July 1995 • NREL/TP-430-7978

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CSI Resource Systems, Incorporated

National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401-3393
A national laboratory of the U.S. Department of Energy
Managed by Midwest Research Institute
for the U.S. Department of Energy
under contract No. DE-AC36-83CH10093

NREL/TP-430-7978 • UC Category: 1414 • DE95009259

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NREL Technical Monitor: Philip Shepherd

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INTEGRATED SOLID WASTE MANAGEMENT IN GERMANY

SUMMARY

Germany has legislation, regulations, and ordinances requiring that the management of municipal solid waste (MSW) be conducted in an integrated manner. The integrated management of MSW in Germany is to be accomplished in accordance with a hierarchy, most recently articulated and clarified in Kreislaufswirtschaft und Abfallgesetz (The Closed Loop Economy and Waste Management Act) which passed the Bundesrat in July 1994. The hierarchy is stated as avoidance/minimization, materials and energy-related recycling, and lastly, treatment and final disposal. This law is expected to take effect in 1996.

Germany has in fact been managing its municipal waste in an integrated fashion for some time. The Waste Avoidance and Waste Management Act of 1986, which amended the Waste Management Act of 1972 (the "Act"), describes waste management as "... the recovery or production of materials/energy from waste (reuse and recycling of waste), depositing of waste, as well as the necessary collection, transportation, treatment and storage." Under the Act, reuse and recycling are to be given priority over other disposal methods, provided that reuse/recycling is technically feasible, that the additional costs compared to other disposal routes are not unreasonably high, and that a market for the materials or energy produced either exists or can be created.

The relative positioning of material and energy recovery in the hierarchy has been the subject of significant discussion and debate in Germany. The Waste Management Act of 1972, as amended in 1986, did not provide a clear distinction. The Packaging Ordinance, which is based on Article 14 of the Act, went beyond the Act by requiring reuse or material-related recycling for used packaging materials. The Ordinance did not allow the recovery of energy from packaging materials to be credited towards achievement of the required recycling rates. The federal government at present is working on an amendment to the Packaging Ordinance to clarify the definition of material-related recycling. The draft amendment changes the required recycling ratios and allows for energy recovery from packaging materials collected above the required recycling rate. Placing materials and energy recovery on an equal level in the hierarchy specified in the Closed Loop Economy and Waste Management Act confirms Germany's policy that materials and energy recovery are equally beneficial forms of the reutilization of solid waste, from a resource conservation point of view.

ENVIRONMENTAL LAWS AFFECTING SOLID WASTE MANAGEMENT

Because the German legal system is based upon the application of codes and does not rely on case history to the same degree as the United States system, the process of establishing these codes and regulations is driven by the need to resolve differences of opinion among key stakeholders sooner rather than later (i.e., during the development and passage of codes and regulations rather than via the courts following promulgation). This has led to the institutionalization of an interactive process involving input from key stakeholders as part of the formulation and preparation of laws, regulations, and ordinances.

There are a number of institutional players involved in the process of regulating waste management in Germany. The federal government and the Landers, or states, have concurrent authority in the area of waste management, as well as air and noise pollution regulation. The Landers may pass legislation in these areas provided that the federal government has not already done so. German law requires that legislation prepared by the federal government which impacts the Landers, including that affecting land use, the environment, and waste management, be approved by the Bundesrat, or Federal Council, which is composed of 79 representatives appointed by the Landers. Furthermore, federal administrative regulations can only be adopted with the consent of the Bundesrat. The Landers are primarily responsible, through their various agencies, for enforcing most of the land use and environmental laws. To coordinate the implementation efforts, the Landers have formed a number of organizations to deal with specific aspects of developing and implementing environmental legislation. One such organization, the Lander Arbeitsgemeinschaft Abfall (LAGA), is a working group established to assist in the development of detailed regulations aimed at implementing the waste management guidelines laid down by the federal government. There are a number of other key groups which are directly or indirectly involved in the development and implementation of waste management legislation and regulations. These include:

- The Committee for Environmental Questions (Kabinettsausschuss für Umweltfragen), which is chaired by the Chancellor, includes members from the 12 federal ministries involved in environmental protection. This committee provides overall coordination of federal environmental programs.

- The Cabinet Committee for the Environment and Health assists with this coordination effort. It is chaired by the Minister for the Environment and includes representatives with environmental responsibilities from the other relevant ministries.

- The Conference of Ministers for Environmental Affairs (Umweltministerkonferenz), comprised of the federal Minister for the Environment and the environmental minister from each Lander, meets regularly to review a wide range of environmental policy matters.

- The Permanent Board of the Heads of Division for Environmental Questions (Stager Abteilungsleiterausschuss für Umweltfragen) coordinates the implementation of environmental policy across federal agencies. The Board's membership consists of the senior environmental officials of 212 such agencies; it is chaired by the secretary of the federal Ministry for the Environment.

- The State Committee for Environment Protection (LAI) advises the federal government on statutory and administrative regulations under the Federal Immission Control Act. It is comprised of representatives from various Lander ministries responsible for environmental protection and from the federal Ministry for the Environment.

A number of nongovernmental organizations also play a role in the development of environmental policy in Germany. For example, the Council of Environmental Advisers (Rat der Sachverstandigen für Umweltfragen) is an advisory committee comprised of 12 members from the public who provide input to the Minister for the Environment. In addition, various professional organizations (e.g., the Association of German Engineers, and the German Association of Gas and Water Management Experts), as well as environmental organizations (e.g., the German Federation for Environment and Nature Protection, the Council of Nature Protection, and Greenpeace), provide important input into policy and regulatory deliberations. Other groups which provide input on policy related to environmental and technical matters include the Office for Estimating the Consequences of Technological Advance of the German Bundestag (Buro für Technikfolgeabschatzung TAB), and the Study Commissions of the German Bundestag.

Key Legislation, Regulations, and Guidelines Impacting Waste Management

Germany has put in place a number of ordinances and instructions regarding waste and materials management. Among the more significant of these are the Verpackungsverordnung (The Packaging Ordinance), passed in June 1991, and Technische Anleitung (TA) Siedslungabfall (Third General Administrative Provision on the Waste Avoidance and Waste Management Act, Technical Instructions on the Recycling, Treatment, and Other Management of Wastes from Human Settlements), approved by the federal government on April 21, 1993, and issued in May of 1993.

The Packaging Ordinance

The Packaging Ordinance was developed pursuant to Article 14 of the Act on Avoidance and Disposal of Waste, which required that the government specify objectives to be reached regarding avoiding, reducing, or reusing wastes from certain products.

The Packaging Ordinance requires that, among other things, producers, distributors, fillers, or packers utilizing packaging materials take responsibility for managing the disposition of packaging materials and that there be in place a system of guarantors who agree to take back the various packaging materials and reuse/recycle certain percentages of the recovered packaging materials. In effect, the combination of the obligation to provide a separate collection and processing system, coupled with the obligation that packaging in the future must be recyclable and in fact recycled, has established the requirement that packaging can no longer be municipal solid waste.

The Packaging Ordinance is significant because it: (i) represents a dramatic shift in responsibility for waste management, (ii) changed the concept of responsibility for managing packaging waste and the mechanisms for funding its collection and sorting, and (iii) places emphasis on reintroducing waste in the form of secondary raw materials into the economic cycle by requiring that certain percentages of the materials be recovered and recycled.

As part of the implementation of the Packaging Ordinance's requirements, a separate organization was formed, the Duales System Deutschland (DSD), to provide collection, sorting, and transport services for the packaging waste stream, thus in effect removing it from the municipal waste stream traditionally managed by the public sector, either directly or via contractual relationships with private companies. This separate collection, sorting, and transport system was established in response to the retail industries' reluctance to directly take back sales packaging. Organizations wishing to have their sales packaging materials handled under the separate collection system put in place by DSD are required to place a Green Point mark on their products. This mark signifies that the producer or distributor has paid to the DSD organization the applicable fee (currently structured on a differential-fee-per-kilogram basis reportedly reflecting the costs of collecting and sorting [and in the case of plastics, the processing] of the various packaging materials). In order to obtain the Green Point, there were to be in place guarantors obligated to take back the material for its reintroduction into the materials cycle.

The implementation of the DSD system has had a number of interesting impacts. While it has resulted in the creation of an institution with a DM 3 billion (1.8 billion U.S. dollars) operating budget and over 270 employees, the major providers of the collection and processing activities have been existing players in the waste management business. In fact, a number of the organizations providing collection, sorting, and transport services are the same organizations who provide similar services for the balance of the municipal waste stream. Approximately 25% of the contracts entered into by DSD to provide these services are with municipal entities responsible for managing the waste in their area, while approximately 70% are with private companies. However, with other draft ordinances in preparation, there appear to be non-waste industry organizations taking an active interest in forming operating companies to provide portions of the required services. For example, RWE, a major utility company in Germany, has entered into agreements with several other companies to develop and implement a collection and processing system for used electronic goods and appliances, the subject of a proposed ordinance now under review.

The implementation of the DSD program has had a significant impact on the secondary materials market, both within and without Germany, and on the waste management system within Germany. In terms of the materials market, a glut of plastics collected in excess of available processing capacity resulted in the export of significant quantities of plastics and the stockpiling of up to two years worth of materials. The DSD system collected upwards of 400,000 tons of plastic packaging material, far in excess of what was anticipated or required. As a result, the system incurred significantly higher than expected costs of collection and sorting (based on per-tonne amounts). This, coupled with problems in setting the initial fee to be paid by the suppliers of packaging products and the failure to collect from all users of the Green Point, led to a near collapse of the system in the fall of 1993. Only by deferring payment obligations, creating a new organization to guarantee the processing and recycling of plastics, and revising the fee collection mechanism to ensure timely payment by the users of the Green Point, was the DSD system able to continue in operation.

Since its inception in 1991, there has been ongoing debate regarding the efficiency and cost-effectiveness of the Duales system. Near-bankruptcy resulted in several significant changes to the system. These included restructuring DSD's outstanding payment obligations to its haulers and processors (estimated at some DM 860 million, including upwards of DM 80 million to municipal authorities), which were converted from operating expenses into long-term loans and in some cases, into equity, thus reducing the immediate cash flow drain. Packaging manufacturers and retail firms also agreed to provide up to DM 120 million in loans and to pay DM 95 million as advance license fees. In addition, fillers and producers are now required to provide substantiation to the retailers that they have in fact made the required payments to the Duales system for products delivered to the stores. Failure by the fillers and distributors to do so can lead to the retailer's withholding up to 2.5% of the amount to be paid to the fillers and/or distributors for the products, and forwarding that amount directly to the DSD.

The revised fee system for DSD is intended to modify the prior volume-based system by incorporating higher fees for heavier and more difficult to recycle materials, thus creating a greater economic incentive to reduce the amount of material used and to find more easily recycled substitute materials. The new fee system ranges from DM 0.16 per kilogram for glass to DM 2.61 per kilogram for plastics. Laminates will pay DM 1.66 per kilogram. Aluminum costs DM 1, while steel costs DM 0.5. The setting of the fees is based on covering the costs of collecting, and in the case of paper, steel, aluminum, plastic, and laminates, also the cost of sorting. In the case of plastics, the fee also includes the cost of processing, storage, and recycling. As reported in the *International Environment Reporter* (*IER*) (April 7, 1993), the new fee structure is especially crucial as a vehicle for expanding the limited infrastructure now in place for processing plastics. (It is clear that the fee structure revision significantly impacts plastic packaging. The fee for a one-liter bottle of fabric softener, for example, is eight times what it was under the prior fee system.)

Another change to result from DSD's early cash flow problem was the creation of a new organization to take over plastics processing from VGK, the original guarantor. Created by plastics manufacturers, the collection companies, the energy companies, and Duales itself, the new company—DKR—was capitalized with an initial investment of DM 50 million. DKR is expected to have in place by 1995 or 1996 sufficient recycling and processing capacity for over 800,000 tons of plastic.

One of the goals of the Packaging Ordinance is to cause fillers and packagers to reduce the amount of unnecessary packaging utilized in bringing a package to market. DSD, in conjunction with the University of Dortmund and the Institute für Empirische Psychologie, performed a survey in 1992. According to the companies responding to the survey, the use of returnable packaging in the beverage sector has increased over the past few years. A study by the Gesellschaft für Verpackungsmarktforschung (GVM) for the Arbeitsgemeinschaft Verpackung und Umwelt indicated that the percentage of returnable packaging in the beverage sector grew from 72.6% in 1991 to 74.61% during the first half of 1992. Twenty-two percent of the companies surveyed reported that they used returnable packaging and 12% plan to increase the amount of returnable packaging used. According to a market research study commissioned by the Ministry of the Environment, packaging dropped by 3.1% in 1992, down to 13.1 million tons, and to 11.8 million tons in 1993.

The 1992 survey also addressed the use of materials recovered from recycling as raw materials (i.e., secondary raw materials) in the production of new products and/or packaging. Twenty-five percent of the companies responding increased the amount of secondary raw materials used in the production of packaging materials. One-third of the companies surveyed plan to increase the percentage of secondary raw materials used for packaging purposes.

The survey results point to a reduction in the amount of plastics used in all packaging, but an increase in paper and glass, based upon a sampling of 506 selected examples of packaging in which one material was replaced by another over the 1990-1992 period. The study also indicated a tendency to increased utilization of PE and PP, and a reduction in the use of PVC.

The companies surveyed indicated that they intend to continue optimizing their packaging efforts and that the activities associated with that effort will include reduction of material, elimination of packaging, simplification of material composition, replacement of composite packaging, and replacement of blister packaging, among others.

The results of the 1992 study appear to support the contention that the Packaging Ordinance has resulted in:

1. The acceptance by the licensees of the Green Point of the principle of increased use of secondary raw materials.

2. Reduction in the number of various materials used for packaging.

3. Standardization of material usage.

As indicated earlier, there is not sufficient capacity currently available to process and recycle the volume of plastic packaging actually being collected. In September 1993, German plastics manufacturers called on the government to reduce the recycling target for 1995 from 64% to 50%, or to expand the allowable uses of recovered plastics to include thermal processing. In October 1993, the head of the International Bureau for Recuperation and Recycling (BIR), Jean-Pierre Lehoux, also requested that the German government allow the incineration of wastes (plastics and paper) as a means of recovery. At issue here was the impact of Germany's exports of wastepaper and plastics to France. According to Mr. Lehoux, German materials are being delivered to French processing facilities at very low prices and sometimes even free of charge, the effect being to virtually drive French recyclers out of business.

A number of other countries have made similar claims that the Duales program has flooded their markets for recovered materials, to the detriment of their own local collection and processing efforts. Their argument is that because the costs of collection, separation, and transportation for the German materials are funded at least in part from a separate source of revenues (the fee for the Green Point), these materials can be made available to foreign processors at greatly reduced cost.

As part of new agreements reached with German municipalities in the early summer of 1993, DSD agreed not to return excess collected plastics to the municipalities for incineration or disposal. DSD indicated that it would attempt to solve the problem by exporting and by storing some materials for up to three years until processing capacity became available. In response to the pressure from EU sources (e.g., Mr. Lehoux), DSD has subsequently agreed not to make new contracts with EU processors. The federal government is proposing amendments to the ordinance which, among other steps, would allow the recovery of energy from packaging materials recovered in excess of the required levels.

TA Siedslungabfall

The Third General Administrative Provision on the Waste Avoidance and Waste Management Act, Technical Instructions on the Recycling, Treatment, and Other Management of Wastes from Human Settlements was issued by the Federal Government on May 14, 1993, with Supplemental Recommendations issued on May 29, 1993. TA Siedslungabfall was issued pursuant to requirements in the Waste Avoidance and Waste Management Act of 1986. The Act stipulates that the federal government, among other things, issue appropriate Technical Instructions to ensure the satisfactory planning, approval, and operation of waste management facilities and provide guidelines for the environmentally safe disposal of waste. TA Siedslungabfall addresses the collection, processing, and disposal of domestic wastes (i.e., wastes generated in human settlements).

The objective of TA Siedslungabfall is to promote waste avoidance and the recycling/reuse of unavoided wastes, to keep the pollutant content as low as possible, and to secure the environmentally compatible treatment and landfilling of non-recyclable wastes to ensure that "... wastes are ... deposited in such a manner that the waste management problems encountered today are not shifted onto future generations."

Among the more significant requirements of the Technical Instruction are the following: (i) separate collection of recyclable materials and pollutant products; (ii) collection of biowastes such that biowastes are free from extraneous materials and pollutants; (iii) garden and park wastes are to be recycled in situ as far as possible; (iv) wastes may only be landfilled if they cannot be recycled and, most significantly, (v) if wastes are to be landfilled, they must meet certain specific criteria, including a maximum allowable organic content, which practically will require that any waste from human settlements destined for final disposal in a landfill must be subjected to thermal processing. Given that almost 75% of the municipal waste generated in Germany in 1990 was disposed of in landfills, this requirement that the organic content be no more than 3% for a Class I landfill or 5% for a Class II landfill will require the addition of significant new processing capacity. By 2005, when no further waivers can be issued and all areas must be in compliance with the requirements of the Technical Instruction, landfills in Germany will be used exclusively for the deposition of residual materials.

MUNICIPAL SOLID WASTE GENERATION, REUSE/RECYCLING, TREATMENT AND DISPOSAL

Waste Generation

Germany has in place a fairly sophisticated and extensive program to gather environmental data, including data on the amounts of waste generated. Data are collected on household waste; commercial waste which is similar to household waste; market waste; street sweepings which are delivered to public waste disposal facilities; and production residues, both solid and liquid. The data are based on information provided to the federal government from public authorities and private industry, as required by the environmental statistics legislation. In the case of information related to various recycling activities, this information is augmented by data provided by various industry associations.

Germany's Environmental Protection Agency reports that verified data on the total amount of waste produced in Germany is not available. Part of the difficulty is that data on the various portions of the waste stream are often based on different criteria and may in fact overlap. In addition, it is difficult at present to establish with certainty the total amount of waste which is diverted from the waste stream for reuse and/or recycling. While much of the waste collected separately by waste disposal authorities is included in the statistical data furnished to the government, information on the amounts collected by charitable organizations, for example, is generally unavailable.

Trade associations dealing with recovered materials have historically provided additional data on the volume of such materials utilized. This is aggregate data, however, which does not differentiate between public and private sector collection and thus can include materials reported elsewhere as part of the public waste system. It is expected that the available data on recovered packaging materials will improve as a natural offshoot of the Duales program, which is required to demonstrate its compliance with mandated recovery targets.

In 1990, an estimated 26 million tons per year of household waste and commercial waste similar to household waste were collected by municipal organizations or their designees, as reported by Referat WA II of Umweltbundesamt, based upon data provided by Statisches Bundesamt. A total of over 55 million tons of household waste, commercial waste similar to household waste, bulky waste, street cleaning debris, and market waste were delivered by public and private haulers to processing and disposal facilities in 1990. The Bundesverband der Deutschen Entsorgungswirtschaft, the German Association representing the waste management industry's private sector, has estimated that a total of over 50 million tons of household waste, commercial waste similar to household waste, bulky waste, street cleaning debris, and market waste was generated in 1990, based on numbers provided by Bundesamt, DSD, GVM and BDE. Included in the 50 million tons are a total of 33.8 million tons of household waste, including 7.75 million tons of packaging waste. As is the case in many countries, the exact determination of the amount of waste generated and its disposition is a mix of science and art, as the availability and quality of data for all the various segments of the waste stream varies.

In 1987, approximately 23 million tons of household wastes, commercial wastes similar to household wastes, and bulky wastes were delivered by municipal organizations or their designees to public waste disposal facilities in the Landers comprising West Germany. This translates into approximately 375 kg per capita per year. Approximately 70% of household and commercial waste generated was disposed of in landfills, with approximately 20% being processed at waste-to-energy (WTE) facilities, and 5% being composted. Historically, landfilling has been the predominant method of disposal. Germany faces a severe shortfall in landfill capacity, however, since new sites are increasingly difficult to find and the number of active existing sites is decreasing. Landfills for household waste, for example, have decreased from 4,000 in 1975 to approximately 300 in 1991. One result of this shrinking disposal capacity is that Germany has been exporting over 1 million tons of waste annually, according to the Ministry for the Environment.

The balance of the waste stream not recycled is processed at WTE and composting facilities. Germany currently has 50 household waste incinerators (49 in the former West Germany, one in the former German Democratic Republic [GDR]) with an estimated annual capacity of approximately 9 million tons. There were an estimated 200 composting facilities in operation in 1990.

Paper and Glass Reuse/Recycling

For the period 1970 through 1991, paper utilization in Germany increased from 7.6 million tons to 15.9 million tons. The production of recycled paper tripled during this period, to approximately 7.5 million tons. Current estimates are that over half of the paper produced in Germany is made from pre- and postconsumer recycled paper.

Between 1970 and 1981, returnable packaging for drinks fell from 90% to 74%. The current level is estimated at 74.6%. In accordance with the Packaging Ordinance, this level must remain at or above 76%, or additional deposit and packaging regulations will be implemented. Ninety-two percent of the mineral water in Germany, 84% of the beer, and 76% of the carbonated beverages are sold in refillable bottles. Wine and fruit juices are at 40 and 37%, respectively.

Drinks packaging is not standardized. A survey conducted by Otto Reichelt AG in their 100 stores identified five different bottles for water and soft drinks and 11 different types for beer. According to the German Retailers Institute, beer comes in 204 different types of returnable cases, water and soft drinks in 42, and fruit juice 21. Efforts to expand the use of returnable packaging include the formation of the Foundation for Returnable Packaging Initiatives, which is directed at standardizing and promoting the use of returnable packaging systems throughout Europe. A study performed for the Ministry of the Environment, however, indicates that there is no simple answer to the question of single use versus multiple use. According to this study, when all of the environmental and economic costs associated with single-use versus multi-use packaging are considered, the choice depends upon a number of situation-specific items, including the distance to the processing facility and the weight of the container.

The total amount of glass consumed in Germany rose from 2.7 million tons in 1975 to 4.24 million tons in 1991. In 1991, 3.7 million tons were produced in Germany. The amount of glass produced from recycled glass rose from 0.2 million tons to over 2.3 million tons during the same time period. Thus, as a percent of German-produced glass, recycled glass represents over 62% and as a percent of total glass sold in Germany (which includes imported glass), over 54%. These figures clearly indicate a dramatic increase in the use of recycled glass as a result of Germany's waste management effort over the past decade.

Disposal of Municipal Waste

Public waste disposal facilities include treatment plants (waste incineration, composting, chemical/physical treatment, neutralization and detoxification, and emulsion separators) and landfill facilities for the disposal of wastes that cannot be processed further. In 1990, in western Germany there were: 290 household waste landfills (over 2,000 in the former East Germany); over 2,000 construction and demolition (C&D) landfills (over 1,000 in the former East Germany); 47 WTE facilities; 218 composting facilities (23 in the former East Germany); and 172 transfer stations (6 in the former East Germany). The large number of active household waste landfills in the former GDR totalled over 2,300 in 1990. This reflects the fact that landfills were the preferred method of waste management in East Germany. These sites generally do not meet current standards and will be phased out as part of the process of upgrading environmental practices in the former GDR.

Approximately 28% of the German population is currently served by waste management systems incorporating waste-to-energy. This percentage will undoubtedly increase as the Landers come into compliance with the requirements of TA Siedslungabfall.

The total amount of waste delivered to public plants in 1987 was 102.3 million tons. Over half of that amount (57.5%) consisted of building rubble, rubble from road works, and excavated earth. Household waste, bulky wastes, street sweepings, and market wastes totaled 31.0 million tons in 1987, the second largest category of waste disposed of in public facilities.
Of the total 102.3 million tons, 88.9% (approximately 89.2 million tons) was disposed of in landfills. Approximately 9 million tons, 8.4% of the total, was processed at WTE facilities. This 9 million tons represented approximately 20% of the household waste processed.

Although landfilling has been the predominant method of household waste management in Germany for many years, as the Landers come into compliance with TA Siedslungabfall, landfills will function only as the final depository for residual materials from waste treatment processes.

Manufacturing Wastes

Hospitals and the manufacturing, construction, mining, and electrical industries generated over 200 million tons of waste in 1987. The largest category of waste produced by these generators is building rubble/excavated earth. As a result of new measures to reduce air emissions, ashes, slag, and soot from combustion increased the amount of wastes produced in the electricity, gas, district heating, and water supply sector by almost 25% from 1982 to 1987.

In accordance with the Environmental Statistics Act, the government periodically surveys the private sector's waste management practices. The most recent data, from a survey conducted in 1987, indicates that of the 206 million tons of commercially produced waste in 1987, 43.7 million tons (21.3%) were reintroduced into commercial circulation.

Nonrecycled waste from industrial plants and hospitals is disposed of in on-site facilities, off-site private facilities, or public waste facilities. In 1987, 21.3% of the waste materials from this sector of the economy were delivered to commercial facilities for further processing, 17.4% was disposed of in on-site incineration facilities or landfills, and 61.3% was disposed of either in public facilities or other commercial plants.

Under German law, hazardous waste materials are subject to special requirements. These requirements include registration, and where necessary, treatment and disposal at specially equipped facilities. In 1987, a total of 2.7 million tons of such materials were treated and disposed of. Of this total, 1.99 million tons were treated off-site for disposal, 0.335 million tons were disposed of in on-site hazardous waste incinerators or landfills, and 0.4 million tons were forwarded for further processing or reuse.

In years past, a significant amount of waste, including hazardous waste, was shipped out of West Germany, most of it to East Germany. In 1988, for example, over 1 million tons of hazardous wastes and other wastes and over 2 million tons of household waste were exported. (Of 3.2 million tons exported, 2.1 million tons went to the GDR.) As a result of actions by some of

Germany's neighbors and, in particular, the Basel Convention on the Transboundary Movement of Hazardous Wastes, these export totals should drop significantly.

CASE STUDIES

In-depth case studies of the integrated municipal solid waste management systems of four German communities (Augsburg, Bad Tölz, Duisburg, and Munich) were performed as part of this study. The case studies provide examples of integrated waste management systems in large, medium and small municipalities in Germany.

Augsburg

Overview

The city of Augsburg comprises an area of 147.14 km^2 in Bavaria, Germany's largest Lander, or state, its largest farming region, and also a major tourist area. Augsburg, with a population of over 260,000, is the third largest city in Bavaria and the twenty-ninth largest city in Germany. The combined population of the region, including the landkreis Augsburg and the landkreis Aichbach/Friedburg totals approximately 600,000. While the Federal Republic's average population density is 222 inhabitants/km^2 and Bavaria's is 166/km^2, Augsburg has over 1,770 inhabitants/km^2. Augsburg's economy is based on engineering and textiles.

In the early 1980s, Augsburg and the entire region encountered increasing difficulty in siting and developing new landfill capacity to meet waste disposal needs. The city of Augsburg and the districts of Augsburg and Aichbach-Friedburg formed the Augsburg Waste Management Administration Union (AWMAU), a regional organization tasked with developing and implementing a regional solution to the growing waste management problems. In the mid-1980s, the AWMAU decided to pursue the development and implementation of an integrated waste management program incorporating waste reduction, separation of recoverable valuable materials at curbside and at a materials recovery facility, composting of the organic fraction, thermal treatment in the form of incineration of the balance, and the processing and recovery of valuable materials from the resulting ash residues.

Description of System Components

Waste management within the city of Augsburg is the responsibility of Referat 2, a department within the city government. Referat 2 is responsible for collection of MSW and packaging wastes and, through the AVA Abfallverwertung Augsburg Gmbh, for the processing and treatment of the municipal waste stream. The main component of Augsburg's integrated waste management program is a recently completed facility that consists of co-located facilities for materials recovery, composting, waste-to-energy, and ash processing. As a result of a design modification implemented during construction, the control functions of each facility have been centralized, thus making it a truly integrated waste management system.

Augsburg's approach to integrated waste management consists of: waste avoidance; collection; composting; materials processing; waste-to-energy; and landfilling.

Waste Avoidance

Augsburg's public education efforts stress waste avoidance. For example, the city is making an active effort to enlist charitable organizations in expanding the ongoing collection of textiles for reuse. The city is also encouraging private composting of kitchen and garden waste and the expanded use of excavated material in building noise protection walls.

Collection

Augsburg's current waste collection program employs a three-container system, with a green barrel for paper, a yellow barrel for packaging materials carrying the Green Point label of the Duales System Deutschland, and a grey barrel for the balance of the residential waste stream. A separate brown barrel for bio-waste is being introduced in 1994 upon start-up of the composting facility for the organic fraction of the waste stream.

Collection of waste occurs once per week; collection of paper and DSD materials occurs once every three weeks. The city also provides drop-off locations for color-separated glass containers and paper. These drop-off materials are collected periodically.

The more rural areas surrounding the city utilize useful-materials drop-off yards and drop-off bins for glass and paper. These communities also provide for collection of paper and the remaining fraction of the waste stream.

In the implementation of the DSD system in Augsburg, the city's own waste management organization plays the collection role served in some other cities by private entities. Augsburg's system for DSD collection includes drop-off containers for paper and glass and yellow containers in each household for light packaging and sales packaging materials.

Drop-Off Sites

The city provides a number of drop-off facilities for paper and glass. In addition, textiles are also generally collected in drop-off boxes sponsored by various nonprofit agencies. Each glass drop-off station consists of separate containers for clear, green, and brown glass. The city is expanding the glass drop-off system to achieve a density of approximately one station for every 1,000 inhabitants, with a goal of having a bin no more than 15 minutes away from every resident.

Materials Processing

The materials recovery facility, which is designed to receive commercial waste and source-separated household waste, has three processing lines—one for commercial waste and two for household waste. The facility is designed to separate cardboard, film, textiles, mixed paper, newspaper and plastics, ferrous and nonferrous metals, glass, and wood. The residual waste after sorting is delivered to the WTE facility.

Composting

The compost facility consists of a receiving area for garden waste and the organic fraction of MSW, a sorting area where materials are screened for contaminants and useable materials, rotating drums where moisture is added and the material is macerated, and a composting area consisting of two large aerated beds (each approximately the size of a football field). The design capacity of the composting facility is approximately 54,000 tons per year of organic MSW and green waste.

Waste-to-Energy Facility

The WTE facility consists of a receiving area for MSW and dewatered sludge; three furnaces/boilers for incinerating and recovering the energy from refuse; two small hospital waste incinerators (approximately 0.5 tonne per hour); a drying system for sludge; an air pollution train for each furnace; a turbine generator to convert the steam energy into electricity; and an ash collection and handling system. The Augsburg facility is designed to process approximately 230,000 tons of waste per year (approximately 10 tons per hour per line). According to the city, the five-stage flue-gas purification system is designed so that under all operating conditions the guidelines of the 17th Federal Emission Protection Ordinance (BImSchV), which were made more stringent in December 1990, are not only met but considerably surpassed.

The bottom ash from the WTE facility is transferred to the ash-processing facility. Here, the ferrous fraction is first recovered via a magnetic separator. The remaining materials are sized, separated into a fine fraction (0 to 30 mm) and a gross fraction (greater 30 mm). This material has various construction applications. The fly ash from the facility is collected separately and disposed of by the South West German Salt Works, Inc.

Landfilling

In 1992, it was estimated that Augsburg's landfill contained approximately 1.1 million m^3 of capacity, enough for an additional 3.5 years at the then rate of disposal. Since then, the amount of material to be landfilled has been considerably reduced by the implementation of the city's integrated waste management program. In 1993, over 150,000 tons of waste generated in the city were landfilled. The city estimates that the amount of material to be landfilled will drop to approximately 33,000 tons in 1994. This material will consist primarily of building and construction debris and excavation materials. Future residues from the integrated waste management facility, primarily residuals from the bottom ash, are estimated at approximately 7,000 tons per year.

Quantities of Waste Handled

Residential waste includes household waste, bulky waste from households, wastepaper, used glass, street sweepings, garden and park waste, and market waste. In 1992, the city collected 62,673 tons of household waste. In 1993, the city collected 66,895 tons. Commercial waste similar to household waste totalled 47,628 tons in 1992 and 43,137 tons in 1993. Construction site and building demolition waste totalled 26,674 tons in 1992 and 20,946 tons in 1993.

In 1993, most of the waste generated in Augsburg and the surrounding regions was disposed of in the landfill located at Augsburg-Nord. This included 204,413 tons of waste generated in the city, 32,230 tons of green waste used in recultivating the landfill, and 8,550 tons of household waste and bulky waste processed during start-up activities. Approximately 12,350 tons were composted in 1992, and 32,223 tons in 1993.

According to data filed by the city with the Bavarian Ministry of the Environment in July 1993, the city anticipates increasing the amount of material (excluding DSD packaging materials) recovered from the waste stream from 14,360 tons in 1993 to over 45,760 tons in 1994 and beyond. For DSD materials, the city estimates that the 24,442 tons recovered in 1993 will increase to 29,069 tons in 1996. A significant portion of the increase in recovered materials in 1994 is due to the recovery of metals and slag from the WTE facility (1,500 tons and 22,050 tons, respectively).

Summary

At Augsburg's new integrated waste management facility, the combined operations of collecting, sorting, and composting can recycle as many as 105,000 tons per year of useful materials contained in the region's waste stream. All wastes that cannot be recycled are treated thermally. This can add up to 220,000 tons out of a total waste generation of approximately 325,000 tons per year. Thermal processing of waste produces about 14 megawatts of power. The residues from the WTE plant are partly used as processed slag in road construction. Salts are used industrially. Fly ash and filter cakes are stored underground in a salt mine in an ecologically safe manner.

Augsburg's integrated waste management system relies primarily upon the public sector. The system has been designed to serve as a regional facility, servicing not only the city of Augsburg, but the surrounding areas as well. Augsburg's waste management system meets the characteristics of an integrated waste management system; namely, it incorporates source reduction, recycling/reuse, composting, resource recovery, and landfilling.

Bad Tölz

Overview

Bad Tölz is one of several municipalities in the region, or landkreis, of Bad-Tölz-Wolfratshausen. The landkreis comprises approximately 1100 km^2 in Bavaria, Germany's largest state, and Bad Tölz itself is located approximately 50 km south of Munich, Bavaria's capital.

While the Federal Republic's average population density is 222 inhabitants/km^2 and Bavaria's is 166/km^2, the landkreis Bad Tölz has approximately 100 inhabitants/km^2. The major economic activities in the region are agriculture and tourism. Bad Tölz, in an area known for its springs, is a major health spa center.

In the early 1980's, the Bad-Tölz-Wolfratshausen region found itself facing increasing difficulty in siting and developing new landfill capacity to meet its waste management and disposal needs. After an extensive review of various processing and disposal alternatives, the regional authorities decided to construct a materials recovery and composting facility as the key element in an integrated waste management system. This original system was based on the separation of municipal waste into two categories at the source: the organic fraction, and the balance of the waste generated.

Description of System Components

Waste management within the region is the responsibility of WGV Recycling Gmbh Quarzbichl, which has contracts with the region's various municipalities. The region's integrated waste management system consists of waste avoidance, collection, composting, materials processing, waste-to-energy, and landfilling.

Waste Avoidance

Waste avoidance is stressed in the waste management system's public education program. Residents are provided with materials describing the importance of "smart" shopping and private composting of kitchen and garden waste. In 1991, in an effort to encourage waste reduction, the region implemented a trial program of volume-based fees. The fee system was structured so that residents had the option of container size, with the fees being based accordingly (i.e., the larger the container, the higher the monthly fee for waste collection services).

Collection

Bad Tölz's waste collection program is based on a three-bin system, the original two-barrel system having been replaced in 1992. The change to a three-barrel system was intended to provide cleaner waste material for the composting facility.

Duisburg is an important transportation center, with its extensive network of highways and its access to the Rhine and Ruhr waterways. Indeed, the Rhine-Ruhr port is the largest inland port in the world.

The Duisburg economy is still based on manufacturing, with the iron and steel industries of primary importance. The micro-electronics sector is rapidly approaching primary importance. Other significant factors in the Duisburg economy are large international trade companies, a substantial middle class, the service sector, and, as indicated above, the transportation sector.

Manufacturing is the leading occupation in Duisburg, as indicated in Table 4.3-2, of Section 4 of this report. Over the last two decades, however, manufacturing jobs have decreased while jobs in the service sector have increased.

Description of System Components

The organization responsible for managing waste in the city of Duisburg is the Entsorgungsbetriebe der Stadt Duisburg. The organization's responsibilities also include water treatment and street cleaning. The city relies on a number of other organizations to help meet its long-term solid waste management needs. For example, while the Entsorgungsbetriebe der Stadt Duisburg operates a compost facility, the system's other facilities are operated by other entities.

Duisburg's waste management program incorporates a number of components, including several drop-off locations for various materials, a composting facility, a WTE facility, facilities for the processing of household waste, and facilities for disposal of household waste, commercial waste similar to household waste, market refuse, street sweepings and other similar refuse.

The following sections briefly describe the role of each of these elements in Duisburg's integrated waste management system.

Waste Avoidance

Waste avoidance is a key element in Duisburg's public education efforts. A waste avoidance component is incorporated into the city's programs and materials related to waste management. For example, the city is making an active effort to enlist organizations similar to the Salvation Army in the United States in fostering the reuse of bulky items such as furniture and electronic goods. Also under consideration is a separate pickup program for usable bulky items, in addition to the current call-in system.

Collection

Beginning in 1992, Duisburg's waste collection, processing, and disposal services have been organized into a separate corporation structured on an enterprise fund basis and comprised of various former departments within the city administration. This organization, the Entsorgungsbetriebe der Stadt Duisburg, provides for collection of household waste, as well as packaging materials targeted under the DSD program. Duisburg's system for DSD collection includes drop-off containers for paper and glass, and yellow bin containers in each household for light packaging materials.

Collection is accomplished via bags and barrels, wheeled containers of various sizes (most commonly, 240 liters), and larger containers (660 to 1,100 liters) for multifamily buildings. The system includes separate wheeled containers for nonsorted wastes, and yellow barrels or bins for light packaging material. The city is also evaluating a pilot program using green bins for organic wastes.

Collection frequency varies by district and ranges from every two weeks for household collection to more frequent collection of bins and large containers. The city also provides for the collection of leaf wastes as part of its routine street cleaning program, has an on-call program for bulky wastes, and a mobile collection vehicle for the collection of household hazardous wastes to supplement drop-off facilities.

Drop-Off Sites

The city provides a number of drop-off facilities for various materials, including hazardous household wastes, bulky wastes, and garden wastes. Prior to implementation of the DSD system, aluminum was collected at drop-off bins located at schools, businesses, and public disposal locations. Aluminum is currently collected in the yellow bins as a light packaging material. Textiles are also generally collected in drop-off boxes sponsored by various nonprofit agencies.

The city also provides drop-off centers for glass and paper. Duisburg's drop-off glass collection system dates to the mid-70s. The city has added containers on an ongoing basis, with the number of containers growing from 293 in 1982 to over 1200 in 1992.

The number of paper drop-off locations has grown from 70 in 1982 to over 1600 in 1992. The city intends to add at least 400 more sites by 1995. By making more drop-off bins available, the city hopes to achieve a travel time of no more than five minutes for each resident to reach a bin. Because it is no easy task to find sites for 2,000 bins in a densely populated city, waste management officials are exploring the use of private parking lots and other private sites.

Materials Processing

In 1990, a group of private waste disposal enterprises founded the "RZO Recycling Center at Oberhausen GmbH" for the purpose of operating a sorting facility. Today, this facility is used to pretreat and preprocess sortable wastes, defined as commercial waste similar to domestic waste, bulky waste, market waste, and garden and park wastes. After preliminary processing in the RZO facility, the balance of the waste is delivered to the WTE facility. The relationship between the operators of the WTE facility and the RZO is regulated by a cooperation contract.

The RZO expects to process 100,000 tons/year of delivered wastes. Approximately 10,000 tons per year will consist of plant material for composting. The remaining 90,000 tons per year will consist of commercial wastes and bulky material for sorting. Approximately 33% marketable materials are expected from this sorting process. Fifty-five percent of the input material is expected to be delivered to the WTE facility as combustible, nonuseful materials. Twelve% will be noncombustible material for landfilling.

As part of the implementation of the DSD program in Duisburg, the RZO facility is also used to process DSD materials. Under a cooperative agreement between the city and RZO, the city is responsible for collection of materials, siting, care and cleaning of depot container locations, and public relation services. A negotiated fee structure covers the city's cost of equipment. The city's costs for public relations, cleaning the drop-off locations, and consulting services are paid for by a fixed per capita fee. For the first 18 months, the fee for public relations and system advice was set at DM 0.5 and DM 1 per capita, respectively (a total of approximately DM 808,000). For the siting, care, and cleaning of the drop-off containers, the city receives DM 3 per capita (approximately DM 1,600,000).

The city will provide yellow bins for household collection of the light packaging fraction. In addition, residents will be furnished a 240-liter wheeled can for the balance of the waste stream. The materials thus collected will be delivered to the RZO facility for sorting and processing.

Composting

The Huckingen composting plant, the oldest plant of its kind in the Federal Republic, has been processing solid waste for more than 30 years. The plant was originally designed to handle domestic trash and sewage sludge from about 150,000 inhabitants. Given the increased awareness of pollutants associated with sewage sludge, no sewage sludge has been composted since November 1990. Necessary moisture is now provided by adding water.

Besides domestic trash, the composting plant processes foliage from public roads as well as stable dung from the zoo and the slaughterhouse. As collected paper has increased, and the reuse market has become more saturated, the city has also decided to compost wastepaper at the Huckingen facility when market conditions dictate. Approximately 56% of the incoming material is recovered as compost, 43% is reject materials, and about one percent is metal recovered at the magnetic separator.

The compost produced at the facility is marketed as filter compost for odor control applications, as a soil amendment, and in horticultural applications. In 1990, approximately 51% was used in landscaping and horticultural efforts, 9% was used in recultivation of landfills, and 38% was used as filter media in biofilters throughout Germany.

Waste-to-Energy Facility

In 1968, Duisburg and several other municipalities formed a regional solid waste management authority. Together they purchased a closed coal power facility at Niederrhein in Oberhausen and converted it for MSW combustion. The plant's existing boilers, turbines, and feedwater systems were incorporated into the new facility. New components included the furnace grates, scale house, refuse pit, air pollution control equipment, chimney, air-cooled condenser, and new instrumentation for process control. The retrofit was completed in 1972, with the three-unit facility rated at 1,740 tons per day (a fourth unit was added in 1985). In 1984, the public company formed by the authority, the Gemeinschafts-Múll-Verbrennungsanlage Niederrhein (GMVA Niederrhein), was converted to a private limited company, whose corporate members are the cities of Duisburg, Oberhausen, Dinslaken, Moers, and Voerde.

Current combined capacity of the four units is approximately 580,000 tons per year. The heat from the gases is converted to steam, which in turn is used in a district heating loop and to make electricity in turbine generators.

The air pollution control (APC) trains installed at the Niederrhein facility have undergone several modifications since the facilities were installed. The initial APC equipment consisted of an electrostatic precipitator. Following the implementation of more stringent requirements contained in TA Luft 74, the new fourth unit and the original three units were equipped with a wet scrubber. As a result of the implementation of still more stringent requirements, the units were also later equipped with dry scrubbers. To comply with the current regulations (including 17th BImShv), the facilities are currently being retrofitted with catalytic converters and activated carbon filters.

Ash from the facility is separated into a ferrous fraction, bottom ash remaining from the combustion process, and fly ash captured through the APC train. The bottom ash is transferred to a processing facility, where it first passes over a magnetic separator and then passes to a drum screen, where it is sorted into various fractions by size. The materials recovered from the ash are utilized as aggregate in road construction. The fly ash captured in the APC train is handled as hazardous waste.

Other Processing Facilities

The city also uses other privately operated processing facilities for managing certain portions of its waste stream. These include private processing facilities for construction and demolition debris, refrigerators, used tires, used oil, and hazardous waste materials.

Landfilling

Digested sludge from Duisburg's three sewage treatment plants, as well as a portion of construction scrap and earth excavations, are landfilled. Street sweepings are partly handled by thermal treatment, but a portion must also be landfilled because of this material's high mineral content, especially during the winter months, when anti-slip chemicals are spread on the streets and roads. A portion of residual substances from the thermal waste treatment process at GMVA Niederrhein are also landfilled.

Quantities of Waste Handled

Residential waste includes household waste, bulky waste from households, wastepaper, used glass, street sweepings, garden and park waste, and market waste. In 1985, the estimated total residential waste generated (based on the amounts handled by the City Waste Department) in developed areas amounted to 221,541 tons. In 1990, waste generation was 278,373 tons. This represents an average annual increase of 4.7%. The per capita figures show much the same pattern over the 1985-1992 period. In 1985, residential waste averaged 416.07 kg/per capita. This grew to 521.69 per capita in 1992. When compared to the national figures for 1984 (362 kg per capita) and 1990 (333 kg per capita), it is clear that a substantially greater than average amount of waste per capita is generated in Duisburg. This is due in part to the greater level of commercial activity in this densely populated, highly industrialized urban environment.

In 1990, the city processed 4,300 tons of household waste, 4,300 tons of leaves, 200 tons of zoo dung, and 2,900 tons of paper (for a total of 11,700 tons) at the composting facility, By 1992, 20,200 tons of garden and park wastes were also composted, either at the compost facility or on site, while 500 tons were chipped and 1,300 tons were combusted.

Market waste, which includes packaging materials and organic materials, was estimated by the city to be about 9,150 tons per year in 1990. In 1992, the city estimated that approximately 10,600 tons were generated, of which 1,100 tons were recovered and 9,500 tons were processed at the WTE facility.

In 1990, the GMVA Niederrhein incinerated 460,447 tons of waste from developed areas. 288,489 tons of this came from Duisburg. This total is composed of various types of waste:

Domestic trash and commercial trash similar to domestic trash	247,117 tons
Bulky waste	22,552 tons
Street sweepings	757 tons
Market waste	6,783 tons
Garden and park waste	5,237 tons
Raked-up material	1,165 tons
Sifting residues from the composting plant	4,878 tons
TOTAL	288,489 tons

Of the 329,091 tons of domestic waste and commercial waste similar to domestic waste from collected developed areas in 1990, 32,885 tons were composted and 11,759 tons were recycled. In addition, 7,648 tons at the GMVA Niederrhein facility and 27 tons at the compost facility, totalling 7,675 tons of metals, were recovered from the waste flow in 1990 by magnetic separators installed at the waste-to-energy and composting facilities. These metals were routed to scrap markets. Thus, approximately 19% of domestic trash (16% of domestic trash plus similar commercial trash) was recovered for recycling.

Wastes from water processing and wastewater purification took two disposal paths. The total amount for disposal in 1990 was 14,461 tons. About 91.9% of these wastes were landfilled, although 8.1% were used thermally.

Construction wastes are assigned to the group of construction scrap, road demolitions, and earth excavations. For 1990, such wastes were estimated at 612,027 tons. Of this amount, about 470,000 tons were recovered for reuse. This amount does not include earth excavations, which are moved at the construction sites and temporarily stored in interim storage areas, then filled in again.

In 1990, 242,345 tons of Duisburg's waste were deposited in landfills. In addition, the overflow from the GMVA Niederrhein, amounting to 12,217 tons in 1990, and filter dusts and filter cakes from the GMVA, amounting to 7,767 tons in the same year, were also disposed of at a landfill.

The distribution, relative to the total recorded amount in 1990, including construction and demolition debris, is as follows:

DISPOSITION OF WASTE STREAM IN 1990

Total Generation (including C&D)	1,051,576 tons	100.00%
Recycling (including C&D)	564,634 tons	48.89%
Incineration	283,611 tons	26.79%
Landfill	242,345 tons	23.04%
Special Waste Treatment	989 tons	0.10%

To analyze developments in materials recycling, the city's 1991 plan used the 1990 waste stream quantities as a basis for estimating future requirements. With regard to the total quantity of waste (domestic and commercial similar to domestic), the city is projecting an increase in the recycling/composting rate to roughly 29% in the year 2000. Taking into account construction, demolition, and building wastes, the total percentage of recycled substances may rise to about 70%. The dominant reason for this high recycling rate is the consistent and complete utilization of construction wastes.

The city estimates that full implementation of the Packaging Ordinance, including the buildup of a separate collection system for packaging materials, will relieve Duisburg's waste disposal burden by about 30% by weight. The Packaging Ordinance prescribes different fulfillment quotas between 1993 and 1995. If these stipulations are completely met, by 1995 approximately 78,000 tons of waste (from domestic trash, commercial trash similar to domestic trash, and usable substances) out of a total of about 263,000 tons would be regarded as packaging waste.

As noted in the city's plan, if expanded recovery of the usable materials is realized, the requirements of the Packaging Ordinance can be met. The necessary regulations for handling the collected packaging materials, which may eventually include magazines and newspapers as part of the announced Ordinance for Returning Print Materials, must be clarified and contractually secured. By 1995, it should be clear whether or not the introduction of city-wide collection of plastics and composite materials, and their sorting, utilization, and recycling, has led to intensive recovery of usable materials.

Summary

Duisburg has in place a waste management system which meets the characteristics of an integrated waste management system; namely, it incorporates source reduction, recycling/reuse, composting, resource recovery, and landfilling. This integrated waste management system is comprised of several facilities, located throughout the city and in other jurisdictions in the region. The facilities in place include composting facilities; a recyclable materials processing facility; construction, demolition, and building waste processing facilities; a WTE facility; hazardous waste treatment facilities; sludge processing and land application facilities; and landfill disposal facilities.

The integrated waste management system in Duisburg draws upon both public and private sector participants. Several of the facilities are operated by private sector companies. Private companies also provide for some collection of certain portions of the waste stream. In addition, the city organization responsible for waste management services has itself recently undergone a significant transition, from a department of city government into a stand-alone enterprise. The new organization has been set up as a separate enterprise-fund-based operating company.

The implementation of the DSD program in Duisburg is drawing upon this private/public sector spirit of cooperation. The same organization within the city that is responsible for providing waste management services is also providing collection services for the yellow bin, which is being distributed to each household for separate collection of the light fraction of packaging wastes. The glass and paper fractions are being collected in numerous drop-off bins located throughout the city.

As part of the city's integrated waste management program, the importance of source reduction and waste minimization has been identified. The role of waste reduction is now an integral part of the city's educational efforts related to waste management, including the information packets developed in support of the implementation of the DSD program. These materials highlight the purpose of the DSD program, the need for consumer cooperation, and the role of the Packaging Ordinance in fostering waste reduction by helping to divert packaging materials from disposal.

Munich

Overview

Munich, the capital of Bavaria, is the third largest city in Germany, with approximately 1,200,000 inhabitants. Bavaria is the largest Lander, or state, in Germany, with a population of approximately 11.2 million and a land area of 70,554 sq. km.

Bavaria is Germany's largest farming region. Munich's early development reflected its role as a rural capital, although its pre-World War II business base also included mechanical and electrical engineering, brewing, and insurance. After the war, Munich became the focal point of rapid economic expansion that included growth in such areas as electrical/electronics manufacturing, automobiles, fashion, advertising, insurance, and publishing. Today, Munich is also a center of higher education, computer software development, and research.

Municipal waste management in Munich is handled by the Kommunalreferat der Landeshauptstadt Munchen. The Office for Waste Handling (Amt für Abfallwirtschaft) is a separate department within the city administration.

Munich's waste management system is based upon three principles—avoiding wastes, recycling wastes, and finally, disposing of the balance in an environmentally sound manner. This conceptual framework, approved by the Munich City Council in 1988, is consistent with subsequent legislation passed at the state and federal level. In March 1991, the Bavarian Waste and Contamination Law took effect, identifying waste avoidance as its top priority.

Description of System Components

Munich's integrated waste management program includes:

- waste avoidance
- collection
- drop-off facilities
- materials processing
- composting
- waste-to-energy
- landfilling

Waste Avoidance

The Bavarian Waste and Contamination Law (BayAbfAlG) established the need for effective ongoing waste reduction programs. In turn, the design and implementation of such programs required input from households and commercial businesses, and the review and support of existing waste prevention programs run by industry, associations, city councils, and other institutions.

At its inception, the Munich waste management plan was predicated upon waste reduction reaching a level of 285,000 tons per year by 1993. In 1992, residual waste was reduced by about 250,000 tons from the 1989 level. During the last three years, the volume of incinerated or landfilled residual waste decreased by a total of 21%. The amount of material delivered to landfills was 30% less in 1993 than in 1991, due primarily to a sharp drop in construction and demolition debris resulting from consistent application of the Industrial and Construction Waste Disposal statute. This ordinance regulates the type of materials disposed of in landfills through controls implemented by landfill personnel.

The city of Munich has implemented the principles of waste avoidance and waste reduction through the broad exclusion of throwaway goods and utensils at city agencies and the requirement that all municipal departments purchase in a manner consistent with reuse goals, separate paper and residual waste, and, as much as possible, recycle office materials.

