Development Bank of Japan Research Report No. 41

Prospects and Challenges for End-of-Life Vehicle Recycling

May 2003

Economic and Industrial Research Department
Development Bank of Japan

This report was originally published in Japanese as *Chosa* No. 36 in March 2002.

Contents

Prospects and Challenges for End-of-Life Vehicle Recycling

Summary

1. The number of vehicles in Japan has increased roughly ten-fold over the past 30 years and now exceeds 70 million. The number of new vehicles sold and registered has generally increased over the same period albeit with some fluctuations related to economic climate and is currently around 6 million per year. The number of vehicles deregistered (end-of-life vehicles), calculated from the number of vehicles in Japan and the number of vehicles sold and registered, is currently around 5 million per year. As the domestic automobile market is mature with most of the demand arising from replacement needs, the annual number of vehicles becoming end-of-life vehicles is expected to remain at the current level in the mid-term.

2. Automobiles have been recycled with a relatively high recycling ratio of 75 to 80% by weight (average recycling ratio of industrial waste: about 40%), because they are mostly made of metals, which are valuable materials. However, due to changes in the industry environment in the 1990s including sharp rises in final disposal costs and falling scrap prices, the value of end-of-life vehicles as a resource has fallen, and this has led to the introduction of charging for accepting end-of-life vehicles throughout the entire flow of end-of-life vehicle trading. This development has resulted in various problems such as increased illegal dumping and inappropriate disposal.

With regard to end-of-life vehicles, the automotive and related industries have been making voluntary efforts since 1997 to improve the recycling ratio and reduce the final disposal volume. To encourage these activities, introduction of an automobile recycling law is currently being planned. The proposed law envisions a mechanism in which auto manufacturers are responsible for disposing of the automobile shredder residue (ASR), chlorofluorocarbons, and airbags and collect the disposal costs by charging a fee to all purchasers of a new vehicle, thereby achieving a recycling ratio of 95% by weight by the year 2015.

3. With the impending introduction of the automobile recycling law, various technological development efforts are being made to increase processing efficiency. These development efforts focus on 1) technological development to enhance ASR processing and 2) reducing the volume of ASR produced. The former aims to improve recycling both in terms of materials and thermal energy with given conditions of volume of ASR produced and ASR composition, and is being pursued by ASR processing companies, nonferrous metal refining companies, and engineering-oriented manufacturers. In particular, Japanese technologies for “gasification melting” ASR are ahead of those of other countries and attracting international attention. The latter area of technological development concerns reducing the volume of ASR produced by enhancing dismantling and processing, and is being pursued by automobile dismantling companies and materials manufacturers. In addition, automobile manufacturers are creating more recycling-oriented designs and using more reusable parts, which should work synergistically with efforts to improve processing technologies.

4. In Europe, an EU Directive on End-of-Life Vehicles (ELV Directive) entered into force in October 2000. The Directive focuses on 1) ensuring free-of-charge acceptance of end-of-life vehicles from their last owners, 2) setting target recycling rates, 3) regulating the use of hazardous substances, and 4) monitoring.

The Member States are now establishing domestic legislation to implement the Directive, but their approaches and challenges vary. The Netherlands had already established a pioneering recycling system based on free-of-charge acceptance of end-of-life vehicles from their last owners and rigorous monitoring before the Directive was adopted, and the fully-computerized system has been working efficiently. Therefore, the institutional effects of introducing domestic legislation to implement the ELV Directive are small

in the Netherlands, but the country has yet to establish a sound ASR processing technology to improve its recycling ratio, which is leveling off at around 86%.

In Germany, the total number of vehicles is slightly above 50 million, and the domestic market is mature. The estimated average registered life of a vehicle in Germany is about 12 years, and approximately 3.5 million vehicles (about 7% of the total stock) are deregistered annually. Before the ELV Directive, the government was trying to promote recycling of end-of-life vehicles by 1) voluntary control efforts by auto manufacturers and 2) an end-of-life vehicle ordinance that channels end-of-life vehicles to dismantling and shredding companies for processing. However, resistance among last owners to the vehicle disposal fee, coupled with steady demands for German used vehicles from Central and Eastern European countries, led to a rise in inappropriate processing/disposal through misuse of the temporary deregistration system and increased end-of-life vehicle exports, which reduced the domestic processing/disposal companies' capacity utilization factors to uneconomic levels. Therefore, the German Government is going to overhaul the existing systems as part of implementing the ELV Directive through its domestic legislation, including 1) strengthening the auto manufacturer participation system (to ensure free-of-charge acceptance of end-of-life vehicles), 2) provision of stronger incentives for manufacturers to pursue recycling-oriented design, and 3) registration system reforms. Technological challenges such as establishing sound ASR processing technology will likely become the central issue in the near future as the number of end-of-life vehicles processed domestically increases.

5. Japan's new automobile recycling framework will also be a modification of the existing one, because there is a relatively strong incentive to recover resources from automobiles compared with other products. The future path of the Japanese automobile recycling industry and those of European countries will be similar in that once the framework for recycling flow for end-of-life vehicles is established, ASR will become a significant technological challenge because of processing difficulties, even though the volume of ASR produced will be limited. Technological development is underway in many fields to make processing and disposal more efficient, and the sophisticated processing technologies that will be developed in the automobile recycling industry, which is at the heart of Japan's post-consumer waste recycling industries, will likely be applied to other post-consumer waste recycling industries, thus dramatically raising the standard of those industries. It is hoped that future efforts to design, refine, and manage new institutional arrangements and systems will facilitate these developments.

[Takako Naito (e-mail:tanaito@dbj.go.jp)]
[Keisuke Takegahara (e-mail:ketakeg@dbj.go.jp)]

I Developments Surrounding the Automobile Recycling Law and Their Background

1. Foreword

In Japan, the proposed Automobile Recycling Law is being discussed with a view to enacting the Law by 2004. End-of-life vehicle recycling in Japan has been conducted within the framework of the "End-of-Life Vehicle Recycling Initiative[1]" (a voluntary initiative by the automotive and related industries started in May 1997; see Table 1-1) and has made good progress, but the Law will stimulate greater efforts within the framework. The planned introduction of the Law is partly a response to recent changes in domestic economic conditions that have so far supported automobile recycling in Japan and new policies relating to vehicle recycling in European countries, which are important markets for Japan's automobile industry. This Chapter starts with an analysis of the domestic developments that triggered the moves to improve the automobile recycling system.

2. Background of the Introduction of the Automobile Recycling Law

2.1 Automobiles as Post-Consumer Waste

In Japan, systems for implementing recycling policies are rapidly being developed, such as the enactment in 2000 of the Basic Law for Promotion of the Formation of a Cyclical Society. With regard to "post-consumer waste" (PCW) that is by definition disposed of after being owned by a consumer, such as container and packaging materials and household appliances, the concept of "extended producer responsibility" (EPR)[2], under which the manu-

Table 1-1 Numerical Targets Defined under the End-of-Life Vehicle Recycling Initiative

	From 2002	From 2015
Newly produced vehicles	Expected recycling ratio of 90% or more	
End-of-life vehicles	Recycling ratio of 85% or more	Recycling ratio of 95% or more
Landfill disposal volume	Three-fifths of the 1996 figure or less	One-fifth of the 1996 figure or less

	By the end of 2000	By the end of 2005
Quantity of lead used	One-half of the 1996 figure or less	One-third of the 1996 figure or less

Source: Industrial Structure Council data.

[1] This is an initiative primarily aimed at (1) reducing hazardous substances, (2) reducing automobile shredder residue volume and improving the automobile recycling ratio, (3) making the existing processing and disposal flow more effective and sophisticated, (4) improving the efficiency of processing and disposal by using the market mechanism, and (5) defining the roles of the interested parties more clearly. The numerical targets are as shown in Figure 1-1.

[2] Extended Product Responsibility (EPR) is a concept that extends the definition of the term "polluter" to include upstream businesses such as manufacturers, processors, and marketers, and is defined as "an environmental policy approach that extends the producer's physical and/or economic responsibility for its products up to the post-consumption stages of their life cycle (*Extended Producer Responsibility – A Guidance Manual for Governments, 2001, OECD*). EPR policy measures include the collection of products by manufacturers and retailers after consumption, deposit refund, pre-payment of processing costs, raw material taxes, the setting of standards for the use of recyclable materials in products, product lease (whereby products are made available under contract to the consumer without transfer of ownership), and product servicization (whereby functions rather than physical products are sold to the consumer).

In Japan, this concept has been introduced through the Basic Law for Promotion of the Formation of a Cyclical Society enacted in 2000 as mentioned above. In terms of area-specific laws, institutional frameworks for post-consumer waste recycling have been established and PCW recycling systems based on the concept of EPR are being introduced under the Container and Packaging Recycling Law which fully entered into force in 2000 and the Home Appliance Recycling Law which entered into force in 2001.

facturers and distributors bear part of the responsibility to collect and recycle PCW, has been reflected in various forms and degrees depending on the type of goods.

The EPR concept of expanding the definition of the term "polluter" to effectively implement the Polluter Pays Principle (PPP), which is a basic principle in environmental protection, in the domain of PCW, has become a major trend mainly in European countries after it was first introduced in Germany in 1991 for container and packaging materials. This change is also being reflected in Japanese policies in such areas as recycling and environmental protection. Automobiles as post-consumer waste are a special category because 1) they have a large and complex structure, 2) they are expensive and have a long service life, and 3) the automobile industry has a much wider range of related industries than other consumer goods industries. As European examples presented later will show, the designing and introduction of EPR measures for automobiles are one of the most important issues in recycling policy.

However, both in Japan and overseas, discussions on developing recycling policies for end-of-life vehicles started only very recently.

This is because automobiles inherently have a high resource value (approximately 70% of an automobile by weight is steel) and thus have normally been traded as valuable goods as shown in Figure 1-1, with an average recycling ratio of 75 to 80% as shown in Figure 1-2, which is very much higher than those of other goods, even under the traditional recycling framework based on voluntary control.

2.2 Development of the Practice of Charging for Accepting End-of-Life Vehicles

A legal framework and policy measures to recycle, as PCW, end-of-life vehicles, which had been traded in the market as valuable goods, became necessary because the traditional voluntary control-based framework was inadequate, and because the significant environmental impacts of illegal dumping and inappropriate processing and disposal required Government action. Among the many causes of these problems, sharp rises in final disposal costs and falling scrap prices are the dominant ones in Japan.

In the past, shredding companies, which are located downstream in the recycling flow, used to make good profits by buying end-of-life vehicles (non-reusable components of spent vehicles) from dismantlers, shredding them, and then re-

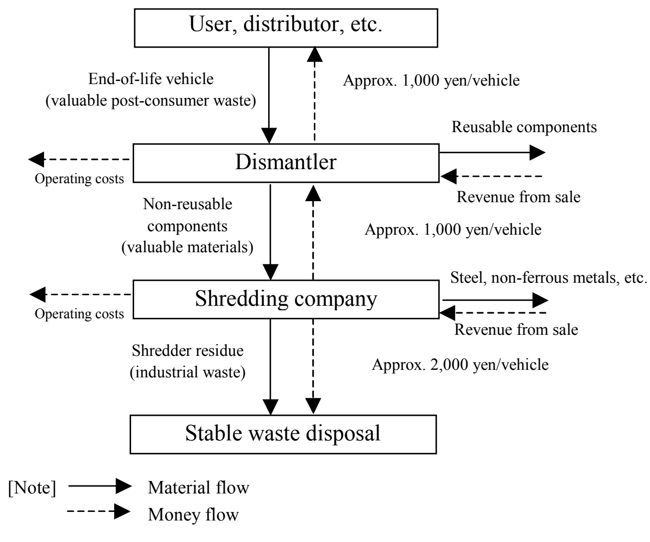


Figure 1-1 Example of Flow of End-of-Life Vehicle Disposal with Stable Shredder Residue Landfilling

Source: Togawa, "Automobile and Recycling."

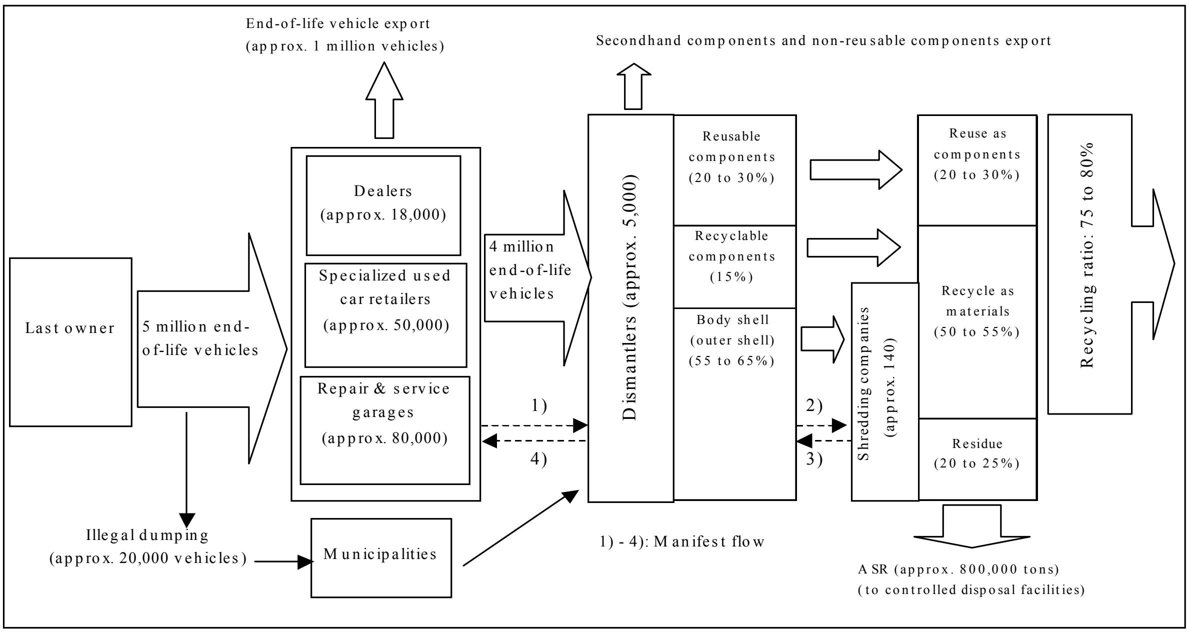


Figure 1-2 End-of-Life Vehicle Recycling Flow and Recycling Ratio

Note: ASR: Automobile Shredder Residue
Source: Industrial Structure Council data (with some modifications made by the author).

covering and selling steel and other valuable materials as scrap and disposing of the residue. However, sales revenues have decreased due to falling scrap prices and costs of disposing of residue (final disposal fees) have increased sharply, squeezing profit margins and threatening the viability of their business. As a result, shredding companies stopped buying end-of-life vehicles and started charging a vehicle disposal fee, which led to the practice of charging for accepting end-of-life vehicles throughout the end-of-life vehicle trading process.

Figure 1-3 shows the current system of end-of-life vehicle trading. Although the amount charged varies among regions as shown in Table 1-2, generally a fee is charged at each of the three stages (dismantling, shredding, and final disposal). This system has fueled illegal dumping and inappropriate processing/disposal by people who try to avoid payment.

As shown in Figure 1-4, steel scrap prices have been falling for many years and thus the value of end-of-life vehicles as a resource has fallen. This is a result of the global market stagnation due to the maturing of steel markets and associated increase in steel stocks, as well as the oversupply of steel and delays by steel producers in adjusting their output capacities. In addition, there are several market structure-related domestic factors such as 1) an increasing supply of scrap (as construction investment decreases), due to the need to demolish and rebuild steel structures which were built during the high economic growth period and now are approaching the end of their service lives and 2) increasing competition in the electric furnace industry which is a large customer. These conditions are unlikely to improve in the near term, and so steel scrap prices will not rise for the time being.

Sharp rises in final disposal fees also encouraged charging for accepting end-of-life vehicles. In the past, automobile shredder residue used to be disposed of at stable waste disposal facilities[3] which charged relatively low disposal

[3] Final disposal facilities for industrial waste with stable characteristics. Measures to prevent scattering (due to wind, etc.) and runoff/spillage of waste are required.

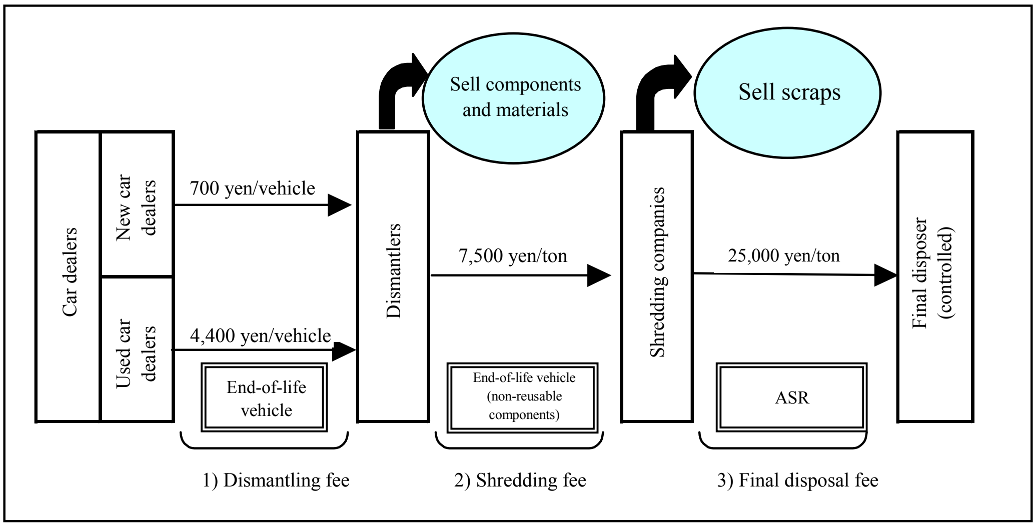


Figure 1-3 Current System of End-of-Life Vehicle Trading

Source: Environmental Agency survey.

fees for landfilling shredder residue, but the Waste Disposal Law Enforcement Rules and related rules were amended after the "Teshima Incident" in 1990 involving illegal dumping of industrial waste including shredder residue, and from April 1, 1995[4], all automobile shredder residue is required by law to be disposed of as landfill at controlled disposal facilities[5] which charge higher fees. This led to sharp rises in final disposal fees[6], which encouraged the practice of charging for accepting end-of-life vehicles. As shown in Figure 1-4, shredder unit prices have risen rapidly since 1996. The capacities of final disposal facilities are being depleted rapidly as shown in Table 1-3, and the situation is being made worse by the disinclination to construct new final disposal facilities due to the more rigorous requirements for such new facilities introduced through the 1997 amendment to the Waste Disposal Law (26 facilities per year in fiscal 1999 compared to over 100 facilities in the preceding years), as shown in Figure 1-5.

Furthermore, some operators started to limit the quantity of automobile shredder residue they will accept for such reasons as the risks of spontaneous ignition and destabilization of the ground.

These factors which hinder the existing autonomous automobile recycling mechanism based on valuable goods trading are difficult to eliminate in the short term, hence the greater effort being made to promote automobile recycling.

4 Those disposal facilities that had been landfilling automobile shredder residue as of September 26, 1994, were ordered to stop the practice by April 1, 1996.

5 This applies to industrial waste other than that processed at shielded disposal facilities (that are completely shielded from public water systems and groundwater systems by means of concrete walls and handle hazardous industrial waste having higher concentration of a hazardous substance than the specified level, including ashes, soot, sludge, and slag) and stable waste disposal facilities and general waste. To prevent the pollution of public water systems and groundwater systems due to seepage from the landfill, water barriers (such as vinyl sheet barriers on the sides and bottom of the landfill) and facilities to collect and treat seepage must be provided.

6 The national average disposal fee paid to controlled disposal facilities is approximately 20,000 yen, with the 20,000 to 24,000 yen range representing the highest proportion at 26.5%. By region, the Kanto region is the highest at 22,000 yen. With regard to disposal fees paid to stable waste disposal facilities, the national average is about 11,000 yen, with the 5,000 to 9,000 yen range representing the highest proportion at 37.4%. (Figures taken from a survey conducted by the Japan Iron and Steel Recycling Institute for the period from January to December 2000.)

Table 1-2 Results of Recent Survey on Charging for Accepting End-of-Life Vehicles

End-of-life vehicle acceptance fee (new car dealer)

	Between new car dealer and dismantler			
	Number of cases of purchase by the dismantler	Number of cases of free-of-charge acceptance	Number of cases of acceptance fee payment by the dealer	Average price (yen/vehicle)
Hokkaido region	88	12	30	-789
Tohoku region	52	3	42	-1,082
Kanto & Koshin-etsu region	69	15	56	-3,017
Chubu region	37	60	41	-840
Kinki region	68	19	3	761
Chugoku region	77	8	15	1,770
Shikoku region	17	13	30	-2,024
Kyushu region	135	5	20	-238
Total	543	135	237	-721

End-of-life vehicle acceptance fee (used car dealer)

	Between used car dealer and dismantler			
	Number of cases of purchase by the dismantler	Number of cases of free-of-charge acceptance	Number of cases of acceptance fee payment by the dealer	Average price (yen/vehicle)
Hokkaido region	8	18	44	-471
Tohoku region	3	0	91	-5,622
Kanto & Koshin-etsu region	3	0	117	-6,534
Chubu region	1	4	91	-5,771
Kinki region	0	14	59	-3,973
Chugoku region	0	20	40	-2,663
Shikoku region	2	4	84	-5,056
Kyushu region	3	35	61	-2,813
Total	20	95	587	-4,392

End-of-life vehicle (non-reusable components) acceptance fee

	Between dismantler and shredding company		Between shredding company and final disposer	
	Average fee (yen/vehicle)	Average fee (yen/ton)	Average fee (yen/vehicle)	Average fee (yen/ton)
Hokkaido region	-4,400	-7,000	-3,000	-15,000
Tohoku region	-3,300	-5,300	-5,200	-26,000
Kanto & Koshin-etsu region	-5,300	-8,400	-5,000	-25,000
Chubu region	-5,300	-8,400	-4,600	-23,000
Kinki region	-4,400	-7,000	-6,600	-33,000
Chugoku region	-4,800	-7,600	-5,200	-26,000
Shikoku region	—	—	—	—
Kyushu region	-3,900	-6,200	-4,600	-23,000
Total	-4,700	-7,500	-5,000	-25,000

Notes:
1. With regard to the end-of-life vehicles (non-reusable components) and automobile shredder residue, an acceptance fee was charged in all cases surveyed.
2. The average acceptance fees per end-of-life vehicle (non-reusable components) were calculated from the average fees per ton by assuming that the weight of one end-of-life vehicle (non-reusable components) was 630 kg.
3. The average acceptance fees per end-of-life vehicle (automobile shredder residue) were calculated from the average fees per ton by assuming that the weight of one end-of-life vehicle (automobile shredder residue) was 200 kg.

Source: Sampling survey conducted by the Ministry of the Environment in May and June 2001.

