10.5

Source: *The Rauch Guide to the U.S. Packaging Industry*, 1990.

C. Packaging Consumption by Final Consumer

Consumption patterns among the final end user and patterns of retail distribution are highly decentralized, complex, and diverse. The Food Marketing Institute estimated in 1993 that some 138,000 grocery stores, with over 3 million employees, sell some $383 billion in products. Of these, supermarkets with sales over $2 million per year represent the dominant category by sales. Over 30,000 stores sell a total of over $286 billion in goods. In 1994, *Food Retailing & Review* magazine reported that around 15,000 different manufacturers supply products to the grocery market.[43] The general trend over the past 30 years has been toward more product and package diversity and greater consumption of packaged goods.[44]

The median number of items sold per grocery store, according to *Progressive Grocer* magazine and U.S. Department of Labor statistics, is around 30,000. However, one analyst has estimated as many as 65,000 different packaged items in all categories of retail outlets.[45]
Even within the category of food consumption, a sizeable portion of food (and accompanying packaging) is consumed outside the home. At a 1992 seminar on packaging trends, analyst Aaron Brody estimated that some 45 to 47 percent of "food dollars" are spent outside the home. One-quarter of this consumption takes place in noncommercial institutions, such as schools and hospitals; about 65 percent is restaurant consumption, of which only a third is in fast-food facilities.[46]

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42 Frans Lox puts the range for packaging costs at between 2 percent and 25 percent of the product selling price. This is consistent with our own survey of manufacturers. Lox notes that "appropriate packaging should not always be considered as a 'cost';...it always limits the damage and thus the losses of marketable goods." Lox notes that 54 percent of product loss is attributed to transportation; 21 percent to humidity; and 25 percent to other factors. (*Packaging and Ecology*, p. 20).

43 Mary Ann Rizzitello of the American Institute of Food Distribution estimates that there are some 14,000 grocery wholesalers.

44 In 1960 on average a grocery store stocked some 6,000 stock-keeping units, which had climbed to between 18,000 and 35,000 by 1992. The trend toward product differentiation has some limits, however, that are a function of shelf space and product movement. Of the average 31,000 SKUs carried by a typical supermarket, the top 520 products move a case or more per week. The bottom 7,000 move less than one unit per week. (Personal communication, H.E. Swift, Procter & Gamble, February 1996).

45 See Kevin Dietly, "Economic Analysis of the Proposed Packaging Law in New York: The Environmental Sound Packaging Act," prepared for American Plastics Council (Lexington, Mass.: Clayton Environmental Consultants, May 1993). In a personal communication, Dietly indicated that the 65,000 figure is based on lower-range estimates from the hardware store industry (10,000–15,000 products); auto parts (10,000 items); supermarkets (10,000–40,000, using a conservative estimate of 20,000); houseware and electronics (20,000 products); and drug stores (15,000–20,000 items).

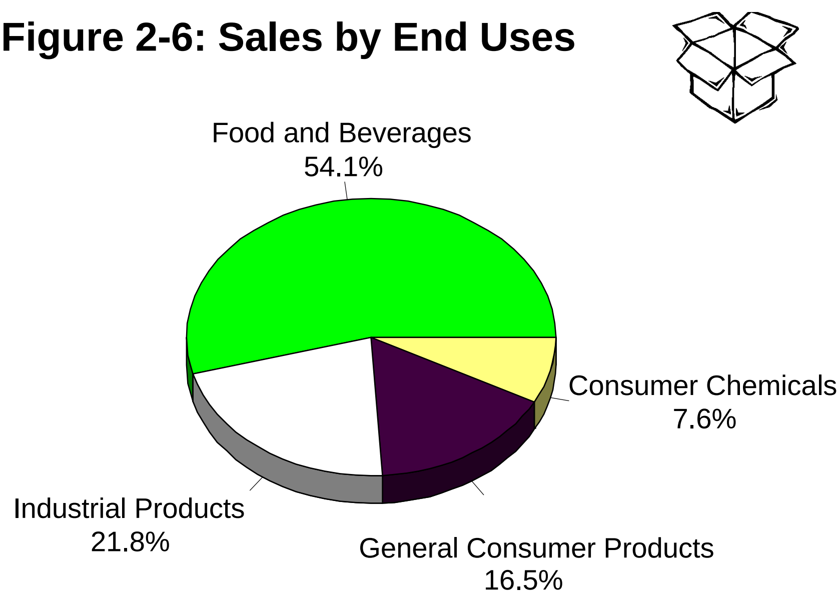
46 Aaron Brody, "Packaging 2000: Forces Shaping Our Future," presented at *Packaging Magazine* conference, Sept. 22, 1992.

No single material or package type predominates in the marketplace.

Table 2-5: Packaging as Percent of Total Product Costs By Category (% of Total Delivered Cost)	
Product	Percent
Household products (cleansers, detergents, etc.)	10 - 15%
Shelf-stable beverages	35 - 45%
Canned foods	10 - 20%
Toiletries	20 - 30%
Cosmetics	35 - 55%
Pharmaceuticals	10% or less
Meats	< 2%
Microwaveable snacks	> 50%

Source: Reason Foundation survey.

Figure 2-6: Sales by End Uses



Source: Rauch Associates, Inc.

D. Summary: Packaging Consumption Patterns and Transaction Costs

Packaging consumption patterns are even more decentralized and complex than packaging production arrangements. At the level of consumption, one is dealing with the personal decisions of virtually an entire population. This sort of decentralization has several implications for packaging policies:

- policies that require consumers to behave in certain ways—for example, Germany's Green Dot program requirement that consumers discard packaging in specific containers—may face high enforcement and monitoring costs (to prevent, for example, misuse of containers);
- tracking conformity of the thousands of packages to prescribed resource-use requirements may require large monitoring and enforcement capability;

- pricing policies are likely to involve lower monitoring and enforcement costs, but may involve high costs associated with administering prices that change according to changing resource costs;

all efforts to regulate resource use in packaging run the risk of stifling innovations that are designed to enhance product durability, consumer safety, and other product-quality attributes, or that are designed to reduce total raw material and fuel use.

Chapter 3

Four Policies:

A Review of Producer and Societal Costs

INTRODUCTION

In this chapter, we estimate the costs to manufacturers and to society for four types of policies often proposed to encourage the use of recycled materials in container manufacture. Those policies are:

- *Recycled content* (RC) mandates, which mandate that a proportion of recycled materials be used in packaging;
- A *virgin materials tax* (VMT), which assesses a tax on the use of material inputs based on the implied disposal costs for those materials;
- An *advance disposal fee* (ADF), which assesses a charge on the final product based on the implied disposal cost for the associated packaging; and
- *Manufacturers' responsibility* (MR), which requires manufacturers to implement waste-collection and material-recovery systems for their packaging, and generally combines required recovery rates with packaging fees.

The levels of recycled content used in our analysis equate to the proportion of post-consumer waste used as initial inputs into the production process. The VMT, ADF and MR are calculated to be equivalent to corresponding recycled-content levels that resulted in reduced waste-disposal rates.[47] We assume the goal of these policies is to improve solid waste management efficiency through waste diversion, *not* simply to increase use of recycled materials alone, to reduce use of scarce resources, or to increase waste management agency revenues—all often implicit goals of recycling advocates. These policies are evaluated as national-level policies, not as local or state efforts, which implies that all regions would be affected whether the policies are cost-effective or not. The costs for each of these policies at different content or fee levels are discussed at the conclusion of this chapter.

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[47] This analysis assumes (naively) that a VMT, ADF or MR policy will not cause manufacturers to shift away from using one material (e.g., glass) to another (e.g., plastic). Such an analysis would require an iterative model that incorporates all of the costs for each packaging material and its substitutes, additional costs of using each material beyond just packaging (e.g., transportation and refrigeration), and consumer responses to changes in packaging. This analysis also assumes that consumer demand is unchanged with the implementation of any of these recycling policies (i.e., it is a “partial equilibrium” analysis that assumes all other factors are fixed.) These assumptions obscure some of the losses and gains to manufacturers as the entire packaging market could change significantly as a result of any of these policies. We instead focus on net overall effects while ignoring firm- or region-specific impacts. The analysis presented here is a necessary first step, however, in undertaking a more complete assessment.

The costs for the proposed policies are estimated for four types of materials—glass, paper, steel cans, and three types of plastic (HDPE, PET, and LDPE). The analysis only focuses on the use of these materials in packaging and containers, since the proposed policies most often aim to increase recycled content in packaging without regard to other potential uses.

Because we focus on how these policies affect packaging alone, we assume the recycling process is *closed-loop*, i.e., that all material can be reused to produce some form of packaging, and higher recycling rates will be absorbed entirely in making this packaging.[48] We also assume that the packaging industry is in a *steady-state*, that is, a level of production and consumption that is physically and economically sustainable and stable. In other words, we ignore everything except packaging, and assume that the industry is not growing.

The only losses accounted for in this analysis are through collection and production waste; these losses are diverted back into the waste stream for final disposal in a landfill. Because of these losses, one ton of waste cannot be transformed into one ton of usable product. Therefore, certain policy scenarios show constrained content levels well below 100 percent. These constraints are discussed further in the policy analysis section. An idealized diagram of the waste management system is shown in the Waste Management Model chart. If the closed-loop analytic assumption is relaxed, the cost estimates made for the packaging industry will *increase* because more waste material will have to be collected and processed to achieve the same levels of recycled content in packaging (assuming that the content level is technically feasible), since some diverted materials will be absorbed by other users.[49]

The costs estimated in this analysis are based on national averages and typical processes. Because no waste management system is actually "typical," and uncertainty exists about how recycled materials might behave in many large-scale manufacturing processes, this study reports "low cost" and "high cost"—or "best" and "worst" case—scenarios as expected bounds on these policy proposals. *In reading this study, one should focus not on the monetary cost estimates per se but instead on (1) the methodology used in the analysis and (2) the general direction of the results.* The uncertainty inherent in the assumptions and variables means that one should not be taken in by the illusion of monetary precision. The methodology discussed here is also appropriate for assessing local and regional recycled material market policies.[50]

A. Chapter Structure

The chapter follows each step in the material life cycle as described in two Argonne National Laboratory (ANL) reports.[51] Direct costs are estimated for purchasing raw materials, collecting and processing

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48 Assuming this kind of quasi-"closed-loop" system is a simplistic assumption that does not allow for diversion of recycled materials to other uses, or for the fact that much recycled material is not suitable for reuse in certain products. For example, paper fibers become shorter as they are recycled, making recycled paper unsuitable for some packaging as it is used over and over. Recovered paper of different grades is suitable for a number of products other than packaging with significant substitution possibilities, but policies examined here implicitly discourage these uses. Other materials have similar quality problems. In addition, many alternative uses exist for recycled material, particularly as fiber substitutes in carpeting and insulation or in construction products. At any given level of supply, demand from these other markets increases the prices for these materials, and thus the cost of these policies to packages required to use these materials at certain rates.

49 If packaging could also *get* its recycled materials from other sources, then supply of recycled materials may increase, and costs might either go up or down. But it is difficult to make packaging out of other materials. As noted elsewhere in this paper, for instance, glass bottles are produced from glass bottles, and other products, like Visionware, are considered contaminants. Similar considerations apply for materials like paper, steel, plastics, and so on. Note, also, that this *analytic* assumption differs from relaxing the assumption about *policy* that recycled content cannot be credited in different ways. The mechanisms for allowing indirect use credits have not been discussed in detail here, but would probably require moving responsibility back from manufacturers to waste-disposal agencies, which is contrary to the core of these policy proposals. A true "open-loop" system that allowed these indirect credits is *likely to be less costly than the closed-loop system discussed here*.

50 Robert P. Anex and Richard J. McCann, *Solid Waste Disposal and Recycling*, Working Paper (Davis, Calif.: M.Cubed, March 1995).

51 This analysis follows the analytic model presented by L.L. Gaines and F. Stodolsky, *Mandated Recycling Rates: Impacts on Energy Consumption and Municipal Solid Waste Volume*, ANL/ESD-25, prepared for U.S. Department of Energy, Office of Policy, by Energy Systems Division, Argonne National Laboratory, Argonne, Ill., December 1993. See also L.L. Gaines and M.M. Mintz, *Energy Implications of Glass-*

recycled materials, manufacturing packages from these materials, and disposing of packaging.[52] The costs for using recycled materials are compared against a baseline of using 100 percent virgin material inputs. Cost estimates are based on specified mixes of virgin and recycled material inputs along with energy, capital and labor expenditures.[53] All of these costs are dependent on recycling rates and changes in production processes necessitated by using recycled versus virgin materials.

The chapter begins by describing the analysis and sources for costs in each step of the production and disposal process. We address virgin raw material extraction, recovery of recycled materials, packaging production, and finally waste disposal. Each of these steps is also discussed in greater detail in the Appendix. Next we discuss the implications for each of the four recycling policies. Finally, we compare the projected costs for each policy and the net private and social costs by material. The tables and figures, organized by material, are discussed for each policy. Each table described relates policy levels to recycled content targets and overall private and social costs.

B. Summary of Results

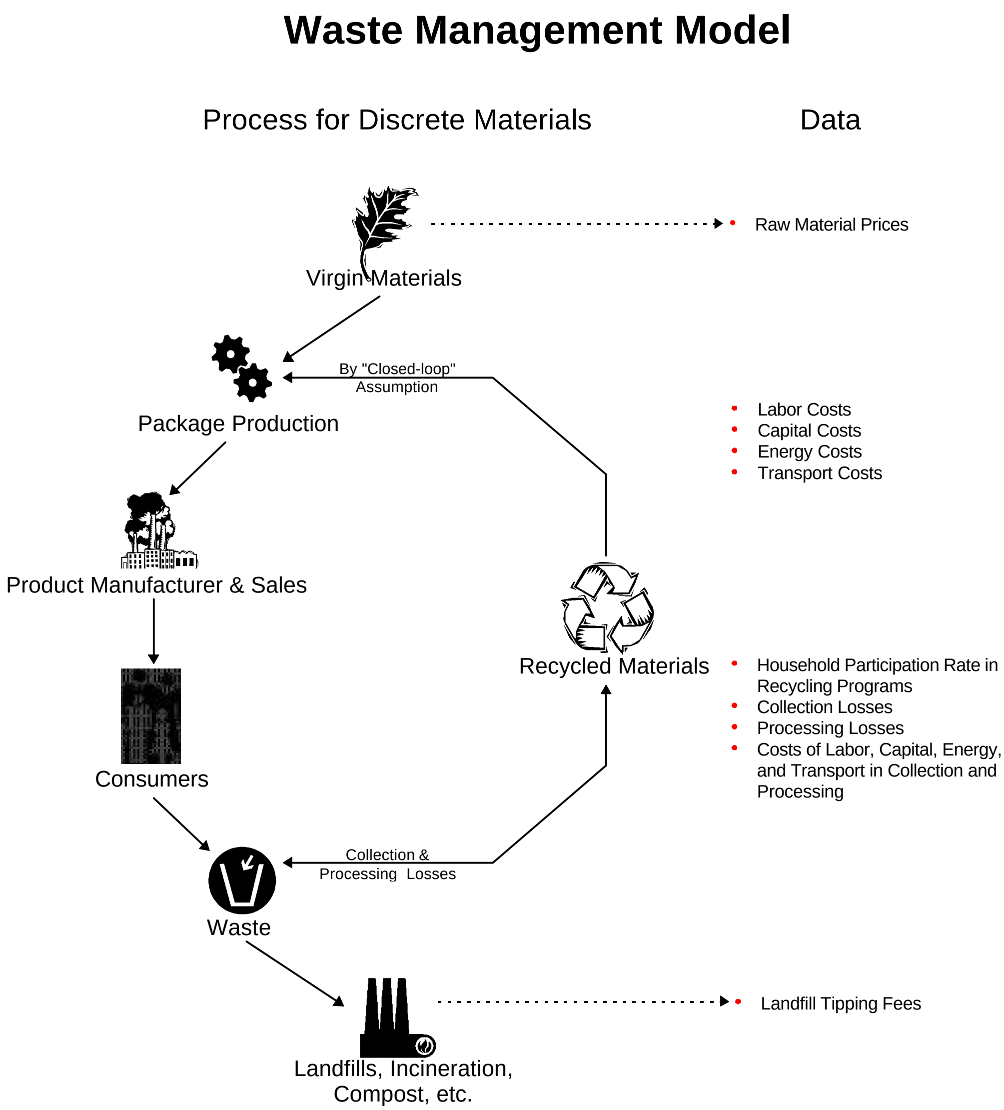
The direct economic impacts on six packaging materials from four national recycling policy proposals were analyzed. The materials were glass, paperboard, steel cans, HDPE, LDPE and PET plastics. The policies were recycled content, virgin materials taxes, advance disposal fees, and manufacturer reponsibility. The levels for each policy were linked to specified recycled content (or conversely, waste-reduction) levels to make the policies comparable.

In general, this analysis shows societal benefits at lower recycled-content levels under “best-case” conditions; however, as content rises and conditions become less favorable, societal costs rise, creating economic losses. The benefits at lower content levels are not surprising—many packaging manufacturers have used recycled-content materials at these levels without governmental intervention. The implied market scrap values at these levels often correlate with historic scrap prices under stable market conditions as well.

Container Recycling, ANL/ESD-18, NREL/TP-430-5703 (NTIS DE94000288) (Argonne, Ill: Energy Systems Division, Argonne National Laboratory; and National Renewable Energy Laboratory, March 1994).

52 External costs such as environmental damages are not included in this analysis, but could be incorporated in the future using much of the information presented in this study. For example, the amount and type of transportation, and the material processing information could be used as a basis for estimating air pollution by applying appropriate emission factors. Differences in ground water discharges also could be estimated based on differences in landfill disposal rates.

53 The baseline year for use and expenditures is 1991. *Recycled material prices in the marketplace do not directly affect the cost analysis*; rather the recycled material prices used here are either derived as residuals of other cost components or reflect true, full costs of material recovery. In other words, *the recycled material prices in this study represent the “demand” and “supply” curves rather than the “market-clearing” price*. As such, the results of this analysis are unchanged by the swings experienced recently in the recycled material markets.



Data Sources and Assumptions Used in the Analysis of Recycling Costs

The quantitative model underlying the policy analysis is based on data collected from a number of sources and assumptions required to overcome the numerous data gaps on solid waste management activity. Perhaps the biggest hurdle to this analysis is the diversity and localized nature of solid waste disposal in this country. No single system can be described as “typical,” which means that a range of values is appropriate for analysis. Of course, this diversity also implies that a national (or even state) policy is likely to be inappropriate. A second problem is the lack of data on production costs using recycled material. Manufacturers sometimes have limited experience with these materials, or the materials may not be appropriate for the original use. We have tried to extrapolate from industry data where appropriate, but we may not have even bounded the problem. The data and assumptions used are discussed in greater detail in an appendix at the end of this report.

A. Cost of Virgin Raw Materials

The baseline for estimating the cost of implementing various recycling policies is the production of a container using all virgin materials (plus internal factory recycling). The cost of these virgin materials is based on the market price plus delivery costs. This analysis assumes that the market price is a close approximation of the true costs to produce raw materials because competition is unlikely to allow taking of excess profits in these markets. These market prices include labor and energy costs plus a return to investment in capital. Energy prices also were estimated for each step of the manufacturing and disposal process. Prices for natural gas, fuel and diesel oil, coal and electricity were identified based on the industry's SIC code or grouping.

B. Recycled Material Recovery and Processing

Recovery of recycled materials is analyzed as a parallel process to production and supply of raw materials. The material recovery process involves three steps: (1) collection, (2) sorting and processing, and (3) transportation to the manufacturer. The collection process cost estimates are based on analysis of co-collection and separate collection systems. The processing costs are based on a typical materials recovery facility (MRF). Costs are differentiated by material, and overall MRF costs are allocated based on the proportion of recycled materials represented by that single material. The final steps in the material recovery phase are additional processing, particularly for glass, and transportation from the MRF to the manufacturing plant.

C. Production Costs

The production processes for each of these materials are discussed in detail in two Argonne National Laboratory (ANL) reports.[54] These reports describe the required material and energy inputs and mass-balances in using either all-virgin or all-recycled materials.[55] Our analysis interpolates between these two values to estimate the costs at various recycled-content levels.[56] The production costs are calculated for each step of the process and are adjusted for material losses in each of these steps. Costs are expressed in terms of dollars per unit of output.

D. Waste Disposal Costs

Waste disposal costs included in this study are for both direct post-consumer waste and losses from the diverted recycled-material stream. In other words, we have accounted for the costs of disposing of consumer waste diverted directly to landfills and for the costs of disposing of residual material that enters the material-recycling process but is rejected for various reasons. This approach can lead to the conclusion that inefficient recycling systems can result in waste-disposal costs that are not substantially less than those for "once-through" material use.

One major drawback of this analysis is that it does not capture the local and regional variations in these costs which are critical to determining optimal levels of recycling.[57] Because virtually all solid waste management costs can be internalized (i.e., paid entirely by the direct users of the service), the most economically efficient level of recycling is a function of both the value of producing a product using recycled materials (the demand), and the costs of collecting and processing the material minus the savings from avoiding disposal of that material (the supply). The supply component varies substantially by location, but this variation is not captured here. For example, landfill tipping fees in the early 1990s ranged from $5 to $120 per ton.[58] For this reason, this analysis is best used as illustrative of how to assess recycling programs rather than as a means of determining a national recycled-material-use policy.

In fact, a national policy is inappropriate because it cannot easily accommodate the local variation in waste disposal costs and product demand.[59] Any national policy will result in large cross-subsidies between regions. Areas with high disposal costs, such as the Northeast, may realize large savings from waste diversion while low-cost regions such as the Rocky Mountains may find the total of their product plus disposal costs rising substantially to pay for the savings in the Northeast. The differences in these benefits are exacerbated by the fact that producers and consumers often reside in different regions. A national company may be compelled to have differing levels of recycled content for different regional markets. In fact, one problem arises where statewide policies by a large state such as California become a *de facto* national policy because that state's market is so dominant. In that case, the state imposing the

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54 Gaines and Stodolsky, *Mandated Recycling Rates*; Gaines and Mintz, *Energy Implications of Glass-Container Recycling*.

55 The two ANL reports do not address the long-term sustainability of using recycled materials under steady-state (or constant) conditions. Their estimates are based on a "snapshot" of a process that relies entirely on recycled materials versus all-virgin—a situation that is simply not sustainable due to the laws of entropy as well as other critical considerations discussed in this study. For this reason, these studies tend to overestimate the benefits of using recycled materials in terms of energy savings.

56 An important distinction exists between recycled *content* and a recycling *rate*. Recycled content describes the amount of recycled material contained in a product. This can be measured either as an initial input or in terms of final content after accounting for manufacturing losses (which are typically higher with recycled material leading to a lower content level). Recycling rate describes the amount of material recovered from the waste stream for reuse in the manufacturing process. While in the short-run or for particular products, recycled content can be higher than the rate, ultimately the recycled content level must be *below* the recycling rate to be sustainable. The constraint imposed by the rate thus limits achievable content levels.

57 Anex and McCann, *Solid Waste Disposal and Recycling*.

58 Gaines and Mintz, *Energy Implications of Glass-Container Recycling*, p. 53.

59 Anex and McCann, *Solid Waste Disposal and Recycling*.

policy (which may have a high-cost waste management system) can force other smaller, low-cost states to subsidize the larger state's waste-disposal costs in a manner similar to a national policy.

FRAMEWORK FOR ANALYZING PROPOSED NATIONAL RECYCLING POLICIES

Tables 3-1 through 3-6 and Figures 3-1 through 3-6 assess the net benefits or costs of meeting a range of specified recycled-content targets. These tables and figures present results based on “best” and “worst” case assumptions.[60]

The methodology used to develop this analysis and the general layout of the tables are described in this section, and the quantitative results are discussed in in the final section. These compare the direct production and social costs for RC, VMT, and ADF policies for glass containers, steel cans, paperboard and three types of plastic. The costs of an MR policy are implicit in this analysis and equal the difference between total costs under a recycled-content scenario and production costs under an all-virgin scenario. The tables compare the relative costs and values for four different levels of post-consumer recycled content, which vary with the material. This information is transformed into either equivalent virgin material taxes or advance disposal fees for the various material components. The tables also summarize:

- the direct production costs, if manufacturers had to bear the entire waste and recycled material collection, processing, and production costs, and do not reflect the savings in reduced waste disposal due to increased recycled material use,[61] and
- the social costs, which include both the direct production costs and the savings in reduced waste disposal costs.

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60 The range of uncertainty about waste-management system costs and performance are so large, and so little information is readily available about national or regional averages, that we chose to present only the *bounds* on these costs rather than *expected* or *average* values.

61 This concept is akin to the German “Green Dot” program, an MR policy.

Table 3-1: Glass

per ton	Best	Worst	Best	Worst	Best	Worst	Best	Worst
a) Recycled Content (1)	20%	20%	30%	30%	40%	30%	50%	30%
b) % of All Recyclables	15%	10%	15%	10%	15%	10%	15%	10%
Virgin Tax/Raw Ton								
c) Virgin Elasticity	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92	-0.92
d) Sand	$9	$9	$14	$14	$18	$14	$23	$14
e) Limestone	$13	$13	$20	$20	$26	$20	$33	$20
f) Feldspar	$10	$10	$16	$16	$21	$16	$26	$16
g) Soda Ash	$29	$29	$43	$43	$57	$43	$71	$43
h) Total/Ton Output	$16	$16	$24	$24	$32	$24	$39	$24
Advance Disposal Fee (compensatory)								
i) $/Ton Output	$23	$14	$30	$29	$38	$29	$45	$29
j) $/Virgin Pkg.	$0.01	$0.01	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02
Recycling Costs								
k) Per Ton Cullet	$146	$553	$146	$553	$146	$553	$146	$553
l) Per Ton Output	$29	$111	$44	$166	$58	$166	$73	$166
Waste Disposal								
m) Tons Generated	0.82	0.82	0.73	0.74	0.64	0.74	0.55	0.74
n) Avoided Cost/Ton Output	$23	$14	$30	$29	$38	$29	$45	$29
Net Cost/Ton Output (2)								
o) Net Production Cost	$21	$104	$26	$149	$31	$149	$36	$149
p) Net Social Cost	($1)	$89	($4)	$119	($6)	$119	($9)	$119
q) Manuf. Responsibility	$82	$173	$80	$203	$77	$203	$75	$203
Value/Ton Scrap (3)								
r) Prod.Cullet Value	$42	$40	$64	$63	$75	$63	$81	$63
s) Total Cullet Value	$152	$106	$159	$154	$162	$154	$163	$154

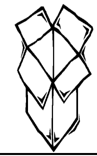
Notes:
(1) Worst Case Content Target is constrained by technical and physical limits.
(2) Net Cost/Ton Output = recycled content compared to 100% virgin base case. These costs are indifferent to the mode of reaching the content targets.
(3) Value/Ton Scrap = Willingness by either producers or society to pay for the use of recycled materials at the Target Content Level, i.e., the "demand value."

The figures compare the relative social values of the various content scenarios based on best-case (low-cost) and worst-case (high-cost) assumptions.

Currently, producers are responsible for production costs and their own disposal costs while consumers are responsible for all postconsumer waste-disposal costs, either in the form of user fees or taxes. We define “direct production costs” as those costs of the producers because they are entirely internalized by the producers themselves. The intent of all of these policy initiatives is to shift at least a portion of the postconsumer disposal costs to producers as a way to change up-front purchasing price signals delivered to consumers regarding the cost of disposal.[62] This leads to an increase in direct production costs.

62 Of course, these costs are already directly evident to consumers in the form of waste-collection fees or are implicitly experienced through taxes for waste services.

Table 3-2: Containerboard



per ton	Best	Worst	Best	Worst	Best	Worst	Best	Worst
a) Recycled Content (1)	30%	30%	40%	32%	50%	32%	60%	32%
b) % of All Recyclables	11%	20%	11%	20%	11%	20%	11%	20%
Virgin Tax/Raw Ton								
c) Virgin Elasticity	-1.34	-0.20	-1.34	-0.20	-1.34	-0.20	-1.34	-0.20
d) Woodchips	$19	$129	$26	$136	$32	$136	$39	$136
h) Total/Ton Output	$19	$129	$26	$136	$32	$136	$39	$136
Advance Disposal Fee (compensatory)								
i) $/Ton Output	$32	$31	$40	$34	$48	$34	$56	$34
j) $/Virgin Pkg.	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Recycling Costs								
k) Per Ton Scrap	$121	$479	$121	$479	$121	$479	$121	$479
l) Per Ton Output	$36	$144	$48	$151	$60	$151	$72	$151
Waste Disposal								
m) Tons Generated	0.70	0.70	0.60	0.69	0.50	0.69	0.40	0.69
n) Avoided Cost/Ton Output	$32	$31	$40	$34	$48	$34	$56	$34
Net Cost/Ton Output (2)								
o) Net Production Cost	($18)	$111	($21)	$116	($24)	$116	($27)	$116
p) Net Social Cost	($50)	$80	($61)	$82	($72)	$82	($82)	$82
q) Manuf. Responsibility	$34	$164	$23	$166	$12	$166	$1	$166
Value/Ton Scrap (3)								
r) Prod.Scrap Value	$240	$167	$230	$133	$224	$107	$220	$89
s) Total Scrap Value	$286	$213	$272	$217	$264	$217	$258	$217

Notes:
(1) Worst Case Content Target is constrained by technical and physical limits.
(2) Net Cost/Ton Output = recycled content compared to 100% virgin base case. These costs are indifferent to the mode of reaching the content targets.
(3) Value/Ton Scrap = Willingness by either producers or society to pay for the use of recycled materials at the Target Content Level, i.e., the "demand value."

In a market, two participants will attempt to find a mutually beneficial trade. If the social benefits are positive in the case of a freely operating market in these recycled materials, a waste-management agency can sell at a profit, while allowing producers to purchase recycled materials at a price that still allows them to benefit as well. From an institutional perspective, we might assume that waste-management agencies act to enhance overall social benefits. Relying on this simple market signal seems a natural approach to guaranteeing this result. However, the tables and figures show at higher recycled-content levels and under less-favorable conditions that waste-management agencies will be selling recycled materials at a loss[63] if the social benefits are negative. This latter condition, which is contrary to our assumption about the objectives of the waste-management agencies, instead could be interpreted as a motive for these agencies to attempt to shift the cost of collecting too much recycled material ("oversupplying") to producers through various policy mechanisms, as we discuss below.

The analysis presented in this chapter ignores two important aspects that are likely to increase the costs associated with any of these policies—implementation costs by government agencies and transaction costs incurred by manufacturers complying with these policies. Each one of these policies requires that a government agency establish some standard or tax level. Since a "blunt" instrument is unlikely to achieve a socially desirable outcome, these policies must be highly tailored and constantly adjusted.

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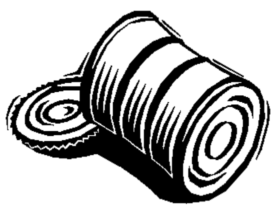
63 The net costs of waste-management choices equal the costs of collection plus processing minus avoided costs of waste-diversion strategies. If the recycling collection and processing costs exceed the benefits from avoiding other waste-disposal costs, then the net benefits are negative, and the waste-management agencies are losing money for their clients, the taxpayers.

Agencies would also require mechanisms to maintain compliance. Producers would have to familiarize themselves with yet another set of regulations and a new evolving marketplace. Lawyers would be necessary for compliance issues; brokers would be needed to maintain sufficient recycled material stocks. Additional contracting and market risk adds further to these costs. In later chapters, some of these transaction costs and implementation costs are discussed generally and in the brief case studies of two actual policies—Green Dot in Germany and ADFs in Florida.

Table 3-3: Steel



per ton	Best	Worst	Best	Worst	Best	Worst	Best	Worst
a) Recycled Content	30%	30%	40%	37%	50%	37%	60%	37%
b) % of All Recyclables	10%	3%	10%	3%	10%	3%	10%	3%
Virgin Tax/Raw Ton								
c) Virgin Elasticity	-1.98	-1.98	-1.98	-1.98	-1.98	-1.98	-1.98	-1.98
d) Iron Ore	$13	$13	$17	$16	$21	$16	$25	$16
e) Limestone	$9	$9	$12	$11	$15	$11	$18	$11
f) Coal	$9	$9	$12	$12	$16	$12	$19	$12
h) Total/Ton Output	$20	$20	$27	$25	$33	$25	$40	$25
Advance Disposal Fee (compensatory)								
i) $/Ton Output	$31	$24	$39	$34	$47	$34	$55	$34
j) $/Virgin Pkg.	$0.00	$0.00	$0.00	$0.00	$0.01	$0.00	$0.01	$0.00
Recycling Costs								
k) Per Ton Scrap	$34	$46	$34	$46	$34	$46	$34	$46
l) Per Ton Output	$10	$14	$13	$17	$17	$17	$20	$17
Waste Disposal								
m) Tons Generated	0.73	0.75	0.64	0.69	0.55	0.69	0.47	0.69
n) Avoided Cost/Ton Output	$31	$24	$39	$34	$47	$34	$55	$34
Net Cost/Ton Output (2)								
o) Net Production Cost	($2)	$33	$6	$59	$18	$59	$36	$59
p) Net Social Cost	($33)	$9	($33)	$25	($29)	$25	($20)	$25
q)Manuf. Responsibility	$50	$93	$50	$109	$55	$109	$64	$109
Value/Ton Scrap (3)								
r) Prod.Scrap Value	$82	$86	$85	$88	$86	$88	$87	$88
s) Total Scrap Value	$178	$153	$174	$166	$171	$166	$170	$166

Notes:
(1) Worst Case Content Target is constrained by technical and physical limits.
(2) Net Cost/Ton Output = recycled content compared to 100% virgin base case. These costs are indifferent to the mode of reaching the content targets.
(3) Value/Lb Scrap = Willingness by either producers or society to pay for the use of recycled materials at the Target Content Level, i.e., the "demand value."

Table 3-5: PET

per pound	Best	Worst	Best	Worst	Best	Worst	Best	Worst
a) Recycled Content (1)	10%	10%	20%	20%	30%	30%	40%	37%
b) % of All Recyclables	2%	1%	2%	1%	2%	1%	2%	1%
Virgin Tax/Raw Lb								
c) Virgin Elasticity	-0.86	-0.84	-0.86	-0.84	-0.86	-0.84	-0.86	-0.84
d) Hydrocarbons	$0.012	$0.012	$0.024	$0.024	$0.035	$0.036	$0.047	$0.044
h) Total/Lb Output	$0.015	$0.015	$0.029	$0.030	$0.044	$0.045	$0.059	$0.055
Adv. Disposal Fee (compensatory)								
i) $/Lb Output	$0.024	$0.014	$0.026	$0.019	$0.028	$0.024	$0.031	$0.028
j) $/Virgin Pkg.	$0.001	$0.001	$0.001	$0.001	$0.001	$0.001	$0.002	$0.001
Recycling Costs								
k) Per Lb Scrap	$0.072	$0.219	$0.072	$0.219	$0.072	$0.219	$0.072	$0.219
l) Per Lb Output	$0.007	$0.022	$0.014	$0.044	$0.022	$0.066	$0.029	$0.081
Waste Disposal								
m) Lbs Generated	0.93	0.96	0.86	0.92	0.80	0.88	0.73	0.85
n) Avoided Cost/Lb Output	$0.024	$0.014	$0.026	$0.019	$0.028	$0.024	$0.031	$0.028
Net Cost/Lb Output (2)								
o) Net Production Cost	$0.025	$0.133	$0.040	$0.160	$0.056	$0.187	$0.071	$0.205
p) Net Social Cost	$0.001	$0.119	$0.014	$0.141	$0.027	$0.163	$0.041	$0.178
q) Manuf. Responsibility	$0.044	$0.163	$0.058	$0.185	$0.071	$0.206	$0.084	$0.221
Value/Lb Scrap (3)								
r) Prod.Scrap Value	($0.237)	($2.229)	($0.170)	($0.904)	($0.148)	($0.462)	($0.137)	($0.299)
s) Total Scrap Value	$0.076	($0.753)	$0.014	($0.267)	($0.007)	($0.104)	($0.017)	($0.045)

Notes:
(1) Worst Case Content Target is constrained by technical and physical limits.
(2) Net Cost/Lb Output = recycled content compared to 100% virgin base case. These costs are indifferent to the mode of reaching the content targets.
(3) Value/Lb Scrap = Willingness by either producers or society to pay for the use of recycled materials at the Target Content Level, i.e., the "demand value."

A. Recycled Content

Table 3-4: HDPE

per pound	Best	Worst	Best	Worst	Best	Worst	Best	Worst
a) Recycled Content (1)	10%	10%	20%	20%	30%	26%	40%	26%
b) % of All Recyclables	3%	4%	3%	4%	3%	4%	3%	4%
Virgin Tax/Raw Lb								
c) Virgin Elasticity	-0.86	-0.84	-0.86	-0.84	-0.86	-0.84	-0.86	-0.84
d) Hydrocarbons	$0.006	$0.006	$0.013	$0.013	$0.019	$0.017	$0.025	$0.017
h) Total/Lb Output	$0.006	$0.006	$0.012	$0.012	$0.017	$0.015	$0.023	$0.015
Advance Disposal Fee (compensatory)								
i) $/Lb Output	$0.024	$0.016	$0.026	$0.023	$0.029	$0.027	$0.031	$0.027
j) $/Virgin Pkg.	$0.001	$0.001	$0.001	$0.001	$0.002	$0.001	$0.002	$0.001
Recycling Costs								
k) Per Lb/Scrap	$0.072	$0.331	$0.072	$0.331	$0.072	$0.331	$0.072	$0.331
l) Per Lb/Output	$0.007	$0.033	$0.014	$0.066	$0.022	$0.087	$0.029	$0.087
Waste Disposal								
m) Lbs Generated	0.91	0.97	0.82	0.94	0.74	0.92	0.65	0.92
n) Avoided Cost/Lb Output	$0.024	$0.016	$0.026	$0.023	$0.029	$0.027	$0.031	$0.027
Net Cost/Lb Output (2)								
o) Net Production Cost	($0.001)	$0.074	$0.000	$0.117	$0.002	$0.144	$0.003	$0.144
p) Net Social Cost	($0.025)	$0.059	($0.026)	$0.095	($0.027)	$0.118	($0.028)	$0.118
q) Manuf. Responsibility	$0.019	$0.102	$0.018	$0.138	$0.016	$0.161	$0.015	$0.161
Value/Lb Scrap (3)								
r) Prod.Scrap Value	$0.096	($0.666)	$0.083	($0.122)	$0.079	$0.007	$0.077	$0.007
s) Total Scrap Value	$0.321	($0.036)	$0.204	$0.077	$0.165	$0.104	$0.146	$0.104

Notes:
(1) Worst Case Content Target is constrained by technical and physical limits.
(2) Net Cost/Lb Output = recycled content compared to 100% virgin base case. These costs are indifferent to the mode of reaching the content targets.
(3) Value/Lb Scrap = Willingness by either producers or society to pay for the use of recycled materials at the Target Content Level, i.e., the "demand value."

Each table shows four policy scenarios with increasing recycled-content requirements. Row (a) shows these content levels. For each scenario, costs under best and worst cases are estimated. Due to physical limits on recycled material use (particularly in the "worst-case" scenarios), some recycled-content mandates are simply not achievable on a steady-state basis. In these cases, only a reduction in package use will achieve these standards. The tables instead show this effect by capping recycled content at the constrained level.

Certain recycled-content levels cannot be achieved due to technological constraints that may not be easily surmounted:

- First, the recycling system may not be able to produce sufficient material of the required quality to meet the higher content levels. *This becomes evident in the "worst-case" scenarios for almost all materials where the sustainable content levels top out between 26 and 37 percent.* The limitations come from limited program participation, spoilage and breakage during collection and processing, and contamination by mixing of materials. Glass is often contaminated with mixed colors or Visionware cookware;[64] plastics must often achieve a purity
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64 Telephone communication, Carl Parlett, glass industry consultant, February 15, 1995.

Table 3-6: LDPE

per pound	Best	Worst	Best	Worst	Best	Worst	Best	Worst
a) Recycled Content (1)	10%	10%	20%	20%	30%	26%	40%	26%
b) % of All Recyclables	3%	1%	3%	1%	3%	1%	3%	1%
Virgin Tax/Raw Lb								
c) Virgin Elasticity	-0.86	-0.84	-0.86	-0.84	-0.86	-0.84	-0.86	-0.84
d) Hydrocarbons	$0.006	$0.006	$0.013	$0.013	$0.019	$0.017	$0.025	$0.017
h) Total/Lb Output	$0.006	$0.006	$0.012	$0.012	$0.017	$0.015	$0.023	$0.015
Advance Disposal Fee (compensatory)								
i) $/Lb Output	$0.024	$0.016	$0.026	$0.023	$0.029	$0.027	$0.031	$0.027
j) $/Virgin Pkg.	$0.001	$0.001	$0.001	$0.001	$0.002	$0.001	$0.002	$0.001
Recycling Costs								
k) Per Lb Scrap	$0.072	$0.331	$0.072	$0.331	$0.072	$0.331	$0.072	$0.331
l) Per Lb Output	$0.007	$0.033	$0.014	$0.066	$0.022	$0.087	$0.029	$0.087
Waste Disposal								
m) Lbs Generated	0.91	0.97	0.82	0.94	0.74	0.92	0.65	0.92
n) Avoided Cost/Lb Output	$0.024	$0.016	$0.026	$0.023	$0.029	$0.027	$0.031	$0.027
Net Cost/Lb Output (2)								
o) Net Production Cost	($0.001)	$0.073	$0.005	$0.119	$0.010	$0.147	$0.016	$0.147
p) Net Social Cost	($0.024)	$0.057	($0.022)	$0.096	($0.019)	$0.120	($0.016)	$0.120
q) Manuf. Responsibility	$0.019	$0.101	$0.022	$0.140	$0.025	$0.164	$0.028	$0.164
Value/Lb Scrap (3)								
r) Prod.Scrap Value	$0.092	($0.626)	$0.058	($0.147)	$0.047	($0.033)	$0.041	($0.033)
s) Total Scrap Value	$0.320	($0.022)	$0.183	$0.072	$0.138	$0.094	$0.115	$0.094

Notes:
(1) Worst Case Content Target is constrained by technical and physical limits.
(2) Net Cost/Lb Output = recycled content compared to 100% virgin base case. These costs are indifferent to the mode of reaching the content targets.
(3) Value/Lb Scrap = Willingness by either producers or society to pay for the use of recycled materials at the Target Content Level, i.e., the "demand value."

