

**BMW: A PROACTIVE APPROACH TO VEHICLE RECYCLING**

Field Study Series on Environment and Industrial Competitiveness

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## CASE A: Abstract

In August 1990, Germany's Environmental Ministry established a draft regulation that would require automobile manufacturers to be responsible for the proper reuse and disposal of old vehicles. While the goal of the regulation was to catalyze joint research efforts among affected parties, including manufacturers, suppliers, and the companies that dismantle vehicles, the imposition of the regulation was a reflection of years of growing public concern over solid waste. BMW AG, a small but successful German auto manufacturer, has been a leader of discussions aimed at developing a viable recycling system. By making proactive investments in recycling and interacting directly with regulators on recycling plans, BMW may be positioned to develop a competitive advantage out of its recycling expertise. While the course of EC and US vehicle recycling legislation remains uncertain, German companies would be expected to have a significant impact on legislative outcomes, based upon the expertise they have gained in Germany.

### 1. Introduction

*"We know it is important to react to developments with speed and agility. Equally, it is vital at an early stage to allow in our planning for possible future developments. After all, we are working today on cars that will not be on the roads for ten or even twenty years. Thus, we help to shape the future. A form of mobility not new to us is to imagine what is currently unimaginable."*

**- Eberhard von Kuenheim, Chairman of BMW, in 1990 Annual Report**

Throughout the 1980s, Germans were becoming more concerned about solid waste. As landfill space declined and incineration became less feasible, the public and regulators began to look for new solutions to growing solid waste. Rather than develop new technologies to treat this growing pool of waste, why not make manufacturers responsible for the waste associated with their products? To reduce the amount of waste generated in the first place, why not extend this responsibility not only to waste minimization in production, but also to "takeback" of a product once it had reached the end of its useful life?

This debate has serious implications for Germany's leading automobile manufacturers, companies such as Volkswagen, Daimler-Benz, Opel (General Motors), and BMW. Automobile companies are major contributors to Germany's economy and highly visible corporate citizens. In assessing their own responsibilities as corporate citizens, they began to look at their contributions to landfills, in the form of "shredder waste" (a combination of glass, fabric, plastics and liquids from used cars), which have been modest but are growing rapidly. Moreover, this shredder waste is increasingly being classified as hazardous and, therefore, requires disposal methods other than landfill. If auto companies must take back this waste, they will have serious environmental and economic problems on their hands.

Recycling of old vehicles has quickly moved to the top of the list of environmental priorities

for automobile companies. During the 1980s, some companies began working on their own to develop expertise in recycling. However, while auto companies can make significant strides by advancing recycling expertise internally, they need the cooperation of suppliers and auto dismantlers and shredding companies in order to dramatically reduce old vehicle waste in an economic fashion. Auto dismantlers are the companies that pull apart used vehicles in order to reclaim and sell components and valuable metals, and shredders are the companies which shred and sort the remaining hulks of vehicles to reclaim remaining metals. Both are disgruntled because the economics of dismantling and shredding are becoming much less favorable, as landfill prices increase and incineration regulations become more stringent. Should the dismantling and shredding industries disappear, auto producers might have to dismantle old vehicles themselves, a financially undesirable prospect.

In August 1990, the Environmental Ministry of the German government accelerated the debate by issuing a draft regulation establishing a timetable in which automobile producers must develop a plan that assures the takeback of old vehicles and maximum recycling of materials. The draft regulation has catalyzed a series of discussions to coordinate recycling strategy, not only among the automobile companies, but also with materials suppliers, component producers, and dismantlers.

BMW AG (hereafter "BMW" or the "company") has been a leader in recycling strategy since regulatory discussions first began. BMW recognized the emerging concern over old vehicle waste well in advance of regulatory discussions, and invested in technologies to increase the reuse of materials from old cars. They worked with regulators to develop a recycling strategy, and they are now leading members of industry consortia that are experimenting with recycling technologies that will serve as the basis for the final regulations. This case does not suggest that BMW was the only German company participating in recycling strategy, but it does illustrate the opportunities that may arise when a single company takes a proactive approach to environmental management. This paper attempts to answer three questions:

- 1) Can companies that invest proactively in recycling gain opportunities to increase their competitiveness?
- 2) From the regulatory perspective, how can regulation be implemented most effectively to reduce waste from old vehicles, thereby relieving pressure on landfilling and incineration problems?
- 3) Seen in an international context, do the German regulations provide a competitive edge to German producers in the German, European or global automobile markets?

The focus of this paper on German automobile recycling is particularly relevant, as similar regulations are now being considered in the European Community. The results of German and EC discussions will likely become a model for the US and for other countries seeking to establish regulations for old vehicle recycling in the near future.

## 2. The Growing Solid Waste Problem in Germany

In the decade of the 1980s, regulators attempting to improve environmental quality began to focus more seriously on the automobile industry. While the fuel efficiency and emissions levels of "mobile sources" had long since been regulated, there were no specific regulations that dealt with the fate of a spent vehicle (one that had reached the end of its useful life), or with the design changes that could be made to new vehicles in order to reduce waste in the future. However, a number of trends were pointing towards a potential waste management crisis for the automobile industry:

### 2.a. Landfill and Incineration Becoming More Costly

With the amount of waste growing in all industrial sectors, legislation over the use of landfill and incineration methods is increasing in stringency. Certain types of waste that were previously accepted by landfill are now prohibited, as for example in Germany, where permitted levels of PCBs in waste have been falling. As a result, landfill prices in Germany, already much higher than those in the U.S. and some European countries, have increased rapidly.

Year	German Landfill Prices (per ton, in DM)	Comments
1987	20	Classification as ordinary waste
1988	30	
1989	40	
1990	60	Scrap car regulation introduced
1991	120	
1992	350	Certain to be higher with classification as hazardous waste (around 600DM)

(Source: BMW)

### 2.b. Design Changes Increase Use of Polymers

Forty years ago, the metal content in vehicles was considerably higher than it is today. Iron and steel have been reduced over the last 20 years from 80% to about 60-70% of total vehicle weight. Since these metals have value in secondary metal markets, the percentage of the vehicle that gets recycled has roughly corresponded to the metal content, around 75%. Reprocessed steel which has little contamination from "tramp metals" (copper and zinc) can be used for critical applications, while the remainder can be used for products such as reinforcing bar. While this recycling is efficient, it is often not a "closed loop" recycling system, wherein metals recaptured from a vehicle are reused in production of new vehicle parts.

Over the years, auto designers have sought to increase performance, reduce noise and corrosion, and add new comfort features, all the while reducing car weight in order to increase fuel efficiency and reduce emissions. Advancements in the development and use of polymers have been critical to implementing these design changes. Currently, a typical car is 10-12% polymers by weight, up from less than 5% 20 years ago, and this figure is expected to grow to 15% in coming years. *Exhibit 1* shows plastics content in each of BMW's major model series.

In addition to polymers' weight advantages, they are also easily moldable to close tolerances and can be cheaper than steel when frequent production changes are necessary. Producers commonly use on the order of 20 different polymers per car. While they are primarily used for interior trim, they may also be found in locations such as the engine, fuel tank, and car body. The following chart shows the variety of plastics (and weight, in kg) found in a BMW 5-series model:

Plastic	Weight	% of All Plastic
PUR- Polyurethane	31.2	20.9
PA- Polyamide	17.8	11.9
PE- Polyethylene	16.4	11.0
PP- Polypropylene	14.3	9.6
UP-GF- Unsat. Polyester	14.1	9.5
PBT+PC- (Blends)	11.1	7.4
PVC- Polyvinylchloride	10.6	7.1
ABS- A-B Styrene	9.4	6.3
ALL OTHERS	35.5	22.5
<b>TOTAL</b>	<b>159.0</b>	<b>100.0</b>

(Source: BMW)

In order for polymers to be recycled, they must be separated; the more polymers in a vehicle, the more effort is required to separate them. In addition, polymers are easily contaminated by substances such as paint, glue and other connecting materials, and additives like fiber and talc. These impurities all reduce the value of the waste polymer, as the polymer loses some of its original characteristics and the consistency of the scrap product is lessened. Substantial capital investment would be required by dismantlers to achieve purer polymer streams. Even if these methods were effective, there would have to be strong secondary markets for polymer waste streams in order to provide incentives for recyclers to separate them.

