Automobile Recycling Policy:
Findings and Recommendations

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In 1993 the Automotive Board of Governors of the World Economic Forum decided to undertake a cooperative activity focusing on the social impacts of automobiles. Two initial projects were approved — the first to develop recommendations for recycling and the second to develop a research agenda for mobility. The MIT International Motor Vehicle Program was asked to undertake these projects and report back to the Automotive Governors at their meeting in 1994.

This report focuses on recycling. As an objective neutral party, MIT has compiled a knowledge base that examines the many complex issues relating to recycling. Although this report was prepared at the request of the Automotive board of Governors, it was not prepared solely as an industry response document. Rather, it attempts to focus on the concerted actions that both industry and government should take. MIT hopes that the document can serve as the basis for forging international consensus on a rational approach to recycling policy.

This document presents the findings and recommendations of this group to the Board of Governors. In addition to these recommendations, supporting materials in the form of four appendices, tracing specific aspects of the problem of vehicle recycling and the ways in which these problems can be analyzed, are appended.

The first appendix summarizes the global status of automobile recycling today and provides a detailed economic framework and analysis of both the existing recycling infrastructure and potential new recycling technologies. The second appendix presents a systematic framework for analyzing the economic structure of the automobile recycling infrastructure and discusses appropriate policy options based upon this analysis. The third appendix discusses the potential of an emerging analytical paradigm that can integrate consideration of the environmental, technological, and economic implications of product design, life cycle analysis. A framework based upon the principles of this paradigm will be required to resolve the conflicting elements of social goals as applied to economic products. The final appendix provides in great detail the evolution of the existing automobile recycling infrastructure in the United States, showing how economic forces and technological innovations led to its development. Further, it articulates the impact of vehicle lightweighting and materials substitution on vehicle recyclability.
Overview

Spurred by initiatives throughout the world, automobile recycling is receiving increasing attention. Specific legislative initiatives in Germany and Japan are being viewed as potential policy blueprints by legislators interested in mitigating environmental ills arising not only from the disposal of automobiles in particular, but consumer durables in general. Automobiles, white goods, consumer electronics, and computers are leading candidates for recycling, in addition to the more prevalent packaging initiatives.

These efforts are taking place against the backdrop of a rising set of environmental initiatives that can be grouped under the rubric of “sustainable development.” Within this context, recycling is viewed not only as a mechanism for reducing environmental impact by reducing the amount of waste released to the environment, but also as a mechanism for reducing consumption of resources in general by reusing materials already extracted from the environment rather than relying upon virgin materials. This duality has served to make recycling a central aspect of many environmental programs.

However, recycling is an industrial process too, relying upon and constrained by established technologies, consuming resources, capital, and manpower, and producing waste. Furthermore, recycling faces unique market dynamics, given the availability of perfect substitutes in the form of established virgin materials. As a consequence, recycling industries are delicate creatures, perpetually walking a fine line between technological feasibility, economic constraints, and market demands. There are numerous examples that demonstrate this delicacy, as well as the perverse consequences of well-intentioned efforts to promote the collection and use of recyclables.

Beyond the fragility of these industries is the fact that, because of the vagaries of local markets, the relative efficacy of recycling can be dominated by regional considerations. The costs of disposal, processing, and virgin materials vary across regions, and these differences determine the economic appropriateness of recycling. As a consequence, recycling requirements imposed in one region, where they may be economically valid, have the potential to limit markets to those suppliers facing similar economic conditions while excluding suppliers whose economies cannot support the development and implementation of the necessary technologies.

The complexity of recycling places considerable burdens on policymakers wishing to influence the scope and nature of the industry. Because present recycling activities are a reflection of the existence of an economic opportunity rather than a response to a technological or environmental necessity, efforts to influence recycling must act carefully to preserve the balance between the demand for recyclables and the economics of the recycling industries. Inadequate consideration of this tension can lead to perverse consequences, where initiatives designed to increase recycling and reduce environmental damage may result in opposite effects.