- of at least 98 percent for a single resin, while at least seven major types of plastic are in the waste stream and are not always easily distinguished.[65]

- Second, recycled materials often are not appropriate for reuse in their original form. Steel cans can typically only be used in flat-rolled steel plate due to contamination problems; paper fibers shorten and lose strength as they are recycled. Because packaging often is a highest use of a particular material requiring the highest quality, recycled materials may not achieve these standards and may be diverted to less valuable uses. Recycled-content standards do not provide credit for these alternative uses.[66]
- Third, these other uses often compete with packaging for recycled material, and other users may be willing to pay a higher price for the material. For example, recycled plastics are often used in producing fiber for carpeting where the material need not meet the cleanliness standards for food containers. By requiring recycled content in packaging, these alternative uses may face higher market prices than are socially efficient due to the mandated increase in demand.

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65 Robert Anex, *Recycling Technologies*, Working Paper (Washington, D.C.: Resources for the Future and the University of California at Davis, December 21, 1993).

66 Tradeable credit schemes are one means of accommodating open-loop uses.

Table 3-7: Virgin Material Tax Ranges	
Glass	\$16–\$39 per ton
Containerboard	\$19–\$136 per ton
Steel	\$20–\$40 per ton
HDPE	\$0.006–\$0.023 per pound
PET	\$0.015–\$0.059 per pound
LDPE	\$0.006–\$0.023 per pound

Determining the basis of "recycled content" is also difficult. In this analysis, we assumed the standard was measured on the initial inputs into the production process from post-consumer waste, not the actual final content level. Two dimensions of defining "content" can confound this approach, however. The use of almost all recycled materials results in higher production losses than use of an equivalent amount of virgin material. Thus, virgin material must be added in to make the final product, and therefore, the final recycled content falls. Accounting for these losses can be complex and variable, though. Second, whether "content" includes in-plant waste or not is also critical. For example, a substantial segment of paper packaging is made from sawmill byproducts of lumber production; steel scrap is constantly recirculated within a steel mill. Often many packages have total recycled content of 50 percent or more under a broader accounting standard.

Row (b) shows the proportion of all types of recyclables (e.g., glass, paper, steel, plastic, etc.) in the municipal waste stream attributable to that material analyzed in this table. For example, glass is 10 to 15 percent of the recyclables that can be collected and processed.

B. Virgin Materials Tax

The second policy assessed is the virgin materials tax. We assume that such a tax will be assessed on the proportion of the packaging attributable to that virgin material. This means that the tax would not be implemented as a single flat rate but would be prorated. In fact, nearly all packaging material would have some VMT component since new virgin material must be introduced to maintain the material-use cycle. A packaging manufacturer may not be able to meet the recycled-content target specified in designing the VMT, due to physical or technological constraints. In these cases, the manufacturer may either substitute with other materials or simply pay the full VMT. This threshold of shifting to other materials represents a "backstop" on the upper bound of the VMT, but we have not identified these levels here.

The key to analyzing the VMT is in the price elasticity for virgin materials used in particular packaging. Row (c) shows an estimated responsiveness of material use and content to changes in price (i.e., price elasticities).[67] This is how much virgin material use would fall with an increase in virgin material prices (i.e., for a 1 percent increase in price, what proportion of 1 percent would material use fall). Rows (d) through (g) show the virgin material tax on each raw material input necessary to be equivalent to the recycled-content level in the appropriate policy scenario. This tax is shown as dollars per ton (or pound) of raw material input, while a total tax in terms of dollars per ton of final product output is shown in row (h).[68] The tax equals the price increase necessary to achieve a reduction in virgin material use given the virgin material price elasticity in row (c).[69] Ranges of VMTs per ton of output for different materials (abstracted from Tables 3-1 through 3-6) are shown in Table 3-7.

Our analysis of the VMT relies on several key (and overly simple) assumptions:

- First, we assume that no substitution will occur with other materials as the tax is implemented. In other words, as the tax is imposed on virgin materials, the manufacturer will not switch to using a different material in its packaging (e.g., from glass to plastic). Of course, if

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67 Tellus Institute, *Disposal Cost Fee Study*, Final Report, 90-131, prepared for the California Integrated Waste Management Board, Boston, February 15, 1991.

68 The cumulative VMT on output *must* only be collected on the purchase price of the virgin materials. A tax on the material *output* would also affect the use of other inputs such as labor, investment and energy without necessarily reducing the use of virgin materials.

69 The equation for calculating the VMT based on a target recycled content (RC) is: $\boldsymbol{VMT_i = P_i * RC / x_i}$ where x_i is the input demand elasticity for the individual virgin materials and P_i is the price of the virgin material.

manufacturers switch to other materials, the total costs will shift in a way not predicted by this analysis, and total societal costs may rise or fall.

- Second, as a corollary, we also assume that the VMT will not cause a distortion in the use of other inputs such as capital, labor or energy. Instead of increasing recycled content or even reducing packaging to lower the VMT paid, the manufacturer may try to reduce cost elsewhere or substitute for the current packaging material with an alternative conveyance method (e.g., more refrigeration) which might have undetermined consequences.
- Third, we assume that the VMT on packaging material will somehow be differentiated from other nonpackaging uses of those materials. For example, a general VMT on wood and steel would affect the construction industry more than the packaging industry. If the VMT must be imposed across the board, the changes in the whole U.S. economy would affect total product demand in an indeterminate manner.
- Finally, we are *not* predicting that a VMT will result in the associated recycled-content level; rather, we are predicting that waste-disposal rates will fall to a level equivalent to that of the recycled-content policy. In other words, the VMT will reduce product demand in such a way that virgin material use will be at the same level as if virgin were replaced with recycled materials. *In fact, a VMT is unlikely to achieve a substantially higher recycled content level due to the equally higher costs of using recycled materials.*[70] Higher packaging prices will lead to lower consumer demand and thus a lower waste-disposal rate.

C. Advance Disposal Fee

The advance disposal fee (ADF) is expressly designed to shift the cost of package disposal from consumers, in the form of waste-service fees or taxes, to producers, in the form of charges on products or packages. Implicit in this policy is the premise that packaging serves no purpose to consumers other than to convey the package contents to the end user, just like trucking from the factory to the store. In this case, the full costs of conveyance are internalized to the producer. If consumers get additional satisfaction out of the packaging, though, such as ease in handling the product, extended storage, or aesthetic pleasure, then consumers are allowed to free ride on the producers who pay the full disposal costs. Of course, *producers will try to pass a portion of the ADF on to consumers*, and so the ADF, *in theory*, can be just as economically efficient as a correctly designed curbside charge. However, the ADF has practical implementation issues that overwhelm its theoretical equivalency.[71] Some of these issues are discussed in the chapter on Florida's ADF.

There are two different sorts of ADF, one of which we calculate.

The one we calculate, the *compensatory ADF*, is merely designed to make consumers pay a portion of disposal costs. For instance, the compensatory ADF associated with a 30 percent recycling rate is equal to the difference between the disposal costs of a virgin package and the disposal costs of a package with 30 percent recycled content. (The compensatory ADF associated with a recycled content equal to the target is therefore 0.) As the target recycled content rises, so do avoided disposal costs and therefore the compensatory ADF. Note, however, that paying the compensatory ADF associated with a 30 percent recycled content level will not necessarily lead to a 30 percent recycled content level, nor will it necessarily lead to a 30 percent reduction in virgin material use. The effects of a compensatory ADF will likely be much smaller, because disposal costs are relatively small. How, then, does a waste management agency decide to use a 30 percent recycled content level as its baseline against which to evaluate disposal costs? The choice is somewhat arbitrary, unless the ADF is chosen to compensate the waste

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70 We cannot know the actual recycled content of a product after the imposition of a VMT without knowing the elasticity of substitution between virgin materials and recycled materials.

71 Anex and McCann, *Solid Waste Disposal and Recycling*.

Table 3-8: Compensatory Advance Disposal Fee Ranges	
Glass	$14–$45 per ton ($0.01–$0.02 per virgin package)
Containerboard	$31–$56 per ton (under $0.01 per virgin package)
Steel	$24–$55 per ton (under $0.02 per virgin package)
HDPE	$0.016–$0.031 per pound ($0.001–$0.002 per virgin package)
PET	$0.014–$0.031 per pound ($0.001–$0.002 per virgin package)
LDPE	$0.016–$0.031 per pound ($0.001–$0.002 per virgin package)

disposal agency for the entire disposal cost.[72] Ranges of compensatory ADFs for different materials (abstracted from Tables 3-1 through 3-6) are shown in Table 3-8.

The second sort of ADF, which we do not calculate, is the *behavioral ADF*. This fee does not aim to compensate the waste disposal agency for disposal costs, but rather aims to achieve a given level of recycled content or to equivalently decrease the use of virgin material. The analysis of this ADF must rely on estimating how responsive packaging consumption is to changes in the cost of packaging.

The behavioral ADF designed to be equivalent to, say, a 30 percent recycled-content mandate, will try to increase the price of the packaging enough to reduce virgin material use by 30 percent. Because consumers are responsive to the total product price (not the price of the packaging itself), the ADF, imposed on packaging, must have a significant enough effect on the total price to affect consumer behavior. However, the cost of packaging is often a tiny part of the cost of the entire product. Moreover, packaging use is relatively inelastic; for most products, a 10 percent increase in cost results in less than a 1 percent reduction in packaging consumption.

Therefore, the behavioral ADF would probably be considerably larger than the compensatory ADF, and would hence more than compensate the waste disposal agency for any disposal costs. The term “advance disposal fee” would thus be a misnomer, since the fee would be unrelated to disposal costs. We nonetheless refer to it as an ADF because governments that adopt ADFs (as in Florida) often do so with the express purpose of achieving certain levels of recycled content or certain reductions in virgin material use, and not with the purpose of compensating waste disposal agencies.

Calculating the behavioral ADF, however, is tricky. To sufficiently increase the price of the product, the price of the package would have to become so high that it would no longer become profitable for packaging producers to use that material in their packaging. Instead, they would switch to cheaper materials. To take into account manufacturers' substitution between materials is beyond the scope of this study. Therefore, we cannot calculate behavioral ADFs. The reader is, however, advised to keep the compensatory and behavioral ADFs conceptually distinct. Compensatory ADFs may be low, but these estimates have no relevance to ADF proposals that strive to achieve particular recycled-content rates or reductions in virgin material use.

The compensatory ADF, shown in rows (i) through (j), is based on the avoided disposal costs associated with the appropriate recycled-content level. The fee per ton of packaging output, shown in row (i), is equal to the avoided disposal costs in row (n), since these costs are calculated per ton of packaging. The dollar per ton of output measures the ADF as if it were charged as the packaging material was delivered to the final product plant. The per package fee in row (j) is based on “typical” package sizes containing 12 to 16 ounces.

The ADF may lead to increased recycling rates rather than simply reduced packaging consumption only if it meets three conditions when implemented:

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72 But this chapter strives to compare recycled content mandates with other, “equivalent,” policy instruments, where “equivalence” is taken to mean some reasonable correspondence between the policy instrument and the recycled content level. If the compensatory ADF were chosen to compensate the waste disposal agency for the entire disposal cost, the ADF would no longer be “equivalent” to different levels of recycled content but would be the same, regardless of target recycled content level. We must therefore choose particular levels of recycled content as our baseline for the purposes of calculating compensatory ADFs.

- *The price of recycled materials in the market must be less than the ADF-implied cost of using virgin materials.* In other words, the cost of recycled materials to producers must be less than the social value associated with the use of the recycled materials used to set the ADF. However, the market price tends to rise to the value placed on a good or service by a consumer, regardless of the cost to produce that good or service. Thus, one would expect recycled-material prices to rise to the value implied in the ADF and producers would be indifferent between paying the full ADF or using recycled materials in their packages.

- *The full disposal costs for the packages collected through the ADF must be removed from the curbside disposal charge to consumers*. The total cost for the package to consumers, including disposal costs, must remain the same so as not to suppress demand. If the full costs are not netted from waste-disposal rates, consumers will be double-charged for the disposal cost of the package and will reduce demand more than is socially desirable as defined earlier. If product demand falls, the potential market for recycled materials will shrink as well.[73]

- *The collection of materials charged an ADF must be segregated from collection of other waste materials.* If the package disposal charge is collected entirely (or even partially) through an ADF, the consumer will not face a curbside charge for disposing of that product. But for products without an ADF (e.g., yard waste, durable goods, non-package consumables, foodstuffs), a curbside charge will be necessary to cover the cost of collection for these materials. If the ADF and non-ADF materials are mixed, consumers will require a larger volume waste container but will pay the same disposal charge as if the collection systems are separated. Consumers will perceive that the incremental cost of disposing of non-ADF material is lower than the true cost because they receive this large volume for free. If ADF and non-ADF materials are segregated, consumers see the true costs of disposal for all materials. However, they have an incentive to “cheat” and dump non-ADF materials in the ADF collection system since they can “free ride.” (In fact, this effect was seen in Germany after implementation of their packaging-fee system.) Given that packaging materials make up less than one-third of the municipal waste stream in the United States, this could be a serious problem. In addition, if the ADF disposal system is not as convenient as the existing system, consumers will perceive both higher product and disposal costs and thus reduce demand.

D. Recycling Costs

Row (k) shows the costs to collect and process a ton (or pound) of recycled scrap material for delivery to packaging material producers, in best- and worst-case scenarios. These costs include curbside collection, central processing, and delivery as described in Section 4. Row (l) shows the costs per ton of final packaging output (i.e., per glass container, steel can, paperboard, etc.).

In an unregulated market (i.e., no specific content policies), prices for these materials may not track these costs because (1) manufacturers typically pay what the material is worth to them in the production process; and (2) disposal agencies may subsidize the market prices to reflect savings in waste-disposal costs. In the case where manufacturers are required to achieve a certain content level or to pay based on the use of virgin materials, the waste-disposal agencies can include the entire cost of the material

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[73] This is true if ADFs are calculated on the basis of *total* disposal costs. The ADFs actually calculated in this paper charge producers for only a portion of disposal costs, namely, those disposal costs that would be avoided by using a specified level of recycled content. If such an ADF is adopted, then only that portion of disposal costs should be deducted from the curbside charge.

recovery process in their price for recycled materials because the manufacturers have no alternative but to buy those materials.[74]

E. Waste Disposal

Row (m) shows the tons (or pounds) of waste material generated per ton (or pound) of final product output. For a package made of 100 percent virgin material and not recycled, the generated waste equals 1 ton (or pound). The difference between the all-virgin baseline and waste generated in the recycled-content scenario does not equal the recycled-content standard because of losses in the production process in using recycled materials. These losses are diverted to the waste stream after the point at which we assume the recycled content level is determined. An alternative measure to the method discussed in Section 1 above for recycled content would equal (1 – (m)).

Row (n) shows expected waste disposal cost savings ("avoided costs") as a national average for the policy scenarios. The avoided costs are shown per pound (or ton) of packaging material, and are equal to the difference between the cost of waste disposal under the recycled-content scenario and the cost of waste disposal with all-virgin content. These avoided costs vary considerably at the regional and local levels in reality, and the national average should only be used as a broad-brush characterization about the potential effectiveness of these policies.

F. Net Costs of Recycled-Content Target Scenarios

One unique aspect in assessing waste-management systems relative to other environmental problems is that virtually all of these costs are already internalized, that is, recovered through direct charges or fees. When looking at the entire production and disposal system and assuming that the current assignment of responsibility is appropriate (i.e., consumers, not producers, pay for disposal), most waste disposal systems are fully self-funded. The pricing mechanism may be incorrect (insensitive directly to changes in disposal rates), but generally no individual or group is imposing untoward costs on others. This distinction between waste-disposal systems and other environmental issues is important in that *all* costs are *private* and *social* simultaneously. Thus, while we make a distinction here about "direct producer" and "social" costs, the fact is that the former is a fully incorporated component of the latter. Producers are getting a "free-ride" on consumers *only to the extent that one can argue that producers should be responsible for disposing of packaging rather than consumers who enjoy the benefits of the package*. Since packaging does produce consumer benefits, it is not at all clear why disposal costs should be shifted away from consumers.

The net costs to both producers and society as a whole[75] are estimated by subtracting the cost to produce the packaging material for the all-virgin content base case from the cost at the targeted recycled-content level. If the cost of using that amount of recycled material for each of the perspectives is higher, the net cost is positive; if the cost is lower, then it is negative, showing a net benefit. The difference in the direct production (row (o)) and social (row (p)) costs reflect the avoided cost savings to the waste-disposal system. The net production costs include the full recycled collection and processing costs, assuming that producers would be required to pay these full costs with either mandated content requirements, virgin material taxes, advance disposal fees, or a manufacturers' responsibility fee.[76] The net social costs are

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74 Under recycled content, producers have an "inelastic" demand, i.e., their recycled material use is insensitive to changes in recycled material prices because they *must* use a prescribed amount of that material no matter the cost. Only a decrease in demand for the final product (ignored here only for simplicity) will cause manufacturers to reduce their purchases. The VMT and ADF convey the same price signals to the waste disposal agencies (through use of a "backstop" price—the taxes or fees), although producers may not demand the full amount of recovered material.

75 The social costs are from the perspective of a "benign" waste-management agency manager. The manager takes into account costs to all parties when assessing potential benefits and costs. An unregulated market in recycled materials conveys the producers' value for recycled materials to the agency manager without the manager having to understand the entire production process.

76 That is, demand by producers for recycled material would become perfectly inelastic up to the content level, and waste-disposal agencies could pass on all of their costs.

indifferent as to the assignment of costs. This analysis differs from other studies that use the market price for those materials as reflecting the cost of recycled materials; our analysis shows how the market price might deviate from the actual cost of collection and processing.

The figures that follow the tables for each material summarize the net direct production and social values for each recycled-content level under best- and worst-case assumptions. The net social values are shown in terms of dollars per unit (per ton or per pound) of final product output. At low recycled-content levels under the best conditions, the social value is positive in almost all cases. However, as content level increases and/or conditions worsen from optimal assumptions, the net social value generally falls. The wide range of uncertainty reflects the variations in local and material-specific circumstances.

It is also important to remember that these estimates are based on a national average and do not reflect the wide range of regional differences. Even in the case where social value is positive, certain regions with low disposal costs often would be subsidizing benefits in other regions with high disposal costs. These policies could result in large distributional changes in product prices and disposal costs, which would then alter the results of this analysis as consumers change their buying and disposal patterns. The likely effect would be to lower disposal costs in currently high-cost regions, thus encouraging higher rates of disposal in those localities—an outcome contrary to the intention of these policies.

Figure 3-1: Comparison of Glass Cullet Value (Net Value by Content Level)

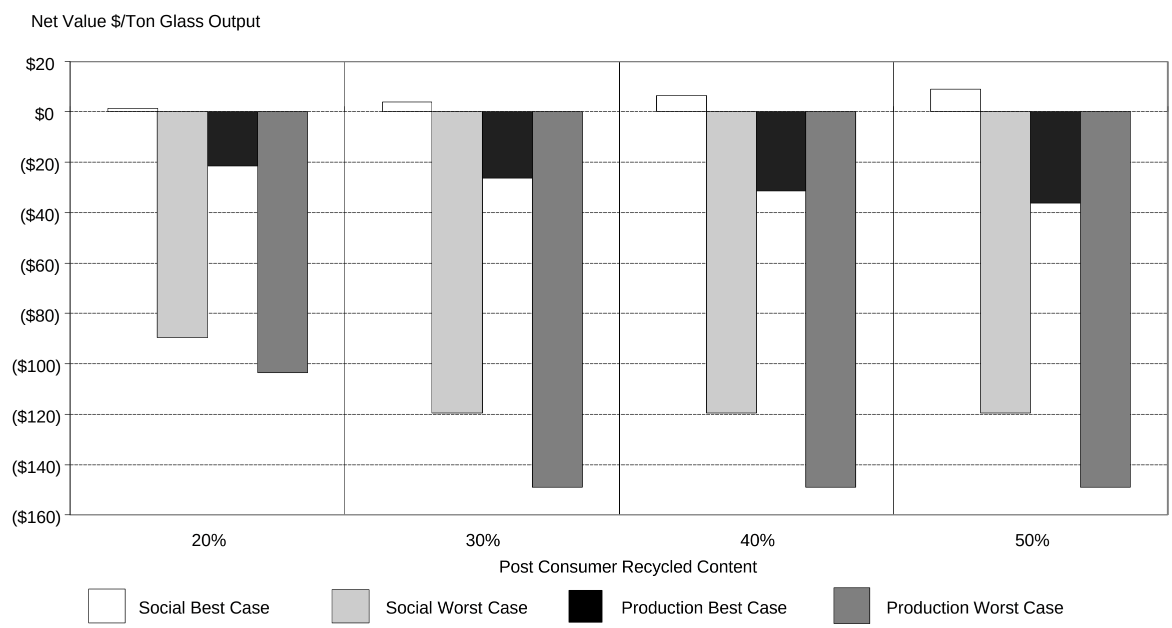


Figure 3-2: Comparison of Recycled Containerboard Value (Net Value by Content Level)

Figure 3-3: Comparison of Steel Scrap Value (Net Value by Content Level)

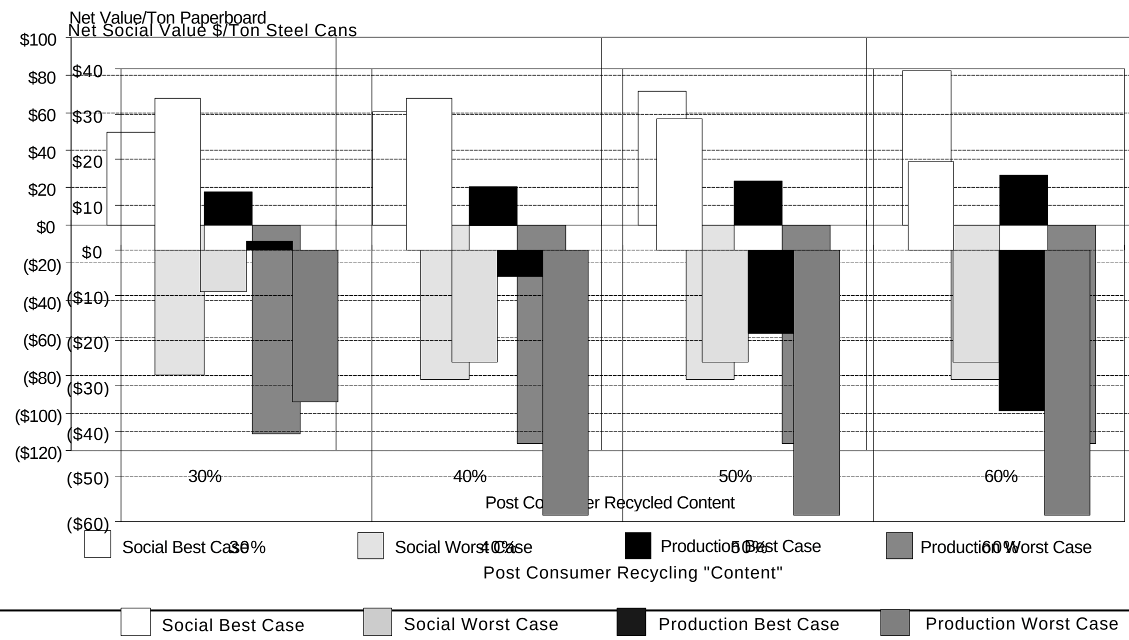


Figure 3-4: Comparison of Recycled HDPE Value (Net Value by Content Level)

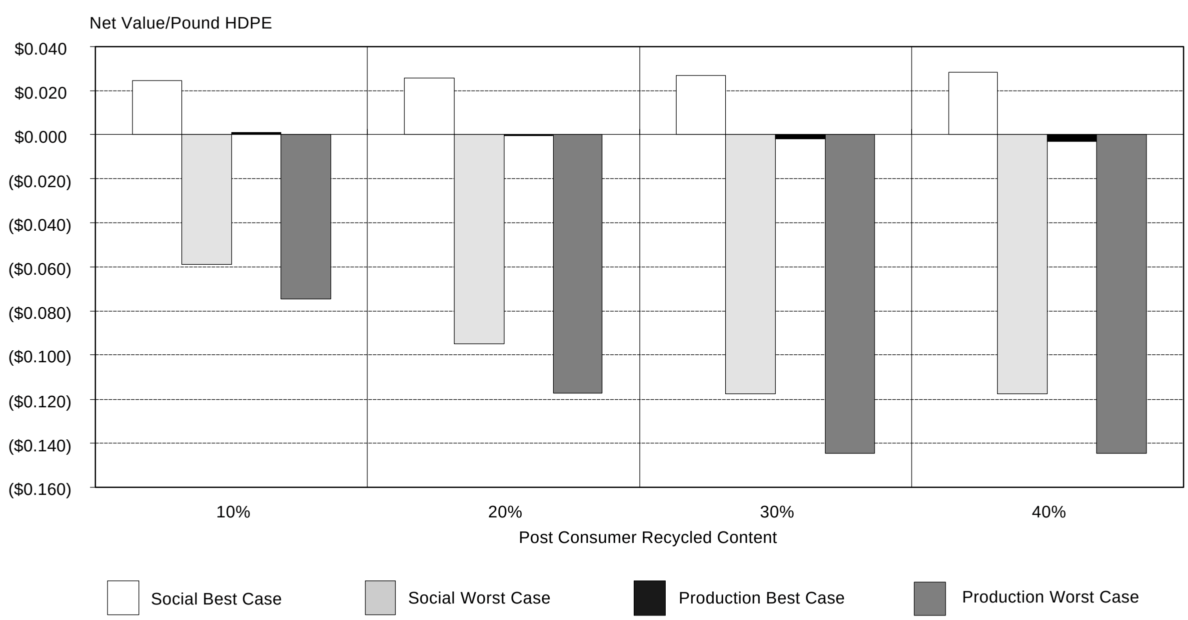


Figure 3-5: Comparison of Recycled PET Value (Net Value by Content Level)

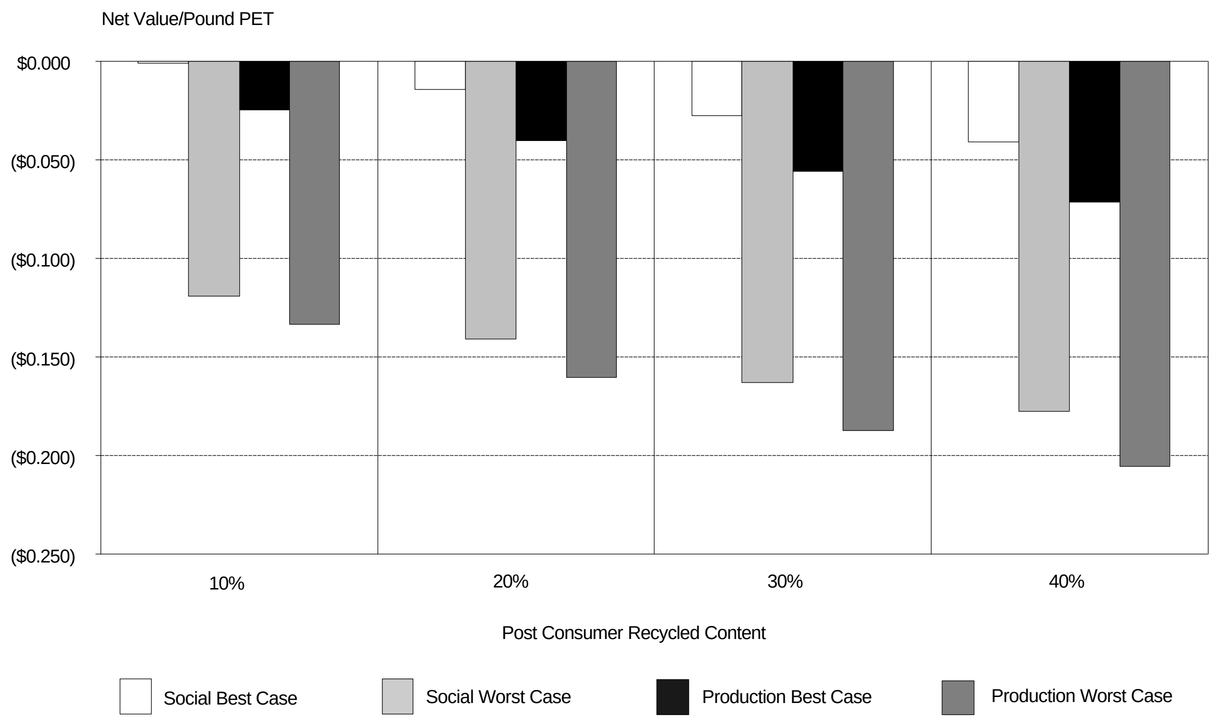
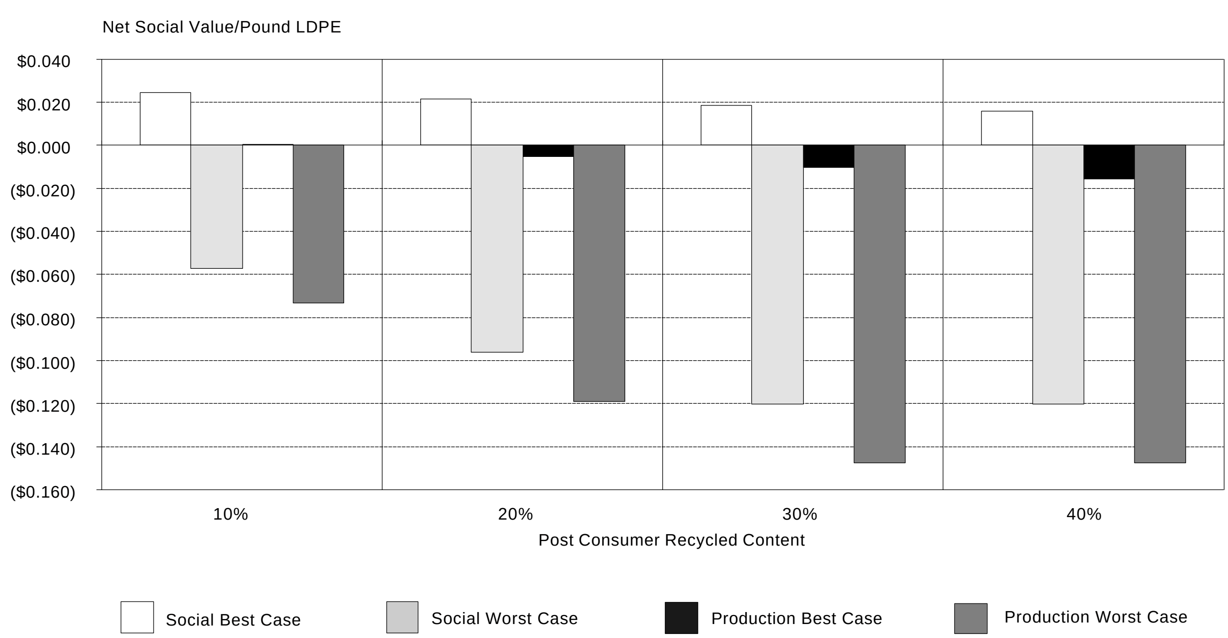


Figure 3-6:Comparison of Recycled LDPE Value (Net Value by Content Level)



Note that the net costs (or benefits) are for levels of recycled content, *not* for the policy mandates per se. Certain content levels are already occurring without policy intervention due to market signals. If no such policy is in place, *the market will tend toward a level where social benefits are positive*. Our analysis confirms that many of these levels are occurring without mandates for glass, paperboard, steel, and certain plastics.

G. Manufacturers' Responsibility

Knowing the net production cost (row (o)) allows us to calculate the costs of a manufacturers' responsibility policy. An MR policy would make the manufacturer pay for both the production and the disposal of his product. Without an MR policy, the manufacturer only pays his own production costs. Therefore, the incremental cost of an MR program is the net production cost (the difference between the cost of virgin production and the cost of producing at the target recycled content level) plus the disposal cost. The cost of an MR policy is shown in row (q). Ranges of MR costs per ton of output for different materials (abstracted from Tables 3-1 through 3-6) are shown in Table 3-9.

H. Recycled Scrap Value

The preceding analysis allows us to determine the actual value of scrap. For example, if using a certain recycled content costs $80 (of which $25 is the cost of scrap) and using all virgin material costs $100, one could save $20 by using that level of recycled content. The cost of scrap could rise by up to $20—to become $45—before producing with all virgin materials became worthwhile. The value of that amount of scrap, therefore, is $45. The value is shown in terms of dollars per ton of scrap (in contrast to the cost per ton of packaging material for the policy).[77]

Table 3-9: Manufacturers' Responsibility Cost Ranges

Glass	$75–$203 per ton
Containerboard	$1–$166 per ton
Steel	$50–$109 per ton
HDPE	$0.015–$0.161 per pound
PET	$0.044–$0.221 per pound
LDPE	$0.019–$0.164 per pound

Row (r) shows the relative value per ton (or pound) of scrap material in the production process. This represents the value added to the production process by replacing a portion of virgin materials with recycled materials. Producers would be willing to pay this amount for a ton (or pound) of scrap at the corresponding recycled-content level. In other words, the scrap value equals the market-clearing price that would lead to a certain recycled-content level if the social benefits are positive and no policy mandates are in place.

Row (s) shows the total social scrap value per ton (or pound) of material recycled. This is what people in the marketplace would be ready to pay for each unit of material recycled *plus avoided disposal costs*. Whether recycled content makes economic sense depends on whether this social scrap value (s) exceeds the avoided disposal costs (n) divided by the recycled content in row (a), plus the recycling costs (k). A positive net social cost (p) indicates that these costs exceed the scrap value and thus recycled content is not socially beneficial.
The difference between the producers' value and the total scrap value is the amount that a waste management agency would subsidize the sale of recycled materials from the avoided costs of diverting waste into recycled feedstock in an unregulated market. Whether this subsidy is appropriate is a *distributional* issue, not one of *efficiency* as often argued by proponents of recycling policy intervention. If consumers benefit from the packaging of a product, one would argue that the current distribution is correct. If consumers gain no benefits from packaging, then producers should pay the disposal costs, and the proposed policies have a proper basis. However, one would be hard-pressed to successfully argue this latter position.

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77 This is essentially the life-cycle *value of marginal product* or the value added from using an incremental unit of recycled materials in the production process. This represents the willingness to pay for the material by manufacturers.

SUMMARY OF ECONOMIC COSTS BY MATERIAL

Tables 3-1 to 3-6 and Figures 3-1 to 3-6 detail the costs of the proposed policies under a range of recycled-content targets. Each of the three policy options is linked to a single measure of recycled "content" and thus the costs are comparable across policies within materials. In general, these policies show societal benefits[78] at lower recycled content levels under "best-case" conditions; however as content rises and conditions become less favorable, societal costs rise, and forcing recycled content to the levels indicated would appear to create economic losses. The benefits at lower content levels are not surprising—*many packaging manufacturers have used recycled-content materials at these levels without governmental intervention*. Note that these results do not mean that a given level of recycled content is achievable or beneficial for each manufacturer, each material, and each product. The benefits we find are not individual benefits, but societal benefits, using average numbers at a high level of aggregation. The implied market scrap values at these levels often correlate with historic scrap prices under stable market conditions as well.

Except in the case of paperboard under best-case assumptions,[79] government policies that shift the cost of disposal from consumers to producers generally result in net increases in direct production costs. These policies essentially impose the disposal costs on producers but retain the savings in reduced waste-management costs for consumers. This occurs because ownership of the disposal systems are not turned over to the producers but rather are held by local waste agencies. This leads to a large discrepancy between production and social costs.

Advance disposal fees appear to range from under $0.01 to $0.02 per typical container (12 to 16 ounces). Virgin material taxes show a wide range due to the differences in production process for each type of material. No estimate was made on how a VMT would affect other industries that consume these materials for uses other than packaging (e.g., electricity generation with coal or natural gas).

A. Glass Containers

The recycled-content targets for glass were specified to range from 20 percent to 50 percent in Table 3-1. However, in the worst case, the steady-state level could not exceed 30 percent.[80] Virgin material taxes would be imposed on four different basic materials—sand, limestone,[81] feldspar and soda ash—with the taxes differing by material and scenario. In the best case, the total VMT ranges from $16 to $39 per ton of glass; in the worst case, the total VMT ranges from $16 to $24 per ton of glass. Advance disposal fees would range from $0.01 to $0.02 per package for all-virgin packaging and from under $0.01 to $0.01 for packages with the target content level. Under best-case conditions, recycled content would produce net social benefits of up to $9 per ton, but would add producer costs of $21 per ton increasing to $36 per ton at higher recycled-content levels. Under worst-case conditions, the recycled content would lead to a net social cost of $89 per ton with costs increasing to $119 per ton; added production costs increase from $104 to $149 per ton.

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78 As a reminder, societal benefits equal producer costs minus savings in avoided waste-disposal costs. In most of these policies, the costs are shifted to producers while the benefits accrue to society in general. Thus, recycled content can show negative producer costs and positive social benefits.

79 The cost of collecting paperboard is apparently less than the cost of virgin pulp production over a wide range of recycling levels and pulp prices. This particular type of recycling has flourished for some time, and the value is reflected in the implicit price estimated in this study.

80 For individual manufacturers and products, of course, these numbers could be different. This does not mean that the same results are achievable for all of the people all of the time.

81 We have left unanswered how a VMT on limestone used in both glass and steelmaking would be differentiated by use.

B. Paperboard

The recycled-content targets for paperboard were specified to range from 30 percent to 60 percent in Table 3-2. However in the worst case, the steady-state level must be less than 32 percent. Virgin material taxes would be imposed on virgin pulp. In the best case, the VMT ranges from $19 to $39 per ton; in the worst case, the VMT ranges from $129 to $136 per ton. Advance disposal fees would be under $0.01 per package, both for all-virgin packaging and for packages with the target content level. Under best-case conditions, recycled content would produce net social benefits of about $50 to $82 per ton as recycled content rises, and give producers benefits of $18 to $27 per ton. Under worst-case conditions, the use of recycled content leads to a net social loss of $80 to $82 per ton and added production costs of $111 to $116 per ton.

C. Steel Cans

The recycled-content targets for steel cans were specified to range from 30 percent to 60 percent in Table 3-3. However, in the worst case, the steady-state level could not exceed 37 percent. Virgin material taxes would be imposed on three different basic materials—iron ore, limestone and coal[82]—with the taxes differing by material and scenario. In the best case, the total VMT ranges from $20 to $40 per ton of steel; in the worst case, the total VMT ranges from $20 to $25 per ton of steel. Advance disposal fees would range from under $0.01 to $0.01 per package for all-virgin packaging and would be below $0.01 for packages with the target content level. Under best-case conditions, these recycling policies would produce net social benefits of $33 per ton falling to $20 as content rises; producers would benefit by $2 per ton at 30 percent, but in all other scenarios, producers experience net costs up to $36 per ton. Under worst-case conditions, the policies lead to social costs of $9 per ton at 30 percent content, increasing to $25 per ton. Added production costs increase from $33 to $59 per ton.

D. HDPE Plastics

The recycled-content targets for HDPE plastic containers were specified to range from 10 percent to 40 percent in Table 3-4. However, in the worst case, the steady-state level must be less than 26 percent. Virgin material taxes would be imposed on the natural gas feedstock,[83] with the total VMT increasing from $0.006 to $0.023 per pound of HDPE in the best case, and from $0.006 to $0.015 per pound of HDPE in the worst case. Advance disposal fees would range from $0.001 to $0.002 per package for all-virgin packaging and would be about $0.001 for packages with the target content level. Under best-case conditions, recycled content would produce net social benefits of about $0.025 to $0.028 per pound, and producers could face benefits of $0.001 per pound, be indifferent, or face costs of $0.002 or $0.003 per pound. Under worst-case conditions, recycled content would lead to a net social cost increasing from $0.059 per pound to $0.118 as content increases; added production costs increase from $0.074 to $0.144 per pound.

E. PET Plastics

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82 We have left unanswered how a VMT on coal used for steelmaking would be differentiated from coal used for electric power generation.

83 We have left unanswered how a VMT on natural gas used for plastic feedstock would be differentiated from (1) gas used for energy or (2) other plastics which might require a higher VMT to achieve the same content level.

The recycled-content targets for PET plastic containers were specified to range from 10 percent to 40 percent in Table 3-5. However, in the worst case, the steady-state level must be less than 37 percent. Virgin material taxes would be imposed on the natural gas feedstock, with the total VMT increasing from $0.015 to $0.059 per pound of PET in the best case, and from $0.015 to $0.055 per pound of PET in the worst case. Advance disposal fees would range from $0.001 to $0.002 per package for all-virgin packaging and would be about $0.001 for packages with the target content level. Under best-case conditions, recycled content would produce net social costs of $0.001 to $0.041 per pound, and producers would face added costs of $0.025 to $0.071 per pound. Under worst-case conditions, recycled content would lead to a net social cost from $0.119 to $0.178 per pound, increasing with content level; added production costs range from $0.133 to $0.205 per pound.

F. LDPE Plastics

The recycled-content targets for LDPE plastic containers were specified to range from 10 percent to 40 percent in Table 3-6. However, in the worst case, the steady-state level would be less than 26 percent. Virgin material taxes would be imposed on the natural gas feedstock, with the total VMT increasing from $0.006 to $0.023 per pound of LDPE in the best case, and from $0.006 to $0.015 per pound of LDPE in the worst case. Advance disposal fees would range from $0.001 to $0.002 per package for all-virgin packaging and would be about $0.001 for packages with the target content level. Under best-case conditions, recycled content would produce falling net social benefits of about $0.024 to $0.016 per pound, and producers could achieve benefits of $0.001 per pound at 10 percent recycled content, or costs of up to $0.016 per pound under all other scenarios. Under worst-case conditions, recycled content would lead to a net social cost increasing from $0.057 to $0.120 per pound as content increases; added production costs increase from $0.073 to $0.147 per pound.

PART II: Chapter 1

Manufacturers' Responsibility From Concept to Practice:

The German "Green Dot" System

INTRODUCTION

"Manufacturers' responsibility" refers to a system in which manufacturers are required to "take back," or otherwise implement waste-recovery and material-recovery systems, for their packaging. This system has been advanced as a means of promoting a spectrum of environmental benefits, including:

- design for low toxicity;
- design for pollution reduction;
- design for waste minimization;
- design for reuse or recyclability; and
- design for material conservation.

The concept's champions in the United States point to the German experience with manufacturers' responsibility as a potential model for the United States. The German program, therefore, is worth examining in detail.