### 2.c. Vehicle Shredder Waste Grows

"Dismantlers" are the organizations that receive used and wrecked vehicles from their

owners, and pull apart the vehicles in order to claim components and materials that have value. Shredding companies use machines that shred the remaining hulk and sort ferrous and non-ferrous metals that can be sold in metal markets. *Exhibit 2* describes the dismantling and shredding industries. These organizations range from "mom and pop shops" to larger organizations, and they often have a relationship with a major metals producer, thus ensuring that the materials they recapture have a ready buyer. Dismantlers and shredders typically recoup about 75% of the material from a used or wrecked vehicle; it is the 25% remainder that presents waste management challenges (See *Exhibit 3*).

Once a vehicle has been shredded and valuable materials have been separated, the dismantler is left with "shredder waste" (also called "fluff"), a combination of polymers, textiles, glass, wood, dirt and other materials. Shredder waste is typically landfilled, since it is mixed waste and has no market value. The net result of increased polymer use is increased shredder waste. The following table indicates the size of the shredder waste problem throughout Europe.

Country	Year	Shredder waste (* 1,000s tons)	
		total	from cars
Germany	1989	530	400
UK	1990	500	N/A
France	1990	N/A	398
Italy	1990	N/A	300
Netherlands	1989	140	115
Denmark	1990	40	10

*(Source: Estimates compiled from BMW, Frank den Hond, CEST (London). All these figures are considered to be extremely conservative.)*

To put the figures for Germany in perspective:

- Vehicle shredder waste is about 1-2% of total municipal solid waste
- The annual growth rate for shredder waste exceeds 20%, implying that it is becoming a bigger part of the problem
- Shredder waste is difficult to handle- it is mixed waste, it stays in landfills for long periods of time, and has high PCBs and heavy metals content

#### *2.d. Number of Disposed Vehicles Grows*

The number of cars that must be disposed is rising annually, and landfill and incineration disposal costs are rising rapidly. There are between 12 and 14 million cars which must be disposed annually in Europe, and Germany represents about 2.4 million (source: VDA, Germany), or 20% of the total. Although vehicle lifetimes are expanding, increasingly stringent environmental legislation, which requires retirement of heavy-polluting vehicles, is

holding cars' real life-spans in check. As net car sales continue to grow, the number of automobiles to be disposed per annum will rise.

## **2.e. Conclusions**

While the increasing use of polymers has been positive from the perspective of improving vehicle quality, it has exacerbated solid waste problems. Based on projections for average car lifetimes, number of cars in use, average percentage plastic per car, and the average weight of a car, polymer waste is expected to grow by at least 50% between 1990 and 1995, and perhaps 2-3x by the year 2000.

Based on the trends described above, the economics of auto recycling is worsening, and the dismantlers industry is becoming threatened. Prior to the increase in polymer use, dismantlers provided a valuable role by taking back vehicles and recapturing materials. They did it because it was economically attractive to do so; the market determined the cost of disposal to the owner of the vehicle. As much as 75% of the vehicle was being recouped, with the remainder going to landfill or incineration.

However, the lower levels of valuable materials in a vehicle and the higher landfill costs are reducing the margins of dismantlers; some predict that most would go out of business by 1995 if current trends continue (although that argument is disputed by others- see the work of Dr. Frank Field, MIT). The fate of dismantlers is of great concern to automobile manufacturers. Even in the absence of regulation, a dissolution of the dismantlers and shredders industries would create a crisis of excess waste from used vehicles. As plastics use in vehicles continues to grow, automobile manufacturers must take proactive measures to better manage plastics waste.

## **3. Options Available to the Automobile Industry**

Automobile companies cannot reduce shredder waste by dealing with it as an isolated problem; it is an "output" that results both from lack of considerations in design and production and from suboptimal recycling and sorting by dismantlers and shredders. It is also a prospective "input," as the polymers in shredder waste can be used again to make new vehicle components or other products. Reducing shredder waste therefore means reassessing and altering major segments of car design, production and disposal.

Companies which already have internal waste minimization programs will have some of the skills required to address the "external" problem of shredder waste. There are two components to the problem: utilizing current waste from old vehicles produced in the late 1970s and 1980s, and reducing waste in the long-term by changing the way manufacturers produce cars. The latter involves the integration of environmental considerations into design, production, maintenance and disposal, and coordination with suppliers and dismantlers. The following strategies may be applied to the vehicle waste problem:



### *3.a. Production Efficiency*

While preventing pollution in the production process does not directly affect the shredder waste problem, it does improve the company's environmental performance and saves money. The knowledge developed in reusing cuttings or in reusing water, solvents and other materials can be directly applied to the challenges of reusing post-consumer waste.

### *3.b. Research on Effective Vehicle Dismantling*

The most immediate challenge is to increase the amount of a vehicle that gets reused. Design changes have no immediate benefit, because the cars being built today will likely last into the early 2000s. However, if the company that builds a vehicle analyzes the ways in which the vehicle can be taken apart, this knowledge can be transferred to dismantlers in order to: 1) reduce the time it takes to dismantle a car, and 2) get more valuable material out of the car for resale. Both of these efforts promote the economic interest of the dismantler and achieve the desired environmental outcome.

### *3.c. Research and Collaborations with Suppliers to Expand Reuse*

Since dismantlers need an incentive to dismantle and sort polymers and other materials that currently become part of the shredder waste stream, someone must pay the dismantler for the sorted product. Suppliers, rather than manufacturers, actually use the raw material polymers to produce components, but the manufacturer must certify that the material (in this case, the recycled polymer) is suitable for the application in which it will be used. Design and production engineers must study the characteristics and cost of a recycled polymer, and determine: 1) whether its characteristics are acceptable for its intended use, and 2) whether the cost differential is acceptable to the company.

### *3.d. Design Changes for Recyclability/Disassembly*

In addition to using more recycled material in the production of new vehicles, manufacturers can reassess the materials and production practices they currently employ in order to reduce future recycling challenges. Options include:

- Reduce the number of polymers used in a vehicle in order make sorting simpler
- Produce entire subcomponents with a single polymer, so that limited sorting is required during disassembly
- Choose polymers and other materials based upon the ease with which they can be recycled
- Label the polymers with a code that makes it easy to determine what type of polymer it is, and speed up the sorting process
- Reduce the application of paints, varnishes and other contaminants onto polymers, unless the material can be easily separated from the polymer during disassembly
- Design components to fit together effectively yet simply, so that they can be disassembled with minimum effort

#### 4. BMW's Commitment to Recycling

Since BMW first initiated discussions on recycling regulation for the automobile industry in 1987, BMW has been a leading representative of automobile companies developing a plan for old vehicle recycling. The knowledge and credibility that BMW developed through years of proactive investment in recycling is proving to be critical to their effectiveness in developing a recycling strategy.

In 1984 and 1985, members of the production department of BMW recommended that the company take full responsibility for the total product life of its cars, and begin investing in economically sensible recycling methods to fulfill this responsibility, in advance of any regulatory system that might emerge. By 1990, BMW was already well versed in key recycling skills, such as the ability to reprocess used components at a profit, that would expand its options for fulfilling the impending regulation.

##### 4.a. BMW Corporate Profile

Bayerische Motoren Werke AG (BMW), founded in 1916 and headquartered in Munich, Germany, produces aircraft engines, motorcycles and automobiles. Automobile-related sales account for over 80% of company sales.