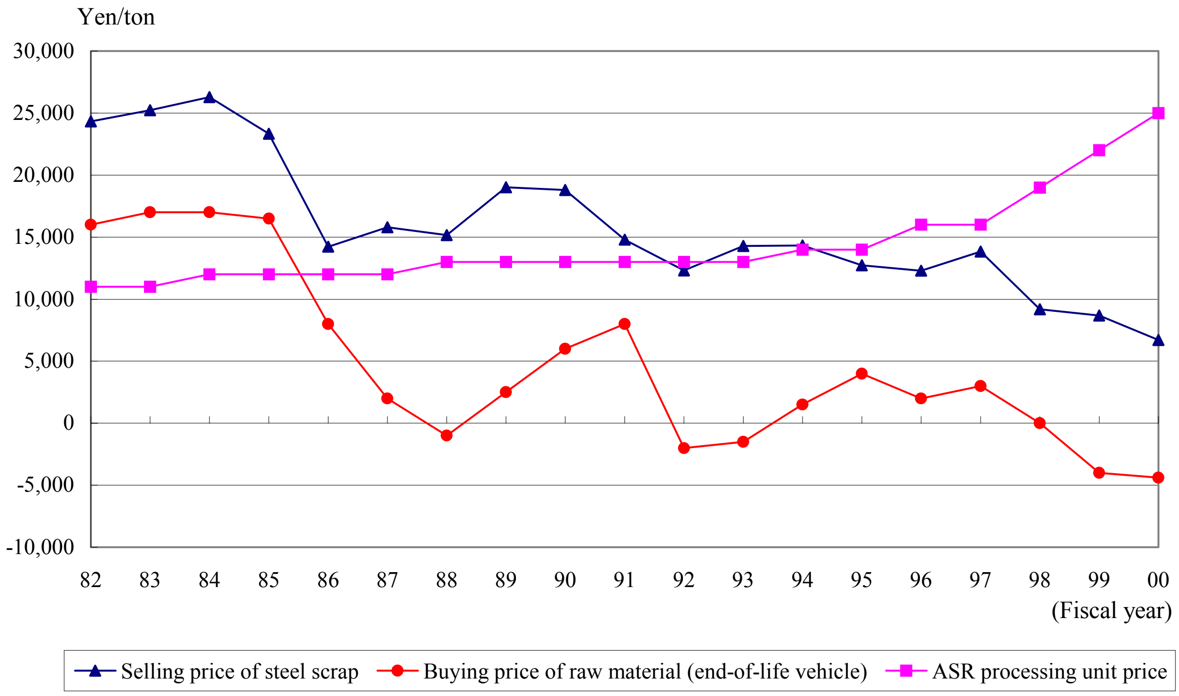


Figure 1-4 Changes in Shredding-related Unit Prices

Source: Japan Iron and Steel Recycling Institute data.

Table 1-3 Remaining Capacities of Industrial Waste Final Disposal Facilities and Time to Reach Full Capacity (As of April 1, 1999)

(Units: 10,000 tons, 10,000 m^3, year)

Region	Final disposal volume	Remaining capacity	Time remaining before full depletion of capacity
Kanto region	1,769	1,380	0.8
Kinki region	806	1,540	1.9
Japan total	5,800	19,031	3.3

Notes:
1. The Kanto region comprises Ibaraki, Tochigi, Gunma, Saitama, Chiba, Kanagawa, and Yamanashi prefectures and Metropolitan Tokyo.
   The Kinki region comprises Mie, Shiga, Kyoto, Hyogo, Nara, and Wakayama prefectures and Metropolitan Osaka.
2. The final disposal volumes for the Kanto and Kinki regions were calculated as "58,000,000 (tons) × 30.5%" and "58,000,000 (tons) × 13.9%," respectively (proportions of the volume generated in 1998).
3. The time remaining was calculated by dividing the remaining capacity by the final disposal volume (assuming a ton-m^3 conversion ratio of 1).

Source: Ministry of the Environment, "Survey on Administrative Organizations for Industrial Waste."

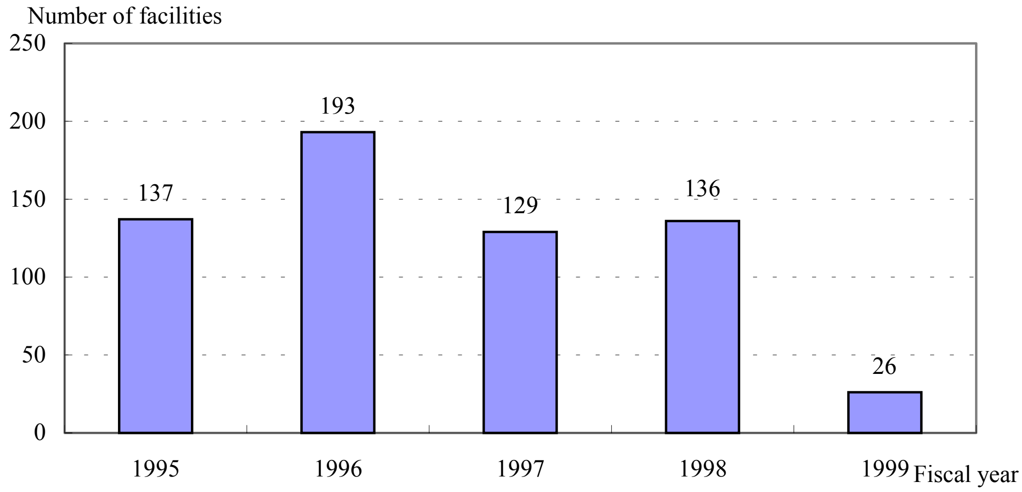


Figure 1-5 Number of Newly Constructed Final Disposal Facilities

Note: The figure for 1999 is taken from an advance report of a separate survey conducted by the Ministry of the Environment and is subject to change.
Source: Ministry of the Environment, "Survey on Administrative Organizations for Industrial Waste."

3. Overview of the Automobile Recycling Law

3.1 Intent of the Automobile Recycling Law

The proposed legal framework for automobile recycling (the Law for Recycling of End-of-Life Vehicles) aims to restore the independence of the traditional end-of-life vehicle recycling framework by addressing these problems. The content of the Law is still being discussed[7] and the details of the new framework have yet to be finalized, but the following key points have been fixed.

The purpose of the legal framework for automobile recycling is to restore the autonomy of the traditional end-of-life vehicle recycling framework, mainly through measures to eliminate or weaken the practice of charging for accepting end-of-life vehicles that has paralyzed the traditional system. Under the new framework, the automobile manufacturers and importers will be required to accept and dispose of three kinds of materials (including contracting-out to a third company), namely chlorofluorocarbons, airbags, and automobile shredder residue (ASR), and the users will be required to pay in advance the costs incurred by the automobile manufacturers and importers. The aim is to improve the end-of-life vehicle recycling ratio to 95% or more by the year 2015. ASR is the main cause of charging for accepting end-of-life vehicles by means of final disposal fees throughout the entire automobile recycling flow, but the processing and disposal of chlorofluorocarbons and airbags also contribute to the practice because they introduce additional costs into the recycling flow. The new legislation is intended to eliminate or weaken the practice by incorporating the costs of recycling these materials into the recycling flow.

3.2 Recycling of the Three Designated Materials

As sharp rises in final disposal fees have led to charging for accepting end-of-life vehicles, the most pressing task relating to the three kinds of materials is to reduce the volume of ASR going

7 The Automobile Recycling Subcommittee (the current Automobile Recycling Working Group) of the Industrial Structure Council of the Ministry of Economy, Trade, and Industry started discussions on a new automobile recycling framework, including the possibility of introducing dedicated legislation, in July 2000. These discussions led to the submission of a bill to the 2002 Ordinary Session of the Diet. The law is currently scheduled to take effect in April 2004.

to landfills. The number of vehicles becoming end-of-life vehicles is not expected to change significantly in the future as will be explained later, but the volume of ASR produced may increase, because 1) new automobiles are becoming larger and 2) the proportion of non-metal materials in the raw material composition is increasing due to the diversification of automobile component materials in a bid to improve the functions and reduce the weight of automobiles. Figure 1-6 shows changes in the raw material composition for mass-market and compact cars since 1973. As can be seen, the proportion of non-metal raw materials was about 14% in 1973, but exceeded 19% in 2001.

Figure 1-7 shows the composition of ASR. The dominance of non-metal raw materials such as resin, fiber, glass, and rubber suggests that the trend toward more sophisticated functions and the ASR problem are closely related. Much of the financial resources newly invested under the Automobile Recycling Law is expected to be used for recycling this ASR, and as will be explained in Chapter 3, this has triggered technological development.

With regard to airbags, the share of vehicles equipped with airbags as a percentage of the total number of end-of-life vehicles was still approximately 2% as of 1998, because such vehicles did not start to appear until the late 1980s in Japan, and it was only in the mid-1990s that automobile manufacturers started to provide airbags in most new mass-market cars. However, as the proportion of vehicles equipped with airbags has increased, so too the proportion of end-of-life vehicles with airbags will soon increase sharply, and the cost of processing and disposal of airbags will then start affecting automobile recycling costs significantly. With regard to processing technologies, the Japan Automobile Manufacturers Association, Inc. and Japan Auto Parts Industries Association have already developed a system[8] for collecting and disposing of undeto-

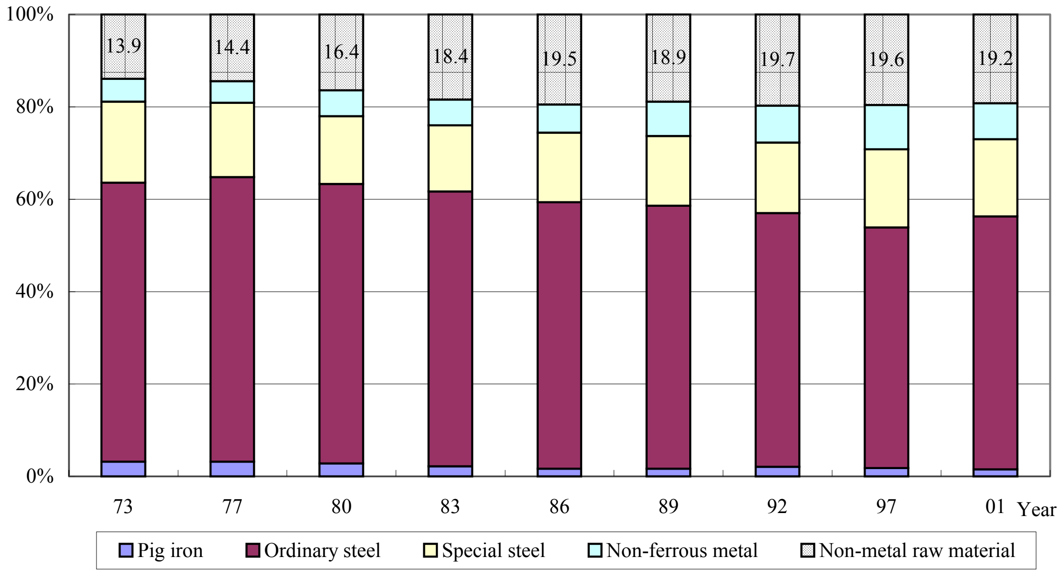


Figure 1-6 Changes in Raw Material Composition for Mass-market and Compact Cars

Source: Japan Automobile Manufacturers Association, Inc., "Japanese Automobile Industry 2001."

8 System for safely and efficiently processing and disposing of undetonated airbag inflators individually without shredding them. Under this system, companies that have registered with the Airbag Inflator Collection and Disposal Center set up in the Japan Automobile Manufacturers Association, Inc. collect airbag inflators disassembled from vehicles and take them to the two Specified Disposal Facilities (Hyogo and Kanagawa prefectures) where they are detonated and processed.

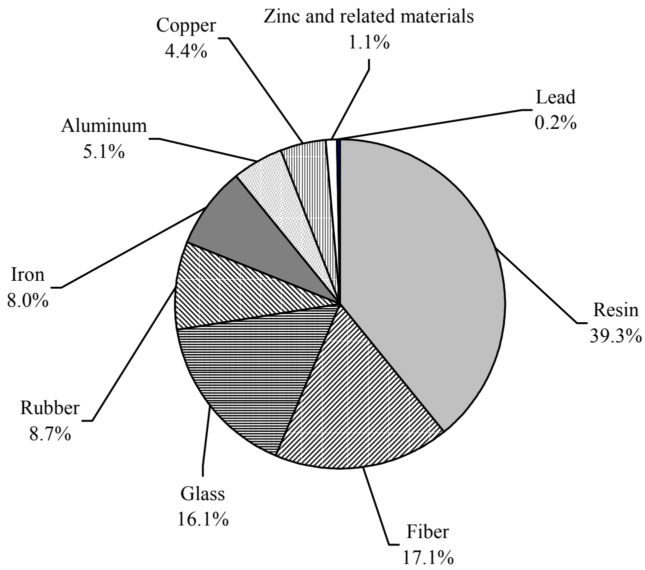


Figure 1-7 Composition of ASR (%)

Source: Survey by the Japan Automobile Manufacturers Association, Inc.

nated airbag inflators (gas generators) of end-of-life vehicles and have been conducting a two-year demonstration testing project since October 2001. Systems for distributing the test results to dismantlers and other interested parties will likely be developed in the near future.

With regard to chlorofluorocarbons (CFCs) used as coolants for automobile air conditioners, the use of CFC-12 (a designated CFC) in automobile production has already been banned completely, and HFC-134a, a substitute coolant that does not deplete the ozone layer, has been used since 1994 in response to the development of an international framework to protect the ozone layer.[9] The problem is the recovery stage. As the existing recovery system[10] is not working as quickly as intended[11] with the total number of automobiles using designated CFCs as coolants for their air conditioners still accounting for approximately 25% of the total number of vehicles in Japan, there has been strong demand for a system to ensure appropriate processing and disposal. In June 2001, the Law concerning Recovery and Destruction of Chlorofluorocarbons Used in the Designated Products (Fluorocarbons Recovery and Destruction Law), which requires chlorofluorocarbons from commercial air conditioners, refrigerators and chillers as well as from automobile air conditioners to be recovered and destroyed, was promulgated. The enforcement of the Fluorocarbons Recovery and Destruction Law started in April 2002 for commercial air

9 With regard to the designated chlorofluorocarbons that deplete the ozone layer, plans to reduce the production and consumption volumes of substances that deplete the ozone layer have already been adopted under the 1985 Vienna Convention and 1987 Montreal Protocol. In Japan, too, efforts have been made to comply with these plans, including the 1988 Law concerning the Protection of the Ozone Layer through the Control of Specified Substances and Other Measures (Ozone Layer Protection Law). Regulation of the production and importing of designated CFCs under the Ozone Layer Protection Law started in 1989, and by the end of 1995, the production of the five designated CFCs was totally banned.

10 As a voluntary effort by the automobile industry, measures such as the provision of CFC recovery systems at points-of-sale of automobile dealers were started around 1991. In 1998, a voluntary action program called the "CFC Recovery Promotion Program" to encourage the destruction of designated CFCs was started.

11 The recovery rate of refrigerant and coolant CFCs in fiscal 2000 was 15%, down 5% from the previous fiscal year.

conditioners, refrigerators and chillers, and the Law for automobile air conditioners is scheduled to be enforced from the end of October 2002. These Laws have spawned discussions on new systems and mechanisms such as a "CFC Ticket System" in which CFC Tickets would be used to require users to bear the cost of recovering and destroying CFCs from products they own until the Automobile Recycling Law is enforced in 2004.

3.3 Envisioned Processing and Disposal Framework

According to the envisioned money flow in end-of-life vehicle processing and disposal, the user, upon buying a new vehicle, would be required to pay a fee specified by the manufacturer[12], and the money (fund) would be managed by a designated body. This approach is similar to that being used in the Netherlands, which will be explained later. The approach was adopted to avoid problems regarding taxes on the collected recycling fee and the risk of loss of the money collected due to bankruptcy or dissolution of an automobile manufacturer or automobile importer. The automobile manufacturers and importers would be required to collect the three kinds of materials mentioned above, but would be allowed to file a claim for reimbursement from the fund management body.

Figure 1-8 shows the end-of-life vehicle recycling flow envisioned by the proposed Automobile Recycling Law. There are many changes to the existing framework to ensure that all or most end-of-life vehicles are channeled to the specified processing and disposal flow, including systems to issue permits to or register persons and companies that accept end-of-life vehicles, dismantlers, and shredding companies. The greatest change to the existing recycling flow is the introduction of a system in which automobile manufacturers/importers contract out the ASR recycling work to new players called "automobile shredder residue (ASR) recycling companies" by paying a contract recycling fee. The greatest impact on environmental industries of introducing the Automobile Recycling Law would be in the area of ASR processing, but as explained later, plant manufacturers, nonferrous metal refiners, and steel producers are currently developing technology in this area.

[12] The cost of processing and disposing of automobiles that have already been sold would be collected by the time of the first mandatory registration renewal inspection after the introduction of the new system, to eliminate the charging of fees at the time of disposal.

3.4 Other Related Activities and Efforts

To achieve smooth end-of-life vehicle recycling, it is important to establish a system that ensures that all or most end-of-life vehicles are channeled to the specified recycling flow. The proposed legislation itself envisions new systems to issue permits to or register persons and companies that accept end-of-life vehicles, dismantlers, etc., but the possibility of various institutional reforms to taxation and registration are also being discussed as in European countries, which will be explained in the following Chapter.

1) Establishment of an Automobile Weight Tax Refund System

For many years, associations and organizations in the automobile and related industries have been calling for the introduction of an automobile weight tax refund system[13] as a policy measure to prevent illegal dumping of end-of-life vehicles and promote end-of-life vehicle recycling. This possibility was studied in conjunction with the introduction of the new automobile recycling framework, and it was

[13] The automobile weight tax is a tax levied on all automobiles that are subject to the mandatory registration renewal inspection due to expiration of their registration and all mini-sized vehicles having an assigned automobile registration number. The owners of automobiles that have undergone and passed a mandatory registration renewal inspection, and the people who apply for an automobile registration number for their mini-sized vehicles, pay a fixed amount based on the type, weight and registration period of the vehicle or mini-sized vehicle. For example, the current automobile weight tax for a passenger vehicle for private use that weighs under 1.5 tons is 18,900 yen per year. The present system requires the tax for two years to be paid in a lump sum (tax for three years in case of an initial registration), and a person who has his or her vehicle deregistered for disposal before expiration of registration does not receive any refund for the remaining period.

Automobile Recycling Law (tentative name)·

- Advance collection of processing and disposal costs, fund management by designated bodies·
- Legal obligation of the automobile manufacturers and automobile importers to collect CFCs, air-bags, and ASR·
- Target recycling ratio of 95% or more for end-of-life vehicles by the year 2015·
- Applicable to 4-wheel passenger vehicles and 4-wheel commercial vehicles (excluding parts that can be detached from the cab & chassis section such as carriers and cargo decks)·
- Introduction of a system to register companies and persons who accepted end-of-life vehicles and recycling companies (with monitoring)

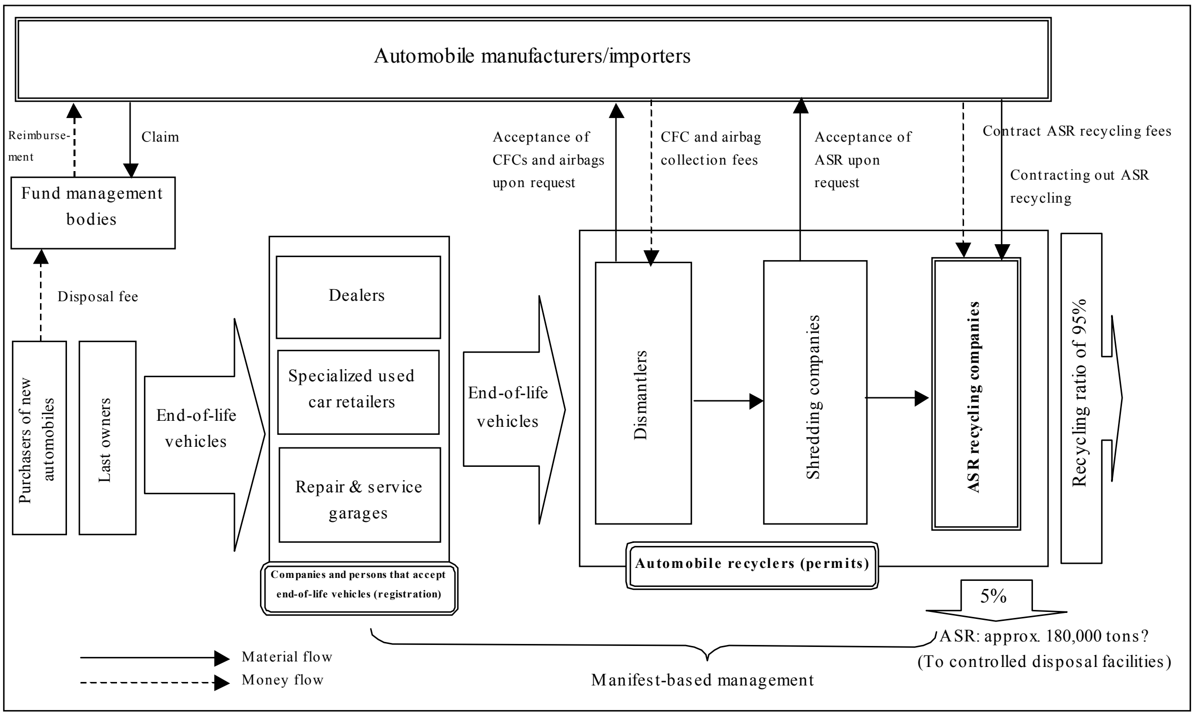


Figure 1-8 End-of-Life Vehicle Recycling Flow Envisioned by the Automobile Recycling Law

Source: Industrial Structure Council data (with modifications by the author).

decided to establish such a system as part of the planned FY 2002 amendment to the automobile taxation system. Under this automobile weight tax refund system, the last owner receives an "End-of-Life Vehicle Tracking Slip" (manifest) from the repair & service garage, etc. at the time of deregistration under the Automobile Recycling Law, and the competent Local Land Transport Office of the Ministry of Land, Infrastructure and Transport notifies the competent Tax Office after confirming the deregistration and issuance of the manifest, so the sum of the automobile weight tax corresponding to the remaining period of registration will be refunded to the last owner. The system is expected to be introduced at the time the Automobile Recycling Law comes into force.

2) Review of the Existing Automobile Deregistration System

The "Road Transport and Motor Vehicle Law (Automobile Law)" provides for an automobile registration system that allows the Local Land Transport Offices to know the names of the automobile owners in their jurisdiction areas, the areas in which the registered automobiles are mainly used, and other relevant information. The deregistration system is used to cancel this registration.

There are two types of deregistration under the present system, namely, "permanent deregistration" (deregistration pursuant to Article 15) and "temporary deregistration" (deregistration pursuant to Article 16). Permanent deregistration is made when an automobile has been destroyed or when the owner of an automobile wishes to dismantle or decommission the automobile. In this case, the competent Local Land Transport Office can confirm the fact that the automobile has been disposed of and how, because the owner is required to submit a certificate of dismantlement to it. Temporary deregistration is made when the owner of an automobile wishes to abandon the ownership of the automobile. Because temporary deregistration does not require the submission of a certificate of final disposal and there is no fixed time limit, the competent Local Land Transport Office cannot know whether a temporarily deregistered automobile has been dismantled, exported or re-entered use as a used vehicle. The annual number of temporary deregistrations is currently about 5 million, which is much higher than that of permanent deregistrations (approximately 200,000), with most of the dismantled vehicles and used vehicles exported to overseas after deregistration using the temporary deregistration system. There have been demands for revision of the present deregistration system, as in the case of Germany that will be explained later, in view of the need for a monitoring system after introducing the new automobile recycling framework. Currently the present deregistration system is being reviewed to make it work in combination with the Automobile Recycling Law to prevent illegal dumping of automobiles and promote automobile recycling. With regard to permanent deregistration, a new system is being discussed that would allow the Local Land Transport Offices to complete the registration of automobiles after confirming that they have been dismantled in accordance with the automobile dismantling scheme of the Automobile Recycling Law by requiring the last owner to submit, at the time of deregistration, the "End-of-Life Vehicle Tracking Slip" (manifest) he or she received from the repair & service garage, etc. under the Automobile Recycling Law. With regard to temporary deregistration, a system will be introduced in which automobile owners are required to notify the competent Local Land Transport Office when they have abandoned ownership of their automobiles and all temporarily deregistered automobiles are required to be reregistered, dismantled, or exported within a specified time in accordance with specified procedures.