A. Passage of the Packaging Ordinance

On April 19, 1991, the German parliament passed an Ordinance on Avoidance of Packaging Waste (Verpackungsverordnung, or VerpackVO), which formally became law on June 12, 1991.[84] With its passage, Germany introduced the first comprehensive packaging law to codify the concept of manufacturers' responsibility. The law required that all packaged-product manufacturers and distributors must be responsible for collecting and recycling or reusing the packaging that they place into the

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84 Regulations associated with the law were promulgated in September 1991, and the first phase of those regulations took effect on December 1, 1991. The first phase applied only to transport packaging; the second phase, implemented in April 1992, applied to secondary (outer) packaging; and the third phase, implemented on January 1, 1993, applied to sales (primary) packaging. The law was not Germany's first packaging or comprehensive waste ordinance. Under Germany's 1986 Waste Products Act, the federal government gave the Minister of the Environment powers to require waste reduction and reuse of packaging. The law included provisions allowing the Minister of the Environment to mandate that all beverages be sold in returnable packaging only. Of particular note, the law first introduced concepts such as waste prevention and the "polluter pay principle," both of which later created the foundation for the 1991 Packaging Ordinance.

market. The law coupled this take-back requirement with specific collection and sorting requirements for packaging materials.[85]

The expressed goal of the Packaging Ordinance was to reduce packaging waste and avoid waste disposal. Germany's then Minister of the Environment Klaus Topfer celebrated its passage by proclaiming that, "this ordinance, unlike any other regulation taken up to now, marks the final abandonment of the throwaway society."[86]

Elsewhere among industrialized nations, the concept has been borrowed and modified to justify similar packaging regulations. Sen. Max Baucus, for example, claimed in 1993 that the centerpiece of his proposed recycling strategy for the United States "rests on the principle that I call 'manufacturers' responsibility' for the life-cycle of a product....Anyone who sells a product should also be responsible for the product when it becomes waste."[87] In December 1994, the European Union adopted a Packaging and Packaging Waste Directive that somewhat modified the concept into a notion of "shared responsibility" in which manufacturers, local authorities, and consumers all share some financial (and operational) responsibility for managing discards.[88]

B. The Idea Behind the Law

The German law aimed at waste reduction and diversion from disposal facilities; the mechanism devised to achieve this end was to make manufacturers responsible for the post-consumer packaging waste associated with their products. Environment minister Topfer proposed that the strategy was consistent with the 'polluter-pays principle': "The costs of preventing and reducing damage to the environment," suggested Topfer, "must be borne by those who make use of it."[89]

While manufacturers contested details of the law and its implementation, they endorsed the basic polluter-pays concept both generally and in its specific application to packaging waste. Officials at Duales System Deutschland, a private-sector consortium set up to manage packaging waste under the new law, vigorously embraced the concept: "making responsible those who've produced and sold materials is the right one; the principle idea of making industry responsible for the diversion of their products from garbage is a good one."[90]

The Packaging Ordinance, according to its proponents, would make the costs of packaging waste part of the total cost of producing and selling a product. In theory, these costs, reflected in the price of the product, would give consumers incentives to purchase products with less packaging waste; in turn, manufacturers, seeking to lower costs associated with handling packaging waste, would reduce or even eliminate some packaging.

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85 In effect, the German program combines the concept of an advance disposal fee with the application of recycling rates. The law did not establish specific goals for use of secondary materials; it only established rates at which these materials must be collected for subsequent recycling.

86 Topfer's statement is quoted in Bette K. Fishbein, *Germany, Garbage, and the Green Dot: Challenging the Throwaway Society* (New York: INFORM, 1994).

87 Sen. Max Baucus, remarks during a presentation to the U.S. Conference of Mayors and National Association of Counties, April 1, 1993.

88 In their extensive review of the German ordinance, policy analysts David Perchard and Gill Bevington write that the German Packaging Ordinance "has set the agenda for the whole of Europe: the new packaging waste management legislation appearing elsewhere in Europe was either inspired by it or else is a defensive reaction to it." See *Packaging Waste Management: Lessons from the German Experience* (St. Albans, England: Perchard, June 1994). Perchard and Bevington note that France, Belgium, Spain, the Netherlands, the United Kingdom, Ireland, and Sweden are all pursuing some version of the concept of manufacturers' responsibility.

89 *Ibid.*, p. 19.

90 Personal communication, Dr. Dieter Uhlig, Duales System Deutschland, October 1993.

Relying as it does on "internalizing" packaging waste costs into the manufacturers' total costs, the German government touts its Packaging Ordinance as reflecting a free-market philosophy.[91] First, say the law's proponents, disposal costs under the system are borne by those who actually use products, not by taxpayers in a publicly operated waste management system. Second, the law does not specify how manufacturers are to achieve waste reduction; it establishes cost responsibility for packaging waste and leaves to market decisions the responses to those cost signals.[92]

The German Packaging Ordinance and its implementation through use of packaging fees to pay for recycling essentially combine two policy concepts: 1) advance disposal fees; and 2) mandatory recycling rates. The "take-back" system invokes both theoretical and practical questions. From a theoretical perspective, the ordinance raises twin issues: 1) what is pollution? and 2) who is the "polluter?"[93]

The Packaging Ordinance also raises theoretical questions about pollution "pricing," and the appropriateness of different pricing schemes. For example, are there benefits to charging waste management fees at the point of actual waste collection rather than "up front" at the point of manufacture or sale of products?

On a practical level, the ordinance raises questions regarding how to establish waste fees, the efficacy of such fees in reducing waste (through recycling, waste reduction, or other diversion means), the overall cost-effectiveness of waste-management systems associated with a take-back ordinance and mandatory recycling rates, and the impact of the DSD fee structure on efficient resource use.

The following discussion focuses on the practical effects of the German Packaging Ordinance and accompanying waste management systems that have emerged to satisfy the requirements of the ordinance. The discussion will evaluate the ordinance in terms of its impact on: 1) waste collection costs; 2) recycling costs and benefits; 3) administrative costs; and 4) natural resource conservation impacts.

Germany's Packaging Ordinance: Requirements and Implementation Structure

When the Packaging Ordinance passed in 1991, Germans were generating approximately 15 million tons of packaging waste each year, of which around 5 million tons were being recycled. The 10 million tons of packaging that was discarded represented about 6 percent of Germany's combined industrial and municipal waste. The Packaging Ordinance required a diversion of approximately 6 million tons of packaging during its first phase; a total of 9 million tons per year were to be diverted in the second phase of implementation. U.K.

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91 Note that one important practical consideration is whether actual fees charged on packaging bear any real relationship to the disposal costs associated with each particular package. From a theoretical perspective, an important consideration is whether disposal charges are most appropriately placed at the point of purchase of a package or at the point of disposal.

92 Thomas Rummler (the German offical initially responsible for overseeing implementation of the Packaging Ordinance) and Wolfgang Schutt (who helped design the Green Dot collection system) claimed that "industry should be able to meet this responsibility with measures taken at its own initiative. There will be no dense web of state rules, no constricting obligations imposed on industry; rather there should be as much leeway for market-oriented solutions as possible. If the Government's objectives are achieved, regulations will not be needed." (See Perchard and Bevington, *Packaging Waste Management*, p. 121).

93 For a discussion of the concept of "pollution," see "Considerations for a New Environmental Agenda," by Lynn Scarlett (Los Angeles: Reason Foundation, 1995). "Pollution" refers to production residuals—air, water, or solid waste 'emissions'—that have impacts that are not incorporated into consumption and production transactions. The crucial characteristic of an externality is that transacting parties do not bear the total costs of their actions. Packaging does not have the defining characteristics of pollution. It is typically "owned" at each point along the production and consumption chain. Costs associated with that ownership are directly borne by the owner and transferred (in the form of the price of a packaged good) from one owner to another along the chain from production through consumption, provided that the consumer pays directly for disposal costs.

policy consultants David Perchard and Gill Bevington calculated that this longer-term diversion of packaging would reduce the total waste stream by around 3 percent.[94]

A. Packaging Targets and Quotas

Germany's Packaging Ordinance targeted most types of packaging in the marketplace. The ordinance phased in collection and sorting requirements by package category, with the law defining three distinct categories:

- *Transport Packaging* is packaging that "protects goods in transit....In general, it is removed by the distributor and does not get as far as to the final consumer."[95]
- *Secondary Packaging* includes "blister packaging, film, cardboard boxes or similar coverings which, as an additional layer of packaging around the sales packaging, are intended to allow goods to be sold on a self-service basis, or to hinder or prevent the possibility of theft, or principally for advertising purposes."[96]
- *Sales Packaging* is packaging used "until the goods are consumed and/or put into use by the final consumer and does not lose its protective function before then. The final consumer usually acquires packaged goods in the shop and takes them home with him/her. Final consumers can equally be either private, commercial or industrial final consumers."[97]

Table G-1: Packaging Consumption* Covered by the Ordinance 1991 (thousands of metric tons)
[Secondary + transport + primary packaging = packaging covered by the ordinance]

Material	Secondary	Transport	Primary	Industrial Primary**	Packaging Covered by Ordinance
Glass	—	—	3812.8	—	3812.8
Tinplate***	—	1.8	703.4	10.8	716.0
Aluminum	—	—	122.7	—	122.7
Paper/Paperboard	9.5	314.4	927.6	122.5	1374.0
Plastics	46.5	2867.3	1553.5	711.0	5178.3
Composites					
• Beverage cartons	—	—	198.2	—	198.2
• Paper-based	—	0.3	174.7	0.1	175.1
• Plastic-based	—	0.2	27.7	0.1	28.0
• Aluminum-based	—	—	6.7	—	6.7
• Composite total	—	0.5	407.3	0.2	408.0
Subtotal (quota materials)	56.0	3184.0	7517.3	844.5	11,611.8
Steel****	—	9.7	1.7	7.4	18.8
Wood, cork	0.7	1030.5	28.7	3.8	1061.7
Other	—	—	6.1	7.4	13.5

94 Perchard and Bevington, *Packaging Waste Management*, pp. 9-10.

95 "The Taking-Back and Recycling of Transit Packaging," Interseroh Information for Foreign Enterprises Exporting to Germany (Cologne: Interseroh, undated). Article 3 of the Packaging Ordinance defines transit (transport) packaging as "drums, containers, crates, sacks including pallets, cardboard boxes, foamed packaging materials, shrink wrapping and similar coverings which are component parts of transport packaging and which serve to protect the goods from damage during transport from the manufacturer to the distributor or are used for reasons of transport safety." (Ordinance on the Avoidance of Packaging Waste, Article 3, (1) 1. Definition of Terms).

96 This translation of the text is from Perchard and Bevington. Bette Fishbein describes secondary packaging as "additional packaging designed to facilitate self-service sales, to prevent theft, or to advertise and market the product (e.g., outer boxes, foils, blister packs)." *Germany, Garbage, and the Green Dot: Challenging the Throwaway Society* (New York: Inform, 1994).

97 *Ibid.* The Packaging Ordinance states that sales packaging includes "closed or open receptacles and coverings of goods, such as cups, bags, blister packaging, cans, tins, drums, bottles, metal containers, cardboard and cartons, sacks, trays, carrier bags or similar coverings which are used by the consumer to transport the goods or until such time as the goods are consumed." (Article 3 (1) 2.).

Subtotal (nonquota materials)	0.7	1040.2	36.5	18.6	1094.0
Total	**56.7**	**4224.2**	**7561.8**	**863.1**	**12,705.8**

* As discussed in chapter 1 of *Germany, Garbage and the Green Dot*, Germany classifies discarded materials as waste (Abfall) or valuable materials (Wertstoffe). The total amount of packaging consumption includes both Abfall and Wertstoffe, and corresponds to the U.S. term "packaging waste."
** Primary packages for goods shipped to large companies.
*** Coated steel cans for consumer goods, mostly food and beverages.
**** Steel barrels, drums, transport containers, pallets, and straps.
Source: Bette K. Fishbein, *Germany, Garbage, and the Green Dot: Challenging the Throwaway Society*, pp. 28-29.

Take-back requirements for transport packaging commenced in December 1991; secondary packaging requirements took effect in April 1992; and the final phase, targeting sales packaging, commenced in January 1993 (see Table G-1).

Sales packaging represents the largest segment of packaging, making up around 60 percent of total packaging covered by the ordinance. The initial requirements of the ordinance set different collection and sorting targets for each package material type (see Table G-2).

The law further specified that containers for beverages, some washing and cleansing agents, and some emulsion paints would be subject to mandatory deposits. Even if collection and sorting targets are met for certain beverage containers,[98] a mandatory deposit is still applied if 72 percent of the returned containers are not refillable. (The corresponding percentage for pasteurized milk is 17 percent.)[99]

B. Duales System Deutschland

The Packaging Ordinance requires that manufacturers and distributors take back packaging that they put into the marketplace. Though the law established take-back provisions, it allows the private-sector to establish a third-party entity to collect and sort packaging waste rather than have consumers deposit their trash directly at retail outlets.

Under this third-party provision, initially some 600 manufacturers created a private, nonprofit consortium, the Duales System Deutschland (DSD), to arrange for a packaging collection and sorting system. This consortium established packaging fees to fund the collection and sorting program. Individual firms paid fees to DSD based on the amount and type of packaging they used. Payment of the packaging fees then entitled these firms to place a special "Grüne Punkt" (green dot) on their packaging, thereby identifying it to customers as packaging that would be collected for potential reuse through the DSD system.

Table G-2: Green Dot Collection and Sorting Quotas

	Collection Quotas		Sorting	
Material	Jan. 1993	July 1995	Jan. 1993	July 1995
Glass	60%	80%	70%	90%
Tinplate	40%	80%	65%	90%
Aluminum	30%	80%	60%	90%
Paper/Paperboard	30%	80%	60%	80%
Plastics	30%	80%	30%	80%
Composites	20%	80%	30%	80%

Source: VerpackVO of June 12, 1991, Annex to Art. 6 para. 3, sections II and III.

98 Beer, mineral water, spring water, table water, drinking water and remedial waters, carbonated refreshment drinks, fruit juices, juice concentrates, vegetable juices and non-carbonated refreshment drinks, wine (except slightly sparkling wines, sparkling wines, vermouth and dessert wines). VerpackVO, June 12, 1991, Art. 9, para. 2.

99 VerpackVO, June 12, 1991, Art. 9, para. 2.

DSD established contracts with both private and municipal waste-hauling and sorting agencies or firms to collect “green dot” packaging materials. They also negotiated a series of take-back guarantees with secondary material reprocessors to use the collected packaging waste.

C. Fees and Implementation

Initially, DSD applied flat fees to sales packaging for each “volume” category. (See Table G-3). These flat fees took effect in January 1993 and remained effective through October 1993. In October 1993, the fee structure was substantially altered. (See Table G-4). DSD established weight-based fees that varied by type of material. The fees were intended to reflect varying costs of recycling different packaging materials. The fees were intended to cover the costs of collection and sorting materials; they did not cover any costs associated with actual material reprocessing. These costs were borne by manufacturers that use recycled materials.

THE PACKAGING ORDINANCE: ACCOMPLISHMENTS AND COSTS

A. DSD as a Collection and Sorting System

At the outset, proponents of the take-back idea anticipated that it would lower costs to operate municipal trash collection systems. Since the packaging industry would be shouldering the responsibility for collecting and sorting packaging waste, proponents assumed that municipal waste collection costs would decline. These savings did not materialize, according to a June 1994 report by European waste policy analysts David Perchard and Gill Bevington.[100]

Even if the program eventually lowers municipal waste management costs as more and more materials are shifted to the DSD collection system, *total* costs for managing waste (the combined costs of the municipal and DSD systems) will continue to exceed pre-Packaging Ordinance waste management costs. The DSD program itself cost some 740 German marks (DM 740) per ton of waste handled in 1994, a sum that is double that of traditional waste-management programs in Germany.

Table G-3: DSD fees before September 1993

Volume	Fee/package
< 15 ml	free
15 ml–200 ml	1 pf
0.2 l–3 l	2 pf
> 3 l	20 pf

Source: Personal communication, Edelgard Bially, DSD, September 1996.

High total collection costs result from at least five features of the DSD system:

- diseconomies of scale associated with operating two parallel waste-collection systems;
- free-rider problems;
- high collection costs associated with handling some targeted packaging;
- unintended disincentives to waste haulers to introduce program efficiencies; and
- prescriptive program-design requirements.

100 See Perchard and Bevington, *Packaging Waste Management*.

1. Dual System Diseconomies

Germans are essentially paying for two parallel waste systems serving the same set of customers. The DSD system collects all packaging waste; the municipal collection program collects all other household waste. This dual collection system means that two sets of trucks may be serving each household, neighborhood, or region. The dual system of waste-service delivery limits opportunities for taking full advantage of potential economies of scale. Since a large proportion of waste-management costs—as much as half to two-thirds[101]—are fixed costs, changes in the amount of waste collected do not necessarily translate into waste-management savings, at least in the near term.

These diseconomies were further reinforced by a May 1993 decision by Germany's Federal Cartel Office that prohibited the DSD program from undertaking any collection of packaging waste from the commercial sector. Since commercial waste is often more uniform in composition and larger volumes are generated at a single site, it can often be collected more efficiently (at less cost per ton) than household waste. Combining household and commercial waste collection systems could have allowed for some opportunities to reduce the per ton costs of some packaging waste. On the other hand, as the Federal Cartel Office anticipated, a combined commercial/household collection system might have further undermined competition in waste hauling, a trend already prompted by the Packaging Ordinance.

Table G-4: DSD Fees: October 1, 1994

Weight-based fees		
Material	*Fee (DM/kg)* [a]	*Fee (U.S. $/lb)* [b]
• Glass	0.15	0.046
• Paper/cardboard	0.40	0.124
• Tinplate	0.56	0.173
• Aluminum	1.50	0.464
• Plastic	2.95	0.912
• Beverage cartons	1.69	0.523
• Other composites	2.10	0.649
• Natural materials	0.20	0.062
Item fees		
Volume	*Fee (Pf/item)*	*Fee (¢/item)*
• < 50 ml, up to 2 g; or, 50–200 ml, up to 3 g[c]	0.1–0.6	0.068–0.408
• 200 ml–3 l	0.7–0.9	0.476–0.612
• > 3 l	1.2	0.816
Item fees		
Area	Fee (Pf/item)	Fee *(¢/item)*
• < 150 cm^2, up to 2 g; or, 150–200 cm^2, up to 3 g[d]	0.1–0.4	0.068–0.272
• 300–1600 cm^2	0.6	0.408
• > 1600 cm^2	0.9	0.612

[a] Fees must be paid for each individual material component of the overall packaging and depends on the material used and its respective weight. The fee for all separable packaging or packaging components is calculated by weight at the price specified for each material. If more than 95 percent by weight of a package consists of one material, the fee for the total weight may be based on the price for the main material. For composite packaging (where several materials are joined in a non-separable fashion such as in laminates), the price for composites will be used unless more than 80 percent of the package consists on one primary material. In that case, the fee for that primary material may be used. However, if more than 50 percent by weight of the composite package consists of plastic, the fee for the total weight shall be calculated at the price specified for plastic.

[b] There are 2.2 pounds in a kilogram, and $1 was worth DM 1.47 in August 1996.

[c] Items with a volume less than 50 ml may be added until their mass exceeds 2 g, and considered as one item. Items between 50 and 200 ml may be added until their mass exceeds 3 g, and considered as one item.

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101 Personal communication, Solid Wastes Association of North America.

[d] Items with an area smaller than 150 cm^2 may be added until their mass exceeds 2 g, and considered as one item. Items between 150 and 200 cm^2 may be added until their mass exceeds 3 g, and considered as one item.

Note: Both weight-related fees and item fees must be paid. Area-based fees are for packaging without a volume.

Source: Duales System Deutschland, *Annual Report 1994* (*Geschäftsbericht 1994*), "License fees for the Green Dot" ("Lizenzentgelt für den Grünen Punkt"), p. 13, valid from 1 October, 1994; and other documents from Duales System Deutschland.

2. Free-Rider Problems

A second feature driving the high costs of the DSD system is the "free-rider" problem that the program engendered. The free-rider problem has two dimensions: 1) a consumer free-rider problem; and 2) a manufacturer free-rider problem.

Consumers, who pay a direct fee for regular trash pickup but not for what they discard in the DSD's yellow trash bins, found them a convenient place to put waste, whether it carried the required Green Dot or not. After a 1993 waste sort of materials in the yellow bins, one waste hauler concluded that "about 40 percent of what we have been collecting in the yellow bins is not green-dot material."[102] Some of what's collected is packaging that doesn't carry the green dot. Some of it is nonpackaging paper. But some of it, noted one DSD official, "is just garbage: dead dogs, shoes, rubbish."[103]

DSD officials, working with waste haulers, attempted in late 1993 to remedy this free-rider problem by putting a cap on the total annual amount of waste per household for which haulers would receive payment. By limiting to DM 40 per capita the amount that DSD would pay annually to waste haulers for collection of yellow bin discards, haulers had a greater incentive to ensure that citizens used the bins only for packaging carrying the Green Dot emblem.

While this change may reduce the consumer free-rider problem, it is not likely to eliminate it. Moreover, hauler efforts to monitor what goes into the yellow bins may add to program costs.

The program has also faced free-rider problems with manufacturers. Some companies underreport how much packaging they actually sell, so they pay lower fees. Others displayed the green dot on their products without paying the DSD at all. DSD officials estimated in late 1993 that over 90 percent of all packaging sold carried the green dot logo. Yet in 1993, DSD was collecting fees for only 50 to 60 percent of packaging. By December 1993, DSD was reporting a 67 percent fee-collection rate.

With over 150 billion different packaging units entering the German marketplace each year, and thousands of individual packaged-product suppliers, on-going enforcement is a constant challenge.

DSD responded to the free-rider problem among manufacturers by introducing stronger enforcement mechanisms. Green Dot licensees now must report and certify packaged product sales on a monthly basis. These reports are subject to auditing, and some licensees deposit their fees with DSD on a monthly rather than year-end basis to permit better oversight.

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102 Dr. Andreas Monnig, personal communication, October 1993. A March 1994 article in *Lebensmittelzeitung* (Grocery Magazine) reported DSD officials as also estimating that some 40 percent of yellow bin waste was non-green dot material.

103 Dieter Uhlig, DSD, personal communication, October 1993.

Moreover, in October 1993 (just 10 months after the DSD system took effect for sales packaging) DSD arranged with a group of twenty large retail chains to deduct owed DSD fees from invoices of any suppliers delinquent on their Green-Dot fee payments.[104]
These measures appear to have alleviated the nonpayment problem among packaged-product manufacturers and distributors. In 1993, DSD fee collection was around DM 2.1 billion. After the enforcement changes, 1994 DSD fee collection rose to DM 3.4 billion.[105] Today, DSD reports that the nonpayment problem among licensees has been virtually eliminated, but free-riding among nonlicensees (i.e., putting non-Green Dot packaging into Green Dot containers) remains. Only 75 percent of packaging bears the Green Dot.[106]

Contracting problems were not limited to DSD. Interseroh, the entity set up to handle paper and paperboard packaging, faced what one Interseroh official called "the same sicknesses as DSD." Specifically, they signed contracts with producers to collect paperboard packaging, and then set up methods to collect this packaging, but not all producers actually paid the fees. In collecting paperboard shipping packaging from a retail location, Interseroh had to take all paperboard material, but they were not always collecting fees for 100 percent of these materials. Moreover, even when they were collecting fees, it was difficult to verify that producers were paying fees on all the packaging that they disseminated into the marketplace. Finally, as one Interseroh official noted, markets for materials were dynamic, but contracts were necessarily somewhat static.

3. Packaging Variables

The Packaging Ordinance established categorical packaging waste-diversion requirements that were based neither on considerations of technical feasibility nor cost. Dr. Dieter Uhlig of DSD pointed out that there was "no scientific background for the original quotas."[107] Perchard and Bevington report industry estimates that "only about 22 percent of the original plastics packaging waste from all sources is mechanically recyclable. If the test of economic viability is applied, this figure comes down to perhaps 14 percent."[108]

Neither technical nor economic constraints shaped collection and sorting dynamics in the DSD program. Instead, these dynamics were driven by prescribed collection quotas and by consumer decisions to utilize the "free" DSD collection bins indiscriminately. These dynamics increased material sorting costs, since much of the plastic and composite packaging waste collected required labor-intensive (costly) sorting, some of it initially had to be stored in the absence of markets (at a cost of some DM 140 per ton per year).[109] Sorting residues are landfilled and incinerated; the DSD pays commercial waste fees of about DM 450 per ton, which are higher than the DM 200–300 per ton that households would have had to pay had their waste gone directly to landfills. Moreover, some local governments, to raise revenues, charged the DSD special rates as high as DM 1050 per ton.[110]

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104 Since calculating exact fees on a company-by-company basis would be both cumbersome and even impossible in the absence of full sales data, the invoice deductions are based on simple formulas. At the retail level, the invoice deductions are based on the sales price of the product. For grocery items, the 1993–94 fee was 2.5 percent of the sales price (applied across all units furnished to the retailer by a supplier). For non-food items, the deduction was 1.9 percent; for textiles the invoice deduction was 0.5 percent. Note that these fees were tied to the value of the product rather than the cost of the packaging. This had the effect of penalizing manufacturers of high-value products relative to low-value items. See Perchard and Bevington, *Packaging Waste Management*, p. 129.

105 DSD *Annual Report 1994*, p. 11.

106 According to the DSD, while all packaging must be taken back by the manufacturer, no one is required to use the Dual System. Individual companies can comply on their own by operating their own take-back scheme. Thus far, little proof has been required. As a result, some manufacturers claim individual compliance but fail to establish a working take-back system, so their packages end up being deposited in Green Dot bins. A planned amendment to the Packaging Ordinance requires companies to present more evidence if they try to comply on their own, but it is unclear whether and when this amendment will be adopted. Personal communication, Edelgard Bially, DSD, September 1996.

107 Dr. Dieter Uhlig, personnal communication, November 1993.

108 Perchard and Bevington, *Packaging Waste Management*, p. 21.

109 Perchard and Bevington, *Packaging Waste Management*, p. 127.

110 This was not typical, and happens very rarely today. Now, the DSD pays DM 450 per ton. Personal communication, Edelgard Bially, DSD, September 1996.

These difficulties with plastic recycling translated into high costs. DSD's Dieter Uhlig reported in 1993 that costs to collect, sort, clean, and actually recycle plastics came to about DM 3 per kilo. This price tag contrasted to a cost for often higher-quality virgin plastics of around DM 1.20 to DM 1.30 per kilo.[111]

The high costs of actually reusing some of the collected and sorted plastic resulted in the application of a special “recycling fee” paid on plastic packaging. The fee is in addition to the DSD fee, which pays for collection and sorting but not actual reprocessing of plastic packaging waste.

4. Cost-Plus Incentives

For waste haulers, DSD contracts were initially a bonanza. Haulers were paid by the tonnage for collecting “yellow bin” waste. They had no incentive to monitor the contents of the yellow bins, taking only appropriately labeled green dot material, since they were paid by the ton with no penalities for delivering contaminated loads of packaging to sorting facilities. Moreover, for packaging waste, they had no means of determining whether manufacturers of packages carrying the green dot had actually paid the required licensing fees. Nor had they any incentive to attempt to make such distinctions.

Dr. Andreas Monnig of DASS reported in 1993 that haulers faced incentives to “cheat” the system by overreporting tonnage of waste.[112] Monnig indicated that early comparisons of the tonnage of materials for which waste haulers billed DSD differed sometimes by a factor of two or three times more than the amount of recyclables actually provided for remanufacturer. (For example, haulers would bill DSD for 1,000 tons of paper; actual receipts for wastepaper delivered to paper mills would be only 300 tons.)

Moreover, Perchard and Bevington note that DSD's bargaining power with waste haulers at the outset of the program was almost nil since manufacturers were required by law to collect packaging.[113]

Some of these adverse incentives have been remedied by redesigning contracts. For example, haulers are now paid a flat rate per capita (DM 40 in 1994), rather than on a tonnage basis.[114] This flat rate prevents costs from escalating unpredictably. The flat rate also gives haulers a greater incentive to refuse collection of non-Green Dot materials or to do waste sorts to identify what percentage of discards in the yellow bins are not packaging. DSD agreements with local sanitation departments typically provide mechanisms through which DSD is reimbursed for collecting non-Green Dot wastes.

However, the dual-system concept has several attributes that undermine incentives that haulers might otherwise have to search for cost-reducing innovations. As a single national entity responsible for ensuring the collection of all sales packaging, it is difficult for DSD to enter into and monitor multiple local waste-hauler contracts. It is easier to manage a smaller number of contracts. As a result, the advent of DSD programs has generally reduced competition, as a few large haulers have obtained a number of citywide contracts with DSD. While it may be easier for DSD to manage fewer contracts, the absence (or near-absence) of competition reduces hauler incentives to reduce costs.

5. Program Prescriptions

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111 Personal communication, October 1993. In most German sorting facilities, plastic film is separated by air blower, and plastic bottles and mixed plastics are sorted by hand. In such facilities, the throughput of plastics is very low—on average 90–100 kg/hour per worker. One metric ton of plastics costs about 3,200 DM (or $2,048 per ton) to collect and process. Bernd Bilitewski and Cynthia Copeland, “Packaging Take-Back in Germany: The Plastics Recycling Picture,” *Resource Recycling*, February 1997, pp. 49, 51.

112 Monnig pointed out that this was accomplished through a variety of ways: some haulers added water to their trucks to increase the scale weight; some drove the same load over weight scales twice. Personnal communication, October 1993.

113 Perchard and Bevington, *Packaging Waste Management*, p. 17.

114 The DM 40 per capita was based on estimates that total program costs would be DM 3.3 billion per year. With 80 million residents in Germany that comes to around DM40 per capita. Total DSD revenues break down into the following contributions by category: 83.1 percent are Green Dot licensing fees; 5.1 percent are point-of-sale fees; 1.5 percent are from fees on fruits and vegetables; 1.5 percent are from import fees; and 7.8 percent of revenues come from miscellaneous other sources. (See Perchard and Bevington, *Packaging Waste Management*, p. 130) Information also comes from personal communication with Dr. Uhlig, DSD, November 1993.

During the first several years of operation, DSD was required to ensure through its contracts with haulers a certain number of drop-off bins for collection of glass and paper packaging for consumer convenience. The program called for a phase-in of bins, ultimately reaching one set of bins for every 500 households. Currently, there is one set of bins for, on average, every 500 to 700 households.[115] But the effectiveness of adding new bins varies according to the material collected. Adding new bins, each requiring separate collection and maintenance, does not always result in corresponding rates of increase in collected materials. DASS, a waste hauler that contracted with DSD to provide collection service in Berlin, collected 138,206 metric tons of paper from 47,804 bins in 1992; by 1995, paper collection had risen to 216,395 tons from 66,129 bins—a 56 percent increase in mass for a 38 percent increase in number of bins. But not every material is as easy to collect as paper. DASS collected 116,126 tons of glass from 53,731 bins in 1992, and 121,857 tons of glass from 90,930 bins in 1995—a 5 percent increase in mass for a 69 percent increase in number of bins.[116]

What, then, has been the general effect of the Packaging Ordinance and the DSD program on waste management costs? And what might one anticipate regarding future cost trends?

Perchard and Bevington report that consumers were paying an additional DM 35 per capita in 1993 for waste collection after introduction of the DSD system. That increase was expected to rise to DM 50 to DM 60 per capita through 1994. Some of this increased cost was attributed to a rapid escalation of landfill costs. In large part, however, the advent of a dual collection system was responsible for the increased waste management costs.

As waste-diversion rates climb, municipalities may be able to move to fortnightly rather than weekly trash collection. One analyst estimated that under this scenario municipal waste-handling costs could drop from an annual DM 500 per household to DM 270 per household. Costs for the DSD program would be approximately DM 150 per year.[117] Total costs under a fortnightly system, therefore, would be approximately DM 420, representing a 16 percent savings over 1993 costs but still higher than costs prior to implementation of the ordinance. Table G-5, developed by Perchard and Bevington, compares an optimistic estimate of costs by Ruhr University professor Erich Staudt to more pessimistic estimates.

These household costs may not reflect real program costs, since DSD faced huge losses in its first year of operation that did not translate into higher household fees. By June 1993, just five months after introduction of the DSD program, DSD had accumulated losses of some DM 500 million; just three months later that loss had risen to DM 800 million.[118] A study by Dieter Berndt and M. Thiele estimated 1993 revenues at DM 2.5 billion, with expected expenditures of DM 4.2 billion.[119]

None of these cost estimates evaluates changes in product prices that may have accompanied the Green Dot program. Perchard and Bevington report the findings of Swiss management consultant Ernst Bischoff, who enumerates some of the other costs.[120]

Table G-5: Costs and Savings in Collection Charges for a Family of Four

Collection Frequency	Best Case (every 2 weeks)	Worst Case (every week)
1993 Dual System	DM 155	DM 155

115 In fact, there are four types of bins—three for glass (clear, green, and brown) and one for paper. The paper bins accept packaging and also newprint; the newsprint is paid for by the local authorities. In some places, depending on the municipality, homeowners can get their personal paper bins. Personal communication, Edelgard Bially, DSD, September 1996.

116 Personal communication, A. Habeck, DASS, August 6, 1996.

117 Erich Staudt, "Comparison between cost structure and charges of domestic waste disposal and recycling," September 1993, cited in Perchard and Bevington, *Packaging Waste Management*, p. 124.

118 Perchard and Bevington, *Packaging Waste Management*, p. 127.

119 Dieter Berndt and M. Thiele, "Status des Dualen Systems und seine Kosten," August 1993, cited in Perchard and Bevington, *Packaging Waste Management*, pp. 134–136.

120 Perchard and Bevington, *Packaging Waste Management*, p. 19.

+1993 Waste Collection	DM 270	DM 500
Total 1993 Charges	DM 425	DM 655
less charges if no Dual System	DM 500	DM 500
Costs (Savings) of Dual System 1993	**(DM 75)**	**DM 155**
1994 Dual System	DM 209	DM 251
+1994 Waste Collection	DM 355	DM 650
Total 1994 Charges	DM 564	DM 901
less charges if no Dual System	DM 650	DM 650
Cost (Savings) of Dual System 1994	**(DM 86)**	**DM 251**
1995 Dual System	DM 313	DM 313
+1995 Waste Collection	DM 465	DM 855
Total 1995 Charges	DM 778	DM 1,168
less charges if no Dual System	DM 855	DM 855
Cost (Savings) of Dual System 1995	**(DM 77)**	**DM 313**

Source: David Perchard and Gill Bevington, *Packaging Waste Management: Learning from the German Experience*, p. 19.

Bischoff estimates the following costs:[121]

- DM 10–20 billion for building post-sorting processing plants;
- DM 10–20 billion for conversion of packaging and filling operations;
- DM 20–30 billion for changes in the packaging industry, including closure of composite film manufacturing plants, and so on.

As Perchard and Bevington point out, "These costs would amount to a total of DM 40–70 billion, or DM 500–875 for every single inhabitant of Germany if passed down the chain via the retailer to the consumer."[122] Perchard and Bevington adjust Bischoff's best-case cost scenario and their own worst-case scenario by adding these additional household costs. The results for each year from 1993 through 1995 are increased total costs to consumers ranging between DM 244 at the low end and DM 1530 at the high end (see Table G-6).

B. Recycling Results

The Packaging Ordinance did not develop recycling markets; it established requirements for collection and sorting of waste. Like most other recycling programs in industrialized nations, the emphasis of the ordinance was on the supply side. It required that packaging waste be sorted for potential reuse.

Table G-6: Annual Costs and Savings in Collection Charges and Price Increases for a Family of Four

Collection Frequency	Best Case (every 2 weeks)	Worst Case (every week)
Collection costs (savings) of Dual System 1993	(DM 75)	DM 155

121 Data come from Ernst Bischoff, "One-trip or multi-trip packaging—study of the German Packaging Ordinance," August 1992, cited in Perchard and Bevington, *Packaging Waste Management*, p. 19.

122 Perchard and Bevington, *Packaging Waste Management*, p. 20.

Price Increases **Cost to Family Budget 1993**	DM 330 **DM 255**	DM 1,165 **DM 1,320**
Collection costs (savings) of Dual System 1994 Price Increases **Cost to Family Budget 1994**	(DM 86) DM 330 **DM 244**	DM 251 DM 1,165 **DM 1,416**
Collection costs (savings) of Dual System 1995 Price Increases **Cost to Family Budget 1995**	(DM 77) DM 330 **DM 253**	DM 365 DM 1,165 **DM 1,530**

Source: Perchard and Bevington, *Packaging Waste Management: Learning from the German Experience*, p. 20.

The ordinance, and its partial implementation through the DSD program, resulted in the creation of a collection and sorting infrastructure. By making that infrastructure both convenient and free to consumers, it stimulated a dramatic consumer response: they enthusiastically used the DSD bins to discard packaging (and other) waste. The results of this incentive structure were threefold:

- Materials collected exceeded capacity to actually reuse those materials;
- Collected materials suffered from relatively high degrees of contamination; and
- Distortions in waste export markets occurred.

1. Supply vs. Recycling Capacity

So successful was the "free service" concept as an incentive to consumers that in its first year DSD collected between 300,000 and 400,000 metric tons of plastic packaging.[123] The 1993 quota of 9 percent would have equaled only 100,000 tons. The actual amount collected was more than double initial DSD projections and dramatically exceeded actual capacity to recycle plastics, which was estimated at between 120,000 and 250,000 metric tons.[124] These surplus plastics represented the most significant mismatch of recycling capacity and collection quantities. The result was waste stockpiling (an estimated 80,000 to 100,000 tons in mid-1993).[125] In 1994, 55 percent of used plastic packaging, or 256,000 tons, was recycled abroad, and 49 percent of plastic waste, or 250,000 tons, was exported in 1995. In general, Germany had sufficient capacity to recycle amounts generated by the 1993 take-back quotas for only two materials—paper/paperboard packaging and tinplate packaging (see Figure G-1).[126]

Projected 1995 plastics recycling capacity was approximately 520,000 tons—344,000 tons of mechanical recycling and 176,000 tons of feedstock recycling. This exceeds the 1995 plastic packaging quota of

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123 Dr. Dieter Uhlig of DSD claimed that some 400,000 tons of plastic were collected in 1993. Personal communication, November 1993. See also Perchard and Bevington, *Packaging Waste Management*, p. 71.

124 Estimates of how much plastic material was collected and how much plastic recycling capacity existed in 1993 and 1994 vary widely. DSD officials claimed that some 280,000 tons of plastics were recycled in 1993, of which 60 percent was exported for recycling in other countries. A Ministry of the Environment official reported in 1994 that domestic plastics recycling capacity was aroung 120,000 tons. By 1995 that was expected to reach 190,000 tons of "feedstock" recycling and 330,000 tons of mechanical recycling, for a total of 520,000 tons, as reported by Perchard and Bevington, *Packaging Waste Management*, p. 21, note 5. DSD's optimistic estimates of recycling rates has been recently questioned by research from the German consulting firm Intecus. Actual recycling levels for paper packaging may be as low as 50–60 percent, not the 90 percent rate DSD announced in 1995. Plastic recycling levels may also be generally lower than DSD estimates. In some large cities where DSD had estimated plastic recycling rates of 60 percent, Intecus reported that actual rates were 25–35 percent. Bilitewski and Copeland, "Packaging Take-Back in Germany," p. 51.

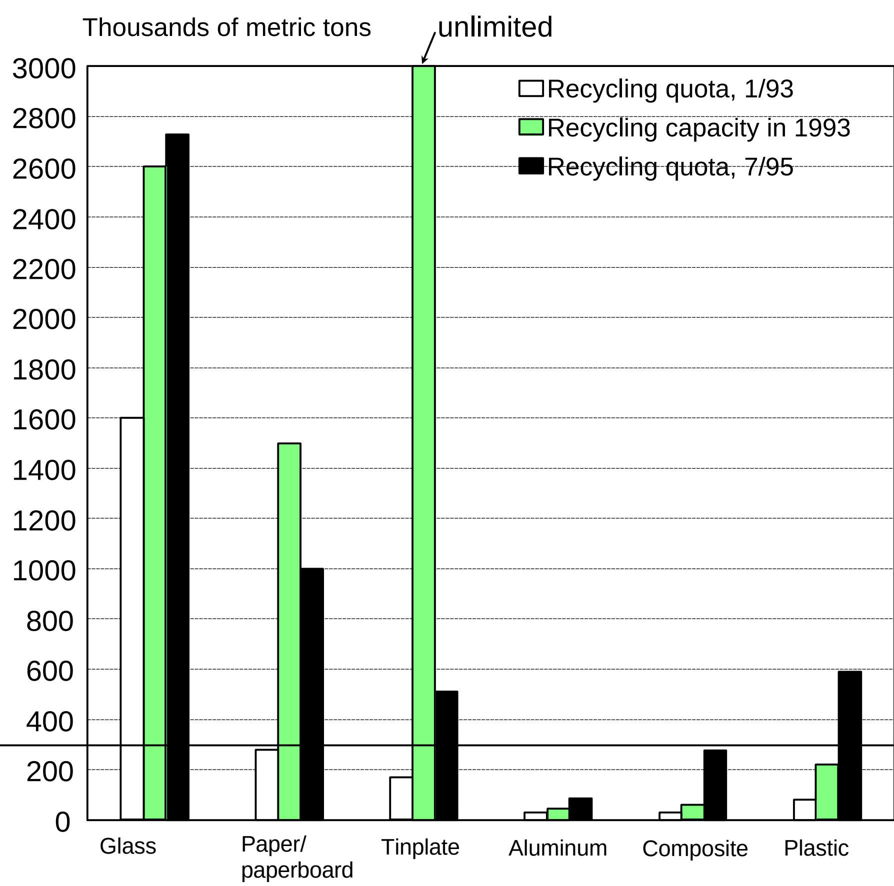
125 Personal communication, Dr. Dieter Uhlig, November 1993.

126 Different sources give different numbers. See also Bilitewski and Copeland, "Packaging Take-Back in Germany," p. 49.

36.5 percent, but falls far short of the plastic packaging quota for later years, which is 64 percent of all plastic packaging. (At current plastic packaging discard rates—1.1 million tons annually—this would make 700,000 tons.)

As manufacturers build additional plastic feedstock recycling capacity, the mismatch between supply and demand will decline by 1997. DSD estimates, perhaps optimistically, that Germany will have adequate capacity to end exporting altogether by 1997. Some 350,000 tons of mechanical recycling capacity will be available; over 800,000 tons of plastics feedstock capacity should be available.[127] These figures suggest that Germany will actually have excess feedstock capacity.