1991 was a difficult year for the automobile industry worldwide, as vehicle unit sales fell by nearly 5% in Western Europe, the USA and Japan. Despite this weakness, BMW's total sales for the company were 24.5 billion DM (approximately U.S. \$15 billion based on current exchange rates) in 1991, up 10% from the 22.1 billion DM level in 1990. 1991 profit was 0.45 billion DM, up from 0.40 billion DM in 1990. Shares of BMW are publicly traded on the German stock market. The company is controlled by heirs of Herbert Quandt, who provided \$1 million to BMW in 1959 to help the company through a difficult period. The 65% share controlled by the Quandts is now worth nearly \$3 billion. See *Exhibit 4* for BMW AG's financial results for the years 1985-1991. The chairman of BMW is Eberhard von Kuenheim, who has held the position for 21 years.

##### 4.a.1. BMW's Product Line

BMW is one of the smaller European auto makers, and provides vehicles in the upper-intermediate, luxury and sports cars segments of the market. The company has traditionally been known for its craftsmanship and engineering capabilities. *Forbes Magazine* notes the unique position which BMW holds among vehicle purchasers- "BMW flourishes by selling to people who feel they are flaunting their affluence less ostentatiously and more intelligently than if they were driving similarly priced cars of other makers." (November 27, 1989, p. 89.) From the 1950s through the early 1980s, BMW's product line was comprised mostly of smaller and mid-sized vehicles, such as the 2 and 3 series, known for their quality and adventurous designs. These vehicles were often placed between the small/functional car market, dominated by companies such as Volkswagen AG, and the luxury segment,

dominated by Daimler-Benz AG and its Mercedes-Benz line.

While BMW had always competed with Mercedes-Benz in some categories, BMW began in 1986 to compete more directly with Mercedes-Benz when it introduced many more large, expensive models with the same sleek designs that had characterized earlier models. It introduced its 7 series luxury sedan, a vehicle that became the top seller in Europe in the over \$50,000 category. The company filled the intermediate luxury segment of the market with the 5 series (introduced in 1988) and in 1990 introduced a 12-cylinder vehicle, the 8 series, which sells for \$85,000. The new version of the 3 series, which now utilizes a 6 cylinder engine originally developed for the 5 series, was introduced in 1990 and is expected to become the company's primary product in the coming years.

BMW production in 1991 was 553,000 cars, more than 95% of which were produced in Germany. 1991 sales amounted to 552,000 cars, of which 40% were sold in the German market. BMW's production data is shown in *Exhibit 5*.

#### 4.a.2. Competitive Position

In the past decade, BMW's responsiveness to new market demands has paid off; sales have grown at better than 10% annually since 1986, well above the industry growth rates. Part of its success was due to its expansion into the luxury/sports car segment. It has also gained some advantage through its ability to produce small lots at moderate cost. While previously introducing new model lines only once a decade, BMW now has the flexibility to introduce new models and engines on an annual basis.

The following are 1990 figures for Germany's new registrations of private vehicles:

Company	# of Vehicles * 1,000	% of Market
Volkswagen	609	20.0
Opel	522	17.2
Ford	299	9.8
Mercedes-Benz	257	8.4
BMW	191	6.3
Audi	167	5.5
Fiat	151	5.0
Peugeot (+ Citroen)	131	4.3
Renault	100	3.3
All Japanese	482	15.8
Others	132	4.3
<b>Total</b>	<b>3,041</b>	<b>100.0</b>

(Source: VDA, Germany)

See *Exhibit 6* for BMW's market share in various European countries. BMW's share of about 3% across Europe exceeds its approximate 1% share in the U.S. Despite BMW's record of success, BMW and most of the other leading European luxury/sports car producers are facing new challenges from Japanese companies moving into this segment of the market.

#### *4.a.3. Research and Development*

BMW's design and engineering teams have outstanding track records, based on their capacity to design and mass produce "adventurous", high quality vehicles and to change production runs quickly in order to produce small runs at low cost. BMW's new 325i series, for example, is bigger, 13% more powerful, and 11% more fuel efficient than its predecessor, yet at \$29,900, costs only 4% more than its predecessor in the 3 series line.

Over the next five years, von Kuenheim has stated that BMW will spend \$4 billion in research, development and automation. The company recently completed a \$600 million Research and Engineering facility in Munich-Milbertshofen which will serve as BMW's design headquarters and house 4,500 employees. The facility is an imaginative new effort to consolidate development, production and manufacturing planning into a single site, with the objective of more closely aligning the efforts of groups such as design, materials engineering and production engineering.

While employees take obvious pride in the research that is being undertaken in-house, the company has announced its intention to spend about \$500 million per year on the acquisition of companies (especially electronics companies) that have technologies directly related to automobile materials or production. For example, BMW recently bought a controlling interest in DesignWorks USA, a California-based engineering design firm.

#### *4.b. BMW's Environmental Record and Policies*

For BMW, environmentally responsible practices are not new. However, they have often been developed with objectives other than the protection of the environment in mind. While environmental programs have increasingly become a reason in themselves for company actions, programs have typically been motivated by economic factors such as profit-making potential, public relations, and customer loyalty. BMW is viewed as a company that has an influence on industry-wide environmental practices.

##### *4.b.1. Early Environmental Management Program*

BMW first constructed a plan for environmental management in the early 1970s. The Munich production plant, which employs about 14,000 people, became surrounded by houses which were built to address the needs of the 1972 Munich Olympic Games. Noise and emissions from the plant began to affect local residents, many of whom were also employees at the facility, and BMW appointed an environmental specialist to reduce local impacts.

#### *4.b.2. Components Reconditioning Program*

In the mid-1960s, BMW began a program that has now been converted into a fine art- the reconditioning of high-value components from used vehicles, and the resale of these components to the public. Initially, this strategy was used with just a few parts, such as engines. The engine could be remanufactured and sold to a buyer at 60-70% of a new component's price, and BMW would still make an acceptable profit over the costs of logistics, disassembly and remanufacture.

Over time, this program has been expanded to approximately 1,700 individual parts. Engines may be the most stellar example of remanufacturing: 94% of an engine is typically reconditioned, 5.5% is remelted for reuse, and the remaining 0.5% is landfilled. Examples of reconditioned components include:

- engines
- starters
- alternators
- transmissions
- waterpumps
- final drive gearings
- electronic components

BMW states, "It is no coincidence that this high-value recycling is referred to as High-Tech recycling: Using the most advanced technologies such as ultrasound cleaning or numerically-controlled grinding systems, each original BMW Exchange Part and Component is carefully overhauled, reconditioned and tested according to strict quality standards at BMW's Recycling Centre in Landshut." (from BMW AG Presse) Perhaps most critical is the fact that BMW offers warranties on these exchange components equal to those on new components.

#### *4.b.3. Pollution Prevention/Waste Minimization Strategies*

Throughout the 1970s and 1980s, the company developed pollution prevention strategies for their production processes. The original motive for waste minimization was the high cost of waste treatment in the Bayern area, which is primarily used for agriculture. For example, it costs about 300-400 DM per ton for incineration of waste from Bayern's paint line.

Steps that have been taken include:

- 1) Increased separation, collection and reuse of production waste (used oils, gases, glass etc.) as an integral part of production activities
- 2) At facilities such as Landshut, cuttings of plastic parts are fed back into the grinders and extruders

3) Beginning in the mid-1970s, BMW began to require suppliers to take back homogeneous plastic waste.

4) Careful study has led to a system that utilizes water as much as six times before it is disposed as effluent.

Manfred Heller, who currently runs the environmental protection staff, claims that these efforts allow for some form of re-use for 80% of waste, with 15% landfilled or incinerated and 5% treated as special waste. Up to the present, efforts in waste reuse have cost 10 million DM, and generated approximately 70 million DM in return.

One of the keys to success in reusing production waste was in making the waste disposal function independent of the technical department, and putting the logistics departments that supply production materials in charge of waste. Therefore, those who purchase supplies choose only those materials that are easy to reuse and dispose. In order to continue to reap returns on waste reduction, BMW's intended next step is to develop some influence over the materials choices of its suppliers.