In addition, discussions are being held to change the present system for mini-sized vehicles, which is based on reporting and inspection instead of registration, to one that is linked to the Automobile Recycling Law as in the case of mass-market and compact cars, by utilizing the system requiring owners to return their registration certificates upon expiration.

4. Impacts of End-of-Life Vehicle Recycling

What will be the impacts of shifting to the new framework based on the above-mentioned legal system? The number of vehicles in Japan has increased roughly ten-fold over the past 30 years and exceeded 70 million at the end of 2000, as shown in Figure 1-9. The number of new vehicles (passenger and freight vehicles) sold and registered has generally increased over the same period albeit with some fluctuations related to economic climate and is currently around 6 million per year (approximately 10% of the total number of vehicles in Japan), as shown in Figure 1-10. The number of vehicles deregistered (end-of-life vehicles[14]), calculated from the number of vehicles in Japan and the number of vehicles sold and registered, is currently around 5 million per year, as shown in Figure 1-11.

The domestic automobile market is maturing as shown by the very low rate of increase in the number of vehicles in Japan in Figure 1-9 and the high automobile ownership rate (pas senger vehicles) of 85% (as of the end of Feb ruary, 2001) and the high average number of automobiles owned by Japanese households

14 [Number of end-of-life vehicles] = [Total number of vehicles in Japan in the previous fiscal year] + [Number of vehicles sold in the current fiscal year] – [Total number of vehicles in Japan at the end of the current fiscal year]

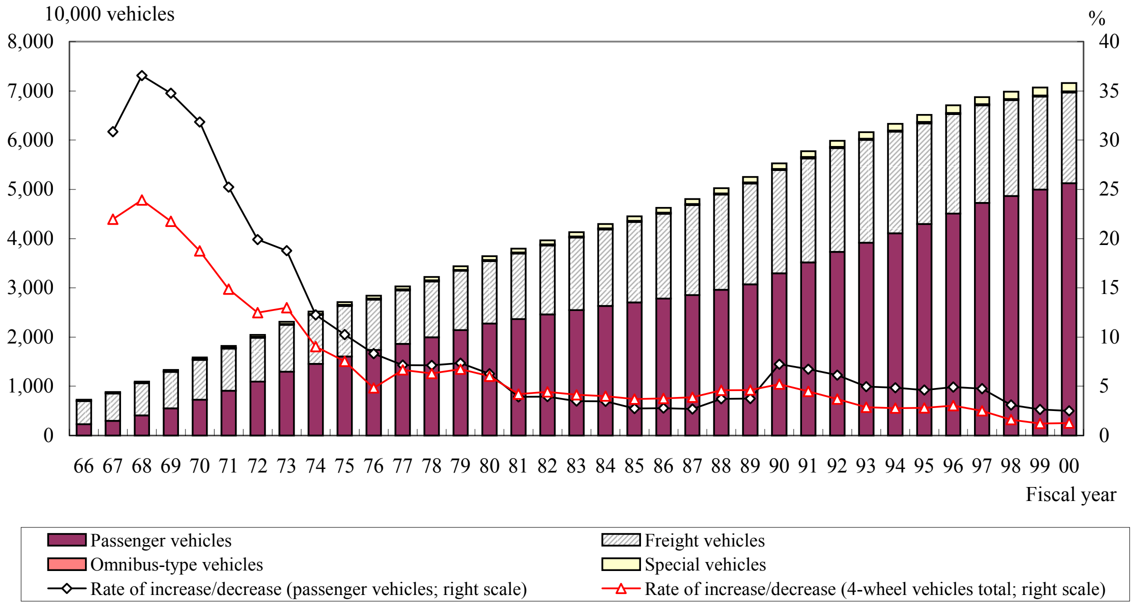


Figure 1-9 Changes in Number of Automobiles in Japan and Rates of Increase/Decrease

Source: Automobile Inspection and Registration Association, "Changes in the Number of Automobiles in Japan (FY 2000 Edition)."

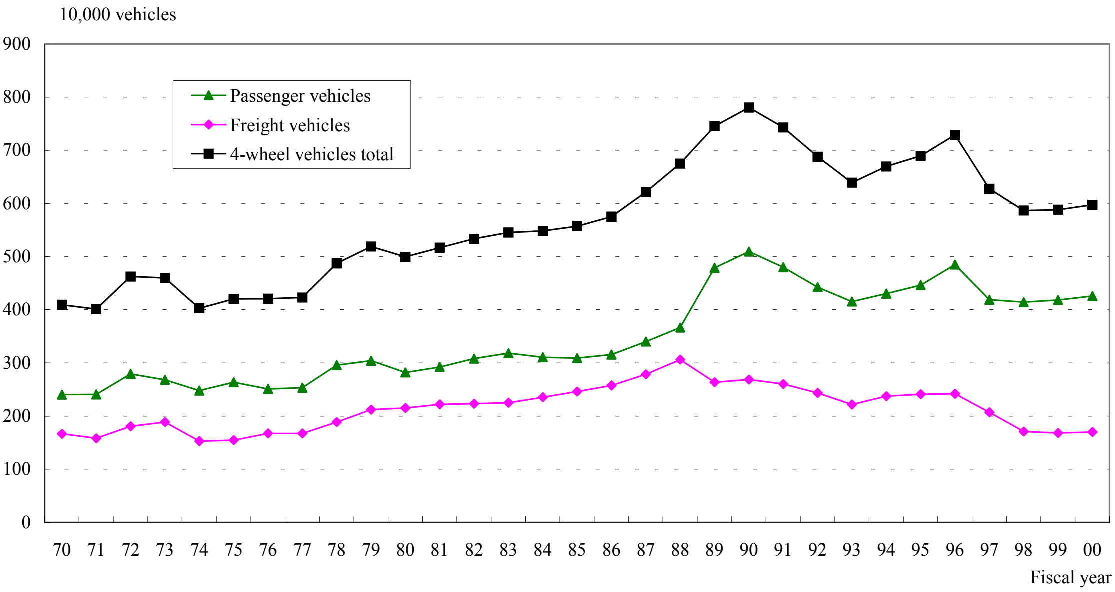


Figure 1-10 Changes in Number of Vehicles Sold and Registered (Passenger and Freight Vehicles)

Source: Data from Japan Automobile Dealers Association and Japan Mini Vehicles

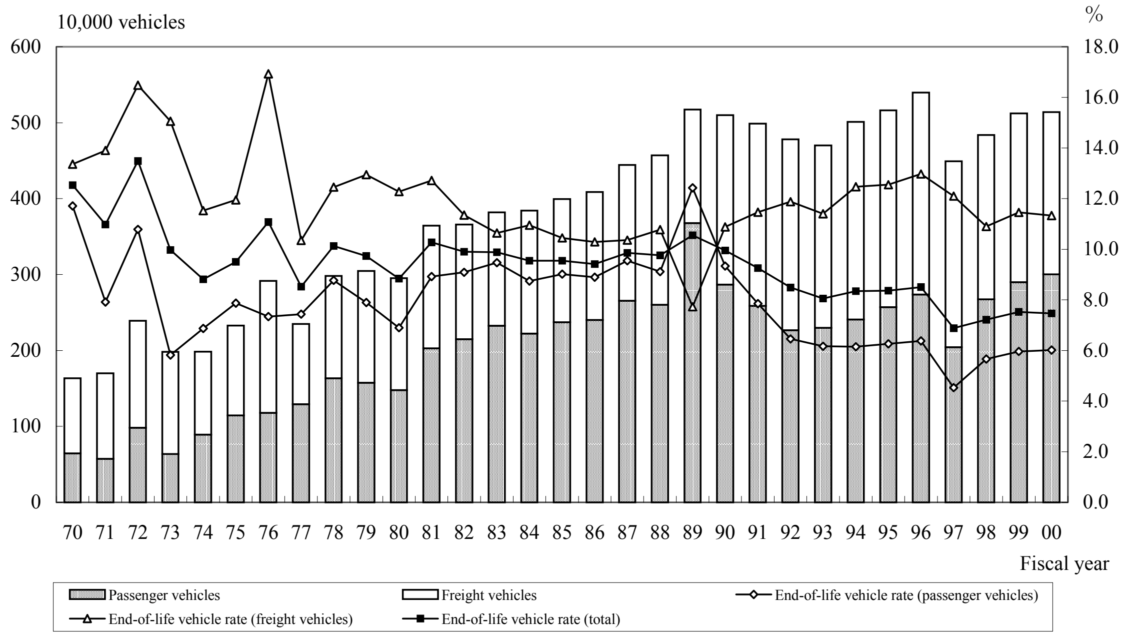


Figure 1-11 Changes in Number of End-of-Life Vehicles and End-of-Life Vehicle Rates (Passenger and Freight Vehicles)

Source: Automobile Inspection and Registration Association, "Changes in the Number of Automobiles in Japan (FY 2000 Edition)."

(130 automobiles per 100 households) shown in Figure 1-12. As automobile demand is expected to continue to be driven mainly by replacement needs, the annual number of vehicles becoming end-of-life vehicles, as calculated from the number of vehicles in Japan and the number of vehicles sold and registered, will likely remain at the current level in the mid-term. The volume of ASR generated from these end-of-life vehicles is estimated to be about 800,000 tons per year, which is equivalent to about 60% of the total volume of the various types of shredder residue.[15] Currently almost all of this ASR is being disposed of by landfilling.

The Automobile Recycling Law may have many different kinds of impact depending on how the term "impact" is defined, but we first consider the simplest impact based on the amount of newly introduced funds. If we assume that 4 million end-of-life vehicles out of the 5 million are disposed of domestically and a disposal fund of 20,000 yen per automobile enters the automobile recycling framework, then 80 billion yen (4,000,000 vehicles × 20,000 yen) in total will flow annually into the existing processes including dismantling, shredding, and used parts trading and will be used for recycling the designated three kinds of materials.

The amount itself may not seem to have a strong impact, especially as the recycling rates of these materials are already high, but the money should result in huge improvements, such as a reduction in the volume of ASR going to final disposal facilities, progress in recycling design, and evolution of waste processing and disposal facilities driven by new ASR processing technologies.

15 The shares of the numbers of installed shredders used for end-of-life vehicles, spent household appliances, end-of-life vending machines, and other end-of-life products as percentages of the total number of installed shredders in Japan are 60%, 20%, 10%, and 10%, respectively.

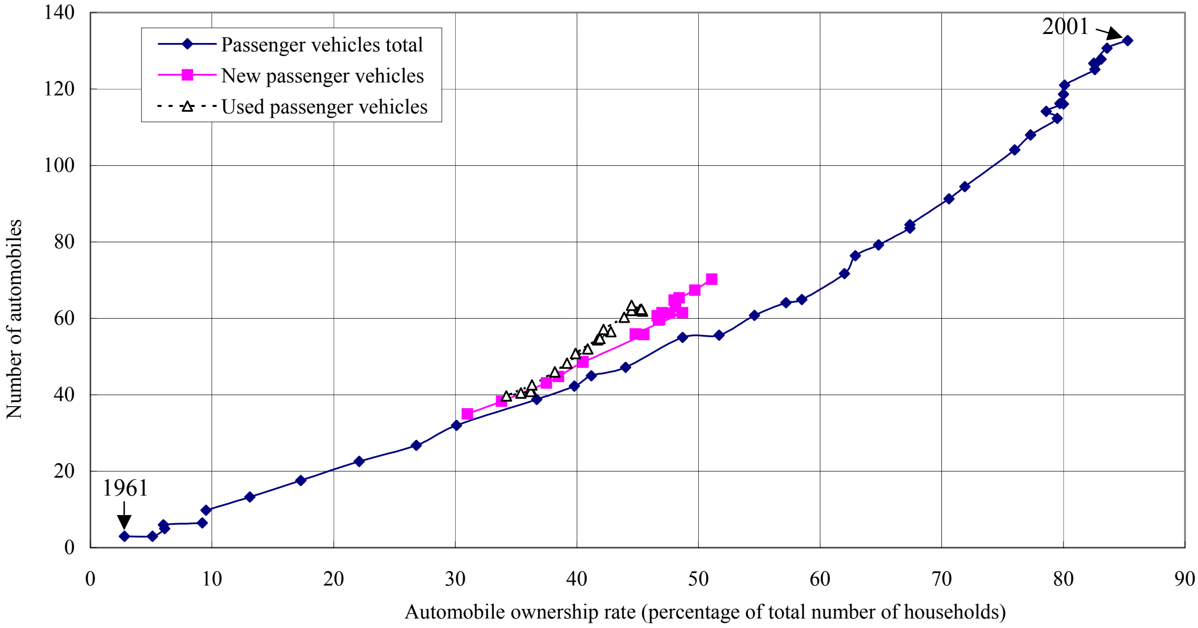


Figure 1-12 Changes in Automobile Ownership Rate (Passenger Vehicles) and Number of Automobiles Owned by Japanese Households (1961 - 2001)

Notes: 1. The number of automobiles owned for 1966 is not shown due to lack of data.
2. The numbers of new and used passenger vehicles are shown separately only for 1983 onward.

Source: Prepared by the Development Bank of Japan from "Household Spending Trends," Economic Planning Agency (Cabinet Office of the Government of Japan).

II Trends in End-of-Life Vehicle Recycling in European Countries

1. Overview of the ELV Directive

Now let us take a look at major overseas trends in end-of-life vehicle recycling. As mentioned earlier, moves to improve national recycling frameworks for post-consumer waste (PCW) through the introduction of the concept of extended producer responsibility (EPR) have been growing in Germany and other European countries, leading to EU-level policies that transcend national boundaries.

The EU's environmental policies have been strengthened gradually since the adoption of the 1987 Single European Act (SEA) that introduced environmental provisions into the EC Treaty of that time, and today the Member States are required to consider the level of environmental protection needed for sustainable development in implementing all common policies of the EU. However, with regard to laws to implement such policies in environment-related areas, "Directives" that stipulate objectives only and leave the implementation to domestic laws of the Member States are typically used rather than "Regulations[1]" that have general binding power, because it is very difficult to coordinate the interests of all parties in such areas. This is also true in end-of-life vehicle recycling, where the EU Directive on End-of-Life Vehicles (Directive 2000/53/EC on End-of-life Vehicles) was adopted by the European Parliament in September 2000 and entered into force in October 2000. The Member States are required to implement the Directive through their domestic laws in accordance with the provisions of the Directive within 18 months, that is, by April 2002.

Appropriate processing and disposal of end-of-life vehicles to reduce the volume and environmental impacts of waste generated from end-of-life vehicles has been perceived for some time by Member States of the EU as a common EU task, and a 1990 European Council Decision designated end-of-life vehicles as a category of waste that must be disposed of based on a unified EU standard. To turn this into law, the ELV Directive was announced by the European Committee in 1997 as a Proposal for a Directive on End-of-life Vehicles. It has been modified and refined into the ELV Directive in its present form through many discussions. Table 2-1 outlines the Directive, which comprises four major elements, namely, 1) ensuring free-of-charge acceptance of end-of-life vehicles from their last owners, 2) setting target recycling rates, 3) regulating the use of hazardous substances, and 4) developing a monitoring system.

Because the ELV Directive is intended to be implemented through domestic legislation of the Member States, it merely presents general objectives to be achieved to ensure appropriate disposal of end-of-life vehicles. However, the Directive will likely have significant influences on Japan's future policy decisions because it represents the future direction of the convergence of European countries' policies that has just started.

[1] The laws and rules used in the EU to enforce its policies are divided into four main types according to the strength of their binding power and other criteria. The first of these is "Regulations," which precede domestic laws and are implemented directly in all Member States. The second is "Directives," which are binding only with respect to the "objectives" to be achieved and leave the approaches and methods to achieve the objectives to the discretion of Member States' national agencies. When a Directive is adopted, the Member States have to amend or establish domestic laws and administrative rules in accordance with the Directive, and the Directive becomes effective only after the relevant domestic laws have been put in place. The third is "Decisions," which apply to one or more specific Member States, individuals, or organizations and therefore can be regarded as specific and individual administrative measures rather than general laws or rules. The fourth is "Recommendations and Opinions," which are legally non-binding and can be regarded as an expression of opinions by the European Council or European Committee.

Table 2-1 Outline of the EU Directive on ELV

Item	Content
(1) Free-of-charge acceptance of ELVs (Articles 5 and 12)	○ The Member States shall take the necessary measures to ensure that vehicles are delivered to authorized processing/disposal facilities without any cost to the last owner and that the producer bears all or a significant part of the collection, processing and/or disposal costs. This shall apply to all vehicles put on the market between July 1, 2002 and December 31, 2006, and on and after January 1, 2007, shall apply to all ELVs(*).
(2) Recycling rate (achievable rate and actual rate) (Article 7)	○ Achievable recycling rate The EU Directive on Vehicle Type Approval (70/156/EEC) will be amended by the end of fiscal 2001 and all automobiles put on the market will be subjected to type approval from the third year after the amendment. Achievable recycling rate: 95% or more (energy collection: 10% or less) ○ Actual recycling rate ・ Vehicles that become ELVs from January 2006: The figure in [ ] is that for vehicles registered in and before January 1980. Actual recycling rate: 85% [75%] or more (energy collection: 5% or less) ・ Vehicles that become ELVs from January 2015 Actual recycling rate: 95% or more (energy collection: 10% or less)
(3) Substances contained in new-type vehicles that cause an environmental impact	○ In principle, the use of lead, mercury, cadmium, and hexavalent chromium will be banned for all automobiles put on the market from July 2003 (**).
(4) Pre-dismantling for ELV processing/disposal (Article 6)	○ The Member States shall ensure that all processing/disposal is done such that ELVs do not cause pollution. ○ All treatment/disposal facilities are required to obtain permission from or register with the competent authority. ○ Removal of catalysts, glass parts, etc. to facilitate recycling
(5) ELV collection network (Articles 5 and 12)	○ The Member States shall take measures to ensure that business entities operating based on economic principles (***) establish systems for the collection, processing, and disposal of ELVs and used components. ○ All vehicles put on the market between July 1, 2002 and December 31, 2006 (and on and after January 1, 2007, all ELVs) must be sent to authorized processing/disposal facilities. ○ The Member States shall establish a system that requires the last owner to present a certificate of dismantlement as a prerequisite for ELV deregistration.
(6) Reporting and information disclosure	○ The Member States shall submit every three years a report about the domestic implementation of the Directive to the European Committee. ○ The Member States shall require, as appropriate, the relevant business entities to disclose information on the following: ・ Designs of their vehicle or vehicles and their components that concern recoverability and recyclability. ・ Environmentally safe processing of ELVs, especially with respect to the dismantling of ELVs and the removal of all liquids. ・ Development and optimization of methods to reuse, recycle, and recover ELVs and their components. ・ Progress status of the reduction of the volume of the disposed waste through recovery and recycling and the progress status toward the targets for improved recovery and recycling.
(7) Implementation of the EU Directive (Article 10)	○ The Member States shall put into effect, within 18 months of the Directive entering into force, the necessary domestic laws, regulations, and administrative rules to comply with the Directive.

* ELVs: End-of-life vehicles
** However, certain items are exempted from this under the Annex.
*** Retailers, ELV collection companies, insurance companies, dismantlers, shredding companies, recyclers, etc.
Source: Directive 2000/53/EC on End-of-life Vehicles.

1) Ensuring Free-of-Charge Acceptance of End-of-Life Vehicles from Their Last Owners

The ELV Directive stipulates that "the EU Member States shall take the necessary measures to ensure that end-of-life vehicles are accepted by authorized processing/disposal facilities without any cost to the last owner and that the producer bears all or a significant part of the collection, processing and/or disposal costs (Article 5)," requiring the Member States to develop a system that allows the last owners to have their end-of-life vehicles accepted by processing/disposal facilities without paying any processing/disposal fee. The Article also provides for the extended producer responsibility for the recycling of automobiles as PCW, by requiring the producer[2] to bear an appropriate share of the costs to process and/or dispose of end-of-life vehicles. This applies to "all vehicles[3] put on the market between July 1, 2002 and December 31, 2006, and on and after January 1, 2007, to all end-of-life vehicles (Article 12)."

2) Setting Target Recycling Rates

With regard to numerical recycling rate targets, a proposal to amend the EU Directive on Vehicle Type Approval (70/156/EEC) was adopted in October 2001 by the European Committee, and it is now required under the ELV Directive to achieve a recycling (reuse[4], recycling[5], and recovery[6]) rate of 95% or more by weight for all vehicles put on the market from the third year after the introduction of the new type approval system, on condition that energy collection (recovery) must be 10% or less (Article 7, Paragraph 4).

With regard to recycling rate targets for the vehicles that have already been sold, it is required under the ELV Directive to achieve a recycling rate of 85% or more (with energy collection accounting for 5%) for vehicles that become end-of-life vehicles from January 2006 and 95% or more (with energy collection accounting for 10%) for vehicles that become end-of-life vehicles from January 2015 (Article 7, Paragraph 2).

3) Regulating the Use of Hazardous Substances

The Member States must ensure that in principle, the materials and components of all vehicles put on the market from July 2003 do not contain any lead, mercury, cadmium, or hexavalent chromium (Article 4).

4) Development of Monitoring System

The ELV Directive requires the Member States to introduce a system under which the competent authority issues permits to or registers processing/disposal facilities (Article 6) and a system which requires the last owner to present a certificate of dismantlement as a prerequisite for end-of-life vehicle deregistration so that all or most end-of-life vehicles are channeled to such authorized processing/disposal facilities (Article 5).

As the Member States are to submit a report to the European Committee every three years on the domestic implementation of the Directive, they are allowed to require the parties concerned to disclose the information they need to prepare the report, including designs of automobiles and their components, environmental impacts associated with and waste generated from the recycling process, and recycling rates (Article 9). The purpose of these provisions is to ensure that systems for appropriate processing and disposal of ELVs are developed

---

2 The term "producer" refers to the relevant automobile manufacturer or the relevant professional automobile importer that imports vehicles to an EU Member State (Article 2, ELV Directive).

3 The term "vehicles" refers to passenger vehicles that accommodate 8 persons or less, commercial motor vehicles weighing less than 3.5 tons, and 3-wheel motor vehicles excluding light motor tricycles (Article 2, ELV Directive).

4 The term "reuse" refers to the use of a component of an end-of-life vehicle for the same purpose as that which it is originally intended for (Article 2, ELV Directive).

5 The term "recycling" refers to the reprocessing of waste in a production process to use it for the originally intended purpose or another purpose other than energy recovery. Energy recovery means the use of combustible waste as a medium to generate energy through direct incineration (including direct incineration with other waste) (Article 2, ELV Directive).