Figure G-1: Comparison of Recycling Quotas with Recycling Capacity



Source: Bette K. Fishbein, *Germany, Garbage, and the Green Dot: Challenging the Throwaway Society*, p. 56.

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127 Perchard and Bevington, *Packaging Waste Management*, p. 71.

While the capacity issue will ultimately be solved, the high costs of this recycling effort will continue. Currently, DSD pays approximately DM 3000 to produce one ton of recycled plastic packaging,[128] and much of this is commingled plastic.[129] On the other hand, virgin plastics cost about DM 1000–1500 per ton, and the additional cost of converting these plastics to packaging is small compared to DSD recycling costs.[130] DSD offical Dr. Uhlig commented at the end of 1993 that if the consortium were free to choose, "they should collect only plastics that can readily be used." Moreover, he noted, they should use a "bring" system like that used for glass to avoid the heavy contamination experienced with the yellow bin, mixed packaging waste collection program.[131]

DSD's Dieter Uhlig noted in 1993 that Germany imported some 50 percent of its paper and paperboard requirements. This reliance on imports means that Germany generates far more wastepaper than could be absorbed by the nation's papermaking plant capacity.[132]

The German paper industry had little capability of absorbing much additional wastepaper. Newsprint already contains at least 70 percent recycled content; packaging paper contains over 90 percent recycled content; and toilet tissue is over 62 percent recycled content. The only sector with potential for significant increases in recycled content is the printing and writing sector, which used on average only around 16 percent recycled content in 1993–94. One analyst suggested that recycled content in printing and writing paper would need to climb to around 50 percent to accommodate additional tons of collected wastepaper.[133]

The transport packaging take-back program faced similar mismatches between supplies and demand for used packaging. Interseroh, an organization similar to DSD but with a focus on transport packaging, noted in October 1993 that is was collecting significantly more wastepaper than could be used by German papermakers.

2. Contamination Issues

Waste haulers and sorters reported that "contraries" (improperly sorted items, nonpackaging materials, and other contaminants) represented between 20 and 40 percent of what was actually collected.[134]

Contamination was a problem for both the yellow bins (which took most Green Dot packaging) as well as for the bins designated specially for paper collection. These bins contained 25 to 35 percent contaminants.[135]

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128 This is divided about evenly between collection, sorting, and recycling. Personal communication, Ulrich Schlotter, Verband Kunststofferzeugende Industrie e.V., September 1996.

129 Most of the plastic used for packaging in Germany is polyolefins (HDPE, LDPE, and polypropylene), as well as some polystyrene. A few categories of easily separable plastic packages, including some bottles, are separated from the waste stream during the sorting process. Personal communication, Ulrich Schlotter, September 1996.

130 Personal communication, Ulrich Schlotter, September 1996.

131 Personal communication, October 1993.

132 Personal communication, October 1993.

133 Perchard and Bevington, *Packaging Waste Management*, p. 76.

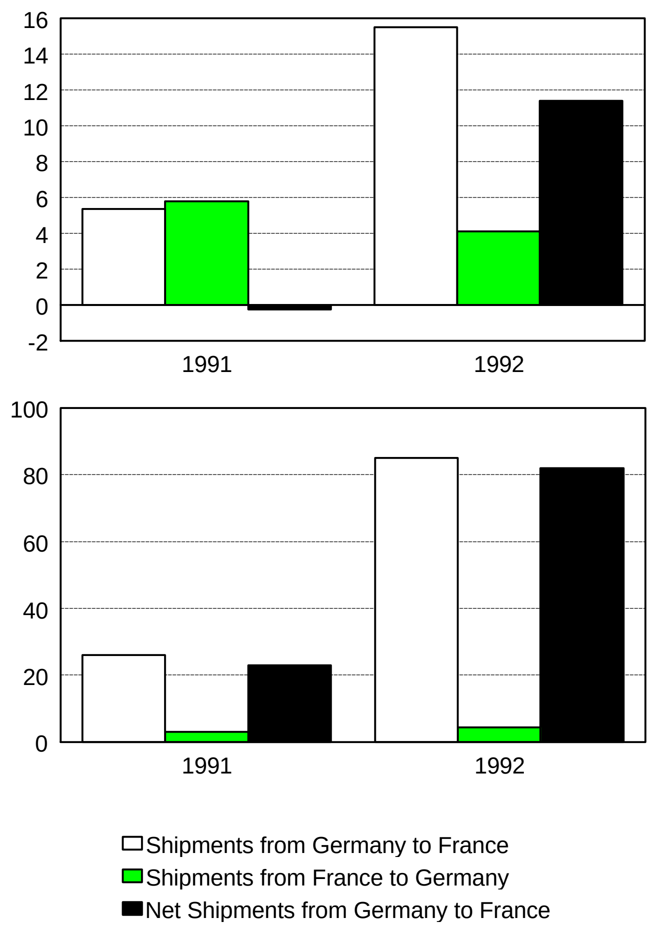
134 Dr. Andreas Monnig reported that a waste sort of materials that DASS collected showed as much as 40 percent of waste in yellow bins was non-Green Dot material. Personal communication, October 1993. Perchard and Bevington report "contraries" as running between 20 and 25 percent. See Perchard and Bevington, *Packaging Waste Management,* chapter 2.

135 Previous, not very accurate, studies had estimated 15 percent contamination; 25 to 35 percent is more current and closer to the truth. Contamination is higher in densely populated urban areas and lower in areas where families have small children. Personal communication, Edelgard Bially, DSD, September 1996.

3. Export Issues

Examining the export impact of Germany's Packaging Ordinance, Christopher Boerner and Kenneth Chilton reported that Germany went from a small importer of some secondary materials to a major exporter after introduction of the ordinance.[136] Waste plastics exports tripled in the year after passage of the law (see Figure G-2). The Council on Packaging and the Environment likewise reported a 450 percent increase in exports of plastic waste to the United Kingdom in 1992 after the first phase (targeting transport packaging) of the German Ordinance took effect.

Figure G-2: Flow of Waste Packaging Materials Between France and Germany



Source: Christopher Boerner and Kenneth Chilton, *Who is "Responsible" for Garbage,* Occasional Paper 140 (St. Louis: CSAB, July 1994).

As indicated above, exports of plastic wastes have slightly decreased, from 55 percent of plastic waste (256,000 tons) in 1994 to 49 percent of plastic waste (250,000 tons) in 1995. A company named DKR, or Deutsche Gesellschaft für Kunststoff-Recycling mbH, works with plants in Germany and abroad to

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136 Christopher Boerner and Kenneth Chilton, *Who Is "Responsible" for Garbage*, Occasional Paper 140 (St. Louis: Center for the Study of American Business, July 1994).

guarantee that used plastic packaging is recycled in compliance with German law; in 1994, DKR was working with 70 such plants in Germany and 50 abroad. The lion's share of the exported waste was sent to China; other foreign recycling contractors are located in neighboring European states and Eastern European countries.[137]

C. Administration and Enforcement

By declaring that responsibility for packaging remains with the manufacturers even after a package changes hands from producer to retailer to consumer, Germany's Packaging Ordinance embodies an attempt to refashion property rights.[138] It essentially makes packaging “ownership” nontransferable. This redistribution of rights and responsibilities for packaging is intended to give manufacturers cost signals about consumer waste, thereby making packaging reduction a key design concern.

Nobel laureate Ronald Coase has demonstrated that, if we lived in a world of no transaction costs,[139] the particular configuration of property rights would not matter. Regarding packaging, for example, it would not matter whether consumers or manufacturers held the property rights (and accompanying responsibilities) for packaging.

But transaction costs always occur, and some arrangements give rise to more transaction costs than others. Though the waste-reduction rationale for the German take-back scheme may be laudable, the scheme has likely increased, rather than reduced, transaction costs associated with managing household and commercial waste. These “deadweight” costs are a predictable outcome of a property rights regime that severs ownership (and responsibility) for packaging from actual possession of billions of consumption items consumed annually, and which change hands daily.[140]

Three implementation features of the take-back waste management system create new monitoring and enforcement requirements in the delivery of waste management service: free-rider problems; “price-searching” problems; and contract-management and licensing oversight.

1. Free-Rider Problems Among Manufacturers and Consumers

For consumers, the free-rider problem is a consequence of offering them “free” waste disposal service in the Green Dot bins: they have an incentive to place non-Green Dot material in the designated bins. Justified as a way of eliminating market externalities, the German program actually creates them. It creates a “public goods” problem where, under the former ownership arrangement in which responsibility for packaging handling and disposal transferred with the sale of the item, consumers were responsible for their own waste; waste was, in effect, a cost internalized to the consumer (either through trash disposal fees or taxes). Under the new regime, consumers are not now paying the costs of items they improperly dispose of in the DSD yellow bins.

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137 Personal communication, Petra Warnecke, DSD, May 1996.

138 I here use property rights as an economic construct that refers to the allocation of rights and responsibilities associated with specific goods or bundles of goods. Well-defined rights typically have three characteristics: they profer to the owner rights to exclude others from using the good; they are transferable; and they are enforceable against involuntary encroachment by a nonowner. Ownership does not always entail possession, as in the case of rental property, for example.

139 Transaction costs refer to costs associated with monitoring and enforcing contracts, developing information and reporting systems associated with program management and enforcement, and so on. These are costs incurred to enable a transaction to occur. In the case of the Green Dot system, these are costs associated with developing waste management contracts, preparing licensing agreements with packaged product manufacturers and distributors, collecting payments, establishing fee structures, monitoring compliance, and enforcing against noncompliance.

140 Severing ownership from possession has some precedent, for example, in rental markets. But the circumstances of such markets are vastly different from that of packaging transactions. At a minimum, far fewer “consumption units” are involved. Moreover, the value of each transaction is much higher, making the monitoring and enforcement costs of rental arrangements only a small part of the total market exchange.

For manufacturers, the free-rider problem is a consequence of creating a packaging waste-collection system in which it is difficult for either the consumer or the waste hauler to distinguish whether waste-collection fees have actually been paid for any given package or product. Nor do haulers of consumer waste have any incentive to make such a distinction. Manufacturers thus have an incentive either to underreport the amount of packaged products they place into the market (and thus pay lower disposal fees); or not to pay any fees at all but nonetheless still utilize the Green Dot logo.

In effect, the yellow bins are a modern-day commons, with everyone having an incentive to use the bins without restraint. The result is mounting transaction costs as DSD must implement enforcement and monitoring measures to overcome the free-rider problems. These enforcement measures are possible, but they carry a price tag.

No data are available on the actual sum of costs associated with mitigating free-rider effects of the program. However, Uhlig of DSD estimated in November 1993 that "administration costs" of the program ran at about 10 percent of total costs.[141]

2. "Price-Searching" Problems

Applying waste fees "upstream" from the point of actual waste collection poses at least two problems: 1) information about location-specific waste management costs are either unavailable or must be aggregated into an "average" cost; and 2) since waste collection systems collect "bins" or aggregated mixes of discards, no information about the specific disaggregated costs of handling a single item really exists. The Green Dot fee system thus does not correspond directly with how waste is actually managed, or with the actual structure of waste management costs. The result is a continual "price-searching" problem in which total costs must be estimated and disaggregated to apply to specific packages or packaging materials. This process generates significant prospects for arbitrary and discriminatory fee structures, which in turn gives rise to "politicking" over fee determination.[142]

For example, one DSD official noted that the initial 2 pfennig fee, multiplied by an estimated 100 billion packages per year, would have generated DM 2 billion, a sum insufficient to cover DSD costs. As a consequence, DSD proposed a new fee structure in March 1993. Under that structure, glass packaging fees were proposed at 16 pf., based on an assumption that glass users would purchase cullet for DM 50. When glass users withdrew their promise to purchase cullet at that rate, DSD then raised the glass fee to 20 pf. The glass industry protested, so the fee was reduced back to 16 pfennigs. The DSD official noted that between March and October 1993, three fee changes were proposed before new fees finally took effect in October.[143]

3. Contract-Management and Licensing Oversight

The DSD acts as a centralized contractor for waste-management services. As of September 1996, DSD had 538 contracts with waste-management companies. All contractors must operate or cooperate with a sorting plant. Contracts generally run for 7 to 10 years; many will expire in 2002. Though the DSD is supposed to negotiate waste-hauler contracts together with local authorities, many local authorities insisted on using their existing waste haulers. As a result, most of the current contracts were not bid out.

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141 Personal communication, Dieter Uhlig, October 1993.

142 Note that this problem does not exist when the commercial sector and households simply negotiate directly for waste management services. In that instance, if privatized, competitive markets exist, the consumer (commercial or private) can shop among haulers for the "best" price for service. Where municipal service for consumers exists, the fee-setting process becomes more politicized, but the politics is over the absolute level of the fee for a particular community, not over particular fee levels for individual materials or products that are discarded.

143 Personal communication, DSD, October 1993.

Costs were sometimes 35 percent higher than they would have been under a competitive bidding system. Still, the DSD has competitively rebid those contracts that were canceled because of contractor fraud.[144]

At the outset, DSD was in a weak negotiating position with waste haulers, since they were under severe time constraints to negotiate hauler contracts. Early on, DSD claimed that it was sometimes paying up to three times the usual waste collection rates to dispose of non-Green Dot waste inadvertently picked up in the DSD yellow bins.

The "take-back" system also generated contract problems with the licensees who paid fees to participate in the Green Dot program. As Perchard and Bevington note, "the way the contracts were written for Green Spot licenses invited underpayment—licensees were asked to estimate their sales for the following year and at year end, submit actual returns, paying the balance if they had underestimated—which most licensees did. There were no penalties for underreporting."[145]

All of these contractor problems can be addressed through various enforcement measures. However, these enforcement measures can add to program costs and complexity. For example, to counter problems of non-payment by Green Dot licensees, DSD worked out agreements with German retailers to deduct Green Dot fees from payments to suppliers that had not submitted audited Green Dot accounts. Certified suppliers would not have fees deducted.

While this system helped to overcome the free-rider problem, it introduced potential fee inequities, since fees deducted by retailers were based simply on sales price of the product rather than on the weight and type of material. For grocery products, the initial fees were 2.5 percent of the sales price; other fees ranged from 1.9 percent to as low as 0.5 percent of the product. Pegging fees to sales price meant the suppliers of high-cost items would pay substantially higher fees—even for similar packaging types—than suppliers of low-cost items.

In addition to transaction costs experienced by DSD as it implements a "take-back" program, individual firms affected by the Packaging Ordinance also face new transactions costs associated with marketing their products. (Note that transactions costs are only those costs associated with reporting requirements, licensing procedures, and so on. Firms will face other direct costs associated with the packaging fees and meeting the regulatory requirements of the packaging laws).

D. Waste Diversion: What is the Record?

Commenting on Germany's Packaging Ordinance, Helmut Fischer of Procter & Gamble exclaimed that "Germans wanted waste avoidance....They wanted to achieve avoidance of landfills and incinerators at any cost."[146] Since packaging represented as much as 25 percent of household waste, the law aimed to avoid waste disposal by promoting reduction (or recycling) of packaging waste.

The basic concept underlying the German law is a simple one. Until passage of the ordinance, its proponents argued that manufacturers had no direct interest in reducing a consumer's packaging waste. The cost of disposing of discarded packages was borne by citizens as taxpayers who paid for local waste management programs, or by citizens as consumers who paid user fees for waste-collection service. For manufacturers, this structure was presumed to translate into an "out of sight, out of mind" attitude. Packaging waste simply was presumed not to be a packaging design consideration. Proponents of the take-back concept have argued that Germany's Packaging Ordinance corrects this "market failure."

1. Packaging Reduction

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144 Planned amendments to the Packaging Ordinance require competitive bidding, but it is unclear whether and when these amendments will be adopted. Personal communication, Edelgard Bially, DSD, September 1996.

145 Perchard and Bevington, *Packaging Waste Management*, p. 127.

146 Personal communication, October 1993.

Though the DSD program has been costly, as argued above, making manufacturers responsible for taking back all packaging has had some of the predicted effects. A walk up the toiletry aisle of a typical German supermarket reveals some packaging innovations. Gone are just about all toothpaste boxes. Instead, toothpaste tubes now stand on their caps in special permanent display holders. Indeed, outer cartons of most products have disappeared or been downsized.

The detergent aisle brings additional innovations. Refillable pouches predominate. Heavy-duty HDPE plastic bottles no longer grace the shelves. Instead, cardboard sleeves wrap around a very thin plastic container of liquid detergent.

Nonetheless, overall impacts of the take-back ordinance were relatively modest in the first two years. Up and down German supermarket aisles most boxes, jars, cans, and bottles resemble their counterparts in the United States and other industrialized nations (see Figure G-3).

The numerical evidence bears out this observation. In late 1993, Germany's Ministry of the Environment announced packaging waste reductions of 500,000 tons since passage of the packaging ordinance in 1991. That's one-half million tons out of 12 million tons of packaging waste, or a 4 percent reduction. And this amounts to a 2 percent reduction of Germany's total municipal waste. Taking into account the 200 million tons of industrial waste generated in Germany, the reduction comes to 0.25 percent. Moreover, not all of the reductions in packaging are attributable to the German ordinance.

In part, these results are modest because secondary packages—allegedly unnecessary outer boxes or wrappers that are often targeted as evidence of excess packaging—only make up a tiny part of overall packaging. In Germany, these outer containers produced about 56,000 tons of packaging waste in 1992—barely 0.5 percent of the 12 million tons of packaging waste generated annually.[147]

Much of the remainder—9 million or so tons—is sales packaging: the soda bottles, food cans, yogurt pots, and so on, that preserve, protect, and contain basic consumption items. The rest is transport packaging.

While there is always room for innovation—lightweighting of packages, introduction of refillables, increased recycling, and so on—most sales packaging offers highly efficient product delivery. Moreover, 78 percent of transport packaging was already being recycled or reused before implementation of the take-back law.

In fact, the persistent pursuit of reduced costs by manufacturers worldwide has translated into "dematerialization"—a reduction in the energy and raw material inputs needed to manufacture and deliver a given unit of output. In the packaging industry, this trend has been extensive and persistent. Thus, for example, upon its first appearance in 1963, the aluminum soda can required 54.8 pounds of material per 1,000 cans. By the 1990s, only 33 pounds of metal were required per 1,000 units.

Plastic milk jugs weighed 95 grams in the early 1970s; by 1990 the same jug weighed just 60 grams. Plastic grocery bags were 2.3 mils thick in 1976; by 1989 they were 0.7 mils thick. Although the amount (by weight) of snack foods consumed between 1972 and 1987 in the United States jumped 43 percent, snack food packaging actually decreased (by weight) 9 percent over the same time frame.[148]

GVM, a packaging market research organization that assembles the packaging data used by Germany's Ministry of the Environment, estimated that by July 1995, some 25 percent of all packaging targeted by the German ordinance would be diverted away from disposal. GVM estimates that this amount represents about 7 percent of all municipal solid waste or 2 percent of total waste (excluding

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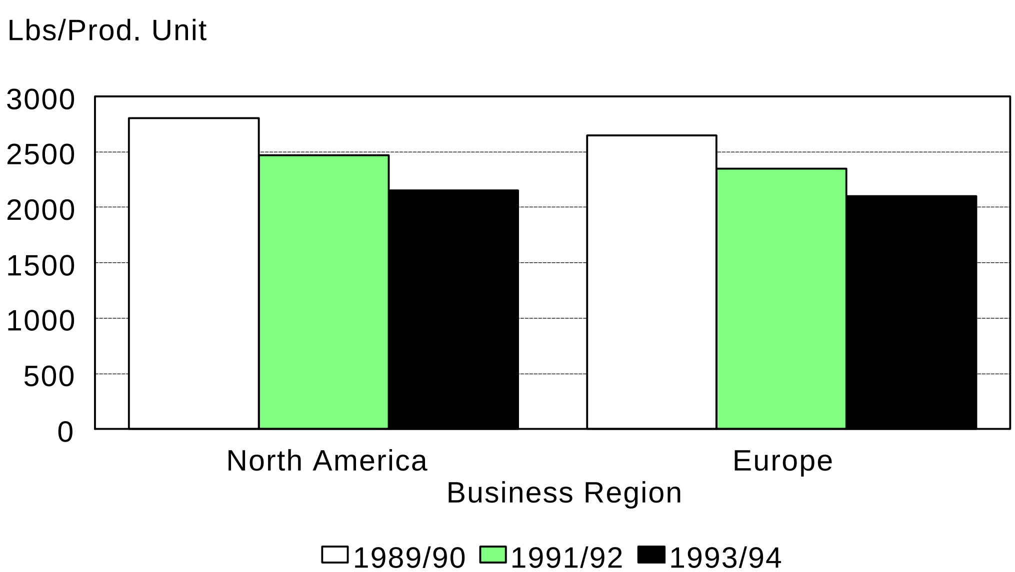
147 Lynn Scarlett, "Recycling Rubbish," *Reason*, May 1994.

148 Some of these figures come from *Analysis of Trends in Municipal Solid Waste Generation: 1972 to 1987*, prepared by Franklin Associates for Procter & Gamble, Browning Ferris Industries, General Mills, and Sears (Prairie Village, Ks.: Franklin Associates, January 1992). Other data were compiled by Lynn Scarlett.

construction and demolition debris).[149] After full implementation of the second-phase diversion quotas,

Figure G-3: Material Use Per Production Unit



Source: Reason Foundation

GVM notes that some 71 percent of targeted packaging will be diverted (or 59 percent of total packaging). This diversion would reduce municipal waste by around 21 percent; it would result in a 5 percent diversion of total waste (excluding building rubble).

2. Costs and Constraints

For manufacturers, some of the packaging changes mean real savings. They are not just a means of reducing Green Dot packaging fees but actually result in materials cost savings. By the end of 1993, Procter & Gamble was buying 25 fewer tons of cardboard per year just by eliminating the outer carton around denture cleaner.[150] The modified package for their Fairy Ultra detergent reduced raw material consumption by 45 percent. And their use of refillable cartons sometimes results in a 90 percent reduction in packaging.

While savings from packaging reductions have materialized in some instances, the Green Dot program carries with it significant "transactions" costs. One estimate put conversion costs for packaging and filling plant operations at DM 10–20 billion, for example.[151]

If the higher Green Dot fees for plastics resulted in a reduction in use of plastic packaging, total weight of packaging could actually increase.[152] GVM estimated the economic and environmental impacts of not

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149 The GVM estimates are cited by Perchard and Bevington, *Packaging Waste Management*, p. 10.

150 Personal communication, November 1993.

151 Ernst Bischoff, cited in Perchard and Bevington, *Packaging Waste Management*, p. 19.

using plastic packaging and concluded that the weight of total packaging in Germany would increase fourfold.[153]

However, it is not clear that the higher plastics fees would actually result in substitution out of plastics, since plastics are extremely lightweight. It may be most cost-effective for manufacturers to continue using very lightweight plastics, paying high fees on a weight basis, rather than paying lower fees on a weight basis for much heavier materials such as glass. A look at some of the packaging changes that occurred in Germany after introduction of the Green Dot fees confirm that some manufacturers have continued to opt for very light weight plastic packaging to minimize total fees.

Germany's Packaging Ordinance could be expected to have some effects on packaging. However, in placing so much design emphasis on recyclability or lightweighting the law may reduce attention paid to other packaging attributes such as convenience, product information dissemination, product shelf-life, and so on. The current fee structure, which discriminates against composites, may drive packaging into more homogeneous, single-layer packaging, thereby foregoing the many benefits associated with multi-layered composite packaging.

Implications of the German Experience for the United States

Germany's Green Dot program was designed to place onto manufacturers the responsibility for disposal of products discarded by consumers. In part, the goal was an instrumental one: it was assumed that making manufacturers responsible for postconsumer waste would spur manufacturers to “design for recycling” or to “design for waste reduction.”

In addition to its expected tangible outcomes, the Green Dot program also arose from a philosophical perspective that, somehow, manufacturers should “pay” for post-consumer waste-handling. This normative assumption rests in part on a seldom-examined assumption that “packaging is pollution” and that product (and packaging) manufacturers are the “polluters” who properly should be held responsible for their pollution.

These philosophical underpinnings of the Green Dot program are questionable. Unlike air or water pollution, which are unintended byproducts of production (and consumption) processes, packaging is itself a product that serves useful (beneficial) functions. Packaging becomes pollution, in the sense of imposing harms on society, only when it is improperly discarded through littering, landfilling in unprotected dumps, and so on. Costs of other resources consumed in making packages are already borne by the manufacturer.

Moreover, unlike air or water emissions, packaging is “owned” throughout its cradle-to-grave cycle: first the manufacturer owns (and therefore has responsibility for) a package; then the wholesaler and retailer “own” packaged products; and finally, “ownership” passes onto the consumer. With this ownership comes all the responsibilities that ownership entails, including liability for improper handling or disposal.

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152 There are lots of environmental and economic trade-offs in packaging decisions. Judd Alexander points out in his book, *In Defense of Garbage* (Westport, Conn.: Praeger, 1993), that prior to the availability of plastic packaging, hot dogs were sold in bulk, with a shelf life of three weeks and a spoilage rate of 10 to 15 percent. High-tech plastics permit sale of hot dogs in small one-pound packaging that lengthens the shelf life to six months.

153 GVM, “Development of packaging consumption 1992/1995 estimate/forecast,” July 1993.

The pollution analogy has been adopted with a “looseness” that has led to policies that may actually end up weakening consumer responsibilities for their own consumption choices and disposal activities. While the philosophical underpinnings of the Green Dot system are questionable, there may be other practical reasons to consider implementing manufacturer's responsibility. Indeed, such arrangements have, in special circumstances, arisen spontaneously through market forces.

For example, in the United States, “product stewardship” (manufacturer's responsibility) programs have been initiated by some manufacturers of solvents, pesticides, herbicides, and other products with high potential toxicity if improperly handled and disposed. In these instances, manufacturers have an incentive to “take back” these discarded products after use, or simply to lease rather than sell them to consumers, to avoid any potential liabilities that might occur when consumers improperly handle and dispose of these products. Film-processing companies, computer manufacturers, and other manufacturers of specialty products that have either high recycling value or pose significant hazard if improperly disposed have also created their own private “take back” programs.

The success of these voluntary private-sector programs suggests that there are some circumstances in which product stewardship may be desirable, feasible, and efficient. Several attributes characterize the market segments in which these voluntary efforts have emerged. Specifically, such programs have emerged spontaneously in the marketplace in cases where there is:

- high risk of improper disposal and associated liabilities to the manufacturer, which create an incentive for manufacturer take-back programs;
- high value in the discarded product (for example, some computers), which gives the manufacturer a motivation to save costs by developing take-back or reuse/recycling partnerships;
- relatively high-value, low-frequency transactions between the manufacturer and consumer, making the transaction costs of implementing a take-back program small relative to the overall product cost; and
- a relatively close and ongoing relationship between the individual manufacturer and a specific customer.

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

- many high-volume, low-value transactions;
- high levels of product heterogenity (e.g., packaging);
- high degrees of centralization of product manufacturing with a wide geographic distribution of the product; and
- existing, safe, efficient waste-handling or product management infrastructure (for example, U.S. auto scrap markets make product stewardship duplicative).

Germany's experience with packaging take-back schemes has been a rocky one: while German manufacturers and the government have worked out some of the kinks in the program, it remains a relatively high cost means of achieving the goal of waste reduction. The program continues to face some free-rider problems, especially by consumers who misuse the designated packaging waste-collection containers. These inefficiencies are likely to be magnified in a U.S. setting in which the geographic size of markets is much larger, the diversity of products is even greater, the existing waste management and recycling system is extensive, and fees for waste service are increasingly utilized so that it is users, not taxpayers, who are footing the bill for their own waste-generation.

A. Structure of Consumer Markets

The U.S. packaging industry is characterized by a high degree of competition among different materials types. The $75–$80 billion industry represents sales of well over 200 billion units of rigid containers of metal, glass, plastics, and other materials each year, as well as billions of paperboard and flexible packages.

Distribution structures vary but often involve centralized production with national distribution systems. Product manufacturers—the intermediate consumers of packaging—are also diverse, and expenditures on packaging are highly decentralized by product category. (See chapter 3 for more details).

Consumption of containers, as noted in chapter 3, is highly dynamic—consumption patterns change relatively rapidly over short periods of time—and are also diverse.

Take-Back Programs

A number of factors are likely to influence the effectiveness and efficiency of take-back programs. These include, for example:

- The number of affected products
- Frequency of product transactions in a given category
- Degree of product homogeneity within a given product category
- Size and scope of the product distribution network
- Degree of harm associated with product mishandling in use or disposal
- Nature of existing waste-handling infrastructure
- Number of manufacturing competitors
- Availability of consumer incentives/disincentives for appropriate product use and disposal or recycling

These production and consumption patterns mean that a packaging take-back program implemented in the United States is likely to face high information-searching costs to determine regulatory criteria, fee structures, and so on, since large intra-industry variations exist. Moreover, the large number of market participants—as well as the relatively low value of each individual packaging transaction—is likely to generate substantial levels of noncompliance or high costs to monitor and enforce compliance.

Chapter two estimated the costs by material that would be borne by manufacturers if a manufacturer responsibility scheme were introduced that was designed to achieve diversion rates ranging from 10 to 60 percent (depending on the material). These costs range widely depending on the material (see Table G-7).

Table G-7: Manufacturers' Responsibility Cost Ranges

Glass	\$75–\$203 per ton
Containerboard	\$1–\$166 per ton
Steel	\$50–\$109 per ton
HDPE	\$0.015–\$0.161 per pound
PET	\$0.044–\$0.221 per pound
LDPE	\$0.019–\$0.164 per pound

Actual costs for individual packages would vary widely, and the impact of these costs on manufacturer behavior are also likely to vary widely. A manufacturer's response would depend in part of the fraction of total product costs represented by packaging costs, and the percent increase in those costs that would result from a take-back and upfront fee system. For example, packaging as a percentage of total product costs varies from as little as 2 percent to as much as 50 percent. In the former case, even fairly large increases in total packaging costs may not create an impetus to change the packaging material or form.

B. Waste Management Structure

Waste management and recycling programs in the United States are both diverse and highly location-specific. Service-delivery arrangements include:

- public-sector collection and recycling;
- public-sector ownership and operation of infrastructure;
- public-sector ownership with private operation of infrastructure;
- public-sector oversight of private-sector contracts;
- private-sector franchise agreements;
- private, competitive customer-subscription services; and
- private ownership and operation of infrastructure.

A take-back scheme could require an overhaul of these arrangements, with manufacturers contracting—either separately or through some form of consortium patterned after Germany's Duales System Deutschland—with cities or private haulers to handle a portion of the waste stream. It is not possible to predict what a reordered waste management system would look like. However, two possible adverse effects might result: 1) a disaggregation of the waste stream with dual, parallel systems to handle the different segments of the waste stream; and 2) a consolidation of contracts and corresponding reduction in competition. Both of these potential results are likely to reduce, not enhance, waste management efficiency.

Apart from these structural implications, take-back schemes would also require changes in how waste services are currently funded—or, in the absence of changes, result in consumers "double-paying" to the extent that either tax dollars or user fees associated with existing waste collection systems are not reduced by an amount corresponding to the upfront disposal fees on consumer goods. Since there is no uniform payment system among cities—some cities pay for solid waste service out of general tax revenues; others apply user fees, which sometimes reflect full service costs—the effects of a take-back system on consumers will vary across locales.
U.S. proponents of manufacturer responsibility often argue that, under the current system, taxpayers unfairly pay for waste management, thereby diverting funds from other purposes such as schools, fire service, and so on. Tax-funding of sanitation services may result in cross-subsidization between low-waste generators and high-waste generators. However, this problem can be resolved by moving to user fees, especially pay-as-you-throw systems. Such user fees are appropriate, since it is the consumer who benefits from the consumption of packaged products and who makes choices that determine waste-generation rates. Once a voluntary transaction between the retailer and consumer has occurred, responsibility for the package transfers to the consumer.

The nature of waste management costs in the United States also affects the potential efficiency of a packaging take-back scheme. Program and system costs vary widely, even within individual states. Weighted average tipping fees, which represent a crude proxy indication of disposal costs. Disposal costs, as reported by *Solid Waste Digest* in December 1996 ranged from a high of $62.90 in the Northeast to a low of $22.06 in the non-Pacific Western states (see Table G-8).

Table G-8: Tipping Fee Index

Region	Price
Pacific	$40.17
Western	$22.06
Midwest	$33.95
Southern	$36.28
Northeast	$62.90

Source: *Solid Waste Digest*, December 1996. Weighted by daily waste disposal volume.

Waste and recycling collection costs also vary widely, depending on location, system design, and other programmatic and demographic variables. There is no “national” waste-handling cost. Indeed, there are no uniform statewide costs. What this means is that any take-back scheme that charged an upfront fee intended to represent the recycling or waste-handling cost of a particular material would, in fact, simply be some sort of average (or arbitrary) sum that bears no real relationship to the costs consumers actually face in specific locales. The upfront fee on manufacturers would mean some consumers would be paying upfront costs (embedded in the price of the product) higher than actual recycling and waste-handling costs in some areas, and lower than actual costs in others, with inefficient consequences.

CONCLUSION

Germany's Green Dot program has achieved some of the intended goals: high levels of packaging diversion and source reduction. However, diversion and source-reduction rates are not substantially different from those being achieved in the United States at significantly lower per ton costs.

When take-back (product stewardship) programs for particular categories of products are effective and efficient, they tend to emerge in the marketplace. The marketplace is not only a context in which trades among buyers and sellers occur; it is also a discovery process in which market participants constantly experiment with new institutional arrangements—leasing, bulk pricing, warehouse retailing, product stewardship—to find more efficient and effective ways of meeting consumer needs and creating value. Experience to date with product take-back suggests that the sort of low-value, high-volume, decentralized, heterogeneous nature of consumer packaging transactions are ill-suited to establishment of efficient and effective product stewardship programs. These attributes especially characterize the U.S. packaging marketplace in which billions of products change hands annually, products move across large geographical distances, and waste-disposal systems (and needs) vary substantially.

Advance Disposal Fees:
From Theory to Practice

INTRODUCTION

Two decades ago, responding to a wave of concern about packaging and other waste, the U.S. Environmental Protection Agency explored whether applying “up-front” fees to consumer goods could effectively incorporate disposal costs into the price of the product. The EPA examined both virgin materials taxes, applied to basic raw material inputs, and advance disposal fees, applied to consumer products and packaging.

- The EPA produced mountains of information on the fee idea. In the end, the idea went nowhere.
- By 1988, however, solid waste had resurfaced as a critical policy issue. And the idea of advance disposal fees was resurrected.
- Though a number of states considered advance disposal fees (ADFs), only Florida moved ahead with the idea initially. (Hawaii eventually put forth its own fee idea in 1993).[154]

What can the Florida experience tell us of ADFs in practice? Though Florida abandoned the fee approach in mid-1995, their two-year experience with ADFs provides insights into implementation issues, fee impacts on waste reduction, and revenue allocation matters.

ADVANCE DISPOSAL FEES: GENERAL DESCRIPTION

A. ADFs: What Are They?

Advance disposal fees refer to taxes applied to products (and packaging) that are intended to include disposal costs in the price of the product.[155] As with all policy concepts, the actual implementation of ADFs can vary widely. In general, ADFs have the following features, or some combination thereof.

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154 A fee of $0.07 per container, which applied to glass containers only, was enacted in 1993 and took effect in 1994. The fee was to continue until repealed. (Personal communication, Hawaii Department of Health).

- They apply either: 1) a flat fee to all packages; 2) a flat fee only to packages not recycled at a particular threshold; 3) a variable fee, depending on recycling rates for different containers; or 4) a variable fee, depending on the costs to recycle different containers.
- Fees either remain in place permanently, or they are eliminated as packages reach specific recycling rates.
- Fees go into a specially designated fund used to finance various recycling or other activities; or they go into a general fund. Fees spent on recycling activities include "bonuses" or rebates to recycling processors and local recycling programs; grants for market development; and financing of recycling infrastructure.
- Some fee proposals offer redemption of fees if containers (or products) are returned.
- Fees are applied at either the manufacturer, distributor, or retail level.

A 1992 Arthur D. Little, Inc. survey of ADFs showed that 60 percent of proposed ADFs focused on packaging; the remaining 40 percent focused on nondurables such as tires and batteries. Most of the latter, however, would have established deposits to ensure proper disposal (or recycling) of the product, rather than establishing a nonrefundable fee system.[156]

The same report found that half of the legislative proposals specified a fee at the retail level; 18 percent proposed to apply the fee at the wholesale level. The remainder identified the manufacturer level to apply the fee or did not specify where it would be applied.[157]

Selection of fee basis involves a trade-off between administrative simplicity versus economic clarity.[158] On the one hand, setting a flat fee for all products is simple to calculate and administer. On the other hand, flat fees, particularly fees designed to reflect recycling costs, obscure significant cost differences among products. Both fee approaches—flat and variable—encounter problems from aggregating what are often highly location-specific costs into a single fee schedule applied across many different locales.

Attempting to set fees based on some relationship to actual solid waste (or recycling) costs is beset with a number of difficulties:[159]

- First, disposal (and recycling) costs are location-specific: there is no *national* or *state* uniformly applicable cost;
- Second, recycling costs may vary by material and product type. Establishing costs on the basis of material obscures differences among products; setting fees by product can involve thousands of different items.
- Third, waste disposal costs are best expressed as a function of volume; but waste collection costs involve both weight and volume considerations. Determining costs on a per product basis

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155 A U.S. Conference of Mayors report describes ADFs as "fees which are designed to incorporate the costs of solid waste management into the price of the product and/or package." (*Alternatives for Industry Involvement in Municipal Solid Waste Reduction and Recycling Programs*, Draft Report, by Jeremy O'Brien and John Williams, HDR Engineering, prepared for Municipal Waste Management Association and U.S. Conference of Mayors (Washington, D.C., May 31, 1994), p. 6.

156 Arthur D. Little, Inc., *A Report on Advance Disposal Fees*, prepared for Environmental Education Associates (Washington, D.C., 1992), p. 3.

157 Ibid., pp. 3-4.

158 David Pearce and R. Kerry Turner note that it is important to link any levy to potential waste disposal and pollution impact. Without that link, the levy is simply a product tax rather than an attempt to internalize any externality. (See Pearce and Turner, "Packaging Waste and the Polluter Pays Principle: A Taxation Solution," in *Journal of Environmental Planning and Management* 1 (1992), p. 6.

159 These fee-setting problems are evident in both the German green dot fee system and in California's processing fee applied to some beverage containers. In the former case, the original flat fees failed to account for major cost differences among materials. The eventual fees based on a combination of materials and weight required extensive product-by-product information about package composition. In the California case, attempts to set processing (advance disposal) fees based on recycling costs have run headlong againt the problem of ever-changing cost structures.

is thus complex and even misleading, since costs are more a function of total weight and volume of a waste mix rather than a function of each individual item in the waste stream (with a few exceptions for wastes that involve special handling).

- Fourth, waste disposal and recycling costs are dynamic; they change over time, sometimes rapidly. This is especially true for recycling, where scrap values are highly volatile.[160]

These fee-setting problems are demonstrated in chapter 2 of this report. Fees based on some approximation of actual recycling and solid waste costs can vary substantially, depending on assumptions about cost variables (see chapter 2).

B. Purpose and Rationale

Proponents present ADFs as a tool for addressing three distinct goals. They view ADFs as a method for: 1) reducing disposal of targeted materials and packaging; 2) securing funds to pay for waste infrastructure and operations; and 3) encouraging recycling and/or waste reduction.

The rationale is fairly simple: "By building the costs of solid waste management into the purchase price of products or packages through the use of ADFs, manufacturers, wholesalers, retailers and/or consumers may be influenced to adopt waste reduction strategies in product design and procurement choices."[161] Some analysts go beyond this descriptive rationale to argue in value terms. The A.D. Little report, for example, proposes that the "cost of waste management of a product *should* be borne by the manufacturer/producer and conveyed to the consumer in the product's price" (emphasis added),[162] though this normative position has no fundamental economic foundation since it can also be argued that the consumer, who chooses to purchase products and who makes decisions regarding the use and disposal of those products, should foot the waste-disposal bill.

Each state has its own particular rationale for proposing ADFs. However, the reasons offered for implementing ADFs fall into several general categories. Proponents claim such fees will:

- reduce litter;
- save resources;
- promote recycling;
- reduce the need for landfills and other disposal facilities;
- strengthen use of recycling programs and facilities; and
- provide revenues to support recycling

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160 Between mid-1994 and 1995, newsprint scrap values jumped over 500 percent in parts of the United States, for example. These changing scrap values have a dramatic effect on net recycling costs. A typical ton of recyclables that brought in $30 per ton in 1993 sold for as much as $125 per ton in the Spring of 1995. This $95 increase was enough to almost entirely offset curbside recycling program costs in some areas.

161 Jeremy O'Brien and John Williams, *Alternatives for Industry Involvement in Municipal Solid Waste Reduction and Recycling Programs*, Draft Report prepared for Municipal Waste Management Association and U.S. Conference of Mayors (Washington, D.C., May 31, 1994), p. 7.

162 A.D. Little, p. 1. This same theme is pursued in David Pearce and R. Kerry Turner, "Packaging Waste and the Polluter Pays Principle," in *Journal of Environmental Planning and Management* 1 (1992). Pearce and Turner refer to packaging taxes as being consistent with a polluter pays principle. The U.S. Environmental Protection Agency has made a similar claim, arguing that "prices of each product should include all costs of production...[including] environmental damage costs...." (cited in O'Brien and Willaims, p. 2).

The "polluter pay" principle imputes to polluters responsibility for their activities: it is an attempt to connect particular production (and consumption) choices with responsibility to assume costs associated with those choices. But stating the moral concept does not establish who the polluter is or what constitutes pollution. Elsewhere, I have argued that packaging taxes are inconsistent with this principle, since packaging is not pollution: it is not a residual of production, it does not represent an "externality" of uncosted resource use (except in the special case where it is littered). Moreover, a consumer, for whose benefit a product is created, may be appropriately designated the party responsible for disposal costs.

There may be efficiency reasons for affixing waste disposal charges at different points along the production/consumption continuum, but what the appropriate point is will vary with circumstance. The appropriate point of application of disposal charges is not inherent in the polluter-pay concept itself. *The notion that all waste disposal charges should apply to manufacturers is simply a misapplication of the concept.*

In its 1992 report, A.D. Little, Inc. identified some 28 bills for the 1990–91 legislative year that proposed some form of an ADF. Most of these, however, were actually deposit-refund schemes rather than nonrefundable packaging or product fees. Though the ADF legislative pace slowed considerably in subsequent years, in 1994–95 at least eight states considered ADFs.[163] Only Florida and Hawaii had actually imposed some form of ADFs on packaging by 1996.