#### *4.b.4. Post-Consumer Recycling*

BMW initiated even more ambitious programs in the late 1980s to enhance the reuse of post-consumer materials:

- In collaboration with its component manufacturers, BMW began a recycling program for catalytic converters in April 1987. In order to recoup the precious metals (platinum and rhodium) in catalytic converters, BMW disassembles the component, crushes the materials, and sends them back to the manufacturer for reuse.

- In order to utilize more of the difficult-to-recycle plastic, BMW initiated research with some of its plastics suppliers into the recycling of plastic materials, as well as chemical and energy recycling of used plastics which are not easy to recycle in their initial form. Early results of this program were demonstrated in the 3 series models introduced in 1990. Plastic waste is separated based on chemical, physical and mechanical properties, then "regranulated" and molded into new components. For example, the luggage compartment linings are made from recycled bumpers of old cars.

A more ambitious effort involves the redesign of the instrument panel of a vehicle in order to enhance recyclability. Instrument panels typically consist of combinations of metal, polyurethane and PVC film; engineers at BMW are now producing the panel with a single polymer, with no reduction in quality. Over time, BMW intends to expand its use of recycled materials to more critical components, such as body parts.

- To enhance opportunities for plastic recycling in the future, BMW is categorizing and labelling parts such that they can be easily sorted during dismantling.

#### *4.b.5. Experimentation with Disassembly- Landshut Facility*

In July 1988, BMW purchased a large piece of land in Wackersdorf, West Germany, with the intent that part of this site serve as a pilot center for automobile recycling. The original plan was that the center would mirror the activities of a typical pilot production center, except that it would focus on design and engineering of cars that were easy to dismantle and recycle. The scheduled date of opening was in the mid-1990s. This was intended as a first step in setting up a BMW infrastructure for automobile takeback, independent of existing dismantlers.

Due perhaps to the impending draft regulation on automobile takeback and on a reconsideration of establishing an independent dismantling infrastructure, BMW altered its schedule by converting an existing facility at Landshut, which was already part of BMW's logistics system, into a pilot site for dismantling and recycling. Knowledge gained there will be transferred to other sites or independent dismantlers, depending upon the strategy BMW selects.

During 1990 and 1991, the pilot center studied the features of various cars and their potential for disassembly, and actually stripped down nearly 2,000 vehicles to experiment with disassembly strategies. Disassembly rates will continue to expand, so that a "large-scale disassembly process" can be developed.

#### *4.c. How BMW Executes Recycling Strategy*

The environmental programs described above succeeded because BMW established an internal process for evaluating recycling demands and business opportunities. An evaluation team helped organize BMW internally to tackle difficult recycling challenges, and serves as BMW's voice to regulators and other automobile manufacturers on recycling policy and strategy.

While parts reconditioning and waste management practices had been in place prior to 1984, the first organized discussions on recycling took place in 1984/1985. Several production departments, including science (the group which is responsible for polymer development), body, and technical planning, came together to analyze the impacts of environmental concerns on vehicle disposal and on BMW's business system. They concluded that vehicle disposal was emerging as a significant environmental problem, and that BMW should take responsibility for the total life cycle of its cars, from conception, through design, production, service and final treatment as waste.

Various representatives from these departments formed an Internal Working Group, which included senior technical staff with the authority to make changes inside BMW. These members remained as part of their departments, and came together on a monthly basis to review strategies for materials recycling and reuse.

#### 4.c.1. Establishment of a Theoretical Framework for Recycling

Through the period of review and experimentation, two objectives were accomplished. First, the group was able to establish a principle for recycling, namely that it should make reasonable economic sense. Hans-F. Tripp, now head of economics in BMW's recycling group, says that a general rule of thumb was developed, that the *cost of disassembly plus treatment plus logistics must be equal to or less than the cost of virgin materials plus the cost for disposal (incineration or landfill)*. Once the framework had been put in place, BMW needed to prove its intentions. Its framework was put into action as several items such as bumpers made from polymers were separated, treated and reused for the production of luggage linings and other non-critical applications. The company was not able to provide an example of the economic analysis used.

The company also developed a waste management hierarchy, which it calls the "Cascade Model." The hierarchy prioritizes activities in the following way:

- 1) parts and material recycling
- 2) metal recycling
- 3) chemical recycling
- 4) energy utilization
- 5) disposal

*Exhibit 7* provides a materials flow chart for the Cascade Model. *Exhibit 8* is a diagram of BMW's overall recycling concept.

#### 4.c.2. Establishment of a Dedicated Recycling Team

While the internal working group was successful, the individuals involved found that they could not continue doing two jobs at the same time- they had regular positions in their departments, yet the activities of the recycling group were expanding rapidly. Reinhard Hooek, a materials expert now based in the dedicated recycling group, notes that many different groups had been working on recycling (rubber, plastics, metals) and while they were performing well, each was working from its own perspective. "We needed a concept of recycling for the whole car," he states.

Chairman Eberhard von Kuenheim also saw the need to formalize BMW's commitment to recycling in all phases of its business, and wanted to increase the profile of the group. In mid-1990, von Kuenheim appointed Dr. Horst-Henning Wolf as Director of the Vehicle Recycling Group ("T-RC"), reporting directly to him. Von Kuenheim directed this "project management" team to:

- manage the activities at the new Landshut facility, which was dedicated to dismantling and recycling [recall that Landshut is also the site where high value components have been reconditioned for years]; and



- interact with regulators and other companies on the draft regulation on vehicle disposal, which was expected before the end of the year from BMU

The T-RC group now includes about 10 people who represent departments such as materials, development, planning, production, logistics and finance. It is neither viewed as a staff nor a line function, although its closest relationship is with the Technical Planning group. In Hoock's view, the project team "cannot do all the work. In the main, we are coordinating the activities of many different departments, and developing the overall concept for recycling."

## **5. The Evolution of Vehicle Recycling Regulation**

In August 1990, the Bundeminister für Umwelt, Naturschutz und Reaktorsicherheit (BMU, the German Environmental Ministry) issued a draft regulation to address growing concerns over waste from used vehicles, which states:

- 1) vehicle manufacturers or their agents must take back used vehicles
- 2) this service must be free of charge to the vehicle owner
- 3) reuse and recycling should take precedence over landfilling or incineration, whenever technologically feasible and economically reasonable
- 4) in order to achieve the goal of recycling, manufacturers must provide facilities where dismantling can occur, and must develop the supporting technology to effectively separate reusable products from toxic waste streams
- 5) looking forward, new vehicle designs should reflect the goal of increased reuse and recycling of components and materials once the vehicles' useful lives are terminated

The regulation seeks to establish a nationwide takeback system by the end of 1993. In addition, BMU is considering a recycling goal for the plastic components in cars. For example, new cars may be required to have 25% of their plastic components produced from recycled polymers (effectively creating a "closed loop"). While the estimated 10,000-20,000 dismantlers in Germany already provide a takeback system, the regulation promotes a more effective system. Only about 10% of the dismantlers currently operating in Germany have a license, and many of the unlicensed operators are causing environmental damage.

Furthermore, there is currently no requirement that a dismantler must accept a vehicle from an owner; disposal occurs when the vehicle owner and the dismantler can agree on a disposal price. The draft regulation forces automobile manufacturers to work with existing dismantlers or develop their own system such that takeback of used and wrecked vehicles is assured.

### *5.a. BMW's Influence on Regulators*

The draft regulations of 1990 did not appear suddenly, but were the result of extensive discussions with industry that dated back to at least 1987. Even prior to the 1987 discussions, BMU issued the 1986 Waste Avoidance and Waste Management Act, which specified that "waste management should be an integral part of the production and distribution of goods."