6 The term "recovery" refers to any one of the operations listed in Annex IIB to Directive 75/442/EEC, as applicable (Article 2, ELV Directive). These include the use as a medium to generate energy such as fuels, recycling through dissolution, and recycling as an organic substance.

and an implementation monitoring mechanism is put in place to secure their effectiveness.

The EU Member States will have to quickly develop domestic laws for end-of-life vehicle processing and disposal that incorporate these elements. Let us now take a look at the cases of the Netherlands and Germany, which have been pursuing their own end-of-life vehicle recycling policies since before the ELV Directive, focusing on the recent developments, current situations and the impacts of the ELV Directive in these countries.

2. End-of-Life Vehicle Recycling in The Netherlands and the ELV Directive

2.1 The Netherlands' End-of-Life Vehicle Recycling System

The Netherlands has been regarded as a model country in end-of-life vehicle recycling, because the country has been successfully operating an end-of-life vehicle recycling framework based on such systems as free-of-charge acceptance of end-of-life vehicles from their last owners and dismantlement certificate-based monitoring since before the ELV Directive. Indeed, the ELV Directive appears to be modeled on the Dutch framework in many aspects. It should be noted, however, that the country had a higher degree of freedom in that it has only one domestic automobile manufacturer[7] and thus the introduction of an extended producer responsibility system for end-of-life vehicles did not produce a strong impact on domestic employment, etc.

The Netherlands has traditionally adopted rigorous policy measures for waste landfilling and water pollution prevention, because the country's small land area and low elevation make it more prone to problems associated with waste landfilling and water pollution. However, end-of-life vehicles did not start attracting attention as a policy challenge in the country until the early 1990s. This is presumably because end-of-life vehicles had been traded and disposed of rather successfully as valuable goods in the country based on the market mechanism up to a certain point of time as in the case of Japan. The Dutch government set the goal of achieving an 86% end-of-life vehicle recycling rate by 2000 in its action program announced in 1992, and a government-approved voluntary program by the country's automobile-related industries was initiated to achieve the target. In 1993, Auto Recycling Nederland BV (ARN) was established as a company fully owned by the Auto and Recycling Foundation (ARF) which had been founded by the five automobile-related associations[8] in the Netherlands, and since 1995, the development of the country's automobile recycling framework has been led by ARN.

2.2 Overview of The Netherlands' Automobile Recycling Framework

Figure 2-1 outlines the Netherlands' automobile recycling framework. The country has adopted a system to pre-collect appropriate sums in the form of a processing and disposal fee within the framework of the agreement with automobile manufacturers and importers that entered into force on January 1, 1995. The fee is paid by automobile manufacturers and importers when they sell a new automobile. The ARN was established as the body to 1) manage the money collected, 2) pay "waste disposal premiums" to dismantlers, collection companies, and recyclers when the collection of materials or components does not justify the cost, and 3) be responsible to the national government for ensuring a recycling rate of 86% or more by weight.[9] The 86% target is to be raised to 95% by the year 2015.

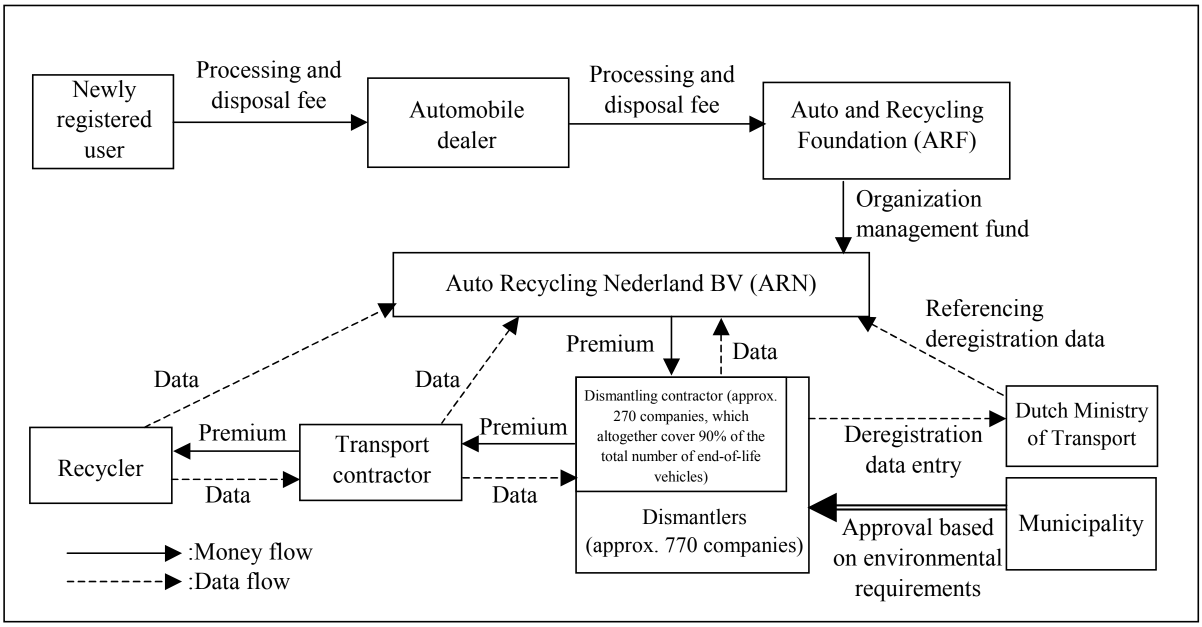
As shown in Figure 2-1, ARN forms a contract-based network with dismantlers that have satisfied the environmental requirements set by the national government and recyclers and transporters that have satisfied the requirements

---

7 For passenger vehicles, Netherlands Car (a company jointly established by the government of the Netherlands, Volvo, and Mitsubishi Motors) is the only auto manufacturer in the country.

8 The five automobile-related associations are: STIBA (dismantlers), RAI (automobile manufacturers and importers), BOVAG (dealers and repair & service garages), FOCWA (post-accident vehicle repairers), and SVN (shredding companies). The SVN does not exist at present.

9 According to the 1997 annual report of ARN, ARN had already achieved the 86% target before that year.



Voluntary control activities by automobile-related industries (ARN, four related economic organizations; since 1995)

- Free-of-charge collection from last owners
- Payment of premium and a rigorous monitoring system fully linked with a processing/disposal database and the automobile registration system
- Emphasis on quality control on a material-by-material basis in the dismantling process

Figure 2-1 The Netherlands' End-of-Life Vehicle Recycling Framework

Sources: Prepared by the Development Bank of Japan from data published and publications issued by the Ministry of Economy, Trade, and Industry of Japan and ARN and other data.

set by ARN, and distributes money appropriately within the network using the pooled fund. ARN specifies the materials and components to be dismantled and/or recycled, determines the amount of premium for each operation (work unit) based on the amount of work required to dismantle, collect, and/or recycle the material/components in question, and pays premiums to dismantlers and collection and recycling companies as necessary. The amount of premium for each operation is determined in advance based on the time required for the operation and other factors, and all relevant data is managed by a computerized system. The country has thus successfully developed a processing and disposal system controlled by ARN.

2.3 Background of The Netherlands' Success

Automobile recycling in the Netherlands has been changed dramatically by the ARN framework: the number of business entities in the country with a license to accept end-of-life vehicles was 907 before the introduction of the framework, and as of the end of 1997, 207 out of the 907 business entities had joined the ARN network and 87.6% of end-of-life vehicles in the country were being processed and disposed of within the ARN network.

The approach of developing a sophisticated recycling flow scheme and implementing measures to ensure that almost all end-of-life vehicles are channeled to the recycling flow was possible because 1) there was almost no incentive to send end-of-life vehicles to an inappropriate processing and/or disposal system thanks to pre-collection of the recycling cost upon sale of new automobiles and so no cost to the owner at the time of disposal, and 2) the success of the special monitoring system. This system is virtually the only successful example in the EU.

Table 2-2 summarizes the monitoring system. With respect to end-of-life vehicle flow, the system does not have a loophole like the one in the German system (which will be explained later); under the Dutch system the only choices for the last owner are either to process and dispose of the deregistered automobile appropriately in exchange for a certificate of recycling, or to register and export it with the specified duty document attached. The last owner is not relieved of the responsibility to pay the automobile tax unless the original of either document is presented (Table 2-3). It is also worth noting that the monitoring system is reinforced by the computerized database of the above-mentioned information that allows the interested parties to obtain the latest information as necessary.

In terms of material flow, ARN uses a

Table 2-2 Administrative Procedures Used for the Netherlands' Monitoring System

Procedure	Description
Newly purchased vehicle registration	The processing and disposal fee is collected and ARN is notified of the vehicle identification number (VIN) of the newly registered vehicle.
Acceptance of end-of-life vehicle by dismantler	The accepted end-of-life vehicle is directly deregistered on-line from the register of the Registration Office (RDW) of the government.
Domestic automobile trading	The previous owner is required to report the name and address of the purchaser and other relevant information to RDW. If RDW cannot identify the purchaser who is responsible for paying the automobile tax, the previous owner is held responsible.
Used automobile export	All exports are tracked using the export document. The last owner is not relieved of the responsibility to pay the automobile tax unless the original of the document is submitted to RDW. RDW provides ARN with all the information on the automobile exported (therefore, unregistered export is impossible).
Temporary deregistration	The responsibility to pay the automobile tax arises automatically three months after the date of temporary deregistration (thereby preventing used car trading from hindering monitoring).

Source: Environmental Agency of the Federal Republic of Germany, "Anforderung an das Monitoring im Rahmen der Verwertung langlebiger, technisch komplexer Produkte am Beispiel des Altautos."

Table 2-3 Deregistration Options in The Netherlands

Deregistration option	Framework/organization	Result
Recycling in accordance with the laws	Voluntary control (ARN model)	Free-of-charge acceptance
Temporary deregistration	Deregistration from the register of the Central Registration Office (RDW)	Processing fee (40 to 200 guilders per vehicle) Nullification of the registration number (The responsibility to pay the automobile tax arises automatically three months from the date of temporary deregistration.)
Registered export	Submission of a copy of the duty document to RDW	Processing fee
Unregistered export	The automobile tax continues to be levied (600 to 2,000 guilders per year)	Impossible
Deregistration procedures other than above	The automobile tax continues to be levied (600 to 2,000 guilders per year)	Impossible

Source: Environmental Agency of the Federal Republic of Germany, "Anforderung an das Monitoring im Rahmen der Verwertung langlebiger, technisch komplexer Produkte am Beispiel des Altautos."

three-part approach: 1) theoretically calculating the total volumes of each material/component generated out of the end-of-life vehicles from the numbers of end-of-life vehicles accepted by individual business entities, 2) determining the total volumes of each material/component actually collected in the dismantling stage based on quantity data from the transporters contracted with ARN, and 3) confirming the volumes accepted by the recyclers based on the certificates of acceptance issued by them. These processes are all performed using a centralized computer database system. Qualitative information obtained through on-site office inspection and other activities is regarded as supplementary data.

The recycling cost is calculated by ARN. This is achieved by projecting the numbers of automobiles that become end-of-life vehicles in the future through a comprehensive analysis based on the number of vehicles imported, the number of vehicles exported, the average periods of use, and other factors, and then calculating the total cost required for recycling from the projected numbers. It is worth noting that the recycling cost has dropped gradually as the new framework has taken root. As shown in Figure 2-2, the recycling cost was 250 guilders per vehicle when the new framework was introduced in January 1995, but dropped to 150 guilders in January 1998 and then to 45 euro (100 guilders) in January 2001, which is less than half of the recycling cost when the framework was introduced. This reduction in recycling cost is considered to be the result of the introduction by ARN of rigorous bid systems for the transportation and processing/disposal work for end-of-life vehicles and the reduction in the certification fee through volume discount negotiations with the certification bodies. However, another factor is that in the Netherlands the number of newly registered vehicles is larger than that of domestically recycled vehicles as a result of used vehicle exports. According to ARN, the current level of 45 euro per vehicle is considered very low because it is less than 0.25% of the average new automobile purchase price, and there has been no particular collection-related problem because all purchasers of new automobiles bear the recycling cost and thus they do not feel that they are unfairly exploited.

2.4 Future Prospects of the New Framework

In the case of the Netherlands, the impacts of implementing the ELV Directive through its domestic laws are not expected to be strong, because the country's existing framework is generally compatible with the ELV Directive. However, the Netherlands is bound to face the challenge of developing a domestic processing and disposal infrastructure for automobile

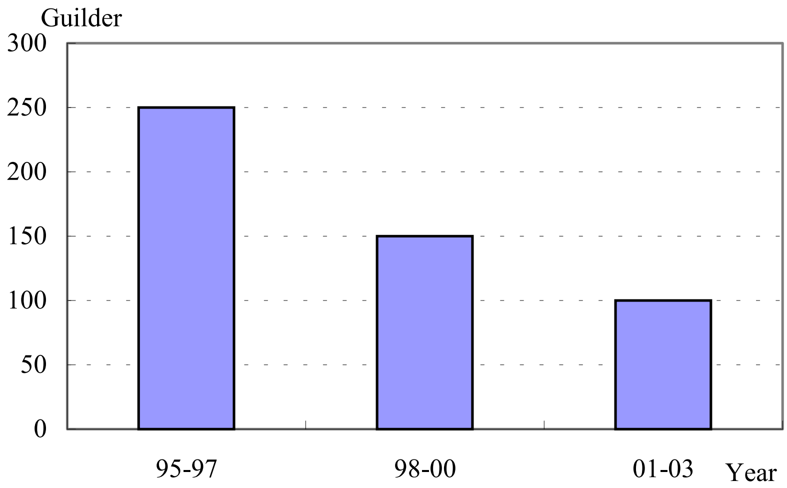


Figure 2-2 Changes in End-of-Life Vehicle Processing and Disposal Fee

Source: ARN, "Milieuverslag Environmental Report."

Table 2-4 Changes in Recycling Rates in The Netherlands

	1998		1999		2000	
	kg	%	kg	%	kg	%
Average weight of end-of-life vehicle	887	100.0	896	100.0	906	100.0
Average weight of end-of-life vehicle in terms of metals contained	665	75.0	672	75.0	679	74.9
Recycling	762	85.9	771	86.0	779	86.0
Residue	125	14.1	125	14.0	127	14.0

Source: ARN, "Milieuverslag Environmental Report."

shredder residue (ASR) as the country strives to raise the recycling rate to 95% in the future.

So far, there is no appropriate domestic ASR processing technology in the country, and ASR is being landfilled domestically or transported to Germany, where ASR can be processed and disposed of at relatively low costs, with the domestic recycling rate remaining at 86% as shown in Table 2-4. ARN considers that the country needs to introduce an ASR recycling technology in the future to improve the domestic recycling rate and is closely watching technological developments in Japan.

3. End-of-Life Vehicle Recycling in Germany and the ELV Directive

3.1 History of End-of-Life Vehicle Recycling Efforts in Germany

Let us now review the case of Germany. As shown in Figure 2-3, the number of automobiles registered in Germany is currently more than 50 million, with passenger vehicles accounting for slightly more than 80% at 43 million. The per capita number of automobiles is 0.5, and the number of automobiles per household has already exceeded one. Contrary to the Netherlands, the automobile and auto parts industries account for a large proportion of domestic production and employment in Germany (Table 2-5), and therefore implementing the concept of extended producer responsibility in automobile recycling in the country is a major challenge from the viewpoint of industrial policy as well.

Recycling policies in Germany have been formulated and implemented based on the 1996 Cyclical Economy and Waste Law as the core legislation and by applying the principles of extended producer responsibility provided for in the Law in such areas as container and packaging and biological waste by means of specialized laws.

Recycling of end-of-life vehicles (which constitute the most important category of post-consumer waste (PCW)) is no exception, and based on the Cyclical Economy and Waste Law, the "Legislative Ordinance concerning Delivery and Environmentally Friendly Processing and Disposal of End-of-Life Vehicles" (Verordnung über die Überlassung und umweltverträgliche Entsorgung von Altautos) (hereinafter referred to as the "End-of-Life Vehicle Ordinance") was enacted in 1997 and put into force in April 1998. Figure 2-4 shows the framework introduced by the End-of-Life Vehicle Ordinance.

To deregister an end-of-life vehicle[10] in Germany, the last owner must deliver the end-of-life vehicle to a collection facility or recycler that has been approved in accordance with the requirements stipulated in the relevant laws. When the last owner has delivered the end-of-life vehicle to such a facility or recycler appropriately, he or she is issued with a certificate of recycling (Verwertungsnachweis). This is a mandatory document for the deregistration procedure, and the automobile tax continues to be levied on the last owner unless he or she submits this document. Thus the system is designed to ensure that all or most end-of-life

[10] The term "vehicle" here means commercial vehicles weighing less than 3.5 tons and passenger vehicles.

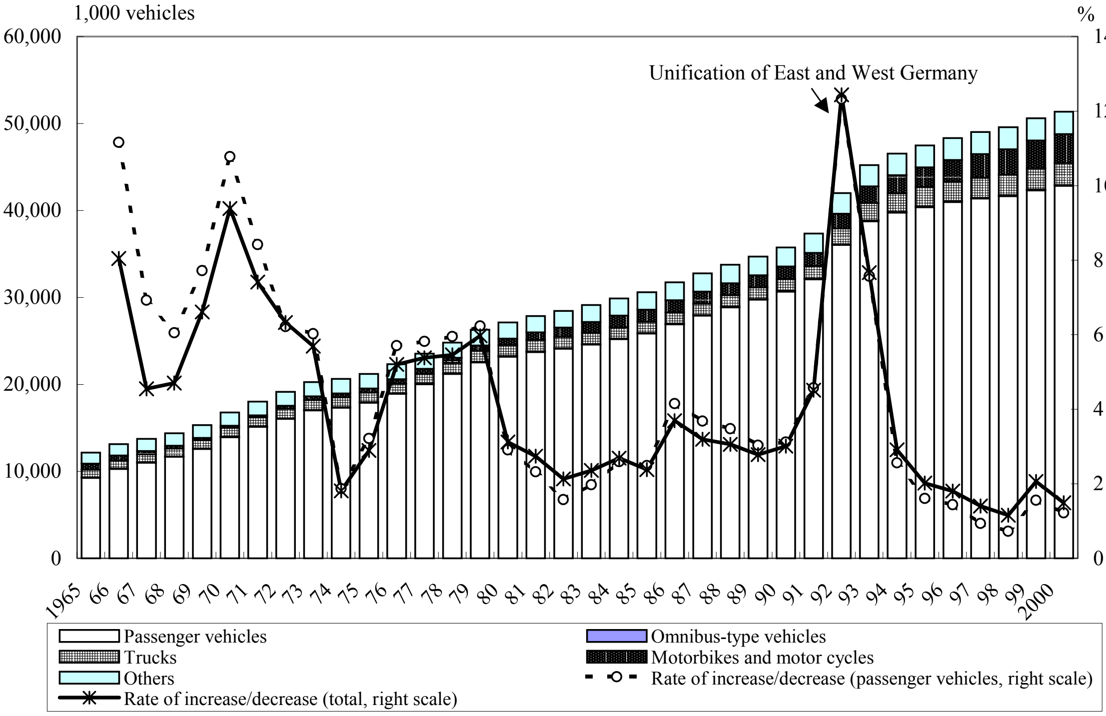


Figure 2-3 Changes in Numbers of Automobiles in Germany

Source: Prepared by the Development Bank of Japan from Kraftfahrt-Bundesamt data.

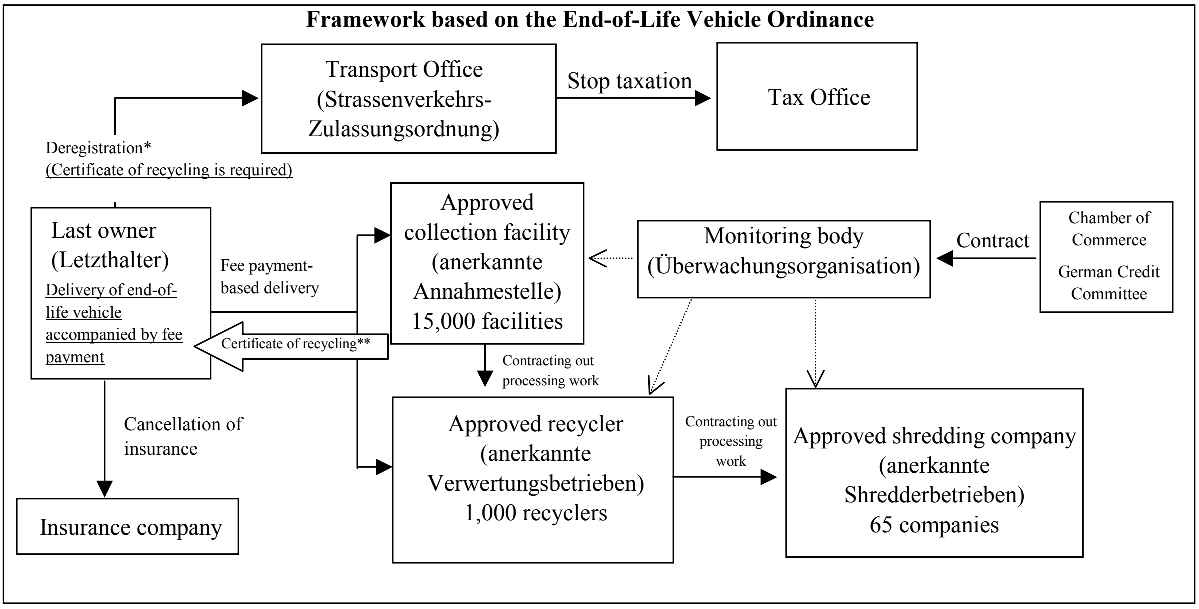
Table 2-5 Share of Automobile Industries as Percentage of German Manufacturing Industries (1999)

	Manufacturing industries total	Automobile and auto parts manufacturing industries	Percentage (%)
Number of offices and facilities	46,884	1,072	2.3
Number of employees (1,000 people)	6,239	755	12.1
Wage (DM 100 million)	4,123	595	14.4
Sales (DM 100 million)	23,172	3,985	17.2
Exports (%)	34.5	55.3	–

Source: Statistisches Bundesamt.

vehicles are channeled to the appropriate processing and disposal infrastructure.

On the other hand, with regard to business entities that accept end-of-life vehicles, rigorous approval requirements with respect to the company size, facilities and the level of processing technology were imposed, and the approved business entities were required to remove liquids and hazardous substances and collect components and materials using appropriate methods, and in the case of shredding companies, to reduce the final disposal volume. Whether such business entities are meeting these requirements or not is continually monitored, but the monitoring work is done not by an administrative agency but by monitoring bodies authorized by the Chamber of Commerce, etc.



* The last owner may contract his or her deregistration work to an approved collection facility or approved recycler.

** In the case of delivery to an approved collection facility, the certificate of recycling is issued after the contracting of the processing work to an approved recycler.

Voluntary control measures by the automobile industry
(German Association of Auto Industries, 15 related economic organizations)

- To promote recycling and optimize material circulation in order to conserve disposal facility capacities and resources.
- To establish a framework for the recycling of components and materials that have traditionally been disposed of, with a particular emphasis on the recycling of ASR.
- Development of a comprehensive infrastructure spanning diverse industries to collect and recycle end-of-life vehicles and used components arising from repairs of privately owned vehicles.
- Introduction of recycling-oriented designs for constant improvement of recycling rates.
- To develop systems to ensure that all or most end-of-life vehicles and non-reusable components and materials are channeled to environmentally friendly processing and disposal facilities.
- To reduce the volume of waste arising from end-of-life vehicles to 15% per manufacturer by 2002 and to 5% per manufacturer by 2015.
- Acceptance of producer liability based on the Cyclical Economy and Waste Law.