Current Status Of Automobile Recycling

At the root of the question is the issue of recyclability. Although widely discussed, there is considerable confusion about its meaning. Recyclability is a characteristic that has both technological and economic implications. On the technological side, recyclability requires the existence of methods that can be
used to extract the constituent materials from an obsolete product. On the economic side, recyclability depends upon the existence of a market for these extracts. Furthermore, there must be a balance between the cost of employing the extraction technology and the quality of the extract such that the recycler has an economic incentive to undertake the recycling.

The problem of automobile recycling today reflects the nature of recyclability. With the downsizing of the automobile, the metallic fraction of the automobile has reduced overall, and the ferrous fraction within that has also reduced. While there currently is a ready market for the ferrous and non-ferrous metallic fractions, there is no demand for the other elements (largely polymers, fabrics, and glass) in the form that they emerge from the shredder. Instead, they are disposed of, usually in landfills. However, the contribution of this “automobile shredder residue” (ASR) to overall landfill burden is relatively small, rarely larger than 2%. If landfill costs are low, the costs of the disposal of this ASR is a small fraction of the cost of operating a shredder. However, if the costs of landfill are high, the shredder may not be able to cover his costs, since there are other competing sources of ferrous scrap.

Although many observers have pointed to the rising polymeric content of the automobile as the primary culprit in the decreasing recyclability of the automobile, the problem is far more complex than the automakers’ decision to employ any particular class of materials. The automobile recycling infrastructure today is composed of several competing economic agents in addition to the automaker, each with his own set of technological and economic constraints.

A complex web of market and technological interactions is currently in place to recycle and dispose of the de-registered or end-of-life vehicle (ELV). Roughly 75% of the automobile by weight is recovered and returned to the used parts market or the secondary metals market today. Increasing the recycled fraction of the automobile will not only require the development and introduction of new materials extraction and processing techniques, but also the recognition that the existing infrastructure is an economic system of considerable complexity and flexibility. While the automaker’s choice of materials impacts this system on several levels, materials selection alone cannot accommodate all the needs of the recycling infrastructure and the needs of the automobile manufacturer. Resolution of this tension will require a system-wide perspective on the problems, both technical and economic, of vehicle production and use, material recovery, and waste disposal.

**Policy Imperatives Underlying Recycling Initiatives**

In light of the current status of automobile recycling, it may be difficult to understand the rationale behind current recycling initiatives. However, when viewed against the backdrop of sustainable development, several underlying themes emerge.

First is the very real interest in increasing the rate of recycling of the automobile. In spite of the fact that 75% of the vehicle is routinely recycled today, there are pressures arising both from the public and from governments to increase this percentage. This can be viewed as an extension of a rising concern about all consumer durables, but automobiles are the most visible members of this product class.
Ancillary to this policy initiative is the desire to raise the overall level of environmental performance within the existing automobile recycling infrastructure. There are any number of apocryphal tales of suspect behavior within the current industry. Recycling initiatives can also be viewed as initiatives directed toward improving practices within the existing infrastructure, particularly with respect to environmental performance.

Second is extended producer responsibility — the idea that the producer’s environmental consciousness should extend beyond the factory walls and into a stewardship of the product throughout its lifecycle. This notion has many proponents, yet there is little knowledge of how it can be made operational within the confines of current economic and regulatory practices. Many of the current initiatives are efforts to develop such instruments.

Finally, there are considerations of product and industrial competitiveness. Environmental technology can be an important area of technological competitiveness, as the size of the markets for their environmental technologies demonstrates. Since much of this technology has been commercialized under the impetus of environmental strictures, recycling initiatives may represent a way to spur the development of new processing technologies. Alternatively, recycling initiatives can serve as a non-tariff trade barrier, restricting markets to those companies which have managed to develop products and technologies which accommodate local recycling imperatives.