The Case of Florida: ADFs in Practice

A. Legislative History and Description

Passed in 1988, Florida's ADF law was originally to take effect on October 1, 1992.[164] Under the law, a one-cent fee was to be applied to all containers that had recycling rates less than 50 percent. The initial version contained provisions whereby consumers could redeem empty containers at recycling centers. Implementation of this initial ADF law was ultimately pushed back to July 1, 1993. The original Florida law called for a sunsetting of the ADF on October 1, 1995.[165]

The law was restructured in 1993, with an elimination of the deposit. The new version established a one-cent fee on all containers of 5 ounces to one gallon that had not achieved 50 percent recycling rates (see Table ADF-1). The fee was to increase to two cents per container on January 1, 1995.[166] The new version did not remove the sunset provision.

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163 These included California, Washington, North Carolina, Minnesota, Wisconsin, New York, Massachusetts, and Connecticut.

164 The law is contained in s.403.7197, Florida statutes. Its details, dated November 11, 1992, were originally specified in Rule 62.714 of the Florida code.

165 See, para. (8), sec. 72, chapters 88-130 of the Florida statutes.

166 Para. 6 at 403.7197 (Florida Statutes) reads: "Except as provided in subsections (4) and (5), beginning October 1, 1993, there shall be imposed on each container sold in this state an advance disposal fee of 1 cent per container. Beginning January 1, 1995, the advance disposal fee shall be 2 cents per container."

Table ADF-1: Governor's Office/Revenue Estimates Conference			
Container Universe	Estimate	1993–94	1994–95
Glass			
• Beer Bottles	804,165,000	835,906,758	852,050,750
• Wine Bottles	98,892,000	102,795,435	104,780,739
• Liquor Bottles	76,161,000	79,167,204	80,696,172
• Non-alcoholic Beverage Containers	434,656,000	451,812,610	460,538,535
• Food Containers	735,022,000	764,034,566	778,790,480
• Chemical/Cleaning Bottles	8,971,000	9,325,101	9,505,198
• Toiletry/Cosmetic Containers	29,533,000	30,698,718	31,291,607
Total Glass Containers	*2,187,400,000*	*2,273,740,392*	*2,317,653,481*
Plastic			
• Carbonated Soft Drink Containers	362,076,000	376,367,755	383,636,601
• Other Beverage Containers	162,760,000	169,184,414	172,451,897
• Milk	281,476,000	292,586,336	298,237,099
• Household Chemicals	240,136,000	249,614,576	254,435,419
• Ind., Agr., and Specialties	27,092,000	28,161,367	29,705,252
• Toiletries and Cosmetics	192,868,000	200,480,827	204,352,744
• Other Foods	138,424,000	143,887,830	146,666,757
• Automotive and Marine	167,232,000	173,832,931	177,190,192
• Misc. Bottles	76,284,000	79,295,059	80,826,496
Total Plastic Containers	*1,648,348,000*	*1,713,41,095*	*1,746,502,457*
Plastic-Coated Paper (PCP)			
• Juice or Drink Cartons	155,000,000	164,153,403	167,323,722
• 1/2 Gallon Milk	82,805,000	87,694,984	89,388,650
• Quart Milk	60,690,000	64,274,000	65,515,333
• Pint Milk	63,369,000	67,111,206	68,407,335
• 1/2 Pint Milk	447,293,000	473,707,535	482,856,319
Total PCP Containers	809,157,000	856,941,128	873,491,359
Unidentified Containers	0	484,409,261	493,764,730
Total Containers Subject to Fee	4,644,905,000	5,328,501,876	5,431,412,027
Aluminum			
• Alcohol and non-alcoholic beer cans	2,571,655,289		
• Soft drink, water and juice cans	2,817,647,766		
• Mixed spirits cans	840,000		
• Food cans	156,445,800		
• Aerosol cans	12,744,601		
Total Florida aluminum cans in 1992	5,559,333,456		
Steel			
• Beer and Beverage	1,696,000		
• Aerosol	113,095,800		
• Paint and Varnish	43,146,720		
• Food	1,422,168,480		
Subtotal	*1,578,411,000*		
Total Cans sold in 1993	***1,580,107,000***		
Total Container Universe	***11,784,345,456***		

Source: "Solid Waste Management in Florida," Florida Department of Environmental Protection, January 1995, p. 40.

Under the new version of the law, companies could have their products exempted from the fee by certifying that they: 1) used specified levels of recycled content; 2) removed specific levels of materials from the Florida waste stream through a "take back" provision whereby they ensured end uses for collected materials; or 3) met recovery goals (see Table ADF-2).

Table ADF-2: ADF Exemption Impact Analysis (June 1994)

ADF Container Universe	Rounded 1994–95 Estimate (Millions)	Estimated # of Containers Exempt Through Goals				Subject to ADF (Millions)	Percent Exempt
		Takeback (Millions)	Content (Millions)	Recovery (Millions)	Total Exempt (Millions)		
Glass							
• Beer Bottles	852.1	0.0	639.1	0.0	639.1	213.0	75%
• Wine Bottles	104.8	0.0	21.0	0.0	21.0	83.8	20%
• Liquor Bottles	80.7	0.0	20.2	0.0	20.2	60.5	25%
• Non-Alcoholic Beverage Conts.	460.5	0.0	368.4	0.0	368.4	92.1	80%
• Food Containers	778.8	0.0	623.0	0.0	623.0	155.8	80%
• Chemical/Cleaning Bottles	9.5	0.0	7.6	0.0	7.6	1.9	80%
• Toiletry/Cosmetic Containers	31.3	0.0	25.0	0.0	25.0	6.3	80%
Total Glass Containers	2,317.7	0.0	1,704.3	0.0	1,704.3	613.4	74%
Plastic							
• Carbonated Soft Drink Conts.	383.6	0.0	378.8	0.0	378.8	4.8	99%
• Other Beverage Containers	172.5	134.1	0.0	0.0	134.1	38.4	78%
• Milk	298.2	278.6	0.0	0.0	278.6	19.6	93%
• Household Chemicals	254.4	7.0	130.0	0.0	137.0	117.4	54%
• Ind., Agr., and Specialties	28.7	0.0	0.0	0.0	0.0	28.7	0%
• Toiletries and Cosmetics	104.4	0.0	11.0	0.0	11.0	193.4	5%
• Other Foods	146.7	1.0	1.0	0.0	2.0	144.7	1%
• Automotive and Marine	177.2	0.0	147.3	0.0	147.3	29.9	83%
• Misc. Bottles	80.8	0.0	1.0	0.0	1.0	79.8	1%
Total Plastic Containers	1,746.5	420.7	669.1	0.0	1,089.8	656.7	62%
Plastic-Coated Paper (pcp)							
• Juice or Drink Cartons	167.3	0.0	0.0	167.3	167.3	0.0	100%
• 1/2 Gallon Milk	89.4	0.0	0.0	89.4	89.4	0.0	100%
• Quart Milk	65.5	0.0	0.0	65.5	65.5	0.0	100%
• Pint Milk	68.4	0.0	0.0	68.4	68.4	0.0	100%
• 1/2 Pint Milk	482.9	0.0	0.0	482.9	482.9	0.0	100%
Total PCP Containers	873.5	0.0	0.0	873.5	873.5	0.0	100%
Unidentified Containers	493.8					493.8	
Total Containers	5,431.5	420.7	2,373.4	873.5	3,667.6	1,763.9	68%

Source: "Solid Waste Management in Florida," Florida Department of Environmental Protection, January 1995, p. 44.

B. Rationale

The Florida legislature justified the ADF as a means to "create sufficient incentives for the establishment of the necessary infrastructure within the state to help solve solid waste management problems."[167] Supporting documents that accompanied passage of the ADF indicate that the original intent of the law was to increase collection of recyclables.[168] The 1993 restructuring was designed to

167 See Florida Statutes (403.7197).

168 See "Advance Disposal Fee Issue Paper," prepared for the Department of Environmental Protection, Feb. 7, 1995. The report asserts that "the intent of the ADF is to increase the demand for recovered materials, thereby ensuring the success of public and private recycling efforts in the state...."

improve recycling markets, provide revenues for establishing waste-handling infrastructure, and raise revenue for environmental programs.[169]

The restructured ADF, which provided exemptions for packaging that met specified recovery rates or recycled content levels, was intended to create incentives for recovery and recycling. Exemptions would give recycled materials some price advantages over nonrecycled materials. A 1995 issue paper prepared during the state's analysis of its ADF program makes the following claim:

> *Just as the 50 percent recycling rate exemptions provided advantages for one material type over another, these exemptions provide competitive advantages among given material types. For example, by being exempt from the ADF, aluminum and steel cans have had favorable public attention when compared to the stigma that became attached to the glass, plastic, and plastic-coated paper containers subject to the fee....The concept is the same for all the goals: containers granted an exemption are less expensive when compared to containers whose companies have not increased their recycling or use of recycled content. This difference was exaggerated after January 1, 1995, when the ADF increased to 2 cents per container for those containers still subject to the fee.*[170]

C. Revenue Generation and Allocation of Funds

An important goal of Florida's ADF was to raise funds to support solid waste and recycling infrastructure. Before the granting of extensive exemptions in 1994 and 1995, the ADF did generate sizeable revenues to the state. In its first full year of implementation (October 1993 through September 1994), the ADF generated nearly $45 million.

Projections for FY94–95 came to $26 million, with another $20 million projected for FY95–96 if the law did not sunset.[171] This substantial drop in projected revenues from FY93–94 to subsequent years resulted from the broad application of exemptions.

In its first year of operation, only aluminum and steel containers were exempted from the ADF. By mid-1994, 105 companies had petitioned for exemptions by certifying that they would meet either recycled content or material recovery goals through June 30, 1996. These exemptions applied to 65 to 70 percent of containers originally subject to the ADF.[172] Exemption requests included all plastic-coated paper milk cartons and drink boxes, virtually all soft drink containers, all glass made or filled in the United States, most plastic automotive and marine products, and many household products. One estimate concluded that these exemptions covered nearly 70 percent of containers subject to the ADF (see Figure ADF-1). An issue brief for the governor's office estimated exemptions as covering 77 percent of all containers of the first two-year exemption period (see Table ADF-3).

ADF revenues were designated to a Solid Waste Management Trust Fund, and no ADF revenues are transferred to the state's General Fund. The trust fund, established in 1988, actually predates any revenue flows from the ADF. In 1993, its total revenues derived from tire fees, a special sales tax collection allowance, an annual sales tax registration fee, a newsprint advance disposal fee, and the packaging advance disposal fee.

Table ADF-3: Governor's Office/Revenue Estimating Conference/DEP Exemption Analysis FY1994–95 &

169 See "Advance Disposal Fee Briefing Summary," Florida Department of Environmental Protection, March 15, 1995.

170 "Advance Disposal Fee Issue Paper," Feb. 7, 1995, p. 2.

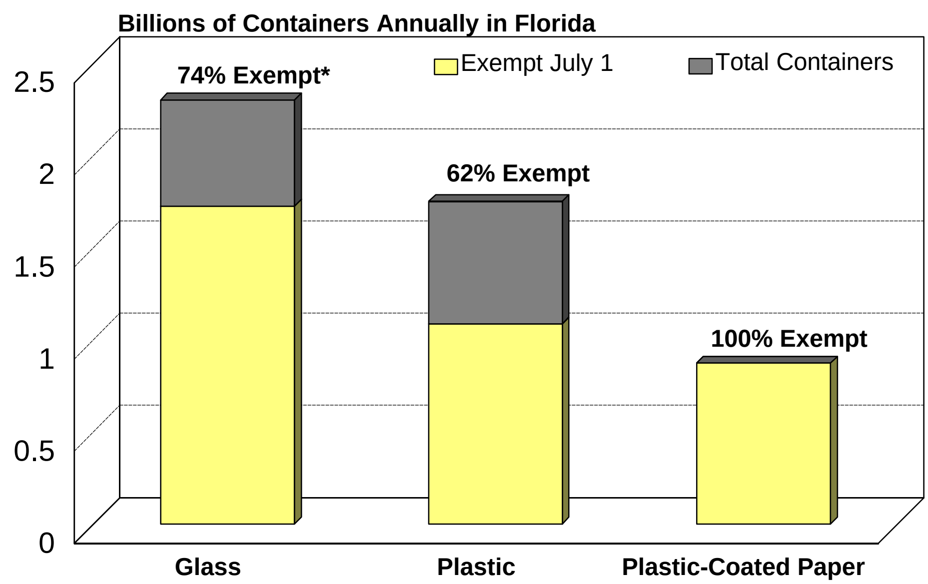
171 See *Advance Disposal Fee Briefing Summary*, Florida Department of Environmental Protection, March 15, 1995, p. 3.

172 Bureau of Solid and Hazardous Waste, Division of Waste Management, *Solid Waste Management in Florida*, January 1995, p. 42.

FY1995–96 Combined to Cover First 2-Year Exemption Period							
ADF Container Universe	Rounded 1994–95 Estimate (Millions)	Estimated # of Containers Exempt Through Goals				Subject to ADF (Millions)	Percent Exempt
		Takeback (Millions)	Content (Millions)	Recovery (Millions)	Total Exempt (Millions)		
Glass							
• Beer Bottles	3,952.10	0.0	3,556.89	0.0	3,556.89	395.21	90%
• Wine Bottles	485.90	0.0	242.95	0.0	242.95	242.95	50%
• Liquor Bottles	374.20	0.0	187.10	0.0	187.10	187.10	50%
• Non-Alcoholic Beverage Conts.	930.30	0.0	744.24	0.0	744.24	186.06	80%
• Food Containers	1,573.30	0.0	1,258.64	0.0	1,258.64	314.66	80%
• Chemical/Cleaning Bottles	19.20	0.0	15.36	0.0	15.36	3.84	80%
• Toiletry/Cosmetic Containers	63.20	0.0	50.56	0.0	50.56	12.64	80%
Total Glass Containers	7,398.20	0.0	6,055.74	0.0	6,055.74	1,342.46	82%
Plastic							
• Carbonated Soft Drink Conts.	774.90	383.09	383.09	0.0	766.19	8.71	99%
• Other Beverage Containers	348.30	290.65	0.00	0.0	290.65	57.65	83%
• Milk	602.40	573.67	0.00	0.0	573.67	28.73	95%
• Household Chemicals	513.90	17.21	319.60	0.0	336.82	177.09	66%
• Ind., Agr., and Specialties	58.00	0.00	14.65	0.0	14.65	43.35	25%
• Toiletries and Cosmetics	412.70	0.00	121.45	0.0	121.45	291.25	29%
• Other Foods	296.40	39.17	39.17	0.0	78.35	218.05	26%
• Automotive and Marine	358.00	0.00	313.64	0.0	313.64	44.36	88%
• Misc. Bottles	163.20	0.00	43.02	0.0	43.02	120.18	26%
Total Plastic Containers	3,527.80	1,303.80	1,234.63	0.0	2,538.44	989.36	72%
Plastic-Coated Paper (pcp)							
• Juice or Drink Cartons	338.00	0.0	0.0	338.00	338.00	0.0	100%
• 1/2 Gallon Milk	180.60	0.0	0.0	180.60	180.60	0.0	100%
• Quart Milk	132.30	0.0	0.0	132.30	132.30	0.0	100%
• Pint Milk	138.20	0.0	0.0	138.20	138.20	0.0	100%
• 1/2 Pint Milk	975.30	0.0	0.0	975.30	975.30	0.0	100%
Total PCP Containers	1,764.40	0.0	0.0	1,764.40	1,764.40	0.0	100%
Unidentified Containers	1,134.70						28%
Total Containers	13,825.10	1,303.80	7,290.37	1,764.40	10,679.03	3,146.07	77%

Source: “Solid Waste Management in Florida,” Florida Department of Environmental Protection, January 1995, p. 40.

Figure ADF-1: Advance Disposal Fee Exemptions (July 1, 1994 estimate)



*Includes 100% of all domestically manufactured or filled glass containers.
Source: Bureau of Solid and Hazardous Waste, Florida Department of Environmental Protection, Solid Waste Management in Florida, January 1995, p. 43.

While all revenues from the ADF were placed in the trust fund, not all of these funds were expended on solid waste and recycling activities. In the 1993 changes to the ADF law, lawmakers specified that 12 percent of ADF revenues must be used for improving recycling markets. The remainder of funds were expended on a variety of other environmental and capital projects. These included 30 percent of funds allocated as supplemental grants to counties, 19 percent for surface water improvements, 27 percent for a sewage treatment revolving loan fund, and 12 percent for small community sewer construction assistance (see Table ADF-4).[173]

Table ADF-4: ADF Revenue Allocation: 1994–95

Program	Amount (millions of dollars)	Comments
Supplemental Grants	$10.8	Small county landfill closures
Recycling Markets	$ 6.1	
Surface Water Improvement	$ 8.0	
Small Community Sewers	$ 3.8	Reduce septic tank runoff
Sewage Treatment Loans	$13.0	Federal fund matching

Source: "Solid Waste Management in Florida," Florida Department of Environmental Protection, January 1995, p. 40.

The expenditures for recycling market development clustered into five categories:

Business Loans and Grants:	$2,925,000
Education:	$1,950,000
R & D:	$550,000
Technical Assistance:	$350,000

173 See *ADF Briefing Summary*, p. 3; and *Recycling Markets Advisory Committee Annual Report*, Florida Department of Commerce, Division of Economic Development, December 30, 1994; and *Solid Waste Management in Florida*, Bureau of Solid and Hazardous Waste, Division of Waste Management, January 1995.

Commerce Dept./Advisory Committee Support: $297,000

Though FY93–95 ADF expenditures applied only 12 percent of funds to recycling market development, the state's Recycling Market Advisory Committee (RMAC) recommended in its December 1994 report that 100 percent of ADF funds "be allocated to support recycling market development activities in Florida."[174]

D. Program Analysis

Evaluating Florida's program is difficult for several reasons. First, in passing its ADF legislation, the state set forth several sometimes competing goals. On the one hand, the state viewed ADFs as a means of raising revenues to support integrated waste management programs, including recycling market development. But the state also structured ADFs (and exemptions) in a manner to foster use of recycled content. These two goals are not necessarily compatible, since the revenue-raising goal ultimately conflicts with the goal of enhancing use of recyclables. As containers and packaging become exempt when they reach specified recovery or recycled content rates, overall program revenues decline. This trade-off is, in fact, precisely what Florida experienced between the first program year and subsequent years. In this sense, assessing program effectiveness depends in part on which goal one selects as the primary measure of success.

More problematic are confounding variables that make it difficult to attribute any increased recycling activity to the ADF program. Throughout the United States, recycling activity was increasing during the time in which Florida's ADFs were in place. Thus, any recycling increases seen in Florida may simply have been part of this larger trend.

The same problem applies to analysis of Florida's expenditures of ADF funds. At least in the short run, ADFs did supply over $40 million in additional revenues to the state for use in environmental programs. Less clear is whether these funds simply replaced other funds that would otherwise have been spent on recycling activities. Also unclear is whether the ADF expenditures actually resulted in net increases in recovery and use of recyclables.

Despite these uncertainties, it's possible to offer some preliminary conclusions about Florida's program, using the goals that the state set forth as the yardstick against which to measure program performance. These goals included: 1) raising revenues for recycling (and other environmental) infrastructure; 2) increasing recovery of recyclables; and 3) increasing recycled content in products sold in Florida.

1. Revenues for Recycling and Environmental Infrastructure

In FY94–95, ADFs generated between $45 and $50 million. About 12 percent of this, or around $6 million, was spent on recycling market development. There are two ways to look at these expenditures: 1) how much they represented in terms of the state's overall budget for solid waste and recycling activities; and 2) how effective these expenditures were in increasing recycling activity in the state.

In its January 1995 report, *Solid Waste Management in Florida*, Florida's Department of Environmental Protection reports that the department awarded over $180 million to local governments over the six-year period between 1988 and 1994. Of this sum, $136.2 million was spent for recycling and education during that time period.[175] The state expended over $252 million from its Solid Waste Management Trust Fund for various waste management and recycling programs from 1988 through 1994.

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174 *Recycling Markets Advisory Committee Annual Report*, p. 9.

175 *Solid Waste Management in Florida*, p. 101.

For FY94, the first full fiscal year in which ADF revenues became available, total solid waste grants and expenditures (including trust fund outlays) came to around $85 million. ADF grants and loans for recycling and solid waste made up around 19 percent of this one-year total. Another way to look at the impact of the ADF fees is as a source of increased funding for recycling and solid waste programs. Once ADF monies became available solid waste and recycling expenditures by the state did jump from $72.5 million in FY92–93 to $85.2 million in 1993–94, an 18 percent increase.

In the context of these overall expenditures, the ADF expenditures of $6 million for recycling market development and the $10 million spent on landfill closures represent 19 percent of the one-year FY93–94 totals, as noted above. Of the six-year total, however, these funds represented under 4 percent of the $431 million spent by the state on recycling, solid waste, and related activities.[176]

It appears, then, that the ADFs contributed a relatively small portion of funding for recycling and solid waste over the six-year period after establishment of the Solid Waste Trust Fund. On the other hand, ADF monies did represent a fairly sizeable (19 percent) portion of total single-year funds in FY93–94. The substantial reduction in ADF revenues for FY94–95 after implementation of the exemption program, however, diminished the potential ADF contribution to solid waste and recycling programs, especially *if the state continued to apportion most of the ADF funds to expenditures not related to recycling and solid-waste handling*.

2. Recycling and Recovery Rates

More important than total dollars spent is their likely effectiveness in increasing recycling in the state. For Florida's ADFs, this assessment has two components: 1) did ADF expenditures on recycling activities result in increased recovery and recycling; and 2) did the ADF packaging fees change manufacturer behavior, nudging them toward increased use of recycled content? A complete empirical assessment of these issues is beyond the scope of this brief case study. However, a comparison of performance in Florida with general nationwide trends in recycling suggests that the impact of ADFs—either through direct expenditures of ADF revenues or as a result of the fee incentive structures—was limited.

As reported in the "Advance Disposal Fee Issue Analysis," Florida's Department of Environmental Protection estimated recycling levels resulting from implementation of ADFs (see Table ADF-5). The DEP estimated that for FY94–95:

> *ADFs will result in at least 53,000 tons of glass being used as recycled content; 11,000–18,500 tons of plastic being removed from the waste stream in Florida and recycled into other products; and 2,300–7,400 tons of plastic recycled content use.*[177]

Table ADF-5: Advance Disposal Fee Impact Analysis Summary (January 9, 1995) FY1994–95 and 1995–96

Material/Goal	Tons of material Necessary to Meet ADF Goals	10%	25%	50%	75%	90%
Scenario 1: 1994–95 Exemption Percentages Used for Both Years						
Plastic TakeBack	23,125	2,312	**5,781**	**11,562**	17,344	20,812
Plastic Content	22,791	**2,279**	**5,698**	11,396	17,093	20,512
Glass Content	529,877	**52,988**	132,469	264,939	397,408	476,890
Scenario 2: Governor's Office/Revenue Estimating Conference/DEP Estimates						
Plastic TakeBack	24,716	2,472	6,179	**12,358**	**18,537**	22,244
Plastic Content	29,666	**2,967**	**7,417**	14,833	22,250	26,700
Glass Content	529,877	**52,988**	132,469	264,939	397,408	476,890

176 See *Solid Waste Management in Florida*, January 1995; and see "Advance Disposal Fee Issue Paper," February 7, 1995.

177 "ADF Briefing Summary," p. 2.

Bold numbers indicate most likely range of ADF's impact
Glass content calculation: (6,055.75 million containers exempt (Table ADF-3)/2 glass containers per pound/2,000 pounds per ton) X .35.
Source: "Solid Waste Management in Florida," Florida Department of Environmental Protection, January 1995.

In a comment presumably intended to applaud the ADF program, the briefing puts these figures into perspective by noting that "the entire solid waste stream in almost one-half of the counties in Florida is 75,000 tons or less per year."[178]

These data are, however, somewhat misleading, since they seem to attribute to ADFs a significant reduction in municipal waste disposed of in Florida. A look at the entire municipal waste stream in Florida paints a different, less-promising picture. Though about half the counties in Florida together produce barely 75,000 tons of waste, the *other* half of Florida's counties generate over 23 million tons of commercial and residential waste. The 78,900 tons of material recovered reportedly as a result of the ADF thus amounts to three-tenths of one percent of Florida's waste stream.

Another way to look at these figures is as a percentage of total waste diverted from Florida's waste stream. In 1994 the state recycled some 8.6 million tons of waste (this figure includes some yard waste composting, and a portion of recycled white goods, C&D debris, tires, and process fuel). The 78,900 tons of material reportedly recycled as a result of the ADF represent about 0.9 percent of the total materials recycled.

Since the ADF targets only packaging, a third way to put the recycling totals attributed to the ADF into perspective is to compare them to total recycling of packaging materials only. For 1994, the state recycled some 223,606 tons of packaging material. The 78,900 tons attributed to the ADF thus represents about 35 percent of recycled packaging material. In this smaller universe, the diversion tonnage attributed to the ADF appears more significant, though the more appropriate way to evaluate ADF effectiveness is in terms of its impact on total waste diversion.

However, two considerations are important in further evaluating the effectiveness of the ADFs. First is the problem of determining whether the amounts of diversion attributed to the ADF would actually have occurred even in the absence of these fees. Second is the question of cost.

3. National Comparison

One way to assess the impact that Florida's ADF had on recovery and recycling rates in the state is to compare trends in Florida with national trends. Florida was the only state that implemented ADFs. Thus, if those fees had a significant impact on the recovery and recycling of packaging, Florida's recycling rates could be expected to outpace national rates. Such a comparison is only suggestive, since other local and regional factors influence state recycling activities. However, a comparison with national trends provides at least a preliminary indication of whether Florida's program might have had a notable impact on the state's recycling activity.

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178 "ADF Briefing Summary," p. 2.

Strong economic conditions nationally and a general nationwide public sentiment favoring recycling resulted in increases in recovery and use of recyclables throughout the United States. One Florida report on the impacts of the state's ADFs acknowledges this trend, noting that “industry demand [for recyclables] is affected even more by the overall state of the economy. During ADF implementation, a relatively strong economy has caused many markets for recyclables to be at all-time highs.”[179] Florida's Recycling Markets Advisory Committee reported in 1994 that “many industry analysts believe the primary reason for the overall improvement in recycling markets over the past year can be attributed to the continued steady growth of the nation's economy.”[180]

In Florida and the nation, end-user demand for materials actually exceeded available supplies in late 1994 through mid-1995, resulting in steep price increases for many recovered materials. By mid-1995 this upward trend had reversed itself, with scrap values for most recyclables dropping precipitously. It is not possible to gauge the effect ADFs might have had on recycling rates during this less attractive economic environment, since Florida's program sunset shortly after these downward price trends occurred.

However, Florida recycling rates appear to track reasonably closely with national trends. In its Second Annual Report, the Florida Packaging Council (FPC) reported that Florida's rates “approximate national averages, with some exceptions. The recovery rates for aluminum cans and PETE carbonated soft drink containers in Florida are less than the national average....On the other hand, the recovery rate for steel cans in Florida is greater than the national average.”[181] The FPC reported that states with bottle bills may skew upwards the national recovery rate for aluminum cans and soda containers, while Florida's higher-than-average reliance on waste-to-energy plants with magnetic recovery systems may account for the state's high steel can recovery rates.

Other data present a somewhat different picture. In its July 1994 presentation to the Florida Packaging Council, the Can Manufacturers Institute (CMI) reported a 1992 aluminum can recovery rate of 54.73 percent for Florida and 67.9 percent for the nation. For the period from April 1993 to March 1994, CMI reported a recycling rate of 54.07 percent, the last year for which data were announced, since ADFs were not reauthorized. By comparison, the national recycling rate for 1995 was estimated at 62.2 percent, somewhat higher than the Florida rate.[182]

Recycled content of aluminum cans ranged from 50 to 55 percent in both Florida and the nation, with 1993 recycled content pegged at almost 52 percent. Specifically, Florida reported a 54 percent rate for 1994,[183] and the Can Manufacturers Institute reported a national rate of 51.3 percent.

Paper recovery rates in Florida also tracked fairly closely with national rates. The recovery rate in Florida for 1992 was reported at 34.5 percent; the national rate for that year ws 38.5 percent. By 1993, Florida rates had climbed slightly, to 36.2 percent; the national rate had increased at a slightly slower

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179 “Advance Disposal Fee Issue Paper,” p. 10.

180 Recycling Markets Advisory Committee, *Annual Report*, December 30, 1994, p. 13.

181 Florida Packaging Council, *Second Annual Report* (Tallahassee, Fl: Department of Environmental Protection, December 1, 1994) p. 2.

182 Personal communication, Can Manufacturers Institute.

183 Personal communication, Florida Department of Environmental Protection.

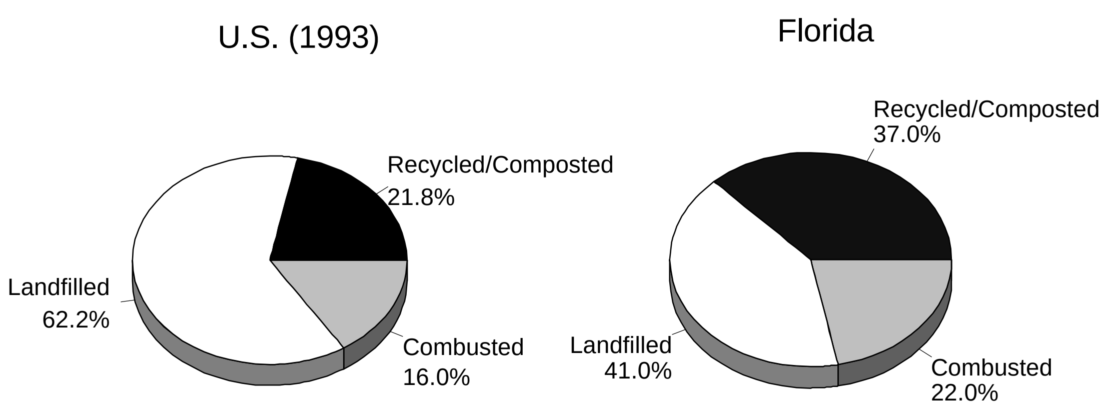
pace, to 39.2 percent. After implementation of its ADF, Florida recycled content rates for paper, averaged across all paper types appeared roughly to parallel the national rate in 1994 of nearly 35 percent.

Overall plastic recovery rates, estimated at 19.7 percent for 1992–1993, matched the national rate of 19.7 percent.[184]

It is also possible to compare the overall disposition of Florida's municipal waste with national trends. Florida generated around 23.5 million tons of municipal solid waste, as reported for 1993. Of that amount, 6.6 million tons were recycled; another 5 million tons were combusted; the remainder was landfilled. By 1994, recycling tonnage had increased to 8.6 million tons (see Figure ADF-2 and Table ADF-6).

This waste-handling system presents a notably different picture compared with five years earlier. Between 1989 and 1994, the state experienced a 28 percent decrease in landfilling, a 69 percent increase in combustion, and a 204 percent increase in recycling. Over a similar timeframe, national waste-handling also moved toward greater recycling.

Figure ADF-2: MSW Management



Source: Franklin Associates, *Characterization of Municipal Solid Waste in the United States*, March 1996, Table 26; and Bureau of Solid and Hazardous Waste, Florida Department of Environmental Protection, Solid Waste Management in Florida, January 1995, p. 43.

Table ADF-6: Florida Municipal Solid Waste Collected and Recycled (July 1, 1993–June 30, 1994)

Materials	Municipal Solid Waste Collected[1]		Municipal Solid Waste Recycled				
	Tons/Yr.	% of Total Tons/Yr.	Public Tons Recycled	Private Tons Recycled	Combined Tons Recycled	% of Total Tons Recycled	Material Recycling Rate[2] (%)
1. Newspapers	1,316,378	5.6	363,956	219,052	583,008	6.8	44.3
2. Glass	707,437	3.0	103,630	28,872	132,502	1.5	18.7

184 Bureau of Solid and Hazardous Waste, *Solid Waste Management in Florida,* January 1995, p. 45.

3.	Aluminum Cans	160,772	0.7	15,371	46,321	61,692	0.7	38.4
4.	Plastic Bottles	245,064	1.0	22,948	6,464	29,412	0.3	12.0
5.	Steel Cans	210,468	0.9	56,156	26,865	83,022	1.0	39.4
6.	C & D Debris	5,160,592	21.9	296,359	2,690,565	2,986,924	34.7	57.9
7.	Yard Waste	3,481,399	14.8	1,158,737	435,868	1,594,605	18.5	45.8
8.	White Goods	226,556	1.0	43,549	129,592	173,141	2.0	76.4
9.	Tires	159,189	0.7	46,677	23,825	70,502	0.8	44.3
10.	Other Plastics	1,095,903	4.7	1,698	12,829	14,527	0.2	1.3
11.	Ferrous Metals	1,397,006	5.9	86,242	733,928	820,170	9.5	58.7
12.	Non-Ferrous Metals	544,817	2.3	3,078	181,140	184,218	2.1	33.8
13.	Corrugated Paper	2,047,451	8.7	61,900	887,894	949,794	11.0	46.4
14.	Office Paper	722,612	3.1	24,819	152,323	177,142	2.1	24.5
15.	Other Paper	2,391,893	10.2	17,045	58,401	75,446	0.9	3.2
16.	Food Wastes	1,302,110	5.5	1,460	73,544	90,004	1.0	6.9
17.	Textiles	662,173	2.8	1,252	29,686	30,938	0.4	4.7
18.	Miscellaneous	1,729,113	7.3	283,516	241,120	524,636	6.1	30.3
19.	Process Fuel[3]	N/A	N/A	23,035	3,078	26,113	0.3	100.0
20.	Total	23,560,931[4]	100.0	2,626,430	5,981,366	8,607,796	100.0	36.5

[1] Municipal solid waste collected is the total recycled, landfilled and combusted.
[2] Unadjusted recycling rate.
[3] Process fuel is composed of yard, wood and paper waste used in process boilers.
[4] Process fuel is not included in the total. The tonnage collected has been counted in other material categories.

Source: "Solid Waste Management in Florida," Florida Department of Environmental Protection, January 1995, p. 18.

Table ADF-7: Industry and County Comparisons of Minimum 5 Materials (July 1, 1992–June 30, 1994)

	Industry			Counties[1]					
Material	Tons Generated	Tons Recycled	% Re-cycled	Tons Collected		Tons Recycled		% Recycled[6]	
				1993	1994	1993	1994	1993	1994
New Paper[2]	808,500	440,000	54	1,300,551	1,316,378	558,168	583,008	43	44
Glass[3]	582,092	102,616	18	731,973	707,437	132,647	132,502	18	19
Aluminum Cans[4]	95,120	55,331	58	158,250	160,772	60,614	61,692	38	38
Plastic Bottles[5]	248,700	49,000	20	267,059	245,064	28,596	29,412	11	12
Steel Cans[4]	106,487	54,426	51	186,057	210,468	64,102	83,022	34	39
Min. 5 Total	1,840,899	701,373	38	2,643,890	2,640,119	844,127	889,636	32	34

1 County numbers are from 1993 R&E grant applications
2 Newspaper calaculations for industry are taken from "Evaluation of Florida Newspaper Generation and Recovery, July 1993 through June 1994," prepared by Franklin Associates, Ltd.
3 Glass figures for industry are taken from "State of Florida 1991 Glass Container Recovery Rate Study," prepared by R.W. Beck and Associates, August 1992.
4 Industry calculations for aluminum and steel cans are from the ADF program, FDEP.
5 Industry plastic figures are from "1993 Florida Post-Consumer Plastics Recycling Rate Study," prepared by R.W. Beck and Associates (included in Florida Packaging Council 1993 Annual Report).
6 Unadjusted Recycling Rate.

Source: "Solid Waste Management in Florida," Florida Department of Environmental Protection, January 1995, p. 46.

The ADF appears to have played a relatively minor role in the state's increased recycling, since much of the increase predates its implementation. The larger influence appears to have been the state's mandate that 30 percent of each county's waste be recycled by 1994.[185]

185 This mandate was revised slightly in 1993, with counties having fewer than 50,000 people exempted from the requirement. This includes 31 counties, or about half the state's counties. The recycling goal allows some yard waste composting to be included in the calculation. The state's law puts restrictions on the amount of recycling from white goods, C&D debris, tires and process fuel that can be included in the recycling rate.

One difficulty in assessing recovery and recycling rates in the state is the inconsistency of data from different sources. This is no small problem. In its Second Annual Report, the Florida Packaging Council notes that "while recycling estimates [of industries and the DEP] are usually comparable, the amount of material estimated to be generated usually varies significantly."[186] Tonnage figures on waste generation reported by counties for five recycled materials are 44 percent higher than those reported by industry (see Table ADF-7). Recovered tonnage reported by counties differs from industry figures by some 20 percent.

Using county data, no material had achieved a 50 percent recycling rate by 1993. By contrast, industry data showed both aluminum and steel achieving at least a 50 percent rate. The state determined that the rates reported by industry were more reliable, since county data may have double-counted some materials or may have been based on sample field studies at waste disposal facilities. The Florida DEP points out that "even detailed field studies provide only a snapshot of the waste at a point in time, and they are dependent on proper statistical sampling for their results, rather than actual sales generation data."[187] Industry data, on the other hand, were based on more reliable calculation methodologies and included independent verification of data.

4. Florida Surveys and Anecdotal Information

Florida's DEP surveyed companies that petitioned for an exemption from the ADF. Over 61 percent of "takeback petitioners" indicated that the ADF did influence their recycling efforts. Around 26 percent of petitioners asking for an exemption from the ADF based on recycled content in their products indicated that "they increased their use of recycled content as a direct result of the ADF."[188] The DEP notes that some petitioners particularly cited the fee increase from one to two cents as "a significant factor in seeking exemption."[189]

In addition, Florida's DEP reports that investment in two facilities—a Piper Plastics plant and an Anheuser-Busch plant—was prompted, at least in part, by the ADF. Piper Plastics officials cite the ADF as an important reason for their decision to locate the plant in Florida. Anheuser-Busch cites Florida's ADF as a factor in its decision to locate a 100,000 ton per year glass recycling facility in Florida.

These decisions may have been influenced by the presence of Florida's ADF. However, as indicated above, national trends in recovery rates and recycled content showed no significant difference from Florida's rates, suggesting that these activities cannot have had substantial impacts on the state's overall recycling. In its January 1995 report, Florida's Bureau of Solid and Hazardous Waste acknowledges that it is difficult to determine the actual impact of ADFs on recycling. After reporting various new recycling activities in the state, the report goes on to say that "it is also unclear whether companies are getting credit for actions previously taken, or whether they are initiating new recovery and use of recycled content as a result of the ADF."[190]

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186 FPC, Second Annual Report, pp. 2-3.

187 Bureau of Solid and Hazardous Waste, Division of Waste Management, *Solid Waste Management in Florida* (Tallahassee: Florida Department of Environmental Protection, January 1995), p. 46.

188 See "ADF Briefing Summary," p. 2. See also, "Advance Disposal Fee Issue Paper," Feb. 7, 1995; and *Recycling Markets Advisory Committee Report*, December 30, 1994.

189 "Advance Disposal Fee Issue Paper," pp. 8-9. In 1994, it cost between one and two cents more to make a plastic soft drink container using recycled content than it cost to use all-virgin resin. Thus, with the fee increase to two cents, it actually became a lower-cost option to incorporate 25 percent recycled content, thereby achieving an exemption from the two-cent fee.

190 Bureau of Solid and Hazardous Waste, *Solid Waste Management in Florida,* January 1995, p 45.

ADFs: Reevaluation of the Concept

A. Setting the Fees

Whether fees will increase recycling markets depends on the actual fee structure. If manufacturers that use specified levels of recycled content are exempted from the fee, such fees might increase use of recyclables. However, this result will depend on a number of factors that shape total packaging costs. If the fee assessment is less than the cost to incorporate recycled content in the product, increased use will not occur. Or, the fee may result in a shift to packaging materials for which use of recycled content is reasonably cost-effective, while not resulting in any increased in recycling of the original material.
Our own analysis of ADFs shows that behavioral ADFs—that is, fees that actually result in increased recycling or reductions in material usage—would need to be well above the two-cents-per-package levels applied in Florida. Our analysis of compensatory fees—fees designed to cover waste-handling costs—showed fees ranging from less than $0.01 per package to $0.02 per virgin package (see Table ADF-8). On the other hand, our analysis showed that fees necessary to change production and consumption choices would need to be much higher. If no substitutions among packaging types were possible—obviously a simplistic assumption—our analysis shows behavioral ADFs could range as high as $0.30 or more per virgin package.[191] Because substitutions would be possible, this high fee level represents the upper bound. Nonetheless, fees designed to change consumption patterns are likely to be much higher than those that merely incorporate up-front into the package the waste-handling cost.

Table ADF-8: Compensatory Advance Disposal Fee Ranges

Glass	$14–$45 per ton ($0.01–$0.02 per virgin package)
Containerboard	$31–$56 per ton (under $0.01 per virgin package)
Steel	$24–$55 per ton (under $0.02 per virgin package)
HDPE	$0.016–$0.031 per pound ($0.001–$0.002 per virgin package)
PET	$0.014–$0.031 per pound ($0.001–$0.002 per virgin package)
LDPE	$0.016–$0.031 per pound ($0.001–$0.002 per virgin package)

B. The Matter of Fairness

High fees introduce a “fairness” dilemma. Like sales taxes, ADFs can be regressive. A low-income household spends a larger portion of its income on basic grocery items—the kinds of purchases typically targeted by advance disposal fees—than do middle- and upper-income families.

Consider the potential annual impact on a household of four. A household of four may spend $100 per week at the grocery store. This sum will represent a purchase of approximately 50 items, some of which have multiple packages (for example, a six-pack of soda). Grocery purchases of $100 may actually include 75 individual packages. Using a high-end fee structure of $0.10 per package, as has been proposed by at least one state, the consumer would pay a weekly premium of $7.50, the equivalent of a

191 Our model is not complex enough to accurately estimate behavioral ADFs. Therefore, we do not estimate them here.

7.5 percent sales tax on grocery items, including food. With this fee structure, the annual tab would be $390. Note that this sum is two- to threefold what a typical household pays for trash collection annually, and it is over tenfold what a typical household pays for recycling collection annually.