Figure 2-4 Germany's Automobile Recycling Framework before the EU Directive

Source: Prepared by the Development Bank of Japan from various literatures and data.

The intent of the Ordinance is to develop a legal framework to achieve appropriate processing and disposal of end-of-life vehicles. In terms of specific measures, the following achievements have been made under the Ordinance:

1) Unification of conditions for competition in the area of processing and disposal of end-of-life vehicles to make it easier for processing and disposal business entities to make facility investment decisions;
2) Provision of supplementary systems to cover those areas that are not covered by the voluntary control efforts by the automobile industry (the voluntary control efforts will be discussed later);
3) Entrustment of the monitoring work to a specialized monitoring body to reduce the administration's burden of monitoring; and
4) Imposition of environmental requirements on collection facilities, recyclers, and shredding companies.

Thus the End-of-Life Vehicle Ordinance is mainly concerned with raising the level of dismantlers and shredding companies as the processing infrastructure and ensuring that all or most end-of-life vehicles are channeled to the right processing and disposal flow, with producers including automobile manufacturers playing very limited roles. The reason for this is the voluntary control measures adopted by the automobile industry (die Freiwillige Selbstverpflichtung der Automobilindustrie; FSV) that were agreed in February 1996 prior to the Ordinance. As outlined in Figure 2-4, the automobile industry in Germany set the goal of improving the recycling rate from approximately 75% by weight at the time, to 85% by 2002, and then to as high as 95% by 2015 and reached an agreement that requires the automobile manufacturers to 1) accept end-of-life vehicles originally produced by them for an appropriate acceptance fee, 2) accept free of charge end-of-life vehicles of less than 12 years old put on the market from April 1998, and 3) report the progress status of these activities to the government every two years in the form of a monitoring report. In the automobile recycling framework developed in Germany, these voluntary control measures are the "main arteries", and the activities under the End-of-Life Vehicle Ordinance supplement these measures as "veins", encompassing matters not covered by them.

This is a pragmatic approach, characteristic of a country whose automobile industry represents a large percentage of its manufacturing industries as a whole; the development and implementation of automobile recycling promotion measures were left to the discretion of the automobile industry in consideration of the harsh competitive environment in the industry, rather than imposing an excessively rigorous extended producer responsibility scheme ahead of other EU countries. However, the approach of letting the interested industries introduce voluntary control measures under an administrative agreement and report the progress status regularly in the form of a monitoring report has been used in construction material recycling and other areas as well, and, like introduction of dedicated individual measures for control, is not an exceptional one in the country's environmental policies.[11]

3.2 Development of Processing and Disposal Infrastructure in Germany

The combined use of voluntary control measures by the automobile industry and the End-of-Life Vehicle Ordinance in Germany established a framework to promote recycling and accelerated the development of the country's automobile recycling infrastructure. As a result, an infrastructure comprising 15,000 approved collection facilities, more than 1,000 approved recyclers, and 65 approved shredding companies has been developed, as shown in Figure 2-4.[12]

What is the processing and disposal design capacity of this infrastructure? The numbers of companies and facilities mentioned above are the results of investment decisions made by private companies based on their own market research data and there is no data on the originally envisioned market size, but we can make some deductions from the related data. Figure 2-5 shows changes in the number of newly registered vehicles in Germany (the plots before the year of unification are data for the former West Germany and those after the year of unification are data for he unified Germany). Except for a sharp rise at the time of unification, as a whole there has been a gradual increase in the number of newly registered vehicles and the number is currently slightly less than 4 million per year. Figure 2-6 shows changes in the number of vehicles deregistered over the same period. It can be seen from the figure that roughly 3.5 million vehicles are being deregistered annually, but Figure 2-7 shows that the number of deregistered vehicles relative to that of newly registered vehicles has been increasing in recent years as the market matures, which means that automobile demand has been driven mainly by replacement needs. Figure 2-8 shows changes in the share of the number of deregistered vehicles as a percentage of the total stocks, indicating that the stock is diminishing by approximately 8% every year.

[11] For trends in construction material recycling in Germany, refer to Takegahara (2002) in the list of references.

[12] "Referat Öffentlichkeitsarbeit Art.-Nr.: 2305," Environmental Agency of the Federal Republic of Germany.

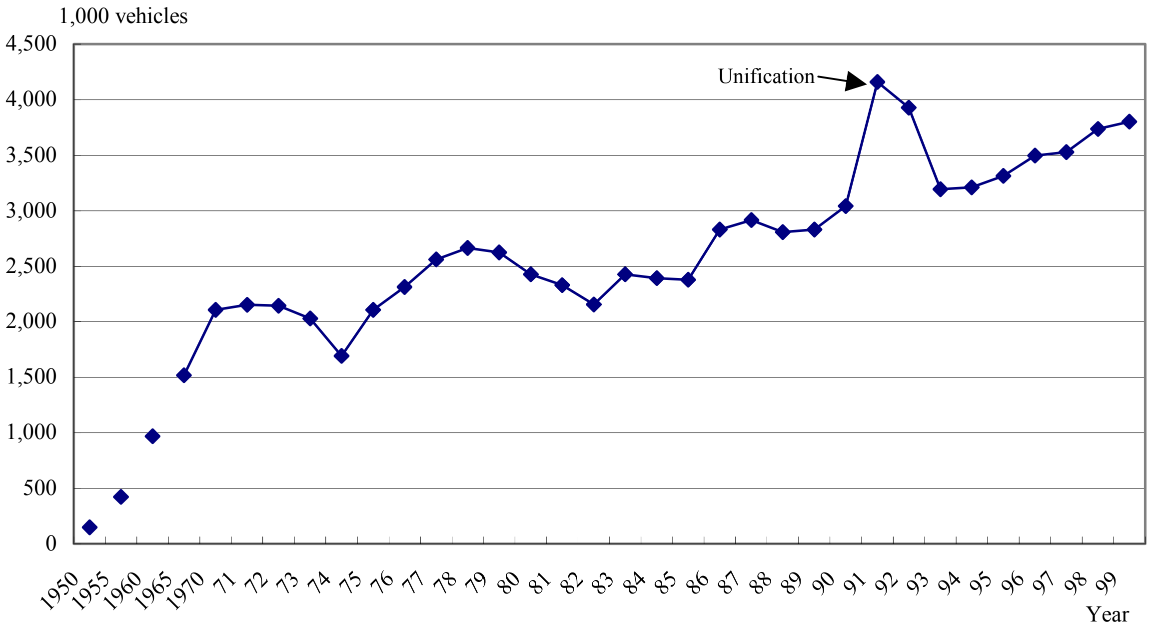


Figure 2-5 Changes in Number of Newly Registered Vehicles in Germany (Passenger Vehicles)

Source: Kraftfahrt-Bundesamt.

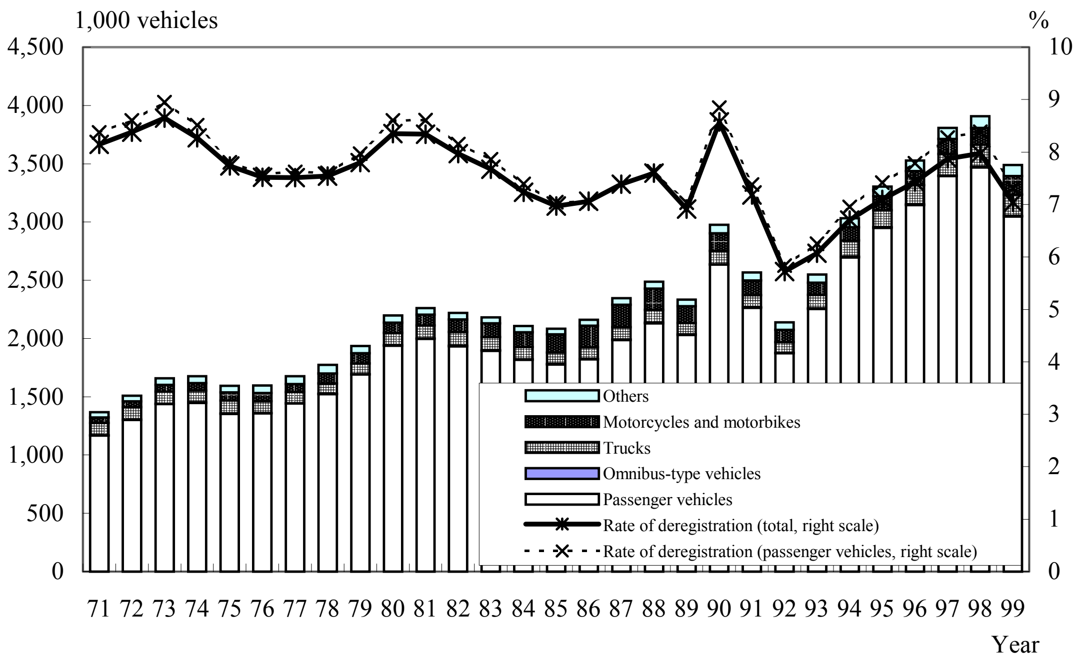


Figure 2-6 Changes in Number of Vehicles Deregistered in Germany

Source: Prepared by the Development Bank of Japan from Kraftfahrt-Bundesamt data.

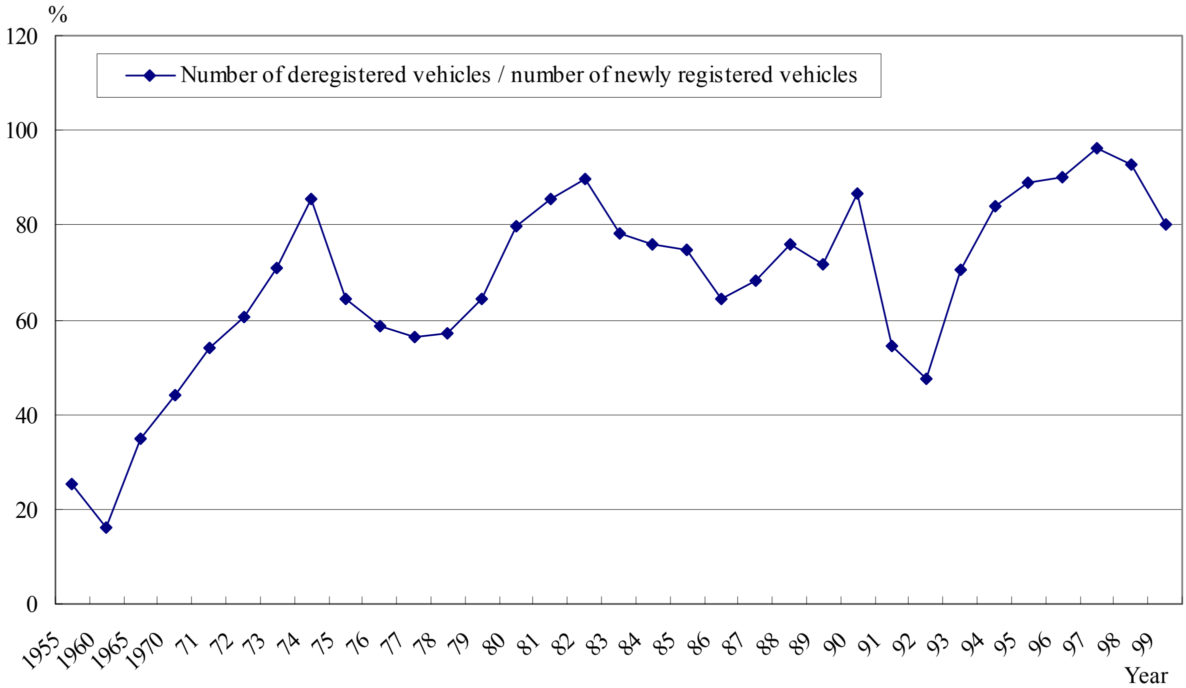


Figure 2-7 Number of Deregistered Vehicles Relative to Number of Newly Registered Vehicles

Source: Prepared by the Development Bank of Japan from Kraftfahrt-Bundesamt data.

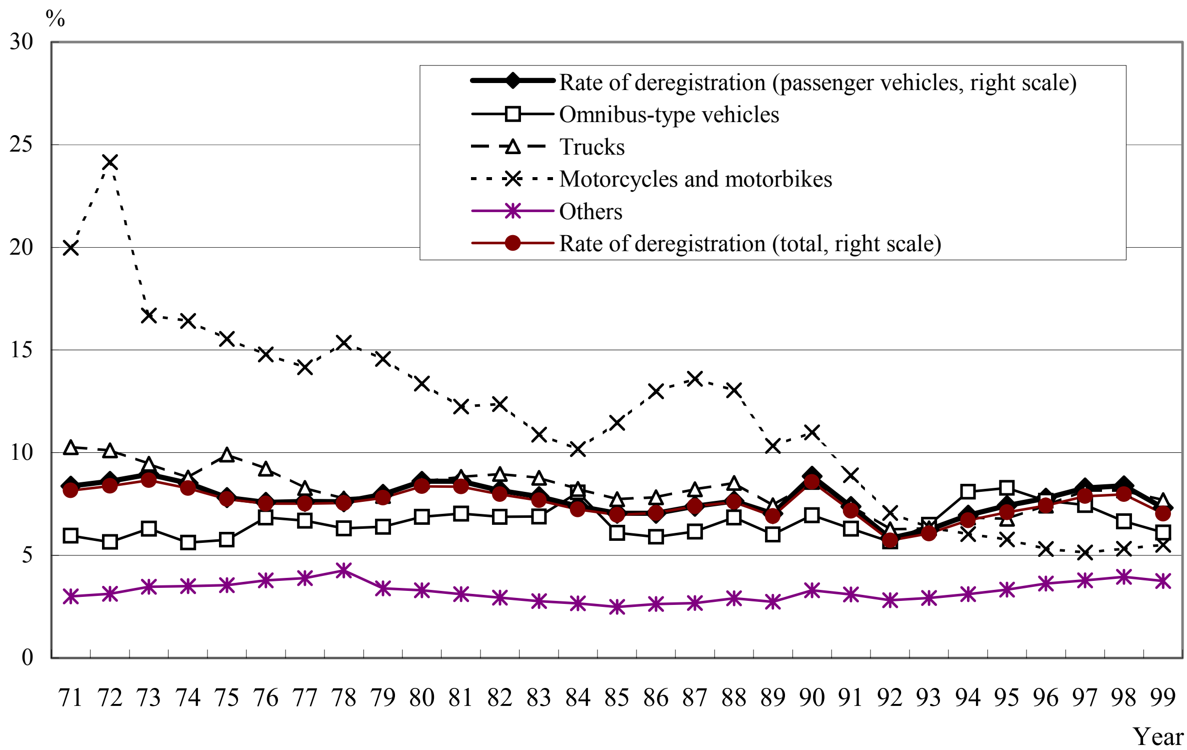


Figure 2-8 Changes in Deregistration Rate by Vehicle Type

Note: Deregistration rate = number of vehicles deregistered / total stock in the previous year
Source: Prepared by the Development Bank of Japan from Kraftfahrt-Bundesamt data.

Table 2-6 Automobile Recycling in Germany by Land

		Schleswig-Holstein	Hamburg	Bremen	Niedersachsen	Nordrhein-Westfalen	Rheinland-Pfalz	Saarland	Baden-Württemberg
①	Number of registered vehicles (stock)	1,443,006	708,618	294,002	4,167,188	8,959,535	2,172,161	590,764	5,548,444
②	Number of finally deregistered vehicles	108,860	58,132	25,964	311,639	717,321	179,467	51,576	447,218
③	Area	15,770.47	755.20	404.23	47,612.24	34,077.70	19,846.50	2,570.15	35,751.76
④	Population	2,756,473	1,704,731	673,883	7,845,398	17,974,487	4,017,828	1,080,790	10,396,610
⑤	Number of end-of-life vehicle collection facilities	238	42	10	271	793	169	103	482
⑥	Number of end-of-life vehicle recyclers	41	24	7	97	236	91	8	123
①/⑤	Number of registered vehicles per end-of-life vehicle collection facility	6,063	16,872	29,400	15,377	11,298	12,853	5,736	11,511
②/⑤	Number of deregistered vehicles per end-of-life vehicle collection facility	457	1,384	2,596	1,150	905	1,062	501	928
⑤/③	Area per end-of-life vehicle collection facility	66	18	40	176	43	117	25	74
⑤/④	Population per end-of-life vehicle collection facility	11,582	40,589	67,388	28,950	22,666	23,774	10,493	21,570
⑤/⑥	Number of end-of-life vehicle collection facilities per recycler	6.8	4.7	1.7	3.4	3.7	2.1	12.9	4.3
①/⑥	Number of registered vehicles per recycler	39,000	35,430	49,000	45,295	40,540	24,406	73,845	53,167
②/⑥	Number of deregistered vehicles per recycler	2,942	2,906	4,327	3,387	3,245	2,016	6,447	4,065

		Brandenburg	Berlin	Mecklenburg-Vorpommern	Sachsen-Anhalt	Hessen	Thüringen	Sachsen	Bayern
①	Number of registered vehicles (stock)	1,294,419	1,185,289	843,236	1,256,307	3,320,305	1,206,714	2,165,585	6,573,044
②	Number of finally deregistered vehicles	109,758	100,412	311,639	107,637	266,548	105,968	187,314	540,680
③	Area	29,475.72	890.86	23,170.24	20,447.46	21,114.45	16,170.88	18,412.71	70,550.87
④	Population	2,573,291	3,425,759	1,807,799	2,701,690	6,031,705	2,478,148	4,522,412	12,066,375
⑤	Number of end-of-life vehicle collection facilities	213	41	134	41	187	443	578	1,114
⑥	Number of end-of-life vehicle recyclers	82	18	33	59	58	79	80	157
①/⑤	Number of registered vehicles per end-of-life vehicle collection facility	6,077	28,909	6,293	30,642	17,756	2,724	3,747	5,900
②/⑤	Number of deregistered vehicles per end-of-life vehicle collection facility	515	2,449	2,326	2,625	1,425	239	324	485
⑤/③	Area per end-of-life vehicle collection facility	138	22	173	499	113	37	32	63
⑤/④	Population per end-of-life vehicle collection facility	12,081	83,555	13,491	65,895	32,255	5,594	7,824	10,832
⑤/⑥	Number of end-of-life vehicle collection facilities per recycler	3.6	3.1	4.5	0.8	3.5	6.7	7.4	7.7
①/⑥	Number of registered vehicles per recycler	16,810	65,849	26,351	22,040	58,250	17,488	27,764	50,562
②/⑥	Number of deregistered vehicles per recycler	1,425	5,578	9,738	1,888	4,676	1,535	2,401	3,754

Source: Arbeitsgemeinschaft Altauto, "ARGE-Altauto."

If we assume that the share of the number of vehicles channeled to the recycling framework, as a percentage of the total number of deregistered vehicles, is 80%, then the number of vehicles processed and disposed of within the framework is about 2.8 million (3.5 million × 0.80) per year, which means that the number of vehicles handled by one approved recycler, calculated by dividing 2.8 million by the number of approved recyclers (1,000), is only about 2,800 (230 vehicles per month). Although there are regional variations as shown in Table 2-6, it is clear that recyclers in Germany are mostly small- and medium-sized enterprises. The same conclusion can be drawn from the amount of money involved. Under the old framework, last owners were required to pay the recycling cost at the time of delivery to recyclers (post-payment system), although there were some exceptions. As the average recycling cost is estimated to be around DM 200/vehicle to DM 300/vehicle, if we assume that the number of vehicles processed and disposed of is about 2.8 million, the size of the automobile recycling market in terms of the processing and disposal fee is approximately DM 500 million/year to DM 800 million/year (30 to 48 billion yen/year). Although this is the size of the market expressed only in terms of the processing and disposal fee and it is necessary to add the money involved in the downstream part of automobile recycling such as the selling of dismantled components and materials, the size of the market is not very large considering the fact that there are 1,000 or more recyclers and shredding companies making facility investments to meet the rigorous requirements. Furthermore, the above figures assume that the share of the number of vehicles channeled to the recycling framework as a percentage of the total number of deregistered vehicles is 80%. In reality, however, the number of vehicles channeled to the proper processing and disposal flow established under the End-of-Life Vehicle Ordinance has been lower than expected from the beginning, and recyclers have been forced to live with low capacity utilization rates.

3.3 Problems

The recycling framework using voluntary control measures and the End-of-Life Vehicle Ordinance in combination have achieved some success in terms of two of its objectives, namely, the unification of conditions for competition in the area of processing and disposal and the development of a processing and disposal infrastructure. In addition, in terms of processing technologies, technological development has been stimulated in the area of ASR recycling (Verwertung) which is regarded as the biggest challenge in automobile recycling, and some of these efforts have led to new businesses such as Schwarzpumpe's commercial production of methanol utilizing thermal decomposition of ASR.

However, this framework is of limited effectiveness regarding the objective of ensuring that most, if not all, end-of-life vehicles are channeled to the developed processing and disposal framework.

According to the 2000 Edition of the Annual Environmental Report (Umweltgutachten) submitted to the German parliament, the volume of end-of-life vehicles (non-reusable components and materials) going to German shredding companies has been declining sharply since the early 1990s. The 2000 Environmental Report states that the number of end-of-life vehicles recycled at domestic shredding companies in 1996 represents less than one sixth of the 3,140,000 vehicles deregistered in the same year and that "although there is no conclusive data on the final destinations of the deregistered vehicles, these figures suggest that the existing framework based on voluntary control measures and the End-of-Life Vehicle Ordinance that supplements them has a serious defect." The defect referred to here is the institutional problem whereby the last owner is relieved of the responsibility to pay the automobile tax without obtaining a certificate of recycling by following the Destination Reporting Procedure (Verbleibserklärung) similar to the temporary deregistration system in Japan. Thus, many owners have taken advantage of this system to avoid paying the recycling cost at the time of deregistration, thereby reducing the

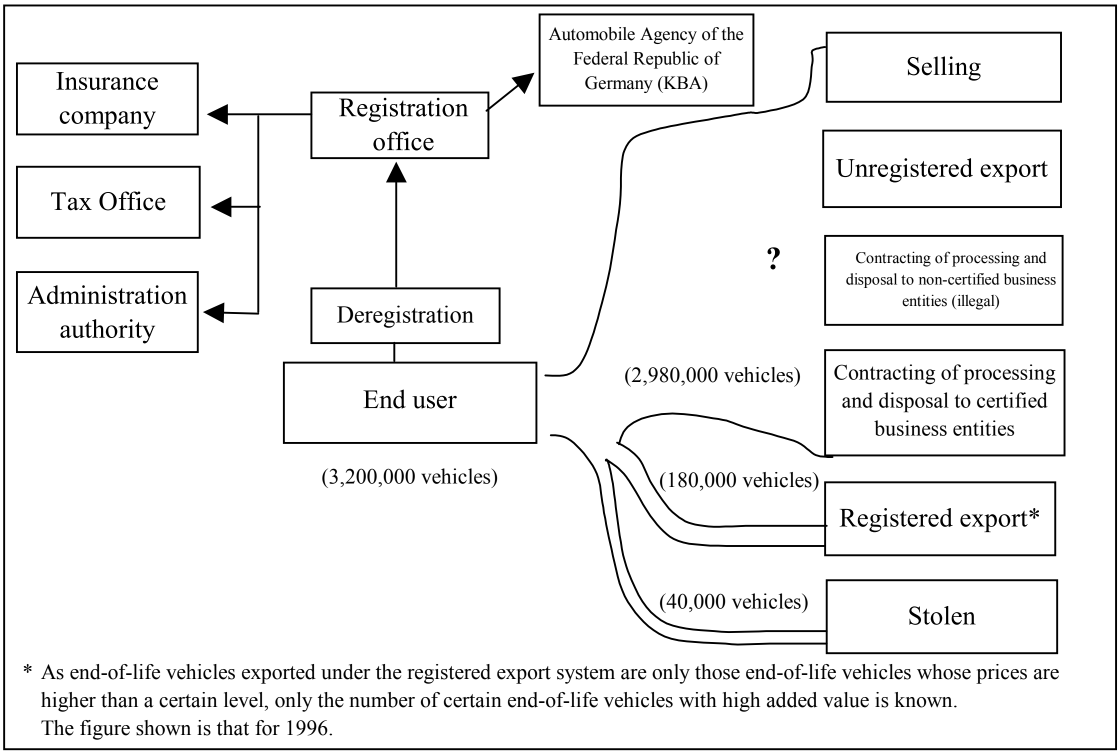


Figure 2-9 Flow of End-of-Life Vehicles

Source: Environmental Agency of the Federal Republic of Germany, "Anforderungen an das Monitoring im Rahmen der Verwertung langlebiger, technisch komplexer Produkte am Beispiel des Altautos."

number of end-of-life vehicles channeled to the proper recycling flow developed under the above-mentioned framework. The major cause of this problem is the strong demand from Central and Eastern European countries for German used vehicles, resulting from liberalization in these countries.