Starting from 1987, regulators began to focus on the contribution that the automobile industry in particular was making to solid waste problems. Klaus Topfer, the head of BMU (Environmental Ministry), was invited to BMW to hear the company's perspective on the environmental impact of vehicle disposal, and its plan for recycling. Dr. Ing. Harald A. Franze, head of development for the vehicle recycling group, states, "He [Topfer] was told by us what the problem really was, and he subsequently based his policy on the BMW strategy." BMW apparently attempted to convince BMU of the importance of increasing recycling of old vehicles, and shared its experiences in materials recycling.

In the period since Topfer's initial visit, BMW and other members of the automobile industry have had frequent contact with BMU. BMW believes that this high level of interaction is a significant point. They contrast it with the low levels of interaction between the Environmental Ministry and other leading industries, such as the packaging industry, which is already dealing with stringent "takeback" regulations. BMW also engaged in discussions with other groups that could shape policies on vehicle disposal. For instance, BMW began discussions with VDA, the German automobile industry and trade association, and VDA-FAT, the VDA's department that performs research for the automobile industry in 1987. VDA soon thereafter formed a working group on plastics recycling and shredder waste treatment [later to become the basis for PRAVDA; see Section 6.].

### *5.b. Analysis of The German Regulation*

The German draft regulation seems to reflect BMU's confidence that industry has a sincere concern for the environment. If companies such as BMW had not constructively engaged with regulators over recycling issues, the draft legislation might have been considerably less flexible. Instead, the regulation is structured to accommodate input from the automobile industry, and thereby balance environmental and economic objectives:

- BMU decided that industry-specific regulation was the most appropriate means of reducing solid waste. By establishing rules for takeback of automobiles, BMU forced manufacturers to focus on recycling and to cooperate with dismantlers, with whom they do not often directly interact.
- BMU issued a broad regulatory outline, suggesting specific rules (such as free cost to the owner for disposal) but allowing industry to develop counterproposals for achieving the recycling infrastructure with fewer economic distortions.

- The regulation's timetable is lengthy enough to allow new ideas to be generated and executed (such as a new dismantlers' network), but firm enough to motivate action by the automobile companies.
- The regulation targets the immediate need to reduce shredder waste going into landfills and incinerators, which is a function of vehicles that were built 5 to 20 years ago. It also promotes a longer-term goal, to reduce shredder waste likely to be disposed of in 10 to 20 years, which is a function of automobiles being designed and built today.

While the debate over the regulation continues, regulators have used other tools to signal their seriousness about the vehicle waste problem. In order to reduce current flows of shredder waste into landfills and incinerators, regulators are tightening the PCB limits for disposal of shredder waste into landfills, and making emissions levels from incinerators more stringent.

Environmental regulators recognized that the existing recycling infrastructure is very complex, and that regulation can have serious economic and redistribution effects. In order to determine what can be recycled and who should pay for it, regulators established a "straw man regulation" and put the onus on affected parties to improve the recycling plan; promoting problem-solving is one of the clear purposes of the German draft regulation as it has been presented.

## **6. Establishment of PRAVDA Consortium**

After the draft regulations had been issued, BMW's T-RC reviewed the company's recycling strategy to determine if a different course was necessary. They had intended to establish their own dismantling network for BMW vehicles (at Wackersdorf), but saw that pressure from an impending regulation might make collaboration with other industry members feasible. In deciding how to tackle recycling, BMW faced several challenges:

- **Conveying BMW's views effectively.** Would BMW influence behavior of regulators and industry more effectively working alone or collaboratively?
- **Working with the existing dismantlers network.** Was this group capable of changing its behavior and learning new ways of dismantling vehicles?
- **Working with other automobile companies.** Would the collaboration produce conflict and ultimately slow the process of responding to the draft regulation?
- **The likely flexibility of regulators.** If a consortium established a proposal different than that contemplated by regulators, would they listen to it?
- **Economics.** What would be the most efficient way to achieve the recycling network?

T-RC generated alternatives for establishing a recycling infrastructure, including 1) postponing any commitments until regulations are promulgated, 2) establishing a centralized recycling system for BMW products, 3) establishing a decentralized recycling system for BMW products in conjunction with other automobile companies, using a newly created dismantler/shredder network, and 4) promoting a decentralized recycling system for BMW products in conjunction with other automobile companies, using existing automobile dismantler/shredder network. In late 1990, BMW concluded that:

1) BMW should take responsibility for the recycling of spent vehicles, and should engage in discussions with other manufacturers, suppliers, dismantlers and policymakers to create a coordinated plan.

2) BMW should not establish its own centralized system for automobile takeback and disassembly. Transportation costs would make the system uneconomic, and environmental benefits would be reduced since additional energy would be required for transportation. BMW should share costs with other manufacturers to make disassembly economically feasible.

3) Auto companies should work with the existing dismantler network rather than creating a new one, because startup costs will be lower and there will be comparatively little job displacement [This apparently satisfied concerns of the Economics Ministry about jobs]. BMW should continue its Landshut experiment to learn about disassembly, and disseminate the knowledge it gains directly to "certified" dismantlers.

4) In order to ensure economic viability of the recycling strategy, BMW should work directly with polymer suppliers on focused projects that will lead to increased use of recycled polymers in new vehicle design.

5) BMW should also participate in similar vehicle recycling discussions occurring in the European Community, to ensure that the EC system reflects the knowledge gained in Germany and, if possible, to harmonize EC and German regulations.

In early 1991, BMW and other automobile manufacturers joined with major plastics suppliers such as Hoechst, BASF and Bayer to form PRAVDA, a group coordinated by VDA (the auto industry association) to develop a recycling network and strategy. By agreement of the manufacturers, seven pilot disassembly sites were established, and the results of disassembling experiments and polymer recyclability experiments will be disseminated to all members.

The evolving concept closely resembles the strategy that BMW recommended internally- a network of licensed dismantlers, to be authorized by auto manufacturers; "certificates of disposal" to be provided by dismantlers as a condition of deregistration; free bargaining between dismantlers and owners over disposal costs; and partnerships with plastics

companies to research characteristics of recycled polymers. BMW's Dr. Wolf has assumed the leadership role in PRAVDA, a further symbol of BMW's influence. See *Exhibit 9* for a list of PRAVDA's current partnerships for polymer research.

To avoid the impression that BMW alone is influencing the recycling system strategy, it is worth mentioning the roles of both Volkswagen and Daimler-Benz. Like BMW, Volkswagen initially preferred the idea of a number of regional dismantling and recovery centers, licensed by Volkswagen and the government and dedicated to dismantling of Volkswagens. Volkswagen is also experimenting with reuse of bumpers for new components, but is still in the test phase. Daimler-Benz is also testing disassembly (in collaboration with BMW) and reuse of materials, but has taken a different approach to disassembly. Rather than following the Cascade Model advocated by BMW, Daimler-Benz intends to strip high-value parts, drain the fluids, then press the hulk and feed it into a melt reactor. Steel is melted, plastics are gassified, and useful energy is created. This technology is expected to become viable in the late 1990s.

## **7. Motivations for Proactive Investment**

Why would BMW choose to invest in recycling prior to the establishment of a vehicle takeback regulation? Why would they try to convince regulators of the importance of establishing a recycling regulation? There is little doubt that German companies like BMW have a strong sense of social responsibility to address issues of public concern such as solid waste. Likewise, BMW and other automobile producers have a mutual interest to work with regulators and the public to minimize the costs required to achieve desired levels of environmental protection. In addition, there may be competitiveness implications to the development of a German recycling strategy. BMW's competitive opportunities can be addressed in two contexts: 1) the development of the nationwide takeback network, and 2) BMW's pursuit of a comprehensive recycling strategy.