This broad range of interests tends to reinforce the notion that recycling as a policy initiative is going to be a part of environmental policy for the foreseeable future. While some observers can easily demonstrate that the problem of automobile recycling is relatively small when compared with other solid waste issues and with other automobile environmental issues, recycling has become an important context within which these broader interests can be explored.

Findings

The automobile is one of the most completely recycled products in the world.

The highest consistent levels of automobile recycling have been in countries with a well-developed secondary materials recovery and reuse market and infrastructure. The automobile is actually one of the great success stories in the world of product recovery and recycling. As little as 25 years ago, the obsolete automobile was an economic and esthetic eyesore, accumulating in heaps throughout the world. However, by the mid-1970s, the automobile was referred to as one of the most recycled and recyclable of post-consumer products.

In terms of recyclability, roughly 75% of the car by weight is recovered and economically reused today. This statistic is particularly striking in two respects. First, this degree of material recovery is achieved wherever automobile recycling takes place. Second, no other product with such a large number of different materials is as highly recycled. Products which are more highly recyclable are composed of many fewer materials. For example, the aluminum beverage can is composed of two aluminum alloys (which can be mixed together) and one plastic resin coating (which can be burned without contaminating the aluminum).
However, it is the economic incentives behind recycling which have driven the development of this enterprise. Although the technology of recycling is roughly the same throughout the world, the most thorough recovery of automobiles takes place in regions where the markets for secondary materials and components are strongest and least encumbered. For example, it is estimated that well over 90% of the vehicles which are dropped from the vehicle registration rolls are actually recycled in the US (in comparison, roughly 80% of the aluminum beverage cans sold are recycled). This degree of recycling occurs in the absence of any requirement for disposal or penalty to the last user, or industry specific monitoring. Rather, it is driven by the fact that recycling of the automobile can be a very profitable business, provided the markets for recycled parts and materials operate freely.

*(See Appendix D)*

**Public awareness of the recycling history of the automobile is poor.**

The effectiveness of the existing modern automobile recycling infrastructure is not generally known among the public. Rather, the public has been traumatized by several specific images which have given the impression that automobile recycling is inadequately performed. For example, the case of automobile tires has been routinely presented as if the problems of their recycling and disposal were representative of the automobile as a whole. In fact, the problem of tire recycling is atypical of automobile recycling practice, reflecting the relatively low value placed upon the chemical commodities that can be produced from them (low grade fuel oils) and the historical aversion of the consumer market for re-manufactured tires.

In this respect, the automobile is not unique. The public’s appreciation for environmental issues has frequently been at odds with that of environmental professionals, and the public’s memory in such cases is short. For example, many people are surprised to find that today’s automobile recycling issues echo concerns that were raised (and resolved) during the late 1960’s and early 1970’s.

**Recycling is fundamentally an economic activity and, as a result, there are significant regional variations in the way recycling takes place.**

Recycling is a historically evolved set of economic practices, reflecting national and regional preferences and materials polices. Recycling is a business activity, focused on profitably extracting economically valuable products from obsolete goods. Recycling is therefore dependent upon the composition of the obsolete product, the costs of acquiring obsolete goods, the costs of employing available extraction technologies, and the market value of the products extracted.

The view of recycling as an economic enterprise helps to explain why the business of recycling proceeds differently in different regions of the world. While the product (and therefore the recyclability of the product) may be the same, the economic and market conditions underlying the recycling enterprise will vary across regions. For example, US automobile recyclers face low landfill costs (roughly $35/ton) and a strong indigenous market demand for used parts and shredded steel scrap. Alternatively, German automobile recyclers face much higher landfill costs (starting at $100/ton) and much weaker local market demand for their products. These differences influence the profitability of recycling and therefore the interest of businesses to participate in the enterprise.
However, these differences are not a function of automaker action; rather, they reflect political attitudes about the value of landfill and economic attitudes about the value of secondary materials.