This problem can also be confirmed from the monitoring report[13] published under the automobile manufacturers' voluntary control scheme. Figure 2-9 shows destinations of the deregistered automobiles shown in the monitoring report. According to this report, the destinations of the vast majority of the 3,200,000 vehicles deregistered in 1996 have not been confirmed, with the sole exception of the 180,000 end-of-life vehicles exported under the registered export system.[14] It is not clear how many end-of-life vehicles have been recycled domestically, partly because of the absence of a body to centrally manage recycling certificate information. Although various reports have been published that provide some figures on this matter[15] other than the monitoring report, none of them are well-grounded.

13 The following is based on a report from the Environmental Agency of the federal government that is entitled "Anforderungen an das Monitoring im Rahmen der Verwertung langlebiger, technisch komplexer Produkte am Beispiel das Altautos."

14 An attempt was made to estimate the number of vehicles for which certificates of recycling had been issued and which had been processed and disposed of appropriately through surveys based on questionnaires to dismantlers and shredding companies, but no conclusion was obtained due to the general lack of data.

15 For example, the estimates published by the Ministry of Economy and other organizations that are cited by the above-mentioned report also vary, with the following four figures presented: 1,200,000, 1,400,000, 1,200,000 – 2,670,000, and 1,980,000 – 2,270,000. BVSE, an association of small- and medium-sized recyclers, has reported that the share of the number of end-of-life vehicles handled by domestic shredding companies as a percentage of the total number of end-of-life vehicles was about 20%. This is consistent with the level mentioned in the above-mentioned Environmental Report.

The Environmental Committee Report mentioned above states that measures should be taken as soon as possible to clarify the destinations of the deregistered vehicles in order to improve the effectiveness of the existing framework and suggests several measures including modification of the temporary deregistration system to make it more rigorous. It also points out that the present framework lacks incentives for automobile manufacturers to pursue environmentally-friendly designs.

3.4 The New Framework under the ELV Directive

The ELV Directive will be implemented through domestic legislation against this background. Although some elements of the ELV Directive, such as the imposition of a legal obligation to recycle automobiles on the automobile manufacturers as well, are not fully consistent with the existing framework in Germany, there is no significant difference in terms of the basic intent and direction if the voluntary control scheme is taken into consideration. Therefore, it has been decided to implement the ELV Directive through domestic legislation by amending the End-of-Life Vehicle Ordinance and relevant laws (the Commercial Law, Tax Law, and Traffic Law). Table 2-7 outlines the new End-of-Life Vehicle Ordinance. As the new End-of-Life Vehicle Ordinance focuses on rectifying the problems of the old framework that have been identified in addition to implementing the ELV Directive through domestic legislation, the part of the new End-of-Life Vehicle Ordinance that has been newly introduced under the ELV Directive and the part aimed at modifying existing systems are shown separately for ease of understanding.

The main elements that have been newly introduced under the ELV Directive are the provision for free-of-charge acceptance of end-of-life vehicles and those relating to the bearing of the costs of acceptance and recycling that is associated with the imposition of the ob-

Table 2-7 Outline of the New End-of-Life Vehicle Ordinance

[Changes to implement the ELV Directive through domestic legislation] → Articles 1 to 3 of the Proposal for Amendment 1) In principle, the last owner may have his or her end-of-life vehicle accepted by the manufacturer or importer for free. In the case of a vehicle that was sold before July 1, 2002, this provision is applied from 2007.
2) The manufacturers and importers of private use automobiles and mini-sized commercial vehicles are required to accept and appropriately recycle vehicles they sold when they have become end-of-life vehicles. The costs of acceptance and recycling are borne by the manufacturers and importers.
3) Beginning in 2006, a legal obligation to achieve a recycling rate of 85% per end-of-life-vehicle, calculated as a percentage of the average weight, will be imposed, with the condition that the recycling of materials and components must account for 80% or more. This will be raised to 95% (total recycling rate) or 85% (recycling rate for materials and components) by 2015.
4) Beginning on July 1, 2003, the use of cadmium, mercury, lead, and hexavalent chromium in automobiles and automobile components will be banned with certain exceptions.
5) When a manufacturer or importer has to set up a reserve to comply with the obligation to accept and recycle automobiles, the reserve for the automobiles sold before July 1, 2002 is forcefully put on the Tax Law-based balance sheet. By the same token, a reserve is set up on the Commercial Law-based balance sheet (an equal amount is put on the list of asset items as a pseudo balance sheet item).
[Modification of existing systems to improve the effectiveness of the existing framework] → Article 4 of the Proposal for Amendment The deregistration system is changed to require the last owner to follow the following procedures, irrespective of whether the deregistration is based on an application by the last owner or due to expiration of the period of a temporary deregistration (amendment of Article 27a of the Road Traffic Permission Rules, etc.): 1) In the case where the last owner delivers his or her end-of-life vehicle to an approved recycler, the deregistration process is completed upon presentation of the original of the certificate of recycling. 2) In the case where the last owner wishes to dispose of his or her end-of-life vehicle as other than waste or take it to another country for disposal, the last owner or other responsible person is required to submit a letter of explanation stating their reasons to the registration office. The registration office completes the deregistration process through this procedure.

Source: Prepared by the Development Bank of Japan.

ligation to recycle automobiles. Because these costs are borne by automobile manufacturers and importers, reserves will be set up in their non-consolidated and consolidated accounts that cover the costs incurred by them for the automobiles they have sold.

The new End-of-Life Vehicle Ordinance 1) makes amendments to the Commercial Law (Accounting Rules) that are necessary to establish this reserve system, 2) allows "reserves for uncertain or unfixed debts" that are intended to cover the costs of free-of-charge acceptance and/or recycling of vehicles sold before July 1, 2002 to be set up (Article 1), and 3) makes amendments to the relevant provisions of the Tax Law that are necessary to establish the reserve system for the Tax Law-based balance sheet (Article 2). As it is stated in the EC Accounting Strategy of the European Committee that the International Accounting Standard (IAS) will be used as the basic standard for consolidated accounts of companies based in the EU from 2005, the reserve-related provisions of the new End-of-Life Vehicle Ordinance are designed to be compatible with the IAS (IAS37).

The modification of existing systems to improve the effectiveness of the framework is centered around changes to ensure that all or most end-of-life vehicles are channeled to the proper recycling flow. These changes are expected to bring significant improvements because the introduction of the legal obligation to accept end-of-life vehicles free of charge and the modification of the recycling cost collection system from a post-payment-based system to a pre-payment-based one are expected to serve as strong disincentives against disposal of end-of-life vehicles outside the proper recycling system and the changes to the post factum certification procedure for deregistration rectified the problem in relation to the temporary deregistration system of the old framework (Article 4).

In general, the new End-of-Life Vehicle Ordinance aims to make the best use of the recycling infrastructure developed under the old framework by increasing the involvement of "artery" side factors such as automobile manufacturers and increasing the flow of end-of-life vehicles from last owners (Figure 2-10).

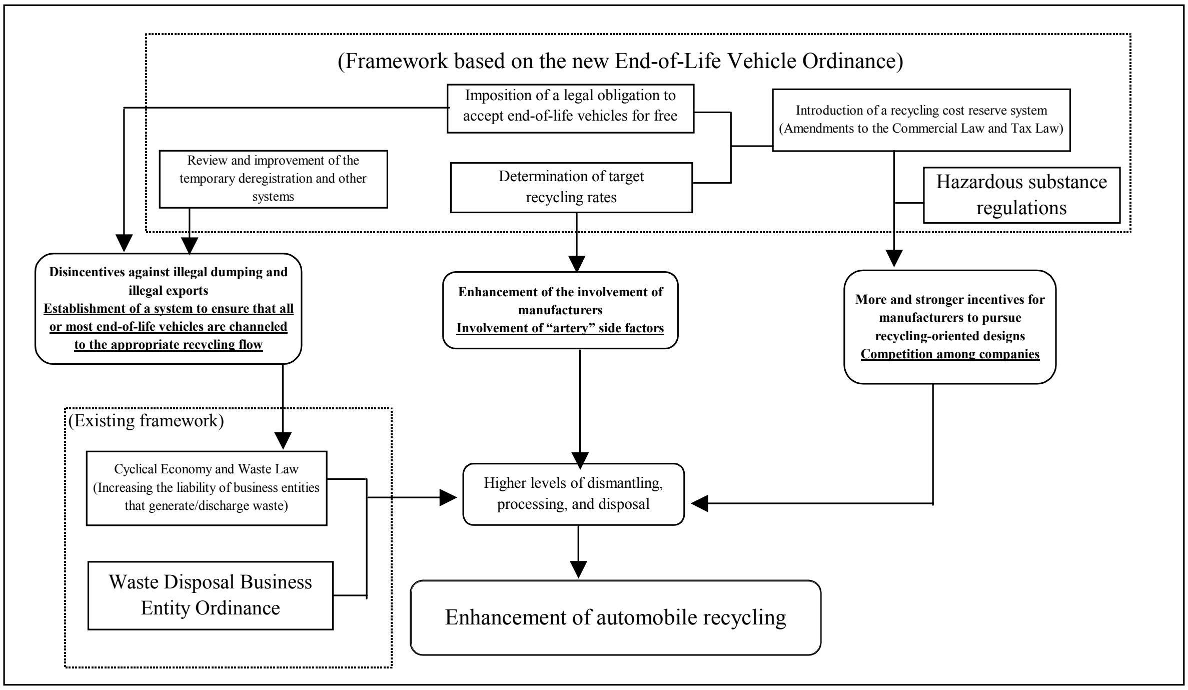


Figure 2-10 Germany's Automobile Recycling Framework under the New End-of-Life Vehicle Ordina

Source: Prepared by the Development Bank of Japan.

3.5 Impacts of the New Framework

The introduction of the new framework will bring various economic and financial impacts due to the imposition on manufacturers of obligations to accept end-of-life vehicles for free and bear the cost of recycling, as manufacturers have not been subjected to regulation under the old framework.

1) Financial Impacts

Possible financial impacts are 1) reductions in tax revenues of the federal government and the Lands due to the creation of the reserve system and the introduction of tax credits and 2) increases in administrative costs associated with the enforcement of the new regulations. With regard to tax revenues, the Legislative Intents Report of the Environmental Agency of the federal government foresees that the total processing and disposal cost will reach DM 800 million (approx. 48 billion yen) per year after the introduction of the system to impose the obligation to accept end-of-life vehicles for free that is scheduled to take place in 2007 and will generally remain at that level thereafter. The reductions in tax revenues due to the resultant deductions are expected to amount to approximately DM 500 million per year in the period between 2002 and 2007. The increases in administrative costs associated with the enforcement of the new regulations are expected arise mainly from the monitoring work by the Land governments. However, as the new End-of-Life Vehicle Ordinance will bring administrative improvements such as shifting the style of monitoring information relating to recycling certificates, etc. from the disorganized traditional system comprising dispersed monitoring offices to an efficient, centralized one with a dedicated monitoring body, the additional costs are unlikely to be very high.

2) Impacts on the Recycling Cost

The introduction of the new End-of-Life Vehicle Ordinance will establish a mechanism which ensures that all or most end-of-life vehicles are channeled to the proper recycling flow envisioned by the law.

However, the recycling cost is unlikely to increase sharply, because in Germany, a good processing and disposal infrastructure has been developed under the old framework as explained earlier and the competition is fierce, although future rises in the recycling cost are unavoidable because it will be necessary to improve the level of the dismantling process and the ASR recycling rate as the target recycling rates rise. In particular, the introduction of much stricter final disposal regulations up to 2005[16] will have significant impacts because they will make it more difficult to rely on landfilling for disposing of ASR. Therefore, the development of sophisticated ASR processing and disposal technologies will attract much greater attention in the near future.

3) Imposition on Manufacturers of Obligation to Bear Costs of Acceptance and Recycling of End-of-Life Vehicles and Passing Costs onto Prices of New Vehicles

Automobile manufacturers and importers will be obligated to bear the costs of recycling and free-of-charge acceptance of end-of-life vehicles. The amounts of these costs will vary among manufacturers and products and according to foreign demand for used vehicles, demand for used components, effects of recycling-oriented designs, and other factors.

These costs are normally passed onto the prices of new automobiles, but whether this is done for all of the costs or for just part of them will be determined by the degree of acceptance by the market. According to an estimate by the Environmental Agency of the federal govern-

[16] This refers to the implementation of the EU Directive on Disposal Facilities (1999/31/EG) through domestic legislation and other regulatory measures. Landfilling in Germany is currently regulated under the "Landfilling Ordinance" (Ablagerungs-Verordnung) that entered into force in March 2001, the "Technical Guidelines on Special Wastes" (TA Sonderabfall), and the "Technical Guidelines on Household Waste" (TA Siedlungsabfall), but the EU Directive is going to be added to these regulations in the near future. This will effectively place a ban on the landfilling of liquid waste, explosive or flammable waste, infectious medical waste, used tires, etc. The Directive and the regulations work together not only to tighten the disposal facility construction requirements, but also to require existing disposal facilities to be closed down unless the required measures are taken by the specified deadline. For Germany's policies relating to disposal facilities, refer to Schnurer (2001) in the list of references.

ment, full internalization of these costs would raise the price of a new automobile by about DM 200. This means a markup of about 0.5% for relatively inexpensive new automobiles with a selling price of about DM 40,000 (approx. 2.4 million yen). If the markup rate is of this magnitude, the costs can basically be fully passed onto the prices of new automobiles because it is well within the ordinary discount range (about 3%), and therefore the obligation to recycle automobiles will have relatively little impact on new automobile sales.[17]

3.6 Future Challenges

The EU Directive will be implemented through domestic legislation in Germany making the best use of the infrastructure developed under the old End-of-Life Vehicle Ordinance. The alleviation of burden on last owners by introducing the free-of-charge acceptance system is expected to increase the number of vehicles channeled to the proper recycling flow and help improve recyclers' facility utilization factors. However, it also means that the volume of ASR to be processed and disposed of within the country will increase. As the target recycling rates are sure to rise in the near future and the Final Disposal Facility Ordinance will make it much more difficult to rely on landfilling for disposal, more sophisticated ASR processing and disposal technologies will need to be developed to reduce the markup on new vehicle prices.

With regard to the administration of the framework, the most important question will be how to achieve efficient monitoring taking into consideration the increase in the number of end-of-life vehicles processed and disposed of within the country. The Environmental Agency of the federal government (UBA) says that efficient monitoring of the recycling of end-of-life vehicles involves closely tracking the flows of the materials and components. The main purposes of this monitoring are: 1) to systematically confirm the movement of end-of-life vehicles to the appropriate processing system (Lenkungswirkung), 2) to check whether end-of-life vehicles are being recycled effectively and successfully and whether hazardous substances are being processed safely, and 3) to verify the compliance of the producers with their obligations to control the generation of waste and pursue recycling-oriented designs. However, it is not easy to collect all this information efficiently and cheaply for automobiles, because they are products which are technologically complex and are used for many years. Various issues remain, such as to what extent the existing labeling standards for materials (e.g. VDA, ISO) can be used to assess the results of recycling-oriented designs. It will be interesting to observe how Germany develops its monitoring system for the new framework and how the system functions.

[17] However, the problem remains that the markup accounts for a greater percentage of the selling price for smaller, lower-priced vehicles than for luxury vehicles.

III Automobile Recycling and Environmental Industries

1. Comparison between Automobile Recycling Measures in Japan and European Countries

1.1 Comparison between the Japanese Framework and the Dutch and German Frameworks

So far we have looked at policy-related measures and historical developments in Japan, the Netherlands, and Germany in the area of end-of-life vehicle recycling, focusing on the recycling frameworks of the three countries. Table 3-1 compares these frameworks. These three frameworks have similar core elements such as 1) free-of-charge acceptance by automobile manufacturers of end-of-life vehicles at the time of deregistration and modification of existing deregistration systems and related tax systems to ensure that all or most end-of-life vehicles are channeled to a well-organized, sophisticated recycling flow system and 2) replacement of existing voluntary recycling rate schemes with compulsory target recycling rates to improve recycling. The main differences are in technical areas such as the extent to which the involvement of manufacturers is legally specified and whether the use of hazardous substances is legally banned.

At first glance, Japan's manufacturer participation system appears to be limited in that it obligates the automobile manufacturers to accept three kinds of materials, namely, CFCs, airbags, and automobile shredder residue, that arise from the dismantling of end-of-life vehicles. This approach of focusing on the three kinds of materials was adopted because, taking

Table 3-1 Comparison of the Frameworks Adopted by Japan, Germany, and The Netherlands

	Japan	Europe	
		Germany	The Netherlands
Free-of-charge acceptance of end-of-life vehicles at the time of deregistration	Guaranteed	Guaranteed	Guaranteed
Amendment of related laws and regulations	Amendment of the Road Transport and Motor Vehicle Law and the establishment of an automobile weight tax refund system	Amendment of the End-of-Life Vehicle Ordinance and the Tax Law, amendment of the Commercial Law to create a reserve system, and amendment of the Traffic Law to rectify the deficiencies relating to temporary deregistration procedures	Modifications to improve the deregistration and automobile export systems
Target recycling rates defined by law	95% by 2015	95% by 2015 (energy collection: 10% or less)	95% by 2015 (energy collection: 10% or less)
Involvement of manufacturers	Acceptance of CFCs, airbags, and automobile shredder residue	・Automobile manufacturers are required to accept end-of-life vehicles originally produced by them and recycle the end-of-life vehicles appropriately. ・Automobile manufacturers are required to bear the costs of acceptance and recycling of end-of-life vehicles.	—
Fund management method	Centralized management by a dedicated fund management body	Distributed system for company-by-company allocation	Centralized management by dedicated fund management bodies (ARF, ARN)
Control of hazardous substances	Voluntary control	Control by law	Control by law
Development of processing and disposal flow system	Introduction of permit systems for dismantlers and shredding companies	Approval system based on the Waste Disposal Facility Ordinance (with rigorous approval requirements on the scale of company, facility items, and the level of processing and disposal technology)	Permit system based on environmental standards
Monitoring system	Manifest-based control centered around a fund management body	Possible improvement measures are being studied while maintaining an enforcement mechanism centered around monitoring bodies authorized by the Chamber of Commerce, etc.	A rigorous monitoring system based on fully integrated use of registered information, information on the statuses of the processing and disposal work, and premium payment
Development of more sophisticated processing and disposal technologies	Various technologies are being developed including thermal decomposition gasification melting technologies.	Some companies are producing methanol on a commercial basis utilizing thermal decomposition of ASR (e.g. Schwarzpumpe).	There is no appropriate domestic ASR processing/disposal technology.

Source: Prepared by the Development Bank of Japan.

into consideration the inherent high potential of end-of-life vehicle recycling, emphasis was placed on removing major obstacles to achieving smooth end-of-life vehicle recycling. In fact, as these three kinds of materials are indeed major obstacles to achieving smooth end-of-life vehicle recycling and, as will be explained later, it is essential to take upstream measures such as improving material compositions and developing easier-to-dismantle designs in order to achieve more sophisticated ASR processing, there are unlikely to be significant differences between the framework adopted by Japan and those adopted by Germany and the Netherlands in terms of manufacturer participation.

With regard to the management of the money collected, it is sometimes argued that the magnitude of the incentive for automobile manufacturers is different between a distributed, company-by-company approach such as the one adopted by Germany and a centralized approach using a fund management body (or bodies) such as the ones adopted by Japan and the Netherlands, but fund management methods and promotion of competition in recycling technologies are essentially two different things. Although Japan's approach is a centralized one, it recognizes that there are differences in the volume of ASR generated and other aspects among different automobiles and reflects such differences in the collected fees, and thus is no different from distributed approaches in terms of the magnitude of the incentive for manufacturers to pursue recycling-oriented designs.

With regard to means of controlling the use of hazardous substances, the ELV Directive has established the policy of banning the use of lead, mercury, cadmium, and hexavalent chromium while the Japanese approach is expected to be based not on a legal ban but on voluntary control measures. Whether to legally ban the use of hazardous substances such as lead from the standpoint of preventing environmental impacts or continue to use them with rigorous control measures is still being discussed, but as a high percentage of automobiles produced is exported and in view of the trend toward using more standardized, interchangeable components due to recent increases in international partnerships, the hazardous substances specified by the ELV Directive as those to be banned will be gradually replaced by substitutes in Japan as well.

In the first place, EPR systems for post-consumer waste recycling vary among countries. They also vary depending on product types. For example, in the case of electrical and electronic equipment, the EU's Proposal for a Directive on Waste Electrical and Electronic Equipment seems to cover electrical and electronic equipment in general and be based on the premise that municipalities' infrastructures are used to collect electrical and electronic equipment that has become post-consumer waste, while the Japanese legislation in this area focuses on four kinds of "large home appliances" and requires retail outlets, etc. to bear the burden of collecting them when they have become post-consumer waste. In addition, with regard to fee collection, the Proposal for a Directive on Waste Electrical and Electronic Equipment envisions a pre-collection system, while Japan's Home Appliance Recycling Law adopts a post-collection system. Compared to these differences, there are more similarities and common points than differences between end-of-life vehicle recycling systems adopted by Japan and those adopted by European countries, especially in view of differences in business environments such as the export rate.

1.2 Common Challenges between Japan and European Countries

A comparison between end-of-life vehicle recycling policies and measures adopted by Japan and those adopted by the Netherlands and Germany reveals that Japan shares not only a common direction but also a number of common future challenges with European countries. Such common challenges can be largely divided into 1) the development of a sophisticated processing and disposal flow system to which end-of-life vehicles are to be channeled by means of policy measures, 2) the provision of an effective and efficient built-in monitoring system, and 3) the development of more sophisticated processing and disposal technologies.