Another way to look at the fee-setting dilemma is by assessing implications for individual products. Consider the impact of the higher-end $0.10 per container fee on some typical grocery items. For a 60-cent container of canned tomatoes, the fee of $0.10 would represent a 16 percent tax; for a six-pack of prepared tea, at $2.49, the fee would be 60 cents (10 cents per container), or a 25 percent tax. Yet even these fees may not be high enough to result in substantial changes in recycling levels, since recycling decisions by manufacturers would depend on what percentage packaging costs are in relationship to total product cost, and also to the costs of using recycled content or substituting to other materials. Even low-end fees (like Florida's $0.02 fee per package) would often exceed existing sales tax rates for some items.

There is another fairness issue that deserves some consideration: in Florida, the ADF was applied to packaging for the purposes of reflecting product disposal costs, yet over 80 percent of the ADF revenues were spent on infrastructure projects unrelated to solid waste disposal. Essentially, this allocation of ADF revenues meant that the packaging industry, and consumers of packaging, were cross-subsidizing other unrelated environmental and infrastructure projects.

Finally, as Germany has experienced in implementing its Green Dot packaging fee system, there is an inevitable tension between simplicity—a single, uniform fee applied to all packages—and fairness—a fee that is designed at least crudely to reflect actual waste-handling or recycling costs of particular materials. Attempts to peg fees to costs can unleash implementation complexity. In California, for example, the implementation of processing fees on manufacturers of certain beverage containers has resulted in complex, frequently adjusted cost calculations.

C. Unintended Consequences

Most ADFs implemented thus far have been in some way pegged to recycling, which introduces another problem. For example, packages were subject to an ADF in Florida depending on the recycling rate for that package or material, or upon the recycled content in the product. In Germany, the Green Dot fees—when they moved to volume and material-based fees—were calculated according to estimates of recycling costs associated with each material (though these estimates were based on averaging, data aggregation, and numerous other assumptions). Likewise, California's processing fees, though not ADFs in the traditional sense, also were a type of up-front packaging fee in which the fee levels were set in relationship to estimated recycling costs. Establishing packaging fees based on recycling costs ignores benefits from source-reduction, especially when the fee is container-based rather than volume-based. Yet numerous studies of packaging and environmental impacts, including the U.S. Office of Technology Assessment report *Green By Design*, demonstrate that recycling may not always reduce environmental impacts relative to other, source-reducing options. Recycling-based fees, especially fee structures that exempt packages that achieve particular recycling rates or recycled content levels, may have the unintended consequence of deterring innovations in source-reduction, including use of laminated (but difficult-to-recycle) packaging, some high-efficiency plastic packaging, and so on.

Setting fee structures is, thus, problematic. If the purpose of the fee is to incorporate into the package actual waste-disposal costs, a justification often proposed by ADF proponents, such fees will be extremely small—even fractions of pennies. If, on the other hand, the purpose is to change behavior and bring about more recycling, the fees will need to be much higher than actual waste-disposal costs. In this latter instance, the fee no longer in any way would represent an "internalizing" of waste-disposal costs. And all fees pegged, even crudely, to recycling costs, may inadvertently deter source-reduction innovations.

Conclusion

ADFs have some theoretical appeal—they seem to offer a means of incorporating waste-disposal costs into up-front purchasing costs, thereby creating potential incentives for manufacturers and consumers to take into account waste costs when making product design and purchasing decisions. However, setting fees for specific package types that in any way actually reflect waste-disposal costs of individual packages is not possible, since those costs are highly location-specific, and since waste-disposal costs for most items are highly aggregated and based on total weight and volume, not on the handling of individual items in the waste stream. Attempts to extrapolate from aggregated weight and volume costs the costs of individual items is likely to lead to substantial distortions, skewing rather than improving market decisions.

Actual experience with ADFs is limited, but Florida's use of such fees illustrates some of the implementation and conceptual problems with such fees. Specifically,

- using a flat fee for all packaging that did not meet recycled-content requirements or recycling rates was easy to implement, but did not in any way correspond with actual disposal costs for the affected products;

- assessing low ($0.02 per package) fees did not appear to significantly affect actually recycling levels, a result predicted from our own economic analysis;

- fees cannot simultaneously be pegged to recycling levels and maximize revenues to pay for recycling programs, since higher recycling levels will mean lower revenues, which in turn will mean less money available to support recycling infrastructure.

Appendix A

Packaging Materials:

Functional Characteristics and Constraints

Though commonplace and apparently simple, some modern packaging actually involves sophisticated technology that enables packaging to serve multiple purposes. Packaging provides product containment and protection, facilitates distribution, conveys product information and graphic presentations, enhances consumer safety, and so on (see Table PL-1).[192] All these variables heighten prospects that uniform recycled content standards will result in substantial inefficiencies and unintended consequences, because such standards cannot effectively take into account diverse production processes and packaging performance requirements.

Table PL-1: Packaging Protective Function Against External Factors

External Factors	*Functional Elements and Required Properties for Packaging and Packaging Materials*
1. Mechanical Shocks Vibrations Compressive Loads	• Compressive strength (resistance to stacking) • Resistance (brittleness) • Bending strength • Shock absorption • Tensile strength (elasticity) • Compressive strength (resistance to stacking) • Seal resistance
2. Gases (oxygen, nitrogen, carbon dioxide) Water Vapor, Odors (aromas and flavors and their mixture) Liquid (water, oil, etc.)	• Permeability • Porosity and density • Solubility, absorption
3. Light intensity and radiation energy (ultraviolet light, visible and infrared (IR) light)	• Light transmission characteristics • Light absorption • Reflection (brilliancy)
4. Thermal content and temperature	• Thermal conductivity
5. Biological factors	• Resistance or sensitivity

Source: Frans Lox, *Packaging and Ecology*, p. 27.

Numerous factors influence packaging material selection, including, for example, the product form and intended use; barrier requirements of the specific product; product fill temperatures; processes used to provide food stability; package configuation and method of distribution; the method of consumer

192 Frans Lox summarizes the function of packaging as "those physical elements used in wrapping goods and assisting their handling. The need is to maintain by an appropriate packaging the initial product quality—obtained at the end of the production process—during further preservation, storage, and transport operations." Lox, *Packaging and Ecology* (Surrey, U.K.: Pira International, 1992), p. 1. Lox notes that packaging "separates the product from its surroundings; this separation...creates an 'internal' environment." Lox points out the packaging has additional "psychological impacts" that affect product saleability, but the basic material components of packaging "are functional and indispensable."

preparation; and the interaction between the product and the package (for example, in aerosols).[193] Table PL-2 shows the packaging requirements needed by package handlers along a continuum from manufacturers through final consumers.

Within each one of these functions are multiple specific attributes that packaging must be designed to meet. For example, protection of food contents requires that the package guard against spoilage and decay, as well as rodent, bacterial, and other infestations. Protection against spoilage often requires barriers against light and moisture, protection against heat (or cold), and protection against gas infiltration (for example, oxygen).[194] All packaging that comes into contact with food must conform to safety requirements for direct and indirect food additives, as determined by the Food and Drug Administration.

Table PL-2: Packaging Requirements Needed by Various Interested Parties from Production Through Distribution to Consumption

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

✓: major interest; ×: minor interest
Source: Frans Lox, *Packaging and Ecology*, p. 23.

Regulations or fees that target packaging in order to change the material composition, structure, or quantity of materials used for a given package will have widely varying cost, environmental, and product-quality impacts, both by package type and material.[195] To better understand the complexity of

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193 *The Packaging Encyclopedia 1985* description of the various performance tests applied to packaging is instructive regarding the potential complexity of packaging choices. These include tests for: 1) tensile strength and elongation; 2) impact strength; 3) tear strength; 4) stiffness; 5) water-vapor transmission; 6) gas transmission; 7) bursting strength; 8) flat crush; 9) fold endurance; 10) grease penetration; 11) haze; and 12) specular gloss (this list is not intended to be comprehensive). See pp. 294-295.

194 Jaye Nagle of Kraft General Foods noted in her testimony to the Oregon legislature on Oregon's SB66 that light, oxygen, heat, and moisture exposure can all speed up chemical oxidation reactions, which, she notes, “for most foods are the general type of staling reactions which result in a loss in flavor, texture, or quality.” She added in her testimony that “without adequate packaging, forms of leakage such as the presence of pinholes and inadequate seals can cause microbial contamination which, if present in a low-acid retort processed food, can result in disastrous consequences. For example, contamination with Clostridium botulinum spores can result in production of an extremely lethal neurotoxin leading to a botulism outbreak...one ounce could kill 14 million people.” Testimony to Oregon senate, 1993, p. 7.

195 Consider the case of milk packaging. A key consideration for manufacturers is to limit vitamin D loss, a goal achieved with packaging that is impermeable to light. HDPE milk jugs offer this advantage over clear glass bottles, for example, which result in vitamin losses in just a two to four-day period. An aluminum foil-laminated carton can also reduce vitamin D losses, but such cartons are less recyclable than either HDPE or glass containers. These are the sorts of trade-offs among packaging options that make one-size-fits-all prescriptions inefficient. (See Frans Lox, *Packaging and Ecology*, p. 53).

these impacts, the following discussion describes basic characteristics of commonly used packaging materials.

PLASTIC RESINS

A. Composition of Plastic Resin Consumption

In *The Graduate*, the young hero Ben, contemplating his future, is soberly informed: “Ben—I want to say one word to you—just one word—plastics.”[196] This late '60s bit of advice proved visionary. Between 1958 and 1988, total U.S. plastics consumption jumped from 3 billion pounds to 57 billion pounds, a growth rate of 10.3 percent annually.[197] Between 1972 and 1987, plastics sales increased by a whopping 475 percent, a growth rate of 31 percent per year.

While the vote of confidence in plastics by Ben's mentor proved to be deserved, the blanket reference to plastics obscures the many variations of this now ubiquitous material. Seven different resins predominate, composing 72 percent of total U.S. resin sales in 1990[198] (see Table PL-3), and they account for 99 percent of nondurable plastic resin production. Packaging (which is approximately the same as the category of nondurable consumer goods) represents over 80 percent of PET market share; the packaging market share is between 30 and 45 percent for four resins (HDPE, PS, LLDPE, and LDPE) (see Table PL-4). Altogether, by the late 1980s some 20,000 different plastics products were manufactured in the United States (see Table PL-5).[199]

The manufacture of plastic products typically involves three components: 1) the resin production; 2) the incorporation of additives into the resin;[200] and 3) processing of resins into end products.

Table PL-3: Estimates of Plastic Packaging and Nonpackaging Uses in 1990

Type	Sales (million lbs)	Percent Total
PET		
• Pet packaging	1,225	2.18%
• PET nonpackaging	664	1.18
Total PET	*1,889*	*3.37*
HDPE		
• HDPE packaging	4,204	7.49
• HDPE nonpackaging	3,589	6.40
Total HDPE	*7,793*	*13.89*
PVC		
• PVC packaging	762	1.36
• PVC nonpackaging	7,598	13.54
Total PVC	*8,360*	*14.90*
LDPE/LLDPE		

196 Calder Willingham penned these words in the 1967 screenplay.

197 This figure is cited by the American Plastics Council in its report to the Florida Packaging Council, November 1993.

198 R.W. Beck, *Study of Markets for Post-Consumer Plastics*, prepared for the Northeast Recycling Council (Lexington, KY: Council of State Governments, April 1992). Plastics fall into two primary categories: thermoplastics and thermosets. The former comprise those resins that can be softened and reformed with no serious damage to the original resin properties; the latter can't be melted and reformed. The malleability of thermoplastics, according to the Beck study, is a key reason why they account for a large share (around 83 percent) of the plastic resin market. Thermoplastics include PVC, PE, PS, PP, and PET. Thermosets, by contrast, retain strength under high temperatures and are used primarily in construction and transportation products.

199 R.W. Beck, *Study of Markets for Post-Consumer Plastics*.

200 The American Plastics Council report to the Florida Packaging Council in November 1993 notes that additives are used to modify the physical characteristics of the plastic, influence the aesthetic properties of plastics, and facilitate processing.

• LDPE/LLDPE packaging	4,886	8.71
• LDPE/LLDPE nonpackaging	5,910	10.53
Total LDPE/LLDPE	*10,796*	*19.24*
PP		
• PP packaging	1,501	2.67
• PP nonpackaging	5,151	9.18
Total PP	*6,652*	*11.85*
PS		
• PS packaging	*1,732*	*3.09*
• PS nonpackaging	*3,209*	*5.72*
Total PS	*4,941*	*8.81*
TOTAL PLASTIC PACKAGING	*14,310*	*25.50*
TOTAL PLASTIC NONPACKAGING	*26,121*	*46.55*
TOTAL PLASTIC	*40,431*	*72.05*
OTHER PLASTIC RESINS	*15,684*	*27.95*
GRAND TOTAL PLASTICS	***56,115***	***100.00%***

Source: R.W. Beck, *Study of Markets for Postconsumer Plastics,* Table 2-1, pp. 2-3/2-4.

Table PL-6: Plastics in the Waste Stream (1990)

Product	Consumption (mil.lb)	% Total Sales
Film	4,908	7.98
PET soft drink	754	1.23
HDPE hshld chem.	926	1.51
HDPE milk/water:	736	1.20

Source: Beck Report, 1992, p. 1-31.

Among nondurables, consumption of plastic resins is highly diversified among product categories. By far the largest portion of the plastic waste stream is plastic film (see Table PL-6), but this single product accounted in 1990 for under 8 percent of total sales. Packaging (including containers, bottles, films, etc.) is the largest end-market for HDPE, LDPE, and LLDPE. Use of PET for packaging is primarily as a beverage container, because PET can yield rigid, transparent bottles that provide a good gas barrier.[201]

Table PL-4: Resin Sales (Consumer Nondurables) 1990

Type	Sales (mil. lbs)	Sales as % of Plastic Category	Sales as % of Total Nondurables
HDPE	3,770	28.47%	44.3%
LDPE	1,889	14.27	30.6
PS	2,196	16.58	42.8
LLDPE	1,801	13.60	38.7
PET	1,759	13.28	82.2
PP	1,083	8.18	13.3
PVC	743	5.61	8.0
TOTAL	**13,241**	**100.00%**	

Source: R.W. Beck, *Study of Markets for Postconsumer Plastics,* Tables 1-6/1-18, pp. 1-8/1-17.

201 In 1990–91 approximately 87 percent of all PET used in packaging was employed for carbonated beverage containers and custom-made bottles. *[See Ernst & Young, Rigid Plastic Packaging Container Act: Appendices, 1993]*

Table PL-5: Plastic Resin Sales by Major Market for 1990 (Shown in Millions of Pounds)							
Market	PVC	PP	HDPE	LDPE	PS	PET	**TOTAL**
Packaging	762	1,505	4,204	4,886	1,723	1,225	**14,305**
Building	5,434	32	562	334	379	0	**6,741**
Electronics	590	47	164	412	493	0	**1,706**
Housewares	140	272	233	440	248	0	**1,333**
Transportation	280	314*	206**	0	0	0	**800**
Toys	37	48	154	170	214	0	**623**
Appliances	119	185	20	0	220	0	**544**
Furniture	94	105	22	0	92	0	**313**
Total	**7,456**	**2,508**	**5,565**	**6,242**	**3,369**	**1,225**	**26,365**

* Includes battery cases. ** Listed as "polyethylene."

Source: *Modern Plastics*; R.W. Beck and Associates, Table 4-1. p.4-2.

B. Resin Properties

The multiple plastic resins that end up in the waste stream complicate significantly plastics recycling. Thus, some critics of plastic packaging have argued for regulations to limit the number of resins that can be used. Yet the use of multiple resins is a consequence of the diverse properties of the different resins (see Table PL-7). These diverse properties allow plastics to be manufactured into near-infinite shapes at relatively low cost, while simultaneously providing packaging barriers against bacteria, moisture, and odors.

While all plastic resins are made from the same basic building blocks (hydrocarbon polymers),[202] they each exhibit specific characteristics that make them suitable for widely differing functions.

C. Resin Prices

Three factors influence the price of virgin resins: 1) the price of natural gas and petroleum,[203] 2) available production capacity relative to demand, and 3) general economic conditions. In the early 1990s, feedstock prices were low, excess capacity existed,[204] and the general economy was slow. All three factors combined to make virgin resin prices low at a time when recycling collection efforts were coming on line. Significant expansion of virgin PET capacity worldwide in the mid-1990s had a similar effect on virgin resin prices. These low prices for virgin PET affected demand for post-consumer PET

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202 In *Packaging and Ecology*, Frans Lox points out that the boom in plastics dates back to the initial appearance of high-quality gasoline. The cracking of crude oil to produce high-quality naphtha also generated residual cracking gases that typically were burnt as waste. These residuals became a marketable, cheap feedstock for the production of polymers. Two kilograms of crude oil generate about one kilogram of plastics. The success of these polymers in the marketplace was largely a consequence of the wide range of properties they demonstrated, as well as their space-saving effects as a raw material. The polymers could be stored in compact bead form in most instances, allowing for highly decentralized, small-scale manufacture of plastic products. Lox notes that these "beads" required little storage space. Consumer product manufacturers could store the beads on-site, produce plastic containers, and fill them as needed. In contrast, glass bottles and cans had to be manufactured in special (relatively) large-scale manufacturing facilities, transported to the consumer product manufacturer, then warehoused in large quantities, and used as needed. The final product is much lighter weight than, for example, glass, facilitating handling and reducing shipping costs. A glass container that weighs 700 grams per unit can be replaced by a polyethylene container weighing about 20 grams (see Frans Lox, *Packaging and Ecology*, p. 176). The melting point of polymers is also low compared to that for glass or metals, also making its use attractive from an energy standpoint (the melting point of glass is about 1,000 degrees centrigrade; that of polyethylene is about 150 degrees).

203 In the United States, around 70 percent of feedstock for ethylene-based plastics is natural gas; around 30 percent of feedstock comes from crude oil. See Jill Kauffman Johnson, "Analysis of Virgin and Recycled Polyethylene Resin Markets," prepared for USEPA, Solid Waste & Geographical Information Section, Region 1, August 1993.

204 For example, in 1987 production capacity for HDPE was operating at close to 100 percent; by 1992 that had dropped to 82 percent (9.8 billion pounds of HDPE were produced from plants with 11.9 billion pounds of production capacity). See Johnson, "Resin Markets."

Table PL-7: Resin Properties and Uses		
	Resin Characteristics	Uses
PP	Tough, hard, doesn't scratch, good tensile strength, good resistance to heat and chemicals, high melting point	Extruded into fibers, filaments Auto batteries
HDPE	Translucent, milky white, resists most chemicals, durable, UV light barrier	Blow-molded nondurables
LDPE	Light, flexible, translucent or opaque, takes high or low gloss, durable	Extruded into packaging film
LLDPE	High tensile strength, puncture resistance, tear qualities, less clear than LDPE	Packaging film
PS	Solid or foam: as solid it is hard, smooth, brittle, scratch-resistant, clear or opaque; as foam it is light, shock absorbent, poor chemical resistance when foamed, insulator	Trays, cups, package stuffing, containers
PET	Clear, lightweight, shatter-resistant, good chemical resistance, effective gas barrier	Bottles
PVC	Tough with smooth finish, scratches easily, flexible, easy to shape into handles, cuts without stretching, strong resistance to reactive materials	Tubing, film, bottles, sheeting

resin, a phenomenon that reoccurred in 1995–96 because of expansions in virgin PET production capacity.

Recycled price trends typically follow virgin trends, and postconsumer resins (PCRs) do not really serve as direct substitutes for virgin resins for several reasons.[205] First, PCRs may have lower performance characteristics as a result of contaminants, or because the PCR has undergone a “heat” history that alters its functionality. Second, virgin resins can be tailored to the precise property requirements of specific uses and can be pigmented to specifications.

Virgin resin prices also vary widely (as much as 100-fold), depending on the resin category.[206]

D. Recycling Opportunities

Postconsumer plastics recycling is a relatively new phenomenon, having commenced in the late 1980s. Most recycling activity is concentrated among a few resins and products, with PET soda bottles, HDPE milk containers, and PP battery casing predominating (see Table PL-8).

E. Recycling Constraints

Significant advances in use of recycled resins occurred between 1990 and 1996. However, most postconsumer resin recycling centered on two resins: HDPE and PET. While recycling gains have been

205 We are indebted to the R.W. Beck report, *Study of Markets for Post-Consumer Plastics*, prepared for the Northeast Recycling Council (Lexington, Ky.: Council for State Governments, April 1992) for the following discussion on the imperfect substitution of PCRs for virgin resins.

206 Commodity plastics, produced in large volumes with few specialized modifications, cost between $0.25 and $0.75 per pound in the late 1980s; performance specialty resins (produced in relatively small quantities for narrowly defined end uses) at the other end of the spectrum cost as high as $20 per pound.

impressive, a number of constraints limit cost-effective opportunities for recycling resins (given currently available collection, processing, and production technologies). These constraints apply both to the collection and processing of recycled resins and to their use in manufacturing new products. Moreover, constraints vary considerably across different kinds of plastic resins and products.

Table PL-8: Plastic Resin & Plastic Container Recovery (1994)

Resin	Amount Sold (million lbs)	Recycled Material Produced (million lbs)	Percent
PET			
Soft Drink Bottles	1,015	493.5	48.6
Custom Bottles & Containers	662	53.0	8.0
Other Packaging	84	0.4	0.5
Total PET Packaging	*1,761*	*546.9*	*31.1*
HDPE			
Natural Bottles	1,172	303.7	25.9
Pigmented Bottles	1,689	182.5	10.8
Base Cups	120	44.9	37.4
Other Packaging	1,739	21.5	1.2
Total HDPE Packaging	*4,720*	*522.6*	*11.7*
PVC			
Bottles	188	1.3	0.7
Other Packaging	627	2.0	0.3
Total PVC Packaging	*815*	*3.3*	*0.4*
LDPE/LLDPE			
Bottles	62	0.1	0.2
Other Packaging	5,070	116.2	2.3
Total LDPE/LLDPE Packaging	*5,132*	*116.3*	*2.3*
PP			
Bottles	151	3.2	2.1
Other Packaging	1,705	6.5	0.4
Total PP Packaging	*1,856*	*9.7*	*0.5*
PS			
Total PS Packaging	*2,313*	*34.7*	*1.5*
TOTAL BOTTLES	***5,074***	***1,082.2***	***21.3***
BOTTLES & RIGID CONTAINERS	***6,398***	***1,098.5***	***17.2***

Source: American Plastics Council

1. Recovery of Plastics

A 1992 R.W. Beck report (hereafter referred to as the Beck Report) on postconsumer plastics recycling identified a number of factors as affecting the potential recovery of plastics.[207] In addition to legislative constraints, these include:

- ***Quantity of postconsumer resin (PCR) in the waste stream.*** Quantity of PCR available depends on the amount of plastic in the waste stream; how these products are discarded; how much of these materials can cost-effectively be collected; and sorting capacity.
- ***Ease of identification and handling by resin type.*** Presence of the SPI code has only partly assisted in this identification, as many consumers disregard the code. One reason for successes in PET soda bottle and HDPE milk containers is the ease with which consumers can distinguish these containers.

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207 R.W. Beck, *Study of Markets for Post-Consumer Plastics*, p. 4.

LDPE and LLDPE films often combine several resins. These films can be difficult to clean because of their large surface area, awkward handling, and sometimes significant contamination, problems more pronounced among postconsumer films than those used in the commercial sector.[208]

- ***Degree of cross-contamination.*** Contamination refers both to nonplastic materials (content residues, metal caps, labels, etc.) and to other plastics, sometimes even including the same resin in different forms. For example, a blow-molded HDPE milk jug cannot necessarily be mixed with an injection-molded HDPE margarine tub (except in mixed resin uses).[209]

  The more dramatic, oft-cited case is that of PVC mixed in with a batch of PET. An entire batch of PET can be unusable if it contains more than 0.1 percent to 1 percent PVC.[210] The Beck Report estimates a 5 to 10 percent tolerance for PP in a batch of HDPE.

- ***Contents within recovered containers.*** Oils, even odors, and other nonresin materials that are difficult to remove through processing can inhibit the potential end-uses for some PCRs.

- ***Processing capacity.*** Even when plastics are collected for recycling, insufficient capacity may exist to process it. This constraint limited Germany's plastics recycling immediately after implementation of the Green Dot program.

- ***Resin production and price cycle.*** In the absence of regulations, market prices of virgin resins determine PCR consumption patterns. Historically, virgin resin prices drop during periods of recession and over-capacity.[211] PCR demand will also be affected by prevailing market prices for off-spec resins. The Beck Report notes that the latter, which generally is more uniform in quality than PCR, is preferred when the price between off-spec resin and PCR is relatively narrow.

- ***Reclaimed material markets.***
- ***Consumer environmental concerns.*** The issue of relative costs looms large as a factor influencing the viability of PCR recycling. As pointed out earlier, recycled resin prices vary greatly. A snapshot of approximate virgin and recycled prices on September 23, 1996 is given in Table PL-9.

Table PL-9: Cost Comparisons: Virgin vs. Recycled Resin Prices (cents/pound), 9/23/96

Resin	Virgin price range	> 20 mil lbs	5–20 mil lbs	Recycled Price Range	Clean Regrind or Flake	Pellets
PET	APET	55–57	59–63	Bottles:		
	Bottle resin	49–50	52–55	• Clear, post-consumer	27–32	30–35
	CPET	70–72	—	• Green, post-consumer	16–20	23–28
HDPE	Blow-molding:			Bottles:		
	• Copolymer (HIC)	42–43	47–49	• Natural, post-consumer	22–27	31–36
	• Homopolymer (Dairy)	43–43	45–48	• Mixed colors, post-consumer	20–24	25–30
	Drums	47–49	51–52	• Mixed colors, industrial	18–23	20–25
	Injection, general purpose	46–47	49–51	HMW-HDPE film, post-consumer	—	27–32
	Extrusion:					
	• Film, HMW	50–52	54–57			
	• Film, MMW	52–54	55–59			
	• Sheet	46–48	50–52			
LDPE	Injection:			Film:		
	• General-purpose	—	55–57	• Clear, post-consumer	—	27–32
	• Lid resin	53–55	57–59	• Colored, post-consumer	9–12	23–27
	Extrusion:					
	• Coating, paper	54–56	—			
	• Film, liner	51–53	54–59			

208 Jill Kauffman Johnson, "Resin Markets."

209 Beck Report, pp. 1–4. The Report notes that the HDPE in a margarine tub and a milk jug have different melt indices that can limit co-recycling of these materials.

210 Personal communication, D'Lane Wisner, Geon. Some recycling processes are praised for reducing halogen (PVC) content to under 0.2 percent. G. Menges, "PVC recycling management," *Pure & Applied Chemistry*, vol. 68, no. 9 (1996), p. 1820.

211 Beck Report, p. 2–20.

Table PL-9: Cost Comparisons: Virgin vs. Recycled Resin Prices (cents/pound), 9/23/96						
Resin	Virgin price range	> 20 mil lbs	5–20 mil lbs	Recycled Price Range	Clean Regrind or Flake	Pellets
	• Clarity film	55–57	58–61			
	• 2–4% EVA film	56–58	59–62			
	• Fractional melt	49–51	55–57			
LLDPE	Butene-1 comonomer:			Stretch film	—	29–34
	• Injection, general-purpose	—	48–52			
	• Extrusion, liner film	47–49	50–52			
	HAO comonomer:					
	• Injection,					
	1. general-purpose	—	52–54			
	2. Lid resin	51–54	57–60			
	Extrusion, liner film	50–52	54–57			
	1. Fractional melt film	52–55	56–59			
	•					
PP	Homopolymer:			Industrial	19-24	25-29
	• Injection, general-purpose	42–44	45–48			
	Extrusion:					
	• Film	43-46	47–49			
	• Profiles	45–48	50–54			
	• Sheet	44–47	48–50			
	Random Copolymer:					
	• Injection	44–46	47–49			
	• Film	45–47	48–50			
	• Blow molding	46–47	49–52			
	•					
PS	High-heat, crystal	46–50	52–53	Industrial	25–30	35–40
	Extrusion, high-impact	45–47	50–52	High-heat, crystal, post-consumer	30–36	43–46
	EPS:					
	• Modified	71–74	76–79			
	• Unmodified	70–73	75–78			
	•					
PVC	Suspension resin:			Clear, industrial	13–21	—
	• Injection, general-purpose	36–38	39–40			

Source: *Plastics News* resin pricing chart, *Plastics News*, September 23, 1996, pp. 25–26.

2. Remanufacturing With Recycled Resins

Postconsumer resins are not necessarily perfect substitutes for their virgin resin counterparts. Thermal treatment of resins can result in some material degradation and oxidation: in short, the plastic in a recycled container may not be the same as the virgin resin from which it was made.[212] The Beck Report proposes that plastic recycling potential depends, in large part, on how refined the quality specifications are for a given product.

- Those products with relatively broad specifications (for example, plastic lumber or trash and recycling receptacles) can incorporate recycled content with little loss in product quality and can tolerate higher amounts of contamination and mixed resins.

- Products with narrow resin specifications, such as soda bottles, nonfood bottles, and some construction materials, can tolerate less contamination (of other resins and of nonplastic contaminants) and may face more limits on the total amount of postconsumer resin (PCR) that can be utilized.

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212 A number of packaging analysts have made this point. See, for example, *Packaging and Ecology*, by Frans Lox; see also the Beck Report; the report of the American Plastics Council to the Florida Packaging Council in November 1992; and the report by Jill Kauffman Johnson to the USEPA, August 1993.

Whatever the resin specification category, a host of devilish details affect the recycling of specific materials into specific end-products. The Beck Report notes several examples:[213]

- Injection-stretch blow-molding is a cost-effective way to manufacture PET soda bottles, but the process shortens some of the molecules, thereby somewhat changing the resin properties upon reuse. The amount of degradation will depend on its molecular weight, processing conditions, moisture content, and on the resin type.[214] This constraint is not absolute: it can potentially be overcome by technological innovations.[215] Such change, however, requires investments in time and capital and outcomes are uncertain.

- Recycled HDPE may have slightly different melt properties than virgin resin, requiring adaptations in manufacturing equipment. Stress crack resistance requirements vary among end uses for HDPE containers (from low for milk jugs to high for detergents). Lower stress crack resistance of postconsumer HDPE can, therefore, limit its incorporation into certain kinds of containers or restrict its introduction to a sandwich-layer structure in which the recycled HDPE is layered in between two layers of virgin resin.[216]

- PCR use in bags requires additives and incorporation of some virgin resin to ensure adequate bag strength. These combinations are required because the PCR suffers some loss of properties when it is re-extruded.

All markets are dynamic, and plastics markets are no exceptions. New technologies can emerge that overcome some current constraints on recycling. However, given the vast diversity of plastics products, even within the realm of packaging alone, any regulations that impose uniform recycled-content requirements (or base packaging fee structures on the single criterion of recycled content) are likely to generate substantial unintended consequences and inefficiencies, since such requirements constrain the ability of manufacturers to optimize across the many variables relevant to improving production efficiencies and product performance.

GLASS PACKAGING

A. Composition of Consumption

Table GL-1: Glass Sales by Segment

Flat Glass	33%
Lighting	18%
Containers	16%
Fiber Glass	16%
Other	17%

Source: *Market Share Reporter*, 1996.

Glass containers make up 16 percent of the $48 billion glass market by category (see Table GL-1).

In the container industry, 39 percent of the glass market is in food containers; 36.8 percent is beer containers; 10.8 percent are containers for carbonated soft drinks.[217]

213 The American Plastics Council report to the Florida Packaging Council mirrors the Beck Report in indicating that much plastics recycling involves some degradation of the physical characteristics of the plastic resins. This degradation requires manufacturing changes, revisions in packaging formulas, and so on, in order to meet package quality and manufacturing requirements.

214 Beck Report, pp. 4–16. The molecular weight of recovered PET bottles can be 10 percent less than the original PET. Moreover, this reduction is irreversible. The lower molecular weight results in a material that has less stiffness and impact strength and reduced barrier properties.

215 *Ibid.* The Beck Report suggests several alternatives: the PCR can be compounded with impact modifiers and reinforcements; it can be blended with other polymers; additives can be incorporated to improve processing and reduce degradation; and new production technologies in bottle-making can be introduced, for example.

216 Capital requirements to change plant facilities to accommodate PCR vary widely. Adding additional extruders to make multi-layered HDPE containers can cost over $1 million per plant site. See American Plastics Council report to the Florida Packaging Council in November, 1992. See also Johnson, “Resin Markets.”

217 See *Market Share Reporter*, 1996, citing data from *Beverage World*, June 1995, p. 59, U.S. Department of Commerce, U.S. Census Bureau, and industrial reports.

B. Glass Manufacturing

Glass is one of the oldest known substances; a volcanic material similar to glass was used for arrowheads during the Bronze Age. In the first century A.D., the Roman historian Pliny the Elder wrote of Phoenician sailors, cooking on the beach, who took their pots of the fire and placed them on blocks of natron, a substance used to embalm the dead. The sailors found that the molten natron mixed with the sand and formed glass. Glass, as we know it, was used substantially before Pliny, since about 3000 B.C. in Egypt and Mesopotamia. The blowpipe was used in Sidon, Phoenicia, during the first century B.C. for making hollow glass articles, and by the third century A.D. glass articles were in fairly common use in Roman households. The term "flint glass" refers to the very pure silica in the form of flint used by 16th-century Venetian glassblowers.[218]

Thanks to the formability of glass, the glass bottle was one of the world's first manufactured products. Aside from increased mechanization and reduced material requirements, glass bottlemaking is similar today to the way it was in Roman times.

Through advances in design and manufacturing technology, the time required to produce a glass bottle has decreased dramatically. Around 1870, the shop system of making glass containers was introduced in the United States. This system involved a team of seven men—three skilled workmen and four boys. The first man on the team took a lump of molten glass out of the furnace on the end of his pipe and partially blew it. A boy called a "mold tender" opened the mold while the blower put the glass into the mold and inflated it with pressure from his mouth. The pipe was then cracked off, and the "snapping-up boy" took the glass to the finisher, who shaped the neck and lips with tools. The "carrying-in boy" took the product to the lehr, and a "cleaning-off boy" prepared the blowpipe for the next iteration of the process. Since the neck was made last, it was called the "finish." It retains this name to this day, even though the neck is now made first. In 1892, mechanization was introduced on a large scale, and in 1896 Atlas Glass Works was using semiautomatic machines in regular production for wide-mouth jars.[219] The first fully automatic forming unit was invented by Michael Owens and placed into operation in 1903 in Toledo, Ohio. While the shop system could make one bottle a minute, bottles could now be produced at a rate of 20 to 70 per minute. Today, a 10-section quadruple forming machine can put out 500 bottles per minute.[220]

Glass containers have also been decreasing in weight. This process is called "source reduction" or "lightweighting." A 1992 Franklin Associates study reported that from 1972 to 1987, on average, nonreturnable glass containers were reduced in weight by 44 percent.[221] A British group reports that a one-pint milk bottle has decreased in weight from 538 grams in 1940 to 245 grams in 1990, or a 54 percent decrease in 50 years.[222] Over 20 international glass container manufacturers recently sponsored a project by Advanced Glass Treatment Systems that assessed the use of a solventless organic polymer coating that would allow greater lightweighting.[223]

Glass is composed primarily of sand (silica), soda ash (sodium carbonate), limestone (calcium oxide), and feldspar—abundant, naturally occurring, inert, nonflammable, nontoxic minerals that require relatively little intermediate processing (see Table GL-2).

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218 Joseph F. Hanion, "Glass bottles—for beauty and function," *Soap-Cosmetics-Chemical Specialties*, vol. 60 (February 1984), p. 46.

219 Hanion, "Glass bottles."

220 Resource Recycling Magazine, *Recycling Market Profile: Glass Containers* (1995), p. 2.

221 Judy Rice, "Green packaging scorecard: packaging waste management is a matter of conscience, compliance and good business sense," *Food Processing*, vol. 56, no. 8 (August 1995), p. 70.

222 Warmer Campaign, "Glass Recycling," p. 3.

223 *Glass Containers*, p. 1. These coatings are not expected to make a big difference in glass recycling. Removable colored coatings, however, could in the long run make a huge difference by eliminating the need to sort glass by color. Personal communication, Steve Apotheker, *Resource Recycling*, November 1996.

- *Glass sand*, unlike beach sand, is nearly white and highly pure (over 99 percent quartz sandstone). It is usually mined in open pits. The purest sources are former shallow marine environments.

- *Soda ash* is the most expensive raw ingredient, and typically costs from $90 to $140 per ton. The U.S. glass container industry uses 3.1 million metric tons of soda ash per year, though use has declined because of increased recycling and lightweighting. Soda ash lowers the melting point of silica (normally about 3,000 degrees Fahrenheit) by decreasing its viscosity when it converts to sodium oxide in the heated furnace. Natural soda ash is called trona rock.

- *Limestone* is quarried mainly from open pits. The extraction of limestone involves blasting, crushing, and screening. The effects of limestone are similar to those of soda ash; limestone also makes the glass more inert.

- *Feldspar* is an aluminum silicate material that converts to aluminum oxide in glass manufacture. The oxide acts as a stabilizer in the melt and improves the chemical durability and stability of the glass.[224]

These raw materials account for about 30 percent of a plant's operating costs, while energy accounts for 11 percent (see Table GL-3).

Glass is not only highly formable but also easily colorable. Glass containers typically come in three colors—about two-thirds are clear (also called flint), a quarter are brown (or amber), and the rest (about one-twelfth) are green. Since some products, like beer and wine, degrade in sunlight, they are packaged in colored bottles. Color selection is also a matter of aesthetics and consumer preference. Amber coloring is provided by 0.3 percent ferrous oxide content, and green coloring by 0.2 percent ferrous sulfate or chromic oxide. Because these substances chemically react with glass, they cannot be removed.[225]

Raw material supply is highly concentrated geographically. About 80 to 90 percent of glass sand is supplied by West Virginia, Illinois, Pennsylvania, New Jersey, and Missouri. Some soda ash is made synthetically, but an increasing amount is obtained from lake brines, natural sources (almost all in Wyoming), and the caustic conversion process. Most commercial feldspar sources are in North Carolina, South Dakota, Georgia, and Connecticut.[226]

Table GL-2: Raw Material Composition of Glass	
Sand	60–70%
Soda ash	15–20%
Limestone	10–15%
Feldspar	3–5%
Other materials	1–3%

Source: Resource Recycling Magazine, *Recycling Market Profile: Glass Containers* (1995), p. 1.

Table GL-3: Operating Costs Of A Glass Plant
(Estimated by Ball-InCon Glass (Muncie, Ind.))

Category	Percent of costs
Labor	32%
Raw materials	30%
Energy	11%
Cost of capital	6%
Transportation	6%
Molds & supplies	6%
Warehousing	5%
Manufacturing services	3%

Source: *Glass Containers*, p. 3.

C. Recycling Opportunities

Glass recycling has had a long existence. An old Russian joke, for instance, defined a party as “substantial” if the proceeds from redeeming its empty vodka bottles could generate enough revenue to buy the drinks for another, smaller party. Moreover, many household items, like glass cooking utensils and drinking glasses are routinely washed and reused until they break; other containers, like coffee, jam, or pickle jars, are often recycled within the home, as nail and

224 *Glass Containers*, pp. 1–2.

225 *Glass Containers*, p. 2.

226 “Materials handbook for refractories, traditional & advanced ceramics,” *Ceramic Industry*, vol. 136, no. 1 (January 1991), p. 25.

screw containers, or as jars for homemade food. Most bottles, however, cannot be directly reused because bottlemakers typically avoid standardized containers in favor of their own distinctive brand-name-associated shapes (for example, the Coke bottle).[227] The U.S. glass recycling industry can be said to have begun in Bridgeton, New Jersey in 1968, when a glass container plant sponsored a “Glass Day” and, for the first time, bought back scrap glass bottles and jars from the public. The response at the Owens-Illinois site was so great that the plant accepted containers the following Saturday. A total of 34 tons of recyclable bottles were recovered—about two hours of the plant's raw material needs—and the public was paid $781. Today, the glass recycling industry recovers 3 million tons of old bottles and jars, worth more than $150 million, per year.[228]

About 23 percent of all glass waste was recycled in 1993, with almost all of that in containers.[229] Glass containers are collected primarily in buy-back and drop-off centers, deposit systems, and curbside collection (see Figure GL-1). After collection, the glass goes to material recovery facilities and various cullet (crushed glass) processors. The glass is then remanufactured mainly into new glass containers and insulation, with smaller amounts used in road and other construction products.[230]

Approximately 35 percent of glass containers were recycled in 1993,[231] and approximately 6.6 percent of municipal solid waste is made up of glass wastes. These wastes are mainly glass beverage, food, and other containers, with a much smaller amount in items like furniture, appliances, and electronic items.[232] By 1994, manufactured container glass contained on average 34 percent recycled glass content, though this percentage varies. In 1988, weather conditions created soda ash shortages, and Anchor Glass Container, the second larger U.S. glass container producer, made 100 percent recycled green bottles at its Royersford, Pennsylvania plant for more than seven weeks.[233]

Much recycled glass is collected through curbside, drop-off, or redemption programs. Recycled glass is first crushed at the local recycling collector's site, and is then further processed at a beneficiation facility. Beneficiation includes material feeding and conveying, impact crushing, air classification, screening, metal separation, vacuum extraction, hand picking and dust control. The direct cost in the mid-1990s to beneficiate bottle scrap, excluding transportation costs, taxes, interest, general and administrative costs, and profit, is about $7 to $15 per ton.[234]

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227 The Warmer Campaign, “Glass Recycling,” Kent, United Kingdom, May 1993, p. 1.

228 *Glass Containers*, p. i.

229 Glass container manufacturers can theoretically use all the color sorted cullet collected to make new containers, but because of transportation cost barriers and mixed-color contamination (see recycling constraints, below), the real world is different. The recovery of glass for noncontainer uses, however, is growing faster than the recovery of glass for new containers. An impressive overview of noncontainer uses for glass cullet can be found in John Reindl, *Reuse/Recycling of Glass Cullet for Non-Container Uses*, Dane County Department of Public Works, September 26, 1996.

230 J. Winston Porter, *Recycling in America: The 25% Solution* (Leesburg, Va.: Waste Policy Center, January 1996), p. 24.

231 Rice, “Green packaging scorecard.”

232 Porter, *Recycling in America*, p. 24.

233 *Glass Containers*, p. 11.

234 *Glass Containers*, p. 10.

Figure GL-1: The Glass Recycling System

Collection

Beer and Soft-Drink Bottles
(1.6 million tons/yr.)

- Buyback Centers
- California System
- State Deposit Systems
- Curbside Collection
- Drop-off Centers
- Commercial Collection

Wine and Liquor Bottles
(0.4 million tons/yr.)