*(See Appendices A & B)*

**Recyclability, a fundamental consequence of product design and technology, is the principal contribution of the automaker to the process of recycling.**

The concept of recyclability is a much narrower notion than that of recycling. Recyclability is a consequence of the attributes of a product that contribute to the economic viability of its recycling. The greater a product’s recyclability, the more economical the extraction of the valuable materials composing that product. The recyclability of the automobile is a strong function of the number and type of materials composing the vehicle and the ease with which they can be identified and isolated. These are attributes which depend upon the design of the automobile and the technologies available for secondary materials recovery.

The distinction between recycling and recyclability is a crucial one. Because recycling is an economic enterprise with many participants and differing economic objectives, the automaker cannot directly act to change the way in which vehicle recycling is undertaken. However, the recyclability of the automobile is directly under the control of the automaker, and is the aspect of the business of recycling where the automaker is best equipped to make a contribution.

*(See Appendices A, B & D)*

**Acting to achieve additional environmental objectives should be done with great care so as not to disrupt the existing economic system. Both short- and long-term economic dislocations can result from such actions.**

Secondary markets have been notoriously unstable and refractory to long-term policy interventions. The reasons for this behavior reflect the fact that secondary materials always face competition from a perfect substitute — primary (or virgin) materials. The existence of this competitor places an upper limit on secondary materials prices, limiting the ability of the secondary materials processor to redistribute the costs of policy actions directed at him. Ultimately, policy actions directed counter to prevailing economic conditions in the secondary market usually lead to the need for external supports to maintain the effected industries.

A classic example of the problems engendered by limiting the action of secondary materials markets is the problems faced by Sweden and Norway during the last automobile recycling crisis of the 1960’s. Like much of the world, Norway and Sweden faced a rising tide of abandoned automobiles with the decline in the use of open hearth steelmaking (and thus the decline in scrap steel demand) and the rise in labor costs. However, the introduction of the heavy duty shredder and the rise of electric arc steelmaking did not eliminate their problems as they did elsewhere in the world. The primary reason for this situation was the fact that these governments, in order to protect their indigenous steel industry, forbade the export of steel scrap, lowering its value and reducing the profitability of the automobile recycling enterprise. These governments were forced to
institute automobile deposit fees and recovery certificates to support their subsidy of the local steel industries.

(See Appendices A & D and their references)

Given the nature and success of existing recycling mechanisms, public policy should build upon and refine these elements, rather than attempting to create new institutions.

Highly interventionist, loop-closing policies, such as mandated recycled content or take back have had mixed successes. While there are many examples where recycling has been successful, mandated recycling has been less so. The recent German experience with their packaging programs has led to a serious restructuring of the institutions developed to carry out the principles of the 1986 Waste Management Act and a slowdown to the expansion of this effort to other product areas. The near financial ruin of the Duales System Deutschland GmbH (DSD) has been an object lesson in the economic risks inherent in imposing recycling requirements in the absence of strong market demand for recycled product.

However, the problems with the DSD are only one of the more recent examples of this principle. A more prosaic example can be found in community curbside recycling programs in the US. Here, communities have instituted programs for the collection of recyclables in the expectation that such materials would be absorbed by the existing recycling infrastructure. Instead, many such programs have overwhelmed these industries, leading not only to financial ruin of some but also to increased use of landfill space.

These examples point up the fact that recycling is a market driven activity. Because of this feature, public policy in this area should instead focus upon facilitating the actions of the market, rather than trying to direct the actions taking place within it. While businesses rely upon the market for their existence, they cannot rectify market imperfections. Rather, it is the role of the government in these cases to assure that the market operates fairly and efficiently, with as few distortions as possible.

(See Appendix B)

Recycling is one of a number of social concerns relating to the automobile. Actions to increase vehicle recyclability have significant implications for meeting other social objectives such as safety and fuel economy. A framework to help reconcile these conflicts is needed not only to help guide automaker design choice but also to frame public policy initiatives.