As explained earlier, the Japanese and European automobile recycling frameworks incorporate measures to channel all or most end-of-life vehicles to a sophisticated processing and disposal flow system such as the introduction of a free-of-charge acceptance system and amendments to existing registration and tax systems. It goes without saying that these measures assume that there will be a sophisticated recycling infrastructure that warrants them. Approaches taken by countries differ depending on the degree to which the "vein" side infrastructure of the country has been developed. It is expected that even within the EU, measures taken will be very different between countries that have already achieved a certain degree of success in the development of a good "vein" side infrastructure and those that have not. In the case of Japan, permit systems for dismantlers and shredding companies will be introduced through a new law. Although the requirements have yet to be determined, efforts are already beginning to be seen in Japan toward achieving higher levels of dismantling in anticipation of the establishment of a sophisticated infrastructure as will be explained later. The development of detailed designs of systems that can support such moves and the implementation of such systems are awaited.

With regard to the provision of an efficient monitoring system, no consensus has been reached yet as to the ideal role and functions of an efficient monitoring system even in the EU that has the ELV Directive which imposes a monitoring obligation on the member states. This is because, unlike the monitoring of recycling of products and materials that can be achieved only by means of calculations based on quantitative measurements (e.g. the volume of recycled waste as a percentage of the total volume of waste generated) such as container and packaging materials, the monitoring of recycling of automobiles and electrical and electronic equipment entails qualitative monitoring activities such as confirming the rate of achievement of the recycling of valuable materials, verifying completion of the processing work to turn the generated hazardous waste into innocuous waste, and verifying whether the producer is fulfilling its obligation to ensure that its designs incorporate measures to reduce the volume of the waste generated when the products become post-consumer waste and are compatible with recycling. The development of methods and techniques for efficient and effective monitoring of automobile recycling would certainly be a cumbersome task, considering the fact that automobiles are technologically complex products with a long service life and a complex "reverse flow." In Japan, a manifest-based monitoring system centered around a fund management body will likely be introduced, and it will be interesting to see whether Japan can develop it into a successful one like that of the Netherlands by introducing systems to electronically manage information relating to reverse flow and to link monitoring with the registration system.

Let us now look at the current situations surrounding the third common challenge, the development of more sophisticated processing and disposal technologies. As mentioned earlier, in EU countries and in Germany in particular, the ongoing development of automobile recycling infrastructures is expected to increase the number of end-of-life vehicles processed and disposed of domestically, and much attention is being directed to ASR processing and disposal technologies and other measures. The same is true in Japan, where companies are competing to develop new technologies with an emphasis on improving the ASR recycling rate, to meet the recycling rate requirements that are to be legally imposed in the future. Some of these technologies are attracting attention from EU countries, and although they were originally spawned by the introduction of a formal system for automobile recycling, they have a great potential to develop into a body of technologies for environmental industries. Let us now take a look at some of the new technologies that have been emerging following the introduction of the Automobile Recycling Law, focusing on recent major developments in Japanese companies' efforts to develop such technologies.

2. Automobile Recycling Law and Environmental Industries

2.1 Major Approaches to Development of Technologies for End-of-Life Vehicle Recycling

In Japan, various technological development efforts are being made to improve the recycling of ASR and reduce the volume of ASR generated as a result of end-of-life vehicle recycling (Table 3-2). Current technological development efforts for ASR recycling can be largely divided into two categories: 1) those that seek to enhance ASR processing with given conditions of volume of ASR produced and ASR composition and 2) those that seek to reduce the volume of ASR generated through upstream measures.

Table 3-2 Current Technological Development Efforts for End-of-Life Vehicle Recycling

Approach	Name of business entity (plant manufacturer / type)	Description	Operation status	Capacity
Achieving more sophisticated ASR processing				
Recycling of materials	Toyota Metals Co., Ltd.	Recovers metals and polymeric materials through carefully sorted collection of ASR with fine categorization, and recycles them into raw materials for automobile components, etc.	Demonstration: since 1995 Mass production: since 1998	180,000 vehicles per year
Heat recovery				
Gasification melting techniques				
Gasification combustion technique	Aomori Renewable Energy Recycling Co., Ltd(Ebara Corporation / fluidized bed type)	Recovers high-temperature heat from melting furnaces by means of boilers and generates electricity using steam turbines. Comprises fluidized bed gasification furnaces and rotating melting furnaces.	Since 2000 (Commercialization phase)	Approx. 160,000 tons per year (Mixed processing with sludge)
	Kanemura Co., Ltd.* (Takuma Co., Ltd. / kiln type)	Recovers high-temperature heat from melting furnaces by means of boilers and generates electricity using steam turbines. Comprises indirect heating pyrolysis drums and high-temperature combustion melting furnaces.	Since 1998 (Commercialization phase)	Approx. 30,000 tons per year
	Eco Valley Utashinai (Hitachi Metals Co., Ltd. / shaft type)	Recovers high-temperature heat from melting furnaces by means of boilers and generates electricity using steam turbines. The entire process flow from drying to pyrolysis gasification to melting is handled by a single furnace.	Since 2002 (Commercialization phase)	Approx. 60,000 tons per year
	NKK Corporation (shaft type)	Uses the product as flammable gas with no power generated by a boiler. The entire process flow from drying to pyrolysis gasification to melting is handled by a single furnace.	Since 1996 (Demonstration phase)	Approx. 80,000 tons per year (mixed processing with other wastes)
Gasification reform technique	Kawasaki Steel Corporation (search-select type)	Gases generated by pyrolyzing and melting waste are reformed at high temperatures and recovered as refined gases.	Since 1999 (Commercialization phase)	Approx. 110,000 tons per year (mixed processing with other wastes)
	Yamanaka Co., Ltd. (Toshiba Corporation / PKA type)	Gases generated in pyrolysis furnaces are reformed at high temperatures into stable gases such as hydrogen and methane and recovered.	Since 2001 (Demonstration phase)	Approx. 20,000 tons per year
Nonferrous metal refining (Recycling of materials and heat recovery)	Onahama Smelting and Refining Co., Ltd.	Recovers valuable metals from the copper refining process and uses ASR as a substitute fuel for coal.	Since 1993	Approx. 180,000 tons per year
	Kosaka Smelting and Refining Co., Ltd.	Recovers valuable metals contained in ASR and uses the generated steam as a heat source for the adjoining refinery.	Since 2002	Approx. 50,000 tons per year
Reducing the volume of ASR generated				
Shredder-free dismantling	West-Japan Auto Recycle Co., Ltd.	Removes reusable components at the time of dismantling, presses the remainder into cubes, and provides them to electric furnace manufacturers as material for steel.	Since 2000	12,000 vehicles per year
Dismantler established by dealers affiliated with automobile manufacturers	Ibaraki Automobile Recycling Center Co., Ltd.	A dismantler of a relatively large-scale was established by dealers affiliated with automobile manufacturers to promote proper recycling.	Since 1995	24,000 vehicles per year
Glass recycling	Sheet glass manufacturers (Asahi Glass Co., Ltd. and other sheet glass manufacturers)	A technology to recycle side and windshield glasses as sheet glasses has been demonstrated.	Since 1998 Demonstration testing	—

* The company filed for Civil Rehabilitation Law bankruptcy protection in February 2002.
Source: Prepared by the Development Bank of Japan from publications, interviews, etc.

2.2 Approach Toward More Sophisticated ASR Processing

1) Efforts Toward More Sophisticated Sorted Processing of ASR

Technological development efforts to improve ASR processing with given conditions of volume of ASR produced and ASR composition are further divided into two subcategories: 1) those focusing on material recycling[1] technologies to recover valuable materials contained in ASR and 2) those focusing on heat recovery[2] technologies based on simultaneous pyrolysis and gasification melting. A typical example of the former is the efforts by Toyota Metals Co., Ltd. shown in Figure 3-2. However, it is obvious that the thorough sorted collection of ASR with fine categorization is not favorable in terms of costs, and thus their efforts are presently focused on research and development of recycling-oriented designs whose outcomes are fed back to the design departments of Toyota Motor Corporation.

2) Gasification Melting

With regard to technological development efforts of the latter category, some of the ASR gasification melting technologies are transitioning from the demonstration phase to the commercialization phase and attracting both domestic and international attention. In this area, not only plant manufacturers such as Ebara Corporation and Takuma Co., Ltd. but also steel manufacturers such as NKK Corporation and Kawasaki Steel Corporation are competing to develop technologies to apply melting furnace technologies to ASR processing.

Pyrolysis gasification melting techniques gasify garbage by roasting it at a temperature of 300 to 500℃, then melting and solidifying the residue using a high temperature of more than 1,000℃. As these techniques offer such advantages as little dioxin generation and easy recycling of by-products, they are being used in several areas as a new garbage disposal methods. However, it has been discovered that ASR processing using these techniques involves problems that impede the operation of the facility used due to the characteristics of ASR. For example:

1) There are large variations in properties depending on the selection and/or volume reduction method used;
2) The heating value and ash and salt contents are 3 to 4 times and 5 to 10 times higher than in the case of household garbage, respectively; and
3) Compared to household garbage, the contents of metals that generate low-melting-point substances when burnt such as Na, Cu, Zn, Fe, and Al are about 10 to (nearly) 100 times higher.

Thus the above-mentioned manufacturers are currently developing and implementing measures to solve these problems while building up their know-how.

For example, in the case of Ebara Corporation shown in Figure 3-2, they have encountered several problems due to the high PVC content in ASR and the many heavy metals included in ASR including the deposition of evaporated low-melting-point chlorides such as $ZnCl_2$ on the exhaust heat boiler (heat transfer piping) and the generation of dioxins catalyzed by copper oxides, and they have barely managed to bring the project to the operational stage by taking measures such as expanding the boiler and adding a process to remove the deposited ash by using sound waves.

Japanese technologies in this area are ahead of those of other countries, and many inquiries have been received from EU countries. These EU countries are acting now in anticipation of future increases in the number of end-of-life vehicles domestically processed and disposed of that will occur as a result of implementing the ELV Directive in these countries through their domestic legislation. These technologies may also lead to new business oppor-

---

[1] In material recycling (also called "mechanical recycling"), thorough sorted collection of "base" materials with fine categorization is made so that the recycled materials have the same composition as the base materials. The recycled materials are used to produce new products or mixed with new materials of the same kind or of different kinds to produce new products.

[2] Heat recovery is the recovery of heat for power generation by means of incineration, gasification melting, etc. It also includes the production of solid fuels (RDF) from waste.

tunities in the future as they have the potential to achieve technological innovations in the recycling of ASR, which is waste that is difficult to process and dispose of, and such technological innovations can be used in other fields to develop more sophisticated waste processing/disposal and recycling technologies.

3) ASR Recycling in the Nonferrous Metal Refining Industry

In the nonferrous metal refining industry, there have been many efforts to utilize existing technologies to recover rare metals from ASR and use ASR as an energy source.

For example, Onahama Smelting and Refining Co., Ltd., whose main business is contracted refining of copper ore, has been using ASR as fuel since 1993 as part of its drive to find alternative fuels for the only operating reverberatory furnace[3] in Japan. The company's processing capacity has increased to 10,000 tons per month from the initial capacity of 3,000 tons per month. Although they faced several problems as the capacity increased, such as the adherence of dust on the boiler and the fraying of refractory bricks due to the gas processing, they have solved the problems such as by introducing a spring hammer[4] and adjusting the oxygen concentration, and have achieved stable operation of the system. The company states that ASR is a very useful material because they can use it as a substitute for coal and extract copper at an average extraction rate of 4%.

Similarly, Kosaka Smelting and Refining Co., Ltd., which was spun off as a new company from Dowa Mining Co., Ltd. in 1990, has entered the field of ASR processing in earnest utilizing the know-how and expertise it accumulated in the rare metal recovery market, as it is in the business of recovering rare metals from cellular phones and waste printed circuit boards utilizing its know-how and expertise in the processing of complex ores (ores with high contents of impurities other than gold, silver, and copper, such as arsenic). The company plans to focus on the business of recovering rare metals from ASR and processing ASR to recover energy for reducing electricity consumption by utilizing its know-how accumulated in the processing of copper, lead, etc., as well as its network of affiliated and partner nonferrous metal refinery companies mainly in the Dowa Group in the Tohoku area.[5]

A common point among nonferrous metal refining companies with respect to ASR processing is the fact that they can take advantage of their existing facilities and know-how. In fact, in the case of Onahama Smelting and Refining Co., Ltd., the only additional facilities for ASR processing were stock areas (with a total capacity of 3,000 tons), belt conveyors to transport ASR to the reverberatory furnace, and an industrial oxygen plant to make up for the shortage in calorific value that is inherent in a furnace that uses ASR. The company has been able to pursue its pioneering efforts in ASR processing because it is the only company in Japan that still has an obsolete furnace of the reverberatory type. By the same token, the entry of Kosaka Smelting and Refining Co., Ltd. into the field of ASR processing would not have been possible without its accumulated know-how and expertise in the recovery of rare metals from complex ores and the network of affiliated and partner companies. Although the availability of such existing facilities and know-how is an advantage common among nonferrous metal refining companies, these cases represent a typical pattern of utilizing existing industrial infrastructures that concerns environmental industries, as does the processing of used plastics using blast furnaces and coke ovens.

---

3 Reverberatory furnace is a melting furnace that melts ores, etc. using a special furnace ceiling which reflects the flames and heat generated onto the furnace floor. It is advantageous in that there is no risk of generation of dioxins, because it operates continuously at a high temperature of 1,300℃.

4 A technique to remove dust by hitting the boiler with an H-shaped steel hammer steel.

5 For example, the company contracts the processing of hydroxides (Zn & Cd) it cannot process to Akita Zinc Co., Ltd. (Dowa Group), and the processing of zinc residue to Hachinohe Refinery Co., Ltd. (Mitsui Group). The company is also pursuing effective utilization of the dust generated by contracting the processing of dust to produce sulfuric acid, plaster, etc. to Nippon PGM Co., Ltd. (Dowa Group) and the processing of dust to produce electric lead, bismuth, etc. to Hachinohe Refinery Co., Ltd.

2.3 Comparison of Technologies Toward More Sophisticated ASR Processing

As discussed in Chapter 1, the annual volume of ASR generated is estimated to be approximately 800,000 tons, and is likely to remain at this level. In addition, because the non-reusable components of end-of-life vehicles are sometimes sent directly to electric furnaces or directly exported, the actual volume of ASR domestically processed and disposed of may actually be around 600,000 tons per year. Some of the plant manufacturers mentioned above are cautious not to enter the field in haste on a commercial basis, even though they have completed demonstrations of their processing technologies, because ASR is a waste that is difficult to handle and the volume of ASR generated will be limited.

How will ASR recycling infrastructures develop as Japan's automobile recycling framework develops? Regarding long-term development, it is necessary to take into consideration the effects of future reductions in the volume of ASR generated (which will be explained later). However, in the mid term (i.e. the next 10 years or so), the development of Japan's end-of-life vehicle recycling infrastructure is expected to be driven mainly by gasification melting furnace and nonferrous metal refining technologies, because the annual volume of ASR generated is unlikely to change significantly.

Table 3-3 shows a comparison between the two industries. Gasification melting furnaces are advantageous in that there are few plant location-related constraints and they can handle ASR and other wastes simultaneously (so the operator does not have to rely entirely on the ASR processing business). However, a large initial investment is required to build the facilities from scratch. In addition, a careful feasibility study is essential to ensure profitability because the only sources of revenue will be processing fees and electricity sales.

On the other hand, nonferrous metal refineries do not have to worry about large initial investments. Many nonferrous metal refineries have incorporated ASR processing as part of their main businesses to recover rare metals and use the recovered energy to reduce energy costs. Thus it is comparatively easier for them to recoup their investments and ensure profitability. However, they have to develop systems to collect ASR and reduce physical distribution costs because of location-related constraints.

In fact, the Onahama Smelting and Refining Co., Ltd. mentioned above has entered into contracts with about 20 shredding companies to ensure that a sufficient volume of ASR is collected, and has developed parking lots for trucks and stock areas to ensure a stable flow of ASR to the furnace. Similarly, Kosaka Smelting and Refining Co., Ltd. has identified reduction of the collection and physical distribution costs as one of the priority challenges to be addressed,

Table 3-3 Comparison between Two Approaches Toward More Sophisticated ASR Processing

	Gasification melting furnace	Nonferrous metal refining
Plant location-related constraints	Few	Not few
Simultaneous handling of ASR and other wastes	Possible	Not possible
Initial investments	Large	Small
Revenues and cost reduction effects	• Processing fees • Electricity sales, etc.	• Processing fees • Revenues from rare metal recovery operations • Cost reduction through the use of ASR as a substitute fuel and internal use of collected energy

Sources: Prepared by the Development Bank of Japan from publications, interviews, etc.

because it is situated in an inland area.

Two important considerations in evaluating the feasibility of a recycling business are the amount of processing fee (a service business revenue) and the sustainability of the flow of revenues arising from processing-based production and sale of recycled materials (manufacturing business revenues). In the case of ASR, processing fees have recently been stable at around 14,000 to 24,000 yen per ton according to data on actual fees charged by nonferrous metal refining companies, although the amount varies depending on composition. The fee is mainly determined based on the amount of the final disposal fee, and will likely increase slightly in the future, as 1) the disposal fee is expected to continue rising gradually as a whole and 2) if the automobile recycling fee under the envisioned recycling framework is assumed to be around 20,000 yen per vehicle as is currently expected, then more money can be spent on ASR processing in the future[6], although there will be processing capacity-related constraints.

However, as is clear from examples in other recycling areas such as the recycling of construction by-products and container and packaging materials, it is the second factor (sustainability of the flow of revenues arising from processing-based production and sale of recycled materials) that largely determines the sustainability and profitability of a recycling business. If we make a comparison between gasification melting and nonferrous metal refining in terms of the second factor, it is clear that the latter is more favorable because it enables processing-based production of various recycled materials from ASR and its residue and sale of such recycled materials, as well as recovery and sale of rare metals. Therefore, development of the domestic infrastructure is expected to be led by nonferrous metal refining businesses which are more sustainable and profitable than gasification melting furnaces, with gasification melting furnaces deployed in areas that cannot be covered by nonferrous metal refining businesses due to location-related constraints.[7]

2.4 Efforts Toward More Sophisticated Dismantling

There are also moves to reduce the volume of ASR generated by means of upstream improvements, that is, by making the dismantling processes more sophisticated.

The West-Japan Auto Recycle Co., Ltd. shown in Table 3-2 has been developing sophisticated end-of-life vehicle dismantling processes to achieve a “shredder-free dismantling” system with thorough recovery of valuable components and materials followed by pressing the remainder into cubes to be sent to electric furnaces and used as material for steel. This system still has many challenges to be addressed including how to ensure an adequate market for the recovered valuable components and materials and technical problems such as those relating to improving the quality of the steel recovered through pressing. Nevertheless, this system paves the way toward ASR-free recycling, and the sustainability and profitability of this kind of system will be improved as recycling-oriented designs become more popular and as reuse component/material markets develop.

There are also moves in some parts of Japan to enhance existing dismantling processes to minimize the volume of ASR generated. One example is the Ibaraki Automobile Recycling Center Co., Ltd. shown in Table 3-2. The company, which was established by dealers in Ibaraki prefecture that are affiliated with automobile manufacturers, started operation in 1995 and is currently handling 24,000 to 25,000 end-of-life vehicles annually (capacity: 30,000

[6] If the total weight of a vehicle is 1 ton and the share of ASR as a percentage of the total weight is about 30%, then about 1 ton of ASR can be recovered from three vehicles. If a fee of 20,000 yen is collected for each vehicle, the total amount of money that can be spent for three vehicles is 60,000 yen. If 50% of this is spent on ASR processing, theoretically about 30,000 yen can be spent for 1 ton of ASR.

[7] However, this scenario is not without problem. The global oversupply of copper and zinc in recent years has led to recessions in the markets for these metals, forcing some operators to close down. If this trend continues and the number of nonferrous metal businesses decreases dramatically, one of the important comparative advantages of nonferrous metal refining companies in recycling will diminish because there will be insufficient capacity to absorb the rare metals recovered.

end-of-life vehicles per year), which account for 16% of the number of vehicles becoming end-of-life vehicles in the prefecture (total number of automobiles: 2,200,000; number of vehicles deregistered annually: 150,000). The company has been able to maintain a high facility utilization factor because it has a constant flow of incoming end-of-life vehicles via its founders (new automobile dealers) despite the fact that its sophisticated dismantling operations are not advantageous in terms of cost. Because the company dismantles valuable components and materials thoroughly and sells them to outside consumers and users, the sale of used components (engines, hoods, doors, etc.) excluding rebuild components, used tires (the company has its own used tire shops) and used materials accounts for about 70% of the total revenue of the company, with the processing fee representing only about 30%.

There are now moves in the automobile dismantler industry toward establishing a relatively large dismantling business entity that engages in appropriate processing like Ibaraki Automobile Recycling Center Co., Ltd. in every prefecture. In fact, the company has received many visitors from local governments that wish to follow suit. Although there are many hurdles to be cleared before such a facility is actually constructed and put into operation, the spread of such moves will accelerate the evolution toward more sophisticated dismantling. Therefore, the registration and approval systems under the Automobile Recycling Law should be designed and implemented to facilitate these moves.

2.5 Recycling of Automobile Glasses as Sheet Glasses

Another development that is likely to contribute to ongoing efforts to reduce the volume of ASR generated and achieve more sophisticated dismantling is moves in the sheet glass industry to recycle automobile glasses as sheet glasses. Asahi Glass Co., Ltd. and other sheet glass manufacturers have recently been conducting demonstration experiments on technologies to recycle side and windshield glasses as sheet glasses, and the technical part of these demonstration experiments has reportedly already been completed. If commercialized, these technologies will enhance the level of dismantling with the addition of a glass recovery process and reduce the volume of ASR generated, because glasses account for about 16% of the total volume of ASR.

However, there are still many challenges to be addressed such as the establishment of an appropriate collection system and how to ensure quality of the collected glasses. It will take some time before glass processing is incorporated into the automobile recycling framework.

So far we have looked at two different approaches to end-of-life vehicle recycling, that is, an approach toward more sophisticated ASR processing and another toward more sophisticated dismantling. However, these two approaches are not contradictory but will complement each other in the development of Japan’s end-of-life vehicle recycling. It is expected that automobile recycling businesses in Japan will develop based on the former approach in the near term, as the annual volume of ASR generated will not decrease significantly, and as recycling-oriented designs spread and used component and material markets develop, the share of the latter approach will increase significantly. The legal target recycling rate of 95% by weight is a very high goal, and can only be achieved if the two approaches work complementarily to each other.

2.6 Recycling Efforts by Automobile Manufacturers

It goes without saying that efforts by automobile manufacturers are also important to achieve the target recycling rate of 95%. The environmental impacts of automobiles are highest during the consumption stage (especially when they are being driven by drivers) in the lifecycle of automobile, and so the ongoing competition among automobile manufacturers to improve fuel efficiency through lighter vehicles and hybrid vehicle technologies has contributed greatly to reducing environmental impacts. However, these efforts to improve fuel efficiency often conflict with the need to improve ease of recycling and dismantling. For example, the share of non-metal components used is increased by using resin for the fuel tank to reduce weight, and the number of components with complex shapes may be increased by changing to component structures to ensure that newly introduced smaller and/or lighter components have the strength required to satisfy the safety requirements. There are many areas where improvements can only be made through automobile manufacturers' efforts, including achieving an optimum balance between the conflicting demands for better fuel efficiency and ease of recycling and/or dismantling, and the selection of materials to improve ease of recycling and/or dismantling. Table 3-4 shows some of the ongoing efforts by automobile manufacturers.