Among its mandates, the 1990 German draft regulation assigns responsibility to automobile manufacturers for developing a takeback system. BMW's strategy, to promote a decentralized, nationwide network to be built upon the existing dismantlers' network and shared by all manufacturers, seems to be winning broad support. It should save all manufacturers from making large capital expenditures to establish dismantling capabilities. It may also provide opportunities for competitive advantage if:

- dismantlers choose to specialize in dismantling of certain vehicle types. Companies that cannot complete a nationwide, certified network may have to pay dismantlers to ensure that their vehicles do not continue to find their way into landfills. BMW's knowledge and training competence should make dismantlers eager to become "BMW certified."
- owners and dismantlers are free to negotiate a disposal price. If there is more value in disassembling one car than another, the disassembler will pay more to the owner.

Automobile buyers will factor these differentials into their new car purchasing decisions. BMW advocates a free pricing system, as it has invested heavily to enhance its vehicles' recycling values.

Still, the takeback network is only one piece of the recycling system. Individual companies that invest in recycling technologies and develop value-adding relationships with dismantlers and polymer suppliers will develop competitive advantages, as their recycling expertise (knowledge of disassembly, effective design, and recycled polymer reuse) will transform the takeback network into a closed loop recycling system. By investing pro-actively in recycling research and technology, BMW may reap the following benefits:

- BMW gains a marketing advantage by publicizing a voluntary takeback program and the environmental design considerations in its new vehicles. Its new advertising program in the Netherlands which emphasizes green characteristics of the 3-series model has been favorably received.
- BMW gains credibility and goodwill among regulators and in the automobile industry for its leadership and vision to establish a recycling network.
- Through its influence on the formulation of final vehicle recycling regulation:

BMW reduces its costs of providing takeback by sharing costs and research through PRAVDA

BMW ensures that the investments it has made to date in recycling are not neutralized by unfavorable regulation

- In the long-term, BMW may gain a cost advantage over other manufacturers by having a better ability to use recycled polymers. While recycled polymers currently cost more than virgin materials, effective recollection of post-consumer waste and increases in virgin materials costs should make recycled polymers more attractive.
- In markets outside Germany, BMW (and other German manufacturers) have a leg up on domestic manufacturers that have not developed recycling technology. BMW may again be able to influence vehicle takeback regulations in these other markets that fit BMW's vision for a recycling system.

**[Authors' Note: Case B is a brief discussion of international competitiveness implications, both for BMW and other German manufacturers, of the German recycling regulation. It is not comprehensive, but is intended only to stimulate further discussion and suggest additional topics for research.]**

## **CASE B: Abstract**

[Note: Case B is not a comprehensive study of international impacts of the German regulation; it is a brief discussion of possible topics for additional research.]

PRAVDA expects to build a consensus among its industry participants that will influence regulators to accept its proposals in finalization of the draft regulation. Based upon its good progress in Germany, PRAVDA is becoming an important advisor and source of knowledge for the EC groups considering vehicle recycling strategies. As Dr. Wolf of BMW represents PRAVDA in the EC discussions, BMW will again play a leading role in vehicle takeback legislation. While both the "Dutch Model" and the "German Model" for vehicle recycling are being considered by the EC, it appears likely that the German Model will win out.

While the German regulation does not close the German market to foreign automobile manufacturers producing in Germany, it will make imported vehicles less competitive in Germany. In responding to the German regulation, German companies will establish expertise in reutilization of materials that will become a cost advantage. When other countries establish vehicle takeback and recycled content regulations, German companies will be well up the learning curve. While waiting for these regulations to be implemented in other countries, German automobile companies may gain new customers through effective marketing of the "greenness" of their products.

### **8. EC Vehicle Recycling Plans**

Dr. Wolf's leading role in PRAVDA has won him a position on the EC's recycling group within the EC Directorate General on Strategic Direction. This group will have primary decision making responsibility for EC vehicle recycling plans. While other vehicle recycling programs have been implemented in Europe, they are not nearly as comprehensive as the proposed German program. The most advanced is the program put in place in the Netherlands in 1989. While Germany's BMU established specific norms for recycling and gave industry the opportunity for self-regulation, the Dutch Environmental Ministry has established a longer-term, more collaborative approach to vehicle recycling. In the Netherlands, a working group was established, which included industry and Environmental Ministry participants, and targets for reduction of shredder waste and vehicle wrecks were established.

In 1990, the EC working group created a structure similar to the Dutch model's. The EC seems to like the goal of establishing a "voluntary" vehicle recycling agreement, especially since the EC does not possess the capacity for direct implementation of vehicle recycling legislation. Still, the process is at a very early stage of development. Over time, observers expect that the working group's "voluntary" plan will look very much like the German solutions, as the Germans will have developed a system that can be shown to work.

## **9. Possible Trade and Competitiveness Impacts of German Regulation**

Dismantlers must be trained and certified in the appropriate dismantling of different vehicles. Manufacturers must invest to learn this knowledge themselves, then communicate their knowledge to dismantlers. If a company's vehicle sales in Germany are small, they will be hesitant to make the investment in disassembly knowledge and dismantlers will have little incentive to become certified. There is at present little consideration in the German draft regulation of companies that import vehicles into Germany. At best, these companies would have to pay dismantlers or domestic vehicle manufacturers to take care of vehicle takeback and disposal. At worst, they might be required to establish their own centers to insure that their cars are not disposed of improperly.

Furthermore, if a company has no capability to reuse polymers gathered through disassembly, they will not be able to meet the 25% recycled polymer content regulation, if it is established. Based upon these considerations, Germany's vehicle imports would be expected to shrink.

In markets outside Germany, the competitiveness of German companies might be expected to improve as a result of the experience they gain in responding to the draft regulation. BMW has moved quickly to communicate its competencies in materials recycling and vehicle takeback to foreign markets- it established a voluntary takeback program in the UK, and recently announced a collaboration with several U.S. dismantlers in order to analyze differences in the German and U.S. recycling markets. While it is unlikely to become a key buying factor in the near term, this "green" message may catch the attention of some buyers who consider the environmental impacts of products when making purchasing decisions.

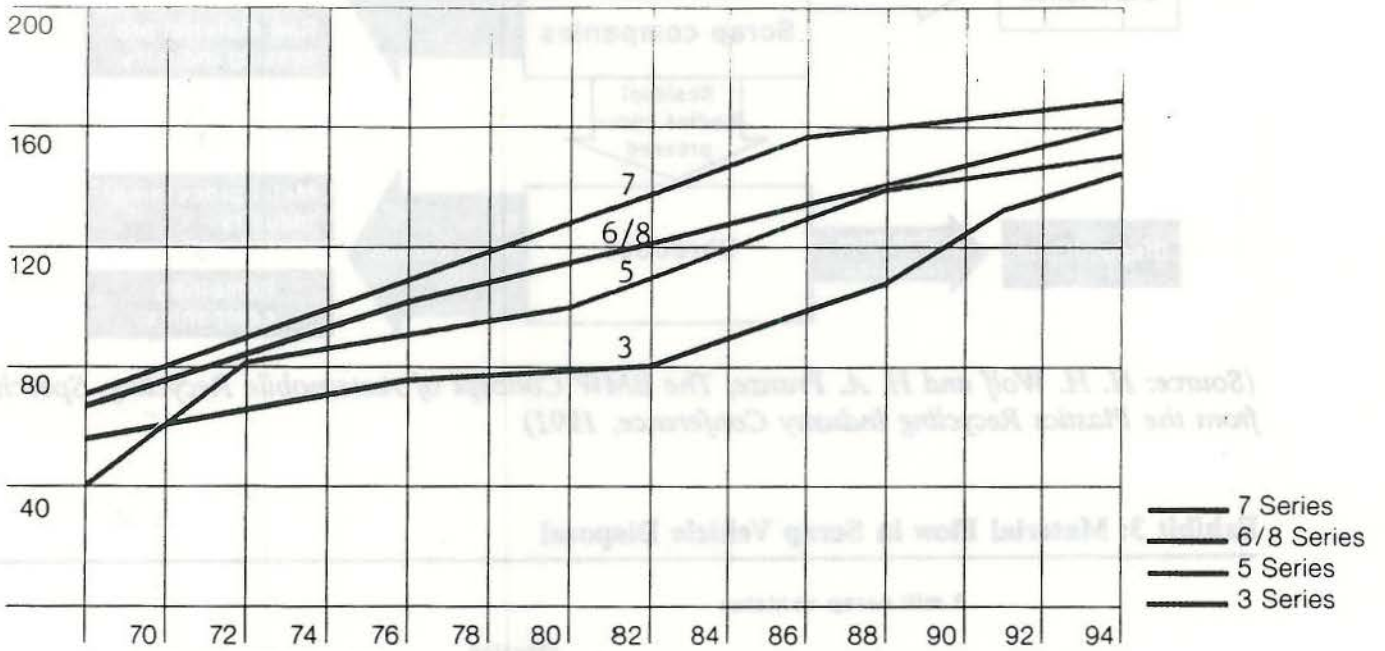
If the EC or other markets establish regulations similar in form to the German system, German manufacturers (and foreign manufacturers that make the investment in recycling capability in Germany) will have a cost advantage that may be sustainable. Again, BMW and other manufacturers have an incentive to work with regulators, to ensure that the regulation is realistic and consistent with investments that they have already made.