Munich's efforts to foster the use of reusable materials and implement effective separation of waste at all city celebrations have contributed to the overall reduction in the volume of waste. At the Oktoberfest, the Bavarian fairs, and the Christmas Market, only reusable dishes and utensils are permitted, and the paper, cardboard, and non-reusable glass must be recycled. Within the entire Olympic Park (especially the Olympic Stadium), food and drink can be distributed only in reusable containers. Private events on public land (theater festivals, street fairs) are likewise subject to the throwaway prohibition.

Two "wash-mobiles" are available for city-sponsored celebrations, and the organizers of private, noncommercial celebrations can also rent them for DM 200. These mobile units make it possible to wash reusable utensils on site.

Collection

In 1991, as an incentive to avoid waste, the city introduced an optional 14-day waste collection cycle, using 110-, 120-, and 240-liter bins. The collection fee was cut in half for those choosing this option. Since January 1, 1991, a total of 18,215 homeowners have taken advantage of this program.

Also in 1991, the City Council passed an ordinance mandating the gradual implementation of a collection system for residential wastes that uses:

- one (blue) bin for paper, cardboard, and cartons;
- one (brown) bin for biowastes; and
- one (gray) bin for residual waste.

Up to 40% of domestic waste, by weight, consists of biological waste; approximately 20% consists of paper and cardboard. Since these materials can be composted, recycled, or reused, the three bin system is expected to significantly reduce the amount of residual waste to be disposed of by incineration or landfilling.

Munich also has in place a number of separate collection programs that target certain portions of the waste stream, including separate collection of school-generated waste- paper, bulky waste and refrigerators, hazardous waste, fluorescent tubes, fluorochlorohydrocarbons, and special wastes (mainly from chemistry laboratories).

Munich's municipal collection system includes 268 collection vehicles operating from three facilities.

Drop-Off Sites

To facilitate the separate collection of paper, cardboard, and color-sorted glass, the city's depot container network was expanded from 443 to 546 locations. The city's plan is to further expand the depot container network to about 1,200 locations. The district boards were asked to identify suitable locations, and many of their proposals have already been implemented. Even so, siting remains a problem, with neighborhood protests having prevented rapid implementation of the expansion plans. As of March 31, 1993, responsibility for the entire depot container network was transferred to the Duales System Deutschland.

Usable Materials Yards

Bulky wastes from private households that exceed the dimensions of a 110-liter or 120-liter waste bin can be delivered free of charge to any of nine collection points for bulky wastes. Five of these collection points for bulky waste are operated by the city, and four by private contractors.

The city is in the process of expanding its existing bulky waste drop-off locations to include provisions for handling additional materials (e.g., paper, glass, metals, plastics, garden wastes, and other useful materials). In addition, efforts are under way to increase the number of usable-materials yards from nine to at least 15.

The bulky waste collection points currently have special containers for the separate collection of recyclable materials, including:

- Paper/cardboard
- Glass (three-color separation)
- Plastics
- Metals
- Garden waste
- Construction scrap
- Waste oil, waste medications, and waste batteries

Materials Processing

In 1987, the sorting facility at the Georg-Brauchie Ring began operation as part of a pilot program developed by the city to test separate collection of commingled recyclables (the "Green Bin," a five-component collection of paper, glass, metals, plastics, and textiles).

This system of mixed collection and subsequent sorting was deemed unsatisfactory, and at the end of the "Green Bin" pilot test, the facility at the Georg-Brauchie Ring was reconfigured for the sorting of paper from the "Blue Paper Bin" program as well as for wastepaper delivered from the usable-materials yard and bulky waste collection points. In 1992, 5,574 tons of wastepaper were delivered to this facility and processed by 15 employees.

In Munich, the DSD system consists of approximately 550 drop-off locations for the various packaging materials. There is no separate system in place for curbside collection of packaging materials, other than paper. The DSD pays the city approximately 25% of the costs of handling paper, based on the agreed-upon estimate that 25% of the paper collected is in fact packaging material. Citizens can, upon request, have a separate bin for paper.

The city turned over to the DSD system some 700 existing sites for their use as part of the implementation of the DSD program. These sites were part of the city's drop-off collection program targeting paper and color-sorted glass. The intent at the time was for DSD to expand the number of sites and to add to each site additional containers for plastic and metal packaging materials. To date, approximately two-thirds of the existing sites have been expanded to include these materials. The current number of operating sites has declined from the initial number of sites turned over, indicative of the difficulty in siting drop-off locations in fully developed urban areas. Among the issues involved in obtaining sites are traffic, noise, and vector problems.

Composting

To promote individual and community composting, the city provides subsidies of up to DM 80 for new composting containers. In 1992, total subsidies amounted to DM 167,832 for 2,128 applications. The city estimates that this program reduces the total volume of waste by about 565 tons. In addition to the subsidy for new containers, residents can obtain bins discarded from the "green waste bin" pilot test, for conversion into composting units. About 1,100 of these bins were distributed in 1992.

In preparation for implementation of the three-bin system, an intense search for locations for composting facilities was carried out in 1992. Two locations were identified within the city limits. In collaboration with the Sternberg County administration, planning was begun for the construction of a composting facility on one of these sites. Negotiations with several private firms were directed at securing markets for the compost to be produced at the site.

Waste-To-Energy Facilities

Munich has two WTE facilities, one in the north and one in the south of the city. These are operated by the City Works—Electrical Utilities (EW)—and serve the city of Munich as well as the surrounding area included in the Landkreis. The city's first WTE facility, Munich North I, began operations in 1964. The facility consisted of two units designed to fire refuse and pulverized coal in separate furnaces. Approximately 40% of the heat input to the facility came from waste. In 1966, Munich North II was added to the facility. Munich North II consisted of a 960-tonne-per-day (TPD) unit designed to fire refuse and pulverized coal together in a common combustion chamber, with refuse providing approximately 20% of the heat input. In 1984, another unit, Munich North III, came on line. This facility consists of two units which combust refuse only, each rated at 480 TPD. Munich North I and II were decommissioned in the late eighties and subsequently replaced with new facilities.

In 1992, Munich North I was replaced by a new waste-fired facility with an annual capacity of 380,000 tons. The facility consists of two units, each rated at 840 TPD. The facility incorporates state-of-the art pollution control systems. Munich North II was replaced by a new coal-fired unit.

Munich South IV and V began operations in 1969 and 1971, respectively. Each facility consists of a single unit with a refuse throughput capacity of 960 TPD. These are natural gas and refuse cofired units, with up to 20% of the heat input coming from refuse combustion.

Currently, the facilities at the North and South Power Plants provide six furnace lines for the thermal treatment of about 4,560 TPD of waste. The city estimates that these have an available annual incineration capacity of about 916,000 tons (taking into account long-term experience with shutdowns for overhaul and for unforeseeable reasons). According to the city, this capacity is sufficient for the thermal treatment of all combustible residual waste.

The heat generated from waste incineration was used by the City Works EW to produce electricity and remote heat. In 1992, the amounts of energy being fed into the public network was:

- 6,476 gigawatt hours of electricity
- 4,209 gigawatt hours of heat.

Landfilling

The North-West landfill at Freisinger Landstrasse 8000 Munich 45 went into operation in April 1987. The design and equipment utilized at the landfill reflected the state of the art at that time. The facility includes equipment designed to collect leachate and transfer it for treatment to the Gut Marienhof wastewater treatment facility. The groundwater downstream is continuously monitored. To implement the current regulations concerning the quality of wastewater entering wastewater treatment plants, it will be necessary in the future to pretreat the leachate water at the landfill site. At the end of 1992, of the site's original 6.2 million cubic meters of landfill capacity, approximately 3.2 million cubic meters had been filled. The amount of waste disposed of in the landfill in 1992 (371,450 tons of waste plus 71,559 tons of cover material) was the lowest amount since the landfill was opened in 1987. Approximately 50% of the landfilled material during 1988 through 1992 was slag. Furthermore, sewage sludge was deposited for the first time in 1992. Thus, in 1992, the most recent year for which data is available, this site was predominantly used for process residues.

Quantities of Waste Handled

The amount of household waste collected in 1992 fell by 5.12%, compared to the previous year. From 1991 to 1992, the quantity of collected household waste, including waste collected from small businesses, was reduced by 22,293 tons to a total of 413,103 tons. This translates into 312 kg per year per inhabitant, compared to 334 kg in 1991. If bulky waste, usable-materials, and problem wastes are added to collected domestic and business waste, the annual amount rises to 400 kg per capita, for a total volume of 531,171 tons during 1992 (compared to the 1991 total of 545,900 tons).

Bulky Waste Involving Household Equipment

The amounts of bulky waste, construction scrap, and garden waste rose in 1992. The total amount for 1992 was 30,820 tons, an increase of approximately 1.2% over 1991.

Wastepaper

During 1992, Munich collected a significant amount of wastepaper using depot containers, bulky waste collection points, blue bins—paper bins at residences, bundle collection (BRK and charitable organizations), and wastepaper collection in schools. In 1992, a total of 55,149 tons were collected. This represents a 32.6% increase over 1991's total of 41,689.

Waste Glass

Waste glass was collected via depot containers (separated by green, white, and brown glass) and at bulky waste collection points/usable-material yards. In 1992, a total of 29,033 tons were collected. In 1991, the total was 31,399. The slight decline in the collection of waste glass is due to the fact that more and more private households were converting to reusable containers. The city claims that this trend is in part a result of increased publicity efforts.

Biological Wastes

The bio-bin (brown bin) pilot test included 20,000 households. Collection and removal during the test were free, and participation was high (above 90%). A high degree of purity was achieved in the collection process, with only one to three percent of the materials collected being rejects. In 1992, during the test, about 1,828 tons of organic wastes were collected, compared to 1,784 tons the previous year.

The original waste management plan forecast a savings potential of 50,000 tons per year from the separate collection of biological waste. The city now estimates that if the bio-bin is introduced throughout the area, this forecast can be exceeded. As the waste plan indicates, however, the introduction of the bio-bin throughout the city depends on obtaining sufficient composting capacity and a significant expansion of the collection vehicle fleet.

Garden Wastes

In 1992, about 9,151 tons, or 65,363 m^3, of garden wastes were collected at the city's bulky waste collection points and composted.

Individual Composting/Shredding Service

By promoting individual composting, approximately 1,800 tons of organic material was diverted from disposal facilities during 1992. To relieve the disposal facilities of additional organic wastes, efforts are under way to introduce an area-wide mobile shredding service to size-reduce woody wastes, which can be used on-site.

Waste Plastic

According to the city, as of 1992, only clean polyethylene film and polystyrene could be reliably recycled. Consequently, only those materials were accepted at the bulky waste collection points. In 1992, 6.3 tons of film, polystyrene, and polyethylene terephthalate core bodies were recycled.

Discarded Clothing

All over the city, as well as at the usable-material yard and the bulky waste collection points, private firms or charitable organizations have set up clothing containers in which discarded clothing is collected for reuse and recycling. The city estimates that 529 tons were collected in 1992.

Waste Metal/Scrap

In 1992, the city recycled a total of 15,400 tons of iron which were electromagnetically recovered from the ash at the city's two waste incineration facilities. In addition, the city recovered from useful-materials yards/bulky waste collection points 5,120 tons of mixed metal (compared to 3,486 tons in 1991). From the Metal Container at the Ratzingerplatz, the city collected 25 tons (compared to the 1991 amount of 7 tons). Thus, the total amount of scrap metal recovered by the city in 1992 was 20,554 tons, an increase of 64% over the 12,512 tons collected in 1991.

Recovery of Materials

According to the city, because of the population's responsiveness to the separate collection of useful materials and the obligation of commercial enterprises to effect such separation, the recycling volume rose markedly during the period 1988 to 1992, from 190,000 tons in 1988 to over 1.2 million tons in 1992. The most significant contributions to the total amounts recycled were from commercial waste and construction, demolition, and building wastes.

Summary

The table below provides a summary of the amount and disposition of domestic and total waste in Munich in 1992. As indicated, the overall rate of recycling of over 50%, while impressive, is driven by the reuse/recovery of construction, demolition, and building wastes, including site excavation materials. When one examines the domestic portion of the waste stream, approximately 23% of the waste was recycled, 76% was processed at the waste-to-energy facilities, and 2.4% was landfilled.

1992 MUNICH WASTE DISPOSITION
(tons)

WASTE TYPE	TOTAL	RECYCLED	PROCESSED AT WASTE-TO-ENERGY FACILITY	LANDFILLED
Domestic Waste	531,850	122,552	404,809	12,517
Total Waste	2,435,055	1,257,411	895,839	281,805

Munich has in place a waste management system which meets the characteristics of an integrated waste management system. It incorporates source reduction, recycling/reuse, composting, resource recovery, and landfilling. Existing major components of the Munich system are drop-off bins for paper and glass, and bulky waste; useful-material collection facilities; two WTE facilities; and a regional landfill. As regards composting, the city has in place a program for composting garden waste and a pilot program for the separate collection of organic wastes, to be expanded throughout the city. The city also has in place contractual arrangements with private composting companies as it seeks to site and develop a new composting facility.

The integrated waste management system in Munich draws upon both public and private sector participants. The city provides collection and processing services for domestic waste, while private companies provide similar services to the commercial sector. The city also uses private sector companies to provide operation of some of its bulky waste drop-off facilities. A separate company, Stadtwerke Munchen, operates the two WTE facilities.

In Munich, the DSD program is being implemented by a private company. The city has turned over to the company all of its depot locations for glass and paper. The city does provide for collection of paper from those residents who request bins, and is reimbursed for 25% of the cost of that service by the company responsible for the DSD program. The ability of the DSD company to achieve the required goals using a collection system relying primarily on drop-off bins remains to be determined.

Munich has implemented an integrated waste management system that achieved a recycling rate of over 50% of the total waste stream and 23% of the domestic waste stream, based on 1992 figures. More significantly, landfill was used for only 2.5% of the unprocessed domestic waste. Waste-to-energy plays a significant role in Munich's integrated program. Over 76% of the domestic waste was processed at the two facilities in 1992.

SUMMARY OF FINDINGS

Highlighted below are the key findings of this study.

- Germany has legislation, regulations, and ordinances that require that wastes be managed in an integrated fashion. The integrated management of municipal waste in Germany is to be accomplished in accordance with a hierarchy, most recently articulated and clarified in the

Kreislaufwirtschaft-und Abfallgesetz (The Closed Loop Economy and Waste Management Act), which passed the Bundesrat in July 1994 as avoidance/minimization, materials and energy-related recycling, treatment, and final disposal.

- The process of implementing legislation and regulation related to the management of waste in Germany is governed by three fundamental principles:

  1. precautionary action (minimizing the potential for impacts on the environment)

  2. the polluter pays

  3. cooperation at all levels among affected parties.

  Implementation of legislation and regulations in the area of waste management consistent with these three principles has resulted in a legislative and regulatory process and structure that: (1) emphasizes avoidance/minimization, places great emphasis on regulating air and water emissions from waste processing and treatment facilities, and places significant restrictions on landfilling of materials by requiring that landfills be limited to use as final repositories for inert,non-transforming residual products; (2) revises the responsibility for, and fee systems in place, to fund waste and materials management programs by removing certain portions of the waste stream from the purview of municipal authorities; and (3) draws upon, and in many cases mandates, the incorporation of input from affected parties early on and throughout the legislative and regulatory process.

- Germany has extensive regulations governing the construction and operation of waste management facilities. The most significant legislation in effect governing waste management is the Waste Avoidance and Waste Management Act of 1986, which amended the Waste Disposal Act of 1972. Another significant piece of legislation is The Act for Prevention of Harmful Effects on the Environment Caused by Air Pollution, Noise, Vibration and Similar Phenomena, The Federal Immission Control Act, March 1974, as amended. The government has issued a number of ordinances and technical instructions pursuant to these laws which establish, among other things, detailed requirements that waste management facilities must meet. The most significant technical instruction affecting integrated waste management issued to date is the Technische Anleitung Siedslungabfall (Third General Administrative Provision on the Waste Avoidance and Waste Management Act, Technical Instructions on the Recycling, Treatment, and Other Management of Wastes from Human Settlements) approved by the Federal Government on April 21, 1993, after review and approval by the Bundesrat, and issued in May of 1993. This technical instruction addresses the planning, approval, and operation of waste management facilities and covers collection, processing, and disposal of domestic wastes. For WTE facilities, the most significant regulations are contained in the 17th Ordinance Implementing the Federal Immission Control Act- 17 BImSchV, Ordinance on Incinerators for Waste and Similar Combustible Materials. This Ordinance applies to the design, construction, and operation of facilities in which solid or liquid wastes are incinerated.

- Germany has implemented a waste and materials management program which is based on limiting the role of landfills to serving as the final disposal site for residual materials remaining after the recovery of materials and energy from the processing of the waste stream. Wastes may only be landfilled if they cannot be recycled as materials and/or energy, and if they are to be landfilled, they must meet certain criteria, including a maximum allowable organic content which practically requires that any waste from human settlements destined to landfills will require some form of thermal processing.

- Germany put in place a Packaging Ordinance which significantly modified the then-existing municipal waste management system. The Packaging Ordinance represented a dramatic shift in responsibility for waste management, changed the concept of responsibility for managing packaging wastes and the mechanisms for funding its collection and sorting, and placed the emphasis on reintroducing waste in the form of secondary raw materials into the economic cycle by requiring that certain percentages of the materials be recovered and recycled.

- The implementation of the Packaging Ordinance, among other things, resulted in the formation of a separate organization—the Duales System Deutschland—to provide collection, sorting and transport services for the sales packaging waste stream. DSD had an operating budget of over DM 3 billion ($1.9 billion) and over 270 employees in 1993. It had over 500 separate contracts with public and private entities providing collection, sorting, processing and transport services throughout Germany. In 1993, DSD collected over 4.5 million tons of packaging materials for processing. This equates to a per-ton cost of over DM 600 per tonne ($380 per ton).

- The DSD Program has endured serious economic difficulties during its implementation. In the fall of 1993, a serious cash flow shortfall required, among other things: (1) a major restructuring of the then outstanding operating obligations into long-term debt; (2) that additional funds be provided by packagers and retailers; and (3) a revision to the fee collection system to reduce the level of delinquent fee payments. These changes were made following extensive negotiations among the affected stakeholders (i.e. the federal government, the retailers, the packaging industry, the haulers, the municipalities, and the materials markets). The annual cost of the DSD program is estimated at approximately DM 40 ($25) per capita per year.

- The DSD Program has been implemented in different ways in various locations. In some communities (approximately 25%), the municipal authority responsible for providing waste management services also provides at least a portion of the collection, sorting, processing and transport services required by the DSD. In other cases, these services are provided by a private sector company or a joint public/private sector partnership. In general, the collection, sorting, processing, and transport services are being provided by affiliates of existing waste management companies.

- The Packaging Ordinance is being used as a model for other proposed ordinances addressing other portions of the waste stream (i.e., used cars, construction and demolition debris, used electronic goods, and paper), which are in various stages of preparation, review, and revision.

- In 1990, an estimated 26 million tons per year of household waste and commercial waste similar to household waste were collected by municipal organizations or their designees (as reported by Referat WA II of Umweltbundesamt, based upon data provided by Statisches Bundesamt). A total of over 55 million tons of household waste, commercial waste similar to household waste, bulky waste, street cleaning debris, and market waste were delivered by public and private haulers to processing and disposal facilities in 1990. The Bundesverband der Deutschen Entsorgungswirtschaft, the German association representing the waste management industry's private sector, has estimated that a total of over 50 million tons of household waste, commercial waste similar to household waste, bulky waste, street cleaning debris, and market waste was generated in 1990 (based on numbers provided by Bundesamt, DSD, GVM, and BDE). Included in the 50 million tons are a total of 33.8 million tons of household waste, including 7.75 million tons of packaging waste. As is the case in many countries, the exact determination of the amount of waste generated and its disposition is a mix of science and art, as the availability and quality of data for all the various segments of the waste stream varies. The methods of inquiry to obtain the data often vary depending upon who is obtaining the data and for what purpose. Thus, the reader is cautioned that tonnage figures provided represent the best estimate of the organizations identified based upon various sources of data, including weigh data, industry estimates, and trade association data.

An estimated 200 million tons of construction waste and 50 million tons of sewage sludge were generated. Approximately 70% of household and commercial waste generated was disposed of in landfills, with approximately 20% being processed at WTE facilities, and 5% being composted. As landfills continue to close (from 4,000 in 1975 to approximately 300 in 1991), and as regions come into compliance with the requirements of TA Siedslungabfall, the amount of waste going directly to landfill will continue to decline.

- Germany has achieved high rates of material recovery for paper and glass. In 1991, over 7.5 million tons of recycled paper was produced, out of a total consumption of 15.9 million tons. In 1991, 2.3 million tons of glass were produced from recycled glass, out of a total consumption of 4.2 million tons.

- Many municipalities in Germany have in place integrated waste management systems that combine various system components consistent with the hierarchy of avoidance/minimization, materials and energy recovery, and final disposal. For example, over 35% of the population is currently served by integrated waste management systems incorporating WTE. Recycling rates achieved vary among the communities examined, depending on the particular programs in place and the materials included in the determination of the recycling rates. The recycling rates estimated by the case study municipalities ranged from 18% to over 50%, with the upper estimates reflecting the inclusion of recycled construction and demolition materials.

- Changes in the future will include elimination of landfill disposal of untreated wastes, increased emphasis on avoidance and minimization and recovery of materials and energy from the waste stream (expansion of the separation of materials into two categories only—secondary materials to be reintroduced into the economic cycle, and residual materials that remain after the processing and treatment of the remaining waste stream), expansion of producer responsibility beyond packaging to encompass other materials and market sectors, and increased reliance on alternative systems of funding (i.e., fees provided by the producers of the products) to fund waste and materials management programs.

REPORT ORGANIZATION

Section 1 provides background information on Germany and its governing organization. Section 2 presents the environmental regulatory structure in place in Germany and describes the legislative and regulatory process, key legislation, regulations, ordinances, and technical instructions dealing with integrated solid waste management. Section 3 describes the generation and disposition of waste on a national level. Section 4 presents the four case studies performed and discusses the integrated solid waste management systems in place in the case study communities—Augsburg, Bad Tölz, Duisburg and Munich. Appendix A delineates the tours and meetings conducted in Germany by Mr. Worster of CSI. All numbers in this report are presented in metric units. Metric conversion factors are presented in Appendix B.

INTEGRATED SOLID WASTE MANAGEMENT IN GERMANY

1. BACKGROUND AND INTRODUCTION

1.1 GERMANY: BACKGROUND

This study examines integrated municipal solid waste management in Germany. Topics covered include relevant environmental standards, the status of compliance efforts, the impact of Germany's packaging reduction program on its integrated waste management systems, and descriptions of the integrated waste management systems in place in select municipalities.

1.1.1 Land

The Federal Republic of Germany is located in the heart of Europe, bordering nine other countries: Denmark to the north; the Netherlands, Belgium, Luxembourg, and France to the west; Switzerland and Austria to the south; and Poland and the Czech Republic to the east. Germany's 16 states, or Landers, include four from the former East Germany, which was reunified with the remaining 12 Landers in October 1990. Germany covers over 357,040 square kilometers (137,854 mi^2), making it slightly smaller than Montana, and approximately 1/25th the size of the United States.

The population of Germany was approximately 80,000,000 in 1990. Eighty-four percent of its inhabitants live in urban settings, nearly one-third of which live in cities with populations greater than 100,000. With a population density of $222/km^2$ ($575/mi^2$), Germany is the third most densely populated country in Europe, after Belgium and the Netherlands. Tables 1.1-1 and 1.1-2 detail the population of each of the 16 Landers and those cities with populations in excess of 250,000, respectively.

1.1.2 People

Germany consists primarily of a homogeneous, German-speaking population, with a very small representation of Danish, Slavic, and Arabic minorities. In part because of its low birth rate in the 1970s and 1980s, Germany has until recently relied significantly on immigrants to provide its entry-level labor pool. Today, over 5 million foreign workers and their families live in Germany. Turks comprise 30% of this group, Yugoslavians 12%, and Italians 10%. With reunification, however, the former East Germany represents a new source of relatively low-cost labor. At least partly because of this demographic shift, Germany is currently revising its liberal immigration laws to curtail the influx of immigrants.

TABLE 1.1-1
THE GERMAN FEDERAL STATES

LANDER	POPULATION	CAPITAL CITY
Baden-Württemberg	10,075,000	Stuttgart
Bayern	11,671,000	Munich
Berlin	3,454,000	Berlin*
Brandenburg**	2,527,000	Potsdam
Bremen	684,000	Bremen*
Hamburg	1,675,000	Hamburg*
Hessen	5,876,000	Wiesbaden
Mecklenburg-Vorpommen**	1,883,000	Schwerin
Nierdersachen	7,521,000	Hannover
Nord-Rhine-Westphalia	17,585,000	Düsseldorf
Rheinland-Pfalz	3,582,000	Mainz
Saarland	1,079,000	Saabrucken
Sachsen**	4,664,000	Dresden
Sachsen-Anhalt**	2,810,000	Magdeburg
Schleswig-Holstein	2,661,000	Kiel
Thuringen**	2,551,000	Erfurt
TOTAL	80,298,000	

* City States
** Reunified in 1990

Source: "Imagine—Germany, Your Logical Choice in Europe," Federal Ministry of Economics, August, 1993

TABLE 1.1-2
CITIES OF OVER 250,000 POPULATION

CITY	POPULATION
Berlin	3,446,000
Hamburg	1,669,000
Munich	1,229,000
Köln	957,000
Frankfurt am Main	654,000
Essen	627,000
Dortmund	601,000
Stuttgart	592,000
Düsseldorf	578,000
Bremen	553,000
Duisburg	537,000
Hannover	517,000
Leipzig	503,000
Nuremburg	497,000
Dresden	485,000
Bochum	399,000
Wuppertal	385,000
Bielefeld	322,000
Mannheim	315,000
Halle/Saale	303,000
Bonn	296,000
Gelsenkirchen	294,000
Chemnitz	288,000
Karlsruhe	279,000
Magdeburg	275,000
Münster	264,000
Wiesbaden	264,000
Monchengladbach	263,000
Augsburg	260,000
Braunschweig	269,000

Source: "Imagine—Germany, Your Logical Choice in Europe," Federal Ministry of Economics, August 1993.

1.1.3 History

Following the devastation of the Second World War, Germany was divided into four zones, each controlled by one of the victorious Allies: France, England, the Soviet Union, and the United States. In 1949, three of the occupied territories combined to form the Federal Republic of Germany. The fourth, occupied by the Soviet Union, became the German Democratic Republic, or East Germany. In 1989, following the relaxation by the Soviet Union of its role and influence in its satellite countries, thousands of East Germans began the mass exodus to West Germany that culminated in the official reunification of the country.

On September 12, 1990, the Treaty on the Final Settlement with Respect to Germany was signed by the Federal Republic of Germany, the German Democratic Republic, and the four war-time allies. The treaty was ratified by the GDR People's Chamber, the Bundestag, and the Bundesrat, and on October 3, 1990, pursuant to the treaty, the five Landers which formerly comprised the German Democratic Republic (Brandenburg, Mecklenburg-Vorpommern, Sachsen, Sachsen-Anhalt, and Thuringen/Saxonia) were reunited with the rest of Germany. In addition, the 23 districts of former East and West Berlin were united into one Lander.

The reunification treaty incorporates specific provisions related to the protection of the environment. Article 34 requires that federal and Lander legislators "protect the natural living conditions of the population in observance of the principle of precautionary action, the polluter pays principle and the principle of cooperation... ." These three principles—precautionary action, the polluter pays, and cooperation at all levels among all affected parties—are the basis of German environmental policy.

1.1.4 Economy

Germany's gross domestic product in 1991 was $1,554,000,000,000, or approximately $24,666 per capita. The country has a diverse economic base. At 38.4%, manufacturing represents the largest concentration of gross domestic product, followed by the service industry (29.4%); trade and transport (14.1%); government and households (13.7%); and agriculture, forestry, and fishing (1.3%). In 1991, 56.1% of the gross domestic product went for private consumption, 19.9% for government consumption, and 23.3% for gross capital investment.

Table 1.1-3 compares Germany, the United States, and Japan for several key indices.

TABLE 1.1-3
GERMANY, JAPAN, AND THE UNITED STATES

ITEM	GERMANY	JAPAN	UNITED STATES
Population (000)	79,220	123,850	250,800
Land Mass: km^2 : (mi^2)	357,040 (137,854)	377,801 (145,870)	9,529,202 (3,679,245)
Population Density: per km^2 : (per mi^2)	222 (575)	328 (849)	26 (68)
Gross Domestic Product ($ Billion - 1991)	$1,554	$3,363	$5,567
Per Capita GDP ($ - 1991)	$24,666	$27,341	$22,179

Source: 1. World Atlas & Almanac - Rand McNally, 1992 Edition.
2. Facts about Germany, Societas-Verlag, May 1992.

In 1990, Germany's average monthly disposable income per worker-household (i.e., net of public levies, such as taxes) was approximately DM 4,380 ($2,720). About 50% of annual income was spent on food and housing, while almost 9% was saved or retained.

Despite the destruction of the Second World War, and to a great extent because of the resulting massive reconstruction, the German economy has flourished since the war. Today, it is one of the world's strongest economies, as evidenced by its high per capita production and its major role in the European Community.

1.1.4.1 The Environment and the German Economy

In what was then West Germany, overall corporate and public expenditure on environmental protection in 1988 totalled DM 35,700 million ($22,150 million), approximately 1.7% of GNP. (DM 18,500 million came from the public sector, including federal, Landers, and local governments, and DM 17,200 came from the manufacturing sector.) Of this total, DM 15,300 million ($9,490 million) was for capital investment and DM 20,400 million ($12,660 million) was for current expenditures. In 1991, the federal government alone provided over DM 6,542 million ($3,690 million) to promote environmental protection, environmentally oriented research, and cooperative programs with developing countries.

Industry in Germany appears to have taken on the challenge of developing environmentally friendly technologies. There is clear evidence of voluntary efforts by many industries to consider such crucial environmental issues as waste management in the design, manufacture, and distribution processes. The Federation of German Industries (BDI) has an extensive program aimed at fostering environmental protection as part of the ongoing managerial responsibility of its members. These efforts include over 40 different voluntary agreements and statements of intent on the part of BDI's members regarding environmental protection.

Today, according to the *IER*, Germany has overtaken the United States and Japan in providing the world's pollution control equipment and services, including gas-cleaning technologies, control equipment, and measuring instruments. Germany now provides 21% of such goods and services, the United States 16%, and Japan 13%. Germany also ranks the highest among the three countries in terms of the percentage of research and development expenditures devoted to environmental research (4.1% versus 0.6% for the United States).

Table 1.1-4 compares the export of environmental goods and services from Germany, the United States, and Japan.

TABLE 1.1-4
ENVIRONMENTAL PROTECTION INDUSTRY, 1990

COUNTRY	PRODUCTION (Billion U.S. $)	EMPLOYMENT (000)	EXPORT (%)
Former West Germany	27.0	250	40
United States	80.0	800	10
Japan	30	200	6

Source: Organization for Economic Cooperation and Development

1.1.5 Governmental Structure

The Federal Republic of Germany is a democratic constitutional state organized on a parliamentary basis, with legislative, executive, and judicial powers allocated among a bicameral parliament, an executive branch headed by the chancellor, and the courts.

State duties in the Federal Republic of Germany are distributed between the federal government (the Bund) and the 16 federal states (the Landers). The constitutions of the Landers must conform to the democratic principles of a republican state based on the rule of law. Executive power resides with the Lander, unless the federal constitution prescribes or permits otherwise. Federal law takes precedence over Lander law.

Although the federal government has exclusive power in some areas, in others, including waste management, air pollution, noise pollution, consumer protection, and trade regulations, the federal government and the Lander have concurrent jurisdiction. However, the Lander may only pass laws if the federal government has not already done so. In certain areas, such as nature protection, land use, and water management, the federal government can only pass what are described as framework laws, which in turn must be implemented by Lander legislation. Thus, the Landers are primarily responsible, through their various agencies, for enforcing most of the land use and environmental laws, both federal and state. To coordinate the implementation efforts, the Landers have formed a number of organizations to deal with specific aspects of developing and implementing environmental regulations. One such organization, LAGA, is an interlander working group established to develop detailed regulations aimed at implementing the waste management guidelines laid down by the federal government.

If the Landers are required by the federal constitution or by statute to administer a federal law, they in turn may be further bound by administrative ordinances issued by the federal executive branch, subject to consultation with the Bundesrat.

The district administration (the Kreis) represents the level of government between the boroughs and the Landers. The district administration is the organization usually responsible for waste management. There are 566 Kreis in Germany. The borough (Gemeinde or Kommune) is the lowest level of government in Germany. The borough government sometimes acts as the waste management authority, especially in those areas such as large cities, where there is no district administration.

The federal constitution guarantees the regional and local authorities considerable powers of self-government, within the limits of the law. The local authorities are also responsible for enforcing many aspects of federal and Lander legislation. Thus, local, Lander, and federal authorities all have roles to play in matters related to the implementation and enforcement of environmental legislation and regulation. In addition, the constitution guarantees the regional/local authorities the authority to regulate local community matters, including building activity and urban planning. This, in addition to their role in providing typical public services, such as sanitation, sewage treatment, and waste management, results in local governments having a considerable role in the implementation of environmental policy in Germany.

1.1.5.1 The Federal Constitution

Having been approved by a two-thirds majority of the parliaments of the participating Landers, the constitution of the Federal Republic of Germany took effect on May 23, 1949. This so-called "Basic Law" was intended as an interim measure, to remain in force until the divided nation could once again be unified. During what proved to be a 45-year interim period, the Basic Law was amended many times.

Each Lander has its own constitution. The specifics of these individual Lander constitutions in some instances reflect the influence of the country which occupied each Lander after the war.

1.1.5.2 Separation of Powers

Governmental powers at the federal level in Germany are separated into the executive, legislative, and judicial branches.

The Executive Branch

The executive branch of the federal government consists of the Chancellor, the President, and the ministries and agencies under the Chancellor.

The federal President (Bundespresident) is elected for a period of five years by a special assembly consisting of all the members of the Bundestag, plus an equal number of members elected by the Lander parliaments based on party strength. The President has little defined authority, other than representing the nation; reviewing the constitutionality of proposed legislation; formally proposing nominees for the position of Chancellor; and formally appointing and dismissing the federal ministers, upon the proposals of the Chancellor.

The Chancellor is the chief executive officer of the federal government. The Chancellor is a member of the Bundestag, the branch of parliament directly elected in national elections. The Chancellor is virtually always the leader of the political party receiving the most votes in the Bundestag general election. Nominated by the president, the Chancellor is formally elected by the Bundestag. The Chancellor's term ends upon the first meeting of a new Bundestag.

The Chancellor has considerable power, by virtue of being both the leader of the majority party in the Bundestag and the government's chief executive officer. However, pressure from within the bureaucracy, as well as political expediency, can certainly affect the Chancellor's ability to implement his or her agenda. The Chancellor, for example, selects the various federal ministers. While chancellors generally prefer to appoint ministers of similar political persuasion, the composition of any given Cabinet will often reflect the prevailing political climate. Thus, the current Chancellor, Helmut Kohl, is a member of the Christian Democrat party, and his cabinet reflects the Christian Democrat/Christian Socialist coalition with the Free Democrats. (Herr Kohl has held office since 1982; Bundestag elections were held in 1994.)

The Cabinet consists of 19 members, including the Deputy Chancellor and the various ministers. The Chancellor is responsible for laying down general policy guidelines, but within those guidelines, each minister conducts the affairs of his or her ministry quite independently.

The Ministry for Environmental, Nature Protection, and Nuclear Safety

The Ministry for Environment, Nature Protection, and Nuclear Safety was formed when the environment and nuclear safety division of the Ministry of the Interior and the nature protection division of the Ministry of Nutrition, Agriculture and Forests were combined on June 5, 1986. In addition, the Federal Research Office for Nature Protection and Landscape Ecology was moved to the new ministry. The current Minister is Mr. Klaus Topfer.

The ministry's organizational structure is detailed in Figure 1.1-1. The ministry is comprised of six divisions:

DIVISION AREA OF RESPONSIBILITY

Z	Administration, environmental policy, and international issues
G	Environmental Policy
WA	Water and waste management
IG	Health, environment, air, noise, and chemical risks
N	Nature and soil protection
RS	Nuclear safety and radiation protection

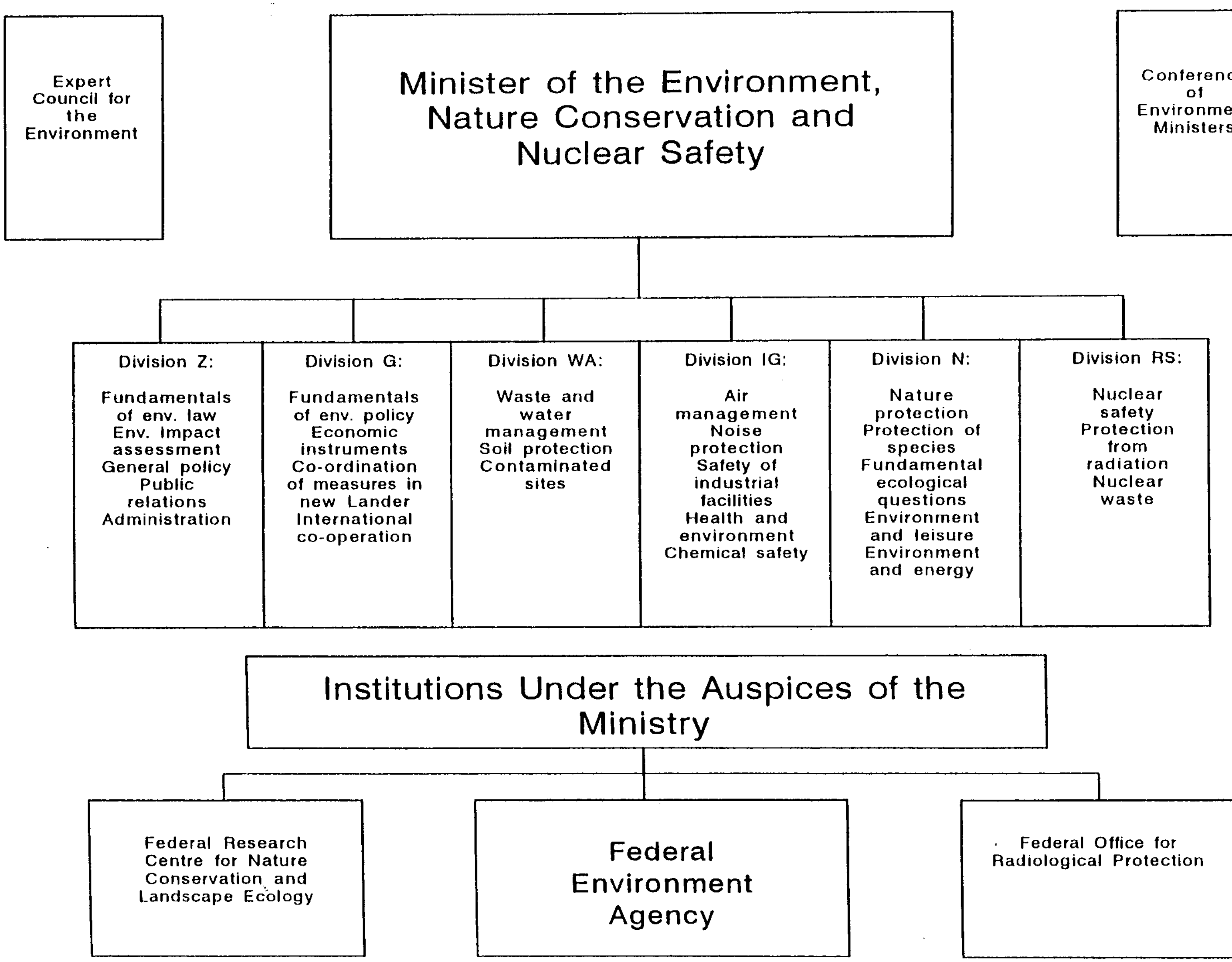
The Federal Agency for Radiation Protection and the Research Institution for Nature Conservancy and Rural Ecology, as well as the Institute for Water, Soil, and Air Hygiene, provide technical support to the ministry.

The Federal Environmental Protection Agency (Umweltbundesamt) is also under the ministry's authority. This agency provides support to the ministry by performing research related to environmental policy, managing information related to the environment, and assisting with the preparation of environmental legislation and regulations.

Other Ministries and Organizations

In addition to the leadership role played by the Ministry for the Environment, Nature Protection, and Nuclear Safety, a number of other ministries have an important role in the development and implementation of environmental policies at the local, Lander, federal, and international level. Table 1.1-5 lists these ministries and their role.

FIGURE 1.1-1
ORGANIZATION OF THE FEDERAL ENVIRONMENTAL ADMINISTRATION IN GERMANY



SOURCE: OECD

TABLE 1.1-5
ROLE OF VARIOUS MINISTRIES IN ENVIRONMENTAL PROTECTION

MINISTRY	RESPONSIBILITY
Foreign Affairs	international relations, including environmental policy
Finance	financial implications of environmental policy
Economic Affairs	economic impacts of environmental policies, including energy, waste and water management, and pollution control
Food, Agriculture and Forestry	landscape management and environmental impacts of pollution from agriculture and forestry
Labor and Social Affairs	environmental aspects related to the workplace
Defense	environmental aspects of national defense
Youth, Family Affairs and Health	health care and toxic substances
Transport	environmental impacts of transportation
Regional Planning, Building and Urban Development	federal policy regarding land use, regional planning, urban renewal
Research and Technology	coordination of research in, among other areas, pollution measurement and controls, clean technology, waste processing, and disposal
Economic Cooperation	international and multilateral environmental policies

The Committee for Environmental Questions (Kabinettsausschuss für Umweltfragen), which is chaired by the Chancellor, includes members from the 12 federal ministries involved in environmental protection. This committee provides overall coordination of federal environmental programs. The Cabinet Committee for the Environment and Health assists with this coordination effort. It is chaired by the Minister for the Environment, Nature Conservation, and Nuclear Safety and includes representatives with environmental responsibilities from the other relevant ministries.

The Conference of Ministers for Environmental Affairs (Umweltministerkonferenz), comprised of the federal Minister for the Environment, Nature Protection, and Nuclear Safety and the environmental minister from each Lander, meets regularly to review a wide range of environmental policy matters.

The Permanent Board of the Heads of Division for Environmental Questions (Stager Abteilungsleiterausschuss für Umweltfragen) coordinates the implementation of environmental policy across federal agencies. The Board's membership consists of the senior environmental officials of 212 such agencies; it is chaired by the Secretary of the federal Ministry for the Environment, Nature Protection, and Nuclear Safety.

The State Committee for Environment Protection (LAI) advises the federal government on statutory and administrative regulations under the Federal Immission Control Act. It is comprised of representatives from various Lander ministries responsible for environmental protection and from the federal Ministry for the Environment, Nature Protection, and Nuclear Safety. Several federal/Lander working committees have also been established to coordinate policies in various areas that relate to environmental protection.

A number of nongovernmental organizations also play a role in the development of environmental policy in Germany. For example, the Council of Environmental Advisers (Rat der Sachverstandigen für Umweltfragen) is an advisory committee comprised of 12 members from the public who provide input to the Minister for the Environment, Nature Protection, and Nuclear Safety. In addition, various professional organizations, (e.g., the Association of German Engineers, and the German Association of Gas and Water Management Experts) as well as environmental organizations (e.g., the German Federation for Environment and Nature Protection, the Council of Nature Conservation, and Greenpeace) also provide important input into policy and regulatory deliberations. Other groups that provide input on policy related to environmental and technical matters include the Office for Estimating the Consequences of Technological Advance of the German Bundestag (Buro für Technikfolgeabschatzung TAB), and the Study Commissions of the German Bundestag.

The Legislative Branch

At the federal level, legislative power is vested in two houses, the Bundestag (Federal Assembly) and the Bundesrat (Federal Council). The 662 members of the Bundestag are the only members of the federal government directly elected by the people in a general election. Bundestag members serve a four-year term, unless the government calls an early election upon losing its majority.

The Bundesrat represents the Landers. Each Lander sends three to five representatives, in proportion to its population. The present Bundesrat consists of 79 members. The Bundesrat has veto power in areas of federal legislation which affect the Landers, including those affecting land use and the environment. The Bundesrat's approval is required on nearly two-thirds of all legislation. Furthermore, federal administrative regulations can only be adopted with the consent of the Bundesrat, because these regulations usually depend upon the Landers for implementation. Thus, the Bundesrat often acts as a brake on federal action.

Legislation drafted by the executive branch is submitted to the Bundesrat for review, then introduced to the Bundestag for review. After it is submitted to the Bundestag, legislation is forwarded to the appropriate standing committee. Passage by the Bundestag requires action by the committee, followed by a simple majority vote, providing the proposed legislation is not a constitutional amendment.

After a bill is passed by the Bundestag, it is returned to the Bundesrat for concurrence or veto. If the Bundesrat's concurrence is required by the constitution (e.g., in areas such as waste management), the Bundesrat can fail to pass the legislation and require that a joint committee be convened to effect a compromise between the positions of the Bundestag and the Bundesrat. If concurrence is not required, a veto by the Bundesrat can be overcome by a majority vote of the

Bundestag. After passage, legislation is forwarded to the federal President for constitutional review and signature.

The Judicial Branch

Germany's legal system is based upon the rigorous application of comprehensive legal codes. A judge's task is to administer the code and apply the written law to each case as it is presented. Legal precedent plays little role in the process and, in theory, there is little room for judicial interpretation.

The judicial branch of the government consists of federal and Lander court systems. The Federal Constitutional Court rules on all federal constitutional cases. The court can rule a statute void if it does not conform to the Constitution. The court also reviews the constitutionality of administrative actions and decides court cases between different levels of government. Similarly, at the Lander level, state constitutional courts decide constitutional issues related to the Lander constitutions.

To handle nonconstitutional cases, the Lander and federal courts are organized into the regular courts and specialized courts. The regular courts, which handle ordinary civil and criminal cases, are organized into four levels: local (Amtsgeriche), district (Landesgeriche), appeal (Oberlandesgeriche), and the federal court (Bundesgerichtshof).

Local courts handle minor civil and criminal matters. District courts are the main criminal and civil courts, hearing cases against the government and the public authority, civil cases involving more than DM 5000, and certain other cases. The appeals court hears appeals from the district court. The federal court hears appeals on cases involving large sums of money (in excess of DM 40,000) or cases involving a legal controversy (i.e., where a law itself is in question). The purpose of the federal court is to ensure uniform interpretation of the law.

The special courts handle administrative, fiscal, labor, and social security matters. The administrative courts, for example, hear cases in which private parties seek to change actions by a government agency or others carrying out public functions. There are two levels of each type of special court in each Lander, a lower court that hears cases directly and an appeals court. The Federal Administrative Court (Bundesverwaltungsgericht) hears appeals from the Lander appeals court as well as cases involving disputes between the federal government and the Lander that do not involve constitutional matters.

Because the German legal system is based upon application of detailed codes and does not rely on case history to the same degree as the United States system, the process of establishing these codes and regulations is driven by the need to resolve differences of opinion among the key stakeholders sooner rather than later (i.e., during the development and passage of codes and regulations rather than via the courts following promulgation). This has led to the institutionalization of an interactive process which involves input from key stakeholders in the setting of regulations and less reliance upon litigation to resolve differences.

1.2 UNDERSTANDING SOLID WASTE MANAGEMENT IN GERMANY

The available methods for management of municipal solid waste in Germany are the same as those utilized in the United States, namely, reduction, reuse, recovery, composting, incineration (with and without energy recovery), and landfilling. The issues and opportunities confronting German officials responsible for municipal solid waste management are similar to those facing their counterparts in the United States. They too must manage their solid waste in an environmentally, technically, and economically sound manner within the constraints of diminishing available landfill capacity and general resistance to the siting of new facilities. Germany has faced these issues for a longer period of time than the United States because of its greater scarcity of available virgin territory upon which to site new landfills, its greater concentration of people, and its longer history of relying upon treatment and disposal methods other than landfilling to meet waste disposal requirements. As a result, Germany has in the past served as a knowledge base and technology resource for waste management professionals in the United States.

Germany has in place strong environmental legislation and regulations regarding waste management, including the strongest packaging legislation in the world. Germany also evidences a reliance on waste management techniques other than direct landfilling. Germany also has in place integrated solid waste management systems that incorporate reuse, reduction, composting, recycling, waste-to-energy, and landfilling. Germany is viewed in the industry and the international environmental community as a trend setter or role model in solid waste management.

1.3 GERMANY AS A ROLE MODEL FOR THE UNITED STATES

Care must always be exercised when imagining the programs, policies, or technologies employed in one country in place in another. The complexities of culture, legal systems, topography, history, geography, geology, economy, demographics, legislative and regulatory processes, resource bases and locations, among other factors, all impact the results obtained within a given system. Further, even within specific countries, there is diversity of opinion and approaches to various programs. Focusing on the "German" way of dealing with a particular aspect of the problem of managing waste requires an understanding of the underlying legislative and regulatory process, the impact of population density on available sites for waste treatment and disposal activities, and the role of stakeholders, including industry, municipalities, the Lander representatives, and trade associations in setting environmental policy in Germany.

Thus, the results achieved from Germany's solid waste management policies may not be reflective of the results that would be achieved upon implementing a similar program in a different country. However, the above notwithstanding, much can be learned from examining the integrated waste and materials management programs in place in Germany.

2. ENVIRONMENTAL REGULATORY STRUCTURE

2.1 OVERVIEW

The development and implementation of environmental legislation in Germany is a complex and extended process, reflecting the conviction that successful environmental policy must be geared to what is practical and possible. Thus, the legislative process is informed and guided by constant lobbying and discussion, both formal and informal, among the various ministries, Bundestag committees, members of the Bundesrat, the Landers, and a wide variety of other public and private interest groups and organizations, many of which were discussed in the previous section.

Consensus is sought at all levels. Thus, the federal government makes a strong effort to discuss its policy intentions with the Landers from the earliest stages, above and beyond what is required by law. The input of trade organizations and industrial federations such as the BDI (Bundesverband der Deutschen Industrie) is also actively solicited.

2.2 ENVIRONMENTAL LAWS AFFECTING SOLID WASTE MANAGEMENT

2.2.1 Act on the Avoidance and Disposal of Waste

The most significant legislation affecting waste management in Germany is the Act on the Avoidance and Disposal of Waste, which was adopted in 1972 and significantly revised in 1986 to bring Germany into compliance with existing EEC legislation. The Act stipulates a general obligation to reduce the quantities of waste being generated and to recover and recycle wastes. It also includes specific provisions related to the management of wastes containing toxic substances. According to the Avoidance and Disposal Act, the government must:

- set targets for the reduction, recovery, and reuse of nontoxic wastes, depending upon technical feasibility, cost, and the availability of markets;
- publish guidelines for the environmentally safe disposal of wastes;
- regulate the volume and conditions associated with the application of wastes upon agricultural land;
- regulate labelling and recycling of products that might produce toxic wastes.

The Act also gives the government the power to prohibit the sale of products which contain toxic substances.

The Act defines waste as "... movable material of which the owner wishes to dispose or the proper management of which is necessary in the public interest, especially for the protection of the environment. Movable property left to the corporation responsible for waste management by the owner or a third-party commissioned by him are also defined as 'waste' if they are recycled, up to the moment this waste or the materials recovered or energy produced from them are returned to the production cycle."

A government waste catalogue lists several hundred items that are likely to be wastes, including specifically those which require special handling in the public interest. Whether any given material, however, is viewed as a waste material depends upon the specific circumstances related to its intended disposition. If the material is viewed as having economic value, it can be classified as residual matter, not waste. Thus, in practice, the classification of materials as waste depends upon whether or not there is a valid economic use for it in the eyes of the responsible party.

In some cases, companies have classified certain materials as residual matter, avoided the statutory requirements for proper handling of wastes, then failed to process the material for reuse. To prevent such circumvention of the law, the government now requires certification of adequate processing capacity at facilities identified as the destination for all materials being shipped for processing.

The Avoidance and Disposal Act defines waste management as "the recovery or production of materials/energy from waste (reuse and recycling of waste), depositing of waste as well as the necessary collection, transportation, treatment and storage." The Act does not apply to materials disposed of in accordance with the Animal Carcass Disposal Act, the Meat Inspection Act, Epizootic Diseases Act, Plant Protection Act, or the ordinances issued under those laws; nuclear fuels and other radioactive substances; mineral prospecting, extraction, preparation, treatment, and processing wastes; gaseous substances not in containers; materials discharged or dumped into waters, sewerage systems, or effluent treatment plants; certain materials collected by nonprofit making organizations for reuse and recycling; materials which are collected commercially and reused or recycled, provided that the public corporations responsible for waste management in the area are notified and the commercial collection of such materials does not conflict with the overriding interests of the public; and materials associated with the search for, recovery, transportation, storage, treatment, and destruction of warfare agents.