For some components, measures are already being taken to improve recycling and to substitute hazardous substances with non-hazardous ones. In addition, systems are being developed to feed back information to design departments to improve ease of recycling and dismantling. Automobile manufacturers are actively seeking to develop systems to handle used components in preparation for the expected dramatic increase in the number of such components after the Automobile Recycling Law enters into force. After the new framework is introduced, these efforts will surely intensify and help improve the automobile recycling rate.

Table 3-4 Recent Automobile Recycling Efforts by Major Automobile Manufacturers

Activity		Description	Company
Recycling	Development of feedback systems for recycling-oriented designs	• Establishment of an "Automobile Recycling Research Institute" to internalize systems to feed back information relating to ease of recycling and/or dismantling.	Toyota Motor Corporation
		• Contracting of the development of an information feedback system to a subsidiary company	Nissan Motor Co., Ltd.
	Development of a recyclability evaluation system	• Development of a recyclability pre-evaluation system for new automobiles	Several automobile manufacturers
	Promotion of recycling	• Promotion of the use of single-material components and substitution of components with ones that are easier to dismantle and/or recycle (e.g. substitution of engineering plastics with PP)	Several automobile manufacturers
		• Engaged in the recycling of side and windshield glasses of automobiles into glass wool in partnership with dismantlers. Also entered the field of automobile recycling singly.	Fuji Heavy Industries, Ltd.
		• Established a technology to achieve 100% recycling of bumpers (made of PP) recovered from end-of-life vehicles for new automobiles.	Honda Motor Co., Ltd.
		• Has demonstrated techniques to collect and recycle valuable metals through sorted collection of ASR with fine categorization.	Toyota Motor Corporation
Used components	Reusing and rebuilding of dismantled components	• Strengthening of the business of selling components collected through partnerships with dismantlers using sales networks. The business of selling collected components after inspection and repair as rebuilt components will also be strengthened.	Several finished automobile manufacturers
Hazardous substance countermeasures	Substitution with water-based paints	• Use of water-based paints not only for the base and intermediate paint layers but also for the colored surface paint layer. Reduction in the quantity of toluene and xylene used.	Nissan Motor Co., Ltd. (Kyushu Plant) and other automobile manufacturers
	Elimination of the use of halogens	• Development of a halogen-free wiring harness through substitution of PVC, which is widely used for coating, with PP, etc. In addition, efforts are being made to reduce the quantity of halogens used by reducing the concentration of chlorine.	Yazaki Corporation
	Elimination of the use of lead	• The industry-wide goal of reducing the quantity of lead used to 50% or less from the 1996 figure had been set and was achieved mainly for vehicles put on the market in fiscal 2000.	Several finished automobile manufacturers
		• Substitution of lead used as the curing agent for the rubber hose of the hydraulic power steering system with magnesium	Koyo Seiko Co., Ltd., Meiji Rubber & Chemical Co., Ltd.

Sources: Prepared by the Development Bank of Japan from published environmental reports and press articles.

3. Afterword

In this report, we have compared domestic and overseas regulatory trends in the recycling of end-of-life vehicles, which constitute a special category of PCW, and discussed the implications of these trends on future recycling businesses.

Because automobiles inherently provide relatively high incentives for recovering resources compared with other products, Japan's new automobile recycling framework will basically be a modification of the existing one, as in European countries. There will also be a parallel between the future path of the Japanese automobile recycling industry and those of European countries in the sense that once a system is established to channel all or most end-of-life vehicles to a sophisticated recycling flow through the development of the framework, the establishment of an effective ASR recycling technology will become a central challenge because of the difficulty of ASR processing although the volume of ASR generated will be limited.

Two important developments in the ongoing evolution of Japan's automobile recycling industry are 1) intensification of efforts by Japanese companies to utilize existing know-how and expertise in recycling infrastructure development such as those evident in the nonferrous metal refining industry and 2) advancements in some new technologies that have put Japanese companies ahead of other countries in terms of commercialization such as those seen in the utilization of gasification melting technologies. The implementation and elaboration of the new automobile recycling framework in the coming years will surely lead to further technological innovation.

References

Amemiya, Takashi. 2001, "Toshiba Netsubunkai Gas-ka Kaishitsu System - Shredder-dast no Senshintekina Thermal Recycle Gijutsu (Toshiba's Thermal Decomposition Gasification Reform System – An Advanced System to Recover Heat from Automobile Shredder Residue)," Automobile Studies, No. 12, Vol. 23, Japan Automobile Research Institute, Inc.

Auto Recycling Nederland BV. 2000, Milieuverslag Envronmental Report 2000.

Automobile Electronics Research Group, Sogo Giken Co., Ltd. (ed.). 2001, "Jidosha Electronics no Genjyo to Shourai Bunseki (Current Situations Surrounding the Automobile Electronics Industry and Predictions on the Future of the Industry)," Sogo Giken Co., Ltd.

Cord-Landwehr, Klaus. 2000, Einführung in die Abfallwirtschaft, B.G. Teubner.

European Commission. 2001, Comments Pursuant to Article 88 (2) of the EC Treaty Concerning the Waste Disposal System for Car Wrecks in the Netherlands, Official Journal of the European Communities.

Funazaki, A., and K. Taneda. 2000, "2002-nen Shiyouzumi Jyoyousha no LCA (Automobile Lifecycle Assessment of End-of-Life Vehicles in 2002, Automobile Studies)," No. 12, Vol. 22, Japan Automobile Research Institute, Inc.

Hayashi, Seiichi. 2001, "Tenkanten ni Tatsu Nihon no Tetsu Recycle (Japan's Steel Recycling at a Turning Point)," Nippon Steel Technical Information Center, Co., Ltd.

Ishikawa, Yoshiaki (ed.). 2001, "Saisentan no Gomi Shori Youyu Gijutsu – Netsubunkai Gas-ka Youyu Gijutsu to Shoukyaku Zansa Youyu Gijutsu (State-of-the-Art Melting Technologies for Garbage Disposal – Thermal Decomposition Gasification Melting and Incineration Residue Melting Technologies)," Nippo Kikaku Hanbai Inc.

Iwano, M., T. Yasuda, and N. Kusakawa. 1997, "Jidoshayou Plastic 'Jidosha no Koukinou-ka to Kankyo-Anzen Needs' e-no Taiou (Plastics for Automobiles – Adaptation to the Trend of Increasing Sophisticated Functions in Automobiles and Satisfaction of Environmental and Safety Needs)," Kogyo Chosakai Publishing, Co., Ltd.

Japan Automobile Manufacturers Association, Inc. and Japan Auto Parts Industries Association. 2001, "Airbag Inflator Kaishu Shori System (Airbag Inflator Collection and Processing/Disposal System)."

Japan Automobile Research Institute, and Japan Machinery Federation. 1995, "Jidosha kanren Mi-Kiseibun ni kansuru Doukou Chosa 'Jidousha no Shredder Dast ni kansuru Chosa' (Report of a Trend Survey on an Unregulated Aspect of the Automobile Industry (a report on situations surrounding automobile shredder residue in Japan))."

Japanese Branch Office of the German Chamber of Commerce (ed.) 1997, "Shakai wo Kaeruka Deutschland no Junkan Keizai, Haikibutsu-ho" (Will the German Cyclical Economy and Waste Law Change Society?)," Japanese Branch Office of the German Chamber of Commerce.

Kahmeyer, M., and R. Rupprecht. 1996, Recyclinggerechte Produktgestaltung, Vogel Buchverlag.

Kajiwara, Takuji. 2001, "Jidosha Recycle (Automobile Recycling)," Kogyo Chosakai Publishing, Co., Ltd.

Kato, R., and K. Miyoshi. 2001, "Shredder Dast no Thermal Recycle Gijutsu 'Ryudou Shouro-houshiki' (Technology to Recover Heat from Automobile Shredder Residue (Fluidized Bed Furnace Method)," Automobile Studies, No. 12, Vol. 23, Japan Automobile Research Institute, Inc.

Masumoto, Tsuyoshi. 1997, "Kinzoku Nandemo Shojiten – Genso no Tanjyo kara Amorphous Kinzoku no Tokusei made (The A to Z of Metals – From the Birth of the Chemical Elements to the Characteristics of Amorphous Metals)," Kodansha Ltd.

Miyoshi, F., M. Shimizu, and A. Taira. 2001, "Kawatetsu – Thermo Select Hoshiki Haikibutsu Gas-ka Youyu Process (Kawasaki Steel's ThermoSelect Gasification Melting Process for Waste, Automobile Studies)," No. 12, Vol. 23, Japan Automobile Research Institute, Inc.

Numajiri, Itaru. 2001, "Oshu no Jidousha Recycle no Genjyo (Current Situations Surrounding Automobile Recycling in European Countries, Automobile Studies)," No. 12, Vol. 23, Japan Automobile Research Institute, Inc.

_____. 2001, “Jidosha no Lifecycle Assessment (LCA) to Recycle Tenbou (The Outlook for Future Automobile Recycling and Automobile Lifecycle Assessment, Automobile Studies),” No. 1, Vol. 23, Japan Automobile Research Institute, Inc.

Recycling Technology Subcommittee (ed.) 2001, “Seiritsu Majika no Jidosha Recycle-ho to Saishin Gijutsu – Dounaru Nihon no Jidousha Recycle (The Impending Enactment of the Automobile Recycling Law and Latest Technologies – What Will the Future Bring to Japan’s Automobile Recycling?),” Japan Society of Automobile Engineers

Sano, A., and K. Shichida. 2000, “Kakudai suru Kigyo no Kankyo Sekinin (Increasing Environmental Liability of Enterprises – From the German Cyclical Economy Law to 3 Different EPR Policy Approaches (Japan, the United States, and the EU)),” Kankyo Shimbunsha, Co., Ltd.

Schnurer, Helmut. 2001, Neuse zum Deponierecht “EG-Deponie-Richtlinie und die Umsetzung in eine deutsche Deponie-Verordnung,” Bundesumweltministerium.

Takegahara, Keisuke. 2001. "Introduction of a Home Appliance Recycling System: Effects & Prospects: Progress towards Utilisation of Recycling Infrastructure," DBJ Research Report No. 18.

_____. 2002. "Urban Renewal and Resource Recycling: For the Creation of a Resource Recycling Society," DBJ Research Report No. 28.

Togawa, Kenichi. 1998, “Jidosha Shangyo no Jyoumyakubu – Jidousha Recycle ni kansuru Keizai-Chirigaku-teki Kenkyu (The “Vein” Side of the Automobile Industry – An Economic Geographical Study on Automobile Recycling),” Taimeido, Inc.

_____. 2001, “Jidosha to Recycle – Jidosha Sangyo no Jyoumyakubu ni kansuru Keizai-Chirigaku-teki Kenkyu (Automobile and Recycling – An Economic Geographical Study on the “Vein” Side of the Automobile Industry),” Nikkan Jidosha Shimbun Co., Ltd.

Tomiyoshi, Kenichi. 2001, “Aratana Jidosha Recycle System no Kento Jyoukyo (A Report on the Present Status of Discussions on the New Automobile Recycling System),” Automobile Studies, No. 12, Vol. 23, Japan Automobile Research Institute, Inc.

Tsugawa, Takashi. 2000, “Kensho – Gas-ka Youyuro – Dioxin-Taisaku no Kirifuda-ka (An Anatomy of Gasification Melting Furnace – Will It Be the Ultimate Dioxin Countermeasure?,” Ryokufu Shuppan, Inc.

Unweltbundesamt. 1999, Anforderung an das Monitoring im Rahmen der Verwertung langlebiger, technisch komplexer Produkte am Beispiel des Altautos, Umweltbundesamt

Unweltforschungsplan des Bundesministeriums fur Umwelt, Naturschutz und Reaktorsicherheit. 2000, Evaluation of Financing Models for Collection Schemes for End-of-Life Vehicles Free of Charge.

Yamane, Hiroko. 1995, “Shinban – EU/EC ho – Oshu Rengo no Kiso (EU/EC Laws; Revised Edition – ABCs of the European Union),” Yushindo Kobunsha, Inc.

Other sources of information: Publications and literature of the Automobile Working Group of the Waste and Recycling Subcommittee of the Environmental Committee of the Industrial Structure Council, publications and literature of the Automobile Recycling Subcommittee of the Waste and Recycling Committee of the Central Environmental Council, web sites of companies, organizations, and government agencies, and environmental reports.

List of Back Numbers (Including JDB Research Report)

No. 14 Consumption Demand Trends and the Structure of Supply: Focus on Retail Industry Supply Behavior, March 2001

No. 13 Recent Trends in the Japanese Economy: Weakness of Current Economic Recovery and Its Background, March 2001

No. 12 Empirical Reassessment of Japanese Corporate Investment Behavior: Features and Changes since the 1980s, based on Micro-level Panel Data, March 2001

No. 11 Survey on Planned Capital Spending for Fiscal Years 1999, 2000 and 2001, October 2000

No. 10 Job Creation and Job Destruction in Japan, 1978-1998: An Empirical Analysis Based on Enterprise Data, September 2000

No. 9 Recent Trends in the Japanese Economy: Information Technology and the Economy, September 2000

No. 8 Trend of International Reorganization Affecting the Japanese Automobile and Auto Parts Industries, June 2000

No. 7 Survey on Planned Capital Spending for Fiscal Years 1999 and 2000, June 2000

No. 6 Current Status and Future Perspective of the Japanese Remediation Industry: Technology and Market for Underground Remediation, May 2000

No. 5 Recent Trends in the Japanese Economy: The 1990s in Retrospect, March 2000

No. 4 Destabilized Consumption and the Post-bubble Consumer Environment, February 2000

No. 3 The Slump in Plant and Equipment Investment in the 1990s: Focusing on Lowered Expectations, the Debt Burden and Other Structural Factors, January 2000

No. 2 Survey on Planned Capital Spending for Fiscal Years 1998, 1999 and 2000, November 1999

No. 1 Corporate Strategies in Japan's Semiconductor Industry: Implications of Development in Other Asian Countries, November 1999

JDB Research Report

No. 96 Recent Trends in the Japanese Economy: Focused on Fixed Investment and Capital Stock, August 1999

No. 95 Efforts to Protect the Natural Environment in the United States and Germany: Environmental Mitigation and Biotope Conservation, July 1999

No. 94 Survey on Planned Capital Spending for Fiscal Years 1998 and 1999, June 1999

No. 93 Towards the realization of 'environmental partnership': A survey of Japan's environmental NPO sector through comparison with Germany, June 1999

No. 92 The Impact of Demographic Changes on Consumption and Savings, March 1999

No. 91 Recent Research and Development Trends in Japanese Enterprises: Technology Fusion, March 1999

No. 90 Recent Trends in the Japanese Economy: Prolonged Balance Sheet Adjustment, January 1999

No. 89 Impact of Asset Price Fluctuations on Household and Corporate Behavior: A Comparison between Japan and the U.S., December 1998

No. 88 Survey on Planned Capital Spending for Fiscal Years 1997, 1998, and 1999, December 1998

No. 87 Foreign Exchange Rate Fluctuations and Changes in the Input-Output Structure, November 1998

No. 86 Structural Changes in Unemployment of Japan: An Approach from Labor Flow, November 1998

No. 85 Recent Trends in the Japanese Economy: Characteristics of the Current Recession, August 1998

No. 84 R&D Stock and Trade Structure in Japan, August 1998

No. 83 Survey on Planned Capital Spending for Fiscal Years 1997 and 1998, August 1998

No. 82 The Significance, Potential, and Problems of DNA Analysis Research: Establishing Public Acceptance is Essential, May 1998

No. 81 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1996, 1997 and 1998 Conducted in August 1997, March 1998

No. 80 Recent Trends in the Japanese Economy: Growth Base of the Japanese Economy, January 1998

No. 79 Information Appliances: The Strength of Japanese Companies and Tasks for the Future, January 1998

No. 78 Challenges and Outlook for the Japanese Machinery Industries: Impact of ISO14000 Series and Environmental Cost, January 1998

No. 77 Current Conditions and Issues of Computerization in the Health Care Industry: For the Construction of a Health Care Information Network, January 1998

No. 76 Household Consumption and Saving in Japan, December 1997

No. 75 The Direction of Japanese Distribution System Reforms: Strengthening the Infrastructure to Support Diverse Consumer Choices, November 1997

No. 74 Foreign Direct Investments by Japanese Manufacturing Industries and Their Effects on International Trade, October 1997

No. 73 The Impact of the Changing Trade Structure on the Japanese Economy: With Special Focus on the Effects on Productivity and Employment, October 1997

No. 72 An Analysis of Foreign Direct Investment and Foreign Affiliates in Japan, August 1997

No. 71 Recent Trends in the Japanese Economy: Stock Replacement and New Demand as Aspects of Economic Recovery, August 1997

No. 70 Corporate Fundraising: An International Comparison, June 1997

No. 69 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1996 and 1997 Conducted in February 1997, May 1997

No. 68 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1996 and 1997 Conducted in August 1996, August 1997

No. 67 An International Comparison of Corporate Investment Behavior: Empirical Analysis Using Firm Data from Japan, France and the US, April 1997

No. 66 Housing in the National Capital: Analysis of the Market for Housing using Micro Data, March 1997

No. 65 The Environment for Locating Business Operations in Major East Asian Cities, January 1997

No. 64 Direction of Reconstruction of Business Strategy in the Chemical Industry, January 1997

No. 63 Reflection on Discussions Concerning Regulation of the Electric Power Industry: Deregulation of the Electric Power Industry in Japan and Implication of Experiences in the United States, December 1996

No. 62 Current Status and Future Perspective of the Japanese Semiconductor Industry, November 1996

No. 61 A Breakthrough for the Japanese Software Industry?: Responsiveness to Users' Needs is the key, October 1996

No. 60 Recent Trends in the Japanese Economy Focusing on the Characteristics and Sustainability of the Current Economic Recovery, September 1996

No. 59 Analysis of the Primary Causes and Economic Effects of Information: Related investment in the United States and Trends in Japan, August 1996

No. 58 Selected Summaries of Research Reports: Published in FY1995, June 1996

No. 57 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1995 and 1996 Conducted in February 1996, May 1996

No. 56 Recent Trends in the Japanese Economy, May 1996

No. 55 Issues Concerning the Competitiveness of the Japanese Steel Industry, February 1996

No. 54 Changes in the Financial Environment and the Real Economy, January 1996

No. 53 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1994, 1995 and 1996 Conducted in August 1995, October 1995

No. 52 Current Economic Trends: Focusing on the Appreciation of the Yen and its Effects, October 1995

No. 51 Problems Concerning the International Competitiveness of the Petrochemical Industry, October 1995

No. 50 An Economic Approach to International Competitiveness, October 1995

No. 49 Selected Summaries of Research Reports Published in FY1994, July 1995

No. 48 Strategies for Improving the Efficiency of the Japanese Physical Distribution System: Part 2, July 1995

No. 47 Issues on International Competitive Strength of the Auto Industry, June 1995

No. 46 Problems Concerning the International Competitiveness of the Electronics and Electric Machinery Industry, June 1995

No. 45 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1994 and 1995 Conducted in March 1995, June 1995

No. 44 Strategies for Improving the Efficiency of the Japanese Physical Distribution System, March 1995

No. 43 Capital Spending Recovery Scenario Cycle and Structure, August 1994

No. 42 Progress of International Joint Development between Industrialized Countries on the Private Level, May 1994

No. 41 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1993, 1994 and 1995 Conducted in August 1994 , November 1994

No. 40 Selected Summaries of Research Reports Published in FY1993, June 1994

No. 39 Recent Trends in Japan's Foreign Accounts, April 1994

No. 38 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1993 and 1994 Conducted in March 1994, April 1994

No. 37 Economic Zones and East Asia Prospect for Economic Activity Oriented Market Integration, December 1993

No. 36 Japanese Corporate Responses to Global Environmental Issues, December 1993

No. 35 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1992, 1993 and 1994 Conducted in August 1993, September 1993

No. 34 Structure of Profit to Capital in the Manufacturing Industry, September 1993

No. 33 Comparison of the Japanese and The U.S. Labor Markets, October 1992

No. 32 The Relative Competitiveness of U.S., German, and Japanese Manufacturing, March 1993

No. 31 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1992 and 1993 Conducted in March 1993, April 1993

No. 30 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1991, 1992 and 1993 Conducted in August 1992, December 1992

No. 29 Flow of Funds in the 80s and Future Corporate Finance in Japan, November 1992

No. 28 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1991 and 1992 Conducted in February 1992, April 1992

No. 27 An Analysis of Foreign Direct Investment in Japan, March 1992

No. 26 Projection of Japan's Trade Surplus in 1995: Analysis of Japan's Trade Structure in the 80s, February 1992

No. 25 Intra-Industry Trade and Dynamic Development of The World Economy, November 1991

No. 24 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1990, 1991 and 1992 Conducted in August 1991, September 1991

No. 23 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1990 and 1991 Conducted in February 1991, March 1991

No. 22 Trends of the Petrochemical Industry and its Marketplace in East Asia, March 1991

No. 21 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1989, 1990 and 1991 Conducted in August 1990, September 1990

No. 20 Deepening Economic Linkages in The Pacific Basin Region: Trade, Foreign Direct Investment and Technology, September 1990

No. 19 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1989 and 1990 Conducted in February 1990, March 1990

No. 18 Petrochemicals In Japan, The US, and Korea an Assessment of Economic Efficiency, February 1990

No. 17 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1988, 1989 and 1990 Conducted in August 1989, October 1989

No. 16 Impact of the EC Unification on Japan's Automobile and Electronics Industries, August 1989

No. 15 Industrial and Trade Structures and the International Competitiveness of Asia's Newly Industrializing Economies, August 1989

No. 14 The Japan Development Bank Reports on Capital Investment Spending: Survey for Fiscal Years 1988 and 1989 Conducted in February 1989, March 1989

No. 13 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1987, 1988 and 1989 Conducted in August 1988, September 1988

No. 12 Growing Foreign Investors' Activities and the Future of Internationalization, September 1988

No. 11 Futures Tasks and Prospects for the Japanese Machine-Tool Industry, July 1988

No. 10 International Division of Labor in the Machine Industries Among Japan, Asia's NICs and ASEAN Countries, June 1988

No. 9 Trends of the Petrochemical Industry and its Marketplace in East Asia around Japan, May 1988

No. 8 The International Competitiveness of Japan and U.S. in High Technology Industries, April 1988

No. 7 The Japan Development Bank Reports on Private Fixed Investment in Japan, March 1988

No. 6 Economic Projections of the Japan's Economy to the Year 2000, February 1988

No. 5 The Japan Development Bank Reports on Private Fixed Investment in Japan, September 1987

No. 4 Current Trends in the Japanese Auto Parts Industry in Overseas Production, July 1987

No. 3 Current Moves for Foreign Direct Investment into Japan, May 1987

No. 2 Overseas Direct Investments by Japanese Corporations, May 1987

No. 1 Current U.S. Consumption Trends, May 1987