## **10. Implications for U.S. Vehicle Recycling Regulation**

The used vehicle disposal problem is less dramatic in the United States. Landfills are more abundant and landfill prices are considerably lower, making the economics of dismantling and shredding more attractive. Dismantlers are also a larger and less cohesive industry in the U.S. They do not have the relationships with metal companies that are typical of the larger dismantlers in Germany. Despite the market differences, the Big Three U.S. automobile manufacturers recently announced the formation of a consortium to develop vehicle recycling technology (February 1992). BMW again is establishing itself as a leader, announcing recently a partnership with U.S. dismantlers to exchange ideas for disassembly. Progress on used vehicle takeback recycling will be slower than in Germany and the EC.

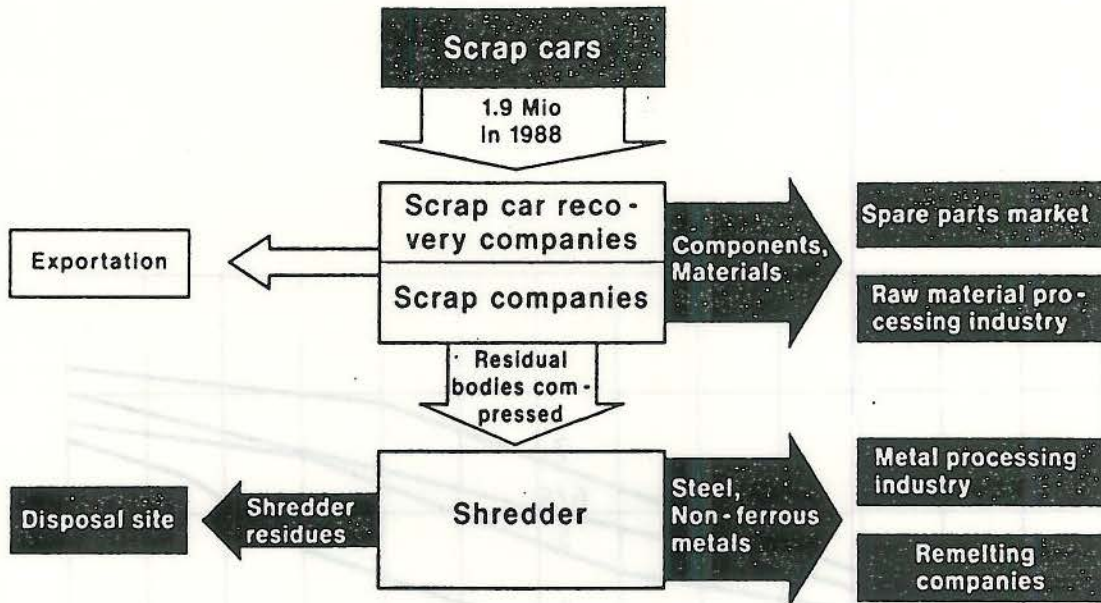


**Exhibit 1: Plastics Use in Current BMW Models (in kg)**



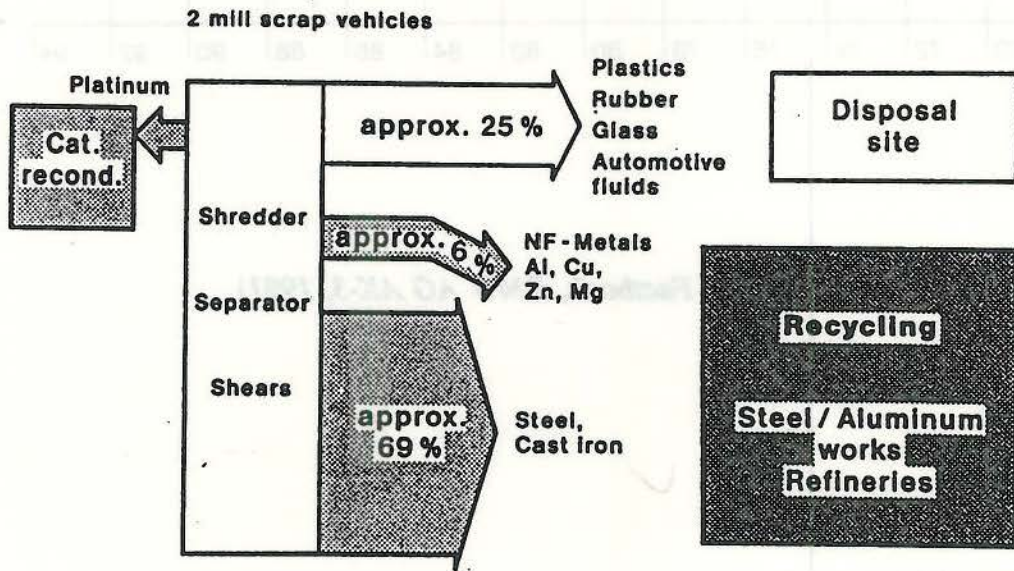
*(Source: Recycling of Plastics Factbook, BMW AG AK-3, 1991)*

**Exhibit 2: Current Industry Scrapping Practices**



*(Source: H. H. Wolf and H. A. Franze, The BMW Concept of Automobile Recycling, Speech from the Plastics Recycling Industry Conference, 1991)*

**Exhibit 3: Material Flow in Scrap Vehicle Disposal**



Status 1987

*(Source: H. H. Wolf and H. A. Franze, The BMW Concept of Automobile Recycling, Speech from the Plastics Recycling Industry Conference, 1991)*

**Exhibit 4: BMW AG Sales Revenue: Automobiles and Motorcycles**

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	<b>Revenue</b> (mil. DM)	<b>Growth</b> (%)	<b>Profit</b> (mil. DM)	<b>%Sales</b> (%)	<b>Export Share</b> (%)
1991	24,477	10.5	450	1.8	51.0
1990	22,147	05.7	398	1.8	55.5
1989	20,958	05.4	386	1.8	58.5
1988	19,884	12.6	375	1.9	59.8
1987	17,657	17.8	375	2.1	65.9
1986	14,994	05.2	338	2.3	65.7
1985	14,246	10.2	300	2.1	65.0

*(Source: BMW 1990 Annual Report; BMW North America, Inc.)*

**Exhibit 5: BMW AG Production: Automobiles and Motorcycles**

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	<b>Automobiles</b>	<b>Motorcycles</b>
1991	553,230	32,190
1990	519,660	31,589
1989	511,476	25,761
1988	484,121	23,817
1987	461,340	27,508
1986	446,438	32,054
1985	445,233	37,104