In the face of increasingly stringent performance requirements, automakers have worked to develop more fuel efficient vehicles while maintaining or improving vehicle performance and cost. Vehicle curb weight reduction has been the primary strategy of the automakers, leading to smaller cars using increasingly sophisticated materials. However, profitable recycling of such materials is considerably more difficult than that of the traditional ferrous materials, putting the automobile designer in a quandary: which goal should be satisfied? While the designer is equipped to balance the classical economic and engineering objectives of the firm, no tool exists which helps the firm, at any level of the organization, to articulate and resolve conflicts in the emerging social agenda.
This difficulty is compounded by the fact that these conflicts can only be resolved in a political arena. The fact that regional political forces have strong design implications for the producers of products in a global marketplace implies that both automakers and policymakers must devise mechanisms both to articulate the design implications of policy initiatives and to reconcile conflicting social and economic objectives in a politically acceptable fashion. Without such mechanisms, the ability of both the automaker and the policymaker to act effectively will be severely restricted.

(See Appendices C & D)

**Improved global recycling performance for the automobile can be accelerated through concerted actions by the world automobile industry.**

The industry can improve the effectiveness of materials use and the reduction of environmental impacts of poor disposal practices for end-of-life vehicles. Similarly, the industry must recognize that many aspects of recycling are local, national, or regional in nature and that global solutions to all dimensions of this problem do not exist.

While regional economic conditions militate against global action in the recycling enterprise, there are indications that the industry can act cooperatively to improve recyclability. Several recycling consortia have formed to perform research into new reprocessing technologies and to facilitate the implementation of standards in labeling and disassembly. Also, research and development of new materials technologies are being undertaken jointly with suppliers. Furthermore, there are cooperative ventures underway to develop useful life cycle analysis tools that can facilitate product design choices. The fact of these programs indicates that the industry can work cooperatively in these areas, although better coordination may ultimately lead to less duplication of effort.

**Policy Theme — Recycling and the Automobile Industry**

The critical point about automobile recycling policy is that the problem it addresses is not purely a problem of the automobile industry. Rather, effective recycling policies rely upon the successful confluence of action by government, automakers and suppliers, automobile consumers, automobile recyclers (dismantlers and shredders), secondary materials processors, and raw material suppliers. In fact, these requirements are shared by all consumer durables, particularly since their recycling ultimately feeds the same secondary materials markets. Actions by the automobile industry alone cannot guarantee that recyclability can be successfully increased or improved. Granted, there are some actions that can be undertaken independently, but effective improvement in recycling requires a larger strategic consideration of the technological constraints upon recyclability, the impact of actions to improve recyclability upon other automobile impacts upon the environment, upon the performance of the automobile, and upon the consumer’s willingness to pay for these changes. Furthermore, given the fact that the automobile industry is a consumer of significant fractions of the total market for many materials, the effects of dramatic action by the automobile industry will also ripple through the materials supplier industry.

Expecting the automobile industry alone to reconcile the relative importance of each of these consequences within the context of an increasingly constrained
design and manufacturing situation is likely to lead to inefficiencies in both the automobile market and in the economy in general. Such inefficiencies may prove disastrous in the increasingly competitive world automobile marketplace.

At the same time, both industry and government must work together to develop policies based upon a rational consideration of options developed from a broad knowledge base. The complexity and relative fragility of the recycling industry requires that a broad perspective be taken, recognizing the factors motivating and constraining this industry. The development of successful policies in this area requires that a systematic consideration of the interrelationships between the participants is undertaken.

**Recommendations**

**Roles For Industry**

The primary responsibility of the automotive industry in the area of vehicle recycling is to assure the highest degree and most economical levels of vehicle recyclability.