Food and other Bottles
(1.0 million tons/yr.)

Handling/Sorting/ Brokering

Materials Recovery Facilities

Cullet Processors

- Allwaste (20 plants)
- Container Recycling Alliance (5 plants)
- Ensley Corporation (3 plants)
- Others (55 plants)

Remanufacturers

Glass Manufacturers

- 12 corporations
- 70 plants in 27 states

Major End Uses

Glass Containers
Fiberglass Insulation
Glassphalt
Construction Aggregate/Fill
Sandblasting Material

Source: Porter, *Recycling in America*, p. 25.

Processed (crushed) scrap glass is called cullet. Historically, glass plants have recycled domestic or factory cullet—the 5 percent or more of glass bottles that were too poor quality to ship. In the last quarter century, bottlemakers have found post-consumer cullet to be a good material source as well. Cullet has a lower viscosity than other glassmaking materials and liquefies at a lower temperature. This speeds up the mixing and reaction of materials, and furnace temperatures can be as much as 200 degrees lower. According to recycling advocates, including the glass industry:

- For every 10 percent increase in cullet consumption in a single furnace, energy consumption is reduced by about 24.5 million cubic feet of natural gas per year.[235]
- Lower furnace temperatures result in less wear on the refractory bricks. A furnace using 30 percent cullet will last 15 percent longer than an all-virgin-material furnace.
- The overall melt time is reduced, improving productivity.
- The use of cullet lowers air emissions (glass container manufacture produces nitrogen oxides, which contribute to smog and act as a respiratory irritant; sulfur oxides, which contribute to acid rain; and fine particles of silica, which may harm worker health by contributing to silicosis, or the scarring of lung tissue).[236]
- Because cullet has a higher alkali content than virgin glass, some glass producers report that less soda ash is needed in the virgin material mixture when cullet is used.

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235 A British organization expresses the savings as a 2 percent decrease in overall energy consumption for each 10 percent increase in cullet, or a 30 gallon decrease in fuel oil consumption for each addition of one metric ton of cullet. *Warmer Campaign*, “Glass Recycling,” p. 2. In 1992, Britain saved the equivalent of 13 million gallons of oil by using recycled glass. W. Guise, “Recycling,” *Packaging*, vol. 66, no. 707 (May 1995), p. 16.

236 According to the Warmer Campaign, using cullet reduces air pollution by 20 percent, mining wastes by 80 percent, and water use by 50 percent. Their document does not say how much cullet use is necessary to achieve these reductions. Warmer Campaign, “Glass Recycling,” p. 2.

- Any reduction in the quarrying of sand and limestone contributes to the preservation of the countryside.[237]

These results have been challenged by a 1994 study by the National Renewable Energy Laboratory and the Argonne National Laboratory, which concluded that glass recycled saved little energy (about 13 percent), saved no valuable raw material, and did not significantly reduce air or water pollution.[238]

D. Recycling Constraints

1. Contamination

It is important to remove contaminants from glass before processing. Troublesome contaminants include magnetic metals, aluminum or steel caps and lids, labels, window glass, and lead-based glass like crystal or television tubes. Some contaminants, like food residue, typically remain with the cullet and are burned in the melting process. Ceramic materials, like baking glass and headlight lenses, are often difficult to detect.[239] Contaminants typically represent 1 to 2 percent by weight of the glass containers generated in a standard recycling collection program. For example, cullet contaminated with Visionware, used by Corning to make Visions cookware, is not usable. Visionware has a much higher melting point than cullet from glass bottles. Cullet contaminated with Visionware results in small chunks of unmelted glass in the final product, rendering it unacceptable. Stones and seeds create similar problems.

Contaminants can also damage the furnace. Glass furnaces operate at temperatures of up to 2,800 degrees Fahrenheit. Some metal contaminants can settle at the bottom of the furnace tank and corrode the ceramic lining. Several container producers, on occasion, have had to shut down their furnaces because holes have appeared and molten glass has flown out. Ball-InCon lost 350 tons of molten glass and had to spend $3.5 million to repair damages from one incident in 1991. Steel lids, which do not melt at furnace-operating temperatures, can block feed lines from the furnace, causing production shutdown. Other metal contaminants melt at this temperature. Aluminum, for instance, melts at 1,220 degrees Fahrenheit, floats on the surface, oxidizes into alumina, and forms small balls (“stones”) or bubbles (“seeds”) that can appear in the bottles as small, dark spots on the glass. These spots create weakness that can lead to breakage, or can create the appearance of impurities in the food or drink.[240] Ceramics and stones can also become stuck in feed lines; smaller stones can cause product imperfections.

Also, glass can be contaminated with cullet of the wrong color.[241] Processors use optical color sorting systems to remove color contaminants, and ceramic detection and removal units to remove ceramic contamination. Ceramic detectors have a high separation efficiency for ceramic pieces above 0.375 inches, but smaller pieces are hard to detect and the throughput from ceramic detectors is relatively low. Moreover, ceramic detectors do not detect glass cookware pieces. The same limitations apply for optical sorting units. Ceramic-contaminated cullet can also be ground finely, but this is a costly process ($20–$40 per ton) because the necessary equipment costs from $350,000 to $500,000 per plant. The powder must then be stored under cover to prevent it from becoming moist and turning into a paste that can clog

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237 W. Guise, “Recycling.”

238 Gaines and Mintz, *Energy Implications of Glass-Container Recycling*.

239 “Refuse Collection: The 1996 Public Works Manual,” *Public Works*, vol. 127, no. 5 (April 15, 1996), p. E8.

240 This and the following paragraph rely on information from *Glass Containers*, pp. 4, 21.

241 As Chaz Miller of the Environmental Industries Association put it, “If cullet is rejected, it's probably due to contamination or mixed color.” “Recycling more glass rests on assured quality,” *Purchasing*, vol. 110, no. 4 (March 7, 1991), p. 114.

screens. And while powdered ceramic and metal do not cause problems in bottlemaking, powdered glass cookware does.

Table GL-4: Average Weight of Bottles

Use	Pounds
Medicinal and health	0.22
Chemical	0.40
Beverage (nonbeer)	0.48
Beer	0.50
Narrow-neck food	0.53
Wide-mouth food	0.58
Liquor	0.90
Wine	0.93

Source: U.S. Department of Commerce, Current Industrial Report Series, Monthly Report on Glass Containers, M32G.

2. Cost

Much cullet, especially scrap beer bottles, comes from states that require deposits on beverage containers, such as Oregon, Vermont, Michigan, Maine, Delaware, Connecticut, Iowa, Massachusetts, and New York. The California system provides for buy-back of containers, instead of a deposit, through a complex system that involves paying a fee to manufacturers and the buy-back price to consumers, with the actual amounts scaled to the fraction of containers returned.[242] The buy-back price in California is one of the highest in the country—2.5 cents per bottle. In addition, local recycling firms were initially paid $41 per ton for cullet deliveries, plus a "processing fee" of $40 per ton. Spurred by this system, the glass redemption rate grew from 14 percent in 1987 to 72 percent in 1992. Glass container manufacturers, however, charge that the California law has hurt their business; packagers have moved to other materials, such as lighter weight plastics or aluminum, or have produced their containers out of state, for instance in Mexico.[243]

Moreover, many municipalities, including Dallas, Tex., Columbia, S.C., and Huntsville, Ala.,[244] have stopped collecting glass because glass is expensive to collect, sort, and transport. In 1993, the cost of collecting glass bottles in a commingled curbside program was $60 per ton. According to another survey, the 1992 cost of sorting and processing collected glass containers was between $73 and $111 per ton, though costs ranged as high as $149. Much of this cost is due to the requirement to sort containers by color.[245] Despite recent source reduction efforts, glass remains heavy compared to other forms of packaging; according to the U.S. Department of Commerce, the average glass bottle weighs 0.54 pounds, though average weights vary (see Table GL-4). Broken bits of glass in the machinery can impede the recycling of other materials.

3. Markets

Since the late 1980s, mixed-color and green cullet have been difficult to sell to glass producers. Since many glass producers do not use green cullet to produce green glass, since their technology relies on coloring clear glass, the supply of secondary colored glass often significantly exceeds the demand for it.[246] The colored glass glut has spurred research into alternative (noncontainer) uses for colored cullet, but these uses are not yet widespread. Some plants have tried to use green cullet in amber furnaces, but the extra step of blending green cullet with amber cullet adds an extra cost of $100,000 per bin.

Some firms have also experimented with new color-coating technologies, with which all bottles would be clear and colors would be added as an acrylic coating. The coating would burn off when the bottle was recycled. An added benefit of color coating is the wider array of possible colors for bottles in the

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242 Harvey Alter, "Cost of recycling municipal solid waste with and without a concurrent beverage container deposit law," *Journal of Consumer Affairs*, vol. 27, no. 1 (June 22, 1993), p. 166.

243 *Glass Containers*, p. 12.

244 Luke B. Schmidt, "The Latest and Greatest: An Update on PET Recycling Programs," presented at International Polyester Week, Jamesburg, N.J., October 9, 1996.

245 *Glass Containers*, p. 10.

246 The United Kingdom imports large quantities of alcoholic beverages in colored bottles. Since their imports are disproportionately colored while their domestic glass production is 70 percent clear, this can also contribute to the supply imbalance. Warmer Campaign, "Glass Recycling," p. 3.

future. But because recycling color-coated bottles would require an extra sorting step, recycling costs would increase, not decrease, under a color-coating process unless the process were widespread.

New Jersey introduced, but did not pass, a legislative proposal to ban green bottles unless the sellers of products in green bottles in the state could assure that a market exists for the empty containers.[247]

4. Collection Systems

The Glass Packaging Institute (GPI) and the Solid Waste Association of North America (SWANA) completed a 1996 survey which determined that commingled curbside programs—where collected recyclables are mixed together and later separated by material type—market 50 to 70 percent of the glass containers they collect.[248] Curbside-separation programs—where recyclables remain separate during collection—were able to market 90 percent of their cullet. Curbside separation is less likely in large urban areas. A majority of recycling programs currently opt for the greater convenience of commingled collection.

Commingled collection generates residue, including broken mixed-color glass. While mixed-color glass sometimes goes on to secondary uses such as roadway construction, end-of-the-belt residue is usually so contaminated by a variety of materials that it must be landfilled. The 1996 GPI/SWANA study found that some program modifications increased the amount of marketable cullet. These include installing wire cable in the truck bed to cushion the dumping of glass containers, changing truck discharge procedures to reduce the angle at which the truck unloads at the material recovery facility floor, and "gentle" handling of the bucket loader in-feed. These modifications increased the amount of marketable cullet in a Vancouver, Wash., commingled program by 33.5 percent.[249]

Even separate collection can lead to contamination, as people can use the separate glass bins to deposit their miscellaneous waste. Depositing colored glass in a clear-glass bin can also cause the entire container-load to be landfilled rather than recycled.

Bottle banks can also have problems of their own, for instance the noise associated with their operation. In some parts of Germany, it is illegal to deposit old bottles outside specified times. Such restrictions, while they may be necessary for the convenience of residents, can hinder glass recovery efforts.[250]

METALS: ALUMINUM AND STEEL

A. Aluminum

1. Composition of Consumption

Aluminum, refined from bauxite ore, is the third most abundant element in the world and forms 8 percent of the earth's crust. In 1886, Charles Martin Hall, an American, and Paul L.T. Heroult, a Frenchman, simultaneously and independently discovered the electrolytic process for producing aluminum that is still used today. Charles Martin Hall's original patent application spelled the metal

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247 *Glass Containers*, pp. 21–22.

248 *Glass Container Market Recovery Study*, conducted by the Solid Waste Association of North America, the Environmental Protection Agency, and the Glass Packaging Institute, December 1995.

249 *Glass Container Market Recovery Study*.

250 Warmer Campaign, "Glass Recycling," p. 3.

“aluminium,” but the first company producing the metal dropped the second “i,” and the metal has been called “aluminum” in the United States ever since. In 1856, Charles Dickens wrote that both “aluminium” and “aluminum” would be too difficult for the average person to pronounce. He has since been proven wrong.[251]

The advantages of aluminum include high strength, low weight, corrosion resistance, and recyclability. U.S. primary aluminum capacity was 9.225 billion pounds in 1995, about a third of which is in the Pacific Northwest and another third in the Ohio Valley. Total aluminum supply was 20.4 billion pounds in 1995; 7.441 billion pounds (36.4 percent) was from primary production, 7.028 billion pounds (34.4 percent) from secondary production, and 5.956 billion pounds (29.2 percent) from imports of ingot and mill products.[252]

Aluminum containers and packaging account for 5.088 billion pounds, or 24.1 percent of total U.S. industry shipments.[253] The two main uses for aluminum packaging are beverage cans and aluminum foil,[254] though aluminum packaging also includes food cans, pie plates, frozen food trays, and flexible packaging and metallized packages coated with a very thin layer of aluminum.[255] Of the 860 million pounds of aluminum foil produced each year in the United States, 67 percent is used in foil wrap, containers, and composite packaging.[256]

Aluminum cans are lightweight, reducing the costs of shipping beverages to stores. From 1972 to 1995, the number of cans per pound of aluminum has increased 43 percent, from 21.75 to 31.07.[257] The size of aluminum cans is also decreasing slightly; aluminum companies plan to decrease the diameter of the typical beverage can lid from 2.125 inches in 1995 to 2.0625 inches in 1997. Aluminum cans are also unbreakable. Moreover, they conduct temperature well, so that they cool quickly.[258] Aluminum accounts for 99 percent of the beverage can market—99 percent of the soft drinks packaged in metal cans and 100 percent of beer packaged in metal cans.[259]

To produce aluminum foil containers, ingots of aluminum are hot rolled to a thickness of 2–4 mm (2,000–4,000 microns) and then coiled before being cold rolled to metal thicknesses of 35–400 microns. The thinnest foil used for wrapping chocolates may be 6 microns, while lidding foil can be between 30 and 40 microns.[260] The benefits of foil food packaging include its strength, its machine performance, its flexibility, and its ability not to affect the taste of foods.[261]

2. Recycling Opportunities

Aluminum waste products make up 1.4 percent of the municipal waste stream, by weight.

Because of the high costs of producing aluminum from raw materials, aluminum is the material most commonly recycled by households in the United States (followed by newspapers, plastic, other paper products, steel, and tin).[262] About half of collected aluminum waste—2.017 billion pounds of scrap in

251 “Aluminum: The 21st Century Metal,” The Aluminum Association, p. 5.

252 “Aluminum: Know The Facts,” The Aluminum Association, July 1996.

253 “Aluminum: Know The Facts.”

254 Guise, “Recycling.”

255 “Aluminum: The 21st Century Metal,” p. 8.

256 “Aluminum: The 21st Century Metal,” p. 9.

257 “Aluminum Can Reclamation,” The Aluminum Association, Can Manufacturers Institute, Institute of Scrap Recycling Industries. Data from 1972 based on Aluminum Association can weight survey; 1995 data provided by Can Manufacturers Institute.

258 “Aluminum: The 21st Century Metal,” p. 8.

259 “Aluminum Pays. Aluminum Pays. Aluminum Pays. Aluminum Pays. Aluminum Gets Recycled,” fact sheet, The Aluminum Association.

260 Guise, “Recycling.”

261 “Aluminum: The 21st Century Metal,” p. 9.

262 Rice, “Green packaging scorecard.”

1995—consists of used beverage cans. At 31.07 cans per pound, this makes 62.7 billion cans, or 62.2 percent of the 100.7 billion cans shipped in 1995.[263] Aluminum cans are nonmagnetic, so they can be easily separated from steel cans. They are also easily collected by consumers before they join the waste stream.[264] About 80 percent of recycled aluminum beverage cans are collected through voluntary programs and commercial recycling centers, 15 percent come from jurisdictions with deposit legislation, and the rest come from community curbside recycling programs.[265] Because aluminum is valuable to producers, much can collection is for-profit.[266] The recycling system for aluminum is shown in Figure M-1.

According to the National Soft Drink Association, 75 percent of all beverage units shipped are packaged in aluminum cans. In 1993, soft drink containers were recycled at a rate of 57.6 percent, making them the most recycled form of packaging in the United States;[267] beverage containers as a whole are recycled at an even higher rate.[268] Other aluminum wastes, like foil wrap, appliances components, lawn furniture, and construction materials are recycled at a much lower rate.[269]

Figure M-1: The Aluminum Recycling System

Collection	Handling/Sorting/ Brokering	Remanufacturers	Major End Uses
Beverage Cans (10 million tons/yr.) • Buyback Centers • California System • State Deposit Systems • Curbside Collection • Drop-off Centers • Commercial/Charity Collection	**Scrap Dealers**	**Intermediate Processors** (scrap ingot producers) • Imco • Others	
	Material Recovery Facilities	**Integrated Mills** (virgin material producers) • Reynolds Aluminum • Alcoa Aluminum • Alcan	**Can Sheet/New Cans**
Foils & Closures (0.03 million tons/yr.) • Commercial Collection	**Metal Brokers**	**Nonintegrated and Mini Mills** • Kaiser • Golden • Mini Mills (dozens)	**Common Alloy** • Housing Products • Transportation Industry • Durables
		Foundries	
		Export	

Source: Porter, *Recycling in America*, p. 23.

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263 "Aluminum Can Recycling Remains America's Favorite," press release from The Aluminum Association, Institute of Scrap Recycling Industries, and Can Manufacturers Institute, March 26, 1996.

264 Guise, "Recycling."

265 "Aluminum Pays."

266 Porter, *Recycling in America*, p. 22.

267 Rice, "Green packaging scorecard."

268 In 1992, the beverage container recycling rate was 68 percent. Charles L. Bell, David Cammarota, Barbara Males, *et al.*, "Metals: Industry Overview," *U.S. Industrial Outlook*, January 1994, p. 13.

Recycling aluminum conserves 95 percent of the energy required to make primary aluminum, and does not change the physical properties of the metal.[270] Using one ton of recycled aluminum avoids the use of 4 tons of bauxite and 700 kg of petroleum coke and pitch, and avoids the emission of 35 kg of aluminum fluoride. Environmental regulation and electric rate increases may increase aluminum recycling rates in the future.[271]

Since alloyed scrap is the same as virgin material, the end uses for used aluminum are the same as the uses for aluminum in general. As mentioned above, secondary aluminum accounts for almost one-third of the supply of aluminum.[272] Since the 100.7 billion cans shipped in 1995 weigh 3.24 billion pounds, and 1.66 billion pounds of recovered aluminum go back into cans (of the 2.017 billion pounds of total recovered aluminum), aluminum beverage cans have an average of 51.3 percent post-consumer recycled content—a higher percentage than any other beverage container.[273]

Not all aluminum packaging is recyclable; aluminum foil film combined with paper or plastic, while technically recyclable, is currently too expensive to recycle. Such packaging represents only 0.17 percent of the solid waste stream. Moreover, even if all such waste is landfilled, it still may reduce environmental impacts, simply because alternative, recyclable forms of packaging are so much heavier. Packaging 65 pounds of coffee in two-pound steel cans requires 20 pounds of steel, while using four-ply lamination flexible vacuum packs only requires 3 pounds of steel.[274] Unless the recycling rate for steel containers exceeds 85 percent (an extremely unlikely scenario), the nonrecyclable aluminum vacuum packs take up less space in landfills than recyclable steel cans.

3. Recycling Constraints

Though the applications for scrap aluminum are the same as those for virgin material, not all aluminums are alike. Different alloys are better for different applications. Accordingly, scrap with high iron cannot be used in a process requiring low iron alloy content.[275]

Ironically, one of the strengths of the aluminum industry when it comes to cost containment can also become a weakness when it comes to increasing recycling rates. As noted above, the industry has made significant progress in reducing the weight of their cans, from 21.75 cans per pound of aluminum in 1972 to 31.07 cans per pound of aluminum in 1995.[276] Since aluminum recyclers pay by the pound, it now takes more cans to make the same amount of money. An individual earning money from the sale of used aluminum beverage cans in 1972, had prices per pound remained constant, would have had to increase can collection by 43 percent, or 1.5 percent per year, to make the same amount of money in 1995. Therefore, in order to increase used beverage can recovery, aluminum companies would have to pay more for aluminum scrap. This may still be worthwhile, given the significant difference between primary and secondary aluminum prices.

The main problems with the reuse of aluminum packaging waste—which is generally generated by residential users—relate to contamination.[277] Purchasers of secondary material require guarantees of quality for the products they buy, or at least they need to know and rely on certain maximum impurity levels. Such assurances are harder to obtain in the case of aluminum cans.

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269 Porter, *Recycling in America*, p. 22.

270 "Aluminum: The 21st Century Metal," p. 7.

271 Bell, Cammarota, Males, *et al.*, "Metals."

272 Bell, Cammarota, Males, *et al.*, "Metals."

273 "Aluminum Can Recycling Remains America's Favorite."

274 "Aluminum: The 21st Century Metal," p. 9.

275 Porter, *Recycling in America*, p. 22.

276 "Aluminum Can Reclamation."

One type of contamination is the intentional adulteration of cans when they are brought to the recycling center. The operators of large take-back programs generally pay by the pound, which tempts waste generators to put fishing sinkers, wheel weights, battery lugs, steel, or anything heavy into their aluminum cans to make them appear heavier. Lead is the great fear, because can manufacturers need to have as lead-free a product as possible to be able to make new food-contact material. Cadmium, which is another leachable metal that raises greater health concerns than lead, is also a potential issue, but in practice is not as much of a problem. Adulterated aluminum scrap—even scrap contaminated with lead—can be "sweetened" by the addition of primary aluminum, but this of course makes the process more costly.

Another type of contamination is inherent in food and beverage containers. Unwashed containers contain putrescible material and run the risk of attracting roaches, bees, rats, and other vermin. These do not change the production process—insects will burn up during recycling—but they make the material more difficult to handle from the point of view of the scrap processor. Unfortunately for the scrap processor, individuals who return aluminum cans are usually simply concerned with getting rid of the waste, and not with selling a marketable commodity.

Finally, paints and coating on cans have caused problems in some circumstances. One aluminum scrap processor noticed that the lead content of his scrap showed sharp increases whenever he accepted scrap from Mexico. Eventually, it came to light that certain Mexican beer cans were painted with a red pigment containing lead.

B. Steel

1. Composition of Consumption

Steel containers represent 8 percent of the sheet steel market. Steel cans come in approximately 600 sizes, shapes, and styles, and contain about 2,500 different products. The steel food can was invented in England in the early 1800s; the steel beer can was first produced in 1938. Most steel cans are used for food (nonbeverage) products (the rest are used for products like paint and aerosols), and 90 percent of food cans are made of steel.[278] The most common food cans are one-gallon cans, which are often used in foodservice settings. Many glass and plastic containers also have steel lids or closures.

Steel cans are made of tinplate steel, which is made in basic oxygen furnaces. To prevent rusting and protect flavor, a thin layer of tin is sometimes applied to the can's inner and outer surfaces—hence the common name "tin can." Today, many cans use a chromium wash instead of tin, and have an aluminum top.[279]

2. Recycling Opportunities

About 6.2 percent of municipal solid waste is made up of steel-containing wastes.[280] Steel cans make up 1.4 percent of municipal solid waste, or 2.9 million tons. At an average weight of 2.8 ounces per steel

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277 Much of the information on aluminum can contamination comes from personal communication with Thomas Wolfe, managing director of government relations, Institute of Scrap Recycling Industries.

278 Chaz Miller, "Waste Product Profile: Steel Cans," *Waste Age*, July 1996, p. 121.

279 Miller, "Steel Cans," p. 121.

280 Porter, *Recycling in America,* p. 30.

can, that makes 33 billion cans.[281] About 68.5 percent of all steel scrap was recycled in 1995,[282] with most of that from cans and household appliances. Most steel can waste comes from residences, while both residences and businesses generate steel appliance waste. Much steel waste is produced and recycled through the scrap metal market, involving scrap automobiles and industrial steel scrap.[283] Steel is also recovered from municipal solid waste; about 25 percent of steel MSW waste was recovered in 1993.[284]

In particular, steel can recycling rates reached a high of 55.9 percent, or 1.56 million tons of cans (17.8 billion steel cans),[285] in 1995, more than 3.5 times the 1988 rate of 15 percent. Curbside collection, drop-off centers, and buy-back operations collect most cans, while other cans and steel-containing wastes stay in the waste stream and are separated magnetically at municipal solid waste processing facilities or waste-to-energy combustion plants.[286] Steel cans magnetically separated from mixed solid waste are generally dirtier than steel cans separated from garbage.[287]

Because new steel and iron are made in part with old steel and iron products, the recycling infrastructure is essential to the steel industry. Most steel is made using basic oxygen furnaces, which use 28 percent scrap steel; steel cans provide less than 10 percent of this scrap.[288] The basic oxygen furnace process produces the steel required for packaging, car bodies, appliances, and steel framing.[289] The electric arc furnace and foundry use almost 100 percent old steel.[290] Electric arc furnaces produce the steel required for steel shapes like railroad ties and bridge spans. They are more geographically diverse than basic oxygen furnaces and have smaller capacities.[291]

Detinners remove the tin from steel cans for resale to tin-using industries, though decreases in the amount of tin used in steel cans have lessened the importance of this market.[292] Steel can recycling can increase energy efficiency in the steelmaking process and reduce air emissions.[293] The steel recycling system is shown in Figure M-2.

3. Recycling Constraints

The contamination issues raised for aluminum also apply to steel. The tin coating on some steel food cans limits the usefulness of the recycled steel; different sorts of steel are produced for different purposes with different ductility and strength, but tin or copper contamination can make steel more brittle and

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281 Miller, "Steel Cans," p. 121.

282 Steel Recycling Institute web site, http://www.recycle-steel.org.

283 Porter, *Recycling in America*, p. 30.

284 Porter, *Recycling in America*, p. 30.

285 Steel Recycling Institute web site. This is enough cans to stretch around the equator 33 times. Rice, "Green packaging scorecard." The SRI futher reports that 17.8 billion steel cans a year is equivalent to about 566 cans recycled every second. Moreover, "in 1995, 41.8 million appliances were recycled, at a rate of 74.8 percent. That's 9.5 appliances recycled for every person who visited the Grand Canyon last year." Furthermore, "the more than 12 million cars recycled in 1995 would cause a traffic jam stretching from New York City to Los Angeles 15 times," and steel recycling "saves enough energy to electrically power about 18 million households for one year." The preceding facts, however, while interesting, are of dubious relevance.

286 Porter, *Recycling in America*, p. 30.

287 Miller, "Steel Cans," p. 122.

288 Miller, "Steel Cans," p. 122.

289 Steel Recycling Institute web site.

290 Porter, *Recycling in America*, p. 30.

291 Miller, "Steel Cans," p. 122.

292 Miller, "Steel Cans," p. 122.

293 Rice, "Green packaging scorecard."

likely to crack. Since the tin in the cans is potentially more valuable than the steel, detinning may also be desirable for its own sake, but it is not widespread, in part because of the high costs involved.

Rotting food, with its associated odor, disease, and vermin problems, is more likely to turn up in steel cans than in aluminum cans, since steel cans are more likely to contain food, while aluminum cans are more likely to contain beverages. Moreover, the effect of contamination will probably be greater for steel than for aluminum, since scrap does not enjoy as significant a price advantage over raw steel as recycled aluminum does over primary aluminum.[294]

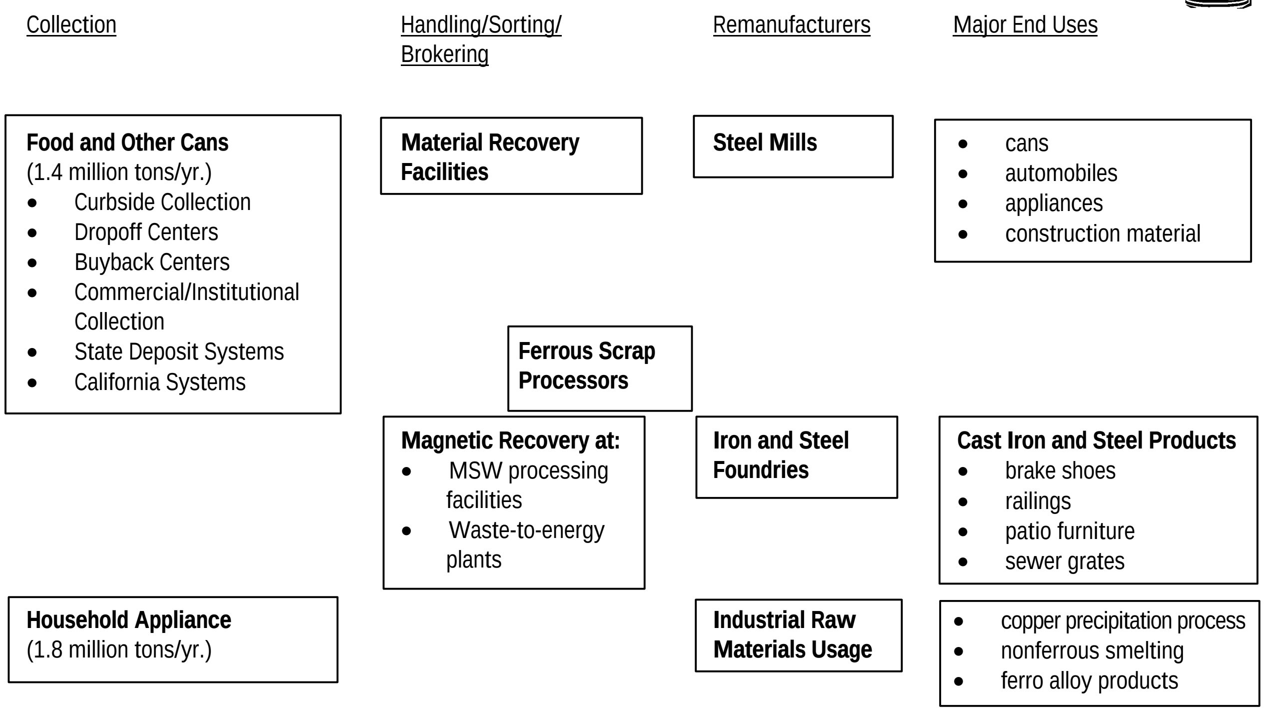
The method of making steel can also constrain recycled content. The basic oxygen furnace method of steelmaking involves injecting oxygen into a mixture of 25–30 percent scrap and 70–75 percent molten iron. Policies that attempt to raise recycled content levels above this amount will be costly. The proportion of scrap can be raised above 30 percent through controlled addition of lump coal into the top of the converter, but only at the expense of some productivity and yield. Electric arc furnaces use 100 percent scrap, but most steel is still made using the basic oxygen furnace method, and the two processes are used for making different kinds of end products.

Finally, regulation threatens to hinder steel recycling. When scrap is melted in an electric arc furnace (EAF), some of the nonferrous metal additives, such as zinc, lead, and cadmium, are captured in a baghouse as constituents of EAF dust. The Environmental Protection Agency (EPA) has listed EAF dust as a hazardous waste and issued land disposal regulations. These regulations have increased steel production costs.

Such problems are typical of hazardous waste law, particularly the Resource Conservation and Recovery Act, which is universally agreed to be costly, confusing, highly technical, and in general regulates substances based on their “wastelike” nature instead of based on the actual environmental risk they pose. Superfund, the hazardous waste cleanup program, has also increased the costs of metal recycling. When a site is designated as a hazardous waste site and placed on Superfund's National Priority List, anyone who “arranged for the treatment of disposal” of any hazardous wastes at that site can be liable for the cleanup of the entire site. But many metals are toxic when discharged into the water at certain concentrations, so they are considered “hazardous substances” under Superfund. Therefore, when scrap dealers sell scrap steel, they may be liable for the cleanup of their customers' property if that property is later declared a Superfund site. This applies even if the property was declared a Superfund site because of the presence of a totally different material.

294 Personal communication, Tom Wolfe.

Figure M-2: The Steel Recycling System



Source: Porter, *Recycling in America*, p. 31.

In the past, courts have held that merely selling a product to someone—as the scrap dealers were doing—is not enough to constitute "arranging for its disposal."[295] But since materials in the recycling process are considered "solid waste," scrap dealers can be held liable. The EPA, by rule,[296] has included all recycled scrap metal in the category of discarded material (solid waste), and pursues in litigation any recycler who has sold recycled metal to a customer who has (through his own activities) contaminated his own land.[297] The EPA does not pursue people who sold comparable virgin materials to the same site owner because these are not "solid wastes," and so no intent to dispose is presumed.[298]

Paper and Paperboard Packaging

[295] United States v. Westinghouse, 22 E.R.C. 1230 (S.D. Ind. 1983), and Florida Power and Light Co. v. Allis-Chalmers Corp., 29 E.R.C. 1486 (S.D. Fla. 1988).

[296] 40 C.F.R. § 261.1.

[297] See *United States v. Pesses* (W.D. Pa., Civil Action No. 90–0654), brief amicus curiae of the Institute of Scrap Recycling Industries in support of Defendants' motions for summary judgment.

[298] For a more detailed discussion of how hazardous waste law discourages recycling, see Alexander Volokh, *Recycling Hazardous Waste: How RCRA has Recyclers Running Around in CERCLAs*, Reason Foundation Policy Study No. 197, October 1995.

A. Composition of Consumption

1. Paper

Paper can be divided into numerous grades:

- *Newsprint*
- Other printing/writing papers:
  1. *uncoated groundwood* (including telephone directory paper)
  2. *uncoated free-sheet* (including stationery and letterhead, books, cotton fiber, bristols)
  3. *coated groundwood and free-sheet* (including magazines and sales brochures)
- *Packaging & industrial converting* (including unbleached kraft sack paper for paper bags)
- *Tissue* (including bath and facial tissue, towels, and napkins).[299]

Statistics on the production of these grades are given in Table PP-1.

Kraft packaging and industrial converting papers include a wide range of bleached, unbleached, recycled, and specialty papers.

- The commodity packaging grades are used for grocery bags and sacks, multiwall shipping sacks, industrial wrapping papers, and other converting papers.
- The specialty packaging grades include flexible packaging, food wraps, glassine, greaseproof, and vegetable parchment papers.
- Many special industrial and technical grades are used in decorative laminates, masking tapes, abrasives, electrical insulators, gaskets, filters, construction papers, and many other products.

Breakdowns of total packaging production by grades and uses are given in Figures PP-1 and PP-2.

2. Paperboard

Paperboard is a general term describing heavyweight grades of paper used in containers, boxes, cartons, tubes and cores, and miscellaneous converted products.

- *Containerboard*, the largest category of paperboard, includes three major products: *linerboard*,

Table PP-1: U.S. Paper Production (Thousands of metric tons)

Grade	1996	1995	1994	1993
Newsprint	6,430 (e)	6,400 (p)	6,336 (r)	6,412 (r)
Uncoated groundwood	2,063 (e)	1,980 (e)	1,915	1,800
Coated papers	4,663 (e)	4,600 (p)	4,446 (r)	4,340 (r)
Uncoated free-sheet (excl. cotton fiber, bristols)	13,869 (e)	13,592 (e)	13,304 (p)	12,355
Cotton fiber	n.a.	n.a.	159	160
Bristols (bleached)	1,458 (e)	1,422 (e)	1,383	1,303
Packaging & industrial converting	4,280 (e)	4,355 (e)	4,725	4,608
Tissue	6,397 (e)	6,240 (e)	6,098	6,008
Packaging share	10.9%	11.3%	12.3%	12.5%
Value share of packaging & industrial converting				31.3%

e = estimated, p = preliminary, r = revised, n.a. = not available
Source: *Fact Book*, pp. 129, 132, 152, 161, 174, 192, 198, 211.

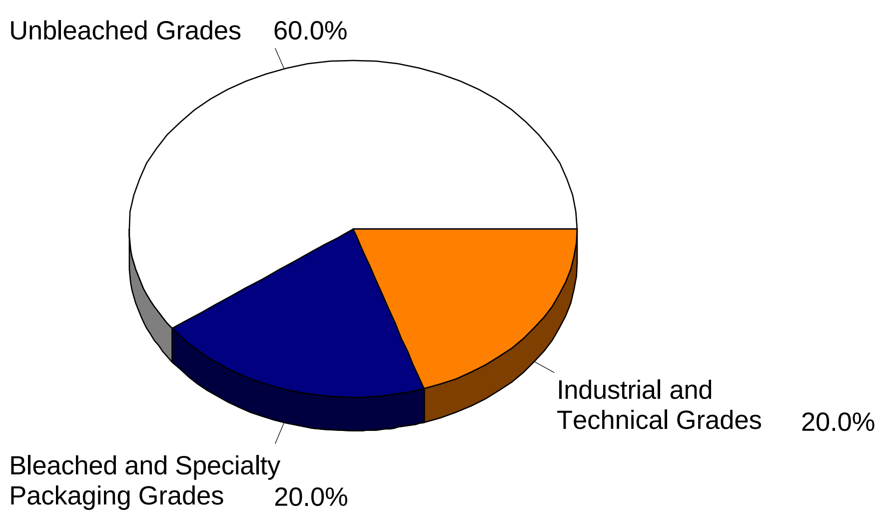
299 Pulp and Paper North American Fact Book ("Fact Book"), pp. 125–126. Much of the information in this section is contained in the Fact Book.

corrugating medium, and *chip and filler boards*. Most containerboard is used for corrugated shipping containers, but much linerboard—about 3 million tons in 1995—is exported. Kraft linerboard is made from 100 percent virgin kraft fiber, but an increasing amount of recycled linerboard and corrugating medium is being made from 100 percent recovered wastepaper.

- *Boxboard* is used for folding cartons and milk cartons, setup boxes, food-service disposables, and other packaging products. Boxboard for folding cartons is made from either bleached or unbleached solid kraft board, or it can be made from 100 percent recycled fiber. *Folding carton stock* is usually clay coated for better printability and consumer appeal. *Sanitary food board* is normally produced from bleached kraft pulp. Several grades are available, and each is custom-coated, waxed, or otherwise treated for packaging moist or oily food products. Typical grades are milk cartons, frozen food packages, ice cream cartons, cup stock, and plates. *Setup boxboard* (also known as *nonbending chipboard*) is used to make rigid or semirigid boxes used in specialty packaging applications. These boxes are custom-produced and usually hand-filled with products such as shoes, jewelry, cosmetics, liquor, and candy, as well as personal computer software products and video games. Chipboard also is used in game boards, book covers, and jigsaw puzzles.

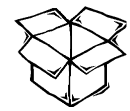
- *Other converted products*, including fiber drums, composite cans, spiral tubes and cores, box partitions, and gypsum wallboard liner. Bending and nonbending chipboard grades (commonly called cardboard) are used for products ranging from stationery pads to game boards.

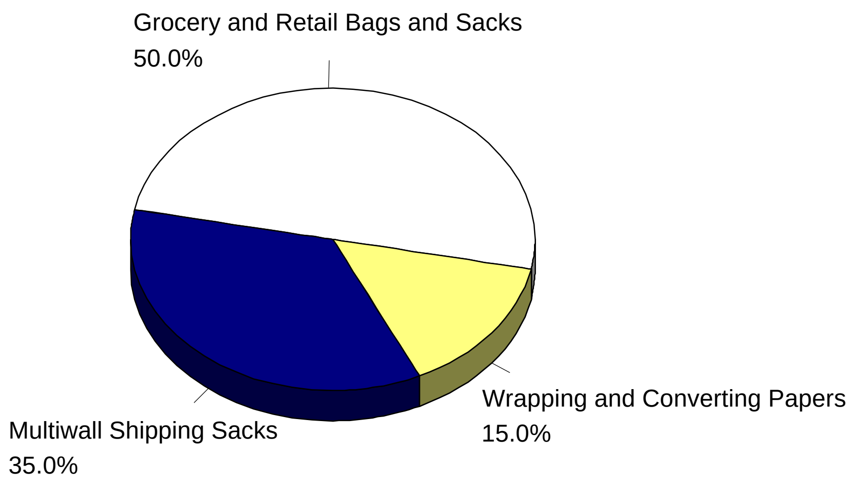
Figure PP-1: Breakdown of Total Packaging Production by Grades



Source: *Fact Book*, p. 197

Figure PP-2: Breakdown of Total Packaging Production by Uses





Source: *Fact Book*, p. 197.

A breakdown of U.S. paperboard production is given in Table PP-2.

Approximately 75 percent of U.S. paperboard production is made primarily from woodpulp, and 25 percent of paperboard is produced primarily from recovered wastepaper.[300]

B. Recycling Opportunities

Paper is one of the easiest materials to collect for recycling because it is abundant, easy to identify, and easy to compact. Most paper collected for recycling comes from the commercial sector. Residential curbside collection is a large and relatively untapped source of used paper aside from newspaper; because of increased efficiencies and higher recovered paper prices in 1994, some cities, including

Table PP-2: U.S. Paperboard Production (Thousands of tons)

	1993	1994	1995 (est.)
Paperboard production	43,113	45,724	47,500
Containerboard (domestic)	26,409	28,086	n.a.
Boxboard (domestic)	7,768	8,229	n.a.
Other paperboard and exports	9,053	9,409	n.a.

Source: *Fact Book*, pp. 221, 222. Numbers may not sum exactly.

Fayetteville, Ark., Cincinnati, Oh., and Austin, Tx., implemented curbside recycling programs with little or no increased costs over their existing refuse-collection and disposal systems,[301] though volatility

[300] See The Paper Task Force, *Paper Task Force Recommendations for Purchasing and Using Environmentally Preferable Paper*, pp. 95–103, for a discussion of environmental, performance, economic, and recycling issues related to corrugated boxes and folding cartons.

of prices makes this result vary over time. In this decade, nonmarket forces have greatly affected wastepaper use—notably the environmental movement and governments. From 1988 to 1995, the North American paper industry spent $7.5 billion to convert much of its capacity to incorporate some recycled fiber. The American Forest and Paper Association estimates that over 400 U.S. mills use some recovered paper, and half of these use it exclusively. The utilization rate, or ratio of wastepaper used to paper or paperboard produced, has been climbing steadily, from 23.3 percent in 1970 to 35.9 percent in 1995 (see Table PP-3).[302]

According to one analyst, "the paper industry in the second half of the 1990s will change more dramatically than it has in the previous 50 years. The structural impacts of recycling on the pulp and paper industry will mean a decreasing reliance on tree cultivation, a rethinking of the size of mills, new attitudes on locations of mills and strong recovered paper grade markets."[303]

In 1997, about half of the wastepaper used is expected to be old corrugated containers (OCC), and OCC and old newspaper (ONP) together are expected to make up 67.3 percent of the total. Mixed papers, including office paper, will account for 14.5 percent. Annual rates of increase in consumption will range from 2.2–3.7 percent for newspapers and pulp substitutes to 5.8–7.5 percent for corrugated and mixed papers, with high-grade deinking in the middle at 4.6 percent.[304]

Depending on what kind of paper is being made, the cost of recovered paper can make up 20 to 40 percent of the total cost of producing 100-percent-recycled paper; this percentage rose in 1995 as recovered paper prices increased and fell as prices fell later that year and in 1996. But the increase in finished paper prices more than offset the increase in recovered paper prices for many manufacturers.[305] The use of recycled paper may become more profitable in the future if virgin pulp prices rise in the next decade, as some analysts predict.[306] The wastepaper industry collects, sorts, and segregates material from many sources into various types, then processes it for ease of handling, transport, and subsequent repulping. The paper recycling system is summarized in Figure PP-3.