The Act specifies that wastes shall be managed in the same area they are generated in, unless otherwise licensed and approved under provisions of the Act. Owners of the waste are required to make the wastes available to the party in their area responsible for waste management, which may be either a public law corporation or third party employed by such public law corporations to carry out the management function.

The Act also allows the local authority to refuse to accept such wastes only if they cannot be managed satisfactorily by the public facility. In such cases, the owner of the waste is obliged to arrange for its management by some other appropriate method.

Under the Act, reuse and recycling shall be given priority over other disposal methods, provided that reuse/recycling is technically feasible, that the additional costs compared to other disposal routes are not unreasonably high, and that a market for the materials or energy produced either exists or can be developed.

The Act requires that waste be treated, stored, and deposited only at licensed facilities. It stipulates that wastes may be collected and transported by commercial entities only with the permission of the competent authority (to be determined by the Land government).

The Act requires (Article 6) that the Landers develop their own waste management plans. It also permits the Landers to authorize the management of certain wastes outside waste management facilities, provided that a need exists and the public interest is not impaired. In Article 7, the Act mandates that the construction, operation, and subsequent substantial alteration of stationary waste management facilities shall require the official approval of the competent authority. For insignificant facilities, the licensing procedure can be a simplified request for a license. The Act provides that facilities which sort household or similar wastes for re-introduction into the production cycle shall be deemed to be insignificant facilities, as are composting facilities with a throughput of up to 0.75 tons per hour.

The Act allows for changing or supplementing the requirements to be met by a waste management facility after the plan has been approved or even after the license has been granted. It also delineates the information and record-keeping requirements to be met by the operators/management of waste management facilities.

The Act also contains specific sections dealing with wrecked cars and used oil. These sections mandate that the provisions associated with waste management facilities shall also apply to facilities storing and processing used cars, and that waste oils shall be considered waste and subject to the provisions of the Act. The Act also requires that commercial establishments selling motor and gear oil to consumers provide for the collection of used oil.

A specific Waste Oil Ordinance was issued on January 11, 1987, limiting those oils that may be reprocessed to those from internal combustion engines and gearboxes and other similar machine oils. Waste oils not reprocessed can be thermally recycled. The ordinance also set up the requirements for collection and labelling. (There are approximately 300 commercial waste-oil collection firms in Germany, collecting approximately 300,000 tons of waste oil annually.)

A key element of the Act is contained in Article 14, which permits the use of selective measures to regulate the use of noxious and bulk waste. Article 14 requires that the government, in order to avoid or reduce the quantities of wastes produced and to promote reuse and recycling, specify objectives to be reached regarding avoiding, reducing, or reusing wastes from certain products. In furtherance of these objectives, the government may issue statutory ordinances, with the consent of the Bundesrat, regarding: specific labelling or marking; the form in which products are brought to market so as to make them suitable for reuse or recycling; the obligation of the manufacturer, distributor, or third party to take back certain products and ensure environmentally sound reuse, recycling, or other management, including appropriate reception and deposit systems; and separate delivery to facilitate reuse/recycling.

Article 14 provides the legal basis for the development and implementation of the Packaging Ordinance, a key piece of waste and materials management regulation significantly affecting Germany's integrated waste and materials management system and the subject of considerable international attention. The Packaging Ordinance is discussed in greater detail later in this report.

The Act also contains descriptions of the civil offenses and attendant penalties associated with failure to comply with specified provisions of the Act.

2.2.1.1 Technical Instructions

The Avoidance and Disposal Act requires the government to issue appropriate Technical Instructions (Technische Anleitung, or TA) to ensure the satisfactory—i.e., environmentally sound—planning, approval, and operation of waste management facilities. Several such Technical Instructions have been issued. Overall, their intent may be summarized as fostering the following treatment and disposal approaches for waste which remains after reduction, recycling and reuse: (1) incineration of organic and, in particular, organic toxic compounds; (2) chemical/physical treatment of wastes consisting of primarily inorganic substances; (3) underground depositing of wastes with high salt contents; and (4) landfilling of wastes only when such disposal can be accomplished in compliance with strict environmental standards.

This report focuses on the management of the nonhazardous portion of the waste stream, which includes household wastes and wastes from commercial, institutional, and industrial facilities which are similar in character and nature to household waste. The following section describes Technical Instructions issued pursuant to the Act and describes in detail those Instructions specific to the nonhazardous portion of the waste stream.

On January 31, 1990, the government issued a TA related to the protection of groundwater from landfilling. On April 10, 1990, a Technical Instruction dealing with hazardous wastes was issued. Known as TA Abfall, this was subsequently incorporated into the Second General Administrative Provision on the Waste Avoidance and Waste Management Act, Part 1: Technical Instructions on the Storage, Chemical, Physical, and Biological Treatment and Incineration of Waste Requiring Particular Supervision (dated March 12, 1991).

TA Abfall contains detailed instructions regarding the treatment of hazardous wastes, covering their acceptance, storage, and treatment by such means as incineration (SAV), chemical-physical, or biological (CPB). TA Abfall also covers disposal sites, both aboveground (SAD/MD) and underground (UTD/MD); required documentation; and personnel qualification requirements. The regulation includes a list almost 30 pages long of hazardous wastes, based upon the processes which generate them and recommended treatment.

The most significant Technical Instruction dealing with household waste to be issued under the Waste Avoidance Act is the Third General Administrative Provision on the Waste Avoidance and Waste Management Act. Entitled "Technical Instructions on the Recycling, Treatment, and Other Management of Wastes from Human Settlements," this Instruction is known as TA Siedlungsabfall.

TA Siedlungsabfall, issued on May 14, 1993, addresses the collection, processing, and disposal of domestic wastes in an integrated fashion. Its requirements cover planning, licensing of facilities, reporting, collection practices, and specific technical requirements for various types of facilities (interim storage facilities, thermal and biological treatment facilities, and landfills). Among the most significant aspects of the requirements are the emphasis placed on separate collection of materials and the requirement that materials be treated prior to disposal.

TA Siedlungsabfall applies to waste from human settlements, which includes domestic refuse, bulky refuse, industrial wastes similar to domestic refuse, garden and park wastes, market wastes, road sweepings, construction wastes, sewage sludge, fecal matter, fecal sludge, residue from wastewater treatment plants, and water purification sludge. Table 2.2-1 outlines the TA's definitions of these various waste stream constituents.

TA Siedlungsabfall, which took effect on June 1, 1993, is intended to be applied by the responsible authorities in the development of waste management plans; approval of plans or authorization for construction and operation of waste management facilities; modifications to conditions of plans already approved; definition of aftercare measures for waste management facilities being closed; and monitoring required under waste avoidance and waste management legislation. The objective of the regulation is to:

- promote waste avoidance
- recycle/reuse as far as possible unavoided wastes;
- keep the pollutant content of wastes as low as possible;
- secure the environmentally compatible treatment and dumping of non-recyclable wastes, and ensure that "... wastes are to be deposited in such a manner that the waste management problems encountered today are not shifted onto future generations."

TA Siedlungsabfall defines a treatment plant as a waste management facility in which wastes are treated by means of chemophysical, biological, thermal or mechanical processes or combinations of these processes.

TA Siedlungsabfall lays out various criteria for selecting the method of waste management. It is consistent with the framework legislation (i.e., the Waste Avoidance Act) and other regulations in placing recycling and pollution reduction at the top of the hierarchy. According to the regulations, wastes must be recycled if:

- recycling is technically feasible;
- the resultant additional costs are not unreasonable in comparison with other methods of waste management;
- a market is available or can be created for recovered products, in particular by commissioning third parties; and
- recycling has an altogether more advantageous effect on the environment than other methods of waste management.

Technically feasible is defined as "... if a practical and suitable method is available. Within the precept of recycling, the characteristic of technical feasibility means exhausting all the recycling techniques that are actually feasible. In order to achieve this objective, it may be necessary not to mix together differing residue materials. The recycling of residues must also be regarded as technically feasible if only methods are available that demand prior treatment of the residues.

TABLE 2.2-1
TA DEFINITION OF WASTE STREAM CONSTITUENTS

DOMESTIC REFUSE	Wastes deriving primarily from private households and which in standardized containers prescribed in a refuse collection district are at regular intervals collected, transported away, and channelled into a system of further management by those corporations responsible for waste management or by third parties commissioned by them (911 01).
BULKY REFUSE	Solid wastes, which as a result of their bulkiness, are unable to fit into the containers prescribed in the refuse collection district and which are collected and transported separately from domestic refuse (914 01).
INDUSTRIAL WASTES SIMILAR TO DOMESTIC REFUSE	Wastes accumulating in commercial undertakings, including business, services enterprises, public institutions, and industry insofar as they can, in terms of type and quantity be managed together with or in a similar way to domestic refuse.
GARDEN AND PARK WASTES	Wastes of a predominantly vegetable origin and accumulating on hydroculturally used sites in public parks and cemeteries as well as green areas adjacent to roads and motorways (917 01).
MARKET WASTES	Wastes, such as fruit and vegetable wastes and non-recyclable packaging materials, accumulating on the sites of markets (916 01).
ROAD SWEEPINGS	Wastes from road cleaning, e.g., road and tire abrasion, leaves, and winter grit (915 01).
CONSTRUCTION WASTES	Nonmineral materials from building activities, also including a small share of extraneous materials (912 06).
SEWAGE SLUDGE	Sludge accruing from the treatment of wastewater in municipal and similar industrial wastewater treatment facilities, including sludge that has been de-watered or dried or treated in any other form (943 01, 02; 945 01, 02, 03; and, if applicable 948 01).
FECAL MATTER	Excrements of human origin accumulating in blind collecting pits or basins and not discharged into sewage systems (951 01).
FECAL SLUDGE	Sludge accumulating from the treatment of wastewater in small-scale treatment plants (domestic treatment plants), residue from wastewater treatment plants (943 03).

TABLE 2.2-1 (CONTINUED)
TA DEFINITION OF WASTE STREAM CONSTITUENTS

WATER PURIFICATION SLUDGE	Sludge accumulating from the treatment of water in water treatment plants, including sludge that have has been dewatered or treated in any other form (941 01, 02, 03, 04, 05).
BUILDING RUBBLE	Mineral materials from building activities, also including a small share of extraneous materials.
BUILDING WASTES	Building rubble, construction site waste, excavated soil, and broken-up road construction material.
BIOWASTE	Degradable native or derivative-organic waste elements (e.g., organic kitchen wastes, garden wastes) contained in municipal waste.
EXCAVATED SOIL	Noncontaminated, naturally generated or used soil or rock material (314 11).
PRODUCTION-SPECIFIC WASTES	Occurring in industry, commerce or other establishments and which are not wastes arising from human settlements but which, in terms of type, pollutant content, and reaction behavior, can be managed in the same way as such wastes.
BROKEN ROAD-MAKING MATERIAL	Mineral materials which hydraulically bound with bitumen or tar or in an unbound state have been used in road construction (314 01).

Note: The numbers in parenthesis refer to the corresponding waste code contained in the waste-type catalogue of the Lander Study Group on Waste (LAGA).

In cases such as this, the recycling precept encompasses the implementation of measures of processing."

Whether the additional cost of recycling/reuse is "reasonable" is to be determined by examining, among other things, whether:

- recycling has an altogether more positive effect on the environment than other methods of waste management;
- recycling of a similar nature is already being performed successfully elsewhere;
- the joint use of facilities by several refuse collection corporations supports the objectives of waste management laid down in the TA Siedlungsabfall.

The existence and/or creation of a market is to be determined by application of the following criteria:

> "A market exists for the recovered products if their sale appears to be secured at the present moment and for a reasonable period to come. In this context, it is, in particular, necessary to examine whether a market can be created by joint recycling of wastes by several refuse collection corporations."

TA Siedlungsabfall also calls for the factoring in of the ecological effects of recycling. The regulation notes that, " Although priority is given to the recycling of wastes for the recovery of resources, it may in some cases be necessary to examine the ecological effects of recycling if there are reasons to suggest that recycling has an altogether higher impact on the environment than that of a system of well-ordered disposal."

It is clear that the German authorities recognize the need for an integrated assessment of the costs and benefits associated with each method of waste treatment, as part of the implementation of an integrated waste management system. They also clearly recognize the need for a market for recovered products, and the potential benefits of pooling materials among regions to facilitate the availability of larger quantities of waste materials.

According to TA Siedlungsabfall, wastes may only be dumped if "... they cannot be recycled," and they meet certain criteria described in the regulations. These criteria, delineated in Table 2.2-2, include the requirement that the deposited material contain no more than 3% by weight unburned carbon for a Class I landfill. Practically speaking, this requires that the wastes remaining after reduction and recycling be further treated by combustion or some other form of thermal treatment process. This specific requirement has led some analysts to conclude that Germany will require approximately 90 additional waste incineration facilities for household wastes, to be on-line in 11 years, when all areas must be in compliance with this requirement. This would almost triple the existing base of WTE facilities (50 facilities).

In addition to adding more facilities based on existing incineration technology, other forms of waste treatment are receiving attention. These include aerobic, anaerobic, and combined treatment of household wastes to render the waste inert via biological and mechanical means and high-temperature incineration.

TABLE 2.2-2
APPENDIX B TO TA SIEDLUNGSABFALL, ALLOCATION CRITERIA
FOR LANDFILLS

In allocating wastes to landfills, it shall be necessary to observe the following allocation values; these are based either on the analysis methods specified in Appendix A or on equivalent methods:*

NO.	PARAMETER	ALLOCATION VALUES	
		Landfill Class I	Landfill Class II
1	Strength[1]		
1.01	Vane shear strength	$\geq$ 25 kN/m^2	$\geq$ 25 kN/m^2
1.02	Axial deformation	$\leq$ 20%	$\leq$ 20%
1.03	Uniaxial compressive strength	$\geq$ 50 kN/m^2	$\geq$ 50 kN/m^2
2	Organic component of dry residue in original substance[2]		
2.01	Determined as ignition loss	$\leq$ 3% by weight	$\leq$ 5% by weight[3]
2.02	Determined as TOC	$\leq$ 1% by weight	$\leq$ 3% by weight
3	Extractable lipophile substances in original substance	$\leq$ 0.4% by weight	$\leq$ 0.8% by weight
4	Evaluate criteria		
4.01	ph value	5.5-13.0	5.5-13.0
4.02	conductance	$\leq$ 10,000 us/cm	$\leq$ 50,000 us/cm
4.03	TOC	$\leq$ 20 mg/l	$\leq$ 100 mg/l
4.04	Phenols	$\leq$ 0.2 mg/l	$\leq$ 50 mg/l
4.05	Arsenic	$\leq$ 0.2 mg/l	$\leq$ 0.5 mg/l
4.06	Lead	$\leq$ 0.2 mg/l	$\leq$ 1 mg/l
4.07	Cadmium	$\leq$ 0.05 mg/l	$\leq$ 0.1 mg/l
4.08	Chromium- IV	$\leq$ 0.05 mg/l	$\leq$ 0.1 mg/l
4.09	Copper	$\leq$ 1 mg/l	$\leq$ 5 mg/l
4.10	Nickel	$\leq$ 0.2 mg/l	$\leq$ 1 mg/l
4.11	Mercury	$\leq$ 0.005 mg/l	$\leq$ 0.02 mg/l
4.12	Zinc	$\leq$ 2 mg/l	$\leq$ 5 mg/l
4.13	Fluoride	$\leq$ 5 mg/l	$\leq$ 25 mg/l
4.14	Ammonium-N	$\leq$ 4 mg/l	$\leq$ 200 mg/l
4.15	Cyanide, easily liberated	$\leq$ 0.1 mg/l	$\leq$ 0.5 mg/l
4.16	AOX	$\leq$ 0.3 mg/l	$\leq$ 1.5 mg/l
4.17	Water-soluble component (dry matter)	$\leq$ 3% by weight	$\leq$ 6% by weight

TABLE 2.2-2 (CONTINUED)

1 1.02 may, together with 1.03, be applied in equivalence to 1.01. Strength must in each case be defined separately in accordance with the static requirements on landfill stability. Particularly in the case of cohesive, finely grained wastes, it shall not be permissible to fall short of the values indicated for 1.02 in conjunction with 1.03.

2 2.01 may be applied in equivalence to 2.02; requirement shall not apply to contaminated excavated soil deposited on a mono dump.

3 Shall not apply to ashes and dusts from coal-firing plants not subject to licensing under the Federal Immission Control Act (BImSchV).

* Refers to various test methods detailed in TA Siedlungsabfall, which generally refer to Deutsche Industrie Normen (DIN) standard test methods. The test methods may vary from test methodologies in use in the United States for measuring identical materials. Thus, caution is recommended in making direct comparison of the numerical limits among different countries, as the specific test methodologies, sampling periods, and other facets of the standard test methods utilized can impact the results obtained.

According to TA Siedlungsabfall, toxic wastes must under no circumstances be dumped aboveground and wastes containing asbestos must be dumped separately in accordance with specifications delineated in the LAGA specifications "Management of wastes containing asbestos."

TA Siedlungsabfall places considerable emphasis on separate collection of the various waste fractions. It requires that municipal and production-specific wastes that are intended to be jointly managed with municipal wastes be sorted into recyclable wastes and nonrecyclable residual waste. It requires that pollutant products (i.e., hazardous wastes) be separately collected and treated. It requires that the local corporation responsible for waste management employ suitable collection systems to ensure that recyclable materials generated in the area serviced by the corporation be directed into recycling processes, and further requires that the corporation provide adequate sorting and composting capacity. In addition, the corporation is required to support the non-municipal collection systems and, if such a comprehensive private system is not in operation, then the corporation shall be required to install their own collection and sorting systems for recyclable materials contained in domestic refuse.

Cooperation between public and private waste management organizations is required, in order to rule out the "... existence of concurrent collection systems." Suitable collection systems are also required for commercial recyclable materials.

TA Siedlungsabfall also calls for collection of biowastes, so that:

- any nuisance, caused in particular by odors, insects and rodents, is avoided;
- biowastes are as far as possible free from extraneous materials; and
- collection covers biowastes that are, as far as possible, free from pollutants.

The TA also calls for the biological treatment of separately collected biowastes. Such treatment is defined as "Controlled degradation and conversion of biologically degradable organic wastes employing aerobic (rotting) or anaerobic (digestion) methods."

Bulky wastes are to be collected, transported, and treated in such a way that they can be reused and recycled.

Garden and park wastes are to be recycled in situ, as far as possible. Such wastes that cannot be recycled internally are to be collected separately and to the maximum extent possible, recycled externally. Compost generated from such wastes originating from areas proximate to roads, intersections, and industries must meet minimum quality requirements delineated by LAGA.

Market wastes not otherwise addressed (e.g., those covered under the Packaging Ordinance) must be collected separately and processed via a resource recovery or composting system. Road sweepings and building wastes must likewise be separated and directed into a recycling system. Sewage sludge must be managed in accordance with the requirements of the Sewage Sludge Ordinance, which regulates the use of such material for agricultural purposes. Fecal matter and fecal sludge are to be managed in wastewater treatment facilities or via biological treatment or other appropriate method. If possible, residues from such wastewater treatment facilities are to be processed and recycled.

TA Siedlungsabfall requires that suitable sorting facilities (preferably using automated sorting processes) be installed to produce a recyclable or marketable product from commercial waste, to the extent that separation at the points of occurrence does not lead directly to a recyclable or marketable product. Facilities to process building wastes (again preferably automated) are also required.

The TA also delineates requirements for facilities that process biologically degradable organic wastes. These requirements cover pretreatment, rotting (i.e., aerobic digestion), and compost-processing facilities. Except for small-scale facilities with no likelihood of nuisance, aerobic digestion is to take place in closed systems, permitting monitoring and control. Such systems must include provisions to protect operating personnel from exposure to spores, odor, and noxious gases. As part of the licensing procedure, operators are also required to provide details of the proposed marketing plan for the compost product.

For anaerobic treatment of biodegradable organic wastes generating a usable gas and recyclable sludge, such wastes are to be presorted and screened to ensure that the resultant gas and residual sludge meet the applicable quality requirements. Such facilities shall be equipped with waste treatment, fermentation, gas treatment, and sludge residue treatment facilities. The gas generated from such facilities, if used internally for the production of energy, must satisfy the requirements of the ordinance on small-scale combustion plants (1st Federal Emission Control Ordinance-BImSchV) or the Technical Instructions on Air Quality Control (TA Luft of February 27, 1986), as discussed elsewhere in this report. Residues from the process (including separated materials resulting from the waste screening and sorting efforts and sludge) are primarily to be recycled.

On an annual basis, all operators of waste recycling facilities are to provide information on the volume and composition of the input material; the quantity, composition, and quality of resource materials recovered; the location of the recovered resources; estimates of the market conditions for the recovered resources; and information on the volume and location of the remaining waste.

All waste management facilities, other than insignificant facilities, should have a separate organizational unit responsible for performing inspections as required. (Insignificant facilities are defined as facilities licensed for less than 10 different waste types which annually store or treat less than 5,000 tons and employ less than a set number of employees, or facilities which are located near and service a production facility.) Personnel shall be appropriately qualified. The facility shall have in place regulations governing facility use; an operating manual detailing standard operating procedures; and an operating journal to be preserved for at least five years detailing data on wastes accepted, materials recovered, inspection results, occurrences, operating times and downtime, the nature and scope of structural and maintenance measures, and other items. The facility operators shall prepare an annual overview of the facility detailing, at a minimum, wastes, materials recovered, unusual events, and operating period. The TA further details general requirements for waste treatment facilities, including the need to provide separate entrance, storage, and working areas, and adequate safety and cleaning facilities and equipment.

According to the TA, thermal treatment facilities (defined as facilities which provide for thermal drying, incineration, pyrolysis, or gasification of wastes, as well as a combination of these processes) must:

- destroy, transform, separate, concentrate, or immobilize harmful or hazardous substances contained in wastes;
- reduce the volume and quantity of the wastes to the furthest possible extent;
- transform remaining residues into usable substances or convert them into a dumpable form.

The TA also requires that the resultant thermal energy be utilized to the "furthest extent possible."

Problem materials, inert substances, and special bulky wastes must be minimized or removed prior to thermal treatment. If necessary, the residual waste to be thermally treated shall be crushed and/or homogenized. Thermal treatment facilities are to be equipped with charging facilities, a principal reaction chamber, and if needed, an interconnected or downstream after-reaction chamber. Provisions are to be employed to ensure that the "... wastes and emission gases burn to the fullest extent possible." For processes involving gasification or pyrolysis under anaerobic conditions in which the resultant gases and particulate are not burned as part of the process, a gas cleaning system must be considered. Residues from thermal treatment facilities, which will include slag and ashes, grate riddlings, and dusts from waste-gas purification, are primarily to be recycled. Such residues are to be collected separately, unless they are to be subsequently recycled, treated, or deposited commingled.

Inadequately burned residues with an ignition loss of more than 5% must be separately collected and returned to the thermal treatment process. Efforts are to be made to achieve the requirements for deposit in a Class I landfill (defined as "landfill permitting the storage of wastes that exhibit a slight organic content and which release a very low level of pollution in the leaching test"). Such materials <u>must</u> meet the requirements for a Class II landfill, defined as "landfill permitting the storage of wastes which contain a higher share of organic material than those wastes dumped on landfills of Class I and which release a higher level of pollution in the leaching test than wastes allowed to be dumped on landfills of Class I; to compensate for this, higher requirements are placed on the landfill site and on the landfill seal."

According to TA Siedlungsabfall, landfills are to be planned, installed, and operated such that "... several extensively independent barriers are created and the release and dissemination of pollutants are prevented by the best available technological means." This is to be accomplished by "(a) selecting geologically and hydrogeologically suitable locations, (b) selecting suitable landfill sealing systems, (c) selecting suitable waste dumping techniques, and (d) observing the allocation values laid down in Appendix B."

The TA describes general locations in which siting of landfills is prohibited, including karst regions or areas particularly permeable to water; drinking water or mineral spring protection areas; flood zones; pits; or nature reserves or other specially protected areas. It further details the elements to be examined in determining the suitability of a site for landfill development, including the required conditions of the geological barrier; location relative to groundwater (minimum 1-meter separation following settlement); leachate monitoring; landfill sealing system requirements, including quality plan and sealing systems designs, as shown in Figure 2.2-1; capping requirements as shown in Figure 2.2-2; leachate treatment; and required site stability.

In addition, an operating plan must be developed which includes all the main regulations regarding placement of wastes; leachate reduction; collection and discharge of gas; and monitoring requirements (including groundwater, settlement, and deformation in landfill body or sealing systems; meteorological data; water balance; leachate quality; temperature at the landfill base; and, if applicable, gas levels). In addition, a "dumping" plan may be required, detailing the waste type, site of dumping, method of dumping, time of dumping, and deviations from the operating plan if landfill sections are to contain different types of wastes with various high pollutant contents. The TA also details post-closure requirements, incorporating portions of the post-closure requirements delineated in TA Abfall, Appendix G.

TA Siedlungsabfall also establishes a compliance schedule for existing facilities. Exemption from the allocation requirements for domestic refuse, commercial wastes similar to domestic refuse, sewage sludge, and other organic wastes can be permitted by the responsible authorities up to June 1, 2005, and for excavated soil, building rubble, and other mineral wastes up through June 1, 2001, if such wastes cannot satisfy the regulations because of inadequate treatment capacity. Compliance with the organization, planning, and training requirements for all facilities; the storage and safety equipment requirements; and the special requirements governing organic waste-processing facilities and thermal treatment facilities must be achieved by existing facilities no later than June 1, 1999. The TA requires the responsible authorities to issue, no later than June 1, 1995, the requirements and compliance timetable for landfill allocation criteria.

TA Siedlungsabfall also delineates the applicable protocols to be followed in any sampling and analyses required under the regulations, cross-referencing a number of sampling, testing, and measurement protocols set by various industrial associations and issued by DIN (Deutsche Industrie Normen).

In the Supplementary Recommendations to TA Siedlungsabfall, dated May 29, 1993, the Ministry stated the following principles:

(a) The implementation of the Technical Instructions on Waste from Human Settlements are designed to promote waste avoidance, and to ensure that unavoided waste is as far as possible recycled/reused, that levels of hazardous substances contained in the waste are kept to a minimum and that non-recyclable waste is treated and deposited in an environmentally-friendly way.

    In this way we intend to restore ensured disposal in the local disposal corporations—which is under serious threat in some places—and guarantee it in the long term.

    Moreover, deposited waste should require no aftercare, thus ensuring today's disposal problems are not transferred to future generations.

(b) Article 1 of the Waste Avoidance and Waste Management Act stipulates that waste avoidance has priority over waste recycling or reuse and that recycling or reuse has priority over other forms of disposal. The corporations responsible for waste disposal should be involved in ensuring as little waste is generated as possible and that waste which cannot be avoided is as far as possible recycled or reused. By, for example, structuring the rates they charge in a particular way, they can create sustainable incentives to avoid and recycle the waste producers generate.

(c) The public sector too can set an example to contribute to the pursuit of these objectives.

The public sector should gear its administrative affairs, in particular its procurement and commissioning policy in such a way that waste is as far as possible avoided, that products are reused and that valuable resources are recycled..."

The Supplemental Recommendations also describe a variety of roles and activities that responsible organizations could follow in developing and implementing programs consistent with these objectives. These activities range from emphasizing composting to developing the guidelines for integrated waste management plans or facilitating separate waste streams to reduce quantities of hazardous materials and maximize recycling/reuse.

The Supplementary Recommendations further state that waste systems are to reflect integrated waste management concepts, which are described as "... designed to ensure priority is given to waste avoidance over recycling/reuse and to recycling/reuse over other types of disposal and to guarantee waste disposal capacity."

The above outline of the Waste Avoidance and Disposal Act and the Technical Instructions issued pursuant to that Act make it clear that waste management in Germany is to be implemented in an integrated fashion, in accordance with a waste management hierarchy which emphasizes waste avoidance/reduction, recycling/reuse, treatment aimed at transforming any residual waste into a stable, essentially inert substance with minimal likelihood of further transformation detrimental to the environment and final disposal. The hierarchy has been clarified as part of the debate related to the recent passage by the Bundesrat, of the Kreislaufwirtschaft, the Cyclic Economy Law (see Section 2.4). Pursuant to the law as passed by the Bundesrat on July 8, 1994, the hierarchy consists of waste avoidance/reduction, followed by material and energy recovery on a par, followed by final disposal.

2.2.1.2 Additional Ordinances

TA Siedlungsabfall has been supplemented by several ordinances. The Special Waste Identification Ordinance, for example, identifies over 350 types of special waste extant in the Federal Republic of Germany. The Residual Substances Identification Ordinance (25/5/1977, 3/4/1990) attempts in part to reduce the likelihood of incorrect waste classifications that might result in the inappropriate treatment of special wastes. The Waste and Residual Substances Monitoring Ordinance (3/4/1990) is aimed at the proper monitoring of waste materials that are especially harmful (i.e., potentially damaging to health, to the air or water, explosive, combustible, or pathogens of transferable diseases). Among its provisions, this ordinance requires that a disposal certificate detailing the amount, type, treatment, and final disposal location must accompany the waste.

FIGURE 2.2-1
BASE SEALING SYSTEMS

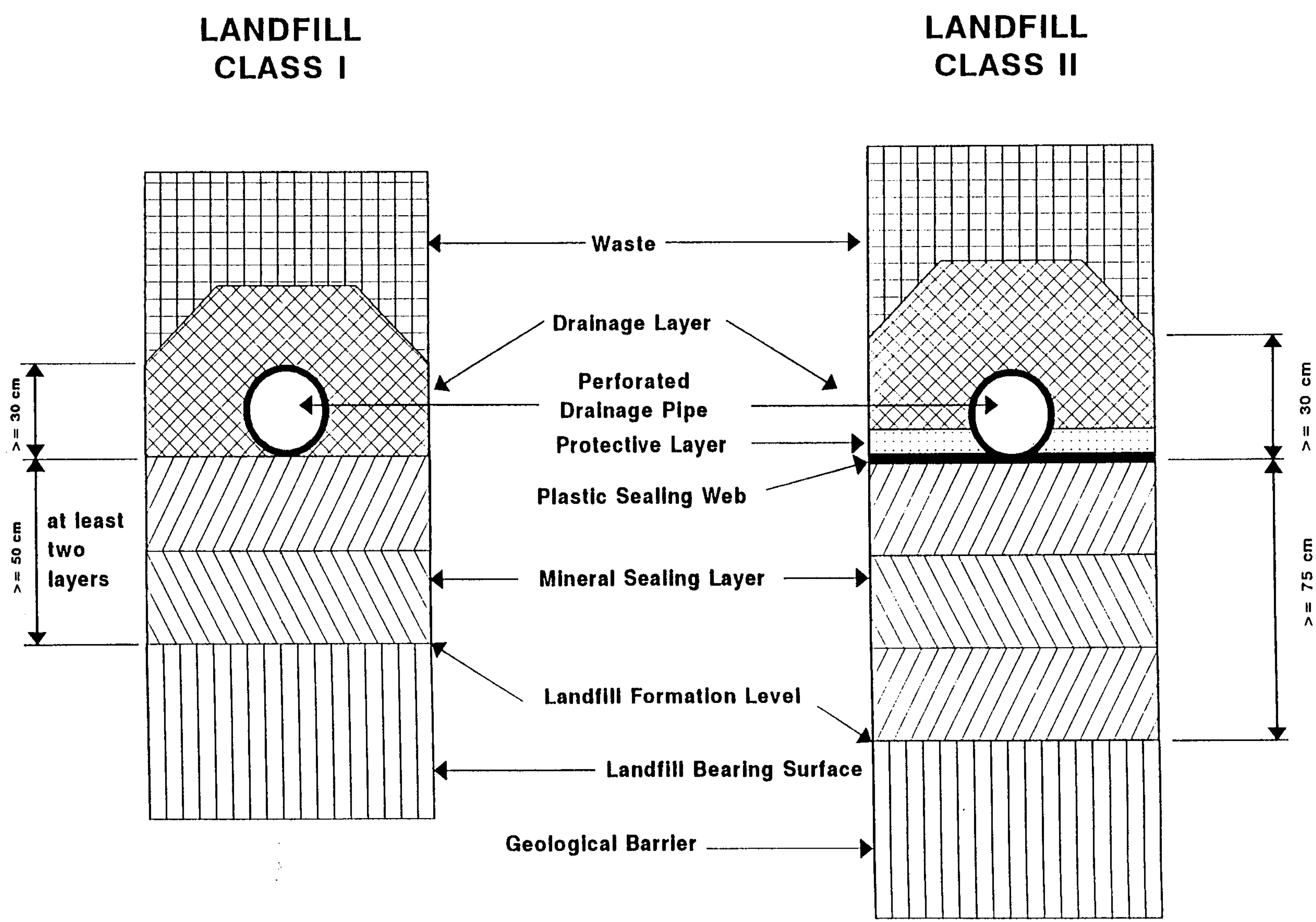
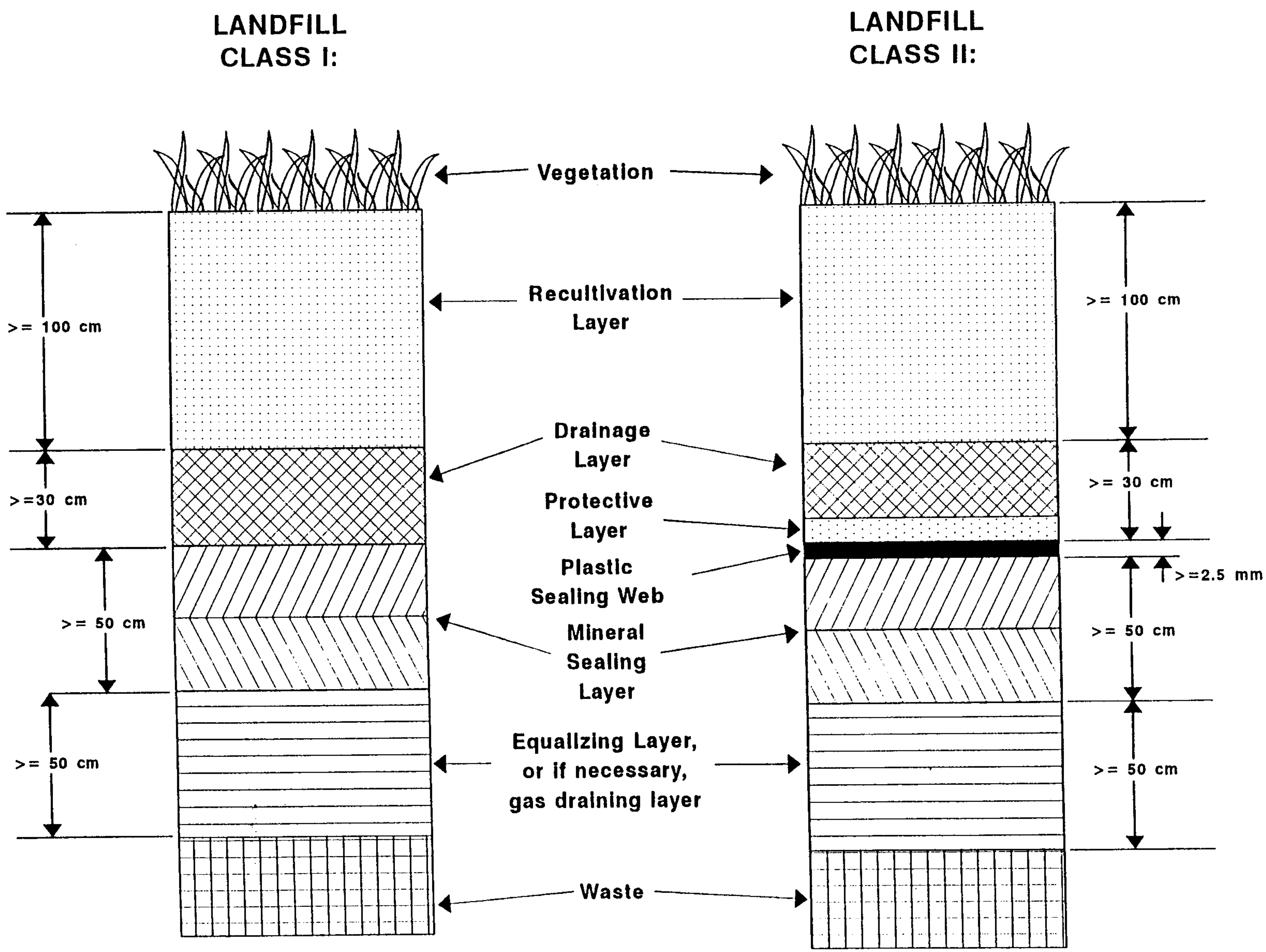


FIGURE 2.2-2
LANDFILL CAPS



The Interstate Waste Working Group (LAGA), among its other efforts, developed a waste catalog which is used throughout Germany when making declarations pursuant to (1) the Waste Evidence Ordinance (2/6/1978), which requires that waste not disposed of with the domestic refuse stream be tracked via an accompanying disposal certificate; (2) the Waste Transport Ordinance (24/8/1983), which details the procedures and conditions associated with the approval of waste transport by reasonable authorities, such approval being required except for earth; road excavation, construction and demolition debris (clean); or scrap cars or tires; and (3) the Waste Import Ordinance (18/11/88). The LAGA catalog is used in setting the conditions for approval to export, import, or transport waste, including appropriate descriptions of the type and amount of waste being transported and processed. The catalog is also used in the approval process for waste management facilities; in connection with the supervision of plants and companies; and in the proper reporting of waste statistics, as required by the Environmental Statistics Act. (This Act, passed in 1980 and amended in 1986, provides for the collection of data related to waste management, water management, and environment-related investments.)

Other ordinances issued in accordance with the Waste Avoidance and Disposal Act deal with the roles and responsibilities of in-house waste management experts; the treatment of sewage sludge; the reduction, recovery, and recycling of packaging materials; used oil; and used halogenated solvents.

The Packaging Ordinance

The ordinance which has received the most attention recently is the Regulation concerning the Avoidance of Packaging Waste (Verpackungsverordnung), which was adopted by the Bundesrat on April 19, 1991. This ordinance was prepared in response to Article 14 of the Waste Avoidance and Disposal Act, which states among other things that the government "... is required to specify objectives to be reached within an adequate period of time for avoiding, reducing, or re-using/recycling waste arising from certain products."

Prior to the implementation of the Packaging Ordinance, a number of measures addressing related issues had been introduced. These included a voluntary industrial agreement to reduce the amount of mercury in batteries, a similar agreement to take back used refrigerators, and agreements regarding the disposal of chlorofluorocarbons (CFCs). In April 1989 and May 1990, the government issued statements of objectives regarding the avoidance, reduction, or recycling of waste from liquid food containers and plastic sales packaging for food and consumer goods, respectively.

Another statement of objectives, also issued in May 1990, dealt with reducing used paper waste; another, in August 1990, dealt with the avoidance, reduction, and recycling of waste associated with used-vehicle disposal. Another ordinance mandated deposits on plastic liquid food containers, and an obligation on the part of distributors to take back such containers.

The Packaging Ordinance established the following objectives:

1. Packaging shall be manufactured from materials which are environmentally compatible and do not hamper the environmentally compatible reuse or recycling of the materials used;

2. Waste from packaging shall be avoided by ensuring that packaging (1) is restricted in volume and weight to the dimensions actually required to protect the contents and to market the product; and (2) is designed in such a way that it may be refilled provided this is technically feasible and reasonable as well as compatible with the regulations applying to the contents;

3. Is reused or recycled if the conditions for refilling do not apply.

As part of its approval of the Packaging Ordinance, the Bundesrat requested that additional measures be adopted over and above those contained in the ordinance. These measures—which dealt, for example, with packaging materials made from environmentally questionable materials—were not included in the ordinance, in part because such measures would have extended the debate and might also have required notification of the European Community, which would have further delayed implementation of the ordinance.

The Packaging Ordinance gives reuse of packaging a higher priority than material recycling. During the debate, the Bundesrat sought to emphasize the priority of material recycling over thermal recycling or energy recovery. As finally implemented, the ordinance does not allow the energy generated from packaging materials recovered under a waste management program to be credited towards the recycling targets set forth in the Avoidance and Disposal Act, although the Act includes energy recovery as a form of recycling.

The Packaging Ordinance applies to anyone who manufactures packaging itself or products from which packaging is directly manufactured (manufacturers). It also applies to anyone who brings into circulation either packaging, the products from which packaging is directly manufactured, or packaged products at any commercial level (distributors). The ordinance targets transport, sales, and secondary packaging.

Transport packaging is defined as drums, containers, crates, sacks, pallets, cardboard boxes, foamed packaging materials, shrink wrapping, and similar coverings which are component parts of transport packaging and which serve to protect goods from damage during transport from the manufacturer to the distributor or are used for reasons of transport safety.

Sales packaging is defined as closed or open receptacles and coverings of goods, such as cups, bags, blister packaging, cans, tins, drums, bottles, metal containers, cardboard and cartons, sacks, trays, carrier bags, or similar coverings which are used by the consumer to transport goods or until such time as the goods are consumed. Sales packaging also includes throwaway dishes and cutlery.

Secondary packaging includes blister packaging, plastic sheets, cardboard boxes, or similar packaging which is intended as additional packaging around the sales packaging (a) to allow goods to be sold on a self-service basis, (b) to make more difficult or prevent the possibility of theft, or (c) to serve primarily advertising purposes.

Under the terms of the ordinance, manufacturers, fillers, wholesalers, distributors, and retailers must take back and either reuse or materially recycle packaging materials. In principle, the packaging is to be taken back to the same place where it was originally transferred to the end user. Thus, for transport packaging, the end user could be the retail outlet, and the transport packaging would to be taken back by the distributor. For transport packaging, the manufacturer and distributor are obligated to take used transport packaging and reuse or recycle it. For secondary packaging, distributors are obliged to remove such packaging upon delivery of the goods to the final consumer, or to provide the final consumer the opportunity to remove and return the secondary packaging free of charge at or in the vicinity of the point of sale. Provisions exist in the ordinance to treat both transport and secondary packaging as sales packaging if the final customer in fact desires to have the product delivered to themselves in the transport and/or secondary packaging.

For sales packaging, the distributor is obligated to accept sales packing free of charge in or near the point of sale. Mail-order firms are obliged to accept used packaging free of charge from the final customer by providing, for example, return options within a reasonable distance of the final consumer. Manufacturers and distributors are also obliged to accept the materials returned and reuse or recycle them.

According to the ordinance, transport packaging was to be taken back starting December 1, 1991; secondary packaging, starting April 1, 1992; and sales packaging, starting January 1, 1993.

The framers of the Packaging Ordinance recognized that the piecemeal return of packaging materials to their point of origin might not be the most cost-efficient method of reuse/recycling, in terms of space utilization at the various points in the distribution chain, transportation costs, and materials-processing efficiency. Thus, the ordinance also provides an alternative collection system to meet the obligations regarding the taking back of sales packaging material.

Essentially, the obligations to take back sales packaging do not apply to manufacturers and distributors who are part of a system which guarantees regular collection of used packaging from the final consumer and complies with specific criteria spelled out in the Packaging Ordinance regarding coordination with local waste collection, recycling, and reuse systems and the achievement of the targeted collection and separation rates shown below in Table 2.2-3. (The numbers in parentheses in the Table are proposed revisions to the original rates, revisions issued by the Ministry for the Environment in January 1994.) The leading private sector system meeting the necessary criteria is the Duales System Deutschland. This system is discussed in detail in Section 3.2 of this report.

The ordinance also contained provisions for mandatory deposits as of January 1, 1993, on nonrefillable liquid food containers; washing and cleansing agents; and certain paints. These deposits ranged from 0.5 DM ($.32) for 0.2 l nonrefillable liquid food containers to 2 DM ($1.28) for emulsion paints with a net weight of 2 kg. Non-refillable liquid food containers can be exempted from the take back and mandatory deposit on a Lander-by-Lander basis, provided that the proportion of refillable containers for beer, water, certain wines, and juices does not drop below 72% nationwide and 17% for milk.

TABLE 2.2-3

EXISTING AND PROPOSED COLLECTING, SORTING, AND RECYCLING RATES

MATERIAL	COLLECTION RATES (%)		SORTING TARGETS (%)		RECYCLING RATES (%)	
Target Date	1/1/93	7/1/95	1/1/93	7/1/95	1/1/93	7/1/95[a,b]
Glass	60	80	70	90	42 (40)	72 (70)
Tinplate	40	80	65	90	26 (30)	72 (70)
Aluminum	30	80	60	90	18 (20)	72 (70)
Cardboard	30	80	60	80	18 (20)	64 (50)
Paper	30	80	60	80	18 (20)	64 (50)
Plastic	30	80	30	80	9 (10)	64 (50)
Composites	20	80	30	80	6 (10)	64 (50)

1. Based on the combination of the collection rate and the sorting target.

2. From January 1, 1993, to June 30, 1995, the quotas specified for each individual packaging material shall be deemed to be met if at least 50% of the total packaging material accumulated has been collected.

3. The federal government shall every three years beginning on August 31, 1992, publish the average amount of packaging per inhabitant by material to be used in determining the rates of collection.

4. Residual material from the sorting process (defined as material which cannot be broken down by manual- or machine-sorting into fractions that may be recycled or reused, soiled, or contaminated materials or non-packaging material) shall be transferred as industrial waste to the authority responsible for public waste disposal.

a. Proposed effective date now January 1, 1996.

b. For cardboard, paper, plastics, and mixed carton containers, a rate of 60% effective January 1, 1998, is proposed.

Any of the obligations of the manufacturers and distributors can be delegated to third parties, pursuant to Article 11 of the Ordinance.

The Packaging Ordinance includes civil penalties. Offenses under the ordinance include failure to accept returned materials; failure to reuse or recycle such materials; failure to provide containers if required; and failure to charge or reimburse a deposit on deposit containers.

2.2.2 Immission Control Act

Air quality regulations are an important element of the regulatory framework related to waste management since approximately 20% of the household-waste materials left for final treatment and disposal (i.e., after separation for recycling) are processed at WTE facilities. In Germany, the Act on the Prevention of Harmful Effects on the Environment Caused by Air Pollution, Noise, Vibration, and Similar Phenomena regulates, among other things, air emissions from WTE facilities and incinerators. The Act establishes the framework for Lander regulations. Adopted in 1972, it was most recently amended in 1990.

Known as the Immission Control Act, its principal aim is to protect humans, animals, plants, soil, water, the atmosphere, cultural, and other objects of value against harmful environmental effects and to eliminate such effects. The Act applies to the construction and operation of facilities, the manufacture of fuels, the condition and operation of vehicles, and the construction of roads and railways.

It should be noted that the German term "immission" refers to "air pollutants, noise, vibrations, light, heat, radiation, and analogous environmental factors affecting human beings, animals, plants, or other objects." They are to be distinguished from "emissions," which are "air pollutants, noise, vibrations, light, heat, radiation, and analogous phenomena originating from air installations."

The facility-related provisions of the Act include approval procedures to be followed in siting, constructing, and operating facilities, as well as minimum emission levels which facilities must meet. The product-related aspects of the Act are directed at reducing the levels of "harmful substances present in certain products which pollute the environment." Other provisions relate to noise reduction. Figure 2.2-3 details the various aspects of the Act and the key ordinances and amendments associated with it.

The Immission Control Act applies to public and private facilities that are likely to cause significant amounts of pollution: cars; facilities for the production, transportation, and sale of fuels; as well as transportation infrastructure construction and operation. Among the key provisions of the Act are:

- The requirement that certain installations must obtain construction and operating licenses from the Lander. These licenses can include requirements regarding emission limits, monitoring, operational limitations, and the application of certain pollution control systems.

- Such facilities must appoint senior level environmental quality monitoring experts to review actual performance, the need for improvement, and approaches for achieving such improvement. Recent amendments include additional requirements regarding the appointment of key management team members with responsibility for managing the licensing process and the operation of such licensed facilities, including an obligation to report annually on facility operations.

- Facilities not requiring a license must nevertheless utilize state-of-the-art equipment to minimize the harmful effects on the environment.

- Violations of the Act can result in cancellation of licenses, facility shutdown, and, if willful, criminal penalties.

2.2.2.1 Additional Ordinances Issued Pursuant to the Immission Control Act

The German government has issued several air quality ordinances pursuant to the Immission Control Act. Table 2.2-4 summarizes certain of these ordinances, including those specific to waste management facilities. More detailed discussion of certain relevant ordinances and decrees is provided below.

The Ordinance on Large Combustion Plants, issued in 1983, led to a significant reduction in sulfur dioxide emissions from major facilities (from around two million tons per annum in 1982 to 0.7 million tons in 1988). Nitrogen dioxide emissions from facilities falling within the scope of the ordinance have been reduced from approximately one million tons in 1982 to approximately 0.3 million tons in 1990.

The Technical Instructions for Air Quality Management, last amended in 1986, regulate the approval and monitoring of facilities which are potentially hazardous to the environment. Known as TA-Luft, this decree contains general emission values for gaseous and dust emissions and immission (ambient) values related to the protection of public health. Table 2.2-5 details these limits.

The fourth ordinance issued under the Federal Immission Control Act requires that plants which due to the nature of their operation are likely to produce harmful effects on the environment, or in some other way constitute a hazard to the community or to the neighborhood, or place the neighborhood or community at a considerable disadvantage, or expose it to major pollution are to be subject to the approval process delineated in the regulations. Depending on the nature of the plant, the approval process can be either simplified or formal. Public input is a key element in the formal approval process. For facilities which are subject to the formal process, the procedure involves publication of an intent-to-proceed notice, review of the proposed design by various authorities, and publication of any objections.

The most recent ordinance affecting WTE facilities is the Ordinance on Incinerators for Waste and Similar Combustible Material issued on November 23, 1990 (17 BImSch V). This ordinance applies to the construction, design, and operation of facilities in which solid or liquid wastes are incinerated.

(Certain facilities are exempt from the requirements of this ordinance: those used exclusively for the incineration of wood or wood residues, straw, nutshells, and similar materials; waste liquor from pulp production; certain liquid combustible materials provided they do not contain more than 10 milligrams per kilogram of polychlorinated biphenyls, pentachlorophenols or polychlorinated aromatic hydrocarbons and the lower calorific value is above 30 megajoules; other liquid combustible materials provided that their emissions are expected to be no different or higher than fuel oil; distillation and conversion residues from oil refineries or from the cracking of naphtha for internal use.)

TABLE 2.2-4
ORDINANCES AND DECREES ISSUED RELATED TO THE AIR QUALITY ACT
(The Act on the Prevention of Harmful Effects on the Environment Caused by Air Pollution, Noise, Vibration and Similar Phenomena)

TITLE	DESCRIPTION
First Ordinance for Implementation of the Federal Immission Control Law (1974, last amended 1988)	Regulates the design, installation and operation of burners using solid or liquid fuels.
Second Ordinance on Limiting Emissions of Volatile Halogenated Hydrocarbons (1986)	Regulates chemical emissions from dry and surface cleaning operations.
Third Ordinance (1975, amended in 1986)	Regulates the maximum sulphur content for light fuel and diesel oil.
Fourth Ordinance on Plants for which an Authorization is Required (1988)	Identifies all types of equipment and plants for which a permit must be obtained prior to operation broken down by facility and type of procedure required.
Fifth Ordinance on Air Quality Monitoring Experts (1975, amended 1985)	Delineates operators who are required to appoint such experts and regulates their tasks and responsibilities, which includes promoting the development and introduction of more environmentally friendly methods and processes, monitoring compliance with the clean air regs and acting as a source of information for employees.
Ninth Ordinance on the Procedure of Authorization (1977)	Regulates the process to be followed in seeking licenses.
Twelfth Regulation on the Implementation of the Federal Immission Control Law (Hazardous Incidents Regulation)(1980, amended in 1985 and 1988)	Regulates the precautionary and safety measures, monitoring and notification requirements required of facilities requiring a license. Provisions include the requirement for a safety analysis and compulsory notification.
Thirteenth Regulation (Regulation on Large Combustion Installations) (1983)	Regulates the reduction of SO_2 and NO_x, CO, Dust and Heavy Metals from large coal-, oil-, or gas-fired installations (> than 50 MW, 100 MW if gas-fired).
Seventeenth Ordinance on Installations for the Incineration of Wastes and Waste-like Materials (1990)	Regulates the operation of hazardous waste incineration facilities, including establishing emission limits for SO2, NOx, particulate, HCL, HF, heavy metals , dioxins and furans.
Ordinance on Specifications and Identification of Automotive Fuels (1988)	Regulates contents of automotive fuels.
Act to Reduce Air Pollution Caused by Lead Compounds in Carburetor Fuels for Motor Vehicles (1971, amended 1986)	Limits the lead concentrations in gasoline.
Smog Ordinance (1987)	Framework legislation permitting each city to set its own concentration limits for smog.
First General Administrative Decree under the Federal Control Act -Technical Instructions for Air Quality Management (last amended 1990)	Known as TA-Luft, regulates the conditions that must be addressed in the awarding of licenses, including the maximum emission levels allowable and sets state-of-the-art requirements for more than 40 types of facilities.
Ordinance in respect of the Return and Recycling of Used Solvents (1/1/90)	Ensures that the processing, re-use, and disposal of used solvents is accomplished in an environmentally sound fashion.
Ordinance on Waste Oil (11/1/87)	Delineates what types of oil can be reprocessed, labelling requirements and collection location requirements.
Ordinance in Respect of Company Waste Representative (1977)	Requires that companies appoint a company representative responsible for supervising waste and its lawful disposal, investigating new avoidance and recycling measures and advising management on the waste impacts of capital investment decisions.