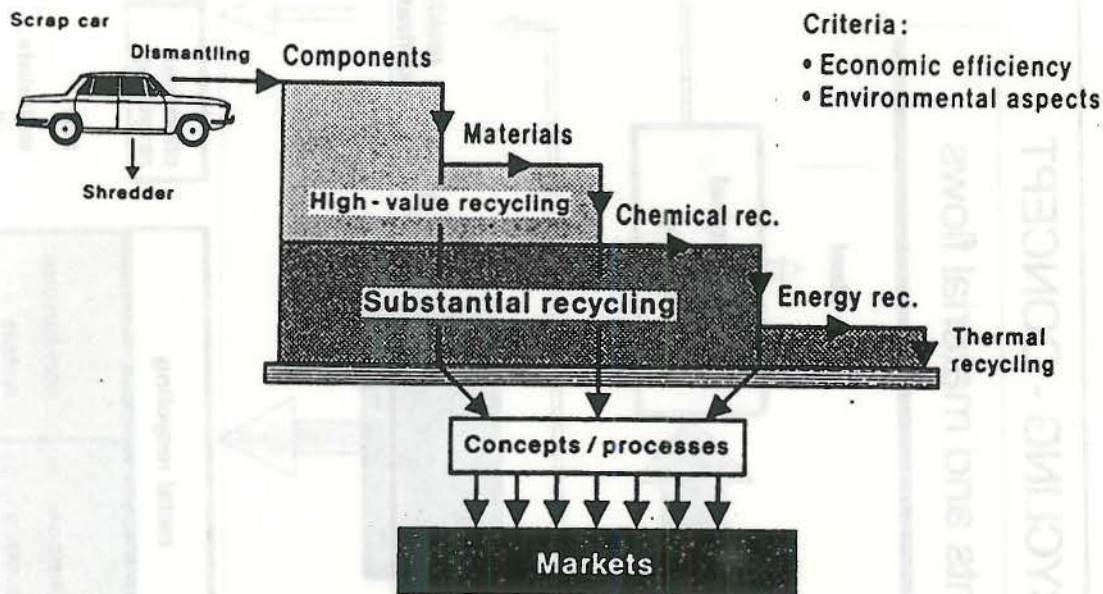
*(Source: BMW 1990 Annual Report; BMW North America, Inc.)*

**Exhibit 6: Market Share by Country, 1990**

Country	BMW Sales	Total Market	Market Share
	(*)	(*)	(%)
Austria	8,900	288,600	3.1
Belgium	11,100	473,500	2.4
France	29,600	2,309,100	1.3
Germany	191,000	3,040,800	6.3
Great Britain	43,000	2,008,900	2.1
Italy	28,200	2,348,200	1.2
Netherlands	9,600	502,700	1.9
Spain	11,000	943,200	1.2
Switzerland	11,400	325,700	3.5
EC Average	343,800	12,240,700	2.8

*(Source: BMW 1990 Annual Report)*

## Exhibit 7: BMW's Recycling Cascade Model



*(Source: H. H. Wolf and H. A. Franze, The BMW Concept of Automobile Recycling, Speech from the Plastics Recycling Industry Conference, 1991)*

Exhibit 8: BMW Recycling Concept



# BMW RECYCLING - CONCEPT

## components and material flows

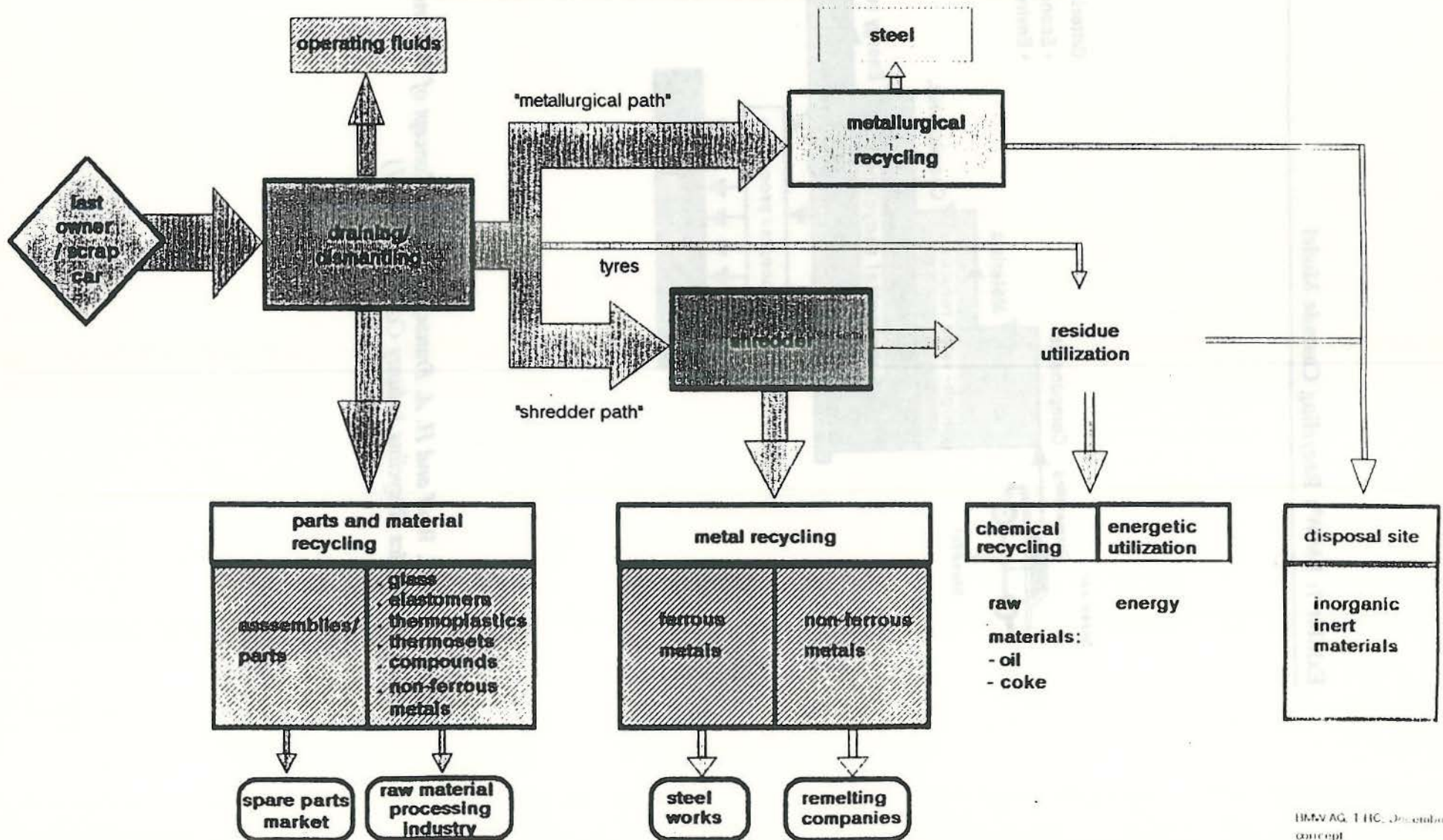


Exhibit 9: PRAVDA's Current Partnerships

Pilotprojekte Autoverwertung („PRAVDA“)

Standort/ Region	Betreu- ender Auto- hersteller	Kunststoffe (Betreuender Kunststoffhersteller)					
		PE (BASF)	PP (Hoechst)	ABS (Bayer)	PA (BASF)	PUR-Sitze (Bayer)	PUR-RIM (Bayer)
Berlin/ Brandenburg	MB	HÜls	Hilmont	Bayer	BASF	BASF	BASF
Darmstadt	Opel	Hoechst	Hoechst	BASF	DuPont	DOW	DOW
Leer	VW	BASF	DSM	DSM	Bayer	Bayer	Bayer
München	BMW	PCD	PCD	Bayer	BASF	ICI	Bayer
Rhein-Ruhr	Ford	HÜls	HÜls	GEP	Bayer	BASF	BASF
Stuttgart	MB	BASF	BASF	Dow	ICI	DOW	DOW

(Source: VDA-FAT, Germany)