**Principles For Action:**

- Coordinate with primary suppliers, secondary processors, and other potential users of recycled automotive materials and components to maximize the overall materials utilization efficiency.
- Facilitate the transfer of information necessary to support potential extractors and users of recycled parts and materials.
- Act to support to the secondary materials infrastructure. The automobile industry has both the financial and technical resources to assist the secondary materials operators towards more effective and economic means of separation, parts recovery, and materials recycling technologies.

**Actions:**

- Develop and implement international industry standards on materials marking and on limiting the number of plastics types.
- Develop improved fasteners and other joining technologies which reduce the cost of disassembly.
- Develop design support systems, indicating the life-cycle implications of design choices.
- Remove industry-imposed barriers to the use of appropriately reconditioned and re-manufactured components in automobiles.
- Choose materials, consistent with meeting other social objectives, such as safety, fuel economy, etc., that maximize recycling. Make use of secondary materials whenever their use does not limit the performance of the vehicle nor significantly impact its economics.
- Support research and development of secondary materials and materials processing technologies. Explore technical and economic mechanisms that support all pathways for materials reuse and recycling—metals, polymers, elastomers, electronic components, and parts in general.

**Roles For Government**

The best approach for the government in the area of vehicle recycling is to assure a smoothly functioning secondary materials economy.

**Principles for Action:**

Because recycling is a market-driven enterprise, government action should be to support and refine the operation of the market, rather than to direct the avenue the markets must follow. For this reason, the government must be extremely cautious when considering the following actions:

- Closed loop recycling mandates
- Fixed recycling targets
- Management and intervention in secondary materials markets

Such command and control approaches to recycling policy run very substantial risks of making the recycling system less effective and less robust.

Government action also must consider that the automobile is only one of many durable products which ultimately enter the recycling stream. Care should be taken to assure that actions to promote recycling are coordinated across all durable products.

**Actions:**

- Monitor the operation of the recycling industry to identify barriers to effective operation and to assure that environmental and social goals are being served by the market.
- Remove market distorting subsidies and other instruments favoring virgin materials.
- Guarantee free access to the supply of used automobiles to all credible players.
- Assure the entry of used vehicles into the secondary market.
- Provide maximum flexibility to private sector players in designing a smoothly functioning recycling system. Avoid prescribing or proscribing specific technical arrangements.
- Assure the economic viability of overall automobile recycling system to the extent that the market for recovered materials in not competitive with virgin stock or other choices. The attached analysis (Appendix C) shows that it is the overall economics as well as the performance of individual tiers in the recycling system that determine the effectiveness of materials use over the long-run.
Reaching Consensus On Future Policies And Practices

Achieving global agreements on appropriate practices and policies rests on resolving differences in values and cultural preferences. Successful recycling systems transcend purely technical considerations. The present process is severely limited by lack of adequate information of the implications of future and present activities.

Actions:

- Use this report to form a consensus on international principles on recycling that can be used to guide the development of specific initiatives and regional actions. A meeting should be convened between the industry, government, and interested stakeholders to revise and agree upon the principles presented here.

- Form an international recycling forum, composed of automobile assemblers and their major suppliers. This forum should serve as a venue for participants to discuss emerging issues in vehicle recycling and to devise strategies to meet them.

- Build on the approach taken in this recycling project to establish a model for ongoing industry efforts to develop industry policy and initiatives to meet realistic social objectives.

- Develop, with both industry and government support, new analytic frameworks that systematically consider the impacts of potential industry choices and public policy on the overall economic and environmental impact of the automobile throughout its production, use and disposal.

- Develop an information program to combat the public’s poor appreciation of automobile recycling in particular and of the emerging tension between policies directed at the automobile in general. Two opportunities in this regard are:
  - Use this document to develop a consensus among the industry, government and environmental stakeholders. Revise this document in accordance with this agreement and use it to make the public aware of the ongoing policy developments and industry actions in the area of automobile recycling.
  - Target specific “high profile” recycling problems. Inform the public about the nature of these issues and explain the actions available for their resolution, presenting the technical, economic, and environmental implications of these actions.