TABLE 2.2-5
IMMISSION VALUES (Ambient)[1]

SUBSTANCE	HEALTH VALUES[2]		DISADVANTAGE OR ANNOYANCE VALUES[3]	
	Annual Mean[4]	Short-Term Value[5]	Annual Mean	Short-Term Value
airborne dust mg/m^3	0.15	0.3		
lead and inorganic lead compounds as components of airborne dust stated as Pb g/m^3	2			
cadmium and inorganic cadmium compounds as components of airborne dust stated as Cd- g/m^3	0.04			
chlorine, mg/m^3	0.1	0.3		
hydrogen chloride, stated as CL-mg/m^3	0.1	0.2[6]		
carbon monoxide, mg/m^3	10	30		
sulfur dioxide	0.14[7]	0.4		
nitrogen dioxide	0.08	0.2		
dust deposits (non-harmful dusts) g/m^2			0.35	0.65
lead and inorganic lead compounds as components of dust deposits, stated as Pb-$mg/(m^2$ d) 0.25			0.25	
cadmium and inorganic cadmium compounds as components of dust deposits, stated as Cd-$g/mg/(m^2$ d)			5	
thallium and inorganic thallium compounds as components of dust deposits, stated as Tl-$g/mg/(m^2$ d)			10	
hydrogen fluoride and inorganic gaseous fluorine compounds, stated as F-g/m^3			1	3

1 These values are to be measured in accordance with measurement procedures as delineated in TA-Luft. Measurement procedures are established by the VDI which require, among other things, that the measurement apparatus must have been inspected by an authorized testing institute in accordance with instructions issued by the Lander committee for immission protection. The test methods may vary from test methodologies in use in the U.S. for measuring identical materials. Thus, caution is recommended in making direct comparison of the numerical limits among different countries, as the specific test methodologies, sampling periods, and other facets of the standard test methods utilized can impact the results obtained.
2 For the protection of human health.
3 For protection against major impacts.
4 Arithmetic mean value.
5 95% value of the cumulative frequency distribution.
6 If HCl cannot be readily measured separately from the chlorides, 0.3 mg/m^3 shall apply for the short-term value.
7 In areas where the mean annual immission load does not exceed a mass concentration of 0.05 or 0.06 mg/m^3, care shall be taken to ensure that this value is maintained.

The Ordinance on Incinerators includes measures for the prevention of detrimental environmental effects from air pollutants; prevention and control of fire; treatment of residual materials; and use of the heat generated from WTE facilities. The Ordinance includes requirements applicable to receiving, combustion practices, emission limits, stack height, residual material treatment, use of thermal energy, measuring and monitoring, requirements for existing facilities, offenses, and other administrative requirements. The following sections describe key provisions.

Provisions Related to Receiving Area

The Ordinance on Incinerators requires that the receiving areas of such facilities (1) be maintained at a negative air pressure and that the air be withdrawn by suction and fed into the combustion chamber; (2) have appropriate fire-monitoring and warning equipment, and if applicable, explosion control measures; and (3) provide for the appropriate storage and transfer of liquid materials.

Combustion Practices

The Ordinance includes minimum temperature requirements: 850°C for gases produced by incinerating domestic waste, sewage sludge, hospital wastes, or other materials not containing halogenated hydrocarbons; and 1200°C for gases generated by the combustion of other materials for a minimum of two seconds in a homogenous mixture of the gases produced and the air supplied, with the minimum oxygen content by volume being 6% (3% in the case of an exclusively liquid feed facility or a pyrolysis process generating primarily a gaseous phase for subsequent combustion). These requirements can be modified by the permitting authority provided that emission testing demonstrates that the emission levels achieved do not exceed those produced under the above conditions. Auxiliary burners shall be supplied for start-up, shutdown, and temperature maintenance, along with automatic controls to ensure that (1) materials cannot be introduced into the combustion chamber until the minimum temperature has been reached; (2) materials can be fed only as long as the minimum temperature is maintained; and (3) material supply shall be interrupted if any of the continuously monitored emission limits may be exceeded.

Emission Limits

The facilities shall be constructed and operated so that emissions do not exceed a daily mean of 50 milligrams of CO per cubic meter and an hourly mean of 100 milligrams CO per cubic meter. In addition, the mass concentration of CO shall not exceed 150 milligrams per cubic meter in at least 90% of all measurements taken within a 24-hour period. These limits are based on 11% oxygen content by volume. Table 2.2-6 details other emission limits applicable to WTE facilities.

Stack Height

The facility stack shall be of the required height as determined in accordance with TA-Luft, Number 2.4 (Technical Instruction on Air Pollution).

TABLE 2.2-6
EMISSION LIMITS ON INCINERATORS FOR WASTE AND SIMILAR COMBUSTIBLE MATERIAL

Installations are to be constructed and operated so that none of the daily means recorded exceeds the following emission limits. (All values are to be related to 11% O_2.)

POLLUTANT	EMISSION LIMITS
Total Particulate Matter	10 mg/m^3
Organic Substances, given as total carbon	10 mg/m^3
Gaseous Inorganic Compounds, given as hydrogen chloride	10 mg/m^3
Gaseous Inorganic Fluorine Compounds, given as hydrogen fluoride	1 mg/m^3
Sulfur Dioxide and Sulfur Trioxide, given as sulfur dioxide	50 mg/m^3
Nitrogen Monoxide, given as nitrogen dioxide	0.2 g/m^3

None of the half-hour means recorded exceeds the following emission limits:

POLLUTANT	EMISSION LIMITS
Total Particulate Matter	30 $mg/^3$
Organic Substances, given as total carbon	20 mg/m^3
Gaseous In Organic Chlorine, given as hydrogen chloride	60 mg/m^3
Sulfur Dioxide and Sulfur Trioxide, given as sulfur dioxide	0.2 g/m^3
Nitrogen Monoxide, given as nitrogen dioxide	0.4 g/m^3

TABLE 2.2-6 (CONTINUED)

EMISSION LIMITS ON INCINERATORS FOR WASTE AND SIMILAR COMBUSTIBLE MATERIAL

No mean determined over the respective sampling period exceeds the following emissions limits:

a.	Cadmium and its compounds, given as Cd Thallium and its compounds, given as TI in total	0.05 mg/m^3
b.	Mercury and its compounds, given as Hg	0.05 mg/m^3
c.	Antimony and its compounds, given as Sb Arsenic and its compounds, given as lead and its compounds, given as Pb Chromium and its compounds, given as Cr Cobalt and its compounds, given as Co Copper and its compounds, given as Cu Manganese and it compounds, given as Mn Nickel and its compounds, given as Ni Vanadium and its compounds, given as V Tin and its compounds, given as SN	
	In Total	0.5 mg/m^3

No mean determined over the respective sampling periods exceeds the emission limit of 0.1 ng/m^3 (toxic equivalents) for the dioxins and furans in accordance with the toxic equivalent factors listed below.

TABLE 2.2-6 (CONTINUED)
EMISSION LIMITS ON INCINERATORS FOR WASTE AND
SIMILAR COMBUSTIBLE MATERIAL
TOXIC EQUIVALENT FACTORS

To obtain the sum total, the concentrations of the following dioxins and furans determined in the waste gas concerned shall, before adding them, be multiplied by the equivalence factors given.

2,3,7,8	Tetrachlorodibenzodioxine	(TCDD)	1
1,2,3,7,8	Pentachlorodibenzodioxine	(PeCDD)	0.5
1,2,3,4,7,8	Hexachlorodibenzodioxine	(HxCDD)	0.1
1,2,3,7,8,9	Hexachlorodibenzodioxine	(HxCDD)	0.1
1,2,3,6,7,8	Hexachlorodibenzodioxine	(HxCDD)	0.1
	Octachlorodibenzodioxin	(OCDD)	0.001
2,3,7,8	Tetrachlorodibenzofurane	(TCDF)	0.1
2,3,4,7,8	Pentachlorodibenzofurane	(PeCDF)	0.5
1,2,3,7,8	Pentachlorodibenzofurane	(PeCDF)	0.05
1,2,3,4,7,8	Hexachlorodibenzofurane	(HxCDF)	0.1
1,2,3,7,8,9	Hexachlorodibenzofurane	(HxCDF)	0.1
1,2,3,6,7,8	Hexachlorodibenzofurane	(HxCDF)	0.1
2,3,4,6,7,8	Hexachlorodibenzofurane	(HxCDF)	0.1
1,2,3,4,6,7,8	Heptachlorodibenzofurane	(HpCDF)	0.01
1,2,3,4,7,8,9	Heptachlorodibenzofurane	(HpCDF)	0.01
	Octachlorodibenzofurane	(OCDF)	0.001

NOTE: The test methods used to measure pollutant emission levels may vary from test methodologies in use in the United States for measuring identical materials. Thus, caution is recommended in making direct comparison of the numerical limits across different countries, since the specific test methodologies, sampling periods, and other facets of the test process can affect the results obtained.

Treatment of Residual Materials

The Ordinance on Incinerators calls for the avoidance, reuse, or recycling of slag, particulate matter from boilers and filters, reaction products, and other residual materials from waste gas treatment. If this is not possible, then these materials are to be disposed of as wastes. The Ordinance calls for the separate collection of particulate matter resulting from flue-gas cleaning and the cleaning of boilers' heating surfaces and waste gas ducts (except for fluidized-bed units). It also requires that steps, including transportation in closed containers, be taken to minimize fugitive dust emissions.

Use of Heat

Heat not transferred to third parties shall be used by the facility operators, where technically feasible. If the thermal energy not used exceeds 0.5 mW in capacity, it shall be used for electrical energy generation. This requirement reflects the government's emphasis on the maximum efficient use of materials and energy.

Measurements

The Ordinance includes requirements related to measuring points and measuring methods and equipment, including: (1) certification of calibration testing upon installation of continuous monitors; (2) annual certification testing of continuous emissions monitors (CEMs) with, at a minimum, tri-annual calibration testing; (3) continuous monitoring of CO, particulate, total carbon, hydrogen fluoride, sulfur dioxide, nitrogen dioxide (unless the percentage of nitrogen dioxide in total nitrogen oxides emitted is less than 10%), hydrogen chloride at the inlet of the air pollution control train and as emitted from the stack, oxygen content of waste gases by volume, and operating parameters as required to assess proper operation (in particular, temperature, volume, pressure, and moisture content). In addition, if equipment becomes available for continuous monitoring of mass concentrations of heavy metals and dioxins, and the responsible authority requires it, then facility operators are required to install such CEMs. The Ordinance also details specific limits on the sampling periods, determination of exceedances, reporting and evaluation, shutdown requirements for failure to comply, and maximum allowable period of operation exceeding limits. Operation exceeding specified emission limits is permissible for no more than eight consecutive hours or 96 hours a year, if technically unavoidable. Under these conditions, total particulate emissions shall not exceed 150 milligrams per cubic meter (half-hour mean).

German test methods may vary from those in use in the United States for measuring identical materials. Because the specific test methodologies, sampling periods, and other facets of the testing process can affect the results obtained, caution is recommended in making a direct comparison of the numerical limits across countries.

Other Administrative Measures

Once a year, according to the Ordinance on Incinerators, the operator of a WTE facility is required to make public the results of an evaluation of the facility's emissions levels and combustion parameters. This requirement is subject to the facility owner's right to protect proprietary data.

The Ordinance also permits exceptions on a case-by-case basis if particular requirements cannot be met or can only be met at unreasonable expense, provided that the measures to limit emissions are in line with best available technology, the stack height is designed to meet emission limits even for those emission limits for which an exception has been granted, and the facility continues to comply with certain directives of the European Community. The Ordinance also allows exceptions on a case-by-case basis to the requirements on enclosed receiving areas and to the organic carbon limit (to allow safe combustion of materials in throw-away containers).

The Ordinance specifically allows the competent authority in any area to set different or more stringent requirements. It also delineates penalties for failure to comply with certain of its provisions.

Existing Facilities

Existing facilities are required to comply with the Ordinance on Incinerators as of March 1, 1994. Facilities which meet the requirements of Number 3 of TA-Luft or have a non-appealable obligation to meet those requirements have until December 1, 1996, to comply. Those existing facilities which cannot meet the minimum temperature requirements shall do so at the latest when the combustion unit is refurbished/replaced. If, at an existing facility, the hydrogen chloride concentration upstream of the pollution control train exceeds 4 grams per cubic meter (daily mean), then the emission limits shall not apply. In that case, however, the facility must meet certain removal efficiency requirements and not exceed a daily mean of 65 milligrams per cubic meter.

The implementation of the Ordinance on Incinerators has resulted in the revision of the APC trains on many facilities in Germany. The systems have generally been revised to incorporate activated carbon filters and catalytic reactors.

2.2.3 Water Quality

The federal government is restricted to framework legislation in this area. The primary responsibility for the legislation and enforcement of water pollution control measures rests with the Lander. However, due to the European Union directives on water management, the federal government is taking a stronger role, since it is required to ensure uniformity within the country.

The Federal Act on Water Management was adopted in 1976, and last amended in 1986. This legislation established a two-tier system of permits regulating the use of water, the discharge of pollutants into the water, and any other activities which may harm the country's water resources (e.g., thermal discharges). Requirements include state-of-the-art technology, appointment of qualified water protection officers, and more stringent limits on effluent.

The Effluent Water Charges Act (1976, amended in 1987) provides for the charging of fees for the discharge of toxic substances into surface waters, based on the units of nuisance associated with the particular discharge. The unit of nuisance is based on the volume, suspended solids, oxygen demand, and toxicity of the discharge.

In addition to the framework legislation described above, the federal government has taken a number of other initiatives related to water management. For example, the Act on Environmental Compatibility of Washing and Cleansing Agents (adopted in 1976 and amended in 1986) prohibits the marketing of detergents that fail to meet biodegradability requirements and other limits. The Act also includes labelling requirements.

2.2.4 Enforcement

Failure to comply with environmental laws in Germany entails both civil and potentially criminal liability. Criminal liability is addressed in appropriate sections of the Criminal Code, including Divisions 17 (bodily injury); 25 (damage to fisheries and the hunting of wildlife); 26 (property damage); 27 (damage caused by fires, explosions, radiation, toxic emissions, and floods); and 28 (environmental damages). Civil liability was recently addressed in the Environmental Damages Act (January 1, 1991). This Act addresses liability for damages to soil and air and includes bodily injury, property damages, and remedies for impairment of nature and landscape. In addition, each piece of environmental legislation generally includes sections detailing applicable penalties for failure to comply.

2.3 FEDERALLY FUNDED RESEARCH AND INVESTIGATIONS

The federal government has sponsored a number of research programs and studies aimed at providing additional information on the various aspects of integrated waste management. A major focus of recent studies has been in the area of packaging. A recent study completed on September 21, 1993, examined one-way beverage cartons for milk delivery versus returnable bottles. It examined several elements of the product life cycle, including water and energy consumption, air emissions, and transportation impacts. The study took three years to complete and examined the life cycles of four different milk packages. The economic and environmental impacts of brick-shaped, gable-shaped, plastic pouches, and returnable glass bottles were examined, from raw material extraction through disposal. The results of the study, as reported in the *IER*, indicated that there was no one clearly superior package, and that package selection depended upon a number of local factors, including the distance to transport returnable containers. According to the study, returnable bottles, for example, contributed to higher air emissions when the transport distance exceeded 100 kilometers. Cartons made from cellulose added to the water pollution.

2.4 PROPOSED LEGISLATION AFFECTING SOLID WASTE MANAGEMENT

Individual measures related to used-paper recycling, used-car recycling, electronic appliances, computers, and building debris have been proposed. In 1993, the federal government prepared and forwarded to the Bundesrat for review a new Waste Management and Product Recycling Act (Kreislaufwirtschaftsgesetz), aimed at fostering product recycling instead of waste disposal. The proposed Act emphasized the concept of "polluter pays" by placing responsibility for the entire life cycle of a product on its producers and consumers. The proposed Act, which was initially rejected by the Bundesrat, was passed by the Bundesrat following significant debate and revision on July 8, 1994. Following its publication in the fall of 1994, the Act will take effect in two years. The Act covers all residual materials produced by manufacturers and consumers. Production processes, including residual material management, are to be directed towards the hierarchy of avoidance, material-related recycling, and energy recycling on a par followed by residuals disposal. This was the subject of considerable debate and discussion. Placing energy recovery on a par with material recycling resolves a long-standing debate in Germany over the role of waste-to-energy and recovery of energy in integrated waste and materials management. Among the requirements of the Act are the development of material balance sheets, reflecting the entire life cycle of the product, including its ultimate disposition at the end of its useful life. The Act allows the federal government to establish ordinances requiring producers and distributors to take back their products (following the precedent set by the Packaging Ordinance). The costs for the necessary programs are to be reflected in the price of the product. The goal of the Act is to "... achieve as far as possible the privatization of waste management and product recycling on the basis of the economically sensible `producer pays´ principle."

As reported in the *IER* (Nov. 17, 1993), the government, in response to pressure from the German Electrical and Electronic Manufacturers' Association and other sources, has agreed to postpone further debate on an ordinance for recycling electrical and electronic components until after the 1994 elections. The trade association has issued a memorandum calling for more time to study the feasibility of the proposed program because of its potential impact on the cost of products and the resultant impact on the competitiveness of German products. The government has apparently decided that further discussions are needed with the industry, and also that problems with the Packaging Ordinance, which is viewed by many as the prototype for similar legislation addressing other materials, should be resolved before pushing ahead. In the meantime, a number of major German companies have proposed collection and processing of used computers, appliances, and electronic goods.

The federal government has also proposed an ordinance targeting paper, and focusing on the printing, publishing, and office paper market. The proposed ordinance would require publishers of newspapers, magazines, catalogues, and advertising supplements to recover their products. The Ordinance requires that recycling rates would rise to 52% by the end of 1994, 55% by the end of 1996, and 60% by 1997. The government is revising a proposed voluntary program developed by the paper industry.

The federal government is also contemplating an ordinance directed at the disposal of building site waste containing harmful substances. The proposed ordinance would be directed at guaranteeing the separate disposal of demolition debris. Table 2.4-7 delineates the proposed recycling targets.

TABLE 2.4-7
CONSTRUCTION AND DEMOLITION DEBRIS RECYCLING TARGETS

MATERIAL	RECENT PERCENT RECYCLED	FUTURE PERCENT RECYCLED	CURRENT ESTIMATED ANNUAL TONNES
Building Rubble	16	60%	23,000,000
Building Site Waste	-	40%	10,000,000
Excavated Soil	32	70%	168,000,000
Road Construction Rubble	55	90%	20,000,000

3. NATIONAL WASTE GENERATION, REUSE/RECYCLING, TREATMENT, AND DISPOSAL STATISTICS

Germany generates an estimated 40 million tons per year of household and commercial waste, 200 million tons of construction waste, and 50 million tons of sewage sludge. In the past, landfilling has been the predominant method of disposal. Germany faces a severe shortfall in landfill capacity, however, since new sites are increasingly difficult to find and the number of existing sites is decreasing. Landfills for household waste, for example, have decreased from 4,000 in 1975 to approximately 300 in 1991. One result of this shrinking disposal capacity is that Germany has recently exported over 1 million tons of waste annually, according to the Ministry for the Environment. This has been the source of some concern for Germany's neighbors. Last year, for example, France imposed a moratorium on accepting wastes from Germany.

Germany currently has 50 household waste incinerators (49 in the former West Germany, one in the former GDR) and 39 hazardous waste incinerators, most of them run by private industry to handle in-house wastes.

The following sections detail the generation, reuse/recycling, treatment, and disposal of waste in Germany.

3.1 MUNICIPAL SOLID WASTE GENERATION, COLLECTION, AND TREATMENT

3.1.1 Waste Generation

Germany has in place a fairly sophisticated and extensive program to gather environmental data, including data on the amounts of waste generated. Data are collected on household waste; commercial waste which is similar to household waste; market waste; street sweepings which are delivered to public waste disposal facilities; and production residues, both solid and liquid. The data are based on information provided to the federal government from public authorities and private industry, as required by the environmental statistics legislation. In the case of information related to various recycling activities, this information is augmented by data provided by various industrial associations.

In its *Facts and Figures on the Environment*, however, Germany's Environmental Protection Agency notes that verified data on the total amount of waste produced in Germany is not available. Part of the difficulty is that data on the various portions of the waste stream are often based on different criteria and may in fact overlap. In addition, it is difficult at present to establish with certainty the total amount of waste which is diverted from the waste stream for reuse and/or recycling. While much of the waste collected separately by waste disposal authorities is included in the statistical data furnished to the government, information on the amounts collected by charitable organizations, for example, is generally unavailable.

Trade associations dealing with recovered materials have historically provided additional data on the volume of such materials utilized. This is aggregate data, however, which does not differentiate between public and private sector collection and can thus include materials reported elsewhere as part of the public waste system. It is expected that the available data on recovered materials will improve as a natural offshoot of the DSD program (see Section 3.2), which is required to demonstrate its compliance with mandated recovery targets.

The following data is taken from *Facts and Figures on the Environment*, 1988/1989.

3.1.1.1 Household Waste

Because almost all producers of household waste, commercial waste similar to household waste, and bulky waste are integrated into the public-disposal networks, the statistics available on these wastes represent a reasonable estimate of the amounts delivered for disposal/treatment. The only exception relates to reusable materials which are separately collected by the producer.

In 1987, approximately 23 million tons of household wastes, commercial wastes similar to household wastes, and bulky wastes were delivered to public waste disposal facilities. This translates into approximately 375 kg per capita per year. Figure 3.1-1 delineates the amount of such wastes collected from 1977 through 1990. Figure 3.1-2 details the per capita rates for household waste for the same years.

Figures 3.1-3 details the amount of waste produced by the manufacturing, construction, mining, and electrical generating industries and hospitals over the period 1977 through 1987, by sector. The largest category of waste is building rubble/excavated earth. Figure 3.1-4 details the tons generated by the hospital, mining industry and electricity generating industry separately. As a result of new measures to reduce emissions in the combustion process, ashes, slag, and soot from incineration increased the amount of wastes produced in the electricity, gas, district heating, and water supply sector by almost 18% from 1982 to 1984, and an additional 5.5% from 1984 to 1987.

3.1.1.2 Reuse of Waste

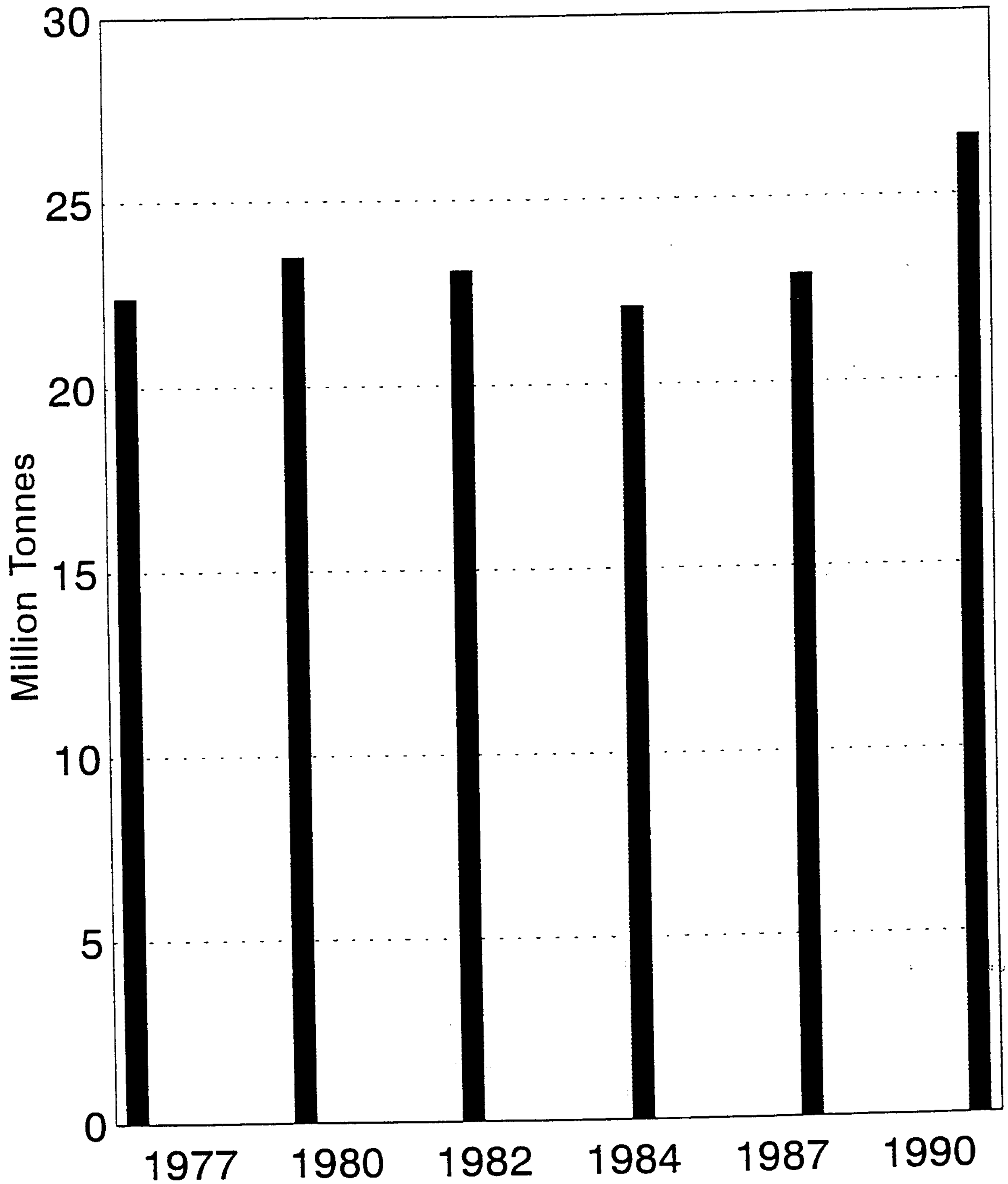
In accordance with the Environmental Statistics Act, the government periodically surveys the private sector's waste management practices. The most recent data, from a study conducted in 1987, indicates that 43.7 million tons (21.3%) of the 206 million tons of commercially produced waste, were reintroduced into commercial circulation.

3.1.1.3 Paper Reuse/Recycling

Figure 3.1-5 delineates the amount of paper consumed in Germany and the amount of recycled paper produced, for the period 1970 through 1991. The production of recycled paper tripled during this period, to approximately 7.5 million tons. Current estimates are that over half of the paper produced in Germany is made from recycled paper, including both pre and post consumer recovered paper.

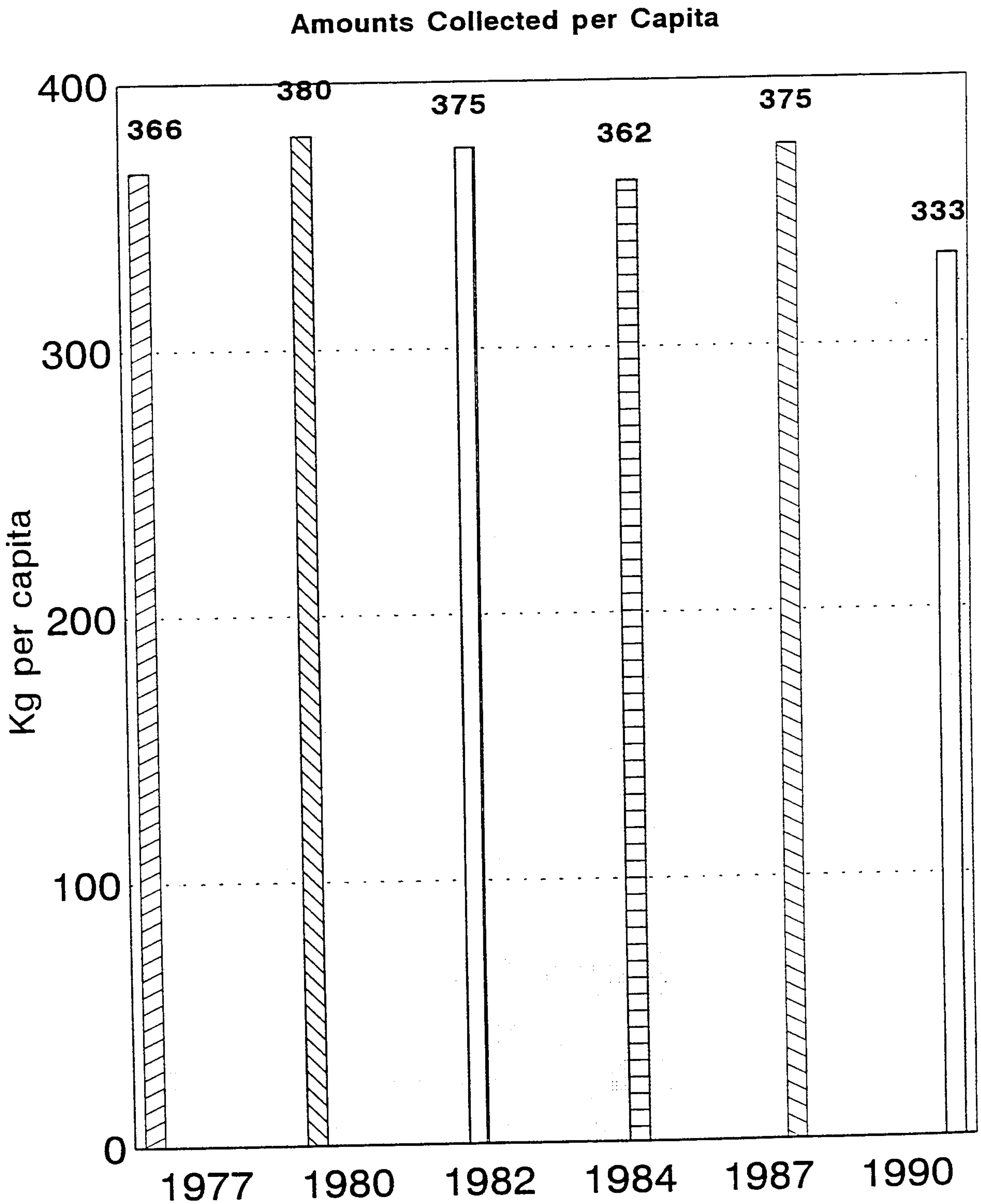
FIGURE 3.1-1
WASTE* 1977-1990

Amounts Collected



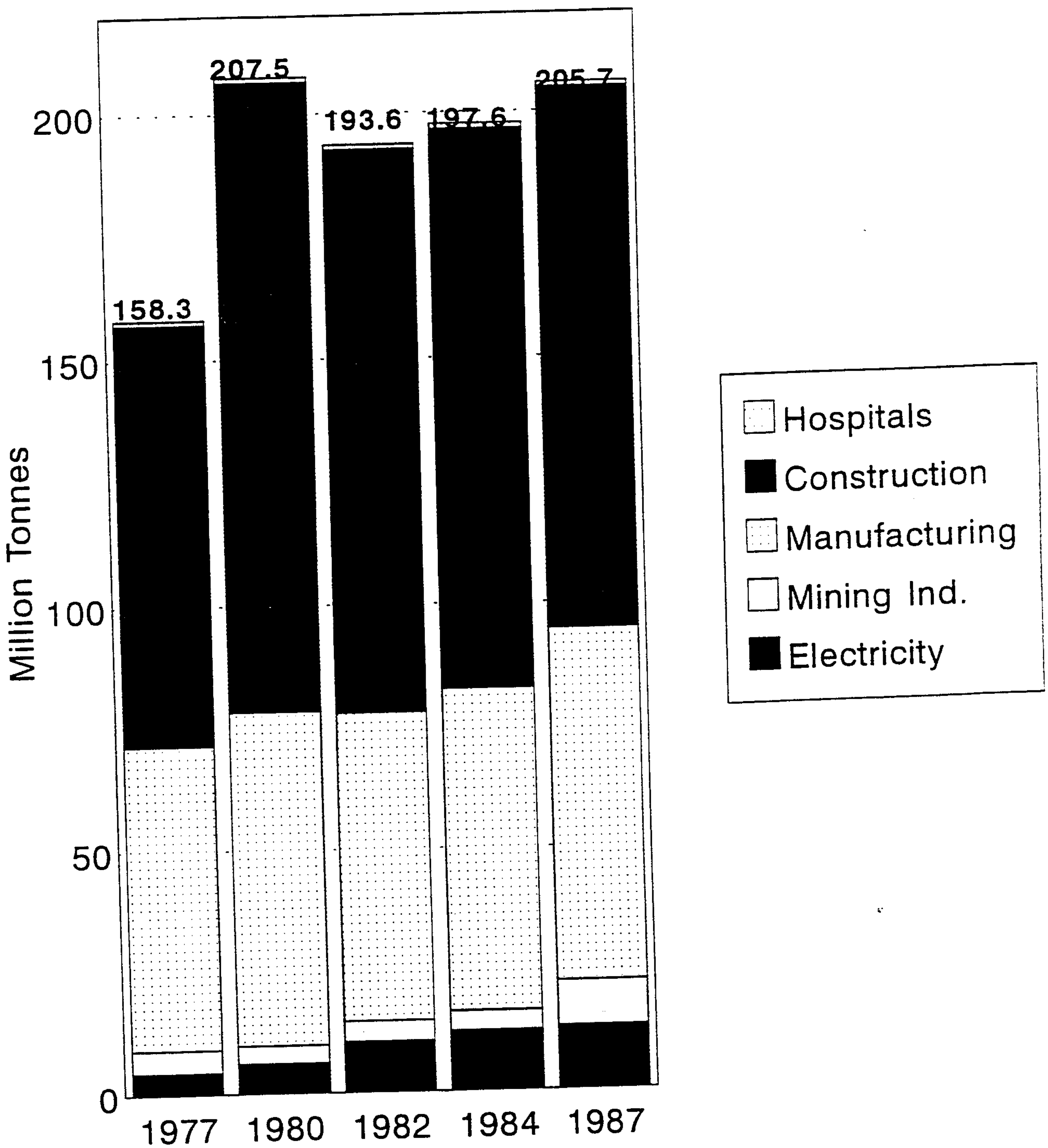
Reference: Facts and Figures (163); Grundalten (T-2); Daten zur Umwelt 1990/91 (460)
* Includes household waste, commercial waste similar to household waste, and bulky waste.

FIGURE 3.1-2
HOUSEHOLD WASTE 1977-1990



Reference: Facts and Figures (163); Grundalten (T-2); Daten zur Umwelt 1990/91 (460)

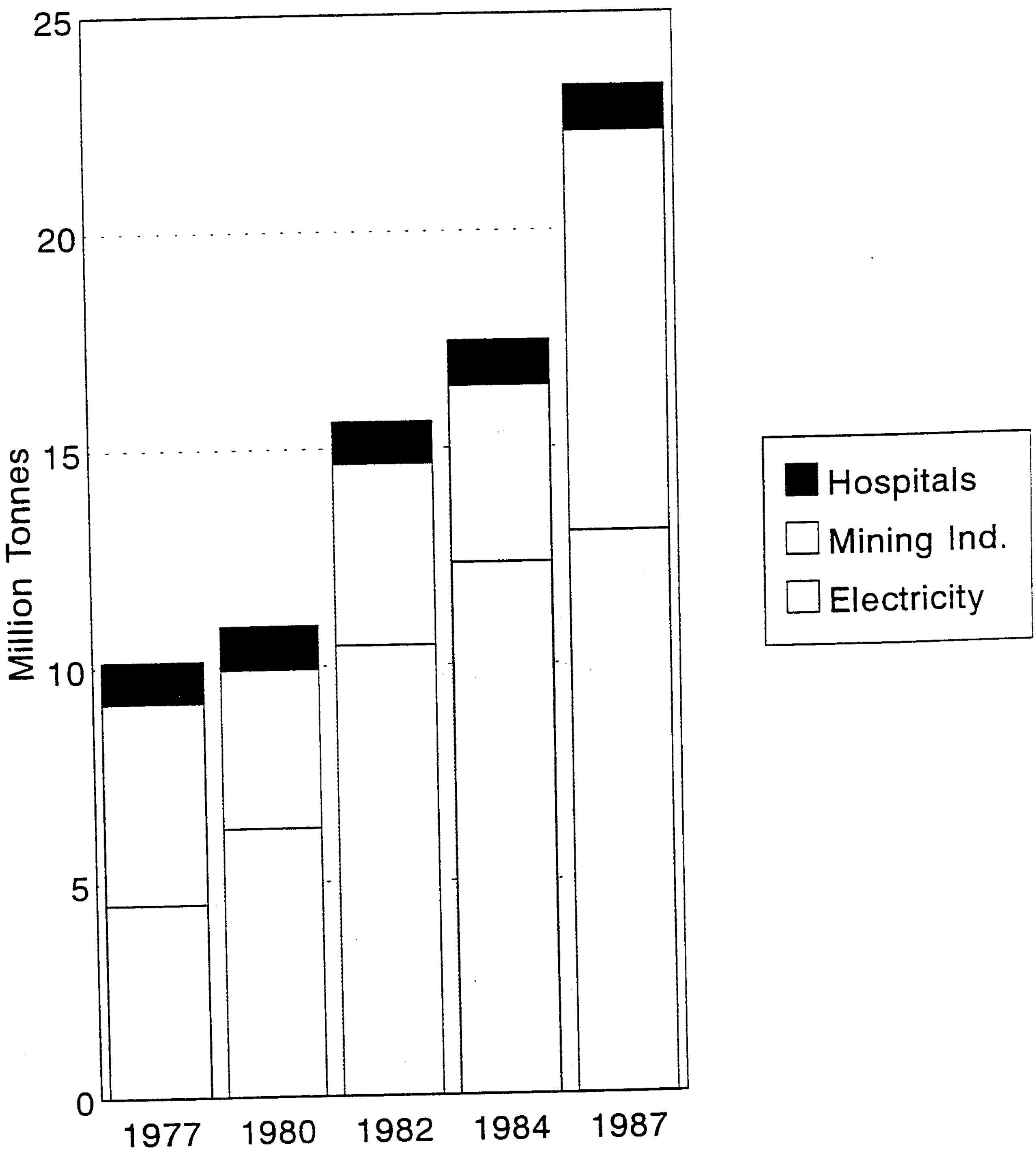
FIGURE 3.1-3 - SOURCES OF MANUFACTURING WASTE
1977 - 1987



Reference: Facts and Figures (165)

FIGURE 3.1-4 - SOURCES OF MANUFACTURING WASTE
1977 - 1987

SECTORS GENERATING LESS THAN 15 MILLION TONNES PER YEAR



Reference: Facts and Figures (165)

3.1.1.4 One-Way and Returnable Packaging

Between 1970 and 1981, returnable packaging for drinks fell from 90% to 74%. The current level is estimated at 74.6%. In accordance with the Packaging Ordinance, this level must remain at or above 76%, or additional deposit and packaging regulations will be implemented. Ninety-two percent of the mineral water in Germany, 84% of the beer, and 76% of the carbonated beverages are sold in refillable bottles. Wine and fruit juices are at 40 and 37%, respectively.

Drinks packaging is not standardized. A survey conducted by Otto Reichelt AG in their 100 stores identified five different bottles for water and soft drinks and 11 different types for beer. According to the German Retailers Institute, beer comes in 204 different types of returnable cases, water and soft drinks in 42, and fruit juice 21. Efforts to expand the use of returnable packaging include the formation of the Foundation for Returnable Packaging Initiatives, which is directed at standardizing and promoting the use of returnable packaging systems throughout Europe. A study performed for the Ministry of the Environment, however, indicates that there is no simple answer to the question of single use versus multiple use. According to this study, when all of the environmental and economic costs associated with single-use versus multi-use packaging are considered, the choice depends upon a number of situation-specific items, including the distance to the processing facility and the weight of the container.

The total amount of glass consumed in Germany is detailed in Figure 3.1-6, as well as the amount of recycled glass. Figure 3.1-7 details the percentage of glass manufactured from recycled glass, as a percent of German-produced glass and a percent of total glass sold in Germany (which includes imported glass). These figures clearly indicate a dramatic increase in the use of recycled glass as a result of Germany's waste management effort over the past decade.

3.1.2 <u>Waste Disposal</u>

3.1.2.1 Disposal of Wastes in Public Facilities

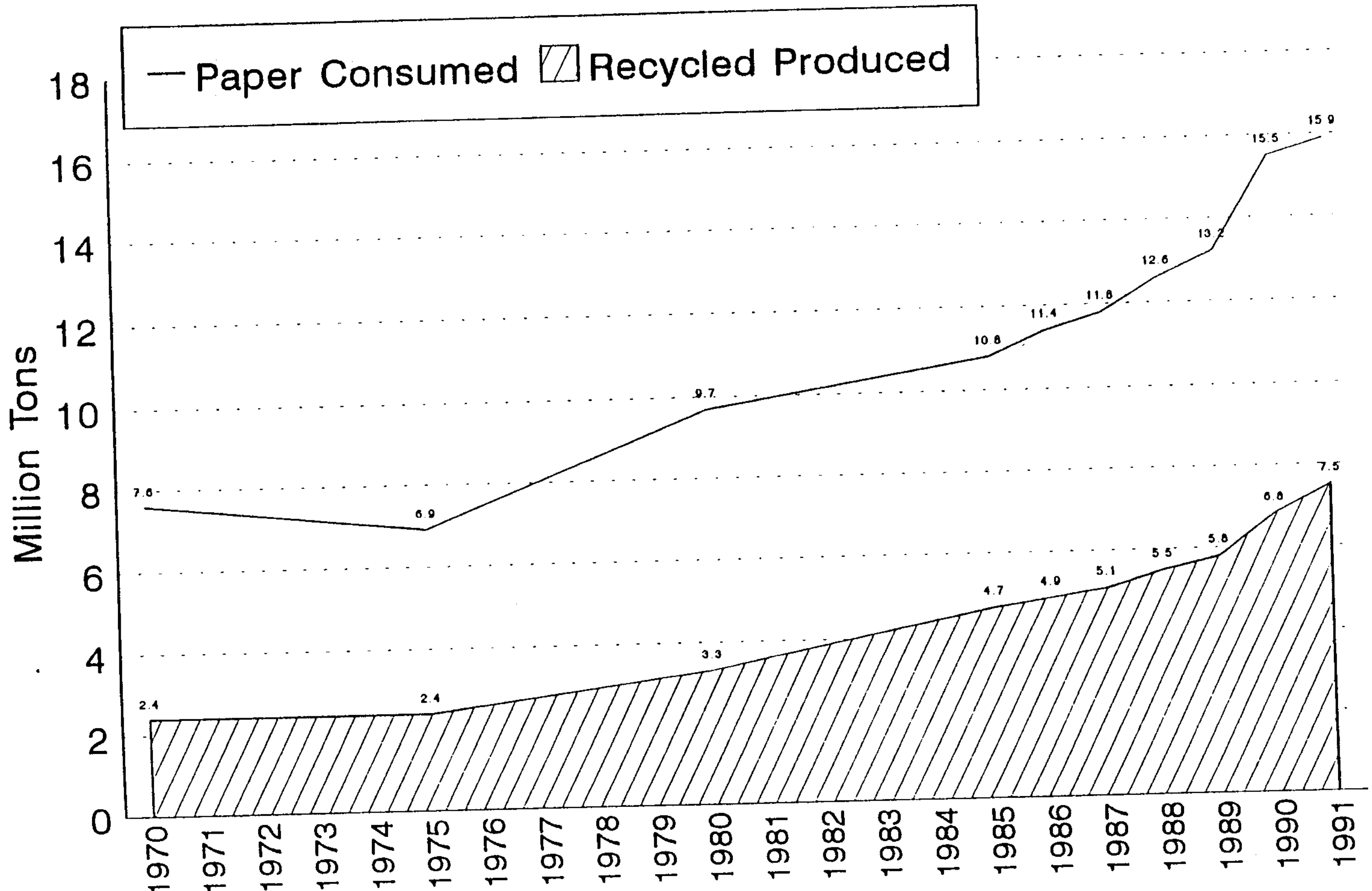
Public facilities are those operated by local authorities, towns, or third-parties commissioned by such bodies. These include treatment plants (waste incineration plants, composting plants, chemical/physical treatment plants, neutralization and detoxification plants, and emulsion separators) and landfill facilities for the disposal of wastes that cannot be processed further.

3.1.2.2 Waste Management Facilities

Table 3.1-1 details the number of waste management facilities by category. The figures for West Germany reflect the ongoing effort to implement an integrated waste management program. As already discussed, the number of landfills for household waste is decreasing. The number of composting facilities has increased over 300%, reflecting the increase in composting efforts directed at garden, leaf, and organic waste.

FIGURE 3.1-5 - RECYCLED MATERIALS (PAPER)

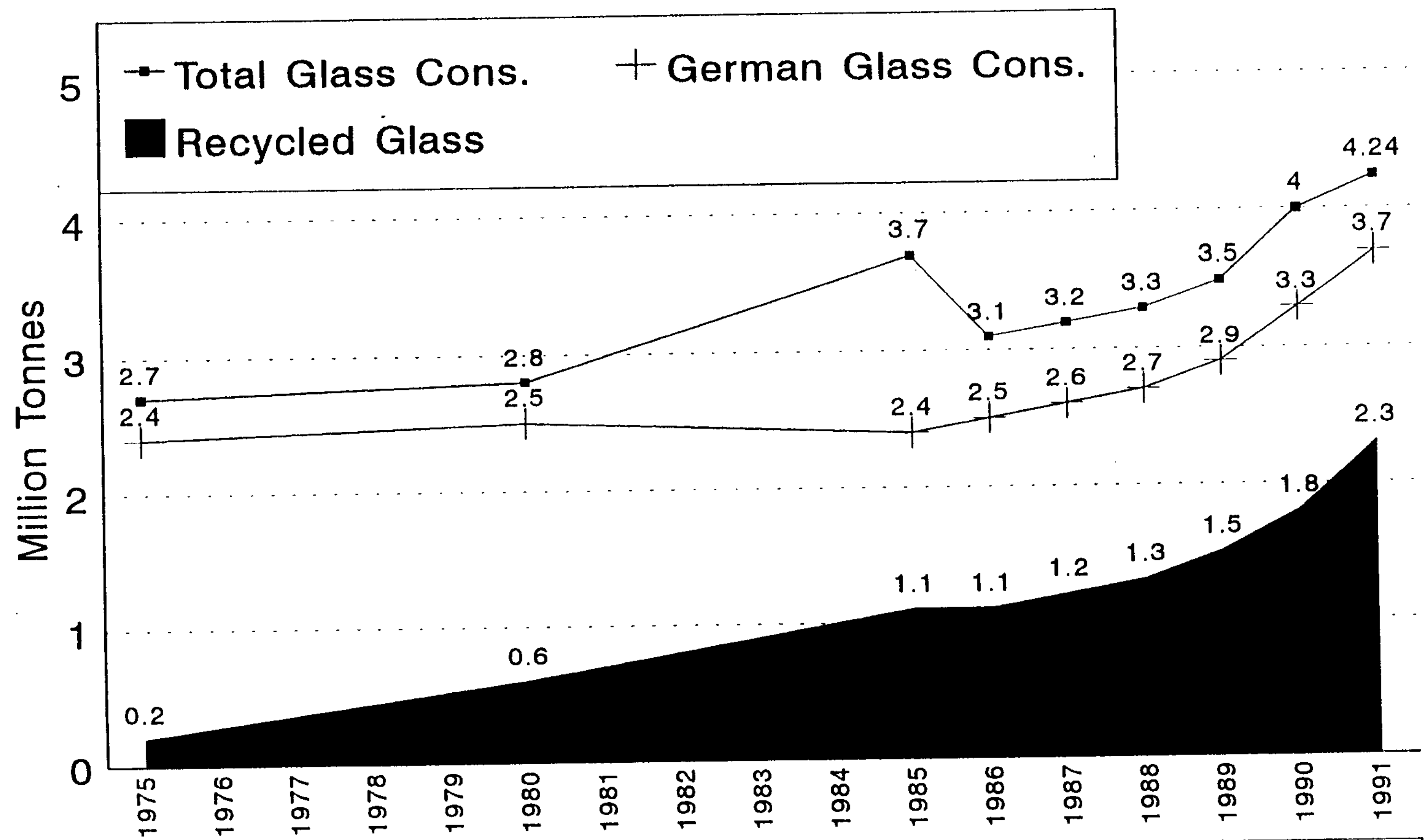
1970 - 1991



	1970	1975	1980	1985	1986	1987	1988	1989	1990	1991
Recycled Produced	2.4	2.4	3.3	4.7	4.9	5.1	5.5	5.8	6.8	7.5
Paper Consumed	7.6	6.9	9.7	10.8	11.4	11.8	12.6	13.2	15.5	15.9

Reference: Grunddaten (T-13)

FIGURE 3.1-6 - RECYCLED MATERIALS (GLASS)
1970 - 1991

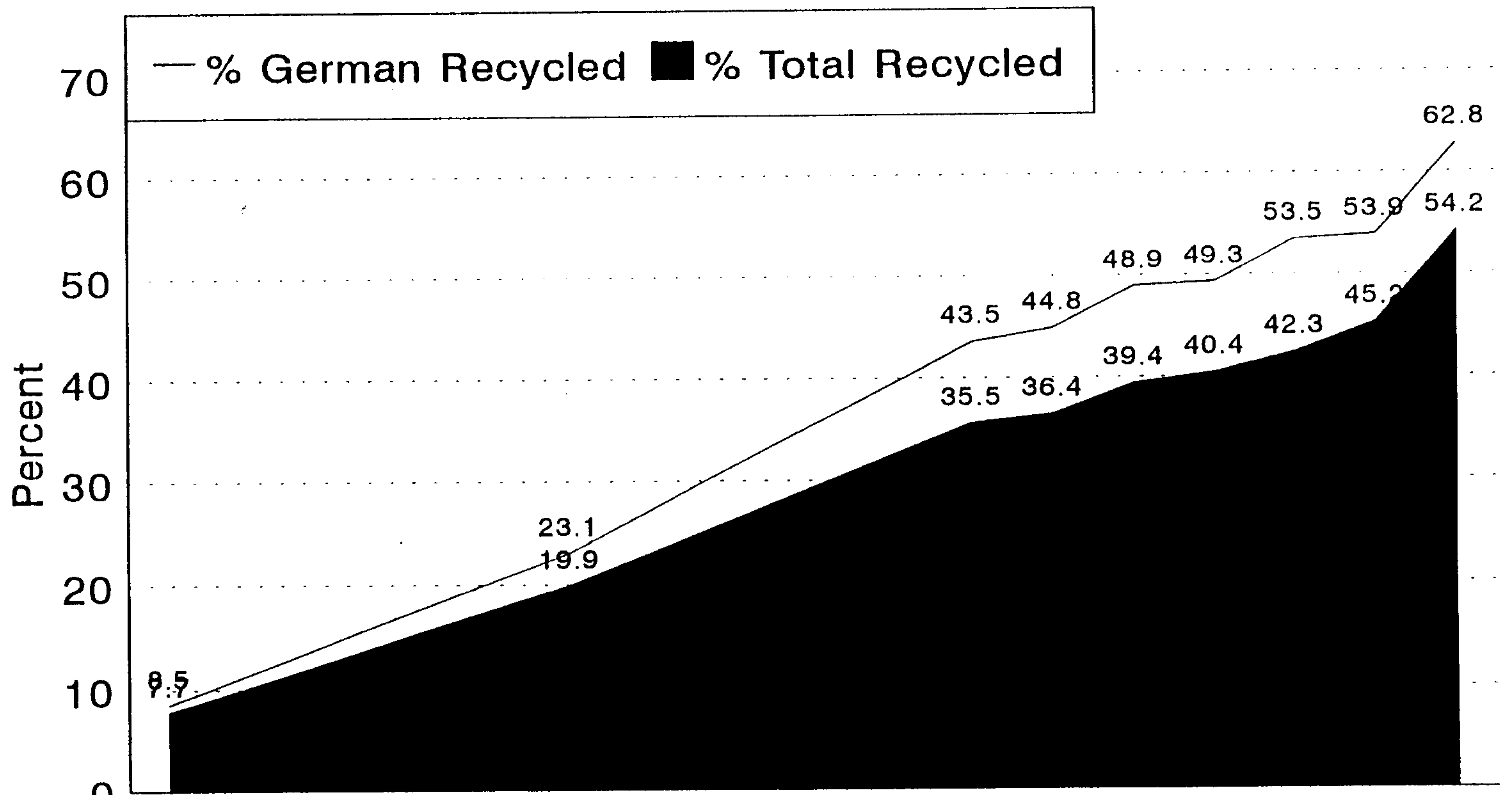


	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
% Total Recycled	7.7					19.9					35.5	36.4	39.4	40.4	42.3	45.2	
Recycled Glass	0.2					0.6					1.1	1.1	1.2	1.3	1.5	1.8	2.3
% German Recycled	8.5					23.1					43.5	44.8	48.9	49.3	53.5	53.9	62.8
German Glass Cons.	2.4					2.5					2.4	2.5	2.6	2.7	2.9	3.3	3.7
Total Glass Cons.	2.7					2.8					3.7	3.1	3.2	3.3	3.5	4	4.24

Reference: Grunddaten (T-13)

FIGURE 3.1-7 - RECYCLED MATERIALS (GLASS)

1970 - 1991



	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
% Total Recycled	7.7					19.9					35.5	36.4	39.4	40.4	42.3	45.2	54.2
Recycled Glass	0.2					0.6					1.1	1.1	1.2	1.3	1.5	1.8	2.3
% German Recycled	8.5					23.1					43.5	44.8	48.9	49.3	53.5	53.9	62.8
German Glass Cons.	2.4					2.5					2.4	2.5	2.6	2.7	2.9	3.3	3.7
Total Glass Cons.	2.7					2.8					3.7	3.1	3.2	3.3	3.5	4	4.24

Reference: Grunddaten (T-13)

TABLE 3.1-1
WASTE MANAGEMENT FACILITIES

CATEGORY	WESTERN GERMANY 1987	WESTERN GERMANY 1990	GERMANY 1990 TOTAL
Household Waste Landfills	332	290	2,620
Construction & Demolition Debris Landfills	2,458	2,128	3,013
Excavated Soil Landfill	255	415	441
Special Waste Landfills	37	41	800
MSW Thermal Treatment Facilities	47	47	47
Composting Facilities	60	218	231
Hazardous Waste Treatment Facilities	31	90	99
Transfer Stations	157	172	178

The number of household waste landfills in the GDR totalled over 2,300 in 1900. This reflects the fact that landfills were the preferred method of waste management in East Germany. These sites generally do not meet current standards and will be phased out as part of the process of bringing environmental practices in the former GDR into compliance.