Wastepaper is first pulped, or mechanically separated into individual fibers. Water and wastepaper are added to a pulper until a fiber-to-water ratio of anywhere from 1-to-6 to 1-to-30 (depending on the mill) is reached. The paper is torn into smaller pieces, which break down and separate further by rubbing against each other. Further screening and trash removal removes pieces that have not been broken down enough. Chemically treated or coated wastepaper may require more processing. Usually the water in the pulper is heated to 65^{o} C (150^{o} F), and chemicals like sodium hydroxide or soaps and dispersing agents are added. Then contaminants, including ink, are removed. Additional brightness can be achieved through a bleaching process.[307]

Table PP-3: Utilization of Wastepaper by U.S. Paper/board Mills (Thousands of tons)

	1993 (rev.)	1994 (est.)	1995 (est.)	1996 (prelim.)	1997 (est.)
Wastepaper used	28,336	30,310	32,862	34,167	35,561
Paper/board produced	85,083	89,256	91,476	n.a.	n.a.
Utilization rate	33.3%	34.0%	35.9%	n.a.	n.a.

Source: *Fact Book*, p. 346.

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301 *Paper Task Force Recommendations*, p. 85.

302 *Fact Book*, p. 346.

303 *Paper Task Force Recommendations*, p. 84, citing Bill Moore, "How Recycling is Changing the Structure of the Pulp and Paper Industry," *Resource Recycling*, September 1994, pp. 83–86.

304 *Fact Book*, p. 346.

305 *Paper Task Force Recommendations*, p. 86.

306 *Paper Task Force Recommendations*, p. 87.

307 Much of the information in the following paragraphs comes from *Fact Book*, pp. 267, 270, 363.

Pulping and contaminant removal equipment are fairly similar in most mills, but chemistries and process designs differ depending on the grade of paper being produced, the level of quality being considered for the finished paper, and the technology available to the mill at the time.

Recycled paperboard is primarily used to manufacture industrial and consumer packaging products. Recycled paperboard is made from 100 percent recovered wastepaper—collected from both paper manufacturing and converting plants and postconsumer sources—and represents the largest market for recovered wastepaper in the United States. In 1995, paper mills primarily producing recycled paperboard collected and processed more than 15 million tons of wastepaper, a 50 percent increase since 1990. Statistics on the production of recycled paperboard are shown in Table PP-4.

The major grades of recycled paperboard are:

- folding boxboard (23 percent of total capacity),
- industrial converting grades (22 percent),
- corrugating medium (23 percent),
- linerboard (19 percent),
- gypsum wallboard (11 percent), and
- setup boxboard (2 percent).

The converting grades include products like spiral tubes and cores, composite cans, fiber drums, tags and labels, file folders, writing tablets, book cover stock, and game boards. The converting grades do not include various types of construction paper and board used for construction and building materials. Roofing, tar paper, and construction panel boards account for an additional 2.2 million tons of wastepaper consumption but are listed separately in industry statistics.

Recycled paperboard demand is increasing by about 6 percent per year; the fastest-growing segments have been clay-coated boxboard grades used for folding cartons and 100 percent-recycled linerboard and corrugating medium used for corrugated shipping containers and boxes. Production of recycled paperboard for gypsum wallboard has also been growing rapidly. At the same time, the output of uncoated chipboard grades, setup boxboards, and some miscellaneous grades has declined. Annual U.S. recycled paperboard production increased by 60 percent, from 7.6 million tons to 12.3 million tons, between 1984 and 1994, fueled by rising demand for paper and paperboard products containing significant amounts of recycled materials.

More than half of the products on supermarket shelves are now packaged in cartons using recycled paperboard, and significant growth has also occurred in nonfood products. The mid-1990s growth in recycled folding carton markets was spurred by a switch to recycled paperboard by a number of large packaged goods manufacturers. The once-dominant market position of bleached paperboard has been undermined by its relatively high price compared with coated recycled and coated kraft grades.

Table PP-4: North American Statistics For Recycled Paperboard

Year	Production
1993	11,410
1994	12,283
1995	13,062
1996	13,535 (e)

Note: Recycled paperboard has 100 percent recycled content. These numbers do not include production of partial-recycled-content paper.
Source: *Fact Book*, p. 268.

Government action has also been responsible for a portion of the increase in the use of recycled paper—because of state recycling laws, newsprint laws, packaging laws, and procurement practices. General concern about the environment, the development of voluntary standards and definitions for recycled paper, and the growth of “environmentally friendly” labeling, has also played a role.

C. Recycling Constraints

1. Economic Constraints

a) Volatile price

In the 1990s, wastepaper use grew faster than woodpulp use because of environmental pressures, but this will probably change as recovered paper costs rise. From 1990 to early 1994, recovered paper prices were low. Many residential and commercial recycling collection programs were started during the 1991–1992 recession, due to rising disposal fees in some regions, government regulation of landfills and other public sector initiatives, and the popularity of recycling.[308] But between 1994 and 1995, recovered paper prices, which are volatile even under the best of circumstances, rose sharply—as much as quadrupling for some grades—but declined just as sharply late in 1995.[309] Recovered paper prices are expected to be higher in the future than they were from 1989 to 1993, though prices remained low through 1996.[310]

The costs of recycling collection and processing, relative to the costs of garbage collection and transfer plus landfilling or incineration, also vary greatly depending on local conditions and recycling program design. Landfill disposal charges in the United States vary between $10 and $140 per ton.[311]

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308 *Paper Task Force Recommendations*, p. 84.

309 *Fact Book*, p. 345.

310 *Paper Task Force Recommendations*, p. 85.

311 Paper Task Force Recommendations, p. 84, citing: Solid Waste Digest, Northeast, Southern and Western editions, December 1994, p. ii (each edition); and William Ferretti then director at Office of Recycling Market Development, New York State Department of Economic Development, letter, May 12, 1995.

Figure PP-3: The Paper Recycling System

Collection	Handling/Sorting/ Brokering	Remanufacturers	Major End Uses
Corrugated Boxes (14.6 million tons/yr.) • Shopping Centers • Retail Stores • Factories	Material Recovery		**From Corrugated Boxes** • Corrugated Boxes • Paperboard • Tissue Paper • Exports
Newspapers (5.9 million tons/yr.) • Dropoff Centers • Curbside Collection • Paper Drives	Paper Brokers	Pulp, Paper, Paperboard, and Tissue Mills	**From Newspapers** • Newsprint • Paperboard • Tissue Paper • Corrugated Boxes • Printing-Writing • Exports
Office Paper (2.6 million tons/yr.) • Office Buildings • Schools	Scrap Dealers		**From Office Paper** • Tissue Paper • Printing-Writing • Paperboard • Newsprint • Exports
Other Paper (3.4 million tons/yr.) • Office Buildings • Industrial Plants • Schools • Telephone Directory Drives • Curbside Collection/Dropoff Centers	Waste Haulers		**From "Other" Paper** • Paperboard • Container Board • Tissue Paper • Exports

Source: Porter, *Recycling in America*, p. 27.

Individual paper grades are subject to particular market conditions of their own. Old corrugated container (OCC) price swings may discourage future recycled containerboard projects, as maximum recovery rates are achieved. The supply of OCC depends on U.S. containerboard consumption, which has been increasing by about 2.8 percent per year. Domestic OCC demand, on the other hand, grew at about 8.6 percent per year in 1990–1995. OCC consumption by the paper industry (mainly for making containerboard) was expected to reach 16.4 million tons in 1995, up 51 percent from its level in 1990, according to a 1994 capacity survey by the American Forest and Paper Association. Consumption was expected to jump at least 11 percent to 18.2 million tons by 1997. OCC exports to Asia increased rapidly as well, jumping 37.6 percent to 3.1 million metric tons in 1994, as increasing by 45 percent through August 1995 to an annualized rate of 4.1 million metric tons per year.

The recovery rate for OCC rose from 41 percent in 1980 to 67 percent in 1995 and would have to reach 77 percent by 1997 to satisfy all of the projected demand; the maximum feasible recovery rate has been estimated at 73 percent.[312] OCC demand will have to be diverted to other wastepaper sources, but these

312 *Fact Book*, p. 243.

are also in high demand already. With domestic and export demand rising and recovery rates near maximum levels, the OCC market has become increasingly vulnerable to supply and demand shocks which cause prices to fluctuate wildly. After remaining around $20 to $30 per ton in 1990–1993, OCC prices grew to $120 per ton in August 1994, fell to $60 per ton in November 1994, increased again to $200 per ton in May 1995, and by November 1995 had sunk back to $20–$30 per ton. Because of the instability in OCC prices, mills that rely on 100 percent recycled fiber "will be more vulnerable to the unstable conditions in the OCC market than integrated mills using OCC as a supplemental fiber for incremental capacity." Most new North American containerboard capacity expansion projects in the future may be based on virgin woodpulp, not secondary fiber.[313]

b) Preferential government procurement policies

Federal paper purchasing favors postconsumer content over preconsumer content. For instance, President Clinton's Executive Order on recycled procurement specifies at least 20 percent postconsumer content after December 31, 1994, and 30 percent after December 31, 1998, for federal procurement of high-speed copier paper, offset paper, forms bond, computer printout paper, carbonless paper, file folders and white woven envelopes. The Executive Order set a minimum content standard for other uncoated printing and writing paper (like writing and office paper, book paper, cotton fiber paper, and cover stock) of 20 percent postconsumer and 50 percent total recovered content.[314] A more recent Recovered Materials Advisory Notice set postconsumer and total recovered content goals for a large variety of different paper grades.[315]

"Preconsumer" recycled material is plant scrap or other recycled materials that were not collected from consumer wastes. Preconsumer generators are primarily converting plants and printers. Converting plants produce recyclable products such as envelopes, books, and business forms. Printers are sources for materials such as magazines, directories, and catalogs. In these operations, waste is generated from machine trim and other manufacturing operations. "Postconsumer" recycled material has been used as a consumer item before having been discarded and then made into something else. Postconsumer generators include homes, factories, offices, and retail outlets.[316]

Many recycling laws distinguish between preconsumer and postconsumer recycled material, and encourage postconsumer recycling. This distinction, in fact, is found in the Resource Conservation and Recovery Act (RCRA), the major piece of U.S. solid waste legislation, which doesn't consider preconsumer material "recovered." According to RCRA, "recovered material" means "waste material and byproducts which have been recovered or diverted from solid waste, but such term does not include those materials and byproducts generated from, and commonly reused within, an original manufacturing process."[317] In the specific case of paper, RCRA does allow for the use of preconsumer material, but it emphasizes postconsumer materials.[318]

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[313] *Fact Book*, p. 243.

[314] The White House, Office of the Press Secretary, Executive Order #12873, "Federal Acquisition, Recycling, and Waste Prevention," October 20, 1993, §§ 504(a) and 504(b).

[315] Environmental Protection Agency, Office of Solid Waste and Emergency Response, Recovered Materials Advisory Notice, May 20, 1996, publication no. 530-Z-96-005, part A (Paper and Paper Products).

[316] *Fact Book*, pp. 346–347.

[317] 42 U.S.C. § 6903(19).

[318] 42 U.S.C. § 6962(h)(1).

The distinction, however, is an artificial one. Several categories of products—such as newspapers, phone books, magazines, and catalogues—can be classified as preconsumer or postconsumer, depending on where they were collected, even though the items themselves do not change.[319] For example, magazines thrown away after they were read are postconsumer waste. But the same magazines, if they weren't sold but were returned by the distributor, are preconsumer waste.

Moreover, unless they are recycled, both preconsumer and postconsumer waste are incinerated or landfilled. Preconsumer waste may have inks, waxes, metallic or plastic coatings, or glues which are difficult to remove. Printers' waste, for instance, has heavy ink content, and bindery trim has adhesives; neither of these can be recycled on-site by the generator, nor can they be reused without being recycled. Governments' continuing preference for postconsumer waste can hinder efforts to use preconsumer waste, as recyclers pursue more expensive postconsumer wastepaper when preconsumer wastepaper would cost less to process. Postconsumer wastepaper is often costly to identify and separate in a mill; postconsumer mandates therefore increase the cost of recycling and raise the prices of products with recycled content.[320] In mid-1995, the American Forest and Paper Association reported that many grades of recovered paper were in short supply, and recovery rates for two of the largest recovered paper grades were closing in on what were estimated to be “maximum feasible recovery levels.” The recovery rate for old corrugated containers reached 63 percent in 1994, compared to an estimated maximum of 66–72 percent. The recovery rate for old newsprint was 59 percent, compared to an estimated maximum of 67–72 percent. Office papers were in tight supply in many places in mid-1995, and the situation was expected to get tighter as recovered paper exports rise and new deinking facilities opened.[321] With the U.S. paper recovery rate at record levels, many mills were reconsidering their decision to use recovered paper as a feedstock, and some closed or reverted to virgin fiber because recovered paper had become too expensive for them.[322]

2. Technical Constraints

a) Quality of recycled paper

The major problem in using recycled pulps is lack of uniformity; recycled pulps differ in their physical and chemical properties, and also differ from virgin pulp. Wastepaper is not as widely used as woodpulp because of variability and other quality considerations. In any event, the need for virgin pulp will never be eliminated because successive repulping tends to lower the quality of some recycled fiber, eventually making it unusable. Primary fibers often are added to recovered fibers to maintain strength and other qualities.[323] Enzymes can also be used to modify the surface characteristics of recycled fibers.[324]

Recycling has different effects on chemical and mechanical pulps. The drying of chemical pulps during papermaking forms bonds between cellulose microfibrils between the fibers—a process called hornification. Recycled chemical fibers are therefore stiffer and swell less than virgin fibers, leading to a decrease in interfiber bonding and lower paper strength (see Figure PP-4).[325]

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319 Testimony of Charles D. Wilson, director of government affairs at Fort Howard Corporation, in *Development of Recycling Markets*, p. 469.

320 Testimony of Charles D. Wilson, p. 469.

321 American Forest & Paper Association, “Paper Industry Concerns with the Distinction Between Pre- and Post-Consumer Recovered Paper,” p. 1.

322 See also Volokh, *Government Building Codes*, pp. 32–34.

323 *Fact Book*, p. 345.

324 Brian R. Moran, “The Use of Enzymes for Increased Paperboard Production Efficiency,” Nalco Chemical Company, May 10, 1996.

325 See also *Paper Task Force Recommendations*, p. 83.

On the other hand, the lignin matrix in mechanical pulps, such as groundwood pulps, prevents hornification; recycling mechanical pulps tends to flatten the fibers and increase their flexibility, resulting in improved interfiber bonding and increased strength (see Figure PP-5).

Whether for better or for worse, each step of the recycling process in general changes the properties of the pulp; the effects of flotation, a component of the deinking process, on the physical and optical properties of certain mixes of wastepaper are shown in Table PP-5.[326]

In addition, the quality of recycled paper may suffer because of the presence of contaminants. Heavy contaminants include metals (nuts, bolts, wire, soda cans, and staples), sand, rocks, and glass. Light contaminants include plastics, Styrofoam, waxes, hotmelt glues and adhesives, pressure-sensitive adhesives (including “stickies”), and wood. Ink is a common contaminant found on paper and is also difficult to separate and remove from paper fibers.[327] A growing number of communities are collecting folding cartons for recycling, but mills that use folding cartons as a feedstock find themselves facing higher level of contaminants, due to the presence of polyethylene coatings, metal tear strips, and plastic handles.[328] Even the water used to deink paper, which often comes from paper machines, can be contaminated with felt hairs, stickies, rust, sand, and pitch. The felt hairs can be mistaken for unbleached fibers, while the stickies might be pitch from the virgin fiber or binders from repulped coatings which might be very small but capable of growing after being introduced to deinking plant water.[329]

With a properly designed contaminant removal system, 99 percent or more of the debris found in grades such as OCC can be removed.[330] Big contaminants are most easily removed by screens, while smaller contaminants are removed by forward or reverse cleaning, depending on whether they are heavier or lighter than water. The still smaller particles are removed by flotation, and the smallest particles by washing. (See Figure PP-6.) (Small stickies in the washable or flotable size range “often come back to haunt” the paper recycler later in the process.)[331]

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326 Woodward, “Behavior of Recycled Pulps.”

327 *Fact Book*, p. 363.

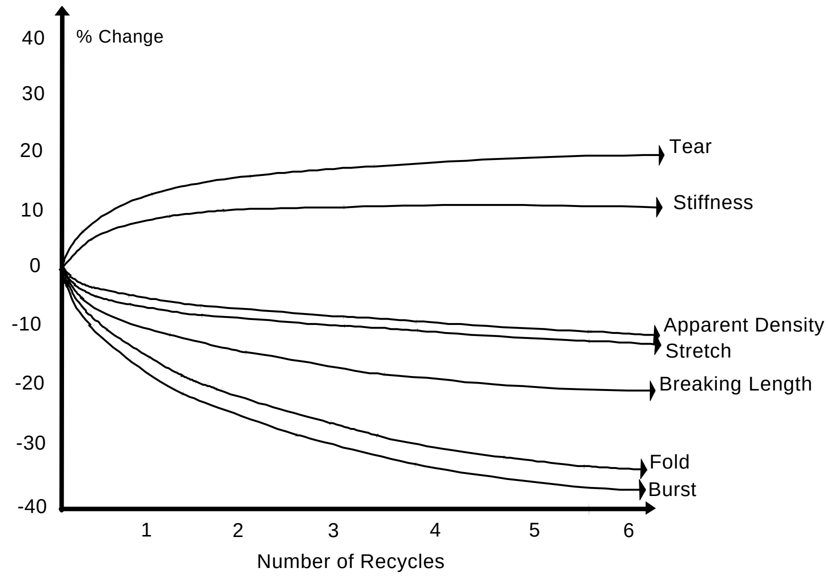
328 *Paper Task Force Recommendations*, p. 103.

329 Edward L. Glass, “Experiences in Office Wastepaper Deinking Contaminant Removal,” Rust Engineering & Construction.

330 *Fact Book*, p. 363.

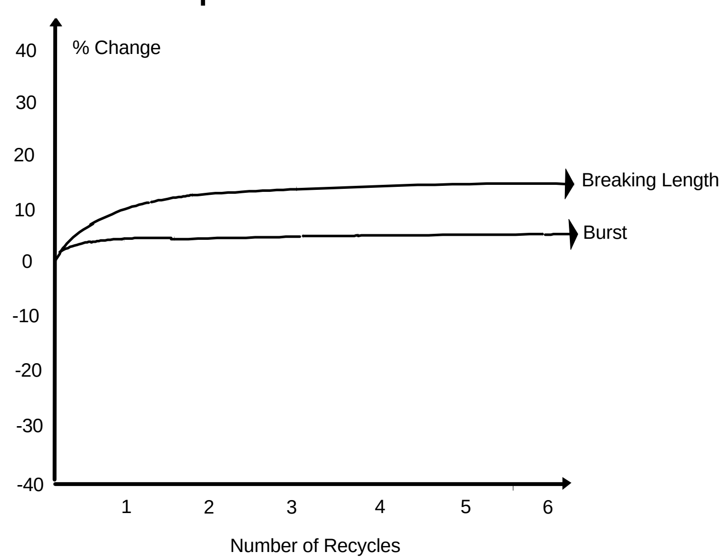
331 Glass, “Wastepaper Deinking Contaminant Removal.”

Figure PP-4: General Effects of Recycling Chemical Pulps



Source: Tom W. Woodward, "The Behavior of Recycled Pulps During Papermaking," Betz Paper Chem. Inc., Jacksonville, Fl., Fig. 1.

Figure PP-5: General Effects of Recycling SGWD Pulps



Source: Woodward, "Behavior of Recycled Pulps," Fig. 2.

Two of the major contaminants, inks and "stickies," are dealt with in the following subsections.

Table PP-5: Effects of Flotation on Physical and Optical Properties—70% ONP/30% OMB		
Increased	Decreased	No Change In
Brightness Tear Tensile Burst Stretch	Opacity Absorption Coefficient Ash Content	Scattering Coefficient

Source: Woodward, "Behavior of Recycled Pulps," Table 1.

Table PP-6: Problems Due To Stickies	
Machine Operation	Product Quality
Web Breaks	Appearance/Sheet Spots
Forming Fabric Deposition	Holes
Press Section Deposition	Sheet Profile Variations
Dryer Section Deposition	Lower Strength
Batch Washes	Printing
Shut Downs	Converting

Source: Tom W. Woodward, "The Behavior of Recycled Pulps During Papermaking," Betz PaperChem, Inc., Jacksonville, Fla., attached transparency.

b) Inks

Deinking systems vary, but most can produced the desired quality of paper unless they have to deal with more contaminants than they can handle. "Almost any deinking plant," says Edward Glass of Rust Engineering and Construction, "can simply be overwhelmed by very dirty paper."[332]

Deinking can be subdivided into the five processes of:

- *repulping*: defibering and removing the ink from the fiber;
- *cleaning and screening*: removing large, dense, and light contaminants;
- *washing/flotation*;
- *dispersion*: reducing contaminant particle size; and
- *clarification*: separating ink from the system.[333]

Each of these processes can be expected to change the properties of the pulp; for instance, dispersion lends a uniform overall appearance to the sheet, but also creates lower brightness levels. It is possible to brighten the pulp by adding a high-consistency bleaching stage, but this requires additional resources.[334]

c) Stickies

The presence of "stickies" (Post-It Notes, self-adhesive stamps, envelopes, and the like) on wastepaper can create problems both in machine operation and in product quality (see Table PP-6). As one commentator puts it, "these little sticky balls tend to give recycled pulp a bad name with paper makers and printers when they glue paper to other sheets of paper or to equipment, such as paper machines and printing presses."[335]

Loreen Ferguson and Tom Windham of Boise Cascade describe the problem of these "troublesome pests" in their article, "Why is a Sticky Like a Cockroach?"[336] "The three biggest problems faced by virtually all office waste recycling plants," Ferguson and Windham explain, "are: one, stickies; two, stickies; and three, stickies."

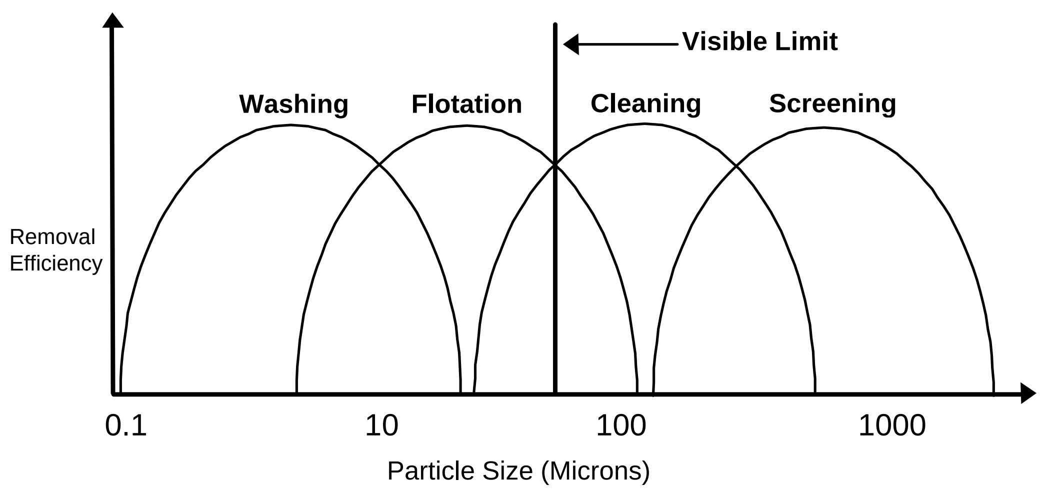
Stickies can be removed through mechanical means—with screens, cleaners, washers, and dispergers—and through chemical means—through passivation, dispersion, and agglomeration. We need not describe the technical intricacies of sticky removal technology, but confine ourselves to noting that at present, there is no cheap, reliable way to eliminate the problems posed by stickies—especially since sticky technology itself is constantly improving, by its own criteria, which are often at odds with the criteria of the paper recycler. As Ferguson and Windham put it, "The sticky continues to elude everything we throw at it and to make it to the final pulp. The sticky particles are a formidable opponent

332 Glass, "Wastepaper Deinking Contaminant Removal."
333 Woodward, "Controlling Contaminants in the Production and Use of Deinked Pulp," Betz PaperChem, Jacksonville, Fla.
334 *Fact Book*, p. 364.
335 Glass, "Wastepaper Deinking Contaminant Removal."
336 Loreen D. Ferguson and Tom Windham, "Why is a Sticky Like a Cockroach?", Boise Cascade Corp., Jackson Recycle Plant, Jackson, Ala.

and consume a disproportionate share of the equipment and operating budget."[337] Like a cockroach, the sticky "evolves to avoid extinction." They conclude:

> *Why not just sort it out of the wastepaper before it ever reaches the recycle plant? Newspaper, lunch bags, boxes, and soda pop cans are easy to spot by the person on the sorting line. Stickies tend to fade into the background paper, being mainly white labels, and are not as easy to spot. Working on a wastepaper sorting line eight hours a day handling unsorted mixed office waste must be one of those jobs one always hopes never to have to take.*
>
> *Tabs on folders, address labels, Post-it Notes, multi-part forms, etc., are difficult to pick out, as are the stickies formed from the latex and binders in coated papers, magazines, and the like. Stickies formed from pressure-sensitive adhesive are one of the most difficult to handle—the government is not helping things by issuing pressure-sensitive stamps, [nor is] the post office [by] using pressure-sensitive change of address labels, in bright yellow no less.*[338]

Figure PP-6: Particle Size Distribution and Removal



Source: Glass, "Wastepaper Drinking Contaminant Removal," attached transparency.

337 Ferguson and Windham, "Why is a Sticky Like a Cockroach?"

338 Ferguson and Windham, "Why is a Sticky Like a Cockroach?"

Appendix B

Assumptions and Data Used in the Model

COST OF VIRGIN RAW MATERIALS

The baseline for estimating the cost of implementing various recycling policies is the production of a container using all virgin materials (plus internal factory recycling). The cost of these virgin materials is based on the market price plus delivery costs. This analysis assumes that the market price is a close approximation of the true costs to produce raw materials because competition is unlikely to allow taking of excess profits in these markets. These market prices include labor and energy costs plus a return to investment in capital. Average reported rates for trucking and rail freight were used to estimate transportation costs.[339]

Energy prices also were estimated for each step of the manufacturing and disposal process. Prices for natural gas, fuel and diesel oil, coal and electricity were identified based on the industry's SIC code or grouping.[340] Energy use in each process was derived from the process descriptions for each step discussed below. The energy consumption was multiplied by the price to find total cost.

A. Glassmaking Raw Materials

The predominant materials used in glassmaking are sand, limestone, feldspar, and soda ash.[341] Approximately 1.2 tons total of these materials are required to make one ton of glass using 1990s technology. The cost per ton for each of the four materials is based on the market price plus a transportation cost derived from the relative proportion moved by either truck or train.[342]

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339 U.S. Bureau of the Census, Statistical Abstract of the United States: 1993, 113th ed. (Washington, D.C.: U.S. Government Printing Office, 1993), Table 1047 for trucks, Table 1052 for rail.

340 For electricity, by SIC code, see U.S. Bureau of the Census, *1991 Annual Survey of Manufacturers: Statistics for Industry Groups and Industries*, M91(AS)-1 (Washington, D.C.: U.S. Department of Commerce, December 1992). For average or industry energy prices, see *1993 Statistical Abstract*, Tables 939, 942, 954, and 1417.

341 Gaines and Mintz, *Energy Implications of Glass-Container Recycling*.

342 *1993 Statistical Abstract*, Table 1186 for sand, limestone, feldspar; Table 1047 for truck freight; Table 1052 for rail freight; Gaines and Mintz, *Energy Implications of Glass-Container Recycling*, Table 3-1, for soda ash, transport proportions.

B. Woodchips for Paper Pulp

While some chemicals are added during the pulping process in making chemical kraft for paperboard containers, woodchips are the dominant virgin input. The average export market price for the 1987 to 1992 period was used to estimate the cost of woodchips.[343] For fully integrated operations, these woodchip costs are likely to be less due to the joint-product nature of producing multiple wood products and reduced transportation costs relative to the market price. Virgin pulp yields are estimated to be 49 to 55 percent for long-fiber chemical kraft.[344] Transportation costs are assumed to be included in the woodchip price.

C. Steelmaking Raw Materials

The predominant materials used in steelmaking are iron ore, limestone and coal.[345] The cost per ton for each of these materials is based on the market price plus the cost to transport by rail.[346]

D. Plastics Raw Materials

The primary raw material for the three types of plastics examined here (HDPE, LDPE and PET) is natural gas.[347] The feedstock price is assumed to be equal to the market price for natural gas.[348] Transportation costs by pipeline are assumed to be included in the market price.

Recycled Material Recovery and Processing

Recovery of recycled materials is analyzed as a parallel process to the production and supply of raw materials. The material recovery process involves three steps: (1) collection, (2) sorting and processing, and (3) transportation to the manufacturer.[349]

The collection-process cost estimates are based on analysis of co-collection and separate collection systems.[350] Gaines and Mintz focus on the range of energy use for each method based on truck-fuel efficiency, route-collection rates, load size and actual material recovery rates. Fuel efficiency can vary by a factor of four; daily tonnage collection rates vary more than twofold; effective recovery rates range from 38 to 83 percent. In addition, Gaines and Mintz identify the purchase costs for each type of truck used in waste collection. We have assumed that these purchase costs can be annualized and recovered over the expected life of these trucks—a range of 12 to 15 years.[351] Labor costs are based on an hourly

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343 Miller Freeman Inc., *Pulp & Paper 1995 North American Fact Book* (San Francisco, 1994), p. 95.

344 *Pulp & Paper Fact Book*, p. 357.

345 Gaines and Stodolsky, *Mandated Recycling Rates*, Figure 5-5.

346 *1993 Statistical Abstract*, Table 1186, for iron ore, limestone; Table 942 for coal; Table 1052 for rail freight.

347 Gaines and Stodolsky, *Mandated Recycling Rates*, Chapter 4.

348 *1993 Statistical Abstract*, Table 942.

349 Each of these steps is discussed in detail, along with cost information, in the following sources. See George Tchobanoglous, Hilary Theisen, and Vigil Samuel, *Integrated Solid Waste Management—Engineering Principles and Management Issues* (New York: McGraw-Hill, 1993) for materials recovery facility costs; Gaines and Mintz, *Energy Implications of Glass-Container Recycling*, for collection, final processing, and shipment.

350 Gaines and Mintz, *Energy Implications of Glass-Container Recycling*, Section B.3.

351 A fixed charge rate was calculated to estimate the annual capital recovery factor. The fixed charge rate includes a return to investment, depreciation, taxes, insurance and other fees and is expressed as an annual percentage rate. The fixed charge rate is multiplied by the total capital investment to derive the annual expected revenue requirements for the investment.

loaded rate of $40 per hour for unionized sanitation workers[352] for collection assuming two per truck,[353] and $20 per hour for transfer. The high- and low-cost scenarios rely on the ranges of fuel use, collection rates and recovery rates used by Gaines and Mintz.

The processing costs are based on a typical materials recovery facility (MRF). Costs are differentiated by material, and overall MRF costs are allocated based on the proportion of recycled materials represented by that single material. Capital costs, equipment requirements and labor rates are detailed.[354] Energy use was derived for specific equipment.[355] Facility life was assumed to be 20 years and the costs annualized to determine the yearly return on investment. Material losses in the MRF from breakage and spoilage are accounted for in the waste-disposal step discussed below.

The final steps in the material-recovery phase are additional processing, particularly for glass, and transportation from the MRF to the manufacturing plant. Glass requires beneficiation and these costs are identified in Gaines and Mintz.[356] Steel cans used to be "de-tinned" but most now use non-tin coating materials.[357] We assume that three-quarters of the recovered material is shipped by truck and the remainder by train.

PRODUCTION COSTS

The production processes for each of these materials are discussed in detail in two ANL reports.[358] These reports describe the required material and energy inputs and mass-balances in using either all-virgin or maximum-recycled materials.[359] Our analysis interpolates between these two values to estimate the costs at various recycled-content levels.[360] Energy costs are based on the energy usage from the ANL reports multiplied by the energy prices identified above. Labor costs are estimated based on loaded rates per unit of output by SIC code.[361] Capital investment costs are developed from specific sources within each material area and are differentiated between virgin and recycled material use. The production costs are calculated for each step of the process and are adjusted for material losses in each of these steps. Costs are expressed in terms of dollars per unit of output.

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352 Loaded rate per hour = wage rate per hour × 2 with benefits and overhead.

353 While certain localities are switching to one-person pickup routes, this is true for both recycled and waste material collection. Thus, the changes in costs should be of similar magnitude between the two processes.

354 Tchobanoglous, Theisen, and Samuel, *Integrated Solid Waste Management*.

355 California Integrated Waste Management Board, *Facility Cost Model Workbook*, Version Two (Sacramento: Policy and Analysis Office, December 1994), pp. 45–60; Gaines and Mintz, *Energy Implications of Glass-Container Recycling*, Section 3.3.2 and Figure 4-2.

356 Gaines and Mintz, *Energy Implications of Glass-Container Recycling*.

357 Gaines and Stodolsky, *Mandated Recycling Rates*, Chapter 5.

358 Gaines and Stodolsky, *Mandated Recycling Rates*; Gaines and Mintz, *Energy Implications of Glass-Container Recycling*.

359 The two ANL reports do not address the long-term sustainability of using recycled materials under steady-state (or constant) conditions. Their estimates are based on a "snapshot" of a process that relies entirely on recycled materials versus all-virgin—a situation that is simply not sustainable due to the laws of entropy as well as other critical considerations discussed in this study. For this reason, these studies tend to overestimate the benefits of using recycled materials in terms of energy savings.

360 An important distinction exists between recycled *content* and a recycling *rate*. Recycled content describes the amount of recycled material contained in a product. This can be measured either as an initial input or in terms of final content after accounting for manufacturing losses (which are typically higher with recycled material leading to a lower content level). Recycling rate describes the amount of material recovered from the waste stream for reuse in the manufacturing process. While in the short-run or for particular products, recycled content can be higher than the rate, ultimately the recycled content level must be below the recycling rate to be sustainable. The constraint imposed by the rate thus limits achievable content levels.

361 Loaded labor rate = wage rate * (total labor costs / total direct wage costs). U.S. Bureau of the Census, *1991 Annual Survey of Manufacturers*.

A. Glassmaking

Glass is made from either firing sand, limestone, feldspar and soda ash or from melting cullet.[362] Even in the all-virgin material process, up to 10 percent of the input material is cullet recovered from production waste and breakage. Using cullet requires less material input (due to reduced gassing losses), lower energy input, and may extend furnace life by 10 to 30 percent.[363] The typical furnace characteristics used for this analysis were 500 tons per day, an expected life of eight years and a construction cost of $5 million.[364] Forming costs were assumed to be similar between the two types of materials.

B. Paperboard Production

Paperboard containers are produced from either kraft paper or recycled old corrugated containers (OCC).[365] The virgin process converts woodchips into chemical kraft pulp with the longest fiber material used in packaging. Virgin pulp yields are estimated to be 49 to 55 percent for long-fiber chemical kraft.[366] Recycled OCC gives yields of 65 to 75 percent.[367] Added chemicals are about 10 percent of raw material costs with chemical byproduct sales from virgin pulp production returning about $8 per ton of paper. Investment costs vary between recycled and virgin papermaking machines. A new virgin mill with a 440,000-ton-per-year capacity costs $496 million or $1,127 per ton; a recycled paper mill at 250,000 tons costs $234 million or $936 per ton—a savings of 17 percent.[368] Labor and electricity costs are based on SIC code 263.[369]

C. Steel Can Production

Steel cans are made almost exclusively from raw iron ore due to impurities in scrap steel,[370] even though recycling rates are quite high for cans.[371] However, we have assumed that the recycling process is “closed-loop” for simplicity in analyzing recycling policies because these policies are developed on this (incorrect) premise. Internal scrap recycling can reach up to one-third of production output in any case however.[372]

The ANL study details the steel-production process and the use of scrap materials, both in-plant and post-consumer.[373] Most virgin steel is produced using a basic oxygen process (BOP) that combines iron ore with coke. For scrap use, smaller electric arc furnaces (EAF) are dominant. EAF capital costs are

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362 Gaines and Stodolsky, *Mandated Recycling Rates*, Chapter 4.

363 Gaines and Stodolsky, *Mandated Recycling Rates*; telephone communication, Paul Hummel, Ball Glass Co., April 17, 1995.

364 Telephone communication, Paul Hummel.

365 Anex, *Recycling Technologies*.

366 *Pulp & Paper 1995 North American Fact Book*, p. 357.

367 Gaines and Stodolsky, *Mandated Recycling Rates*, p. 32.

368 Telephone communication, Ken Wagoner, RISI, July 1995.

369 U.S. Bureau of the Census, *1991 Annual Survey of Manufacturers*.

370 Telephone conversation, Wilson Kramer, consultant, June 12, 1995.

371 Anex, *Recycling Technologies*.

372 Gaines and Stodolsky, *Mandated Recycling Rates*, Section 5.2.

373 Gaines and Stodolsky, *Mandated Recycling Rates*, Section 5.2.

based on the average for new mills in 1994.[374] On the other hand, integrated BOP facilities are long-lived and most have fully recovered capital investments, so marginal capital costs are assumed to be zero.[375] Due to the use of coal in producing coke, the BOP process actually produces excess energy, and this analysis assumes this energy is used fully in other production processes. Labor costs for SIC 3312 are assumed to be roughly equivalent between BOP and EAF production.[376]

D. Plastics Production

The production processes for HDPE and LDPE are somewhat different from that for PET.[377] However, the basic principles remain similar for using virgin materials. Natural gas is refined and ethylene used as feedstock. Additional natural gas is used as energy input into the process. Capital, labor and electricity costs for each material are based on the industry average for SIC code 2821.[378] Annual capital costs are assumed to equal new capital expenditures on equipment for 1991. Recycled material-use costs vary by material as discussed below.

1. HDPE and LDPE Recycled Material Costs

Recycled HDPE and LDPE are generally used in non-food containers. Even so, the purity levels must be quite stringent to prevent contamination with other plastics.[379] Generally, HDPE and LDPE scrap are reground and simply remelted before being introduced into the package-making process.[380] We assume that labor costs for regrinding recycled materials are about 50 percent higher than for production of virgin plastics to reflect higher handling costs. In addition, costs for LDPE scrap appear to be about one-third higher than for HDPE due to its lower density.[381]

2. PET Recycled Material Costs

The use of recycled PET has been limited by an implicit requirement that the Food and Drug Administration issue a “letter of non-objection” for its use in food packaging.[382] Generally, recycled PET materials are used in three ways to comply with this requirement:

1. repolymerization, where the PET is essentially completely re-refined;
2. multi-layer, where the recycled material is sandwiched between virgin layers; and
3. reground into “superclean” flake, which is remelted directly with virgin materials.

While repolymerization appeared to have the most promise initially and could lead to the highest levels of recycled content, it appears to be too expensive to be used in large amounts of packaging. The multi-layered process is now being developed by the Coca-Cola Co.[383] However, this method has obvious physical limits to the recycled content level due to the required virgin sandwich material. Finally,

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374 George J. McManus, “High-voltage spending by the electric steelmakers,” *Iron Age: New Steel*, September 1993, pp. 30–36.

375 Telephone communication, Wilson Kramer.

376 U.S. Bureau of the Census, *1991 Annual Survey of Manufacturers*.

377 Gaines and Stodolsky, *Mandated Recycling Rates*, Chapter 4.

378 U.S. Bureau of the Census, *1991 Annual Survey of Manufacturers*.

379 Anex, *Recycling Technologies*.

380 Gaines and Stodolsky, *Mandated Recycling Rates*, p. 57.

381 Telephone communication, Tom Rattray, Procter and Gamble Co., July 18, 1995.

382 Jerry Powell, “The ups and downs in bottle-to-bottle plastics recycling,” *Resource Recycling*, May 1992, pp. 98-104; Alexander Volokh, *The FDA vs. Recycling: Has Food Packaging Law Gone Too Far?*, Reason Foundation policy study No. 196, October 1995.

383 Telephone conversation, Mike Mathews, Coca-Cola, July 5, 1995.

Johnson Controls has developed a “supercycle” process in which it regrinds PET scrap and then cleans the material to point where biological impurities are less than 0.5 part per billion.[384]

Our analysis is premised on regrinding of recycled scrap, but PET bottle recycling methods are in development and still quite costly. Food companies appear to be reluctant to incorporate more than 25 percent recycled content until these materials become less costly to use. Based on a regrind process, the expected yield on recycled flake is 85 percent of delivered scrap.[385] The regrind costs are assumed to be the same as for HDPE.[386]

WASTE DISPOSAL COSTS

The waste-disposal system is modeled based on previous analysis done by ANL.[387] Post-consumer waste is collected at the curbside with cost ranges similar to those for recycled material collection discussed above; capital, labor and energy costs are on a comparable basis. Both post-consumer and recycling-loss waste are collected at a transfer station before being transported to a landfill. Transfer-station costs are also estimated on a basis similar to that for a MRF.[388] Landfill costs are assumed to equal the national average of $35 per ton. Avoided costs for waste disposal are estimated for each level of recycled content use. In some areas, of course, landfill tip fees are higher than the national average used here, sometimes exceeding $100. However, these higher prices often reflect specific conditions in noncompetitive markets.

384 Telephone communication, Doug Smith, Johnson Controls, Inc., July 25, 1995.

385 Steve Apotheker, “PET recycling polishes its image,” *Resource Recycling*, January 1995, pp. 38-43.

386 Gaines and Stodolsky, *Mandated Recycling Rates*, p. 61.

387 Gaines and Mintz, *Energy Implications of Glass-Container Recycling*, Sections 3-3 and 5-2.

388 California Integrated Waste Management Board, *Facility Cost Model Workbook*, pp. 45–60.