Table 3.1-2 delineates the total number of household waste combustion facilities by Lander. Over 95% of these facilities recover energy. Approximately 28% of the German population is currently served by waste management systems incorporating waste-to-energy. This percentage will undoubtedly increase as the Landers come into compliance with the requirements of TA Siedlungsabfall.

Table 3.1-3 details the number of landfills by category in 1987 and 1990, and provides an estimate of the remaining useful lives of the facilities in western Germany as of 1987. These estimates suggest that the capacity of the existing landfills will decline significantly over the next 20 years. This decrease in capacity, coupled with the difficulty of siting new landfill facilities in an increasing urbanized society, and an environmental program aimed at eliminating the disposal of unsorted, untreated waste, makes it clear that Germany will require significant new waste treatment capacity over the next two decades. (As mentioned earlier, it is estimated that some 90 new household waste incinerators will need to be built by the year 2005.)

The total amount of waste delivered to public plants in 1987 was 102.3 million tons. Over half of that amount (57.5%) consisted of building rubble, rubble from road works, and excavated earth. Household waste, bulky wastes, street sweepings, and market wastes totaled 31.0 million tons in 1987, the second largest category of waste disposed of in public facilities.

Of the total 102.3 million tons, 88.9% (approximately 89.2 million tons) was disposed of in landfills. Approximately 9 million tons, 8.4% of the total, was processed at WTE facilities. This 9 million tons represented approximately 20% of the household waste processed.

Disposal of Waste from Manufacturing Industry and Hospitals

Unrecycled waste from industrial plants and hospitals is disposed of in on-site facilities, off-site private facilities, or public waste facilities. Figure 3.1-8 details waste disposal in the manufacturing sector for 1980-1987, by treatment/disposal mechanism (including waste materials delivered to third parties dealing in used materials or for further commercial processing). As shown in Figure 3.1-8, landfilling has been the predominant method of waste management in Germany for many years. What is changing, and will continue to change, is the role of landfills in the country's waste management system. In the past, significant quantities of untreated waste were deposited in landfills. As the Landers come into compliance with TA Siedlungsabfall, landfills will continue to be a component in the waste management system, but only as the final depository for residual materials from other treatment processes.

In 1987, 21.3% of the waste materials from this sector of the economy was delivered to commercial facilities for further processing; 17.4% was disposed of in on-site incineration facilities or landfills; and 61.3% was disposed of either in public facilities or other commercial plants.

Under German law, hazardous waste materials are subject to special requirements. These requirements include registration, and where necessary, special treatment and disposal at specially equipped facilities. In 1987, a total of 2.7 million tons of such materials were treated and disposed of. Of this total, 1.99 million were treated off-site for disposal; 0.335 million tons were disposed of in on-site hazardous waste incinerators or landfills; and 0.4 million tons were forwarded for further processing for reuse.

In years past, a significant amount of waste, including hazardous waste, was shipped out of West Germany, most of it to East Germany. In 1988, for example, over one million tons of hazardous wastes and other wastes and over two million tons of household waste were exported. (Of this total 3.2 million tons, 2.1 million went to the German Democratic Republic.) As a result of actions by some of Germany's neighbors and, in particular, the Basel Convention on the Transboundary Movement of Hazardous Wastes, these export totals should drop significantly.

3.1.3 Waste Composition

The federal government commissioned the Technical University of Berlin to conduct an analysis of household waste produced in private households in 1979/1980 and again in 1983/1985. Figure 3.1-9 presents the results of that analysis for 1983/1985.

TABLE 3.1-2
STATUS OF HOUSEHOLD WASTE INCINERATION FACILITIES

LANDER	NO. OF FACILITIES	THEORETICAL CAPACITY (Tonnes/Year) (000)	POPULATION SERVED (000)	PERCENT TOTAL
Baden-Wurttemberg	4	690	1,220	12.8
Bavaria	16	2,076	6,070	54,6
Berlin	2	470	1,010	29.9
Brandenburg	0	0	0	0
Bremen	2	505	667	100.
Hamburg[1]	2 (+1)	330	1,284	79.7
Hessen	4	870	2,060	36.8
Mecklenburg-Vorpommern	0	0	0	0
Niedersachsen[1]	1 (+1)	110	698	9.7
Nordrhein-Westfalen	13	3,591	7,100	41.9
Rheinland-Pfalz	1	180	620	16.9
Saarland	1	114	260	24.6
Sachsen	0	0	0	0
Sachsen-Anhalt	0	0	0	0
Schleswig-Holstein	4	553	1,081	42.0
Thuringen	0	0	0	0
TOTAL	50	9,489	22,070	28.1

[1]Under consideration.

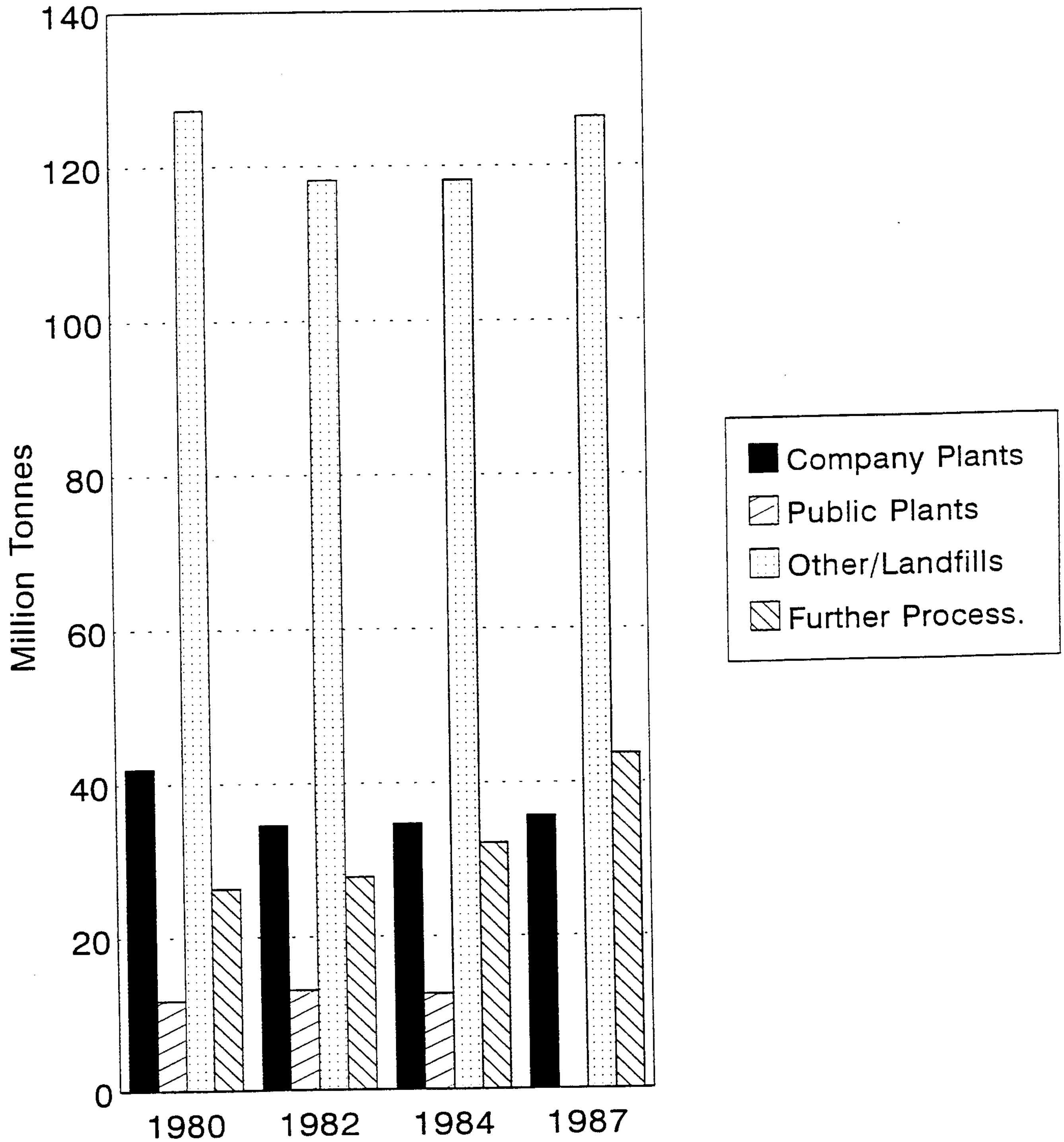
Source: Umweltbundesamt

TABLE 3.1-3
STATUS OF LANDFILLS IN GERMANY

CATEGORY	TOTAL NUMBER OF FACILITIES			REMAINING CAPACITY ESTIMATES: 1987 (YEARS)				
	1987	1990 (Western Germany)	1990 (Germany)	< 1	3 to 6	6 to 11	11 to 21	21+
Household Waste	332	290	2,620	99	80	63	56	34
Construction and Demolition Debris	2,458	2,128	3,013	655	578	635	449	141
Excavated Soil	255	415	441	98	62	61	24	10
Hazardous Waste	37	47	77	11	8	9	8	1

FIGURE 3.1-8 - MANUFACTURING WASTE DISPOSAL TOTALS

1980 - 1987



Reference: Facts and Figures (177)

3.2 PRIVATE SECTOR RECYCLING

Duales System Deutschland is the largest private sector program dealing with materials recycling in Germany. A privately held company established in 1991, DSD came into being in direct response to the Packaging Ordinance. As described previously, the Ordinance requires, among its various provisions, that manufacturers and retailers take back used sales packaging—unless they are part of an approved system that guarantees regular collection from the final consumer. Such a system must also meet a variety of other criteria, including guarantees related to the processing of the recovered materials and their return to the production cycle. Thus, a key aspect of the Duales System is its ongoing ability to process and market the packaging materials it collects. For most materials, specific trade organizations have provided blanket guarantees to the Duales System regarding their willingness to accept and process some particular material collected by the Duales program. Such guarantees have been provided for each of the materials shown in Figure 3.2-1 by the organization indicated.

The anticipated schedule for country-wide implementation of Duales System Deutschland is shown in Figure 3.2-2.

Since its inception in 1991, there has been ongoing debate regarding the efficiency and cost-effectiveness of the Duales system. At best, the program can be described as an ongoing experiment. Clearly, the jumpstarting of a 3 billion DM organization to collect, sort, and deliver millions of tons of material to various processors and end markets over an 18-month period represented a significant logistical undertaking. Start-up problems were to be expected, and the system has been subject to a number of changes since its inception.

The most serious problem was a severe cash crisis in the first two years of operation. The crisis has been attributed primarily to the German population's contributing significantly greater than expected amounts of material to the system. The problem was especially acute with respect to plastics. VGK, the company which had guaranteed DSD processing and marketing services for plastics, had planned to handle 110,000 tons of material during 1992. In fact, over 440,000 tons were collected. The extra, unanticipated costs placed a drain on system resources. In addition, DSD's fee structure proved inadequate to fund the cost of handling the unexpected volume of material. This problem was exacerbated by the fact that fees were actually paid on only 60% of the materials collected. Thus, the Duales System was confronted with the dual problem of expenditures exceeding the estimated amount budgeted and a revenue shortfall.

The result, in the spring and fall of 1993, was near bankruptcy for the entire operation. Only through extensive negotiations with the involved parties (the retailers, haulers, municipalities, and materials markets) was a fiscal catastrophe averted. The negotiations resulted in several significant changes to the system. First, DSD's outstanding payment obligations to its haulers and processors (estimated at some DM 860 million, including upwards of DM 80 million to municipal authorities) were converted from operating expenses into long-term loans and reportedly, in some cases, into equity, thus reducing the immediate cash-flow drain. Packaging manufacturers and retail firms also agreed to provide up to DM 120 million in loans and to pay DM 95 million as advance license fees. In addition, fillers and producers are now required to provide substantiation to the retailers that they have in fact made the required payments to the Duales system for products delivered to the stores. Failure by the fillers and distributors to do so can lead to the retailer's withholding up to 2.5% of the amount to be paid to the fillers and/or distributors for the products, and forwarding that amount directly to the DSD. Another measure put in place to strengthen the Duales program will be increased pressure on the companies providing collection and processing services to exercise more effective cost control.

The above measures, in conjunction with increased revenues from a new fee system based on weight and material, should help ensure the program's long-term viability. The revised fee system is intended to modify the prior volume-based system by incorporating higher fees for heavier and more difficult to recycle materials, thus creating a greater economic incentive to reduce the amount of material used and to find more easily recycled substitute materials. The new fee system ranges from DM 0.16 ($0.10) per kilogram for glass to DM 2.61 ($1.64) per kilogram for plastics. Laminates will pay DM 1.66 ($1.05) per kilogram. Aluminum costs DM 1 ($0.63), while steel costs DM 0.5 ($0.31). The setting of the fees is based on covering the costs of collecting, and in the case of paper, steel, aluminum, plastic, and laminates, also the cost of sorting. In the case of plastics, the fee also includes the cost of processing, storage, and recycling. As reported in *IER* (April 7, 1993), the new fee structure is especially crucial as a vehicle for expanding the limited infrastructure now in place for processing plastics. (It is clear that the fee structure revision significantly impacts plastic packaging. The fee for a 1 liter bottle of fabric softener, for example, is eight times what it was under the prior fee system.)

Another change to result from DSD's early cash-flow problem was the creation of a new organization to take over plastics processing from VGK, the original guarantor. Created by plastics manufacturers, the collection companies, the energy companies, and Duales itself, the new company—DKR—was capitalized with an initial investment of DM 50 million ($31.5 million). DKR is expected to have in place by 1995 or 1996 sufficient recycling and processing capacity for over 800,000 tons of plastic.

As described earlier, one of the goals of the Packaging Ordinance is to cause fillers and packagers to reduce the amount of unnecessary packaging utilized in bringing a package to market. DSD, in conjunction with the University of Dortmund and the Institute für Empirische Psychologie, performed a study in 1992 directed at determining: (1) changes and measures in the packaging sector associated with the Packaging Ordinance and directed at standardizing the types of materials used in packaging; the material savings; weight reduction; and other factors; (2) future plans to optimize packaging; and (3) examples of ecologically optimized packaging. The study was based upon a questionnaire sent to 8,689 companies holding a license to use the "Green Point" on their packaging, and thus be part of the Duales System. Responses were received from 1,062 organizations, representing annual volume of about 21.1 billion sales packages, out of an estimated 100-120 billion packages used each year in Germany.

As reported, the efforts under way include changes in materials, the use of refill packaging, and outright reduction or elimination of packaging. According to the companies responding to the survey, the use of returnable packaging in the beverage sector has increased over the past few years. A study by the GVM for the Arbeitsgemeinschaft Verpackung und Umwelt indicated that the percentage of returnable packaging in the beverage sector grew from 72.6% in 1991 to 74.61% during the first half of 1992. Twenty-two percent of the companies surveyed reported that they used returnable packaging and 12% plan to increase the amount of returnable packaging used.

FIGURE 3.1-9 - COMPOSITION OF HOUSEHOLD WASTE

Percentage by Weight - 1985

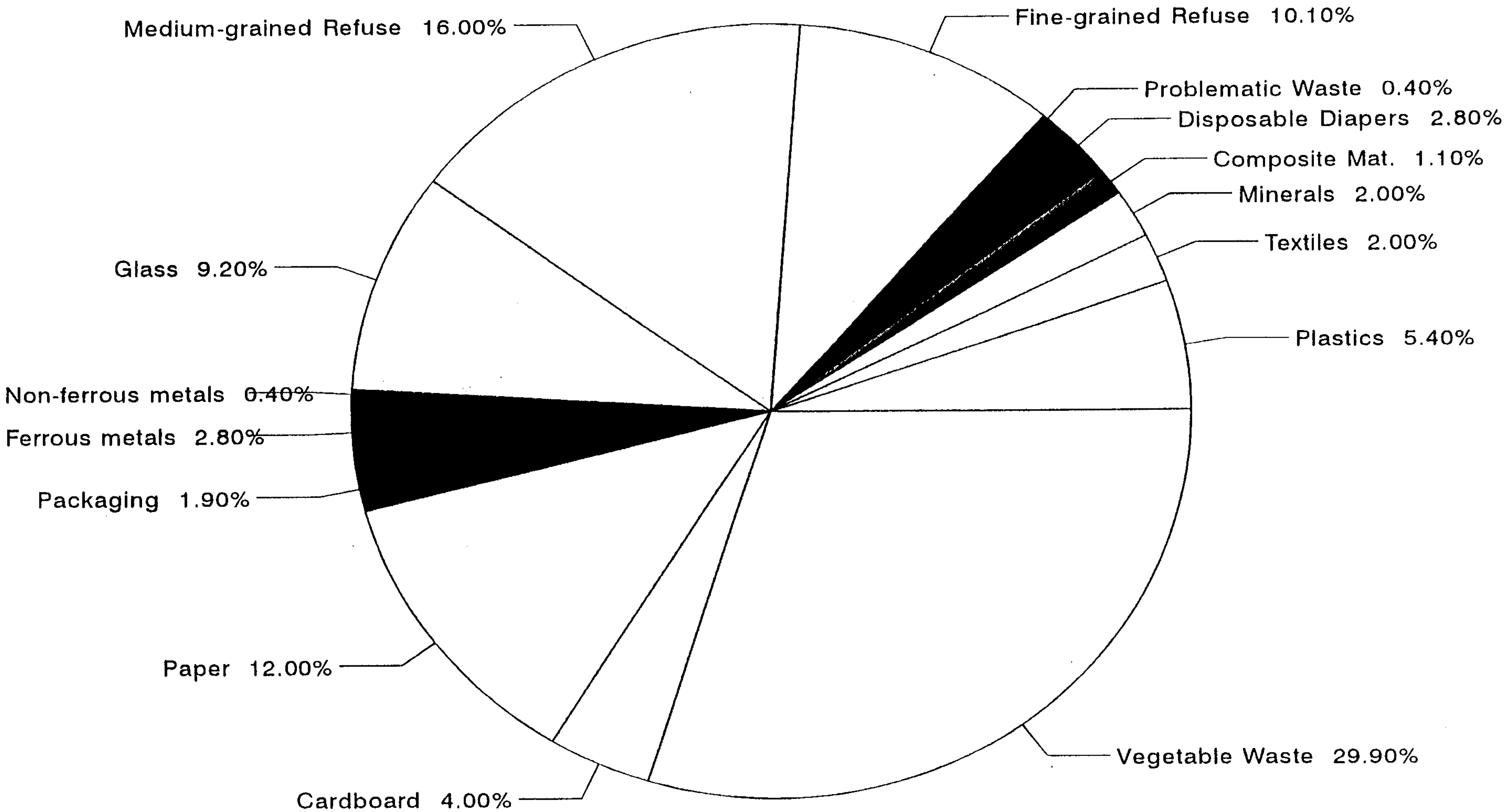


FIGURE 3.2.1
DSD MATERIAL FLOW AND GUARANTORS

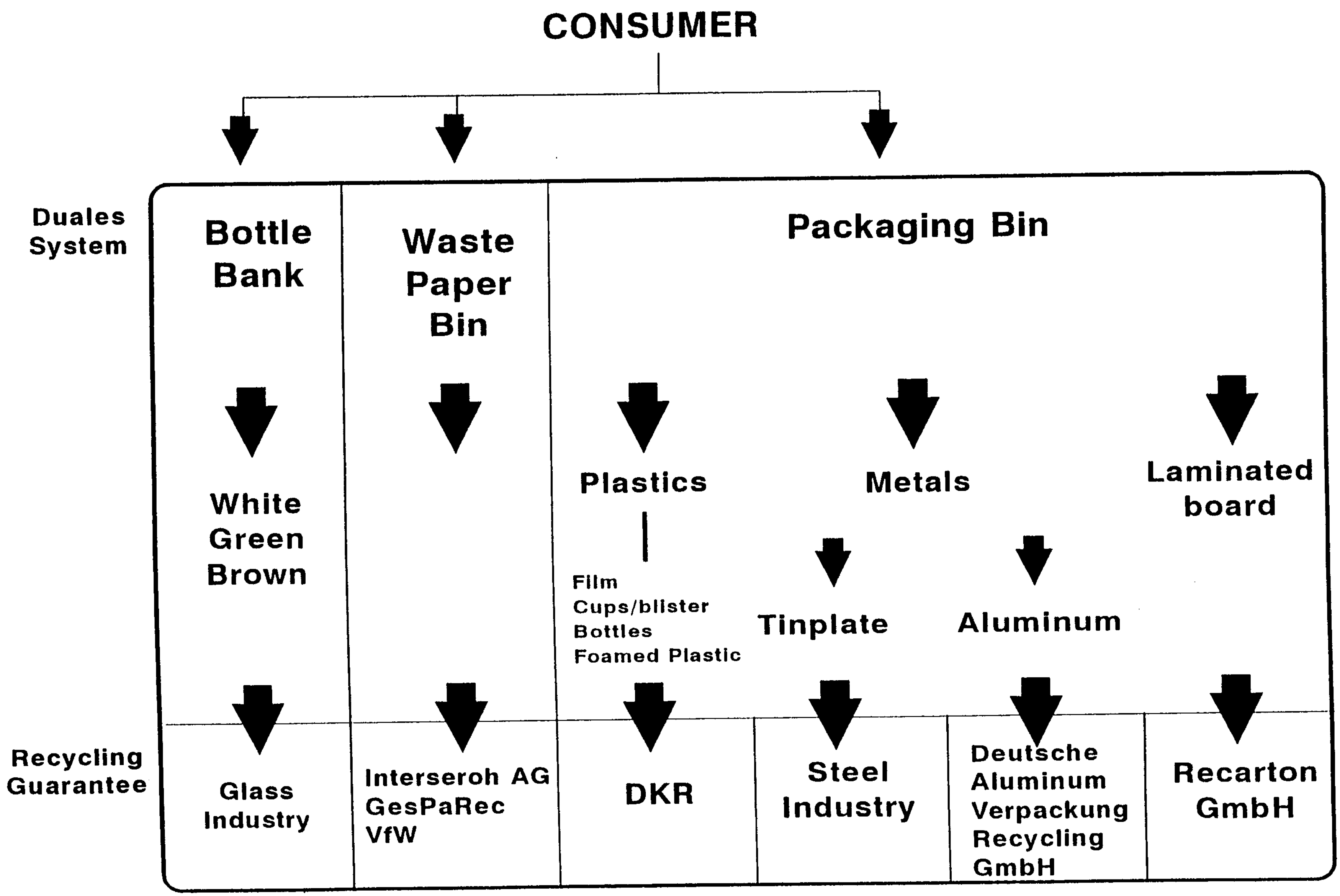
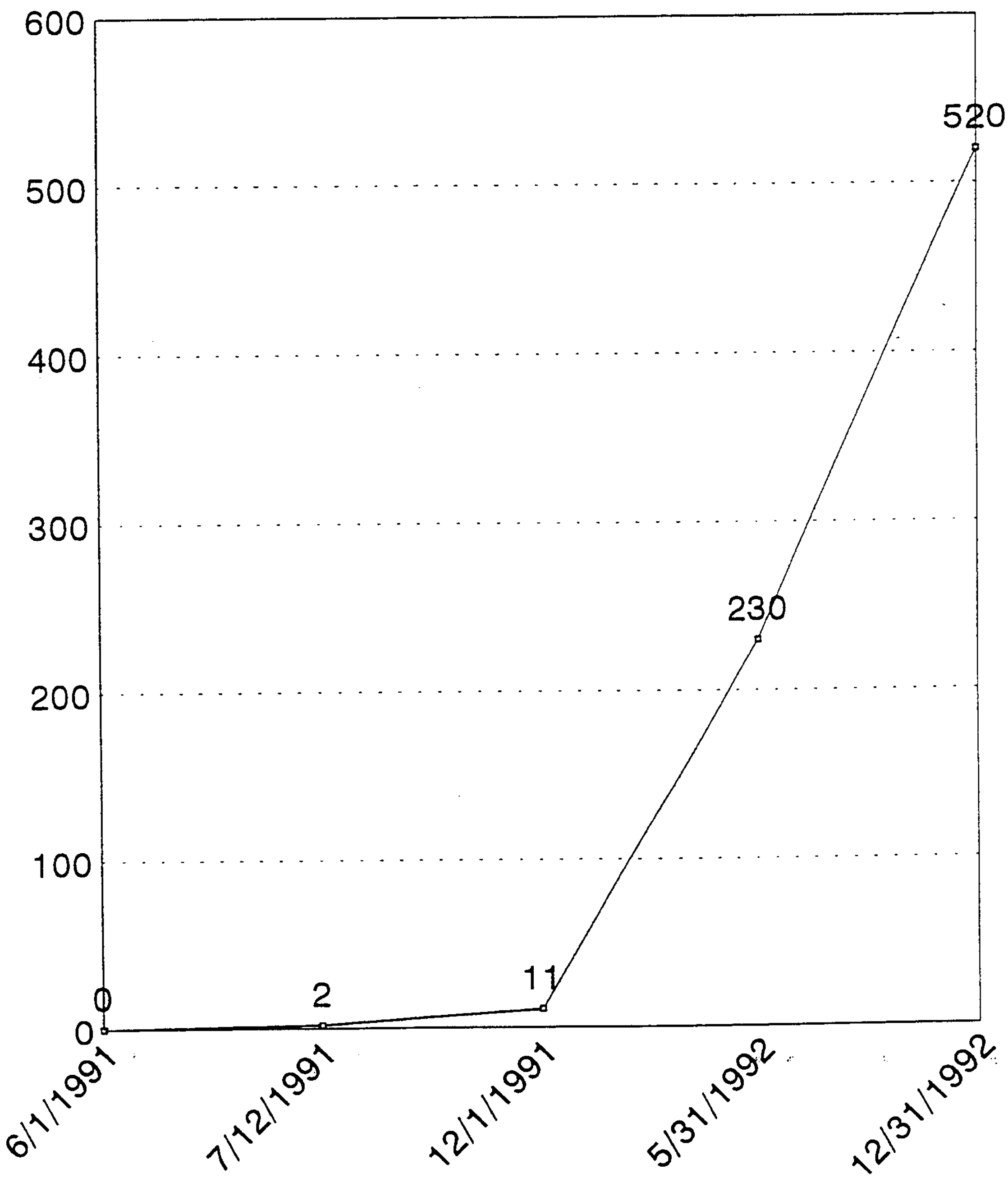


FIGURE 3.2-2
DEVELOPMENT OF REGIONS CONNECTED TO THE SYSTEM



Reference: DSD (13)

According to a market research study commissioned by the Ministry of the Environment, packaging dropped by 3.1% in 1992, down to 13.1 million tons, and to 11.8 million tons in 1993.

The survey also addressed the use of materials recovered from recycling as raw materials (i.e., secondary raw materials) in the production of new products and/or packaging. Twenty-five% of the companies responding increased the amount of secondary raw materials used in the production of packaging materials. One-third of the companies surveyed plan to increase the percentage of secondary raw materials used for packaging purposes.

The survey results point to a reduction in the amount of plastics used in all packaging, but an increase in paper and glass, based upon a sampling of 506 selected examples of packaging in which one material was replaced by another over the 1990-1992 period. The study also indicated a tendency to increased utilization of PE and PP, and a reduction in the use of PVC.

The companies surveyed indicated that they intend to continue optimizing their packaging effort and that the activities associated with that effort will include reduction of material, elimination of packaging, simplification of material composition, replacement of composite packaging, and replacement of blister packaging, among others.

The results of the study appear to support the contention that the Packaging Ordinance has resulted in:

1. The acceptance by the licensees of the Green Point of the principle of increased use of secondary raw materials.

2. Reduction in the number of various materials used for packaging.

3. Standardization of material usage.

3.2.1 Implementation Issues

One of the major issues raised during the development of the Duales program was that of a private system's impact on public waste management systems. The issue was partly addressed through the legislative requirement that the Duales System work in harmony with existing public collection and processing operations, such cooperation to include compensation to the public system.

Among the elements of the Duales System which concerned the federal cartel office was DSD's decision to expand into industrial and commercial waste. The issue here was the possible chilling effect on competition that would result from the expansion of DSD from just household collection to industrial and commercial accounts as well. DSD, for its part, maintained that this expansion was being undertaken at the request of various Landers. To resolve the issue of potential competitive advantages for DSD contract haulers, DSD agreed to reimburse all other operators, on the presumption that a portion of the materials they handle are packaging materials covered under the DSD system.

As indicated earlier, there is not sufficient capacity currently available to process and recycle the volume of plastic packaging actually being collected. (Current capacity is 160,000 tons; current volume is 400,000 tons.) This situation has resulted in pressure from both industry and some of the Landers to make changes in the system. In September 1993, for example, German plastics manufacturers called on the government to reduce the recycling target for 1995 from 64% to 50%. Another option under discussion was to expand the allowable uses of recovered plastics to include thermal processing (i.e., incineration with energy recovery).

Another alternative receiving a great deal of attention is the processing of plastic waste by hydrolysis. This energy-intensive process can convert plastics into a synthetic fuel similar to oil, which is then combusted in transportation, power, or thermal plants. A number of parties are opposed to this, however. In August of 1993, several local communities indicated their opposition to hydrolysis on the grounds that the amount of energy required to transport and convert the plastics outweighs the benefits. (According to *IER*, the estimated cost of oil produced by hydrolysis is DM 2,500 [$1,575] per tonne, six times that of petroleum.)

In October 1993, the head of the International Bureau for Recuperation and Recycling (BIR), Jean-Pierre Lehoux, also requested that the German government allow the incineration of wastes (plastics and paper) as a means of recovery. At issue here is the impact of Germany's exports of wastepaper and plastics to France. According to Mr. Lehoux, German materials are being delivered to French processing facilities at very low prices and sometimes even free of charge, the effect being to virtually drive French recyclers out of business.

A number of other countries have made similar claims that the Duales program has flooded their markets for recovered materials, to the detriment of their own local collection and processing efforts. Their argument is that because the costs of collection, separation, and transportation for the German materials are funded at least in part from a separate source of revenues, the fee for the Green Point, these materials can be made available to foreign processors at greatly reduced cost.

As part of new agreements reached with German municipalities in the early summer of 1993, DSD had agreed not to return excess collected plastics to the municipalities for incineration or disposal. DSD indicated that it would attempt to solve the problem by exporting and by storing some materials for up to three years until processing capacity became available. In response to the pressure from EU sources (e.g., Mr. Lehoux), DSD has subsequently agreed not to make new contracts with EU processors. In addition, the government is considering an amendment to the ordinance that would allow the processing of plastic to recover energy in those instances where amounts greater than required to meet the ordinance's quotas have been collected.

3.2.2 Cost of the Duales Program

The cost to establish the Duales System has been estimated at DM 7 billion. The cost of running the program has been estimated at upwards of DM 3 billion per year, assuming nearly 90% participation among the packagers and retailers. DSD estimates the operating costs for 1994 at DM 3.3 billion ($2.1 billion), or DM 40 ($25.60) per capita. This works out to an estimated cost per tonne of DM 675 ($430), assuming recovery of 4.8 to 5 million tons of packaging materials.

3.3 MUNICIPAL SOLID WASTE MANAGEMENT COSTS

The level of funds expended on waste collection, treatment, and disposal by the public sector and by industry has been growing in Germany. As shown in Table 3.3-1, at the national level these expenditures have grown from over DM 5.3 billion (1989) ($3.3 billion) in 1980 to over DM 8 billion ($4.9 billion) in 1989. This growth can be attributed to a number of factors, including the implementation of more stringent environmental regulations and the resulting expansion of waste collection and management programs.

TABLE 3.3-1
EXPENDITURES FOR WASTE COLLECTION, TREATMENT, AND DISPOSAL IN WESTERN GERMANY
(million DM/1989)

	1980	1985	1987	1989
Total Expenditure	5,349	6,119	7,143	8,149
Public Sector	3,985	4,185	5,043	5,721
Industry	1,364	1,934	2,100	2,428
Investment	867	955	1,557	1,956
Current Operating Expense	4,483	5,164	5,586	6,193

Source: Organization for Economic Cooperation and Development

The ability to determine the costs of the entire waste management system has been made more complex as a result of the implementation of the Duales program. Because this program is still in its implementation phase in some areas, and because the costs associated with it are distributed among a large number of organizations (i.e., collection companies, processing companies, and material reusers), it is difficult to fix the true system-wide costs. However, as described in Section 3.2, the cost of the Duales system has been estimated at upwards of 3 billion DM per year. Adding that to the existing costs of waste management is not strictly correct in that one could expect that there would be certain cost savings available associated with the removal of the packaging materials from the existing system.

4. CASE STUDIES

4.1 AUGSBURG

4.1.1 Augsburg Municipal Waste Management System

4.1.1.1 General Description

The city of Augsburg comprises an area of 147.14 km^2 in Bavaria, Germany's largest Lander or state. Bavaria also has the country's largest farming region, and is a major tourist area. Augsburg, with a population of over 260,000, is the third largest city in Bavaria and the twenty-ninth largest city in Germany. The combined population of the region, including the landkreis Augsburg and the landkreis Aichbach/Friedburg, totals approximately 600,000. While the Federal Republic's average population density is 222 inhabitants/km^2 and Bavaria's is 166/km^2, Augsburg has over 1,770 inhabitants/km^2. Augsburg's economy is based on engineering and textiles.

History of Augsburg's Integrated Waste Management System

In the early 1980s, Augsburg, and, indeed, the entire region, encountered increasing difficulty in siting and developing new landfill capacity to meet waste treatment and disposal needs. The city of Augsburg and the districts of Augsburg and Aichbach-Friedburg formed the Augsburg Waste Management Administration Union (AWMAU), a regional organization tasked with developing and implementing a regional solution to the growing waste management problems. The AWMAU contracted with a waste management engineering and consulting firm, Ingenieursozietat Abfall Professor Tabasaran und Partner, Stuttgart, to review the status of waste reduction, treatment, and disposal programs and to recommend an approach. In the mid-1980s, on the basis of several studies, the firm recommended the development and implementation of an integrated waste management program incorporating waste reduction; separation of recoverable valuable materials at curbside and at a materials recovery facility; composting of the organic fraction; thermal treatment in the form of incineration of the balance; and the processing and recovery of valuable materials from the resulting ash residues.

The study process included a review of the amounts and types of wastes generated in the region, the chemical and physical nature of the various constituents in the waste stream, and the potential uses for various materials. In reviewing alternative treatment options, the study investigated the potential utilization of compost, recyclable materials, WTE facility residues, and the markets for electricity and heat. Based on the results of these studies, the city concluded that there was a market in the region for approximately 15,000 to 20,000 tons per year of clean compost (i.e., not containing many pollutants or filler matter) for use in greening noise protection barriers, on parks, and for land reclamation of former waste dump sites. The city also concluded that a market was available for recovered materials such as glass, paper, and some plastics. In addition, the city concluded that processed slag resulting from the incineration of waste could be utilized in road building and in noise protection wall construction. As a result, the city, along with the other governmental units in the region, elected to pursue the design, construction, and operation of an integrated waste management facility in accordance with the following guidelines:

1. Assign the highest priority to environmental protection.

2. Avoid waste whenever possible.

3. Keep pollutants out of the waste and dispose of them properly.

4. Reuse waste materials as efficiently as possible.

5. Treat nonusable residual waste in an environmentally responsible manner.

6. Store the treated residual waste in an environmentally responsible manner.

4.1.1.2 Description of System Components

Waste management within the city of Augsburg is the responsibility of Referat 2, a department within the city government. Referat 2 is responsible for collection of MSW and packaging wastes and, through the AVA Abfallverwertung Augsburg Gmbh, for the processing and treatment of the municipal waste stream. The main component of Augsburg's integrated waste management program is a recently completed facility located on 17.5 acres at the city's northeast boundary in the industry and trade area, with good road access to the Stuttgart/Munich Autobahn. This facility consists of co-located, separate facilities for materials recovery, composting, waste-to-energy, and ash processing. As a result of a design modification implemented during construction, the control functions of each facility have been centralized, thus making it a truly integrated waste management facility.

The following section details the city of Augsburg's integrated waste management system, broken down into the following components: waste avoidance; collection; composting; materials processing; waste-to-energy; and landfilling.

Waste Avoidance

Augsburg's public education efforts stress waste avoidance, and a waste avoidance component is incorporated into the city's programs and materials related to waste management. For example, the city is making an active effort to enlist charitable organizations in expanding the ongoing collection of textiles for reuse. The city is also encouraging private composting of kitchen and garden waste and the expanded use of excavated material in building noise protection walls and other uses.

Collection

Augsburg's current waste collection program employs a three-container system, with a green barrel for paper, a yellow barrel for packaging materials carrying the Green Point label of the

Duales System Deutschland, and a grey barrel for the balance of the residential waste stream. A separate brown barrel for biowaste is being introduced in 1994 upon start-up of the composting facility for the organic fraction of the waste stream.

Collection of waste occurs once per week; collection of paper and DSD materials occurs once every three weeks. The city also provides drop-off locations for color-separated glass containers and paper. These drop-off materials are collected on an as-needed basis.

The more rural areas surrounding the city utilize useful-materials drop-off yards and drop-off bins for glass and paper. These communities also provide for collection of paper and the remaining fraction of the waste stream. These systems have been implemented in part in response to the recent legislation on waste disposal related to packaging in the Augsburg region. This legislation affects not only the disposal system but also the collection system.

In the implementation of the DSD system in Augsburg, the city's own waste management organization plays the collection role served in some other cities by private entities. Augsburg's system for DSD collection includes drop-off containers for paper and glass and yellow containers in each household for light packaging and sales packaging materials.

Drop-Off Sites

The city provides a number of drop-off facilities for paper and glass. In addition, textiles are also generally collected in drop-off boxes sponsored by various nonprofit agencies.

Each glass drop-off station consists of separate containers for clear, green, and brown glass. The city is expanding the glass drop-off system to achieve a density of approximately one station for every 1,000 inhabitants, with a goal of having a bin no more than 15 minutes away from every resident.

A city ordinance limits the hours of use for drop-off facilities from 7:00 a.m. to 8:00 p.m., with a DM 1,000 fine for violations. This ordinance is a response to complaints about noise that arose as part of the process of siting many new drop-off locations.

Table 4.1-1 below delineates the number of drop-off locations for various materials in the period 1992 through 1996. As indicated in the table, the city intends to phase out drop-off locations for certain materials as separate collection of these materials is implemented as part of the curbside program.

TABLE 4.1-1
NUMBER OF CONTAINERS FOR VARIOUS MATERIALS
(by year)

MATERIAL	1992	1993	1994	1995	1996
Glass	102	260	260	260	260
Paper	21	21	21	21	21
Plastics	15	15	0	0	0
Metals	1	1	1	1	1
Tin	64	112	0	0	0
Aluminum	15	15	0	0	0
Textiles	15	11	11	10	10
Green Waste	1	1	0	0	0

Construction and Demolition (C&D) Debris

The city does not play a major role in the collection of construction and demolition (C&D) debris. Most of this material is handled by the private sector, using a combination of roll-off collection and drop-off capability at the processing locations. Construction and demolition waste processing is likewise accomplished by private firms, including Thaler Gmbh and GFR Gmbh.

Materials Processing

Figure 4.1-1 details the layout of the facilities comprising the integrated waste management system servicing Augsburg, including the materials recovery facility. This facility is designed to receive commercial waste and source-separated household waste, with three processing lines—one for commercial waste and two for household waste. The facility is designed to separate cardboard, film, textiles, mixed paper, newspaper and plastics, ferrous and nonferrous metals, glass, and wood. The residual waste after sorting is delivered to the WTE facility. Figure 4.1-2 provides a schematic of the materials recovery facility.

FIGURE 4.1-1
AUGSBURG INTEGRATED WASTE FACILITY
LAYOUT

1. Compost Processing Area
2. Biofilter
3. Compost Fascility Receiving Area
4. Materials Recovery Facility
5. WasteWater Treatment Facility
6. Main Office
7. Rail Siding
8. Maintenance Garage
9. Waste-to-Energy
10. Air Pollution Control Train
11. Ash-Processing Facility
12. Hazardous Waste Storage Dropoff
13. Scale Area
14. Visitor Center

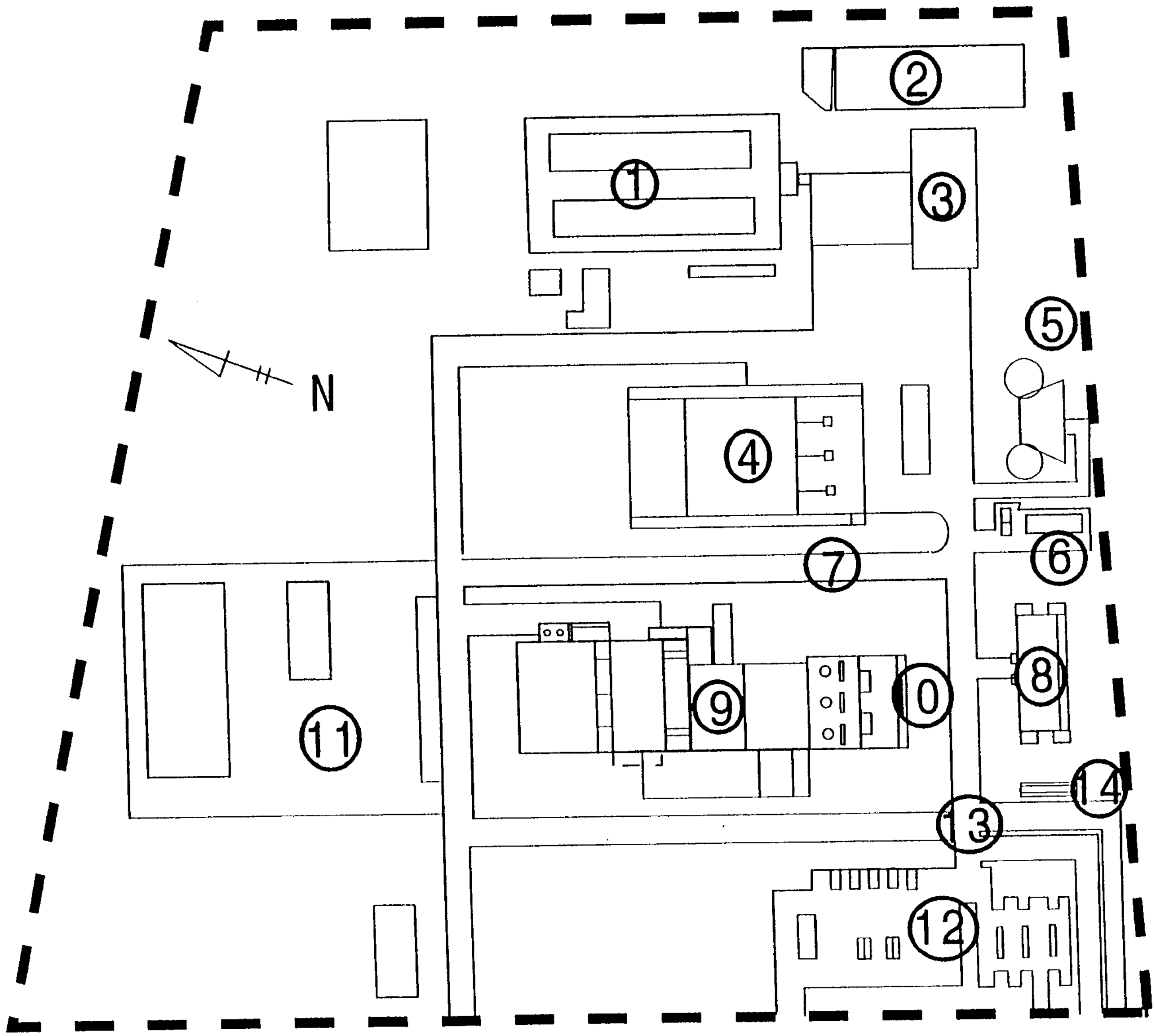
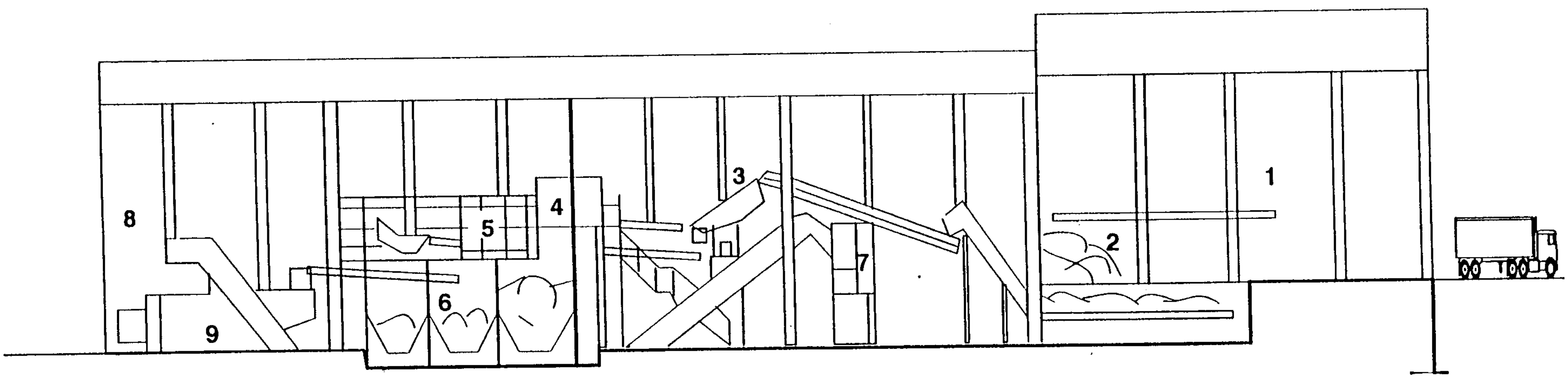


FIGURE 4.1-2
RECYCLED MATERIALS SORTING FACILITY

1 Unloading zone
2 Storage area
3 Mechanical separation/sorting machine
4 Switch room
5 Manual sorting area
6 Valuable raw material storage bins
7 Bailing press
8 Valuable raw material container loading area
9 Compactor



Source: Das Abfallverwertungsmodell Augsburg

Composting

The compost facility, also located at the integrated facility, consists of a receiving area for garden waste and the organic fraction of MSW. The materials are run through a sorting area to be screened for contaminants and useable materials. The remaining refuse is dumped into rotating drums where moisture is added and the material is macerated. The material exiting the drums is conveyed to the composting area, an enclosed hall consisting of two large aerated beds (each approximately the size of a football field) upon which the material is deposited via a shuttle conveyor. A wheeled bucket conveyor mixes, aerates and adds moisture to the material, then returns it to the aerated bed. The air from the enclosed hall is collected and exhausted through a biofilter to remove odors. The material remains in this building for approximately 10 weeks.

The design capacity of the composting facility is approximately 54,000 tons per year of organic MSW and green refuse. Figure 4.1-3 is a schematic of the facility.

Waste-to-Energy Facility

The WTE facility located at the integrated facility consists of a receiving area for MSW and dewatered sludge; three furnaces/boilers for incinerating and recovering the energy from refuse; two small hospital waste incinerators (approximately 0.5 tonne per hour); a drying system for sludge, which will dry the sludge to 90 to 95% solids prior to combustion; an air pollution train for each furnace; a turbine generator to convert the steam energy into electricity; an ash collection and handling system; and ancillary water treatment systems and offices. Figure 4.1-4 is a schematic of the WTE facility, whose operation is described below.

The Augsburg facility is designed to process approximately 230,000 tons of waste per year (approximately 10 tons per hour per line). The combustion gases generated in the furnace by the combustion of waste pass through a boiler and into the air pollution control train. The heat from the gases is converted to steam, which is used to generate electricity for in-plant use and for distribution to the public power supply network. The facility also has the capability to provide steam for industrial use.

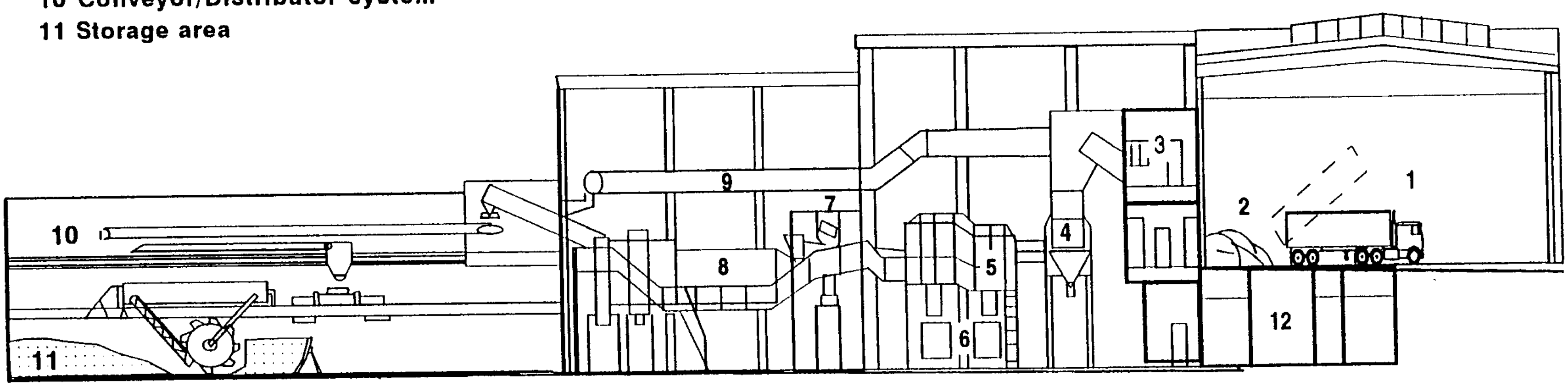
The flue-gas purification system is designed so that, according to the city, under all operating conditions the guidelines of the 17th Federal Emission Protection Ordinance (BImSchV), which were made more stringent in December 1990, are not only met but considerably surpassed. The five-stage flue-gas purification system is intended to achieve emission levels far lower than required by the 17th BImSchV. The technical processes are as follows:

- 1st Stage: Electrostatic Precipitator

  The flue gas of a waste-heat power plant, like smoke from a house fire, is laden with dust. The Augsburg facility uses electric filters to remove this dust from the flue gas. The gas flows through the electric filter housing, which contains spray electrodes (negative pole) opposite grounded deposition electrodes (positive pole). A high DC voltage is applied to the spray electrodes. Through the action of the resulting magnetic field in the electric filter, the charged dust particles are attracted to the deposition electrode and deposited. The dust is knocked off periodically and sent to the de-ashing process.

FIGURE 4.1.3
THE COMPOSTING/BIOLOGICAL RECYCLING CENTER

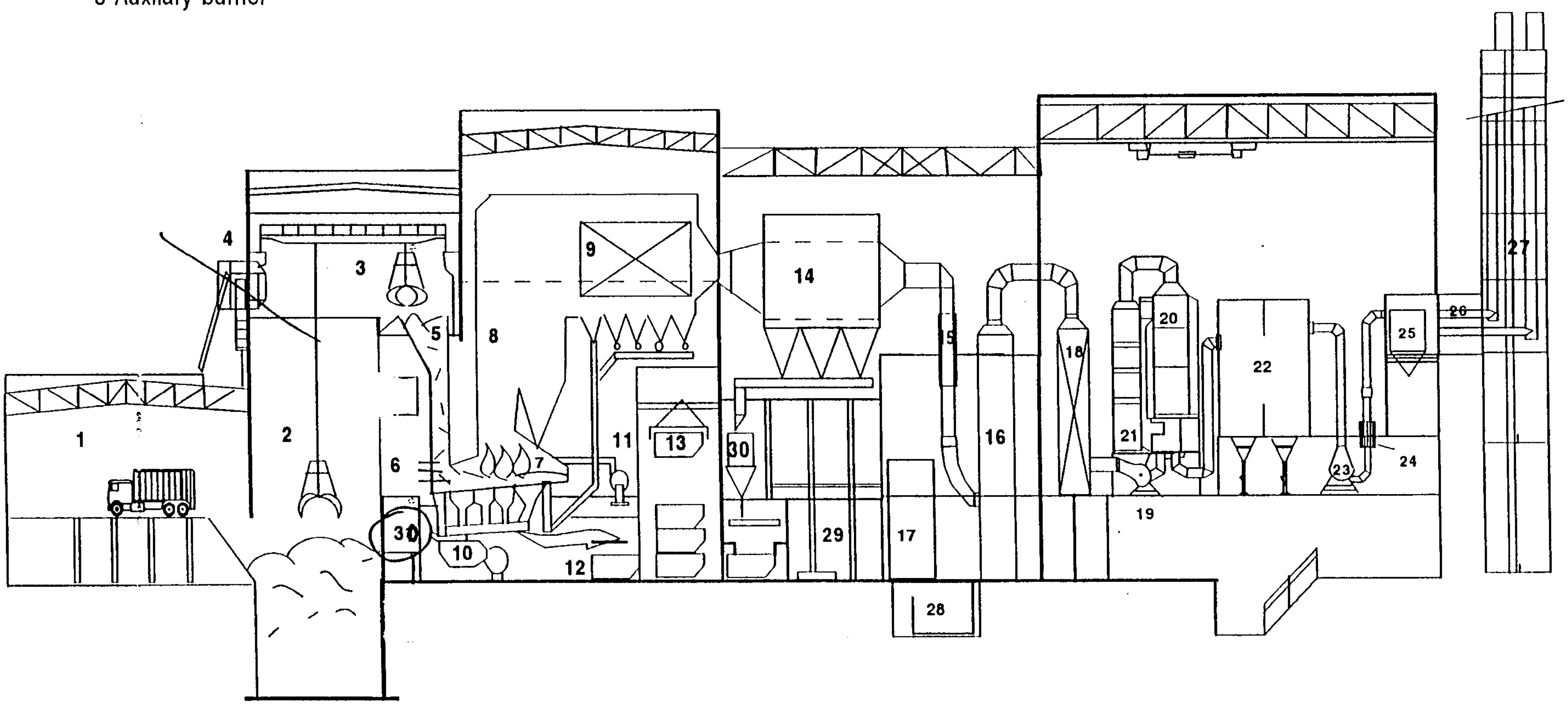
1 Unloading zone
2 Storage area
3 Switch room
4 Fine screening machine
5 Sorting area
6 Rejects container
7 Magnetic separator
8 Homogenizer-mixing trommel
9 Ventilation system
10 Conveyor/Distributor system
11 Storage area



Source: Das Abfallverwertungsmodell Augsburg

FIGURE 4.1-4
WASTE-TO-ENERGY FACILITY

1 Unloading zone
2 Waste pit
3 Waste crane
4 Crane control room
5 Waste feed chute
6 Waste feed mechanism
7 Combustion chamber
8 Auxilary burner
9 Steam boiler
10 Primary air blower
11 Secondary air blower
12 Bottom ash landout area
13 Ash handling system
14 Electrostatic filter
15 Economizer
16 Wet Scrubber
17 Storage tank for wet scrubber
18 Wet electrostatic filter
19 Induced draft fan
20 Flue gas heat exchanger
21 NOx Catalytic convertor
22 Baghouse
23 Induced draft fan
24 Silencer
25 Activated carbon storage silo
26 Emissions monitor
27 Chimney
28 Overflow storage tank
29 Sewage treatment plant
30 Fly ash storage silo



Source: Das Abfallverwertungsmodell Augsburg

- 2nd Stage: Flue-Gas Scrubber

The purpose of the second purification stage is to remove acid gases, heavy metals, and fine dust from the flue gas. The flue gas flows through the scrubber in two sections. In the first section, the water-soluble components are removed at various spray levels. These components are absorbed with water. In the second section, the SO_2 and O_2 components of the flue gas are oxidized to sulfite through the wash liquid (dilute sodium hydroxide, ph 8), which is subsequently oxidized to sulfate and separated out.

- 3rd Stage: Wet Electrostatic Precipitator

To remove even the last residues of pollutant-laden dust, the flue gas is passed through a wet electric filter. Flue gas saturated with water vapor from the flue-gas scrubber enters the wet electric filter through a connection piece. There it is sprayed by wetting nozzles. The flue gas then reaches the electric separation field (honeycomb bundles), still carrying a small portion of excess water. Within the space of the electric field, electrostatic forces cause the water-dust mixture to deposit on the walls of the honeycomb bundle. Some of it drips downward, and some adheres to the moist walls. The purified gas exits from the honeycomb bundle at the bottom. The dust residue must be flushed off the walls at appropriate intervals. Rinsing nozzles for this purpose are installed under the filter cover. During the flushing process, voltage is reduced. The frequency of the flushing process is automatically geared to operating conditions.

- 4th Stage: Denitrification System

In the denitrification system (Denox system), nitrogen oxides are converted at 260°C to nitrogen and water through the addition of ammonia and the use of a catalyst. To reach the necessary temperature, the flue gas passes through a steam and a gas/gas heat exchanger with an additional flue-gas heating system powered by natural gas. The catalyst itself consists of carrier materials coated with active metals. The amount of ammonia needed for the reduction is determined by the quantity of NO_x measured in the Denox reactor, then applied through nozzles. The gases are uniformly distributed in the catalyst housing by baffles and conducted through the catalyst elements.

- 5th Stage: De-dioxination System

Activated charcoal is continuously added to the flue-gas stream before it reaches the bag filter. The resulting mixture then passes through entry valves into four individually isolable chambers. Each chamber contains a large number of vertically suspended filter bags supported by interior baskets. As the flue gas flows through these bags, the activated charcoal deposits uniformly on the outer walls of the bags. Through the contact of the flue gas with the activated charcoal, especially when passing through the activated charcoal layer, the chlorinated hydrocarbons (dioxins, furans, etc.), as well as the last residues of mercury and other heavy metals, are adsorbed.

Measurement Checkpoint for Flue Gas

Before they reach the 80-m chimney, flue gases are continuously tested at the measurement checkpoint for adherence to the limits of the 17th BImSchV. These measurement data must be made accessible to the Bavarian Provincial Office for Environmental Protection and the Bavarian Environmental Ministry.

Wastewater Treatment System

The wastewater from the flue-gas scrubber is treated by various neutralization processes. The wastewater arrives in a sludge tank, where it is thickened. Afterward, in the filter press, the solid component is pressed into filter cakes. The residual liquid which still contains soluble salts goes to an evaporation system, where these salts can also be concentrated into solids and separated out.

Residual Material

The bottom ash is transferred to the ash-processing facility located at the north end of the site. Here, the ferrous fraction is first recovered via a magnetic separator. The remaining materials are sized and separated into the fine fraction (0 to 30 mm) and the gross fraction (greater 30 mm). This material has various construction applications.

The fly ash from the facility is collected separately and disposed of by the South West German Salt Works, Inc., with which the AVA has a contract through December 2000. The processed bottom ash is carried by conveyor to an interim storage hall for eventual shipment by rail or truck. The material is used primarily in road construction, but other uses include the construction of anti-noise earth walls and the filling of inoperative mine shafts. Table 4.1-2 details the estimated throughput of the ash-processing facility on an annual basis.

TABLE 4.1-2
ESTIMATED ANNUAL THROUGHPUT OF ASH-PROCESSING FACILITY

	Tons
Anticipated Annual Throughput	63,600
Usable Slag	58,150
Iron Scrap	4,270
Other Metals	730
Residue	450

Landfilling

In 1992, it was estimated that Augsburg's landfill facility contained approximately 1.1 million m^3 of capacity, enough for an additional 3.5 years at the then current rate of disposal. Since then, the amount of material to be landfilled has been considerably reduced by the implementation of the city's integrated waste management program. In 1993, over 150,000 tons of waste generated in the city were landfilled. The city estimates that the amount of material to be landfilled will drop to approximately 33,000 tons in 1994 and after. This material will consist primarily of building and construction debris and excavation materials. Future residues from the integrated waste management facility, primarily residuals from the bottom ash, are estimated at approximately 7000 tons.

4.1.2 Quantities of Waste Handled

Residential waste includes household waste; bulky waste from households; wastepaper; used glass; street sweepings; garden and park waste; and market waste. In 1992, the city collected 62,673 tons of household waste. In 1993, the city collected 66,895 tons. Commercial waste similar to household waste totalled 47,628 tons in 1992 and 43,137 tons in 1993. Construction site and building demolition waste totalled 26,674 tons in 1992 and 20,946 tons in 1993. Approximately 12,350 tons were composted in 1992, and 32,223 in 1993.

In 1993, most of the waste generated in Augsburg and the surrounding regions was disposed of in the landfill located at Augsburg-Nord. This included 155,318 tons of waste generated in the city and disposed of in the landfill, 32,230 tons of green waste used in recultivating the landfill, and 8,550 tons of household waste and bulky waste processed during start-up activities. Table 4.1-3 details the disposition of tons of waste by category.

TABLE 4.1-3
WASTE UTILIZATION IN AUGSBURG—1993

TYPE OF WASTE	Tons
Household Waste	58,347
Bulky Waste	3,409
Commercial Waste Similar to Household Waste	43,137
Building Site Waste	20,947
Asbestos	496
Sludge	21,129
Grit	99
Screenings	3,043
Slag and Ash	160
Street Cleanings	4,546
Green Waste Not Composted	5
TOTAL DELIVERED TO THE LANDFILL - 1993 (ACTUAL)	**155,318**
Landfill Material Green Waste Used in Recultivating Landfill	32,230
Recycled Materials	23,072

According to data filed by the city with the Bavarian Ministry of the Environment in July 1993, the city anticipates increasing the amount of material (excluding DSD packaging materials) recovered from the waste stream from 14,360 tons in 1993 to over 45,760 tons in 1994 and beyond. For DSD materials, the city estimates that the 24,442 tons recovered in 1993 will increase to 29,069 tons in 1996. Table 4.1-4 details the estimated materials to be recovered. As indicated, a significant portion of the increase in recovered materials in 1994 is because of the recovery of metals and slag from the WTE (1,500 tons and 22,050 tons, respectively).

TABLE 4.1-4
USEFUL WASTE UTILIZATION IN AUGSBURG

MATERIAL	1993	1994	1995	1996
Bulky scrap, electronic scrap, and appliances	950	1,000	1,000	1,000
Metal residues from ash		1,500	1,500	1,500
Slag		22,050	22,050	22,050
Textiles	300	300	300	300
Household organic waste (e.g., kitchen scraps, food waste, etc.)		5,000	5,000	5,000
Green waste from households, landscaping, public parks, etc.	13,000	13,000	13,000	13,000
Waste wood		1,800	1,800	1,800
Other useful materials recovered from bulky waste sorting		1,000	1,000	1,000
Auto batteries	25	25	25	25
Used oil	10	10	10	10
Miscellaneous materials	75	75	75	75
Subtotal	14,360	45,760	45,760	45,760
Glass from DSD program	7,100	7,800	8,500	9,200
Paper packaging from DSD	16,500	16,600	16,700	16,800
Plastics from DSD	222	1,384	1,384	1,384
Aluminum from DSD Composite from DSD	10 10	120 255	120 255	120 255
Tin plate	600	1,310	1,310	1,310
Subtotal DSD Materials	24,442	27,649	28,269	29,069

Source: Augsburg Solid Waste Management Program, 1993 to 1996, July 1993

Augsburg's integrated waste management facility has only recently undergone start-up and testing. Thus, there is no solid base of data detailing the actual tons processed at each of its various component facilities. The city's consultants did, however, develop estimates of the quantities of waste materials to be processed at each facility as part of their design and sizing of the system. These estimates are shown in Table 4.1-5. (Please note that these figures reflect waste from the city proper.)

TABLE 4.1-5
WASTE TO BE PROCESSED AT THE AUGSBURG
WASTE-TO-ENERGY FACILITY

Material	1993	1994	1995	1996
Household waste		58,000	58,000	58,000
Bulky waste		5,800	5,800	5,800
Commercial waste similar to household waste		44,000	44,000	44,000
Residue from sorting facility		500	500	500
Residue from compost facility		3,000	3,000	3,000
Sludge (95 % total solids)		7,200	7,200	7,200
Combustible building debris		6,500	6,500	6,500
Hospital waste		500	500	500
Total		125,500	125,500	125,500

Landfill Utilization

The city estimates that landfill utilization will decline from over 150,000 tons in 1993 to 33,000 in 1994 and beyond, a reduction of over 75%, as shown in Table 4.1-6.

TABLE 4.1-6
ESTIMATED LANDFILL UTILIZATION BY THE CITY OF AUGSBURG

MATERIALS	1993	1994	1995	1996
Household waste, unsorted	63,000			
Bulky waste, unsorted	6,000			
Residue from sorting activities	1,900			
Commercial waste similar to household waste	45,000			
Sludge	7,200			
Building and construction Debris	20,000	15,000	15,000	15,000
Dirt	10,000	10,000	10,000	10,000
Hazardous waste	1,000	1,000	1,000	1,000
Subtotal	154,100	26,000	26,000	26,000

Table 4.1-7 indicates that the city's integrated waste management facility has significantly increased the amount of waste being diverted from disposal.

TABLE 4.1-7
WASTE DISPOSITION IN AUGSBURG

MATERIAL	1993 (tons)	1993 (percent)	1994 Without Ash (tons)	1994 Without Ash[1] (percent)	1994 With Ash (tons)	1994 With Ash (percent)[4]
Recycled (including composting)	38,800	20	45,179	23	72,229[2]	37
Waste-to-Energy			125,500	64	125,500	64
Landfilled	154,100	80	26,000	13	33,000[3]	17

Source: city of Augsburg Waste Management Program Data - 1993 to 1996, June 1993.

[1]Excluding ash and metals recovered from residue stream of WTE facility.
[2]Includes materials recovered from WTE facility residue.
[3]Includes residue materials from WTE landfilled.
[4]Percentages exceed 100 because certain tons are counted more than once (e.g., a portion of the tons processed at the WTE facility is also included in the materials recycled or landfilled).

4.1.3 Budget and Fees

Augsburg's 1993 budget for waste management services included DM 31.3 million for collection, processing, and disposal of MSW and DM 2.3 million for packaging materials handled under the Duales program. Prior to implementation of the integrated waste management facility, the city estimated that it spent approximately DM 20.7 million on collection and treatment of waste, exclusive of the cost of landfilling, which was estimated to be approximately DM 10 million.

The city funds its waste management program mainly through a per capita charge. In 1993, it charged DM 90 per capita. In part because of the added cost of the new facility, this fee rose to DM 190 per capita in 1994. The estimated total capital cost of the three facilities is approximately DM 800 million, or approximately DM 800,000 per daily throughput ton.

4.1.4 Summary

At Augsburg's new integrated waste management facility, the combined operations of collecting, sorting, and composting can recycle as many as 105,000 tons per year of useful materials contained in the region's waste stream. All wastes that cannot be recycled are treated thermally. This can add up to 220,000 tons out of a total waste generation of approximately 325,000 tons per year. Thermal utilization of waste produces about 14 megawatts of power. The generated power can be fed into the city's electrical network. The sale of process steam to an industrial user is also possible. The residues from the waste-heat power plant are intended to be used as processed slag in road construction and salts used industrially. Fly ash and filter cakes are stored underground in a salt mine in an ecologically safe manner.

Augsburg's waste management system meets the characteristics of an integrated waste management system; namely, it incorporates source reduction, recycling/reuse, composting, resource recovery, and landfilling. This is based on an integrated facility located at the northeast corner of the city. The facility is truly an integrated waste management facility, including a composting facility; a recyclable materials processing facility; a WTE facility; and an ash-residue processing and treatment facility.

Augsburg's integrated waste management system relies primarily upon the public sector. The facility has been designed to serve as a regional facility, servicing not only the city of Augsburg, but the surrounding areas as well.

4.2 BAD TÖLZ

4.2.1 Bad Tölz Municipal Waste Management System

4.2.1.1 General Description

Bad Tölz is one of several municipalities in the region, or landkreis, of Bad Tölz-Wolfratshausen. The landkreis comprises approximately 1100 km^2 in Bavaria, Germany's largest state, and Bad Tölz itself is located approximately 50 km south of Munich, Bavaria's capital.

While the Federal Republic's average population density is 222 inhabitants/km^2 and Bavaria's is 166/km^2, the landkreis Bad Tölz has approximately 100 inhabitants/km^2. The major economic activities in the region revolve around agriculture and tourism. Bad Tölz, in an area known for its springs, is a major health spa center.

History of Bad Tölz's Integrated Waste Management System

In the early 1980s, the Bad Tölz-Wolfratshausen region found itself facing increasing difficulty in siting and developing new landfill capacity to meet its waste treatment and disposal needs. After an extensive review of various processing and disposal alternatives, the regional authorities decided to construct a materials recovery and composting facility as the key element in an integrated waste management system. This original system was based on the separation of municipal waste into two categories at the source: the organic fraction, and the balance of the waste generated.

4.2.1.2 Description of System Components

Waste management within the region is the responsibility of WGV Recycling Gmbh Quarzbichl, which has contracts with the region's various municipalities. The following section details the region's integrated waste management system, broken down into the following components:

waste avoidance; collection; composting; materials processing; waste-to-energy; and landfilling.

Waste Avoidance

Waste avoidance is stressed in the waste management system's public education program. Residents are provided with materials describing the importance of "smart" shopping and private composting of kitchen and garden waste. In 1991, in an effort to encourage waste reduction, the region implemented a trial program of volume-based fees. The fee system was structured so that residents had the option of container size, with the fees being based accordingly (i.e., the larger the container, the higher the monthly fee for waste collection services).

Collection

Bad Tölz's waste collection program is currently based on a three-bin system, the original two-barrel system having been replaced in 1992. The change to a three-barrel system was intended to provide cleaner waste material for the composting facility.

The original system employed a green barrel for nonorganic materials such as paper, plastic, metal, etc., and a gray barrel for the wet fraction of the waste stream (kitchen waste, food, etc.). The new system entails a green barrel for paper products; a brown barrel for the organic fraction (vegetable waste, fruit waste, coffee and tea, other kitchen scraps); and a grey barrel for the balance of the waste stream not delivered to drop-off locations or collection centers.

Drop-Off Sites

The Bad Tölz region provides a number of drop-off facilities for color-separated glass. Like other German municipalities, the region is targeting a density of one container per thousand residents. In addition to the drop-off locations for glass, paper and the DSD light fraction, these components are also collected at collection centers, which consist of separate see-through bags for each fraction attached to a common frame. The fractions include plastics, such as film, blister packs, beverage containers, etc., and metals. The number of collection centers is being expanded from 10 to over 60.

Materials Processing

In the region's original two-bin system, dry materials were delivered to the sorting facility, while the wet fraction was delivered to the composting facility. With the three-barrel system, the paper is delivered to the sorting facility for processing. The organic fraction is delivered to the composting facility for processing. The balance of the waste is also delivered to the sorting facility.

The sorting facility consists of two parallel lines. Waste materials are unloaded onto the sorting facility floor and placed in the storage bunkers by a front-end loader. From the storage bunkers, the materials are conveyed to a sorting trommel, where the waste is separated into fractions of up to 60 mm, 60 to 200 mm, and greater than 200 mm. Materials less than 60 mm are sent to the composting facility. The 60- to 200-mm fraction is magnetically processed to separate out the ferrous materials and hand sorted for foreign materials. What is left is primarily mixed paper, which is shipped to a regional WTE facility. The greater-than-200-mm fraction is hand sorted into three categories, mixed, market papers, and newsprint, which are separately baled for shipment to market. Residuals from the processing are delivered to the landfill

Composting

The compost portion of the facility is designed to handle 20,000 to 25,000 tons per year. Three composting activities are conducted at the facility, for the green waste, the organic fraction, and the balance of the waste stream. The green waste (grass, leaves, tree trimmings, etc.) is shredded as necessary and then placed into static piles by a front-end loader, where it is turned every four weeks. After approximately six months, it is screened and sized for use as a soil amendment or in agricultural applications.

The organic fraction of the waste stream is currently processed using a windrow system. First, the waste is screened with a mobile trommel. The trommel rejects are mixed with the balance of the waste stream for mixed-waste composting. The organic waste is mixed with a portion of the composting green waste and placed in windrows on an aerated bed. After 10 days the waste is turned with a composting turning machine. After four to six weeks, the waste is transferred to the curing area. After 14 to 16 weeks the cured compost is screened and sized for use in agricultural applications or as a soil amendment.

A tunnel reactor is being built to process the mixed organic waste and residuals from the biowaste fraction. Currently, the interim process involves the screening of these materials (mixed rejects from the sorting plant, trommel rejects from the organic fraction, and grey waste) in a magnetic separator, with the remaining waste being processed in a homogenizing trommel, where it is size separated. The large-size fraction is then transferred to the landfill for disposal, while the small-size fraction is delivered to the composting area.

The shift to a three-bin system was driven in part by the need to improve the quality of the compost being produced at the facility. The quality factor is also the motivation for expanding the facility to include more intensive composting production capability, by replacing the aerated windrows with tunnel reactors.

WGK has conducted several analyses of the quality of the compost product being produced from various feedstocks as part of its ongoing quality assurance program. These results are shown in Table 4.2-1. As indicated, the quality of the compost has improved as a result of the introduction of the three-bin system, which produces a cleaner feedstock.

TABLE 4.2-1
COMPOST QUALITY

COMPOST FEEDSTOCK	MIXED WASTE (two bins)	BIOWASTE (three bins)	GREEN WASTE
Total Solids (%)	72	64	41
ph	8.3	7.8	7.7
C/N Ratio	18	10	16
ORGANIC FRACTION			
(% TS)	54	39	38
Pb (mg/kg)	262	75	87
Cd (mg/kg)	1.1	0.4	0.6
Cr (mg/kg)	46	30	30
Cu (mg/kg)	123	59	60
Ni (mg/kg)	16	13	11
Zn (mg/kg)	600	249	222
Hg (mg/kg)	1.4	0.2	0.2

Waste-to-Energy

The light rejects from the sorting and trommeling activities conducted at the Bad Tölz sorting/composting facility are shipped out of the region to a WTE facility for combustion. In 1992, an estimated 4,800 tons were processed in this manner.

Landfilling

In 1992, 17,875 tons out of 42,463 were landfilled (42%). In 1991, WGV landfilled 20,624 tons, out of a total of 38,382 tons delivered to the sorting/composting facility (54%). WGV estimates that the proportion of the waste stream landfill will continue to decline.

The estimated tons generated per year are:

• Paper/Cardboard	9,031
• Light Packaging	1,080
• Wood	1,870
• Biowaste	13,750
• Glass	3,600
• Metals	582
TOTAL	29,213
Tons Landfilled	~18,000 (approximately 37%)

4.2.2. Quantities of Waste Handled

In 1991, WGV handled 38,382 tons of household waste. In 1992, WGV handled 42,463 tons. Table 4.2-2 details the waste by various categories. Of the 42,463 tons, 14,415 were diverted to use as recycled materials or as compost product and 17,875 tons were landfilled. Table 4.2-3 details the materials recovered/reused.

As shown, WGV recovered over 5,600 tons of paper, 300 tons of plastic, 700 tons of metals, 100 tons of glass, and just under 1,170 tons of wood. In addition, the composting processes utilized by WGV resulted in the generation of over 6,400 tons of useful compost.

In 1991, of the 38,380 tons handled by WGV, over 20,600 tons (53.8%) were landfilled. In 1992, 17,875 tons out of 42,463 were landfilled (42.1%), a reduction of over 10%.

According to data filed by WGV with the Bavarian Ministry of the Environment in 1993, Bad Tölz anticipates increasing the amounts of material recovered from the waste stream to over 20,000 tons per year of paper and cardboard, glass, metals, plastics, wood, and compost.

TABLE 4.2-2
DETAILED WASTE COMPOSITION—1992
BAD TÖLZ WASTE MANAGEMENT PROGRAM

WASTE STREAM COMPONENT	Tons
DSD Materials: Light Fraction	227.09
Paper: Curbside Drop-Off	3,247.85 1,579.68
Metal	129.48
Mixed	257.43
Wet Fraction	16,362.52
Unsorted Household Waste/Commercial	5,819.28
Commercial Compost	2.45
Commercial Plastic	49.71
Green Waste	2,961.09
Biowaste	7,062.65
Metals	257.52
Commercial Plastic	49.51
Green Waste	2,961.09
Biowaste	7,062.65
Metals	257.52
Self-Sorted: Plastic Glass Paper Mixed Paper Foil Metal	7.48 17.97 135.4 166.57 8.99 18.05
Plastics	687.01
Street Cleaning	114.04
Aggregate	289.0
Wood	1,094.42
Bulky Waste	114.88
Subtotal	40,610.56

WASTE STREAM COMPONENT	Tons
Transport Packaging: Paper	1,427.24
Plastic	77.37
Metal	0.29
Wood	348.01
Subtotal	1,852.88
TOTAL	**42,463.44**

TABLE 4.2-3
RECOVERED MATERIALS — 1992

WASTE COMPONENT	Tons
Paper	5,661.52
Glass	134.32
Plastic	300.12
Metals	729.09
Compost	6,420.79
Wood	1,169.15
TOTAL	14,414.99
LANDFILLED	
Sorting Residue	7,663.83
Composting Residue	10,211.63
TOTAL	17,875.46

4.2.3 Budget and Fees

WGV estimates the capital cost of the Bad Tölz sorting/composting facility at DM 50 million. The annual operating costs are estimated to be approximately DM 6 million. The fee system is designed to foster recycling and reuse. By establishing a graduated fee based on the size of the grey bin used to collect the balance of the waste after separation of the organic fraction (the brown bin), paper (the green bin), and other recyclable materials (at drop-off locations and collection points), the system encourages consumers to minimize the amount of waste going into the grey bin. (The annual fee for an 80-liter container is DM 378; for a 110/120-liter container, DM 522; for a 240-liter container, DM 984; and for an 1,100-liter container, DM 4,518.)

4.2.4 Summary

Bad Tölz has in place a waste management system which meets the characteristics of an integrated waste management system, insofar as it incorporates source reduction, recycling/reuse, composting, and landfilling. The key element in the system is a regional integrated sorting and composting facility.

Through the combined operations of collecting, sorting, and composting, Bad Tölz can recycle as many as 20,000 tons of useful materials annually. This includes recyclable materials recovered from the waste stream (i.e., paper, plastics, glass, wood, and metals), as well as compost derived from source-separated organic and green waste.

The collection systems in place in the region make use of source separation to provide a beneficiated waste stream to the sorting and composting facilities. The number of collection containers has been expanded to encourage source separation of organic wastes, and thus improve the quality of the compost product generated by the facility. This effort has been successful, and the improved quality should expand the available uses and outlets for the compost product.

4.3 DUISBURG

4.3.1 Duisburg Municipal Waste Management System

4.3.1.1 General Description

The city of Duisburg comprises an area of 232.81 km^2 in Nord-Rhine Westphalia, the most densely populated state in the Federal Republic. This is the Ruhr region, Germany's industrial heartland. With its 31 power stations, this area is also Germany's major source of energy.

Approximately half of the region's people live in cities of 500,000 or more. In 1992, there were 538,940 residents in Duisburg, making it the eleventh largest city in Germany. Aside from its total population, Duisburg is also one of the country's most densely populated cities. While the Federal Republic's average population density is 222 inhabitants/km^2 and Nord-Rhine Westphalia's is 489/km^2, Duisburg stands at 2,299 inhabitants/km^2.

Table 4.3-1 details the land use in Duisburg.

TABLE 4.3-1
AREA UTILIZATION IN 1990

TOTAL AREA IN HA. 23,282.2	
Residences	≈ 14.6%
Residences and Business	≈ 2.4%
Public Facilities	≈ 4.2%
Other Building-Related Areas	≈ 2.1%
Trade and Commerce	≈ 2.5%
Business	≈ 1.9%
Industry	≈ 9.1%
Traffic	≈ 15.0%
Sports and Recreation	≈ 1.4%
Green Areas	≈ 5.5%
Green and Cultivated Land	≈ 22.2%
Forest	≈ 8.2%
Water	≈ 9.9%
Reservations, Suburbs	≈ 1.1%

Duisburg is an important transportation center, with its extensive network of highways and its access to the Rhine and Ruhr waterways. Indeed, the Rhine-Ruhr port is the largest inland port in the world.

The Duisburg economy is still based on manufacturing, with the iron and steel industries of primary importance, but the micro-electronics sector is rapidly becoming more important. Other significant factors in the Duisburg economy are large international trade companies; a substantial middle class; the service sector; and, as indicated above, the transportation sector.

Manufacturing is the leading occupation in Duisburg, as indicated in Table 4.3-2. Over the last two decades, however, manufacturing jobs have decreased while jobs in the service sector have increased.

TABLE 4.3-2
WORKFORCE BY OCCUPATION
[Employed Persons Subject to Social Security (Status: June 30, 1989)]

TOTAL	185,969	100%
Agriculture, Forestry, and Fishing	649	≈ 0.35%
Energy Generation and Water Supply, Mining	12,754	≈ 7.00%
Manufacturing	73,602	≈ 50.00%
Construction	10,399	≈ 6.00%
Trade	24,566	≈ 13.00%
Traffic and Communications	15,993	≈ 9.00%
Credit Institutions and Insurance	4,355	≈ 2.00%
Services and Independent Occupations	31,858	≈ 17.00%
Nonprofit Organizations	4,231	≈ 2.00%
Regional Associations and Social Insurance	7,562	≈ 4.00%

4.3.1.2 System Components

Duisburg's waste management program incorporates a number of components, including several drop-off locations for various materials; a composting facility; a WTE facility; facilities for the processing of household waste; and facilities for disposal of household waste, commercial waste similar to household waste, market refuse, street sweepings, and other similar refuse.

Duisburg uses the WTE facility in Oberhausen. Recovered recyclable materials are processed at the recycling facility built by RZO adjacent to the Oberhausen facility. Organic wastes (leaf and grass refuse, as well as some nonsorted household waste and mixed papers) are processed at the composting facility located in Huckingen. Additional garden and park wastes are also composted in windrows on city land, and a small portion has in the past been delivered to the WTE facility for processing.

That portion of the waste stream that is not combustible, as well as grit and screenings from wastewater treatment facilities, is delivered to the landfill for disposal. Sludge treatment and disposal options used by the Duisburg region include landfilling, land application, and incineration. Construction and demolition debris is processed at four privately operated facilities. Residual materials resulting from these processes are disposed of at various landfills in the region.

Household hazardous wastes generated in the region are processed at either the Abfallentsorgungs Gesellschaft Ruhr (AGR) facility in Duisburg-Walsum, several other processing facilities in the region where the materials are chemically and physically treated, or the AGR incineration facility in Herten, or they are disposed of at special waste landfills in Húnxe, Herfa-Neurode.

Figure 4.3-1 lists the facilities comprising the waste management system in Duisburg, and their operators.

The organization responsible for managing waste in the city of Duisburg is the Entsorgungsbetriebe der Stadt Duisburg. Figure 4.3-2 details its organizational structure. As indicated, the organization's responsibilities include water treatment and street cleaning. The city also relies on a number of other organizations to help meet its long-term solid waste management needs. For example, while the Entsorgungsbetriebe der Stadt Duisburg operates the compost facility, the system's other facilities are operated by other entities, as shown in Figure 4.3-1.

The following section details the integrated waste management system in place in Duisburg. The description of the system is broken down into the following components: waste avoidance; collection; composting; materials processing; waste-to-energy; and landfilling.

Waste Avoidance

Considerable change took place in Duisburg's waste avoidance program from 1985 to 1990. As a result, the baseline data and documentation necessary for a reliable assessment are not yet available. In the absence of accurate information about waste generated domestically, waste generated commercially, and changes among commercial and industrial businesses, as well as legally binding reports from private dump operators, the city has not made an attempt to analyze and evaluate the success of its waste avoidance efforts.

Waste avoidance is, however, a key element in Duisburg's public education efforts and a waste avoidance component is incorporated into the city's programs and materials related to waste management. For example, the city is making an active effort to enlist organizations similar to the Salvation Army here in the United States in fostering the reuse of bulky items such as furniture and electronic goods. Also under consideration is a separate pickup program for usable bulky items, in addition to the current call-in system.

Collection

Beginning in 1992, Duisburg's waste collection, processing, and disposal services have been organized into a separate corporation structured on an enterprise fund basis and comprised of various former departments within the city administration. This organization, the Entsorgungsbetriebe der Stadt Duisburg, provides for collection of household waste, as well as packaging materials targeted under the DSD program. (Thus, in the implementation of the DSD system in Duisburg, the city's own waste management organization plays the collection role served in some other cities by private entities.) Duisburg's system for DSD collection includes drop-off containers for paper and glass and yellow bin containers in each household for light packaging materials.

For collection purposes, the city is divided into 43 collection districts. Of the 1,000 employees at the Entsorgungsbetrebe, 330 are responsible for collection and transportation.

FIGURE 4.3-1
ISWM SYSTEM - CITY OF DUISBURG

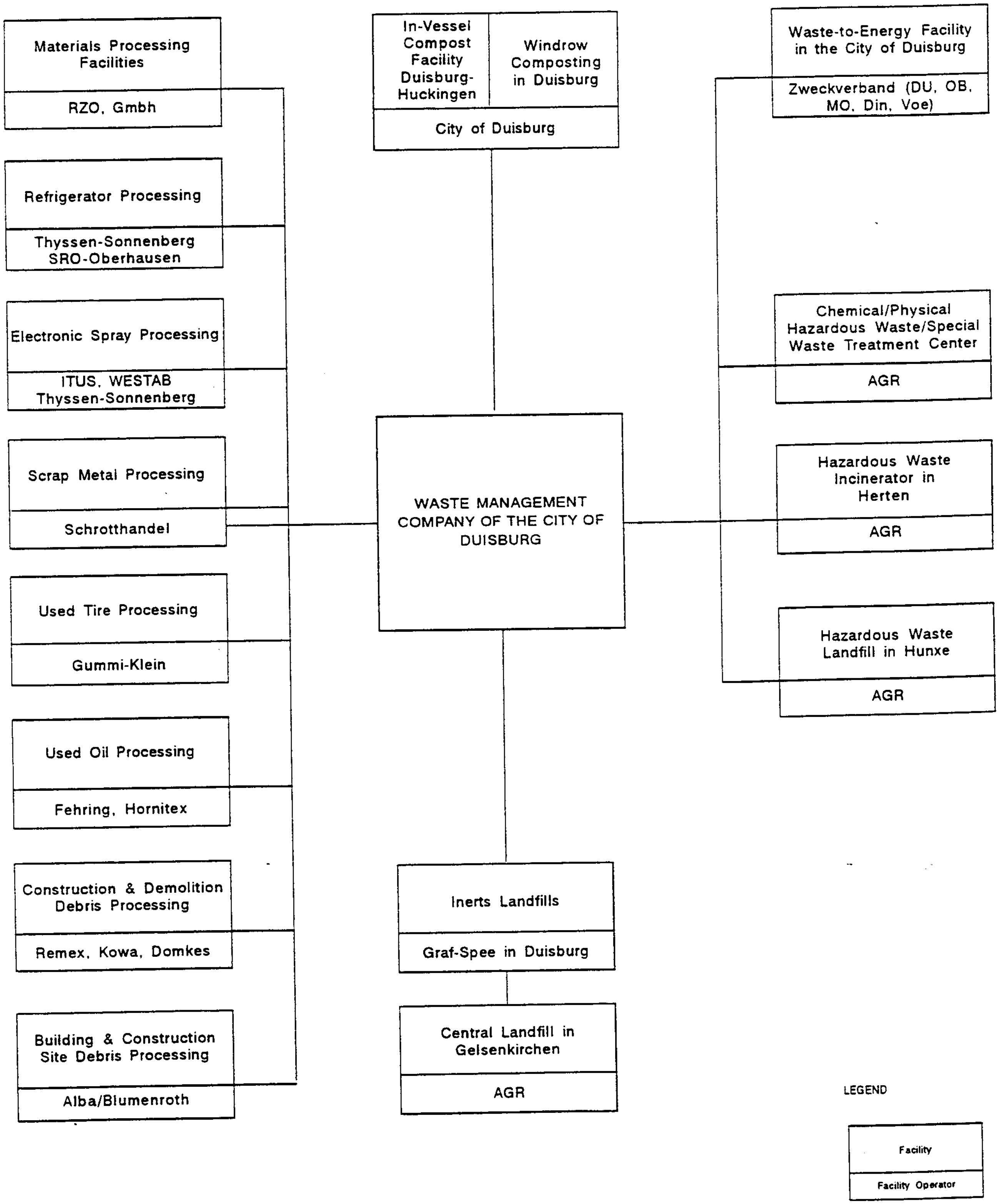
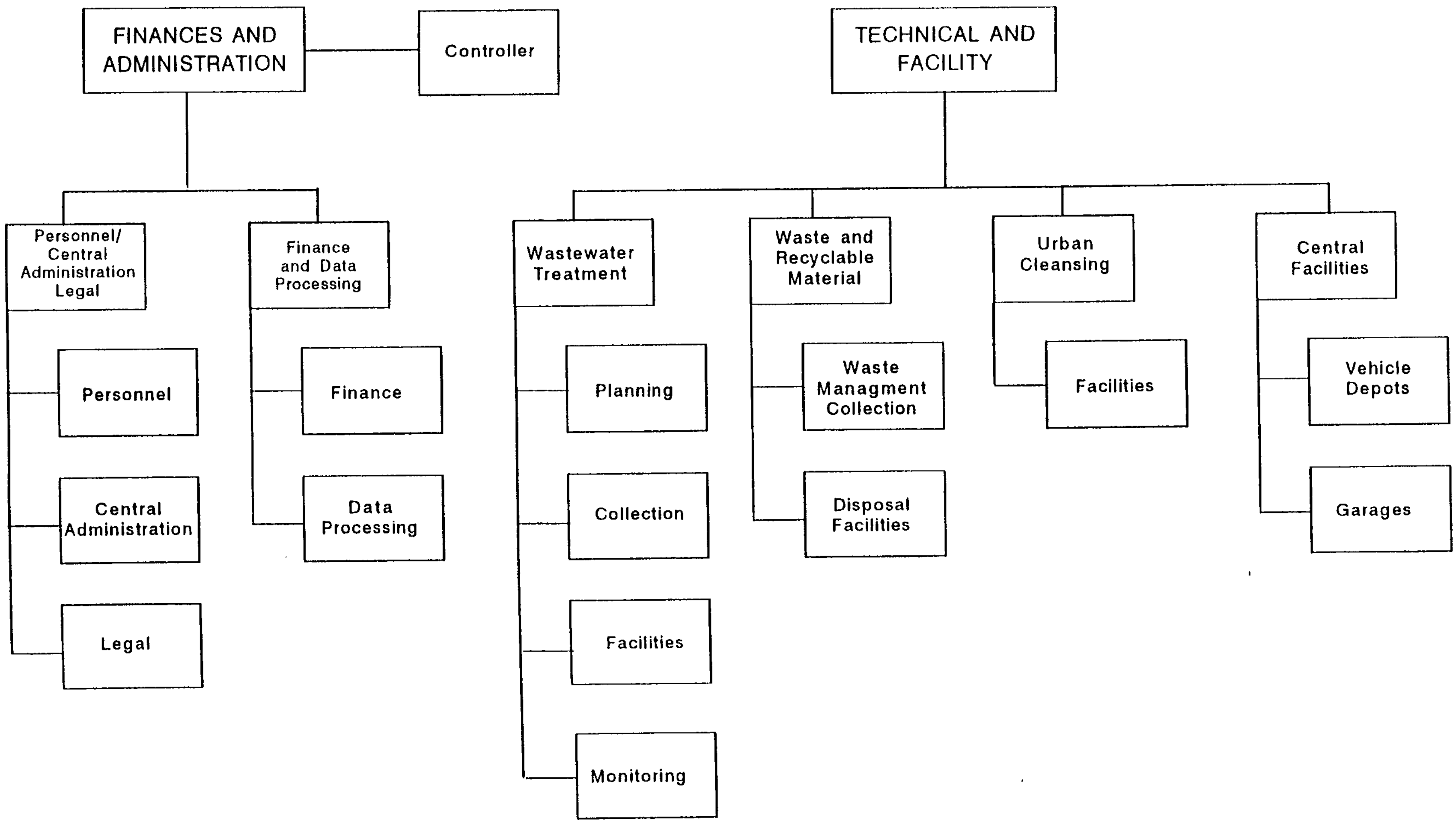


FIGURE 4.3-2
ORGANIZATION CHART - CITY OF DUISBURG WASTE MANAGEMENT COMPANY



Source: City's Waste Management Plan - 1991

Collection is accomplished via bags and barrels; wheeled containers of various sizes (most commonly, 240 liters) and larger containers (660 to 1,100 liters) for multifamily buildings. The system includes separate wheeled containers for nonsorted wastes and, as indicated above, yellow barrels or bins for light packaging material. In some areas, the city is also evaluating a pilot program using green bins for organic wastes.

Collection frequency varies by district and ranges from every two weeks for household collection to more frequent collection of bins and large containers.

Garden and Park Wastes

Leaf wastes are collected as part of the routine street cleaning program. Chipping vehicles are used to process brush and limbs. The resulting mulch is often placed on parks and traffic islands. In addition, the city operates several collection points where unprocessed garden and park wastes are accepted for transfer to composting facilities.

Market Wastes

Wastes from the large markets located in Duisburg are collected by private firms. Wastes from the weekly markets held in various locations throughout the city are collected by both the city and by private collection companies (approximately 56% public, 44% private).

Bulky Waste

The city has an on-call program for bulky waste pickup. Residents can either call in or send in a postcard requesting pickup. The city also provides bulky waste drop-off points at several locations.

Problem Trash

Household hazardous wastes are collected at six specially designated drop-off facilities located throughout the city (in operation since 1984) and via mobile collection vehicle (in operation since 1986). Among the materials collected are batteries, waste oil, prescription medicines, insecticides, mercury, and fluorescent lights.

Drop-Off Sites

As indicated in the above sections, the city provides a number of drop-off facilities for various materials, including hazardous household wastes, bulky wastes, and garden wastes. Prior to implementation of the DSD system, aluminum was collected at drop-off bins located at schools, businesses, and public disposal locations. In addition, certain nonprofit organizations have in the past targeted aluminum for fundraising efforts. Aluminum is currently collected in the yellow bin as a light packaging material. Textiles are also generally collected in drop-off boxes sponsored by various nonprofit agencies.

The city also provides drop-off centers for glass and paper, as described below.

Glass

Duisburg's drop-off glass collection system dates to the mid-1970s. Table 4.3-3 below shows the number of drop-off locations for the period 1982 to 1990. Clearly, as the number of available containers has increased, the amounts recovered have increased as well. As indicated above, the city intends to provide still more containers and expand public information programs to further increase the amounts recovered.

Paper

Duisburg also uses a drop-off system for the collection of paper (in place since the 1970s). Since 1981, drop-off collection (and recycling) of paper has been carried out on a city-wide basis, with the exception of the Rheinhausen area, where a private company collects bundled papers at the same time as the normal garbage pickup. Table 4.3-4 details the number of paper drop-off containers in the city from 1982 through 1992 (and the estimated number for 1995).

TABLE 4.3-3
NUMBER OF CONTAINERS FOR COLLECTION OF GLASS

YEAR	NUMBER OF CONTAINERS COLLECTED	ESTIMATED Tons
1982	293	3,655
1983	334	4,154
1984	390	4,351
1985	418	4,758
1986	440	4,717
1987	458	4,623
1988	483	4,571
1989	546	5,041
1990	601	5,901
1992	1,200+	8,030
1995	1,500+	16,000+

TABLE 4.3-4
NUMBER OF CONTAINERS FOR COLLECTION OF PAPER

YEAR	NUMBER OF CONTAINERS	TOTAL Tons COLLECTED FROM DROP-OFF* AND BUNDLE COLLECTION
1982	70	1,112
1983	88	2,135
1984	160	2,603
1985	367	3,031
1986	396	4,113
1987	407	4,711
1988	446	4,818
1989	502	5,287
1990	828	6,060
1992	1,600	10,080
1995	2,000	26,000+ (est.)

* Bundled paper collection totals approximately 1,000 tons per year in the Rheinhausen.

Not surprisingly, the numbers again indicate that as the number of containers increases, the amount of material collected also increases. By making more drop-off bins available, the city hopes to achieve a travel time of no more than five minutes for each resident to reach a bin. Since it is no easy task to find sites for 2,000 bins in a densely populated city, waste management officials are exploring the use of private parking lots and other private sites. The city also hopes to expand participation by improving the esthetics of the bin locations, making them more pleasing to the eye and easier to use, and intensifying the public education and public relations efforts necessary to make the residents more responsive to the program.

Construction and Demolition Debris

The city does not play a major role in the collection of construction and demolition debris. Most of this material is handled by the private sector.

Materials Processing

Sorting Facility

The Oberhausen Recycling Center (RZO). In 1990, a group of private waste disposal enterprises founded the "RZO Recycling Center at Oberhausen GmbH" for the purpose of operating a sorting facility. Today, this facility is used to pretreat and preprocess sortable wastes, defined in this context as commercial waste similar to domestic waste; bulky waste; market waste; and garden and park wastes. After preliminary processing in the RZO facility, the balance of the waste is delivered to the WTE facility, as described below. The relationship between the operators of the facility and the RZO is regulated by a cooperation contract.

The RZO is expected to process 100,000 tons/year of delivered wastes. Approximately 10,000 tons per year will consist of plant material for composting; the remaining 90,000 tons per year will consist of commercial wastes and bulky material for sorting. Approximately 33% marketable useful materials are expected from this sorting process. Fifty-five percent of the input material is expected to be delivered to the WTE facility as combustible, nonuseful materials. Twelve percent will be noncombustible material for dumping.

As part of the implementation of the DSD program in Duisburg, the RZO facility is also used to process DSD materials. Under a cooperative agreement between the city and RZO, the city is responsible for collection of materials, siting, care and cleaning of depot container locations, and public relation services. A negotiated fee structure covers the city's cost of equipment (vehicles, containers and drop-off bins, personnel and administrative overhead). The city's costs for public relations, cleaning the drop-off locations, and consulting services are paid for by a fixed per capita fee. For the first 18 months, the fee for public relations and system advice was set at DM 0.5 and DM 1 per capita, respectively (a total of approximately DM 808,000). For the siting, care, and cleaning of the drop-off containers, the city receives DM 3 per capita (approximately DM 1,600,000).

The contract has a term of 10 years, with an automatic extension available for an additional five years. The contract contains a provision whereby the DSD can renegotiate the price paid for materials after 18 months.

To meet levels of capture and recycling necessary to continue the DSD exemption granted to retail outlets, the city and RZO have determined that they must increase the density of drop-off locations for DSD materials. The target density for glass drop-off centers, for example, is one for every 400 inhabitants. This will require over 1,200 drop-off locations. The original DSD glass collection drop-off points were set up to collect mixed glass. All of these sites, as well as the new sites, will include drop-off bins for color-separated glass fractions (green, brown, and clear).

For paper, the target density is one bin for every 250 inhabitants. In 1991, there were 950 drop-off boxes for paper. This is expected to increase to over 2,000. Paper from packaging represents 25% of the paper being collected in the system. As described earlier, pending legislation on printing and office paper (similar to the Packaging Ordinance) would likely provide an additional source of revenue from the paper manufacturers, sufficient to cover the expenses associated with processing the remaining 75% of the paper.

The city will provide yellow bins for household collection of the light packaging fraction. In addition, residents will be furnished a 240-liter wheeled can for the balance of the waste stream. The materials thus collected will be delivered to the RZO facility for sorting and processing.

The city's goals are to capture the following amount of material per inhabitant, based upon the regulatory requirements and the estimated amount of materials generated per capita.

TABLE 4.3-5
TARGETED PER CAPITA CAPTURE RATES FOR PACKAGING MATERIALS

MATERIAL	7/1/95	AMOUNT IN 1992
Glass	30 kg/capita	14.9 kg/capita
Paper	49 kg/capita	18.7 kg/capita
Light	11 kg/capita	--

The expanded collection system is expected to require significant capital investment. The estimates as provided by the city are as follows:

YEAR	DM
1993	6,000,000
1994	7,600,000
1995	4,900,000
1996	1,050,000
TOTAL	19,550,000

For each tonne of paper, DSD pays to RZO and the city DM 350; for glass, DM 160 to 280, depending on the color; and for plastic, DM 1,600. The city did not provide us with figures on the revenue it will receive from RZO for each tonne of city-collected material.

Other Processing Facilities

The city also uses other privately operated processing facilities for managing certain portions of its waste stream. These include private processing facilities for construction and demolition debris, refrigerators, used tires, used oil, and hazardous waste materials.

Composting

Composting of Domestic Trash

The Huckingen composting plant, the oldest plant of its kind in the Federal Republic, has been processing solid waste for more than 30 years. The plant was originally designed to handle domestic trash and sewage sludge from about 150,000 inhabitants. Given the increased awareness of pollutants associated with sewage sludge, no sewage sludge has been composted since November 1990. Necessary moisture is now provided by adding water.

Besides domestic trash, the composting plant processes foliage from public roads (since 1984), as well as stable dung from the zoo and the slaughterhouse. As collected paper has increased, and the re-use market has become more saturated, the city has also decided to compost wastepaper at the Huckingen facility when market conditions dictate. In some cases, large quantities of wastepaper have been processed in this way.

Description of the Plant and Operations

The Huckingen composting plant uses the Dano-biostabilizer process. This process is designed to provide better control over the biological process of composting than is achieved in static pile or windrow approaches. It also requires less space for material storage, compared to conventional turned windrows, for example.

Residential waste is tipped into a receiving pit, which feeds an incline conveyor. The conveyor leads to a magnetic separator, which removes the magnetic fraction of the waste. The balance of the material is then conveyed to a horizontal hand-picking belt, where glass bottles, nonferrous metals, hard plastic, and oversized items are sorted out manually. The remaining materials are then fed into rotating drums, where the waste is mixed and further reduced in volume. After passing through the drums, the materials are screened. Oversized material is taken to the WTE facility at Oberhausen; undersized material is further processed into two grades of raw compost, which are then allowed to mature.

Approximately 56% of the incoming material is recovered as compost; 43% is reject materials; and about one percent metal is recovered at the magnetic separator.

The raw compost is matured on an aerated bed, where air from the Dano drums and the plant buildings is blown up through the piles of compost. The aerated beds serve as an odor control system for the process. The facility recently added a modified compost turning and aeration system to help ensure that no anaerobic conditions develop during the maturation process. Figure 4.3-3 details the process flow at the facility.

In addition to the equipment described above, the facility also includes a bridge scale; a processing building with two waste-storage bunkers; a control room; a compost/glass-sifting residue-ejection system; a loading ramp; a compost storage area; and a biological compost off-air filter. For each unit, two steel-laminated conveyors serve as floors for: the waste-storage bunkers; rubber-belt conveyors with magnetic rolls; vibrating troughs; blowers for intake air; air classifiers for separating plastic; and screens. Each unit also has one trough-belt conveyor for compost sifting residue; a glass separator; a tension-corrugated screen with plastic mats; and dust-removing equipment.

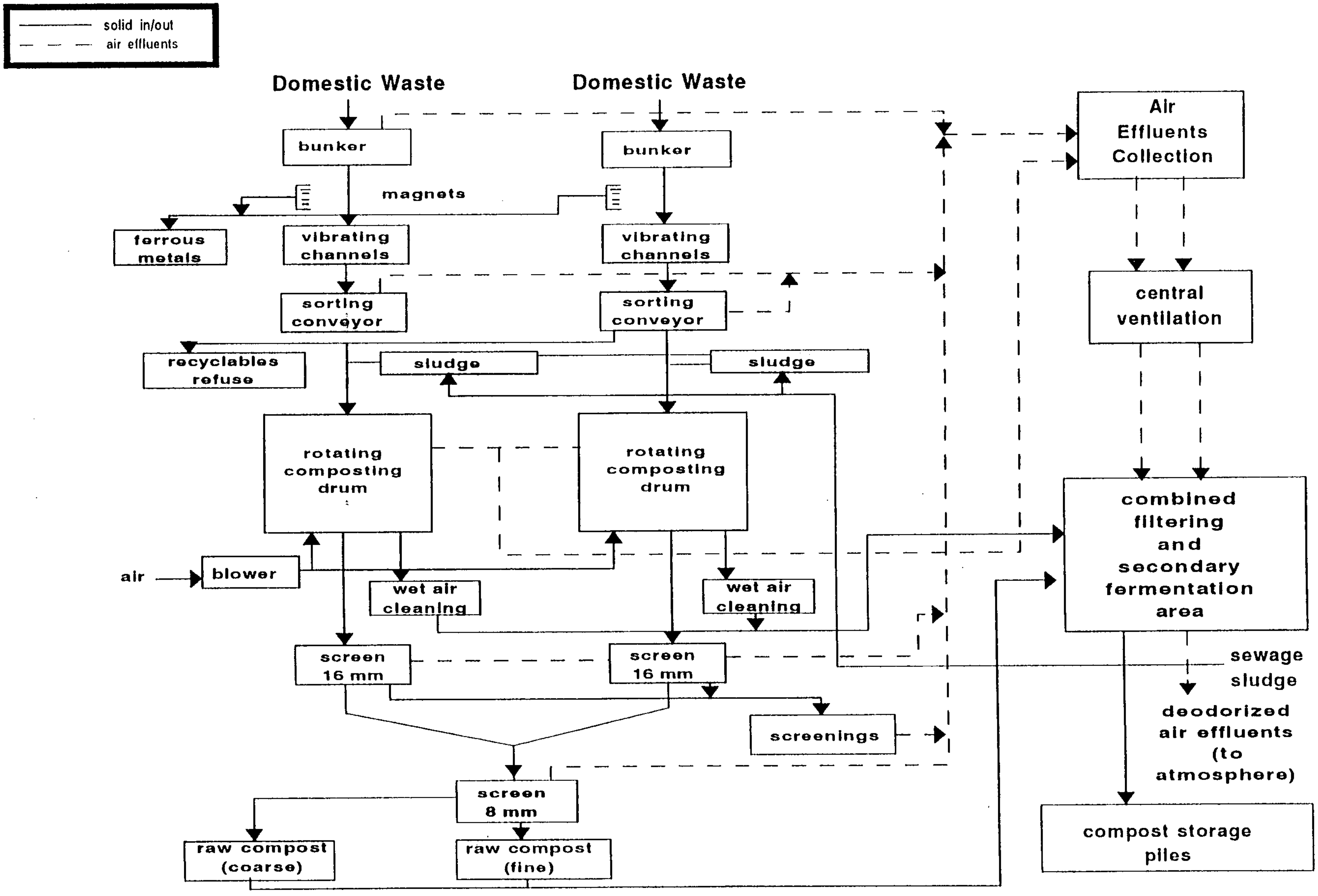
The compost produced at the facility is marketed as filter compost for odor control applications, as a soil amendment, and in horticultural applications. In 1990, approximately 51% was used in landscaping and horticultural efforts (31% on public lands, 20% on private gardens); 9% was used in recultivation of landfills; and 38% was used as filter media in biofilters throughout Germany.

In addition to the composting facility itself, the city also encourages on-site composting of garden and park wastes at local gardens, parks, and cemeteries.

The Niederrhein Waste-to-Energy Facility

In 1968, Duisburg and several other municipalities formed a regional solid waste management authority. Together they purchased a closed coal power facility at Niederrhein in Oberhausen and converted it for MSW combustion. The plant's existing boilers, turbines, and feedwater systems were incorporated into the new facility. New components included the furnace grates; scale house; refuse pit; air pollution control equipment; chimney; air-cooled condenser; and new instrumentation for process control. The retrofit was completed in 1972, with the three-unit facility rated at 1,740 tons per day. In 1984, the public company formed by the authority, the Gemeinschafts-Müll-Verbrennungsanlage Niederrhein (GMVA Niederrhein), was converted to a private limited company, whose corporate members are the cities of Duisburg, Oberhausen,

FIGURE 4.3-3
PROCESS FLOW DIAGRAM - DUISBURG-HUCKINGEN COMPOSTING PLANT



Source: City's Waste Management Plan - 1991

Dinslaken, Moers, and Voerde. According to the corporate contract, these member cities are responsible for GMVA's expenses. In 1991, the most recent year for which data was obtained, the shares of the corporate members were distributed as follows:

- Duisburg 58.46%
- Oberhausen 26.41%
- Dinslaken 6.41%
- Moers 4.62%
- Voerde 4.10%

The Board of GMVA Niederrhein is composed of members of the councils of Duisburg, Oberhausen, Moers, and Voerde; staff of the cities of Duisburg, Oberhausen, and Dinslaken; and staff of the labor unions.

Facility Description

Waste is delivered to the Niederrhein facility in trucks, which dump their loads into push pits. Hydraulic rams then force the waste into a 12,000-m^3 waste storage pit that holds 8-10 thousand tons (approximately four days' capacity). The pit area is sealed off from the outside, and combustion air for the furnaces is drawn from the pit area, thus preventing the escape of odors. Waste from the pit is fed to the furnaces via one of two cranes. The waste fed into the furnace passes onto the proprietary Deutsche Babcock roller grate system, where it is combusted in a controlled environment. The facility has four combustion trains, the first three built in the early 1970s, the fourth added in 1985. Current combined capacity of the four units is approximately 580,000 tons per year.

The combustion gases pass through a boiler and into the APC train. The heat from the gases is converted to steam, which in turn is used in a district heating loop and to make electricity in turbine generators.

The APC trains installed at the Neiderrhein facility have undergone several modifications since the facilities were installed. The initial APC consisted of an electrostatic precipitator. Following the implementation of more stringent requirements contained in TA Luft 74, the new fourth unit and the original three units were equipped with a wet scrubber. As a result of the implementation of still more stringent requirements, the units were also equipped later with dry scrubbers. To comply with the current regulations, the facilities are currently being retrofitted with catalytic converters and activated carbon filters. Thus, the facility's APC system will soon consist of an electrostatic precipitator, wet and dry scrubbers, a catalytic converter, and an activated carbon filter.

Ash from the facility is separated into ferrous fraction; bottom ash remaining from the combustion process; and fly ash captured through the APC train. The bottom ash is transferred to a processing facility, where it first passes over a magnetic separator and then passes to a drum screen, where it is sorted into various fractions by size. The materials recovered from the ash are utilized as aggregate in road construction, limited to use outside watershed areas.

The fly ash captured in the APC train is handled as hazardous waste.

Table 4.3-6 details the amount of ash generated at the Niederrhein facility for the period 1985-1990.

TABLE 4.3-6
ASH FROM THE WASTE-TO-ENERGY FACILITY

MATERIAL (Tons)	1985	1986	1987	1988	1989	1990
Slag	74,103	77,063	88,380	101,344	98,730	97,824
Ferrous Metal	12,566	13,756	11,718	9,225	7,696	7,648
Fly Ash	8,506	9,606	10,024	10,218	10,626	6,923
Filter Cake	NA	224	509	742	738	844

The Niederrhein facility is currently undergoing the construction of two new lines. This new construction, plus the latest revisions to the APC train, will cost approximately DM 520 million.

Description of Modifications

As indicated above, GMVA Niederrhein is undergoing extensive reconstruction. The 17th BImSchV, the latest federal air emission regulations applicable to WTE facilities, has been the most important guide for this restructuring.

Planned Adaptations

GMVA Niederrhein's pit capacity is no longer adequate. 12,000 m^3 are available at this time, although there are sometimes considerable bottlenecks in the intermediate storage of wastes. The current plan is to expand this capacity by about 10,000 m^3. The expansion also includes the installation of a third crane system to service the pit. Completion is expected by January 1, 1996.

As indicated above, extensive reconstruction measures are also under way to restore or reconstruct the APC train to meet the requirements of the 17th Bimschv.

To optimize the generation of electricity, the 16-MW back-pressure turbine was replaced by a 50-MW turbine in September 1991.

Lines 1 and 2 are to be dismantled by the end of 1995 and replaced by lines 1a and 2a, now under construction. The retrofit of line number 4 will also be completed by the end of 1995. Thus, by the beginning of 1996, three lines with a total capacity of 450,000 tons per year should be operating to meet the requirements of the 17th BImSchV. Completion of line 3a is currently planned for the beginning of the year 2000. With the construction of 3a, GMVA Niederrhein will be equipped to process approximately 580,000 tons/day. The decision whether or not to construct a fourth line will then depend, among other things, on the consequences of the Packaging Ordinance and the Ordinance on Utilization of Waste.

Landfilling

The digested sludge from Duisburg's three sewage plants, as well as a portion of the construction scrap and earth excavations, are landfilled. Street sweepings are partly handled by thermal treatment, but a portion must also be landfilled because of this material's high mineral content, especially during the winter months, when anti-slip chemicals are spread on the streets and roads. A portion of residual substances from the thermal waste treatment process at GMVA Niederrhein must also be landfilled.

Landfills Used

Those landfills used by the city of Duisburg or by GMVA Niederrhein are discussed below. The quantities cited in the discussion are from 1987 through 1989, since the operators of the facilities were only able to provide data for this period.

The Emscherbruch Central Landfill in Gelsenkirchen (ZDE), is operated by the Waste-Disposal Company mbh (AGR) in Essen. For the city of Duisburg, the ZDE provides an alternate facility if problems at the GMVA Niederrhein make it difficult for the latter to accept the city's waste. In addition, the ZDE landfill is the disposal facility for the digested sludge from the Duisburg-Walsum, Duisburg-Hochfeld, and Duisburg-Huckingen city sewage plants. Construction scrap, which cannot be processed because of its contaminants, is likewise landfilled here. In 1989, a total of 124,689 tons of wastes were transported from the Duisburg city area to the ZDE landfill. These materials included:

• Construction scrap	1,431 tons
• Earth excavation	33,285 tons
• Asbestos-cement waste	243 tons
• Asbestos waste	833 tons
• Solid waste from developed areas	24,823 tons

Other Duisburg wastes landfilled at the ZDE facility include wood scraps; cellulose, paper, and cardboard waste; waste of mineral origin; waste involving chemical conversion and synthesis products; as well as wastes from developed areas.

The Hünxe Landfill in the Wesel District. The Hünxe Landfill, on the boundary of the communities of Hünxe and Schermbeck, is operated by the Ruhr District Waste-Disposal Company mbh. The Waste Disposal Company mbh uses this facility to landfill household hazardous substances (e.g., batteries) from local communities, including Duisburg. For Duisburg, the Hünxe landfill is important as a disposal facility for filter cake from the pollution control trains at the WTE facility (GMVA Niederrhein). In 1989, 6,969 tons of waste from the city area of Duisburg were deposited at the Hünxe landfill.

The Hühnerheide Landfill in Oberhausen. The Hühnerheide Landfill is located in Oberhausen, on the boundary between Dinslachen and Duisburg. It too is operated by the Ruhr District Waste Disposal Company mbh.

For Duisburg, the Hühnerheide Landfill is important for disposal of ash from the WTE facility. Until 1987, the Hühnerheide landfill also served the city as a landfill for mixed construction waste, street sweepings, and digested sludge.

Winterswick Landfill in the Kresel District. The Winterswick Landfill is located within metropolitan Rheinberg. It is also operated by the Ruhr District Waste Disposal Company mbh. The last time the city of Duisburg disposed of waste at the Winterswick site was in 1987. This was mainly construction scrap, earth excavations, mixed construction waste, and street sweepings. In 1989, the rest of metropolitan Duisburg deposited a total of 5,019 tons waste at Winterswick, from wood-processing and site-clearing debris.

The Eyller Berg Landfill in the Wesel District. The privately owned Eyller Berg Landfill is located in Kampt-Lintfort. The city of Duisburg uses the Eyller Berg Landfill for construction scrap, mixed construction scrap, and street sweepings.

Remberger Lake in Duisburg-Huckingen. Remberger Lake in Duisburg-Huckingen was created by excavations that began more than 60 years ago. A part of it has been filled again as a recultivation measure. As part of the reclamation efforts, a private gravel and sand excavation company manages the landfilling in the lake of inert earth excavations, as well as concrete and masonry demolition products. In 1990, 47,239 tons of earth excavation intervals and 52,886 tons of construction scrap were landfilled here.

The three landfills discussed above, which are operated by the Ruhrgebiet Waste Disposal Company mbh, will continue to be important to Duisburg's waste disposal program. The central landfill at Emscherbruch will be the disposal site for the city of Duisburg for all wastes which cannot be avoided, reused, or treated. The landfills at Hühnerheide and Hünxe will also continue to be the most important disposal sites for nonreusable residual materials from the incineration process at the GMVA Niederrhein.

The lifetimes of these landfills cannot be estimated because so many factors are unknown. However, the Lohmannsheide landfill in Duisburg-Baerl, which will soon be in operation, should ensure sufficient capacity over the next 10 years.

4.3.2 Quantities of Waste Handled

4.3.2.1 Overview

Table 4.3-7 provides an estimate of the waste generated in the city of Duisburg. These estimates were developed by the city on the basis of quantities collected by public disposal operations run by the city's waste department and by third parties commissioned by the city. Given the expansion of various collection systems (e.g., paper and hazardous substances), these numbers may not accurately represent the actual proportion of various wastes, but rather the shifting of waste materials among various collection and disposal options. The estimates of the total amount of waste from developed areas disposed of by the city's waste department should be relatively accurate, however, since it can be assumed that shifts within the collection systems do not affect total quantities. As noted in the city's solid waste management plan of 1991, private collection

TABLE 4.3-7

WASTE QUANTITIES IN DUISBURG

TYPE OF WASTE	1985	1986	1987	1988	1989	1990	1991	1992
Residential Waste/City Collected								
Household Waste/Domestic Waste	173,748	174,176	190,658	198,578	194,008	201,058	199,400	200,600
Bulky Waste	14,464	14,457	15,280	15,326	17,867	23,454	25,500	28.200
Waste Paper/Used Glass	7,788	8,830	9,334	10,286	11,961	16,100	16,100	18,110
Household Hazardous Waste	112	160	176	192	250	272	310	260
Street Sweepings	3,000	3,000	3,000	3,227	3,082	1,769	1,900	1,390
Garden and Park Waste	13,279	22,885	17.727	22,430	23,312	30,709	21,900	22,000
Market Wastes	9,150	9,150	9,150	9,150	9,150	9,160	16,200	10.600
SUBTOTAL - RESIDENTIAL WASTE	221.541	232,658	245.325	258.292	257.955	278.373	281.310	281.160
Commercial/Industrial Wastes Similar to Household Wastes (Private Collection)	47,844	48,364	65,230	65,406	67,436	50,348	56,200	55,500
Useful Material - Paper				1,100	1,100	500		
Private Collection								
Used Clothing				300	333	300		
Metal	—	—	—	—	12,940	11,900	10.200	12,000
TOTAL RESIDENTIAL AND COMMERCIAL WASTE	269.385	281,022	310.555	325,098	339,764	341.421	347.710	348.660
PER-CAPITA ESTIMATES								
Population	532.456	528,303	525,482	528.060	532,302	535,230	537.146	538.940
Residential Wastes - Tonnes Per-Capita/Year	416.1	440.4	466.9	489.1	484.6	520.1	523.7	521.7
Total Residential and Commercial Waste - Tonnes Per-Capita/Year	505.9	531.9	591.0	615.6	638.3	637.9	647.3	646.9

of materials such as glass, wastepaper, iron, and textiles do affect this estimate, but these amounts were small compared to the waste collected by the municipal department, at least during the periods prior to the implementation of the DSD program. In order to account for these private efforts, however, the city noted in its report that the actual generation of waste is greater than indicated by the figures in Table 4.3-7.

As indicated in Table 4.3-7, the city of Duisburg in its 1991 report separated waste into the following categories: Residential Waste (collected by the city); Commercial/Industrial Waste Similar to Household Waste and Useful Materials Collected by Private Companies; Construction and Demolition Debris; Road and Earth Excavations; and Wastewater Treatment Plant Residuals. Collection, processing, and disposal of these various categories of waste material are discussed below.

4.3.2.2 Per-Capita Residential Waste

Residential Waste includes household waste; bulky waste from households; wastepaper; used glass; street sweepings; garden and park waste; and market waste. In 1985, the estimated total residential waste generated (based on the amounts handled by the City Waste Department) in developed areas amounted to 221,541 tons; in 1990, it amounted to 278,373 tons. This represents an increase of 58,892 tons, or 25.65% over a five-year period (an average annual increase of 4.7%). Residential waste increased approximately 1.05% in 1991 and remained almost constant in 1992, actually falling 0.05%.

Household Waste, one component of residential waste, showed a similar increase during the period 1985-1990 (15.72% over five years, or almost 3.0% per year). In 1991, however, this figure declined slightly, then rose slightly in 1992, for a decrease of 0.23% over the two-year period. This may be due in part to the increased quantities of waste being diverted to recycling (18,110 tons in 1992 versus 11,961 tons in 1990).

The per-capita figures show much the same pattern over the 1985-1992 period. In 1985, residential waste averaged 416.07 kg/per capita. This grew to 520.1 kg/per capita in 1990 and 521.69 per capita in 1992. Adding industrial/commercial wastes similar to household waste and useful materials yields a rate in 1985 of 505.9 kg per capita, and in 1990, of 637.9 kg per capita (an average annual increase of 5.25%). In 1991, however, the per-capita rate rose only to 647.3, an increase of 1.48%, and in 1992, actually fell to 646.9, a decrease of 0.06%.

When compared to the national figures for 1984 (362 kg per capita) and 1990 (333 kg per capita), it is clear that a substantially greater than average amount of waste per capita is generated in Duisburg. This is due in part to the greater level of commercial activity in this densely populated, highly industrialized urban environment.

4.3.2.3 Waste by Category

Paper

Table 4.3-8 compares the per-capita tonnages captured in the curbside collection area versus the drop-off areas. While the amount recovered per capita is greater for the curbside program, the amount captured per capita through the drop-off program increases as the density of drop-off containers increases.

TABLE 4.3-8
Tons OF PAPER COLLECTED

YEAR	DROP-OFF (Tons)	CURBSIDE (Tons)	DROP-OFF (kg/capita)	CURBSIDE (kg/capita)
1982	108	1,004	0.22	15.21
1983	1,111	1,024	2.27	15.81
1984	1,716	887	3.61	14.01
1985	2,420	611	5.51	9.76
1986	3,225	888	6.92	14.27
1987	3,667	1,044	7.91	16.82
1988	3,863	955	8.29	15.43
1989	4,360	928	9.28	14.87
1990	4,982	1,078	10.54	17.24

NOTE: The curbside program is limited to the Rheinhausen district, which represents approximately 12% of the city's total population.

Glass

The amount of glass collected by the city was discussed earlier in Section 4.3.1.2.

Organic Waste

Table 4.3-9 details the types and quantities of waste that have been processed in the composting plant from 1985 through 1990.

TABLE 4.3-9
MATERIALS PROCESSED AT THE COMPOSTING FACILITY: 1985-1990
(000 Tons Per Year)

Material	1985	1986	1987	1988	1989	1990
Household Waste	13.3	11.0	10.7	2.9	9.4	4.3
Leaves	1.5	4.2	1.0	2.5	2.5	4.3
Paper			0.3	2.0	0.1	2.9
Zoo Dung					0.2	0.2
Sludge	2.8	2.4	2.2	0.6		
Total	17.6	17.6	14.2	8.0	12.1	11.7

Garden and park wastes (including leaves) are collected and/or processed as part of the city's integrated waste management system. Table 4.3-10 summarizes the treatment approaches utilized by the city for its garden and park wastes for the period 1985-1992.

TABLE 4.3-10
GARDEN AND PARK WASTE PROCESSING: 1985-1992
(000 Tons Per Year)

PROCESSING APPROACH	1985	1986	1987	1988	1989	1990	1991	1992
Composted (either at the compost facility or in static piles on site)	9.5	17.1	15.4	16.9	16.62	25.01	19.72	20.2
Chipped	--	0.1	0.2	0.4	0.45	0.5	5.	5.
Combusted	3.8	5.7	2.2	5.2	6.2	5.2	1.7	1.3
TOTAL	13.3	22.9	17.8	22.5	23.25	30.7	21.9	22.0

Market Waste

Market waste, which includes packaging materials (cardboard containers, paper, plastic, pallets), and organic materials, was estimated by the city to be about 9,150 tons per year through 1990. In 1992, the city estimated that approximately 10,600 tons were generated. Of the 10,600 tons generated in 1992, 1,100 tons were recovered and 9,500 tons were processed at the WTE facility.

Construction and Demolition Debris and Road and Earth Excavations

Construction and demolition debris, and road and earth excavations amount to 60% of Duisburg's total waste. The quantitative data for construction waste provided in the city's 1991 report is based only on deliveries to processing facilities and landfills; materials directly reused on site have not generally been included in the estimates. In addition, as noted in the city's report, the Duisburg portion of the quantities delivered to processing facilities and landfills is only an estimate.

Table 4.3-11 shows that construction waste increased each year from 1989 to 1991 and then declined in 1992. Thus, in 1990, approximately 612,000 tons of such waste were treated or disposed of, some 180,000 tons more than in 1989. As noted in the city's plan, this increase was probably due to recent economic developments, which stimulated the growth of the construction business in Duisburg. Similarly, the decline in the total generated in 1992 may well be due to a decline in construction activity.

As indicated in Table 4.3-11, the percentage of such materials recycled/reused has grown each year and exceeds the recycling targets delineated in the proposed ordinance for construction and demolition debris.

The city estimated in 1990 that the following quantities of construction and demolition waste, excavated spoils, and excavation material were generated:

• Construction and Demolition Debris	134,000 tons
• Excavation Materials	
- Roads	113,000 tons
- Land Clearing	913,000 tons

The city estimates that a significant percentage of the land-clearing debris is reused on site for fill and grading. For the balance of the materials, four local private companies process the materials and separate out the reusable portions, which include metals, wood, soil, as well as aggregate, for reuse in other applications. The processing involves sorting, crushing, and separating the materials into various fractions. The residuals from these processes are generally landfilled.

Waste from Water Processing and Wastewater Purification

The waste handling plan of the city of Duisburg deals only with the waste associated with its own sewage systems. In the rest of the Duisburg City area, however, three wastewater associations (the Emsch Society, the Ruhr Association, and the West-Lower-Rhenish Drainage Society) operate six sewage treatment plants. According to the Lander Waste Law, these associates are responsible for the disposal of sewage sludge and residual substances from the purification of wastewater in their plants. The Emsch Society disposes of its sludge via a sludge incinerator located in Bottrop. The Ruhr Association disposes of its waste in a monofill for sludge. The Drainage Society relies on land spreading.

TABLE 4.3-11
C&D AND ROAD AND EXCAVATION MATERIALS

	Proposed Target	1989	1990	1991	1992
Processed/Reused:					
Excavated Material (spoils)		113,000	152,000	189,900	211,000
Road Excavation Material		165,000	195,000	216,800	145,000
Construction & Demolition Waste		103,000	133,000	209,000	227,000
TOTAL		381,000	480,000	615,700	583,000
Landfilled:					
Excavated Material (spoils)			44,400	38,000	21,500
Road Excavation Material			33,300	600	
Construction & Demolition Waste			54,300	41,100	23,900
TOTAL		51,000	132,000	79,700	45,400
Fraction Recycled/Recovered					
	Proposed Target				
Excavated Material (spoils)	70%	NA	77.5%	83.3%	90.8%
Road Excavation Material	90%	NA	85.4%	99.7%	100.0%
Construction & Demolition Waste	0%	NA	71.0%	83.6%	90.5%
TOTAL		88.2%	78.4%	88.5%	92.8%

Table 4.3-12 details the amount of sludge and residual materials generated at the city-owned facilities for the period 1987-1992.

TABLE 4.3-12
WASTEWATER TREATMENT PLANTS - CITY OF DUISBURG
QUANTITY OF DIGESTED SLUDGE, SCREENINGS, AND GRIT
1987 - 1992

YEAR	Tons
1987	9,858
1988	9,045
1989	10,344
1990	14,461
1991	15,440
1992	16,210

As the table indicates, from 1987 to 1989 the amount of sludge from the city's three sewage systems varied only slightly, but in 1990 it increased noticeably to about 14,500 tons. This was the result of the establishment of the biological section of the Hochfeld sewage plant in 1990. The city reports that the amended Wastewater Administrative Directives will impose more stringent minimum requirements relating to, among other things, the elimination of phosphate and nitrate from wastewater. These directives, together with the Federal Waste-Water Quality Program, will necessitate further expansion of all city sewage plants. Accordingly, further increases in sludge and residual substances can be expected.

Waste Metal/Scrap

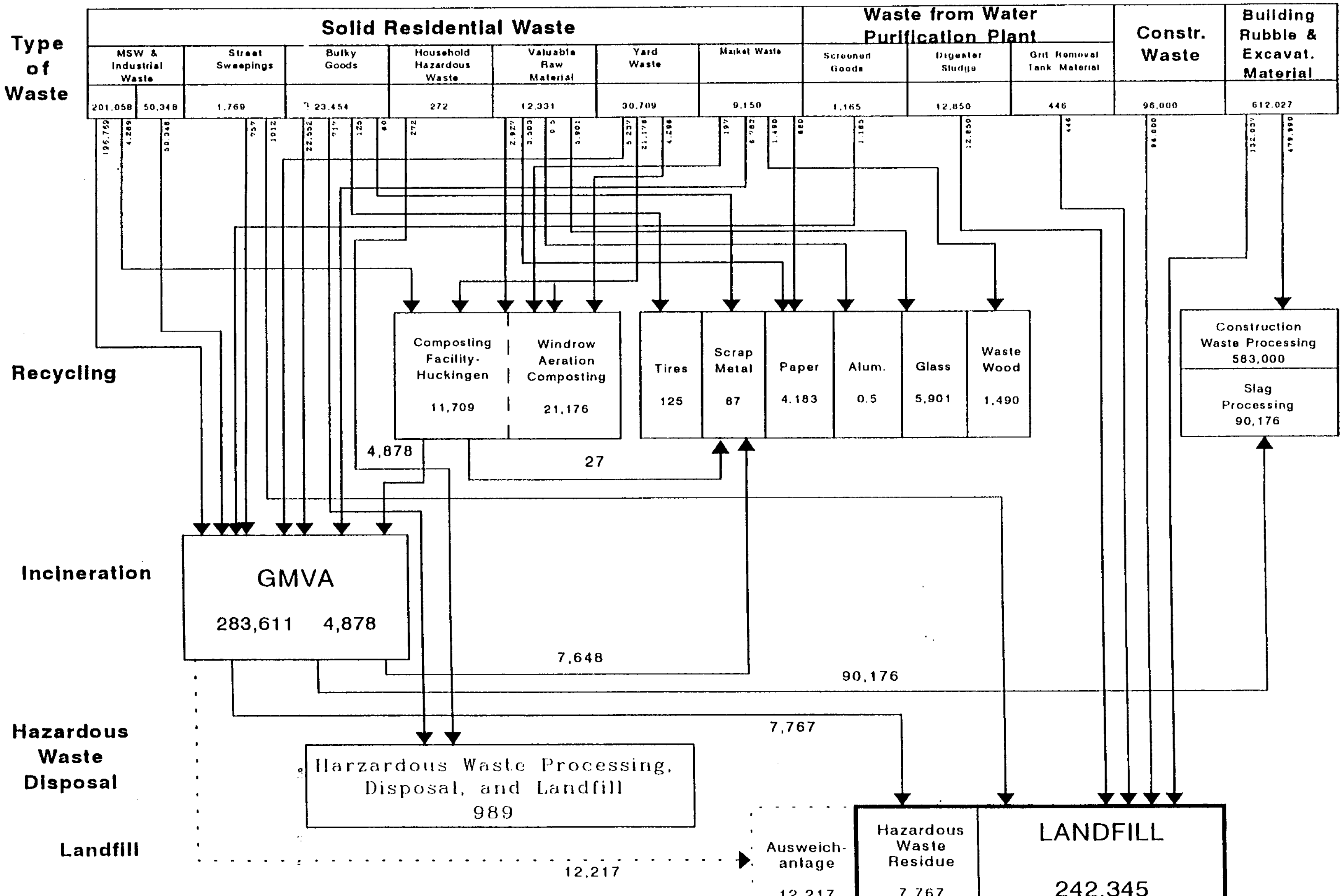
Ferrous metals are recovered at both the WTE facility and the composting facility. At the WTE facility, they are recovered from the ash by use of a magnetic separating pulley on the ash conveyor. At the composting facility, ferrous materials are removed from the feed prior to its entering the compost drums, again by use of a magnetic separator. Ferrous metals are also recovered from bulky waste. All of the recovered metals are delivered to the steel industry for recycling.

4.3.2.4 Waste Management in 1990

The following section describes the disposition of wastes in 1990, as detailed in the city's Waste Management Plan.

Figure 4.3-4 provides an overview of the city's waste streams during 1990 and their assignment to respective disposal or recycling facilities. (The data in this figure were taken from the city's 1991 plan.)

FIGURE 4.3-4
IWM SYSTEM FLOW DIAGRAM - CITY OF DUISBURG - 1990



Source: City's Waste Management Plan - 1991

In Figure 4.3-4, the first row lists the types of wastes by groups. Their 1990 quantities are specified, as well as the institutions (city or private) responsible for their collection and transport. A step model illustrates the various disposal steps: recycling; waste treatment (GMVA or special waste treatment);and landfilling. On the line connecting the types of waste and the disposal facilities or recycling possibilities, the flow of waste is always shown by a directional arrow.

With respect to street sweepings, it should be noted that the combustible portion cited in Figure 4.3-4, amounting to some 760 tons per year, does not correspond to the total portion of street sweeping wastes. At the operating yard, wastes like domestic trash and street sweepings are loaded together and transported in containers to the GMVA, so a precise apportionment is not possible.

Of the domestic waste and commercial waste similar to domestic waste from developed areas, amounting to 329,091 tons, 32,885 tons were composted and 11,759 tons were recycled—a composting fraction of approximately 10% and a recycling fraction of 3.6%, totaling 13.6%.

Of this total (approximately 329,000 tons), 50,348 tons were commercial waste similar to domestic waste. These commercial wastes were delivered by private firms to the GMVA Niederrhein facility. Of the remaining 278,743 tons of domestic waste, 11.8% were composted and 4.2% were recycled, totalling 16%.

In 1990, the GMVA Niederrhein incinerated 460,447 tons of waste from developed areas. 288,489 tons of this came from Duisburg. This total is composed of various types of waste:

• Domestic trash and commercial trash similar to domestic trash	247,117 tons
• Bulky waste	22,552 tons
• Street sweepings	757 tons
• Market waste	6,783 tons
• Garden and park waste	5,237 tons
• Raked-up material	1,165 tons
• Sifting residues from the composting plant	4,878 tons
TOTAL	288,489 tons

In 1990, 89.1% of the city's domestic trash and commercial trash similar to domestic trash were disposed of at the GMVA Niederrhein. This figure includes useful materials extracted at GMVA as well as the materials re-routed for disposal at the central landfill at Emscherbruch when capacity was temporarily unavailable at the Niederrhein facility.

The figures below indicate the percentage of waste by category that was processed at the GMVA Niederrhein in 1990.

• Domestic trash and commercial trash similar to domestic trash	89.1%
• Bulky waste	96.2%
• Street sweepings	42.8%

- Market waste 74.1%
- Garden and park waste 17.1%
- Raked-up material 100.0%

In addition, 7,648 tons at the GMVA Neiderrhein facility and 27 tons at the compost facility, totalling 7,675 tons of metals, were recovered from the waste flow in 1990 by magnetic separators, while the waste was being incinerated or composted. These metals were routed to the scrap business. The recycling fraction is therefore increased to 18.6% (domestic waste) or 15.7% (total amount, including commercial waste similar to domestic waste). The requirement of 30% recycling, relative to the domestic waste sector, thus has not yet been achieved.

The portion of waste from developed areas that was treated thermally in 1990 was about 283,611 tons, corresponding to 86.2%. To this quantity must be added the sifting residues from composting, in the amount of 4,878 tons. It must also be considered that about 12,217 tons could not be processed in the GMVA because of conversion operations. These materials had to be brought directly to the Emscherbruck Central Landfill.

The amount conducted to special waste treatment or processing facilities was 989 tons. This represented 0.3% of the total waste handled by the city. Here it must be taken into account that the processing of problematic bulky waste (717 tons in 1990) yields considerable quantities of metals for recirculation.

As indicated in Figure 4.3-3, wastes from water processing and wastewater purification take two disposal paths. The total amount for disposal in 1990 was 14,461 tons. About 91.9% of these wastes had to be landfilled, while only 8.1% are utilized thermally.

Construction wastes are assigned to the group of construction scrap, road demolitions, and earth excavations. For 1990, such wastes were estimated at 612,027 tons. This amount was recorded at the facilities for construction-scrap processing and landfilling, but does not contain earth excavations, which are moved at the construction sites and temporarily stored in interim storage areas, then filled in again. Such waste does not come in contact with the above facilities and consequently cannot be recorded. The operation of such construction-scrap processing facilities eliminates a great load from the landfill volume.

242,345 tons of Duisburg's waste were deposited in landfills. To this must be added the overflow from the GMVA Niederrhein, amounting to 12,217 tons in 1990. Filter dusts and filter cakes from the GMVA, amounting to 7,767 tons in the same year, were also disposed of at a landfill.

The distribution, relative to the total recorded amount in 1990, is outlined in Table 4.3-13.

TABLE 4.3-13
DISPOSITION OF WASTE STREAM

Total Amount	1,051,576 tons	100.00%
Recycling	564,634 tons	48.89%
Incineration	283,611 tons	26.79%
Special Waste Treatment	989 tons	0.10%
Landfilling	242,345 tons	23.04%

4.3.3 Budget and Fees

As a result of the recent reorganization of Duisburg's waste management department into a separate operating company, the city is in the process of restructuring its accounting and billing functions. The administrative staff were not, therefore, in a position to provide cost data on the existing system.

4.3.4 The Future

The city has identified the following areas as having an impact on its future waste management programs:

- developments in waste avoidance;
- developments in the recovery of usable materials;
- effects of the Packaging Ordinance; and
- assured disposal for individual types of waste.

These areas can be discussed with varying degrees of confidence. In the case of waste avoidance, for example, it is only possible to hypothesize; in the area of material reuse, it is possible to speak with somewhat more certainty, at least about the near term. As for the effects of the Packaging Ordinance, they cannot yet be accurately estimated, although they will clearly have a major impact on waste handling and management. On the other hand, reliable statements can be made regarding the city's continued disposal capacity through the year 2000.

4.3.4.1 Avoidance of Waste

In any discussion of waste avoidance, the main focus is on domestic trash and commercial waste similar to domestic trash.

With regard to domestic trash (domestic trash plus useful substances plus pollutants), the city's forecast is for an increase from 213,000 tons in 1990 to 256,000 tons in the year 2000. This projection is based on the rates of increase during recent years and the overall trend from 1985-1990. It is essential to counteract this trend using reasonable means of waste avoidance. Thus, if the city can achieve the 15% avoidance rate required in its 1990 plan, the alternative forecast scenario yields a drop from 213,000 tons in 1990 to approximately 180,000 tons in the year 2000.

The effectiveness of the city's waste avoidance efforts will probably fall between these two extremes. It remains to be seen how much can actually be achieved in this area. As noted in the city's plan, the only feasible course of action is to utilize and expand all the current methods of waste avoidance, including consultation, education, and regulation, evaluating success year by year through the waste survey and waste balance sheet.

As for wastes from water processing and water purification systems, these should actually increase as part of increasingly effective wastewater purification systems. With respect to construction waste (earth excavations, construction scrap, street excavations, and waste from construction sites), these depend largely on the business cycle. In individual branches of the construction trade, techniques must be designed to minimize the use of nonrecyclable materials. Close collaboration with trade organizations, such as the Chamber of Handicrafts in Germany, as well as with individual enterprises, will be essential to this effort. Here again, however, the results remain to be seen.

4.3.4.2 Development of Materials Recycling

To analyze developments in materials recycling, the city's 1991 plan used the 1990 waste streams quantities as a basis for estimating future requirements. Table 4.3-14 outlines these estimates.

With regard to the total quantity of waste (domestic and commercial similar to domestic), the city is projecting an increase in the recycling/composting portion from approximately 14% (in 1990) to roughly 29% in the year 2000. This anticipated rate approaches the specification of 30% required by the legislation and regulations.

When taking into account construction, demolition, and building wastes, the total percentage of recycled substances rises to about 70%. The reason for this high recycling rate is the consistent and complete utilization of construction wastes.

4.3.4.3 Effects of the Packaging Ordinance

The city estimates that full implementation of the Packaging Ordinance, including the buildup of a separate collection system for packaging materials, will relieve Duisburg's waste disposal burden by about 30% by weight. The Packaging Ordinance prescribes different fulfillment quotas between 1993 and 1995. If these stipulations are completely met, by 1995 approximately 78,000 tons of waste (domestic trash plus commercial trash similar to domestic trash plus usable substances) out of a total of about 263,000 tons would be regarded as packaging waste.

The city's usable substance containers are already being filled with components of this packaging waste, such as waste glass and wastepaper. The increased recycling of usable materials through this collection (see previous section) will significantly increase the amount of waste that can be dealt with separately. Large quantities of usable materials and packaging materials will also be sorted out from commercial wastes similar to domestic trash fed to the RZO. Metals separated by magnetic separators in the disposal facilities come mainly from cans and thus could also be considered packaging materials.

TABLE 4.3-14
FUTURE DEVELOPMENTS IN THE UTILIZATION OF MATERIAL

SYSTEM COVERED	PREVIOUSLY CAPTURED QUANTITIES (tons)	QUANTITIES TO BE CAPTURED ACCORDING TO PLAN (tons)	INCREASE OF THE QUANTITY CAPTURED (tons)
Wastepaper	6,060	16,100	10,040
Waste Glass	5,901	10,700	4,799
Metals from GMVA (Duisburg share) • Processing Yards • Problem Bulky Material	≈7,650 60 717	≈7,650 500 1,500	 440 783
Aluminum - 0.4 weight %	0.5	300	3200
Problem Wastes	272	550	278
Junked Tires	150	200	50
Sorting of 90,000 Tons Commercial Waste in the RZO, 33% Marketable, 29,700 Tons Fraction, Duisburg 60%	--	17,820	17,820
Green Wastes from: • Collection of Bulky Material • Processing Yards • Maintenance of Green Areas	 -- -- 25,472	 3,000 1,000 30,700	 3,000 1,000 5,230
Market Wastes	2,367	3,500	1,130
SUBTOTAL	48,649.5	93,520	44,870
Construction Site Wastes	--	96,000	96,000
Construction Scrap, Street Excavation, Earth Excavations 90% of 612,027	479,990	550,800	70,810
SUBTOTAL	528,639.6	740,320	211,680
Pilot Project 1: Intensive Coverage of All Dry Usable Substances 15,000 E x 52 kgE*a	--	780	780
Pilot Project 2: Bio-barrel 15,000 E*2 kg/W*52	--	1,560	1,560
SUBTOTAL	--	2,340	2,340
TOTAL	528,639.5	742,600	214,020

Source: Duisburg Solid Waste Management Plan, 1991

As noted in the city's plan, if expanded recovery of the usable materials listed here is realized, the requirements of the Packaging Ordinance can be met. The necessary regulations for handling the collected packaging materials, which may eventually include magazines and newspapers as part of the announced Ordinance for Returning Print Materials, must be clarified and contractually secured. By 1995, it should be clear whether or not the introduction of city-wide collection of plastics and composite materials, and their sorting, utilization, and recycling, has led to intensive recovery of usable materials.

4.3.4.4 Ensured Disposal of the Various Categories of Waste

According to the city, the existing waste disposal system (with the changes described in earlier sections of this report) will be adequate to meet the city's disposal needs for the near term (at least until the year 2000). Existing disposal facilities, such as the Huckingen composting plant and the GMVA Niederrhein in Oberhausen, and the available markets for usable substances (e.g., the glass works or wastepaper recycling facilities) are considered adequate, with the proposed upgrades and adaptations to the state of the art. Construction of an interim pollutant depot in the processing yard at Rheinhauser Street seems advisable for the safe and proper interim storage, sorting, and preparation for transport of problem wastes. An additional composting facility is necessary for the further processing of vegetative matter and for the continued composting of green and park wastes. This could provide long-term composting of about 40,000 tons per year of compostable waste.

The existing construction-scrap processing facilities and the processing facilities for mixed construction-site wastes, for which permits are now in process, should ensure adequate disposal of this type of waste.

As discussed in the city's plan, most of its waste management needs are being met by facilities located within the city proper or within local jurisdictions with which Duisburg has a long history of cooperative efforts. Only in landfill use must Duisburg fall back on regional solutions. Thus, particular efforts must be made to reduce the load on existing landfills. The Emscherbruch landfill in Gelsenkirchen will be sufficient until the year 2000. The city's 1991 plan recommended that preparations be made for site approval of the Lohmannsheide landfill in Duisburg-Baerl. In addition, the plan also recommended the construction of the Duisburg disposal center for disposal of special waste (including commercial and industrial waste). This facility would serve as a reliable disposal facility for special waste and would relieve the landfill of shredder wastes and sewage sludge.

4.3.5 <u>Summary</u>

Duisburg has in place a waste management system which meets the characteristics of an integrated waste management system; namely, it incorporates source reduction, recycling/reuse, composting, resource recovery, and landfilling. This integrated waste management system in Duisburg is comprised of several facilities, located throughout the city and in other jurisdictions in the region. The facilities in place include composting facilities; a recyclable materials processing facility; construction, demolition, and building waste processing facilities; a WTE facility; hazardous waste treatment facilities; sludge processing and land application facilities; as well as landfill disposal facilities.

The integrated waste management system in Duisburg draws upon both public and private sector participants. Several of the facilities are operated by private sector companies. Private companies also provide for some collection of certain portions of the waste stream. In addition, the city organization responsible for waste management services has itself recently undergone a significant transition, from a department of city government into a stand-alone enterprise. The new organization has been set up as a separate enterprise-fund-based operating company.

The implementation of the Duales System Deutschland program in Duisburg is drawing upon this private/public sector spirit of cooperation. The same organization within the city that is responsible for providing waste management services is also providing collection services for the yellow bin, which is being distributed to each household for separate collection of the light fraction of packaging wastes. The glass and paper fractions are being collected in numerous drop-off bins located throughout the city.

As part of the city's integrated waste management program, the importance of source reduction and waste minimization has been identified. The role of waste reduction is now an integral part of the city's educational efforts related to waste management, including the information packets developed in support of the implementation of the DSD program. These materials highlight the purpose of the DSD program, the need for consumer cooperation, and the role of the Packaging Ordinance in fostering waste reduction by helping to divert packaging materials from disposal.

Duisburg's waste management program has been developed over an extended period of time. Certain portions of the system have been in place since the 1970s, and the composting operation is among the oldest operating composting facilities in Germany. It is also clear that the city has in the past relied upon the process of testing alternative approaches in pilot programs in order to better address the impacts associated with full-scale implementation of major programmatic changes. This approach continues in the city's current pilot program to test a bio-bin program for the separate collection of source-separated organics from domestic wastes.

Among the more interesting aspects of the Duisburg system are: (1) the use of both an extensive network of drop-off boxes and curbside collection in some sections of the city for paper; (2) the public/private sector partnerships sharing responsibility for several core elements of the integrated system; (3) the decision by the city to establish a separate stand-alone corporate entity to provide for its waste management needs; and (4) the use of a composting facility to process mixed MSW (albeit currently a small fraction of the city's waste mixed MSW and, given the emphasis being placed on source-separated organic materials as the preferred feedstock for such facilities, likely to decrease even more).

4.4 MUNICH

Munich, the capital of Bavaria, is the third largest city in Germany, with approximately 1,200,000 inhabitants. Bavaria is the largest Lander or state, in Germany, with a population of approximately 11.2 million and a land area of 70,554 sq. km.

Bavaria is Germany's largest farming region. Munich's early development reflected its role as a rural capital, although its pre-World War II business base also included mechanical and electrical engineering, brewing, and insurance. After the war, Munich became the focal point of rapid economic expansion that included growth in such areas as electrical/electronics manufacturing; automobiles; fashion; advertising; insurance; and publishing. Today, Munich is also a center of higher education, software development, and research.

4.4.1 Munich Municipal Waste Management System

4.4.1.1 General Description

Municipal Waste Management in Munich is handled by the Kommunalrefertrat der Landeshauptstadt Munchen. The Office for Waste Management (Amt für Abfallwirtschaft) is a separate department within the city administration. More than 1,500 people are employed in the city's waste management system. The organizational chart is shown in Figure 4.4-1

Munich's waste management system is based upon three principles—avoiding wastes, recycling wastes, and finally, disposing of the balance in an ecologically sound manner. This conceptual framework, approved by the Munich City Council in 1988, is consistent with subsequent legislation passed at the state and federal levels. In March 1991, the Bavarian Waste and Contamination Law became effective, identifying waste avoidance as its top priority. Similarly, Munich's hierarchy of waste avoidance, recycling, and finally, ecologically sound disposal is certainly consistent with the federal legislation previously discussed.

Munich's integrated waste management incorporates the following components:

- Source reduction
- Recycling/reuse
- Composting
- Waste-to-energy
- Landfilling.

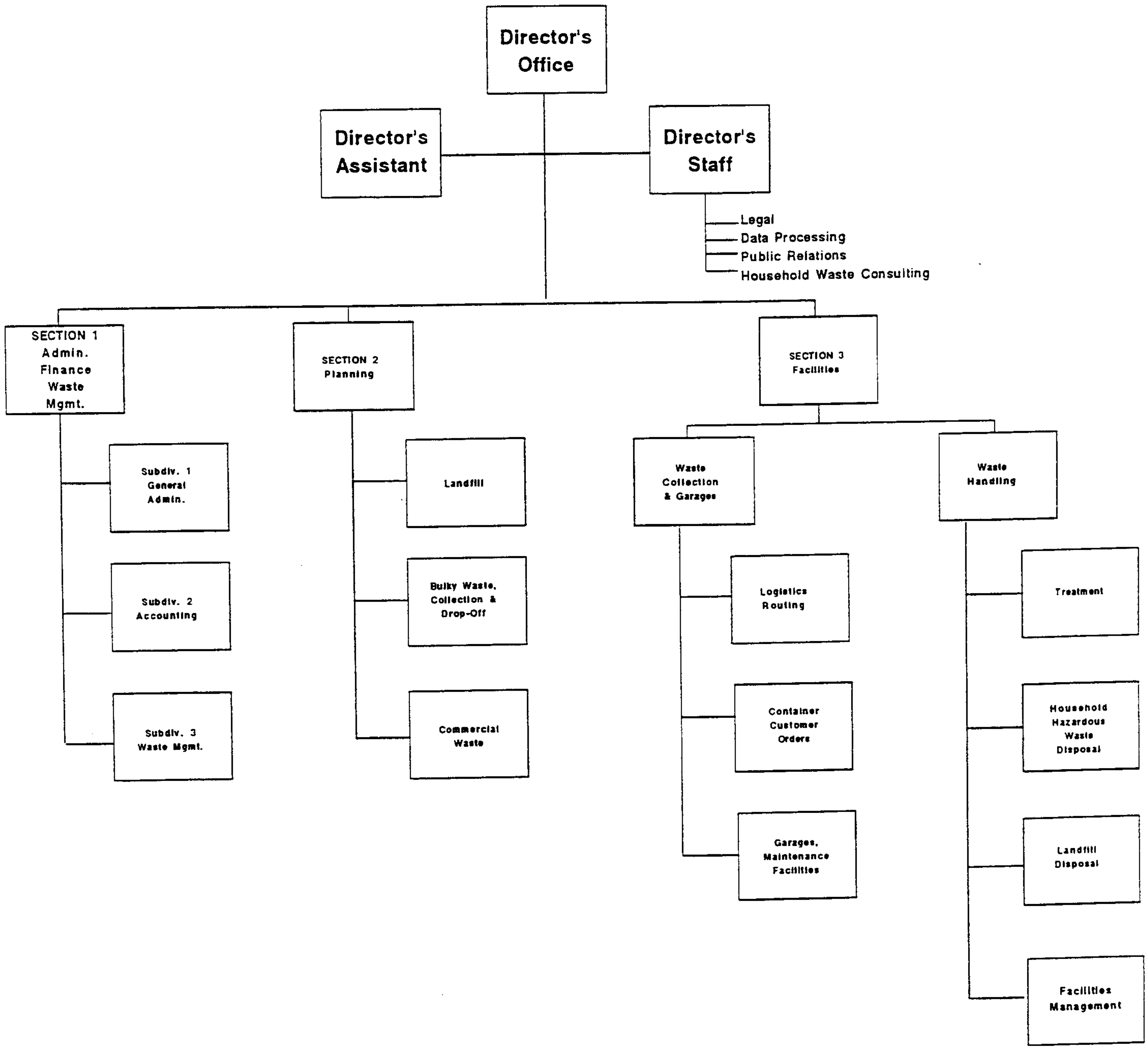
The existing major components of the system include over 500 drop-off locations for paper and glass; nine useful material yards providing drop-off capacity for bulky waste, as well as other materials with additional capability to be added; garden composting programs; a pilot collection program for organic wastes; two WTE facilities, and a regional landfill. Section 4.4.1.2 details the key components of Munich's program.

4.4.1.2 Integrated Waste Management System Components

Munich's integrated waste management program breaks down as follows:

- Waste avoidance
- Collection
- Drop-off facilities
- Materials processing
- Composting
- Waste-to-energy
- Landfilling.

FIGURE 4.4-1
CITY OF MUNICH - OFFICE OF WASTE MANAGEMENT



Each of these components is discussed below. Figure 4.4-2 details the facilities that comprise the city's waste management system.

Waste Avoidance

The Bavarian Waste and Contamination Law (BayAbfAlG), which became effective March 1, 1991, defined waste avoidance as its top priority. This mandate clearly established the need for effective ongoing waste reduction programs. In turn, the design and implementation of such programs required input from households and commercial businesses, and the review and support of existing waste prevention programs run by industry, associations, city councils, and other institutions.

At its inception, the Munich waste management plan estimated that waste reduction would reach a level of 285,000 tons per year by 1993. In 1992, residual waste was reduced by about 250,000 tons from the 1989 level. During the last three years, the volume of incinerated or landfilled residual waste decreased by a total of 21%. The amount of material delivered to landfills was 30% less in 1993 than in 1991, due primarily to a sharp drop in construction and demolition debris resulting from consistent application of the Industrial and Construction Waste Disposal statute, which regulates the type of materials disposed of in landfills.

The Industrial and Construction Waste Disposal Statute mandates the separation of such waste into three categories: contaminated soil, useful materials, and inert materials. Since going into effect on October 31, 1989, this ordinance has had noticeable results. Clean fill, as well as clean building scrap—so-called inert material—may no longer be landfilled, so the number of deliveries of construction waste to the North-West landfill has substantially declined.

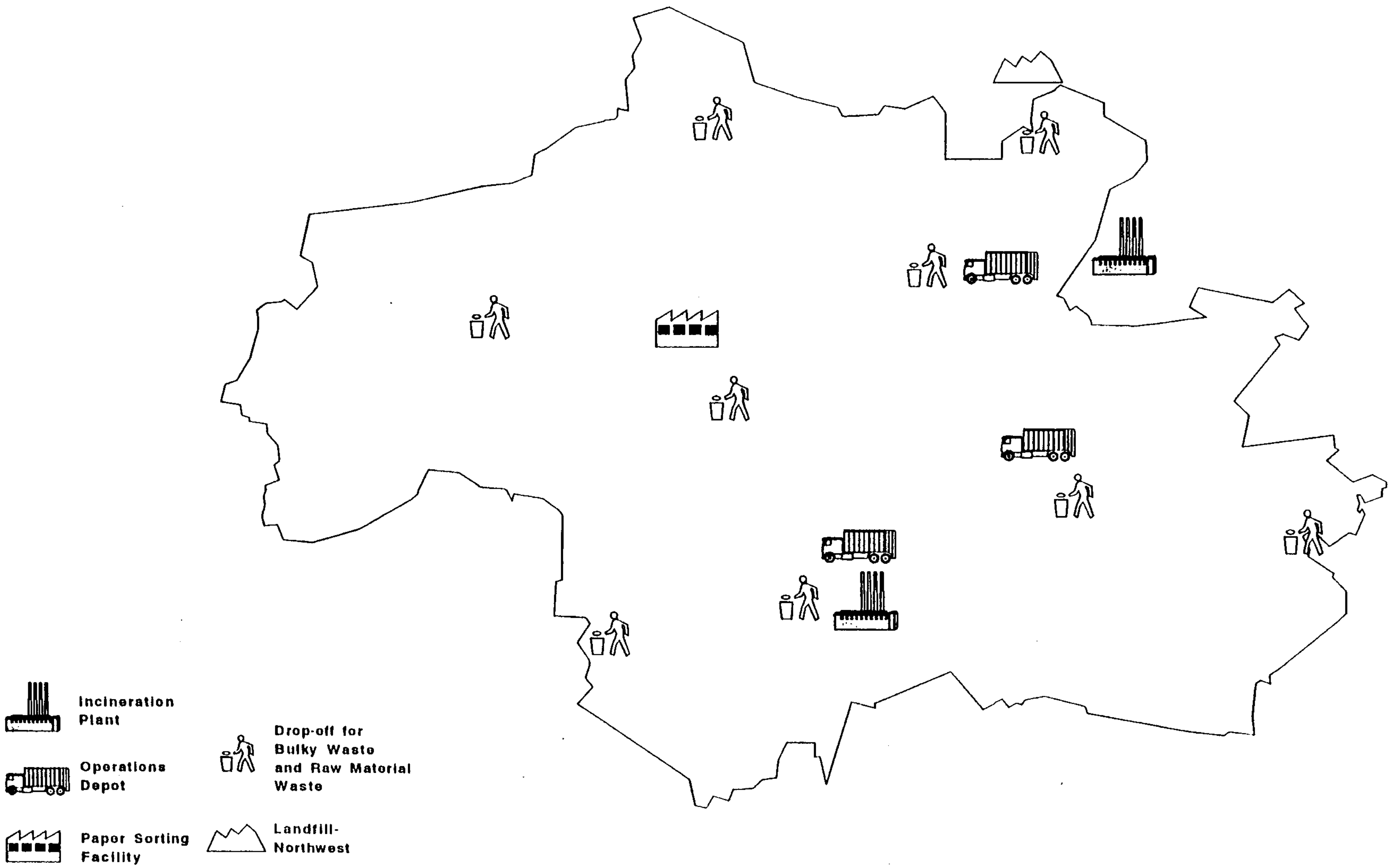
Furthermore, since August 1990, the additional separation of industrial and construction wastes into six categories of usable material has been required. As a result, in 1992, the volume of industrial and construction waste delivered to landfills and to incineration facilities decreased by 58,403 tons.

More generally, consistent controls at the landfill, including the rejection of loads with usable material, reduced landfilled waste from within the Munich city limits by about 20% from 1991 to 1992, from 461,560 tons to 363,509 tons. The volume of waste delivered to the city landfill by the county fell even more sharply, from 55,935 tons in 1991 to only 7,941 tons in 1992. Thus, the total volume of waste disposed of at the city landfill declined by 371,450 tons, or 28%, in just one year.

The city of Munich has implemented the principles of waste avoidance and waste reduction through the broad exclusion of throw-away goods and utensils at city agencies and the requirement that all municipal departments purchase economically and ecologically; separate paper and residual waste; and, as much as possible, recycle office materials.

Munich's efforts to foster the use of reusable materials and implement effective separation of waste at all city celebrations have contributed to the overall reduction in the volume of waste. At the Oktoberfest, the Bavarian fairs, and the Christmas Market, only reusable dishes and

FIGURE 4.4-2
SOLID WASTE MANAGEMENT FACILITIES IN THE CITY OF MUNICH



utensils are permitted, and the paper, cardboard, and non-reusable glass must be recycled. Within the entire Olympic Park (especially the Olympic Stadium), food and drink can be distributed only in reusable containers. Private events on public land (theater festivals, street fairs) are likewise subject to the throw-away prohibition.

Two "wash-mobiles" are available for city-sponsored celebrations, and the organizers of private, non-commercial celebrations can also rent them for DM 200. These mobile units make it possible to wash reusable plates, dishes, and other items on site. The wash-mobile of the Office of Waste Handling has been used 24 times since the middle of June 1992; the wash-mobile of the Municipal Youth Office has been used 34 times.

A few years ago, the city introduced legislation that would have further restricted the use of throw-away packages for beer and mineral water throughout the region, beginning in 1991, and completely prohibited throw-away packaging of fresh milk beginning in 1992. The legislation was overturned by the Administrative Court in a judicial review proceeding; the city appealed to the Federal Administrative Court, which upheld the initial judgment. Despite this setback, the city continues to look for ways to foster the use of reusable packaging.

Collection

In 1991, as an incentive to avoid waste, the city introduced an optional 14-day waste collection cycle, using 110-, 120-, and 240-liter bins. The collection fee was cut in half for those choosing this option. Since January 1, 1991, a total of 18,215 homeowners have taken advantage of this program.

In 1991, the City Council also passed an ordinance mandating the gradual implementation of the following collection system for residential wastes:

- One (blue) bin for paper, cardboard, and cartons;
- One (brown) bin for biowastes; and
- One (gray) bin for residual waste.

Up to 40% of domestic waste, by weight, consists of biological waste; approximately another 20% consists of paper and cardboard. Since these materials can be composted, recycled, or reused, the three-bin system is expected to significantly reduce the amount of residual waste to be disposed of by incineration and landfilling.

The three-bin system was pilot tested in Berg am Laim (population: 10,000). While the total volume of waste remained nearly constant, the paper bin skimmed off one kg per resident per week, and the bio-bin 0.67 kg per resident per week. Extrapolated to the number of residents in all of Munich, this would mean that approximately 114,680 tons of usable materials per year would be kept out of city disposal facilities.

The pilot test on bio-bins was continued and expanded to other parts of the city, raising the number of bio-bin households to 20,000 (about 40,000 persons). Three-axle compactor vehicles, equipped with a special seal, were used for collection. The vehicles were also equipped with

400-liter tanks to handle the resulting press water, since the biological wastes in certain areas of the inner city had an unexpectedly high water content (up to 77%).

The residents of Aubing and Neuperlach had previously used paper bins. In 1991, the residents of several other areas were switched from a single-bin system for commingled paper, glass, and plastics to separate paper bins, bringing the total using such a system to 88,000 residents. Another 140,000 residents in the areas of Freemann, Haderu, Posting, Aubing, and Lochhausen began using paper bins in 1993. By the end of 1995, paper bins are expected to be in use throughout the city.

Paper Collection at Schools

In 1991, in collaboration with the School Committee, the Office of Waste Handling introduced the separate collection of school-generated wastepaper at nearly all city schools. For a fee, state schools and private schools can also participate in a separate paper collection program.

Bulky Waste Collection

In 1992, the Office of Waste Handling offered free bulky waste pickup in addition to continuing to provide nine drop-off sites where citizens can deliver such wastes, also free of charge. 35,323 orders were received; an actual pickup was carried out at 26,163 households.

Refrigerator Collection

In 1992, 8,735 refrigerators were picked up, on call, free of charge (1991: 7,272).

Problem Waste Collection

Mobile Household Hazardous Waste Collection Vehicles. Since 1989, two mobile household hazardous waste collection vehicles have collected pollutants from private households. In addition, the usable-material yard at Duisburger Street has a stationary receiving facility for problem waste from households. In 1992, a total of 158 tons of problem waste were deposited with the mobile collection units and at the usable-material yard on Duisburger Street. This decline of about 33 tons from the previous year is the result of the increasing use of ecologically safe propellant gases and the availability of new disposal options (e.g., for waste oil and car batteries). (In addition, in 1992, certain materials were also reclassified as domestic waste [e.g., up to two liters of dispersion paint; dried lacquers; and empty spray cans without fluorinated-chlorinated hydrocarbons].) These materials were therefore no longer handled by the hazardous waste facility or vehicles.

Fluorescent Tubes. Fluorescent tubes can be deposited with the household hazardous waste collection vehicles and at the usable-material yard on Duisburger Street. Collections also take place at the public schools and city agencies. In 1992, 25,413 tubes were deposited at the schools and city agencies: 4,108 units at the usable-material yard, and 4,873 with the mobile units. Another 2,852 tubes were returned to commercial suppliers. This total of 37,246 tubes collected was up from 24,819 in 1991.

Fluorochlorohydrocarbons from Refrigerators. Since December 1, 1988, refrigerators brought to Munich's bulky waste collection points or picked up by the city's refrigerator mobile service have had their coolant removed through the use of a leased disposal vehicle developed especially for this purpose. (The coolant, which contains fluorochlorohydrocarbons, is suctioned off, then the refrigerator is brought to scrap dealers for recycling.) In 1992, 16,930 refrigerators were disposed of, compared to 26,122 in 1991.

Special Wastes from Schools. Special wastes (mainly from chemistry laboratories) were picked up from 75 schools and delivered to the Society for Disposing of Special Wastes in Bavaria.

Collection Facilities

Munich's municipal collection system is operated from the facilities listed in Table 4.4-1.

Vehicle Fleet

268 collection vehicles, including 14 ash-hauling vehicles are available for waste collection. In addition, the city operates a number of other support and service vehicles. In all, the collection operation involves 323 vehicles. Table 4.4-2 shows the number of vehicles by category.

Drop-Off Sites

Depot Containers

To facilitate the separate collection of paper, cardboard, and color-sorted glass, the city's depot container network was expanded from 443 to 546 locations. The Office of Waste Handling has also appointed honorary "waste consultants" to make daily checks of the depot containers, to notify the waste disposal companies and cleaning service of overly full containers, to keep records of such occurrences, and to provide advice to the citizens who live in the surrounding neighborhood.

The city's plan was to expand the depot container network to about 1,200 locations. The district boards were asked to identify suitable locations, and many of their proposals have already been implemented. Even so, siting remains a problem, with neighborhood protests having prevented rapid implementation of the expansion plans. As of March 31, 1993, responsibility for the entire depot container network was transferred to the Duales System Deutschland.

Collection Points for Bulky Waste – Usable Materials Yards

Bulky waste from private households, exceeding the dimensions of a 110-liter or 120-liter waste bin, can be delivered free of charge to nine collection points for bulky wastes distributed across the city area. Five of these collection points for bulky waste are operated by the city, and four by private lessees.

TABLE 4.4-1
MUNICH COLLECTION SYSTEM OPERATING FACILITIES

OPERATING FACILITIES	FUNCTIONS
South Operating Yard (main operating yard) Sachsenstrasse 25 8000 Munich 90	Head Office: • Administration • Workshops • Dispatch Office • Filling and Washing Stations • Garages for Waste Collection and Other Special Vehicles • Dressing Rooms and Washrooms • Canteen
North Operating Yard Duisburger Street 8 8000 Munich 40	• Garages for Waste Collection and Other Special Vehicles • Filling and Washing Stations • Dressing Rooms and Washrooms • Canteen
East Operating Yard Truderinger Street 2a 8000 Munich 82	• Garages for Waste Collection and Other Special Vehicles • Dressing Rooms and Washrooms • Social Room • Additional Usable Material Yard

TABLE 4.4-2
MUNICH COLLECTION FLEET

TYPE OF VEHICLE	NO. OF VEHICLES IN FLEET
Domestic Waste Collection	187
Roll-Off Collection	39
Bulky Waste Pickups	13
Hazardous Waste Collection	7
Ash Hauling	14
Biowaste Collection	4
Paper Collection	4
TOTAL COLLECTION VEHICLES	268
Dump Trucks	15
Other Motor Vehicles	40
TOTAL VEHICLES	323
Trailers	16

The city is in the process of expanding its existing bulky waste drop-off locations to include provisions for handling additional materials (e.g., paper, glass, metals, plastics, garden wastes, and other useful materials). In addition, efforts are under way to increase the number of usable-materials yards from 9 to at least 15. At the end of 1991, the first Munich usable-materials yard was opened on Duisburger Street and three more building permit processes have been completed.

Special containers for the separate collection of the following materials are set up at all the collection points for Bulky waste:

- Paper/cardboard
- Glass (three-color separation)
- Plastics (only for certain plastics)
- Metals
- Garden waste
- Construction scrap
- Collection containers for waste oil, waste medications, waste batteries.

Old Batteries–Car Batteries

550 battery collection containers have been placed in locations across the city (in schools, administrative buildings, specialty stores, etc.). In 1992, 91.91 tons of old batteries were collected; this includes batteries delivered by residents to bulky waste collection points. (In 1991,

the figure was 97.32 tons.) The collection vehicle servicing the drop-off locations made a total of 2,186 calls in 223 working days.

In addition, 16,318 car batteries (1991: 18,619) were delivered to the bulky waste collection points. These were not weighed and were forwarded for recycling.

Waste Oil

In 1992, 149,300 liters of waste oil were delivered to the city's bulky waste collection points and subjected to recycling processes (1991: 138,000 l). 39,100 liters of waste oil from the workshops and vehicles of the Office of Waste Handling were delivered to a waste oil processing company (1991: 42,700 l). As of January 1, 1993, the bulky waste collection points no longer accepted waste oil, all of which is now recycled by private companies into the markets.

DSD Packaging Materials

In Munich, the DSD system consists of approximately 550 drop-off locations for the various packaging materials. There is no separate system in place for curbside collection of packaging materials, other than paper, which is included in the waste materials routinely separately collected by the city. The DSD pays the city approximately 25% of the costs of handling paper, based on the agreed-upon estimate that 25% of the paper collected is in fact packaging material. Citizens can, upon request, have a separate bin for paper. The city turned over to the DSD system some 700 existing sites for their use as part of the implementation of the DSD program. These sites were part of the city's drop-off collection program targeting paper and color-sorted glass. The intent at the time was for DSD to expand the number of sites and to add to each site additional containers for plastic and metal packaging materials. To date, approximately two-thirds of the existing sites have been expanded to include these materials. The current number of operating sites has declined from the initial number of sites turned over, indicative of the difficulty in siting drop-off locations in fully developed urban areas. Among the issues involved in obtaining sites are traffic, noise, and vector problems.

Materials Processing

Sorting Facility

In 1987, the sorting facility at the Georg-Brauchie Ring began operation as part of a pilot program developed by the city to test separate collection of commingled recyclables (the "Green Bin," a five-component collection: paper, glass, metals, plastics, and textiles).

This system of mixed collection and subsequent sorting was deemed unsatisfactory, and at the end of the "Green Bin" pilot test, the facility at the Georg-Brauchie Ring was restructured for the sorting of paper from the "Blue Paper Bin" program, as well as for wastepaper delivered from the usable-materials yard and bulky waste collection points. In 1992, 5,574 tons of wastepaper were delivered to this facility and processed by 15 employees (1991: 4,105 tons).

Composting

Individual and Community Composting

To promote individual and community composting, the city provides subsidies of up to DM 80 for new composting containers. In 1992, total subsidies amounted to DM 167,831.65, for 2,128 applications. The city estimates that this program reduces the total volume of waste by about 565 tons. In addition to the subsidy for new containers, residents can also obtain bins discarded from the "green waste bin" pilot test, for conversion into composting units. About 1,100 of these bins were distributed in 1992.

The Search for Locations for Composting Facilities

In preparation for implementation of the three-bin system, an intense search for locations for composting facilities was carried out in 1992. Two locations were identified within the city limits. In collaboration with the Sternberg County administration, planning was begun for the erection of a composting facility on one of these sites. Negotiations with several private firms were directed at securing markets for the compost to be produced at the site. As a contingency plan, long-term acceptance contracts were secured and are in effect with four private composting facilities:

- Schernthaner Company
- Glück GmbH & Co.
- Ottchen GmbH & Co.
- AR Waste Recycling Company.

Waste-to-Energy Facilities

Munich has two Waste-to-Energy (WTE) facilities, one in the north and one in the south of the city. These are operated by the City Works – Electrical Utilities (EW), and serve the city of Munich as well as the surrounding area included in the Landkreis. The city's first WTE facility, Munich North I, began operations in 1964. The facility consisted of two units designed to fire refuse and pulverized coal in separate furnaces. Approximately 40% of the heat input to the facility came from waste. In 1966, Munich North II was added to the facility. Munich North II consisted of a 960-tonne-per-day unit designed to fire refuse and pulverized coal together in a common combustion chamber, with refuse providing approximately 20% of the heat input. In 1984, another unit, Munich North III, came on line. This facility consists of two units which combust refuse only, each rated 480 TPD. Munich North I and II were decommissioned in the late eighties and subsequently replaced with new facilities.

In 1992, Munich North I was replaced by a new facility with an annual capacity of 380,000 tons. The facility consists of two units, each rated 840 TPD. The facility incorporates state-of-the-art pollution control systems, as described below. Munich North II was replaced by a new coal-fired unit.

Munich South IV and V began operations in 1969 and 1971, respectively. Each facility consists of a single unit with a refuse throughput capacity of 960 TPD. These are natural gas and refuse-cofired units, with up to 20% of the heat input coming from refuse combustion. The total waste-processing capacity at the Munich North and South facilities is approximately 4,560 TPD.

Thus, the facilities at the North and South Power Plants provide six furnace lines for the thermal treatment of waste. The city estimates that these have an actually available annual incineration capacity of about 916,000 tons (taking into account long-term experience with shutdowns for overhaul and for unforeseeable reasons). According to city estimates, this capacity is sufficient for the thermal treatment of all combustible residual waste.

Since 1992, the flue-gas purification products derived from these plants have been placed in a subterranean deposit.

The heat generated from waste incineration was used by the city Works EW to produce electricity and remote heat. In 1992, this resulted in the following amounts of energy being fed into the public network:

- 6,476 gigawatt hours of electricity (compared to 6,454 in 1991)
- 4,209 gigawatt hours of heat (compared to 4,555 in 1991).

In 1992, 18.3% of the fuel heat input for the North and South facilities came from 685,422 tons of waste. Tables 4.4-3 and 4.4-4 detail the source of this tonnage.

Air Pollution Control Train

The systems in place at the new Munich North Facility to minimize pollution emissions include:

- Extensive process controls, including the monitoring of temperatures; O_2 concentrations; pollutant concentrations; and other key operating parameters;

- Addition of a sulphur compound to the scrubber to act as a scavenger for mercury in the flue gas;

- Selective noncatalytic reduction using ammonia injected into the furnace; electrostatic precipitators;

- A two-stage scrubbing process utilizing a venturi scrubber and spray dryer/absorber flue-gas desulphurization unit.

Figure 4.4-3 details a schematic of the process flow line.

The ammonia-injection system is designed to take into account variations in waste composition by varying the amount and location of injection as a function of the temperature profile in the furnace. The temperature profile is also used to adjust the rate of overfire/underfire air injection to the furnace, to help ensure complete burnout and minimal production of unburned hydrocarbons.

TABLE 4.4-3
SOURCE OF WASTE INCINERATED IN 1992
HOUSEHOLD AND COMMERCIAL

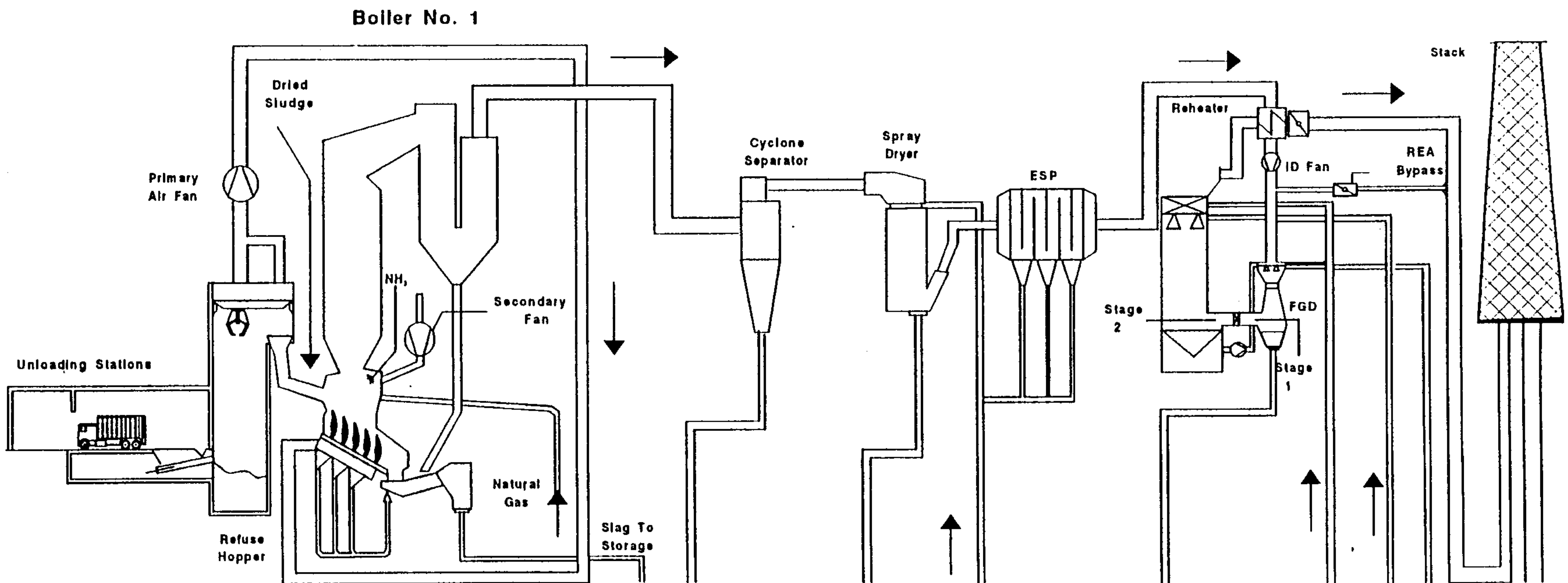
SOURCE	Tons
Household Waste*:	
• South	192,289
• North	276,417
Commercial Waste:	
• North	30,172
• South	185,464
Hospital Waste	1,080
TOTAL	685,422

* Approximately 86% is from the city, 14% from the surrounding region.

TABLE 4.4-4
SOURCE OF WASTE INCINERATED IN 1992
CITY AND SURROUNDING AREAS

TYPES OF WASTE	CITY OF MUNICH	SURROUNDING AREA
Household Waste	404,460	64,070
Bulky Waste	174	1
Commercial Waste	168,217	7,160
Data Processing Waste	53	
Street Sweepings	3,662	
Recovery Residue	26,403.75	8,801.25
Building Waste	12	
Wood Waste	295	
Waste Drugs	107	10
Hospital Waste	1,080	
Airport Waste	916	
TOTAL	605,379.75	80,042.25
TOTAL:		
• North	462,961	
• South	222,461	
GRAND TOTAL	685,422	

FIGURE 4.4-3
MUNICH WASTE-TO-ENERGY FACILITY



Block 1

Landfilling

The North-West Landfill

The North-West Landfill at Freisinger Landstrasse 8000 Munich 45 went into operation in April 1987. The design and equipment utilized at the landfill reflected the state of the art at that time. The facility includes equipment designed to collect leachate and transfer it for treatment to the Gut Marienhof wastewater treatment facility. The groundwater downstream is continuously monitored. To implement the current regulations concerning the quality of wastewater entering wastewater treatment plants, it will be necessary in the future to pretreat the leachate water at the landfill site. The design concept for leachate pretreatment was worked out in 1992. During 1992, about 400 m^3 landfill gas per hour were collected and flared.

At the end of 1992, of the site's original 6.2 million cubic meters of landfill capacity, approximately 3.2 million cubic meters had been filled. The amount of waste disposed of in the landfill in 1992 (371,450 tons of waste plus 71,559 tons of cover material) was the lowest amount since the landfill was opened in 1987. Table 4.4-5 details the amount of waste landfilled since 1988.

TABLE 4.4-5
AMOUNT OF MATERIALS LANDFILLED AT NORTH-WEST LANDFILL

YEAR	Tons
1988	830,000
1989	840,000
1990	820,000
1991	730,000
1992	443,000

Approximately 50% of the landfilled material during 1988 through 1992 was slag. Furthermore, sewage sludge was deposited for the first time in 1992. Thus, in 1992, the most recent year for which data is available, landfilling at this site consisted of predominantly inert substances.

Future Landfill Requirements

The city intends to meet its landfill disposal requirements by continuing to utilize the available space at the North-West facility and by expanding its permitted capacity. The regional planning process has been completed for the expansion of the northwest landfill and the documents required for the zoning process have been prepared.

Other Landfill-Related Activities

The active out-gassing facility for a previous waste landfill at Grosslappen was completed in December 1991. This facility consists of gas wells and associated piping and ancillary equipment necessary to collect gas generated by the decomposition of waste in the landfill. The gas is collected and piped to flaring units, where it is burned. 600 m^3 of landfill gas per hour are currently being collected and flared at this facility. The future beneficial utilization of this gas is currently in the planning phase.

4.4.2 Quantities of Waste Handled

4.4.2.1 Collection

Domestic Waste

Table 4.4-6 details the amount of household waste collected in Munich from 1984 to 1992. As indicated, the amount of household waste collected in Munich has declined since 1990.

TABLE 4.4-6
HOUSEHOLD WASTE COLLECTION IN MUNICH

YEAR	Tons
1984	420,000
1985	419,000
1986	435,000
1987	449,000
1988	419,500
1989	430,000
1990	441,000
1991	435,396
1992	413,000

The amount of household waste collected in 1992 fell by 5.12%, compared to the previous year; the total amount of household waste (including bulky wastes, usable materials, and problem wastes) fell by 2.7%.

The quantity of collected household waste, including up to 1.1 m^3 per week collected from small businesses, was reduced by 22,293 tons to a total of 413,103 tons (1991: 435,396 tons). This translates into 312 kg per year per inhabitant, compared to 334 kg in 1991. If bulky waste, usable-materials, and problem wastes are added to collected domestic business waste, the annual figure rises to 400 kg, for a total volume of 531,171 tons during 1992 (previous year: 545,900 tons). Thus, here too the trend is downward.

Waste Generated in City Celebrations

Table 4.4-7 shows the amounts of residual waste collected at city celebrations in 1991 and 1992.

In the meantime, the city's efforts to make city celebrations "free of throw-away containers" and to implement waste separation at these events have been greatly successful. Not only at the Oktoberfest, but also at other city celebrations, the amount of residual waste was reduced by more than 80%, compared to the previous year, and by nearly 90%, compared to 1990.

TABLE 4.4-7
Tons OF RESIDUAL WASTE COLLECTED AT CITY CELEBRATIONS

EVENT	QUANTITIES IN Tons (YEAR)	
	1992	1991
Oktoberfest	1,393	8,093
Christmas Market	18	52
May - Bavarian Feast	11	22
Jacobi - Bavarian Feast	30	41
Church Dedication - Bavarian Feast	28	43
Springfest	12	69
Flea Market	NA	6
TOTAL	1,492	8,326

Bulky Waste Involving Household Equipment

The amounts of bulky waste, construction scrap, and garden waste rose in 1992. The total amount for 1992 was 637,153 m^3, compared to 629,714 m^3 for 1991, an increase of approximately 1.2%.

Table 4.4-8 delineates the amount of bulky waste handled in 1991 and 1992.

TABLE 4.4-8
BULKY WASTE QUANTITIES BY MAJOR SOURCE CATEGORY

SOURCE	**1992**		**1991**
	Tons	**m³**	**m³**
Bulky Waste Total	30,820.29	637,153	629,714
From Collection Points	21,088.74	444,874	443,762
Bulky Waste Picked Up by the Office of Waste Handling Upon a Call from a Citizen	9,344.29	184,754	178,353
Unauthorized Disposal at the Depot Container Locations and in the city Area	360	7,000	5,447
Bulky Waste from the U.S. Army	10	200	925
Bulky Waste from the Eco-Waste Campaign	16	325	1,125

Wastepaper

During 1992, the residents of Munich collected a significant amount of wastepaper, using the following collection systems:

- Depot containers
- Bulky waste collection points (including usable-material yard)
- Blue bin—paper bin at residences (in parts of Neuperlach, Aubing, Hasenbergl, Harthof, Lerchenauer See, Harlaching, Oberwiesenfeld, Schwebing)
- Bundle collection (BRK and charitable organizations)
- Wastepaper collection in schools.

Table 4.4-9 outlines the amounts of wastepaper (in tons) collected by various methods. The amount collected in 1992 increased 32.6% over that collected in 1991.

TABLE 4.4-9
Tons OF PAPER COLLECTED

	1992	PERCENT	1991
Depot Containers	35,832	65	26,100
Bulky Waste Collection Points/Usable-Material Yard	3,393	6	2,579
Blue Bin	5,362	10	2,969
Bundle Collection	10,387	19	9,772
Schools	175	--	169
TOTAL	55,149		41,689

Waste Glass

The following collection systems are available for waste glass:

- Depot containers (separated by green, white, and brown glass, with appropriate directions)
- Bulky waste collection points/usable-material yard.

Table 4.4-10 lists the quantities of waste glass (in tons) collected.

TABLE 4.4-10
Tons OF GLASS COLLECTED

	1992	1991
Depot Containers	27,818	30,400
Bulky Waste Collection Points/Usable-Material Yards	1,217	999
TOTAL	29,033	31,399

According to the city, the slight decline in the collection of waste glass is due to the fact that more and more private households are converting to reusable bottles. The city claims that this trend is in no small part a result of increased publicity efforts in this area.

During 1991, numerous restaurants illegally used depot containers to dispose of throw-away bottles. During 1992, increased supervision by city personnel significantly reduced the scope of this problem.

Biological Wastes

The bio-bin pilot test (brown bin) included 20,000 households. Collection and removal during the test were free of charge and readiness to participate in the separate collection of source-separated organic wastes was very high (above 90%). A high degree of purity was achieved in the collection process, with only one to three percent of the materials collected being rejects. In 1992, during the test, 1,827.9 tons of organic wastes were collected, compared to 1,784 tons the previous year.

The original waste management plan forecast a savings potential of 50,000 tons per year from the separate collection of biological waste. The city now estimates that if the bio-bin is introduced throughout the area, this forecast can be exceeded. As the waste plan indicates, however, the introduction of the bio-bin throughout the city depends on obtaining sufficient composting capacity and a significant expansion of the collection vehicle fleet.

Garden Wastes

In 1992, 9,150.82 tons, or 65,363 m^3, of garden wastes were collected at the city's bulky waste collection points and composted (1991: 7,014 tons or 56,356 m^3). By promoting individual composting (Division of Composting Containers), approximately 1,800 tons of organic material was kept away from disposal facilities during 1992. To relieve the disposal facilities of another 4,273 m^3 in organic wastes, efforts are under way to introduce an area-wide mobile shredding service to break down woody wastes, which can be used on site as mulch.

Waste Plastic

According to the city, as of 1992, only absolutely clean polyethylene film and polystyrene could be reliably recycled. Consequently, only those materials were accepted at the bulky waste collection points.

There were 6.3 tons of film, polystyrene and PET core bodies recycled in 1992.

Discarded Clothing

All over the city, as well as at the usable-material yard and the bulky waste collection points, private firms or charitable organizations have set up clothing containers in which discarded clothing is collected for reuse and recycling. The city estimates that 529 tons were collected in 1992.

Waste Metal/Scrap

From Waste Incineration Facilities

Table 4.4-11 details the tons of ferrous metals which were electromagnetically recovered from the ash at the city's two waste incineration facilities (figures in tons per year) during 1991 and 1992.

TABLE 4.4-11
Tons OF FERROUS METALS RECOVERED

	1992	1991
North Waste-to-Energy Facility	12,197	4,341
South Waste-to-Energy Facility	3,221	4,077
TOTAL	15,408	9,018

From Useful-Materials Yards/Bulky Waste Collection Points

At the municipal bulky waste collection points and the usable-material yard, 5,120 tons of mixed metal were delivered and forwarded to scrap dealers (compared to 3,486.5 tons in 1991). Table 4.4-12 details the tons of metal recovered by category in 1991 and 1992 from the Useful-Material Yards/Bulky Waste Collection points.

TABLE 4.4-12
Tons OF METAL BY CATEGORY RECOVERED AT USEFUL-MATERIAL YARDS/BULKY WASTE COLLECTION POINTS

	1992	1991
Ferrous Metals	*	276
Bulky Scrap	*	80
Mixed Scrap	5,087	3,108
Nonferrous Heavy Metals	*	10
Aluminum	10	11
Tin Cans	72	11
TOTAL	5,120	3,486

* No longer itemized separately.

From the Metal Container at the Ratzingerplatz

By setting up a waste metal container at the Ratzingerplatz, the Office of Waste Handling is testing another way to collect metal. In 1992, this site collected 25.34 tons (1991: 7 tons).

Thus, the total amount of scrap metal recovered by the city in 1992 was 20,554 tons, a significant increase of 64% over the 12,512 tons collected in 1991.

4.4.2.2 Utilization of Materials

According to the city, because of the population's responsiveness to the separate collection of useful materials and the obligation of commercial enterprises to effect such separation, the recycling volume rose markedly during the period 1988 to 1992. Table 4.4-13 summarizes the amount of material recycled since 1988.

TABLE 4.4-13
Tons OF MATERIAL RECYCLED

YEAR	Tons
1988	190,000
1989	500,000
1990	1,070,000
1991	1,200,000
1992	1,258,000

Table 4.4-14 shows the amount and composition of materials recycled in 1992. As indicated, the most significant contributions to the total amounts recycled are commercial waste and construction, demolition, and building wastes, as discussed below.

Commercial Waste

As indicated in the city's 1992 waste plan, there are few reliable studies of the composition of commercial waste. Similarly, the figures for direct recycling of such waste are difficult to pinpoint, since these materials are not handled through the municipal disposal system. Thus, in order to plan more precisely for the "reuse of commercial waste," and to estimate the effects of new statutes relating to industrial and construction waste disposal in particular, the city conducted an extensive survey of Munich disposal companies in 1992. Table 4.4-15 shows the various materials diverted from disposal and reused, as reported in responses received from 76 of the 88 businesses surveyed.

TABLE 4.4-14
Tons OF MATERIAL RECYCLED - 1992

MATERIAL	Tons
Paper	54,974
Glass	29,033
Plastics	6
Metals	5,569
Biological Waste	1,828
Garden Wastes	9,151
Bulky Wastes Involving Household Equipment	4,627
Textiles	529
Fluorochlorohydrocarbons from Refrigerators	3
Construction Scrap	7,321
Useful Material	1,933
Construction/Commercial Bulky Waste	34,378
Commercial Waste	544,007
Construction Scrap/Brick Scrap	500,828
Scrap from Waste-to-Energy Plants	13,606
Residue Substances	50,068
TOTAL	1,257,861

Source: Amt für Abfallwirtschaft

TABLE 4.4-15
Tons OF COMMERCIAL WASTE RECYCLED - 1992

	Tons
Glass	11,100
Paper	210,851
Plastics	11,007
Green Waste	48,959
Metals	188,526
Wood	29,307
Computer Scrap	10,541
Other Usable Materials	32,916
TOTAL	544,007

According to the survey, the total amount of commercial waste also fell in 1992, as compared to the previous year. Not the least important factors in this decline were the strict regulations of the Industrial and Construction Waste Disposal Statute, which impose an obligation to separate waste into six categories:

1. Paper, cardboard, cartons
2. Wood
3. Metals
4. Plastics
5. Glass
6. Organic wastes

Another factor in the overall decline in commercial waste in 1992 was the city's hiring six building-site inspectors and three commercial waste consultants to implement the waste avoidance and separation concepts in the commercial sector. Some 280 compliance-related consultations took place on-site, another 100 consultations at the Office of Waste Handling, and approximately 1,500 by telephone consultations.

Construction, Demolition, and Building Wastes

Compared to 1991, the nonusable construction wastes in 1992 declined by 30,985 tons (16,762 tons in 1992 versus 47,747 in 1991). This decline is also the result of strict regulations imposed by the Industrial and Construction Waste Disposal Statute, according to which inert material must be landfilled in gravel pits, and pollutant-containing components may not be landfilled.

Contaminated Soil

The delivered quantity of contaminated soil also declined slightly in 1992, compared to the previous year. (The decline was 8,875 tons; 45,160 tons in 1992 versus 54,025 tons in 1991.) The Industrial and Construction Waste Disposal Statute imposes the following restrictions on contaminated soil (e.g., soil, excavations, and demolition scrap contaminated with oil or chemicals).

(1) The material may be landfilled only if cleaning is technically impossible, or cleaning is economically unfeasible.

(2) The burden of proof lies with the owner of the waste.

(3) The decision about whether cleaning is technically possible is made by the Environmental Protection Committee.

(4) Cleaning is not economically feasible if it amounts to 18% or more of the fair market value of the land.

Construction Scrap: Material Utilization in Gravel Pits

In 1992, 404,828 tons of construction scrap were filled into gravel pits, compared to 591,467 tons in 1991. In 1992, 96,000 tons of used bricks were separated and reused.

Construction and Industrial Bulky Wastes

Table 4.4-16 shows the quantities of construction and industrial bulky wastes delivered from Munich to the contract firm AR-Waste Recycling for sorting and utilization:

Table 4.4-17 shows the quantities of commercial wastes trucked out of the city of Munich from 1984 to 1992.

4.4.3 Budget and Fees

4.4.3.1 Description of 1992 Operating Budget

The administrative budget (fee budget) rose from approximately DM 332.5 million for 1991 to approximately DM 421 million in 1992.

TABLE 4.4-16
Tons OF CONSTRUCTION AND INDUSTRIAL BULKY WASTE DELIVERED FOR PROCESSING

Tons	1992	1991
Quantity Delivered	64,173	63,393
Quantity Used	34,378	35,570
Nonusable Remainder	29,795	28,223
Utilization Quota	53.57%	56.11%

TABLE 4.4-17
Tons OF COMMERCIAL WASTE TRUCKED OUT OF MUNICH

YEAR	QUANTITY
1984	140,000
1985	175,000
1986	180,000
1987	252,000
1988	220,000
1989	260,000
1990	255,000
1991	195,000
1992	183,357

The administrative budget was equalized by taking DM 81,345,010 from the special reserve for the equalization of fees. Tables 4.4-18 and 4.4-19 detail the estimated budget for FY 1992 as described in the Annual Report for 1992.

4.4.3.2 Capital Budget

Table 4.4-20 summarizes the capital budget for 1992.

TABLE 4.4-18
1992 ADMINISTRATIVE BUDGET
(Income in DM)

INCOME	DM
Waste Pickup Fees (domestic waste)	232,807,812
Charge for Container Service	8,836,399
Charge for Commercial Waste (Waste Bins, Large Container)	9,725,995
Charge for Special Pickups (Additional Waste and City Celebrations)	2,009,151
User Fees (Use of Landfills)	68,199,658
User Fees (Waste Bags)	107,024
Replacements and Surpluses from Warehousing	36,174
Allocation of Land	419,000
Interest from Private Enterprises (See Equalization Reserve)	7,780,263
Interest from Private Enterprises (See Landfill Reserves)	133,783
Provision from Capital Budget (See Special Reserves)	81,345,009
Other Income	483,456
TOTAL INCOME	421,050,087

TABLE 4.4-19
1992 ADMINISTRATIVE BUDGET (EXPENSES IN DM)

EXPENSES	DM
Personnel Expenses	85,833,131
Maintenance of Owned Buildings, Operating Facilities	765,864
Maintenance of Landfills and Collection Points	1,413,194
Technical Equipment, Tools	184,498
Rents and Leases for Real Property, Objects	648,019
Heating	360,283
Gas, Electricity, Water	530,276
Motor Vehicles	5,595,437
Operating Materials and Lubricants	2,073,876
Service and Protective Clothing	655,920
Loading and Removing Bulk Material/Pollutants and Additional Waste	12,925,054
Incineration of Domestic Waste	168,477,000
Removal of Waste by Contractors	8,161,178
Public Relations	2,217,953
Legal and Similar Costs, Expert Opinions	1,433,699
Reimbursement of Administrative Expenses - Internal Accounting	5,718,969
Depreciation	26,973,318
Depreciation for KW North (Domestic Waste Blocks)	38,801,050
Interest on Investment Capital	10,478,810
Interest on Investment Capital for KW North (Domestic Waste Blocks)	42,375,680
Special Reserve for Landfills	1,500,000
Other Expenses	3,917,872
TOTAL EXPENSES	421,050,087

TABLE 4.4-20
CAPITAL BUDGET FOR 1992

CAPITAL BUDGET	DM
EXPENSES:	
Motor Vehicles, Utility Vehicles, Trailers	23,867,776
Technical Equipment	209,616
Other Chattels (GB and Containers)	987,125
Data Processing Systems, Hardware, and Software	139,613
Telephone Facilities (Component for New Equipment)	216,436
TOTAL EXPENSES	25,420,585
INVENTORY	
Procurement of Services and Protective Clothing	668,941
Procurement of Fuel and Accessories	3,201,808
Original Cost Indemnification to US 7200	400,716
TOTAL	4,271,465

4.4.3.3 Charges for Domestic Waste

Table 4.4-21 shows the annual fee charged for household waste collection for 1991 and 1992. The fee varies based on the volume of the container and the collection frequency. The fees charged for household waste collection did not change from 1991 to 1992. This was due to unanticipated revenues that offset an expected 1992 deficit predicated on rising incineration and operating costs as well as a decline in fees due to more requests for 14-day collection service. Some 7,500 applications for reduction or increase of the remaining container volume were in fact processed, reflecting the elimination in 1991 of the previously prescribed minimum volume per property and the option of 14-day pickup of a 110-/120-liter bin. (5,350 applications for 14-day pickup were processed in 1992.)

The charge for waste pickup was DM 124.50 per tonne plus a transport charge of DM 110.00 per cartage.

The fee for delivering commercial waste to the incineration plants and landfills on one's own was DM 195.50 per tonne.

TABLE 4.4-21
ANNUAL FEE FOR HOUSEHOLD WASTE COLLECTION

TYPE OF CONTAINER	1992 (DM)	1991 (DM)
Standard Container (110/120 l)	367.00	367.00
(14-Day Pickup)	183.85	183.85
Standard Container (240 l)	735.00	735.00
(14-Day Pickup)	367.70	367.70
Large Container (0.77 m^3)	2,359.50	2,359.50
Large Container (1.1 m^3)	3,370.60	3,370.60
Additional Waste Bag (70 l)	5.00	5.00

Revisions To Fee System Being Contemplated

In its 1994 budget, the city is contemplating a number of fee system revisions to foster greater care by consumers in separating the waste fractions to minimize contamination. These include fees for failure to separate waste and fees for setting out contaminated wastes for collection.

4.4.4 Summary

Table 4.4-22 provides a summary of the amount and disposition of domestic and total waste in Munich in 1992. The overall rate of recycling (1,257,411 tons out of 2,435,055 or over 50%), while very impressive, is driven by the reuse/recovery of construction, demolition, and building wastes, including site excavation materials. When one examines the domestic portion of the waste stream, approximately 23% of the waste was recycled, 76% was processed at the WTE facilities and 2.4% was landfilled.

TABLE 4.4-22
1992 MUNICH WASTE DISPOSITION
(Tons)

WASTE TYPE	TOTAL	RECYCLED	PROCESSED AT WASTE-TO-ENERGY FACILITY	LANDFILLED
Domestic Waste	531,850	122,552	404,809	12,517
Total Waste	2,435,055	1,257,411	895,839	281,805

Munich has in place a waste management system which meets the characteristics of an integrated waste management system. It incorporates source reduction, recycling/reuse, composting, resource recovery, and landfilling. Existing major components of the Munich system are drop-off bins for paper and glass, bulky waste, and useful material collection facilities; two waste-to-energy facilities; and a regional landfill. As regards composting, the city has in place a program for composting garden waste and a pilot program for the separate collection of organic wastes, to be expanded throughout the city. The city also has in place contractual arrangements with private composting companies as it seeks to site and develop a new composting facility.

The integrated waste management system in Munich draws upon both public and private sector participants. The city provides collection and processing services for domestic waste, while private companies provide similar services to the commercial sector. The city also uses private sector companies to provide operation of some of its bulky waste drop-off facilities. A separate company, Stadtwerke Munchen, operates the two WTE facilities.

In Munich, the DSD program is being implemented by a private company. The city has turned over to the company all of its depot locations throughout the city for glass and paper. The city does provide for collection of paper from those residents who request bins, and is reimbursed for 25% of the cost of that service by the company responsible for the DSD program in Munich. The ability of the DSD company to achieve the required goals using a collection system relying primarily on drop-off bins remains to be determined.

Munich has implemented an integrated waste management system that achieved a recycling rate of over 50% of the total waste stream and 23% of the domestic waste stream, based on 1992 figures. More significantly, landfill was used for only 2.5% of the unprocessed domestic waste and 11.6% overall. Waste-to-energy plays a significant role in Munich's integrated program. Over 76% of the domestic waste was processed at the two facilities in 1992 and over 36% of the total waste stream was processed at these facilities in 1992.

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APPENDIX A

MEETINGS AND TOURS CONDUCTED IN GERMANY

TRIP ITINERARY

MONDAY, OCTOBER 18, 1993

2:00 - 5:00 p.m.	Mr. Hans-Joachim J. Muller, Hauptreferent - VSK Dr. Ulrich Doose, Hauptreferent Ms. Tatianna Detering, International Relations Mr. Schroter VKS (Verband Kommunale Abfallwirtschaft und Stadtreinigung e.V.) (Municipal Solid Waste Association) Deutscher Städtetag Postfach 51 06 20, 50942 Köln Marienburg Lindenallee 13-17 50968 Köln TEL (02 21) 3771-280 FAX (02 21) 37 25 27

TUESDAY, OCTOBER 19, 1993

10:00 a.m. - 12:30 p.m.	Klaus-Peter Beuth Öffentlichkeitsarbeit Interseroh AG StollwerckstraBe 9 a, 51149 Köln Postfach 90 06 40 51116 Köln TEL (0 22 03) 91 47-0 FAX (0 22 03) 91 47-394
3:30 - 5:30 p.m.	Dr. Armin Rockholz Deplom-Volkswirt Referat Umweltschutz DIH Deutscher Industrie-Und Handelstag (Association of German Chambers of Industry and Commerce) Adenauerallee 148, D-5300 Bonn 1 TEL (02 28) 1045 38-539 FAX (02 28) 104543 104158

WEDNESDAY, OCTOBER 20, 1993

8:30 - 11:00 a.m.	Mr. Hans-Jürgen Schmidt Dipl.-Volkswirt Dr. Adolf von Röpenack Abteilung Umweltpolitik Bundesverband der Deutschen Industrie e.V. (Association of German Industries) Gugstav-Heinemann-Ufer 84-88 D-5000 Köln 51 TEL (02 21) 37 08 550 FAX (02 21) 37 08 730
2:00 - 5:30 p.m.	Mr. Thomas Schmid Bundesministerium Für Umwelt Naturschutz und Reaktorsicherheit (The Ministry for the Environment, Nature Conservation and Nuclear Safety) AhrstraBe 20, 53175 Bonn Postfach 12 06 29, 53048 Bonn TEL (02 28) 3 05-25 56 FAX (02 28) 3 05-23 99

THURSDAY, OCTOBER 21, 1993

9:30 - 11:00 a.m.	Ms. Edelgard Bially Kommunikation und Öffentlichkeitsarbeit Duales System Deutschland RochusstraBe 2-6 53123 Bonn TEL (02 28) 97 92-262 FAX (02 28) 97 92-195
2:30 - 6:00 p.m.	Dr. Schmidt Abfallwirtschaft und Atlasten Baudirektor Nord Rhine Westfalen Landesamt fur Wasser und Abfall TEL (02 11) 45 66-388

FRIDAY, OCTOBER 22, 1993

8:30 a.m. - 2:00 p.m.	Dr. Holzapfel Referat Umweltshutz Burgplatz 19, D-4100 Duisberg 1 TEL (02 03) 28-32-674

MONDAY, OCTOBER 25, 1993

10:00 a.m. - Noon	Ms. Kornelia Hülter Landeshauptstadt Düsseldorf KirchstraBe 14/18 4000 Düsseldorf 1 TEL (02 11) 7340-272 FAX (02 11) 89-29072
2:00 - 5:00 p.m.	Dr. Tonndorf-Kremer Laitende Direktorin für Umweltschultz 1st Flr. Rm. 15 Frederick Ebert Str. Solingen TEL (02 12) 29-04-4206

TUESDAY, OCTOBER 26, 1993

9:00 a.m. - Noon	Mr. Ekkehart Gartner Engineering and Projects Martin GMBH für Umwelt- und Energietechnik Leopoldstrasse 248 D-8000 München 40 TEL 0 89/3 56 17-0 FAX 0 89/35617-299
1:00 - 6:00 p.m.	Mr. Reinhold Wenninger Berufsmässiger Stadtrat Umwelt und Kommunales Maximilianstrasse 86150 Augsburg TEL (08 21) 324 4801

WEDNESDAY, OCTOBER 27, 1993

9:00 a.m. - Noon	Mr. Prattrop Kommunalreferat Robmarkt 3, Munich TEL (08 92) 33 22-871
2:00 - 4:30 p.m.	Dipl.-Ing Günter Meinking Geschäftsführer Mr. Gernd Angermann stellv Geschäftsführer Quarzbichl 82547 Eurasburg TEL 081 79/10 17 FAX 081 79/84 76

THURSDAY, OCTOBER 28, 1993

11:00 a.m. - 2:00 p.m.	Dr.-Ing. Gerhard Sierig Technische Sonderprojekte Berliner Stadtreinigungs-Betriebe Ringsbahnstrasse 1000 Berlin 42 Postfach 420152 TEL (0 30) 75 92-0 FAX 1 84 520

FRIDAY, OCTOBER 29, 1993

10:00 a.m. - Noon	Dr. Georg Goosmann Umweltbundesamt (Federal Environmental Agency) Bismarckplatz 1 D-1000 Berlin 33 TEL (0 30) 89 03 25 85 FAX (0 30) 89 03 22 85
12:30 - 1:30 p.m.	Dr. rer. nat. Joachim Heidemeier Dipl.-Chemiker Umweltbundesamt Bismarckplatx 1 D-1000 Berlin 33 TEL (0 30) 8903-2780 FAX (0 30) 8903-2285

TUESDAY, NOVEMBER 16, 1993

2:00 - 4:30 p.m.	Mr. Hanskarl Willms Dezernat Öffentlichkeitsarbeit BDE (Bundesverband Der Deutschen Entsorgungswirtschaft e.V.) The German Association for the Waste Disposal Industry Postfach 90 08 45 5000 Köln 90, Haupstrt. 305 TEL (0 22 03) 8 06 22 FAX (0 22 03) 8 06 99

APPENDIX B

METRIC CONVERSION FACTORS

APPENDIX B

METRIC CONVERSION FACTORS

	METRIC UNITS	U.S. EQUIVALENTS
Length	1 centimeter (cm)	0.394 inches (in)
	1 meter (m)	3.28 feet (ft) 1.09 yards (yd)
	1 kilometer (km)	0.621 miles (mi)
Area	1 square meter (m^2)	10.8 square feet (ft^2) 1.20 square yards (yd^2)
	1 square kilometer (km^2)	0.386 square miles (mi^2)
Volume	1 cubic meter (m^3)	35.3 cubic feet (ft^3) 1.31 cubic yards
Weight	1 kilogram (kg)	35.3 ounces (oz) 2.20 pounds (lb)
	1 tonne (t) (1,000 kg)	1.10 tons
Capacity	1 liter (l)	1.06 liquid quarts (qt)
Concentration	1 gram per normal cubic meter (g/Nm^3)	0.437 grains per dry standard cubic foot (gr/dscf)
Energy	1 kilocalorie per kilogram (kcal/kg)	1.80 British thermal unit per pound (Btu/lb)

REPORT DOCUMENTATION PAGE

Form Approved
OMB NO. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	August 1995	Final Subcontract Report

4. TITLE AND SUBTITLE

Integrated Solid Waste Management in Germany

5. FUNDING NUMBERS

(C) AC36-83CH10093
(TA) WM51.1010

6. AUTHOR(S)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

CSI Resources Systems, Incorporated

8. PERFORMING ORGANIZATION REPORT NUMBER

DE95009259

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

NREL/TP-430-7978

11. SUPPLEMENTARY NOTES

NREL technical monitor: Philip Shepherd, (303) 275-2929

12a. DISTRIBUTION/AVAILABILITY STATEMENT

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

12b. DISTRIBUTION CODE

UC-1414

13. ABSTRACT *(Maximum 200 words)*
Report covers Germany's experience with integrated solid waste management programs. The MSW practices of four cities include practices and procedures that waste facility managers with local or state governments may consider for managing their own day-to-day operations.

14. SUBJECT TERMS

energy conservation, material recovery facilities, municipal solid waste management, water quality

15. NUMBER OF PAGES
210

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT