X WASTE MANAGEMENT

A sustainable policy for the protection of natural resources attaches great importance to closed material life cycles. The principles of life-cycle management are set out in the Act for Promoting Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal (Kreislaufwirtschafts- und Abfallgesetz – KrW-/AbfG) (radioactive waste falls under the Atomic Energy Act). Priority is given to the highest possible degree to the effective use of materials taken from nature in order to prevent waste originating at source. The aim is to decouple the amount of waste from economic growth. Unavoidable waste should be reused as new raw material in industrial production or processed in such a way so as to allow it to be stored as environmentally compatible "inert" (neutral) slag.

X 1 Waste generation

X 1.1 Amounts of waste generated according to waste statistics

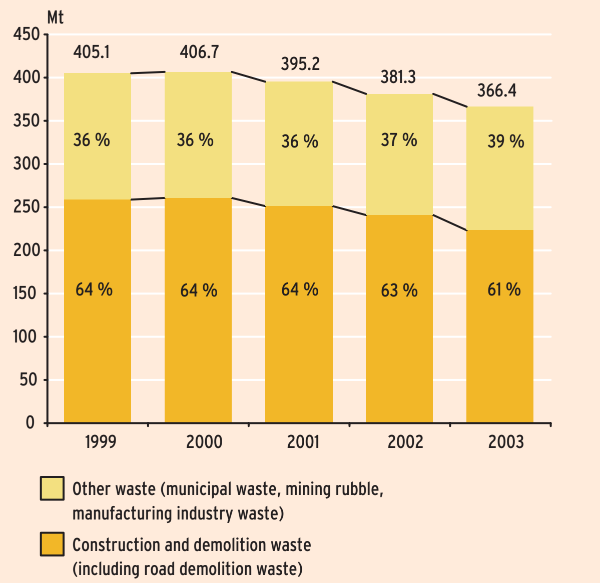
While interpreting the following figures on the main individual waste streams, note that there is no direct correlation between waste statistics and an actual recording of waste amounts. Respective levels of consumed waste, primarily from waste disposal plant operators, have been recorded since 1996. The Federal Statistical Office has integrated the volume of waste figures using a computer model. Double counts cannot be completely avoided.

Limitations to the comparability of data arise for the period under consideration due to the changeover from the materials-oriented waste register of the Working Group of the Federal States on Waste (LAGA), a document used up to 1998, to the predominantly origins-oriented European Waste Catalogue (EAK), used after 1999). This has led to waste levels being shifted to certain positions lower down on the scale, particularly in the case of municipal, manufacturing, trade, construction, and demolition waste. In 2002, the EAK was replaced by the European List of Waste (LOW), which resulted in shifts within municipal waste as well as between waste not requiring any special supervision and that requiring special supervision. In contrast to previous years, waste requiring special supervision has been treated as one of the waste types presented below since 1999 and evaluated separately for information only.

Furthermore, since 1999 manufacturing and trade has disregarded waste levels treated in-house, while recovery and disposal continue to be recorded.

The most quantitatively significant waste category "construction and demolition waste (including road demolition waste)", which made up the majority of waste amounts in 2003 (223.4 Mt – 61 %), plays a key role in closed substance-cycle waste management. Spoil, the majority of which is recycled, made up the largest share in this waste category (Chapter X 2.2). A significant amount of the remaining mineral construction waste is also recovered. Construction and demolition waste trends run largely parallel to economic trends in the construction trade (Fig. X 1.1-1 and Tab. "Amounts of waste generated").

Fig. X 1.1-1: *Amount of waste generated*



2000: data partially with Hamburg 1999
2002: Changeover from European Waste Catalogue (EAK) to European List of Waste (LOW) with shift of waste levels to certain lower positions, particularly between waste requiring no special supervision and waste requiring special supervision and within municipal waste.

Source: *Federal Statistical Office 2005*

49.6 Mt (approximately 14 %) of the waste amounts were attributable to municipal waste in 2003. This is the most important group after construction waste.

58 % of municipal waste was recovered in 2003 (Chapter X 2.1).

Domestic waste made up 43.9 Mt (almost 90 %) of municipal waste in 2003.

Domestic waste from public household refuse collection and trade wastes (not requiring any special supervision), so-called residual waste amounted to approximately 209 kg/cap. in 1999, and 192 kg/cap. in 2003. In addition there was approximately 37 kg/cap. of bulky (household) waste in 1999, 32 kg/cap. in 2003. Altogether this amounted to 246.37 kg/cap. in 1999, 224.37 kg/cap. in 2003.

In contrast, waste collected separately for recovery (compostable waste from the organic waste bin and other categories collected separately, not requiring any special supervision) nevertheless amounted to approximately 195 kg/cap. in 1999 and as much as 306 kg/cap. in 2003. However, compostable garden and park waste, first included in 2002, (47 kg/cap.) was an important contributory factor here.

Altogether, 441 kg/cap. of domestic waste (not requiring any special supervision) were generated in 1999 and 532 kg/cap. in 2003.

The total quantity of waste from private households has therefore been rising since the end of the 1990s. This is largely attributable to the effects of amended statistical methods.

49 % of domestic waste was recycled in 1999, and 61 % in 2003.

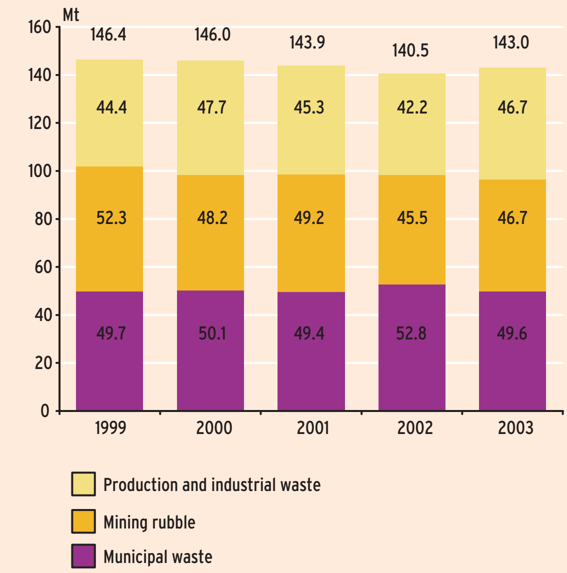
Mining rubble made up approximately 13 % (46.7 Mt) of the quantity of waste in 2003, mainly from lignite mining. The majority of mining rubble is stockpiled. The decline in mining rubble is in line with the falling demand for coal.

Approximately 13 % of waste came from production and industry in 2003. This amounted to 46.7 Mt (Fig. X 1.1-2 and Tab. "Amounts of waste generated").

Waste requiring special supervision has been separately statistically evaluated for information only since 1999. Approximately 5 % of the volume of waste came under this waste stream in 2003 (1999: 3.3 %). It was principally accumulated within the industrial and construction trade. 28 % of it was recycled in 2003 (Chapter X 1.2).

Germany's economic performance had been slowly improving since 1999, and then stagnated, while the total quantity of waste decreased (Fig. X 1.1-3). The intensity of waste, or the total volume of waste measured against trends in gross domestic product (1995 prices) decreased by 13 percentage points from approximately 212 kg/thousand EUR to approximately 184 kg/thousand EUR (Fig. X 1.1-4).

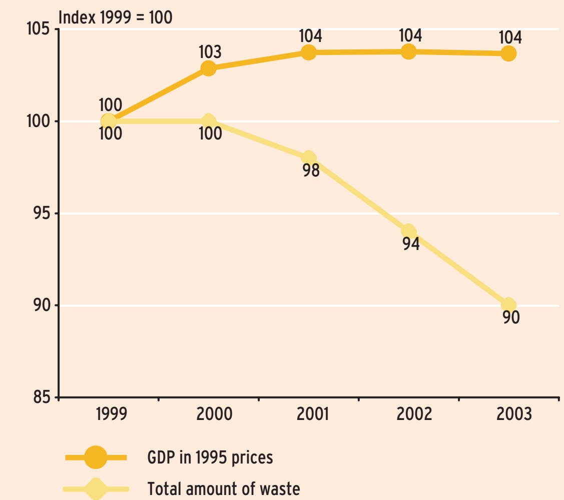
Fig. X 1.1-2: *Amount of waste generated – "other waste"*



2000: data partially with Hamburg 1999
2002: Changeover from European Waste Catalogue (EAK) to European List of Waste (LOW)with shift of waste levels to certain lower positions, particularly between waste requiring no special supervision and waste requiring special supervision and within municipal waste.

Source: *Federal Statistical Office 2005*

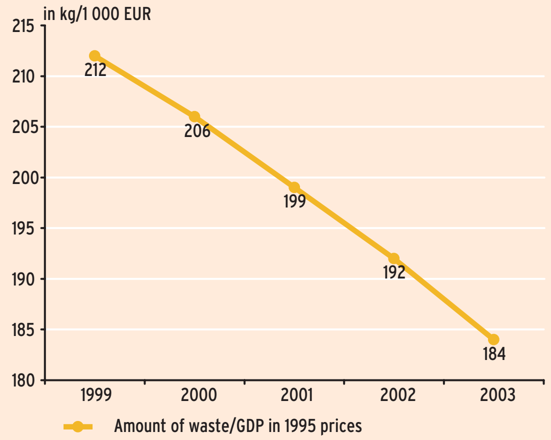
Fig. X 1.1-3: *Decoupling waste generation from economic growth*



Source: *Federal Statistical Office 2005 a*

The non-recoverable share of waste volume is to be disposed of in an environmentally sound manner. Before final disposal, organic waste must be mechanically-biologically or thermally treated for it to be made inert and thus to reduce leaching and the release of landfill gas. Landfilling of organic waste which has not been pre-treated has no longer been permissible since the middle of 2005. Strict air quality management standards apply to incineration plants (Chapter X 2.1, Chapter X 3.2)

Fig. X 1.1-4: *Waste intensity*



Source: *Federal Statistical Office 2005 a*

Further waste statistics information from the Federal Statistical Office can be accessed on the Web at http://www.destatis.de.

X 1.2 Generation of waste requiring special supervision (hazardous waste)

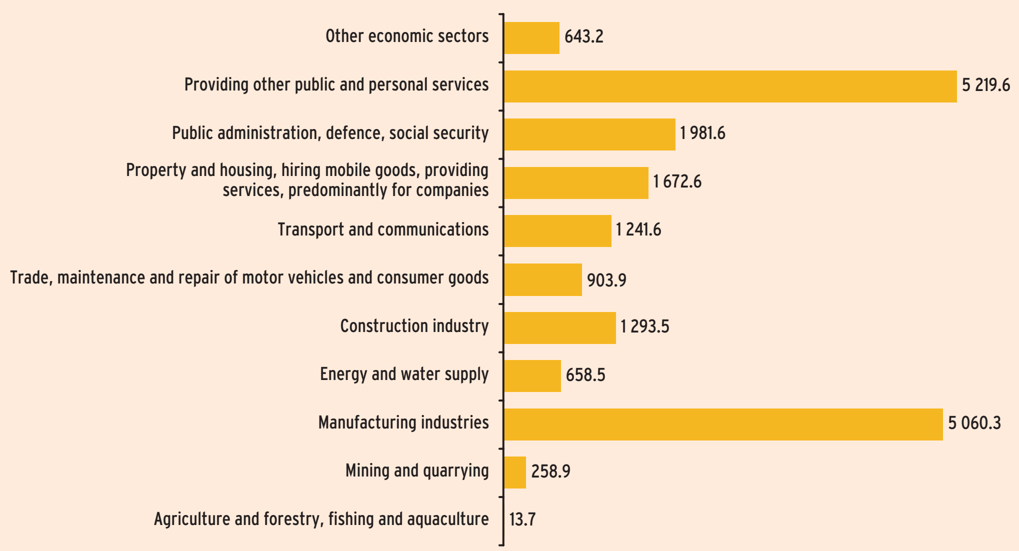
The prevention, recovery and disposal of waste are to be supervised by the competent authorities under paragraph 40 KrW-/AbfG; paragraph 41 provides that all waste disposal requires supervision. Particular requirements apply to the disposal of hazardous waste from manufacturing and other companies or public institutions which especially poses a risk to health, air, or water according to type or composition. The same applies to recoverable waste where particular substance properties make special requirements necessary for recycling (recoverable substances requiring special supervision, listed in ordinances).

In the *Länder* where there is an obligation to deliver or surrender, the waste producer must inform its waste disposal authority of the type, amount and composition of the waste and of the foreseen disposal plant. The authority then allocates a suitable plant for disposal of the waste.

Until the end of 2001, the "Ordinance on Ascertaining Waste Requiring Special Supervision" regulated which waste types were to be classed as hazardous. This was replaced by the "Ordinance on the Implementation of the European Waste Catalogue" (Waste Catalogue Ordinance – AVV) on 1 January 2002, which marked waste requiring special supervision with an asterisk (*). This rating is often taken from hazardous substances legislation.

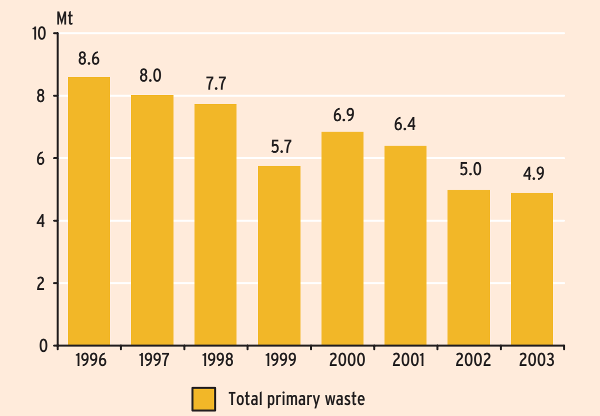
The survey of waste requiring special supervision is partly based on the examination of the proof procedure tracking forms (Fig. X 1.2-1). The appropriate authorities are obliged to provide the statistical offices with information. This however provides neither for recording of waste disposed of in-house (Fig. X 1.2-2) nor for transboundary waste levels (exports and imports). Double counts must be taken into account when ascertaining the original volume of waste (primary waste). "Hazardous waste" taken from company A to treatment plant B must be accompanied by a tracking form. Transporting new waste (secondary waste) which originated in treatment plant B as primary waste to disposal plant E must also be recorded on a tracking form.

Fig. X 1.2-1: *Origin of waste requiring special supervision (tracking form) 2003 in kt*



Source: *Federal Statistical Office 2005 b*

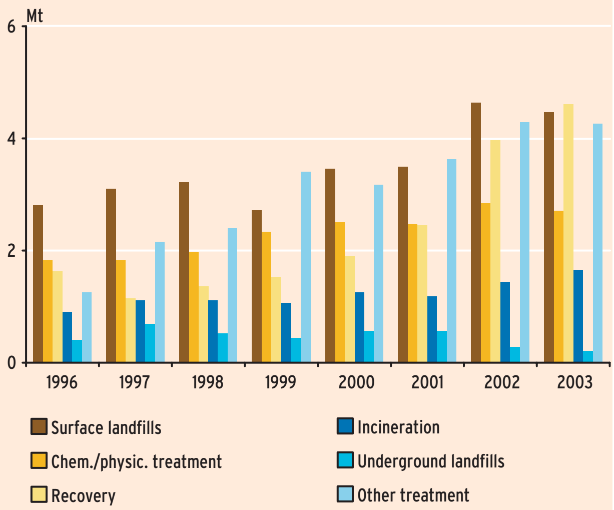
Fig. X 1.2-2: *Amount of waste requiring special supervision not recorded on tracking forms (operators with own disposal plants)*



Source: *Federal Statistical Office 2003*

Although the amount of primary waste is useful for commenting on quantity trends or assessing waste prevention measures, only actual waste streams are meaningful for concrete disposal planning measures. Finally, waste which is first treated and then dumped requires corresponding treatment plant and landfill capacities. In turn, increasing (pre-)treatment of waste gives rise to growing demand for treatment capacity if the amount of (primary) waste does not increase (Fig. X 1.2-3).

Fig. X 1.2-3: *Destination of waste requiring special supervision (tracking form) (excl. imports and exports)*



Source: *Federal Statistical Office 2004*

Waste properties can also alter while inside the treatment plant. For example, filtration dust requiring special supervision can develop from domestic waste not requiring special supervision in a domestic waste incineration plant. Likewise, waste not requiring special supervision can develop from waste requiring special supervision (e.g., acidic residues) in neutralization plants.

X 1.3 Management of radioactive waste and spent nuclear fuel elements

In accordance with paragraph 9a of the Atomic Energy Act, it is the responsibility of the producer of radioactive residual products to have them harmlessly recovered or disposed of as radioactive waste.

All waste management activities are subject to supervision by the authorities, enacted via the atomic law authorities of each Land. In the case of waste generated in the controlled area in nuclear power plant operations, the operator draws up a waste programme which is presented before the responsible supervisory authorities. The operator minimizes the volume of radioactive waste by way of suitable management and appropriate planning of plant revisions. The nuclear power plant operators carry out the treatment, conditioning, and disposal of radioactive waste with partial support from specialized industrial companies.

The accumulated radioactive waste is separated according to activity and material as soon as it is produced. This is done with the primary aim of unconditionally or conditionally recycling the largest possible share following a clearance measurement and in some cases obligatory decontamination. If it is not possible to remain below the stated limit values, at least the clearance criteria for disposal as conventional waste are to be accomplished.

The clearance levels for radioactive materials with minor activity and the clearance process are set out in the new ordinance of the protection against radiation hazards (StrlSchV). This ordinance sets around 300 radionuclide mass-specific clearance levels for solids and liquids, clearance of buildings and plots of land and clearance for disposal on domestic waste landfills or in an incineration plant, based on the 10 µSv concept. Clearance is carried out by the authorities. The required clearance measurements are carried out by the operator and are subject to supervision by the appropriate Land authorities, who also carry out control inspections.

The pre-treatment of radioactive waste serves to minimize volumes and convert raw waste into manageable, conditionable intermediary products ready for final disposal. All radioactive waste is separated as soon as it is produced and documented according to type, content, and activity. The separating criteria and requirements for the collection, ascertaining the activity and documentation are given in Appendix X of the Radiation Protection Ordinance (StrlSchV). This enables the party causing the waste to supply information at any time on the processing progress, activity, and whereabouts of all radioactive waste.

Pre-treatment, conditioning, and packaging of radioactive waste is carried out in the nuclear power plants in line with professional procedures and as sensibly as possible. Requirements for eventual final storage are taken into account as far as possible for each foreseen conditioning. Pre-treatment equipment (e.g., for concentration, separation, pressing and packaging) is available in all nuclear power plants. For example, non-combustible fluid waste is concentrated and non-combustible solid waste compacted with high-pressure presses. Conditioning for final storage is often carried out by contractors who have access to mobile equipment (e.g., in-drum drying plants for fluid concentrates or remotely controlled underwater dismantling equipment for medium activity waste) who bring it to the nuclear power plants. Incineration of combustible waste and conditioning (cementing) of the ashes produced is carried out by contractors in external plants. The conditioned bundles of terminal waste are returned to the nuclear power plants and either stored there or taken to central (external) temporary storage facilities.

Data compilation on radioactive waste from nuclear power plants

Every year, the Federal Office for Radiation Protection (BfS) surveys incidental radioactive waste in Germany. The amount and stocks of radioactive waste from nuclear power plants are also ascertained. In Germany, basic differences are drawn between radioactive waste with heat generation and that with negligible heat generation. Table X 1.3-1 shows data covering the 1996 to 2001 period.

Storage of spent nuclear fuel elements

Spent nuclear fuel elements are initially stored in wet storage ponds at the nuclear power plants and later in temporary storage planned in the vicinity (Tab. X 1.3-2) or are already in facilities put into operation. Among these is the on-site temporary storage facility in Lingen and the interim storage facilities in Neckarwestheim, Philippsburg, Biblis, and Krümmel.

Undercriticality and cooling of combustible elements in wet storage ponds and protection from external influences are ensured. In accordance with approval conditions, a capacity exceeding the atomic load is to be kept free at all times – with the exception of the Stade nuclear power plant – in order to allow the complete unloading of the nuclear reactor at any time. The internal storage capacities may not, in principle, be used for all power plants, with the exception of the double block plants Neckarwestheim and Philippsburg. Operation of an additional wet storage tank set up previously in the earthquake-proof emergency building external to the reactor building was approved in 1998 in the Obrigheim nuclear power plant. Nuclear fuel elements were first stored here in 1999.

Table X 1.3-3 contains amalgamated figures on approved storage capacities – stocks of spent and partially spent nuclear fuel elements and free storage capacities for all nuclear power plants in operation at the time (heavy metal content per nuclear fuel element is plant-dependent) – for the 1997 to 2001 period. Nuclear fuel elements used in the reactor cores are also given. Temporary storage of spent nuclear fuel elements in wet storage was detailed for the last time in Germany in May 2003 in the report "Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management" [1].

The spent nuclear fuel elements may be taken to a central interim storage facility used by all power plants and to others in France and Great Britain for reprocessing until the intended temporary storage facility in the vicinity goes into operation. Transport tank loading is carried out in the storage ponds. The tanks leave the nuclear power plant in the form

Tab. X 1.3-1: *Radioactive waste stocks from respective nuclear power plants in operation on 31 December in m^3*

	Amount of waste[1)]											
	(non-heat generating)						(heat generating)					
	1996	1997	1998	1999	2000	2001	1996	1997	1998	1999	2000	2001
Untreated residual and intermediate products	7 671	6 183	6 075	5 252	6 886	7 974	390	390	–	–	–	–
waste conditioned on nuclear power plant premises[2)]	5 926	5 325	4 540	4 865	4 986	5129	1	1	1	6	6	6
year conditioned[2)]	3 174	2 048	1 561	1 238	623	827	–	–	–	5	–	–

[1)] Amount and stocks from nuclear power plants closed down or taken out of operation are not included in these figures.
[2)] Figures in m^3 Container volumes

Source: *Federal Office for Radiation Protection 2002*

Tab. X 1.3-2: *Requested and approved temporary storage facilities located in vicinity (as of: 26 November 2004)*

Nuclear power plant	Type of storage facility	Application date	Mass HM [Mg]	Parking spaces	Approval/ Supplementary approval issued	Mass HM [Mg]	Parking spaces
Biblis A and Biblis B also for Mülheim-Kärlich	Temporary storage facility location Interim storage facility	23.12.1999 30.11.2000	1400 300	135 28	22.09.03* 20.12.01/16.04.03**	1400 300	135 28
Brokdorf	Temporary storage facility location	20.12.1999	1000	100	28.11.03*	1000	100
Brunsbüttel	Temporary storage facility location Interim storage facility	30.11.1999 15.08.2000	450 140	80 18	28.11.03* not yet notified	450	80
Grafenrheinfeld	Temporary storage facility location	23.02.2000	800	88	12.02.03*	800	88
Grohnde	Temporary storage facility location	20.12.1999	1000	100	20.12.02*	1000	100
Gundremmingen B and Gundremmingen C	Temporary storage facility location	25.02.2000	2250	192	19.12.03*	1850	192
Isar 1 and Isar 2	Temporary storage facility location	23.02.2000	1500	152	22.09.03*	1500	152
Krümmel	Temporary storage facility location Interim storage facility	30.11.1999 15.08.2000	800 120	80 12	19.12.03* 20.06.03*	775 120	80 12
Lingen (Emsland)	Temporary storage facility location	22.12.1998	1250	130	06.11.02*	1250	130[1)]
Neckarwestheim 1 and Neckarwestheim 2	Temporary storage facility location Interim storage facility	20.12.1999 20.12.1999	1600 250	151 24	22.09.03* 10.04.01/20.12.02**	1600 250	151 24
Philippsburg 1 and Philippsburg 2	Temporary storage facility location Interim storage facility	20.12.1999 20.12.1999	1600 250	152 24	19.12.03* 31.07.01/17.02.03**	1600 130/250	152 12/24
Stade	Temporary storage facility location	20.12.1999	300	80	Appliation withdrawn		
Unterweser	Temporary storage facility location	20.12.1999	800	80	22.09.03*	800	80

* further approval steps to follow
** Process concluded
1) For 125 containers loaded with nuclear fuel and 5 containers with negligible heat generation

Source: *Federal Office for Radiation Protection 2004*

Tab. X 1.3-3: *Temporary storage of spent nuclear fuel elements in wet storage in all nuclear power plants on 31 December*

Storage capacity	1997		1998		1999		2000		2001	
	Quantity	(t HM)	Quantity	(t HM)	Quantity	(t HM)	Quantity	(t HM)	Quantity	(t HM)
approved total capacity	20 843	6 575	21 865	6 877	21 865	6 877	22 037	6 965	21 247	6 613
spent and partially spent nuclear fuel elements[1)]	6 442	2 289	7 382	2 582	8 410[2)]	2 931[2)]	9 614[2),5)]	3 278[2)]	10 373	3 474
free capacity[3)]	5 982	1 840	6 288	1 909	5 570	1 606	4 898	1 382	3 849	1 004
Nuclear fuel elements in reactor core[4)]	6 473	1 898	6 473	1 898	6 473	1 898	6 473	1 900	6 473	1 902

1) Partially spent nuclear fuel elements can be used again
2) Data from Federal Radiation Protection Office surveys
3) Parking spaces used for unloading reactor core and for other operational purposes not included in calculation
4) Spent fuel elements from the Mülheim-Kärlich reactor core are in wet storage ponds
5) An additional total of 126 nuclear fuel elements in either transport or transport/storage containers have been made available on the plant premises

Source: *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 2004*

of wet transports (Great Britain) or dry transports (France). In accordance with the agreement between the Federal Government of Germany and the utility companies dated 14 June 2000 and signed 11

June 2001, no more transports for reprocessing are foreseen as from 1 July 2005. Delivery of irradiated nuclear fuel elements from nuclear power plants to reprocessing plants was banned as from 1 July 2005 in accordance with an amendment to the atomic law in 2002.

To minimise future transports of spent nuclear fuel elements, nuclear power plant operators requested the erection of on-site temporary storage facilities for all 13 locations (excluding Mülheim-Kärlich) from 1998 to 2000 and authorisation (1st authorisation steps) was granted by the end of 2003 for all on-site temporary storage facilities and all interim storage facilities with the exception of Brunsbüttel (Tab. X 1.3-2). In the case of the interim storage facility in Brunsbüttel, the applicant had not reached a decision in 2003. The application for the on-site temporary storage facility in Stade was withdrawn due to the premature closure of the power plant.

These temporary storage facilities are concerned with dry storage for spent nuclear fuel elements predominantly in CASTOR transport and storage tanks. The capacity of this storage facility is measured to allow it to take all spent nuclear fuel element stocks by final closure of the power plant. This also enables storage as well as closure of the power plant until the final storage facility goes into operation by around 2030. In order to avoid short-term storage bottle necks, the Biblis, Brunsbüttel, Krümmel, Neckarwestheim, and Philippsburg power plants have requested additional temporary storage possibilities (interim storage facilities) within a capacity of between 12 and 28 storage tank storage spaces. The Federal Office for Radiation Protection is responsible for approval of the temporary storage facility.

Disposal

The Atomic Energy Act forms the legal basis for disposal. In accordance with this, nuclear power plant disposal measures are carried out thus:

- intermediate storage of spent nuclear fuel elements in central (external) temporary storage facilities and as swiftly as possible to on-site temporary storage facilities on the power plant premises, and eventual direct final storage of nuclear fuel elements,
- reprocessing of spent nuclear fuel elements, accounting for the fact that delivery of irradiated nuclear fuel elements from nuclear power plants to reprocessing plants is permissible up to 30 June 2005 at the latest, and recovery of returned nuclear fuel and proper disposal of radioactive waste thereby generated in Germany,
- conditioning, intermediate storage and eventual final storage of radioactive waste from the operation and closure of nuclear power plants.

The Morsleben final storage facility was in operation until September 1998 for final storage purposes of low- and medium-radioactive waste. The plan fixation procedure for the Schlacht Konrad final storage facility was concluded in May 2002 with an official declaration decree. There are currently four complaints filed against the decision, preventing its completion. Exploration of the Gorleben salt dome shall be stopped for at least 3, at most 10 years. The Federal Government plans to make available a final storage facility for all radioactive waste by around 2030. The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) convened the final storage locations selection procedure group which is working on a traceable procedure for the selection of suitable final storage locations based on sound criteria and delivered this to the BMU in December 2002. The BMU now intends to translate the results into legal regulations.

Until a final storage facility goes into operation, the operator's disposal precautions shall be carried through by way of temporary storage verifiction as from 1 July 2005.

[1] http://www.bmu.de/files/behandlung_brenn.pdf

X 2 Waste recovery

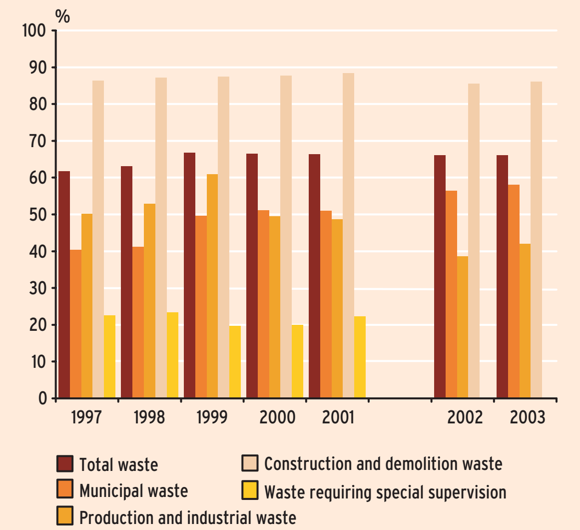
Sustainable development requires decoupling of resource use from economic growth. The efficiency strategy can only be successful in the long-term if increasing production and higher consumption levels do not sap efficiency gains. Waste prevention and increased recovery are key to this. Finally, waste management must dissociate itself from its special role in an "end-of-pipe" mentality associated with the cheapest possible waste disposal in an affluent society and instead continue to develop as a source for the procurement of raw materials and production of goods.

X 2.1 Recovery rates for main waste streams

In interpreting the following figures on the individual main waste streams it should be noted that in the timeframe under consideration, several adjustments to the survey and additions to the recorded levels of waste types were made. Respective waste levels, primarily those generated by waste disposal plant operators, have been recorded since 1996.

Limitations on data comparability for the period considered come to light in the changeover from the materials-oriented waste register of the Working Group of the Federal States on Waste (LAGA) used until 1998, to the origins-oriented European Waste Catalogue (EAK), used from 1999. This led to waste levels being shifted to certain positions lower down on the scale, particularly in the case of municipal waste, manufacturing and trade waste, and construction and demolition waste. In 2002 the EAK was replaced by the European List of Waste (LOW) which resulted in shifts within municipal waste as well as between waste not requiring any special supervision and waste requiring special supervision. Up to and including 2001, waste requiring special supervision was listed as a separate waste stream; in the 2002 figures it was included under other waste types (Fig. X 2.1-1 and Tab. "Amount, removal and recovery of waste, 1999–2003").

Fig. X 2.1-1: *Recovery rates for main waste streams*



1998: Hamburg with data from 1997
from 1999: Changeover from European Waste Catalogue (EAK) with shifts to certain positions lower down on the scale (municipal, manufacturing, trade, construction, and demolition waste)
2000: Hamburg with data from 1999
2002: Introduction of European List of Waste (LOW) with shifts between waste not requiring any special supervision and that requiring special supervision as well as within municipal waste.
Waste requiring special supervision: Waste requiring special supervision included in main waste streams from 2002 onwards.

Source: *Federal Statistical Office 2005*

A further disruption in the 1998 to 1999 time period in terms of manufacturing and trade waste exists because after 1999, waste levels processed in-house are no longer taken into account, while recycling and disposal continue to be recorded.

Over half of all municipal waste is recovered. This puts Germany well above the average European Union recovery rate (26 %) [1].

The recovery rate for manufacturing and trade waste rose at first and then fell to below the 1997 level during the course of conversion of statistical waste classification from the Working Group of the Federal States on Waste (LAGA) list to the EAK waste register. It is presumed that the rise is attributable to statistical effects.

Construction and demolition waste amounts to around 60 % of the volume of Germany's waste. Recovery of this waste has been at a high level for many years.

[1] European Commission report to the Council and to the European Parliament on the Implementation of Community Legislation (Waste Framework Directive 75/442/EEC, Hazardous Waste Directive 91/689/EEC, Waste Oils Directive 75/439/EEC, Sewage Sludge Directive 86/278/EEC and Packaging and Packaging Waste Directive 94/62/EC) for the 1998–2000 period, KOM (2003) 250 conclusive as from 19 May 2003, page 20

X 2.2 Recovery of selected waste types

The following investigates more closely the recovery of selected waste streams in Germany.

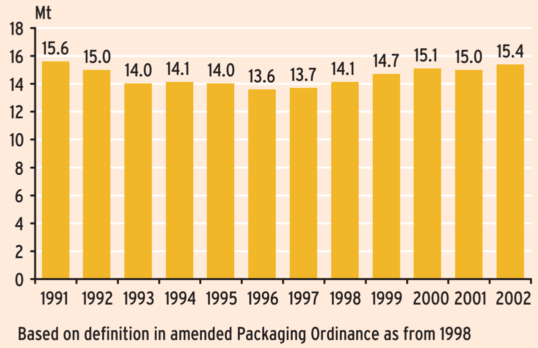
Packaging consumption and recycling of packaging waste

Based on EU Directive 94/62/EC on Packaging and Packaging Waste dated 20 December 1994, the Federal Government is obliged to convey data on consumption and recycling of packaging to the European Commission as from 1997 by way of annual reports.

Based on surveys, pilot surveys, and independent surveys by the Gesellschaft für Verpackungsmarktforschung, (GVM) in Wiesbaden, data on packaging consumption and packaging recycling trends in Germany is available for the 1991 to 2002 period. According to this data, annual packaging consumption fell between 1991 and 1996. It rose again between 1997 and 2000. Following a negligible decrease in 2001, packaging consumption rose again in 2002 (Fig. X 2.2-1). Over the entire period, paper/paperboard/cardboard packaging made up the largest share in terms of mass, followed by glass, wood/cork, synthetic material and other packaging materials (Table "Packaging consumption trends"). In 2001, 79 % of Germany's packaging waste was recycled. This data shows that packaging consumption has been successfully disassociated from general economic growth and that recycling of packaging waste has increased sharply.

Trends in packaging waste reflect both the effects of the Packaging Ordinance (VerpackV) and changes in packing material supplies based on cur-

Fig. X 2.2-1: *Packaging consumption trends*



Source: *Gesellschaft für Verpackungsmarktforschung mbH 2004*

rent market trends. Differentiations can be drawn between the individual trends. For example, glass packaging supplies have decreased steadily in comparison to 1991 (reducing weights, replacing glass drinks packaging with cans, cartons and synthetic bottles), while there has been a clear increase in paper, synthetic and wood packaging supplies (sharp increase in corrugated cardboard, cardboard and solid fibre board as well as in wood for transport packaging, strong growth in synthetic packaging; predominantly in disposable synthetic bottles).

Packaging made from glass, tinplate, aluminium, synthetic and paper, paperboard or carton including composite material for each material base accounted for 81 % of packaging consumption in 2001, of which 58 % in turn was accounted for by private end users. This means that packaging from these materials in this sector, for which the Packaging Ordinance states material recycling rates, accounted for almost half of total packaging consumption. Consumption by private end users reveals similar trends to packaging consumption in general, yet consumption for 2002 published by GVM is lower than that published for 1991. Good results were attained for packaging waste recycling by private and end users. The recycling levels doubled between 1991 and 2002. Strong growth in recycling was in aluminium and synthetic packaging, where recycling rates of 5.1 % for aluminium (including aluminium-based composites) and 3.1 % for synthetic (including plastic based composites) in 1991 had grown to 71.5 % and 54.7 % respectively in 2002 (Tab. X 2.2-1).

Under paragraph 6.3 of the Packaging Ordinance, all packaging waste generated by private end users is collected and recycled by the Dual System (DSD). From 1993 until the end of 2002, a total of 51.34 Mt were recovered. The DSD is required to demonstrate compliance with recycling quotas set out in the Packaging Ordinance, and was able to meet or exceed all quotas during this period. With the 1998 amendment to the Packaging Ordinance, not only

Tab. X 2.2.-1: *Recycling of retail packaging – private final consumers[1)]*

in kt	1991	2000	2002	2003[2)]
Consumption **Glass**	3 817.3	3 318.0	2 895.8	2 684.2
Recycling levels	2 049.7	2 709.2	2 466.4	2 320.2
Recycling rate in %	***53.7***	***81.7***	***85.2***	***86.4***
Consumption **Tin plate**	740.8	645.9	635.2	495.8
Recycling levels	250.6	515.3	521.2	436.9
Recycling rate in %	*33.8*	*79.8*	*82.0*	*88.1*
Consumption **Aluminium**	84.5	79.3	81.9	76.8
Recycling levels	4.3	60.3	58.5	55.8
Recycling rate in %	***5.1***	***76.0***	***71.5***	***72.6***
Consumption **Synthetics**[3)]	976.9	1 120.9	1 380.4	1 354.3
Recycling levels	30.0	651.1	755.1	784.3
Recycling rate in %	***3.1***	***58.1***	***54.7***	***57.9***
Consumption **Paper**[3)4)]	1 834.2	1 992.6	2 049.4	2 080.4
Recycling levels	514.0	1 541.9	1 659.6	1 640.9
Recycling rate in %	***28.0***	***77.4***	***81.0***	***78.9***
Consumption **Liquids packaging**	193.0	218.1	227.2	246.9
Recycling levels	N/A	134.3	144.0	159.1
Recycling rate in %	***N/A***	***61.6***	***63.4***	***64.4***
Consumption **Total**[5)]	7 646.7	7 374.8	7 269.9	6 938.4
Recycling levels	2 848.7	5 612.1	5 604.9	5 397.2
Recycling rate in %	***37.3***	***76.1***	***77.1***	***77.8***

1) based on definitions in amended Ordinance on the Avoidance of Packaging Waste as of 1998
2) GVM forecast
3) incl. composite material for each material base
4) excl. liquids packaging
5) quoted packaging materials only

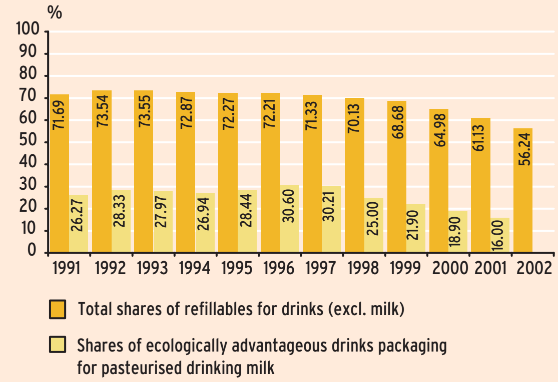
Source: *Gesellschaft für Verpackungsmarktforschung mbH 2004* manufacturers and distributors who belong to the DSD (which handles disposal for them and provides proof of having met the quotas), but also those who dispose of waste themselves are now required to demonstrate quota compliance (paragraph 6.1-2).

Refillable drink packages are subjected to special protection under the Packaging Ordinance due to their ecological profitability. The share of refillables on the drinks market are for this reason to be the subject of annual surveys and published by the Federal Government, in accordance with paragraph 9 of the Packaging Ordinance.

According to paragraph 9 of the Packaging Ordinance at least 72 % of drinks (excluding milk) is to be packaged in refillable containers. The share of refillables (excluding milk, without vats > 5 l, post and premix) in Germany was already large in 1991 (71.69 %). After an increase and leveling off in 1992 and 1993, the trend has been downwards since 1994. In 1997, the refillable quota failed to meet the 72 % set out in the Packaging Ordinance for the first time, and it fell further in 1998. Since then, the share of refillable packaging in Germany has been falling (Fig. X 2.2-2). In accordance with the Packaging Ordinance, mandatory deposits on disposable drink packages came into effect after falling short of the quota again on 1 January 2003. The beer, mineral water and fizzy drink sectors have so far been affected as their specific respective refillable shares have sunk to below the 1991 level, despite taking into account unavoidable statistical errors (Tab. X 2.2-2). 2003 surveys show that this backwards trend was stopped by the introduction on 1 January 2003 of mandatory deposits on disposable drink packages and the refillable share rose again.

The refillables share of pasteurised drinking milk in Germany has been falling after brief growth between 1991 and 1996. The 1998 amendment to the Packaging Ordinance raised the refillable quota for pasteurised drinking milk from 17 % to 20 %, including polythene tubular bags as well as refillable packaging. Calculated on this basis, the quota in 1997 was easily met, with a total share of 30.21 %. This share has been decreasing since 1998. The legal quota for ecologically friendly milk packaging was not met for the first time. Only 16 % of pasteurized drinking milk was packaged in ecologically friendly packaging (Table X 2.2-3 and Figure X 2.2.-2).

Fig. X 2.2-2: *Shares of ecologically advantageous drinks packaging*



Source: *Gesellschaft für Verpackungsmarktforschung mbH 2004 a*

Paper consumption and waste paper recycling

In 2003, paper consumption per capita in Germany was 224 kg, producing a total consumption of 18.5 Mt Waste paper supplies, i.e., the quantities of waste paper collected by the waste paper industry and private or local authority waste management, and then returned to the paper industry or exported, was 13.6 Mt in 2003, a recovery rate of 73.7 % (Tab. X 2.2-4). The German paper industry recovered 12.4 Mt of waste paper (Fig. X 2.2-3). The share of waste paper inputs to total domestic paper production (waste paper utilization rate) was 64.5 % or 19.3 Mt in 2003. The share of waste paper supplies in areas such as corrugated paperboard production or newspaper exceeds 100 %, since sorting residues and any impurities harmful to paper quality must be removed before waste paper is processed (Table X 2.2-5). Only slight increases are expected for these types. There is a strong possibility of increase in waste paper supplies for newspapers and office and administrative paper, but also tissue, presupposing an increase in consumer demand.

Tab. X 2.2-2: *Total refillable shares for drinks (excluding milk) in %*

Drinks sector	1991	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Drinks in total (excluding milk)	71.69	73.55	72.87	72.27	72.21	71.33	70.13	68.68	64.98	61.13	56.24	63.74
Mineral water	91.33	90.89	89.53	89.03	88.68	88.31	87.44	84.94	80.96	74.03	68.33	72.98
Fruit juice and other drinks without CO_2	34.56	39.57	38.76	38.24	37.93	36.81	35.66	34.75	33.62	33.16	29.46	25.40
Soft drinks with CO_2	73.72	76.67	76.66	75.31	77.50	77.76	77.02	74.90	66.96	60.21	53.97	66.09
Beer	82.16	82.25	81.03	79.07	79.02	77.88	76.14	74.83	72.81	70.84	67.99	89.24
Wine	28.63	28.90	28.54	30.42	28.66	28.10	26.20	26.75	25.03	25.41	25.29	24.62

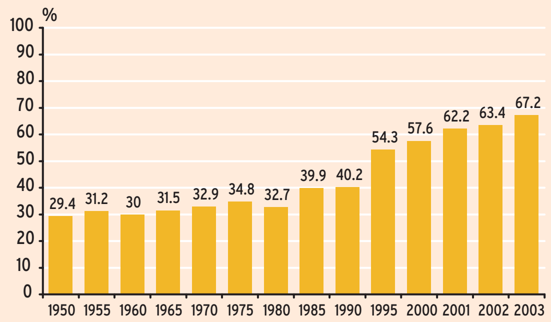
Source: *Gesellschaft für Verpackungsmarktforschung mbH 2005*

Tab. X 2.2-3: *Shares of ecologically advantageous packaging for pasteurized drinking milk in %*

	1991	1996	2000	2001
Total pasteurized drinking milk	26.27	30.60	18.90	16.00
Reusable	24.17	20.10	11.80	11.50
Tubular bag	2.10	10.50	7.10	4.40

Source: *Pack Marketing GmbH 2004*

Fig. X 2.2-3: *Waste paper recycling rate[1)]*



[1)] old *Länder* up to 1989, Germany from 1990
Waste paper recycling rate: Waste paper/paper consumption

Source: *Verband Deutscher Papierfabriken e.V. 2004*

Due to the increase in waste paper supplies, the German paper industry has succeeded in reducing specific sources of environmental pollution. For example, mean energy supplies for manufactured paper fell from 3.4 million wh/t in 1990 to 2.6 million wh/t in 2003. Put in perspective, this success was offset by increases in production over the same period: total energy supplies rose from 190 PJ (1990) to 260 PJ (2003). This attributes particular significance to moderating paper use in terms of continued positive environmental impacts.

The Federal Environment Agency is investigating the quantitatively significant graphic paper sector – i.e., paper used for newspapers, magazines, writing, or photocopying paper – for environmental impacts caused during its life cycle and the environmental relief potential of the use of waste paper in the production process. The most important results are:

- manufacturing waste paper is considerably more environmentally compatible than using fresh fibres from wood raw material.
- taking Light Weight Coated (LWC) news paper as an example, a comparison between LWC papers containing waste paper and that exclusively based on wood speaks clearly in favour of waste paper products: particular advantages can be seen in the impact categories of demands on natural areas, greenhouse potential, scarcity of fossil fuels, photo-oxidant potential (summer smog), aquatic and terrestrial eutrophy potential and in the ecotoxicity (environmentally toxic) and human toxicity (toxic for people) indicators.
- Recycling waste paper in order to manufacture new paper is considerably more environmentally compatible than burning waste paper for energy. Disposal of waste paper on landfill sites is the worst solution in terms of environmental protection.

Increased waste paper recycling is more favourable for almost all impact categories considered. This applies to the scarcity of fossil fuels, greenhouse potential, summer smog, acidifying potential, and overfertilisation of soils and waters. The advantage of greenhouse potential, which has top priority in terms of environmental policy, is stressed here. Another advantage to waste paper recycling is that more wood remains in forest areas and as a result the natural area potential, or the share of forest areas less intensively cultivated by man, are able to grow.

Glass recycling

In 2003, a total of 7.279 Mt of glass and mineral fibre were manufactured in Germany. Container glass was one of the main products with approx 4.207 Mt and flat glass with 1.572 Mt.

Tab. X 2.2-4: *Paper production, consumption and waste paper consumption*

		1990	2000	2003
Paper production in Germany[1)]	Thousand t	12 773	18 182	19 310
Import	Thousand t	6 931	9 818	9 949
Export	Thousand t	4 243	8 907	10 742
Paper consumption in Germany[1)]	Thousand t	15 461	19 093	18 517
Amount of waste paper[1)]	Thousand t	6 803	13 677	13 643
Waste paper consumption[1)]	Thousand t	6 212	10 992	12 449
Waste paper return rate[2)]	%	**44.0**	**71.6**	**73.7**
Waste paper processing rate[3)]	%	**48.6**	**60.4**	**64.5**
Waste paper recycling rate[4)]	%	**40.2**	**57.6**	**67.2**

[1)] Survey basis altered after 1985
[2)] Waste paper return rate: Amount of waste paper/paper consumption
[3)] Waste paper processing rate: Waste paper consumption/paper production (excl. consumption for waste paper material export)
[4)] Waste paper recycling rate: Waste paper/paper consumption

Source: *Verband Deutscher Papierfabriken e.V. 2004*

Tab. X 2.2-5: *Waste paper processing rates in Germany in %*

	1995	2000	2003
Corrugated cardboard raw paper	109	108	108
Foldable box carton	81	82	77
Other packaging paper and cardboards (excluding protective cardboard)	73	71	76
Total packaging paper and card	**95**	**95**	**97**
Newspaper	113	117	115
Other graphic papers incl. natural newspaper	9	18	21
Printing and press paper, office and administration paper	**33**	**37**	**43**
Toilet paper	**70**	**74**	**75**
Paper and cardboard for technical and specialized uses incl. protective card	**46**	**41**	**38**
Total processing rate for waste paper and cardboard types[1)]	**58**	**60**	**65**

[1)] Waste paper consumption % for paper and cardboard production (as from 1996 incl. MarktAP material)

Source: *Verband Deutscher Papierfabriken e. V. 2004*

Glass can basically be recycled and reprocessed into new products indefinitely. Since recycled glass melts at lower temperatures than the raw materials for glass production, every 1 % of recycled glass used reduces the energy consumption of the melting process by 0.2 to 0.3 %. Glass recycling therefore reduces considerably the environmental pollution associated with glass production (e.g., CO_2 emissions), and saves landfill areas, alongside the obvious savings in raw materials (quartz sand, soda, lime).

Production waste (e. g., rejects) has traditionally been recycled by glass manufacturers, although there are technical and economic limits to the use of waste glass, depending upon the quality requirements (e.g., impurities, colour) for specific products.

Container glass

Each glass manufacturing branch has specific quality requirements for the conditioned cullet. In container glass production, for which recycled glass has become the major input, the ceramics, stone, and porcelain fraction must be below 25g, the non-ferrous metals fraction below 5g per tonne of recycled glass. There are also minimum requirements on the content of ferrous metals and organic impurities (e.g., paper and synthetics). The requirements for the colour purity of the cullet entail especially high technical efforts. To produce white container glass with 50 % cullet a colour purity of 99.7 % is required. Discoloured inputs to brown glass production must remain at a ratio of 8 % or lower, and only green glass can contain up to 15 % discoloured cullet. The conditioning of cullet is a fully automated process. For technical and economic reasons, colour sorting requires that the recycled glass is collected separately by colour.

A further basic prerequisite for returning container glass to the melting process in order to manufacture new bottles and other glasses is that the collected glass is well-sorted. A pre-sorting done by the consumers is absolutely necessary. Flat glass, car glass, crystal glass and above all refractory glass such as laboratory glass, ceramic glass, Pyrex etc. are difficult to sort out in glass recycling processes and can lead to significant losses in production or to the enrichment of heavy metals in the container glass cycle, e.g., in the case of lead crystal glass.

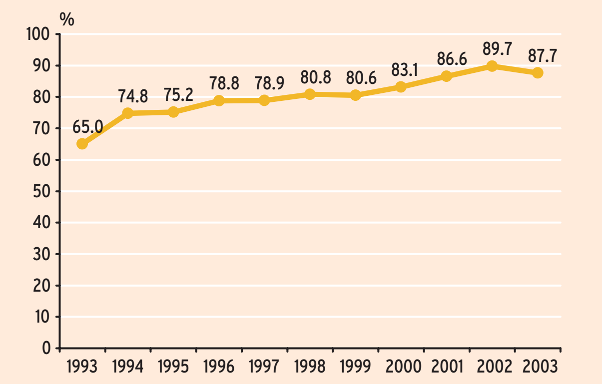
The mean cullet fraction amounted to 46 % in brown glass production, 51.4 % in white glass and 74 % in green glass in 2003. The peak value – around 70 % for white and brown glass or around 90 % for green glass – depends on the individual furnace, the glass color, and the melting technique.

A nation-wide collection system for container glass was set up in 1974. The glass is most commonly collected in separate bins for white, brown, and green glass, with over 300 000 glass recycling bins currently in use, one container for each 600 to 800 citizens

27.8 kg of glass per household were collected in 2003.

Container glass recovery in 2003 attained a quota of 87.67 % (Figure X 2.2-4 and Table "Waste glass collection and recovery in the German container glass industry").

Fig. X 2.2-4: *Container glass recycling*



Source: *Gesellschaft für Glasrecycling und Abfallvermeidung mbH 2004*

Flat glass

Quality requirements are especially high for plate glass (e.g., that used in buildings or vehicles), and the flat glass industry therefore recycles predominantly only its own cullet or well-sorted cullet from the glass processing industry. Collection systems for recovering well-sorted and pure flat glass products have recently been established, especially in the processing industry. Glass which does not meet the purity requirements must undergo a pre-treatment process, which is currently available at ten pre-treatment plants. Cullet fractions whose quality makes them unsuitable for flat glass manufacture can be used in the production of container glass, mineral wool, sandpaper, or glass objects, for example.

The German association for Secondary Raw Materials and Waste Disposal (bvse) estimates that approximately 495 000 t of waste flat glass was produced in the construction and vehicles industries in 1998, of which some 60 % (300 000 t) was recovered.

The End-of-Life Vehicle Regulation which came into force on 1 April 1998 had no quantitative impact on glass recovery quotas within the automobile industry as the regulation did not cover compulsory glass removal or recycling. The majority of potential glass obtained from the automobile scrapping process was then, as now, disposed of along with lightweight fraction obtained during the shredding process.

The 2000 EU End-of-Life-Vehicle Directive necessitated amendments to the End-of-Life Vehicle Act. The amended regulation – now the End-of-Life Vehicles Ordinance – covers compulsory glass removal and recycling in accordance with the EU Directive. In line with this, glass must be removed and recycled.

At its 81st session the Working Group of the Federal States on Waste (LAGA) agreed that this requirement is set to be fulfilled if the total recycling quotas cited in the directive and the ordinance are met as from 2006. Due to this broad interpretation of the ordinance text, the recquirements for the dismanteling companies to remove and recycle flat glass is not fulfilled.

According to the bvse, the flat glass availability from dismantling companies have further decreased since the LAGA decision. Of around 75 000 t glass from end-of-life vehicle disposal, only approximately 5 000 t (7 %) was recycled in 2002. Also, due to stagnation in the construction industry, full use cannot be made of the available plants for processing used sheet glass products for furnace shards, in spite of a corresponding demand for raw materials in the glass industry.

Cathode ray tubes

Between 5 and 6 million colour television sets are sold each year. Add to this colour monitors.

The average use life for television sets is between 10 and 12 years.

The main fraction of the total weight of television sets or monitors is the cathode ray tube which is mainly made of glass.

Some 525 000 t of glass are used annually to produce cathode ray tubes (CRTs) for monitors and television sets in the EU. Three specialist manufacturers are active in this sector in Germany, with a circa 69 % market share.

Colour CRTs are made up of four different types of glass:

- *the screen*, or panel glass, is the main component of a cathode ray tube. The panel glass used is a barium strontium silica glass (8–13 % BaO, 2.2–8.8 % SrO). It also contains antimony (0.2–0.6 % Sb_2O_3),
- *the funnel*, or cone, requires glass with a high lead oxide content (20–24 %, depending on the year of manufacture and origin of the CRT). Modern appliances may well contain traces of strontium and barium,
- *the neck* requires lead glass (28–30 % lead oxide).
- The panel and the funnel are joined with a *glass frit*, a lead borate glass (approximately 80 % PbO).

In terms of quantity, only the panel and the funnel are relevant for recycling purposes. A CRT weighs between 5 and 20 kg, with the two glass types in a proportion of about 2/3 to 1/3 respectively.

The directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on Waste Electrical and Electronic Equipment (WEEE) came into force on the 13 February 2003 with the publication in the European Union official journal.

The directive includes a minimum recycling quota for waste electrical and electronic equipment containing CRTs of 75 % of the average weight of each piece of equipment. The re-use and recycling quota for components, materials and matter must attain at least 65 % of the average weight per piece of equipment. Fluorescent coating is to be removed. The EC-directive will be implemented nationally as a federal statutory ordinance.

Environmental friendly recycling of spent picture tubes still causes problems. Available cullet capacities for the production of CRT glass have not yet been exhausted due to high demands on processed waste glass shards. Of Europe's estimated annual cullet volume of approximately 500 000 to

700 000 t, only approximately 30 000 t of cullet were made use of in Germany in 2003, mainly for funnel glass.

Returning cullet to the melting process is advantageous in reducing energy demands for melting and considerably decreases the use of lead oxide.

In the mid-term, the implementation of improved sorting process techniques should contribute to a sharp increase in cullet supplies in funnel glass and panel glass manufacturing.

If recovered in other processes than those for CRT production, especially in view of the high lead content in funnel glass, care must be taken to prevent CRT glass from diffusely distributing heavy metals throughout products and contaminating normally heavy metal-free products and material cycles, since product use (use risk) and post-use product disposal (disposal risk) must be taken into account when considering the general good.

Discharge lamps

Around 100 million discharge lamps are currently in use in Germany. They are of a particular environmental concern due to their mercury content.

Mercury in spent discharge lamps:

- standard fluorescent tubular lamps < 15.0 mg
- single layer triple-band tubular fluorescent lamps < 7.5 mg
- compact fluorescent lamps < 7.0 mg
- high pressure discharge lamps < 30.0 mg
- special emitters 1.5 g

The new EU Directive on waste electrical and electronic equipment also aims towards a standardized disposal level for discharge lamps (recovery quota at least 80 % of average lamp weight).

The end-cap separation process is implemented for processing tubular discharge lamps. It allows large-scale clean separation of glass, metals, and fluorescents.

Compact fluorescent lamps and non-tubular fluorescent lamps (ring- and u-shaped) are dismantled by a shredding process. The quality of the cullet from the shredding process is usually insufficient for the manufacture of new lamp glass.

The companies cooperating under the Lamp Recycling Working Group (AGLV) of the German Electrical and Electronic Industry (ZVEI) process around 30 million spent discharge lamps per year. Member companies monitor the environmental compatibility of the recycling processes and check material flows with an inspection and certification process. However, mass flow verifications have not been published, yet.

According to information from lamp glass manufacturers, full use of the available recycling capacities in lamp glass production is far from being made.

It should be taken into account that in all recycling options fluorescent lamp glass absorbs mercury via diffusion processes when in operation and depending on processing quality, dust containing mercury remains on the cullet.

For example, mercury can be released unchecked into the environment during storage via the effect of acidic media or during melting.

Mercury content in the processed glass of spent fluorescent lamps is usually between 4 and 6 mg/kg glass.

Cullet from the processing of lamp rejects in the manufacturing plants reveal an Hg-content of approximately 1 mg/kg.

With this in mind, lamp glass should only be used in processes that meet immission control legislative guidelines. According to No. 5.2.2 of the Technical Instructions on Air Quality Control (TI Air) dated 24 July 2002, mercury emissions (class 1) in waste gas may not exceed mass flow of 0.25 g/h or mass concentration of 0.05 mg/m^3.

In the near future mercury content in fluorescent lamps will decrease further. Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment stipulates the following maximum per lamp mercury levels:

- compact fluorescent lamps 5 mg
- tubular fluorescent lamps (for general use)
  - halophosphate: 10 mg
  - normal-life triplephosphate: 5 mg
  - long-life triplephosphate: 8 mg

Generation and disposal of synthetic waste

In Germany, one of the world's largest synthetics manufacturers, some 10.6 Mt synthetics were processed in 2003, more than 60 % of which were thermoplastics

- polythene (PE): 2.74 Mt,
- polyvinyl chloride (PVC): 1.59 Mt,

- polypropylene (PP): 1.72 Mt and
- polystyrene (PS): 0.42 Mt.

Around 15 % of the total processed quantities were other thermoplastics, such as polyamide (PA), polycarbonate (PC), styrene copolymers (ABS, SAN), or polythene terephthalate (PET), while just under 25 % were duroplastics. PET revealed the highest growth rate in comparison with 2001.

The largest supply area for synthetics was again packaging – 33 % (2001: 29.5 %) of synthetics treated in Germany were supplied for this purpose. The construction industry continues to occupy second place with 23.5 % (2001: 24.5 %). Further significant supply areas were the vehicle manufacturing industry with 9 % (2001: 9 %) and the electral/electronics industry with 7.5 % (2001: 7.5 %). Together, these four areas consumed over 70 % of the supplied synthetics.

Synthetic waste arises during the manufacture of moulded synthetic products, semi-manufactured and final products, and after their use. Around 4 Mt of synthetic waste were produced in Germany in 2003. Of this, 1.42 Mt was allotted to PE alone, 0.49 Mt to PVC and 0.43 Mt to PP. Approximately 2.34 Mt synthetic waste were recovered, 1.67 Mt disposed of via landfills or incineration. The total recovery quota amounted therefore to over 58 % (Table X 2.2-6).

Tab. X 2.2-6: *Amount and recovery rate for synthetic waste according to origins of waste 2003*

	Amount of waste in 1 000 t	Amount recovered in 1 000 t	Recovery rate in %
Synthetics production	86	81	94.2
Synthetics processing	802	710	88.5
industrial end use	1 402	714	50.9
private end use	1 715	833	48.6
Total	**4 005**	**2 338**	**58.4**

Source: *CONSULTIC Marketing & Industrieberatung GmbH 2004*

Recent studies have shown that recovery rates differ widely according to the origins of the waste. The waste recovery rate for synthetics generation and treatment were 94 % and 89 % respectively. In contrast, only 50 % of post-consumer waste from industrial end use and households was recovered. The most significant difference between the recovery rates is mainly attributable to increased contamination and mixing of post-consumer waste.

In Germany, 94 % of the 1.67 Mt synthetic waste disposed of in 2003 originated from commercial and private use. From an environmental point of view, it would be advisable to examine the suitability of this synthetic waste for recycling in order to fraction off suitable synthetic waste types and recover them effectively, despite processing and recycling difficulties caused by contaminated synthetic waste (see Table "Recycling and disposal levels of synthetic waste from the post-consumer sector").

Evaluation of waste balances for the *Länder* according to separately collected waste electrical and electronic equipment from private households

Waste electrical and electronic equipment includes products with widely varying useful lives, retail prices and profiles of use. Owing to the broad product palette, the mix of harmful and valuable materials is hard to analyse with regard to the environment. Some particularly pollutant-rich components are mercury switches, PCB capacitors, CRTs, polyurethane foam containing CFCs, or printed circuit boards.

Proper disposal of waste electrical and electronic equipment includes removing components which contain pollutants and extracting recyclable fractions, such as precious and other metals or synthetic fractions.

The European Union passed two directives in January 2003 with the aim of reducing environmental pollution caused by waste electrical and electronic equipment under manufacturers' product responsibility.

The European directive dated 27 January 2003 on waste electrical and electronic equipment (WEEE) [1] came into force on 13 February 2003 with its publication in the European Union official journal. All Member States are to transpose this directive into national law within 18 months. Important aspects of the directive:

- separate collection, treatment and recycling of WEEE and setting collection goals and recovery quotas,
- free right of return for private households and distributors,
- product responsibility for the treatment, recycling, and environmentally sound disposal of equipment lies with the manufacturer.

The directive sets out the following key points which are to be fulfilled by 31 December 2006:

- equipment is divided up into 10 categories, each of which is to produce recycling and recovery quotas by the above mentioned deadline:
  - bulky domestic equipment (refrigerators, washing machines, etc.),

- small domestic equipment (toasters, clocks, etc.),
- IT and telecommunications equipment (computers, printers, telephones, etc.),
- entertainment equipment (TVs, stereos, etc.),
- lighting equipment (fluorescent tubes, low energy lamps, sodium vapour lamps, etc, excluding living space lighting and light bulbs),
- electric and electronic tools (drills, sewing machines, etc.),
- toys, leisure, and sports equipment (electric railways, video games, gambling machines, etc.),
- medical equipment (e.g., dialysis machines),
- monitoring and controlling equipment (e.g., smoke detectors, thermostats),
- automatic vending machines (e.g., drinks machines).

• An average of at least 4 kg per resident per year is to be recorded separately in the case of used equipment from private households (collection quota for private household equipment).

Priority is to be granted to the re-use [2] of intact equipment. For all equipment not re-used, recycling quotas [3] of between 70 % and 80 % or 50 % and 80 % [4] depending on category, are to be attained by 31 December 2006. Furthermore, concrete waste equipment processing methods for the reduction of contamination are to be carried out, e.g., removing picture tubes from TV sets or separating brominated synthetic parts (more details on this in “Glass recycling”).

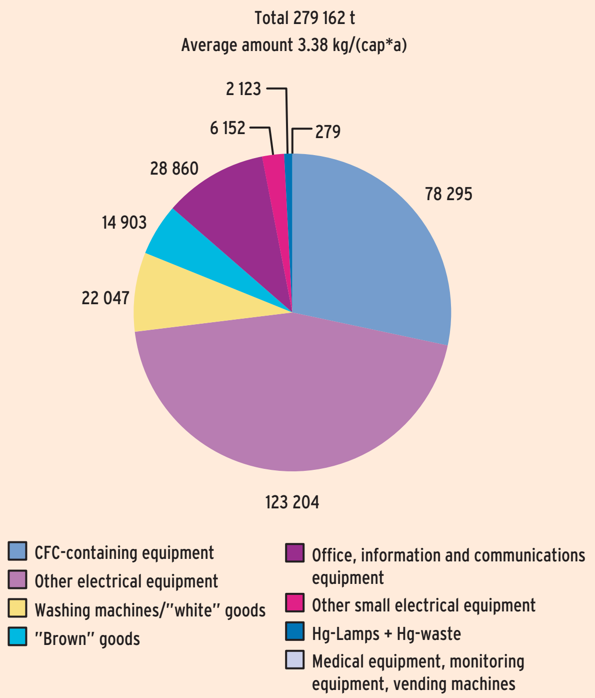
Directive 2002/95/EC on use restrictions of certain hazardous substances in electrical and electronic equipment (ROHS) [5] also regulates the use of certain heavy metals and chemicals in WEEE recently put on the market as from 1 July 2006.

In accordance with the WEEE law [6], consumers will be able to return their used WEEE to communal collection points in the future, free of charge. Manufacturer responsibility begins with collecting waste equipment from these collection points. Taking on responsibility means that the manufacturer takes care of the processing and recovery of waste equipment and fulfils recovery and recycling demands.

Waste balances for all *Länder* were evaluated against this background from the point of view of “separately collected waste electrical equipment”. In February 2004 current information on separately collected waste electrical equipment was requested from all Länder to enable updating. The levels provided only explain the scale of waste electrical equipment separately collected up to the present time since no statistical support for the data could be put together. Furthermore, it is not possible to provide separate information on waste electrical equipment collected from other return points (trade, manufacturers,…).

Figure X 2.2-5 “Recorded amount of waste in t for waste electrical equipment for Germany in 2002” contains the overall figures on waste balances for Germany. The complete evaluation of the document is to be taken from the Table “Recorded amount of waste for electrical equipment from waste balances provided by the *Länder* in t”. The evaluation has given rise to numerous problems:

Fig. X 2.2-5: *Recorded amount of waste for waste electrical equipment in 2002 (tonnes)*



Source: *Federal Environment Agency; IFEU Institute 2003*

• data collection was carried out in different ways by the separate *Länder*. Even cooling equipment containing CFCs is not always clearly identifiable in the waste balances. The levels of waste equipment collected from bulky (household) waste are not always clearly indicated.
• depth of the data according to equipment category also differs.
• waste balance is sometimes recorded in tonnage, sometimes according to number of items, sometimes calculated using average tonnage weight. If number of items is given in the balances, the calculation of levels is based on speculation.

Moreover, separately collected amounts from private households are not to be equated with separately processed amounts. No figures are available for the total collected and recovered waste equipment from private and non-private households.

Overall, the data situation does not justify statistically sound statements.

As regards this current unfavourable data situation, the following data on the collection of waste equipment must be ascertained in the future:

- separately collected waste equipment from private households
- total amounts of waste equipment separately collected from private and non-private households for each category.

The Federal Environment Agency has sponsored a research project [7] in preparation for the Federal Government's duty to provide regular reports and the documentation of quotas, according to which the basic structure of a monitoring system is to be developed.

Further information on WEEE and ROHS and on WEEE law can be found under http://www.bmu.de.

[1] Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE)
[2] "Re-use" describes measures where WEEE or their components are used for the same purpose for which they were designed, including the further use of equipment or its components which are taken to return points, distributors, recycling companies, or manufacturers (Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE), Article 3 (d))
[3] Applicable processes in accordance with Appendix IIB of Directive 75/442/EEC (Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE), Article 3 (f))
[4] "Recycling" describes the reprocessing of waste material carried out as part of a production process for the original purpose or for other purposes, excluding energy recovery, i.e., the use of burnable waste for energy generation via direct incineration with or without other types of waste, but where heat is recovered (Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE), Article 3 (e))
[5] Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (ROHS)
[6] Law on market placement, return and environmentally compatible disposal of WEEE (electrical and electronic law – ElektroG) dated 16 March 2005, German Civil Code (BGB)1. I, No. 17 dated 23 March 2005
[7] Ermittlung von Verwertungskoeffizienten für die Fraktionen und Bauteile zur Dokumentation von Quoten auf der Basis von Artikel 7 der EU – Richtlinie zur Verwertung von Elektroaltgeräten (WEEE), UBA Texte 51/04, Berlin 2004 (free of charge in Germany only) http://www.umweltbundesamt.de/uba-info-medien/dateien/2825.htm)

Battery return and recovery

Battery market

In Germany, over 1 billion batteries and accumulators are placed on the market each year. This corresponds to 30 000 t in weight a year. The number of starter batteries (accumulators) amounts to approximately 14 million.

Of those primary batteries placed on the market in Germany, approximately 70 % are imported, mainly by manufacturing firms themselves. The remaining 30 % are produced by one manufacturer in Germany. Altogether, approximately 85 % of primary batteries placed on the market are imported or produced by only four manufacturers.

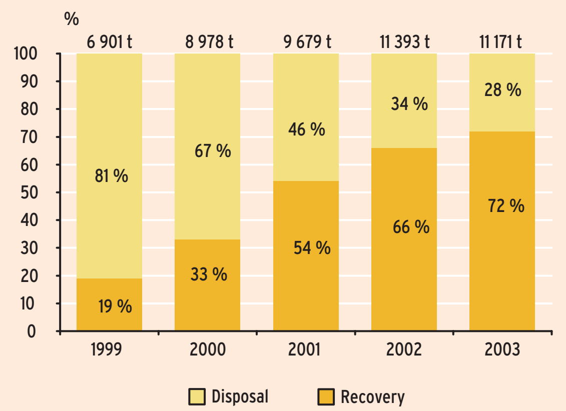
The German market for rechargeable batteries (secondary batteries) is considerably more diverse in terms of suppliers. Besides eight major suppliers who together represent a market share of around 70 %, there is a very high share of other suppliers who are mostly difficult to identify, if at all. The import share of these batteries amounts to 84 %. Only 16 % are manufactured in Germany.

Battery return and recovery

The Battery Ordinance [1] came into effect on 1 October 1998. In 2003, 11 557 t batteries were returned via the Batteries Collection System (GRS Batteries).

The recycling share, which remained at 19 % in 1999, was increased to 72 % by 2003. 8 039 t batteries were recovered. 3 132 t batteries, mainly unsortable battery mixes and non-UV coded AlMn batteries were disposed of at hazardous waste dumps (Fig. X 2.2-6).

Fig. X 2.2-6: *Share of recovered batteries in battery disposal*



Source: *Stiftung Gemeinsames Rücknahmesystem Batterien 2004*

EU Directive 98/101/EC was transposed into national law by the first ordinance on the amendment of the Battery Ordinance. As a result the mercury content in batteries is decreasing. Recycling opportunities for spent batteries have therefore considerably improved.

The collection and recycling quota for starter batteries amounts to almost 100 %.

[1] BattV – Battery Ordinance (Ordinance on the collection and disposal of spent batteries and accumulators) 2 July 2001 announcement (BGBl. I page 1486, amended via law dated 9 September 2001, BGBl. I page 2331)

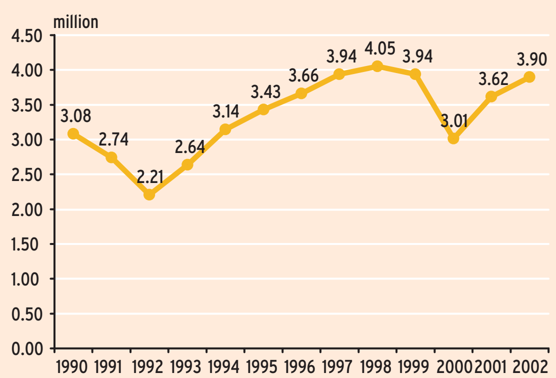
End-of-life vehicle (ELV) volumes and recycling

The precise number of end-of-life vehicles awaiting disposal in Germany is not known. This type of waste has as yet been covered only very roughly in official waste statistics. Annual statistics from the federal motor transport authorities – the Kraftfahrt-Bundesamt (KBA) where vehicles are licensed and registered under seven groups, provide an important basis for estimating ELV scrap production. According to the KBA, the most common reasons for registering vehicles as off-road are scrapping and export.

Since the reasons of the last owners for getting rid of the cars are not recorded, estimating the number of vehicles awaiting disposal is difficult. The share of permanent exports of used goods vehicles, in particular, is thought to be very high. The inadequate data also means that the number of licensed used vehicles cannot yet be determined precisely. Estimates are that some 30–50 % of final off-road notifications result in a vehicle awaiting disposal.

This section uses off-road notifications at the KBA as a rough indicator of ELV scrap production (Fig. X 2.2-7).

Fig. X 2.2-7: *Final deregistration of vehicles*



Source: *Federal Bureau of Motor Vehicles and Drivers 2003*

The Working Group on end-of-life vehicles' (now dissolved) monitoring report for the 1 April 1998 to 31 March 2000 period estimated the volume of end-of-life vehicles in Germany for the 1997 to 1999 period at approximately 1.1-1.7 million units per year. The final share of weight to be disposed of for an end-of-life vehicle was estimated by the study group (ARGE-Altauto) at 18–22 %, as relative to the corresponding 100 % motor vehicle registration weight.

Both of these trends have counteractive influences. Registrations are increasing: for example, the number of cars newly registered between 1987 and 1998 rose from approximately 2.9 million to approximately 3.7 million and from 120 to 237 thousand for heavy goods vehicles. In line with this, subsequent registration cancellations are also increasing, which raises the total quantity of end-of-life vehicles. On the other hand, increasing used car exports are reducing this volume. Reliable forecasts are therefore not available. Current data on the annual new registrations and deletions are available from the KBA.

In the future data on quantities and recovery of end-of-life vehicles will improve greatly. In 2004 the first survey on end-of-life car approval and recovery in disassembling companies was carried out under the Environmental Statistics Act. The shredders survey was improved and geared towards providing figures on vehicle recovery.

The EU Directive on end-of-life vehicles (2000/53/EC) and the German end-of-life vehicles ordinance calls for a recovery quota (including energy recovery) of 85 % of unladen weight and a recycling quota of 80 % as from 2006. These quotas apply to the total amount. They do not have to be attained for each vehicle.

Almost 100 % recovery and recycling of metallic parts from end-of-life vehicles is carried out by way of highly effective shredder separation and in subsequent sorting steps (magnetic separators, current separators, swim-sink systems).

The main problems in end-of-life vehicle recovery are currently the recycling of synthetic materials, glas,s and shredder light fraction (SLF) which occurs during the shredding process, which amount to approximately 25 % of the vehicle's original weight.

Synthetic materials and glass can be recycled in principle. The problem is the expenditure required for dismantling and sorting. There are sufficient recycling capacities in Germany for glass from end-of-life vehicles and for dismantled synthetic materials. End-of-life vehicle guidelines and ordinances call for glass and large synthetic parts to be dismantled for material recovery.

The enforcement of these regulations was however deferred until 31 December 2005 in a LAGA decision at its 81st session in September 2003. In accordance with this, these regulations are considered fulfilled if the required quotas are maintained from 2006 onward. Until 2006, the dismantling of glass and material parts or high quality recycling of non-metallic shredder output must therefore be strictly enforced. The latter is currently still being disposed of.

Mechanical sorting processes or energy recovery are possible in principle for processing or recycling SLF. Various mechanical processes are currently being worked on. These processes are based on separation in various material flows with various applications (e.g., reducers for blast furnaces, sewage sludge drying aids, or extensive inert mineral residues for waste filling). Separation of metallic residues is also being optimized. One example is the so-called VW-Sicon process which has not yet been implemented in Germany.

The only large-scale recycling process realized to date (February 2004) in Germany is synthetic gas production at the "Black Pump" secondary raw material recycling centre (SVZ).

Recycling of building waste

Building waste is quantitatively the most significant waste group (Chapter X 1.1).

Construction, architect and engineer associations, demolition companies and building trade workers combined under KWTB, an environmental umbrella organisation for the construction sector, made a voluntary commitment in 1996 to halve the 1995 quantity of stored recyclable building waste (except spoil) by 2005.

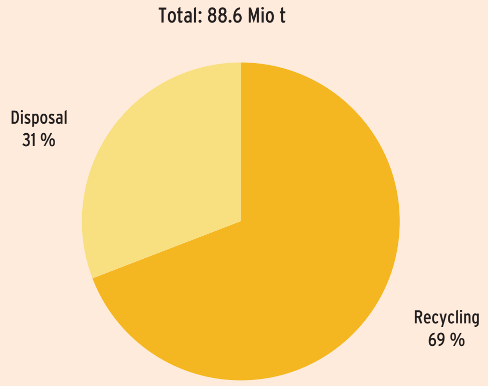
KWTB submitted the third monitoring report on the construction industry's voluntary commitment (report period 1999 to 2000) to the Federal Environment Ministry in November 2003.

According to the report, approximately 89 Mt building waste (except spoil) was accumulated during the 1999/2000 report period, of which 61 Mt (69 %) was recovered and approximately 27 Mt (31 %) was disposed of on landfill sites (Fig. X 2.2-8).

The amounts recycled are mostly used in road construction (Fig. X 2.2-9).

The life-cycle management body for construction is aiming for a further reduction in residual construction material waste by way of separating recyclable fractions on the building site.

Fig. X 2.2-8: *Amount and disposal of construction waste[1)] 2000*



[1)] Building waste, road construction waste, residual construction material

Source: *Arbeitsgemeinschaft Kreislaufwirtschaftsträger Bau (KWTB) 2003*

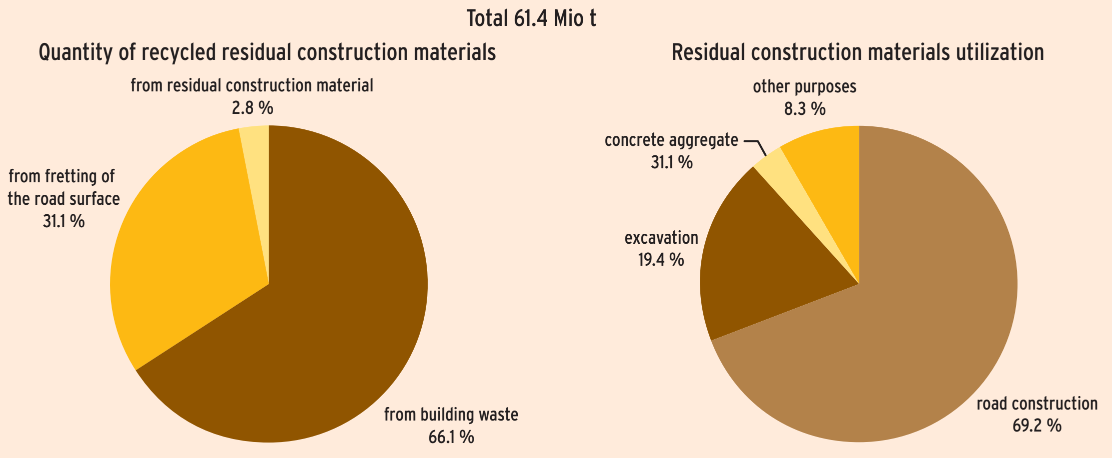
In addition, the demolition, construction, and recycling industries depend on the development of innovative demolition and processing techniques which ensure the highest possible recycling rate for the maximum possible equivalent utilisation purpose in line with sustainable construction engineering.

The majority of spoil and stone was recovered in 2000 (Fig. X 2.2-10).

Recycling mineral waste in landfills

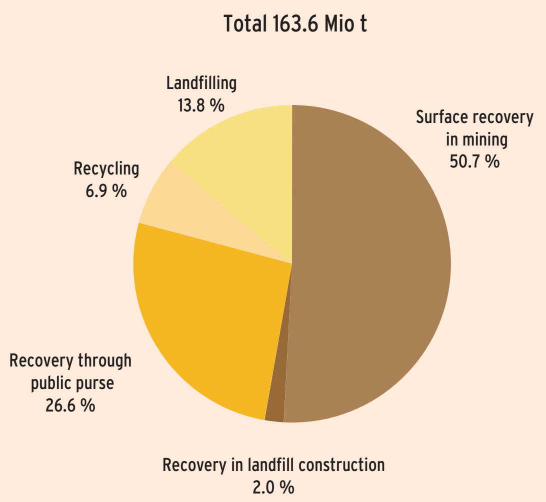
Although waste disposal is the main purpose of landfills, waste reclamation is also possible through engineering measures if primary raw materials are replaced by waste utilisation. Such engineering measures include the manufacture of sealing and drainage layers for the required surface profile or restoration layer. Mainly mineral waste such as building waste, spoil, and road construction rubble is recycled in this way, though considerable amounts of material will be required for closing down landfills. Inadequately equipped or landfills filled to capacity were closed down in large numbers in the run-up to 1 June 2005. The number of domestic waste landfills (now landfill class II) decreased between 2000 and June 2005 from 358 to 162. Almost 200 former domestic waste landfills have been closed down and require the use of large amounts of material for environmentally compatible closure. In order for these measures to ensure that the waste recycling is carried out properly and harmlessly and that deceptive recycling is prevented in accordance with the Waste Avoidance, Recycling and Disposal Act (KrW-/AbfG), the Federal Government passed the "ordinance on the recovery of waste in landfills" (BGBl. I, no. 46/2005, page 2252), effective as of 1 September 2005.

Fig. X 2.2-9: *Recycling of residual construction materials (excluding soil and stones) 2000*



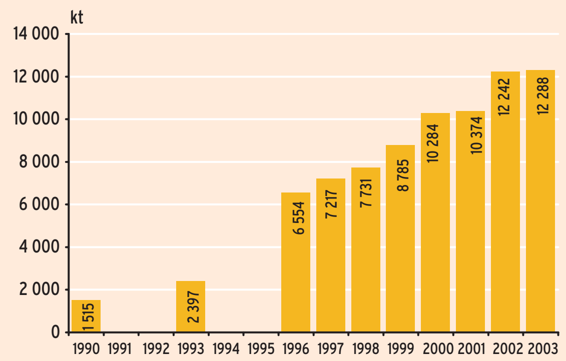
Source: *Arbeitsgemeinschaft Kreislaufwirtschaftsträger Bau (KWTB) 2003*

Fig. X 2.2-10: *Amount and disposal of soil and stone 2000*



Source: *Arbeitsgemeinschaft Kreislaufwirtschaftsträger Bau (KWTB) 2003*

Fig. X 2.2-11: *Biologically degradable material delivered to biowaste processing plants[1)]*



[1)] Domestic, garden, and park biowaste as well as agricultural waste

Source: *Federal Statistical Office 2004 a*

Collection and treatment of bio-waste

Separate collection and recycling of biogenic waste began about 20 years ago. Since then there has been a constant rise in the amount of treated biowaste (Fig. X 2.2-11). According to figures from the Federal Statistical Office [1], around 12.3 Mt biogenic waste was biologically treated, i.e., composted or fermented in Germany in 2003. These amounts cover domestic, garden and park biowaste as well as agricultural waste in composting and incinerating plants.

If domestic waste alone is taken into account, around 3.4 Mt were collected and recovered. Around 90 % of this was recycled in composting plants, 10 % of domestic biowaste was fermented in alkaline fermentation plants.

The Federal Statistical Office recorded nation-wide figures for over 1 500 composting and fermenting plants treating biogenic waste. These figures include the majority of agricultural alkaline fermentation plants and small private composting plants, a total of around 900 biowaste treatment plants. This also reflects the German quality standards group's estimate. Around 75 of these plants are fermentation plants which also produce biogas during the biowaste treatment process.

Separate collection of biowaste has a considerable influence on amounts and combination of residual waste. Residual waste levels are reduced by a third as a result of the separation of biowaste. At the same time, waste is separated from wet components, for example by mechanical sorting, which greatly facilitates subsequent residual waste treatment. See Chapter VII 3.3 for quality of collected waste and generated compost.

[1] Federal Statistical Office, http://www.destatis.de/download/d/um/entsorgung2003.pdf (29.08.2005)

X 3 Waste disposal

Unavoidable waste should be re-used as new raw material in industrial production or processed in such a way so as to allow it to be stored in an environmentally sound manner. Waste destined for final deposition is therefore to be mechanically-biologically or thermally treated to greatly reduce levels of seepage water and landfill gas being released from landfills. Strict environmental standards apply to incineration plants and mechanical-biological treatment plants.

X 3.1 Waste management

Municipal waste management facilities

Municipal waste management facilities in Germany are operated by the responsible local or municipal authorities and by private companies. They comprise landfill sites, thermal treatment plants, composting plants and others, such as waste separation plants, recycling plants, building waste reclamation plants, and mechanical-biological or chemical/physical treatment plants.

The facilities are supplied by local authority waste collection (which may be outsourced to private companies), by retailers, business and industry, as well as by private persons. Production waste is treated and disposed of by the industry itself, but it may also be sent to public facilities. Total waste quantities delivered to public landfill and thermal treatment or compost plants are shown in Figure X 3.1-1.

While a decrease in deliveries to landfill sites has been ascertained for the 1996 to 2003 period, there has been a constant increase in deliveries to incinerator plants and composting plants.

Waste management by companies

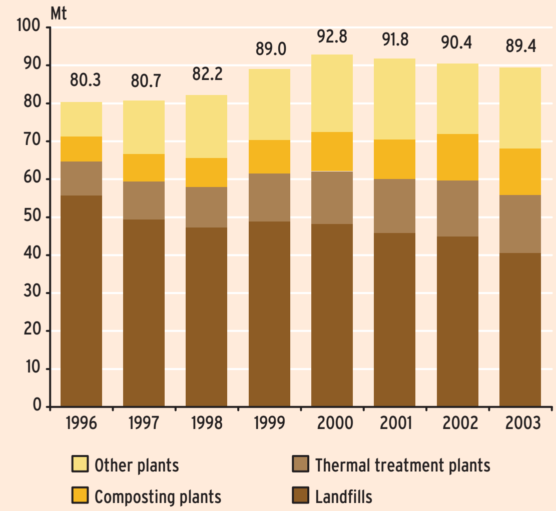
Companies may dispose of their own waste, and that of third parties, either completely or partially in their own facilities.

As in the municipal waste management sector, a fall in landfill disposal can be found, although the quantities of waste disposed of in waste incineration plants has risen by a factor of 2.6.

Other waste management

Underground stowage: Extraneous waste is disposed of as stowage in many mines in Germany. The waste is predominantly mineral which must fulfil certain quality criteria. In 1996, just under 0.97 Mt of extraneous waste was stowed in mines; in 2003 the amount was slightly higher (1.24 Mt).

Fig. X 3.1-1: *Waste disposal in waste management industry facilities*



Excluding waste requiring special supervision
1998: excluding Hamburg
2003: provisional figures
Other plants: Chemical-physical processing plants, shredding plants, Mechanical-biological waste treatment plants, soil treatment plants, other processing plants

Source: *Federal Statistical Office 2005 c*

The mining regulation which came into effect on 30 October 2002 regulates requirements in terms of type and coordination of waste recovered from mining as well as safety of the mines concerned.

Surface filling: considerable quantities of mineral waste are used to fill in decommissioned open-cast or strip mines (for raw materials such as lignite, sand, gravel, and clay).The majority of the waste is soil excavation. The quantities used here increased by about a third between 1996 and 2000 to around 98 Mt and fell again to 82.8 Mt by 2003.

Stockpiling in the mining industry: Exploring for, extracting, treating, and processing mineral ores produces mineral waste which must be disposed of. The greatest share of mining rubble is produced during coal mining; smaller quantities originate in potash and rock-salt extraction. The total amount produced in 1996 was 54.3 Mt, which fell to 46.7 Mt in 2003. The waste has been stockpiled (Tab. X 3.1-1).

X 3.2 Disposal rates for main waste streams

In interpreting the following figures on the individual main waste streams it should be noted that in the period considered several adjustments to the survey and additions to the recorded levels of waste types were made. Respective waste levels, primarily

Tab. X 3.1-1: *Waste disposal in selected waste disposal plants (delivery in 1 000 t)*

	1996	2000	2003
Waste incineration plants	**13 177**	**20 457**	**23 177**
of which: Waste management industry	8 970	13 920	15 217
in-house disposal[1)]	1 905	4 167	5 352
waste requiring special supervision	2 302	2 370	2 608 [2)]
Mechanical/biological residual waste treatment plants	**551**	**1 246**	**1 509**
Landfills	**78 565**	**67 089**	**59 040**
of which: Waste management industry	55 619	48 183	40 562
in-house disposal	18 326	13 845	13 346
waste requiring special supervision	4 620	5 061	5 132 [2)]
Composting plants	**6 554**	**10 284**	**12 286**
Underground landfilling	**1 482**	**1 685**	**1 238**
Surface landfilling of decommissioned open-cast or strip mines	**73 521**	**97 996**	**82 817**
Stockpiling	**54 308**	**48 187**	**46 689**

[1)] including furnaces
[2)] provisional figures

Source: *Federal Statistical Office 2005 d*

from waste disposal plant operators, have been recorded since 1996.

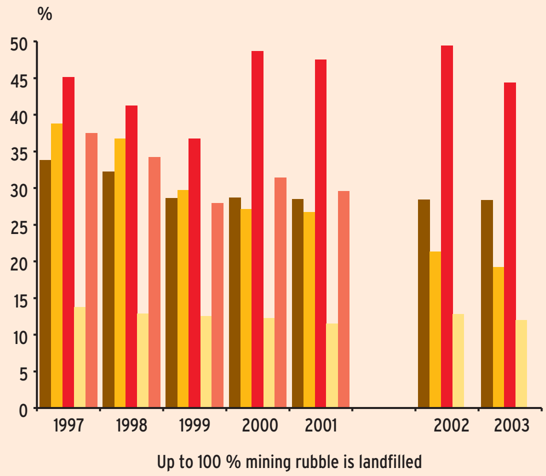
Limitations on data comparability for the period considered come to light in the changeover from the materials-oriented waste register of the Working Group of the Federal States on Waste (LAGA) used through 1998, to the origins-oriented European waste catalogue (EAK), used from 1999. This led to waste levels being shifted to certain positions lower down on the scale, particularly in the case of municipal waste, manufacturing and trade waste and construction and demolition waste. In 2002 the EAK was replaced by the European List of Waste (LOW) which resulted in shifts within municipal waste as well as between waste not requiring any special supervision and waste requiring special supervision. This caused an interruption in the time period: Up to and including 2001, waste requiring special supervision was listed as a separate waste stream; in the 2002 figures it is included under other waste types (Fig. X 3.2-1).

Furthermore, waste levels treated in-house have not been taken into account since 1999. Recovery and disposal continue to be recorded.

Altogether, waste disposal on landfills in the time period dealt with fell from 34 % (1997) to around 28 % (2003) of the amount of waste. Mining rubble is included in these figures. This waste category is almost exclusively dumped and so makes up the majority of the total dumped amounts. If mining rubble is not included in the rate disposed of on landfills calculation, 22.5 % of the amount of waste would still go to landfills. In 2003 it was 15.6 %.

Dumping of municipal waste which has not been pre-treated has been banned since 1 June 2005. By 2020 municipal waste dumping is to be completely

Fig. X 3.2-1: *Landfill rates for main waste streams*



- Total waste (incl. mining rubble)
- Municipal waste
- Production and industrial waste
- Construction and demolition waste
- Waste requiring special supervision

1998: Hamburg with data from 1997
from 1999: Changeover to European Waste Catalogue (EAK) with shifts to certain positions lower down on the scale (municipal, manufacturing, trade, construction, and demolition waste)
2000: Hamburg with data from 1999
2002: Introduction of European List of Waste (LOW) with shifts between waste not requiring any special supervision and that requiring special supervision as well as within municipal waste.
Waste requiring special supervision:
Waste requiring special supervision included in main waste streams in 2002.

Source: *Federal Statistical Office 2005 e*

stopped and prevention and recovery attained to the most comprehensive level possible. This calls for the establishment of concrete action goals in legal standards and the development of corresponding technologies (e.g., sorting technology), in order to allow the goals to be attained. Between 1997 and 2003 the dumping rate for municipal waste was reduced by almost half.

The inconsistent dumping rate course for production and industrial waste is not currently meaningful due to specific missing time periods. The waste register changeover possibly contributes to the implausible course.

X 3.3 Waste disposal plants

Thermal waste treatment plants

Thermal treatment plants for residual municipal waste

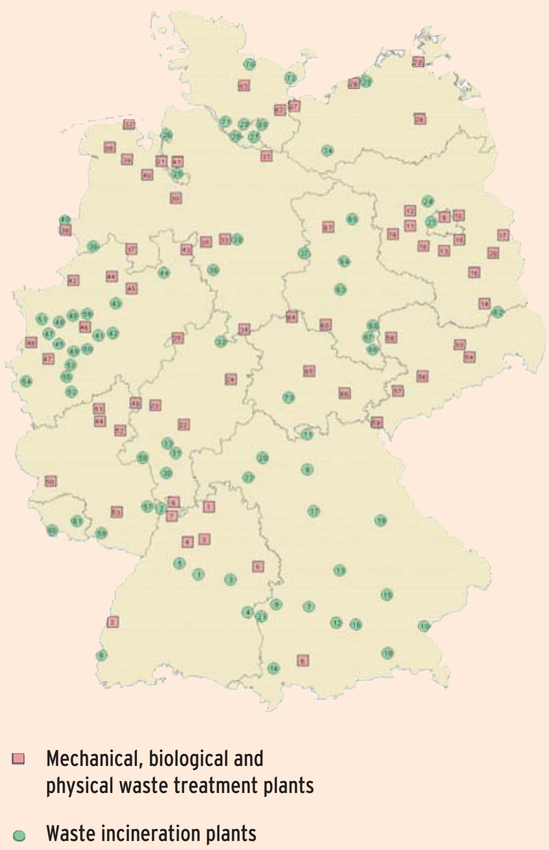
In 2003, 60 residual waste thermal treatment plants were operating in Germany, with an annual approved capacity of some 14 Mt. Triggered by the coming into force of the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities (AbfAblV, 2001) on 1 June 2005 the Working Group of the Federal States on Waste (LAGA) surveyed incineration capacities to be available in 2005. The survey resulted in 72 waste incineration plants with an annual capacity of around 17.8 Mt currently being operated or in advanced planning stages in Germany (Fig. X 3.3-1 and Tab. X 3.3-1).

All existing waste incineration plants have energy utilisation (electricity, process steam, district heating). The total fuel use efficiency is around 47 % on average for all plants. Existing plants could produce much higher levels of energy, especially in the form of heat, if the basic conditions at the plant locations in terms of energy transfer opportunities were improved. Sewage sludge from municipal waste water treatment plants is combusted together with municipal waste in 8 plants. All plants are equipped with flue gas cleaning which complies with the 17th Pollution Control Ordinance (BimSchV). Most operate without producing sewage. Incineration ash is generally recovered. Ferrous and non-ferrous metals are separated from the ash and recycled.

Currently the only large-scale pyrolysis treatment plant for residual waste has been operating in Burgau (in Bavaria, near Ulm) since 1987, with an annual throughput of some 25 kt.

In future, energy recovery from waste combined with mechanical-biological treatment could become a significant factor. This combination places priority on a material flow-specific waste disposal, whereby the recovery process is optimized to suit each waste fraction. This way, only good combustible waste arrives at the incinerator; materials that are recycable are separated before incineration.

Fig. X 3.3-1: *Treatment plants for municipal waste for the implementation of the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities*



Source: *Federal Environment Agency 2004*

Tab. X 3.3-1: *Domestic waste incineration trends*

	Number of plants	Waste throughput capacity in 1 000 t/a	Average throughput capacity per plant in 1 000 t/a
1990	48	9 200	191
1992	50	9 500	190
1993	49	9 420	192
1995	52	10 870	202
1998	53	11 900	225
2000	61	13 999	230
2005[1)]	67	16 900	252
2007[1)]	72	17 779	247

[1)] Estimated values

Source: *Federal Environment Agency 2004*

Sewage sludge incineration and drying plants

According to the Federal Statistical Office around 2.4 Mt sewage sludge dry solids from communal sewage treatment plants were accumulated in Germany in 2001. 555 kt were incinerated, corresponding to 23 %. According to a survey carried out in spring 2004 available capacities for the incineration of communal sewage sludge were over 1.2 Mt in 2003 (Tab. X 3.3-2).

Tab. X 3.3-2: *Incineration capacities for municipal sewage sludge*

	Number of plants	Incineration capacity t/a
Mono-incineration plants	17	480 000
Co-incineration in MVAs	8	60 000
Co-incineration in coal-fired power plants	25	658 000
Co-treatment in coal gasification	1	40 000
All	**51**	**1 238 000**

Source: *Federal Environment Agency 2004 a*

The development of co-incineration in coal-fired power plants is the predominant contributory factor in recent years' increase in incineration capacities. Incineration in mono-incineration plants for sewage sludge and co-incineration in waste incineration plants has seen little expansion in recent years. It is therefore expected that more sewage sludge will be co-incinerated in power stations and industrial plants (e.g., cement plants) in the future.

Pre-drying is often required for the incineration of sewage sludge, depending on the selected incineration process. Around 70 sewage sludge drying plants are in operation in Germany for this purpose. The current annual capacity is approximately 340 kt sewage sludge dry solids.

Material recycling takes up the largest share in sewage sludge disposal. In 2001, 57.5 % of the accumulated agricultural sewage sludge was used in agricultural recovery or for composting. The share of unrecycled sewage sludge taken to landfills was about 6.6 %.

According to requirements under the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities (AbfAblV, 2001), sewage sludge may be sent to landfills only after thermal treatment or mechanical-biological co-treatment along with residual waste as of June 2005.

There are increasing reservations from the environmental and agricultural camps regarding the agricultural recycling of sewage sludge (Chapter VII 3.2). It is to be expected that the requirements on sewage sludge quality will increase in the future meaning that ever-decreasing amounts will be materially recycled and a larger share will have to be incinerated.

Hazardous waste incineration plants

The total combustion capacity at the 8 public sector and 24 company incineration plants for hazardous waste (5 of the company plants are available for the public sector) in Germany is currently approximately 1.25 Mt/a, yet only 0.8 Mt/a of this is currently in use.

This capacity is not expected to increase due to additional plants in the near future. There is a trend towards reducing capacity at some locations.

Alongside these facilities, there is a further plant where hazardous waste is treated in a thermal gasification process.

Mechanical-biological treatment plants (MBAs) for residual waste

In accordance with the requirements of the Biological Waste Treatment Plants Ordinance (Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and from Biological Waste Treatment Facilities (AbfAblV, 2001) 30th Federal Immission Control Ordinance (30. BimSchV), Annex 23 of the Wastewater Ordinance), mechanical-biological waste treatment is only permissible in MBAs with high technical standards which fulfil strict waste gas control and treatment requirements. The Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities renders important requirements in the technical instruction on recovery, treatment and other municipal waste disposal methods (Technical Instruction on Municipal Solid Waste,– TI Si) legally binding, covering landfills, particularly their technical equipment, quality of waste to be disposed of and its maximum transition period. Additional requirements are also being set on the quality and landfill technique of mechanical-biologically treated waste. According to the state-of-the-art in the case of municipal waste, these requirements can only be fulfilled inline with currently available technologies, using thermal or mechanical-biological pre-treatment.

According to a survey carried out by LAGA, 66 MBAs with a total capacity of around 7.1 M t/a will be available as from 1 June 2005 (Fig. X 3.3-1).

Storage of waste on landfills

The Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities (AbfAblV, 2001) prohibits the storage of untreated waste failing to fulfil the landfill classification criteria by 1 June 2005 at the latest. This supports the identical waste treatment requirement in the Technical Instruction on Municipal Waste (TI Si, 1993) and invests it with higher legal standing. In line with this, exemptions are no longer permissible.

Prior to 1 June 2005 many exemptions still in existence could only be approved in case sufficient treatment capacities were unavailable. For example, well over half of domestic and trade waste was stored on landfills without pre-treatment in 2000. Of the approximately 34 Mt residual waste in need of treatment, only approximately 14 Mt was thermally treated and approximately 2 Mt mechanical-biologically treated. There was still a considerable additional treatment capacity demand to be met by 1 June 2005 through the construction of new plants (waste incineration plants and mechanical-biological waste treatment plants) and the co-use of combustion sites (energy from waste recovery).

In addition to the 34 Mt mentioned above, around 28 Mt predominantly mineral or industrial residual waste were stored on landfills accessible to the public in 2000.

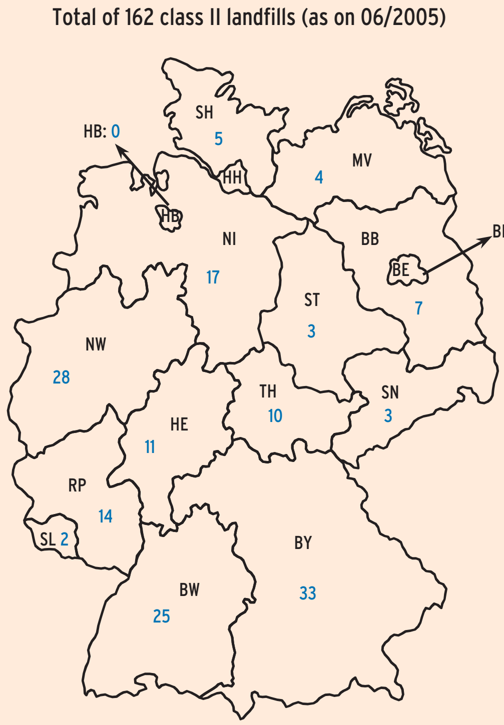
TI Si requirements on upgrading landfills (TI Si, no. 11) have been increasingly complied with in recent years. Alongside operating requirements and setting up leachate purification equipment, this essentially involves capturing, treating and, where possible, recycling landfill gas. This destroys methane, a greenhouse gas, and produces energy. Landfill sections which are already full are to be covered over, for the most part, temporarily, to allow the deposited waste to settle first and prevent any rupturing of the final surface sealing.

The sharp fall in waste dumping over recent years has led to overcapacity in landfills in Germany. When pre-treatment of waste becomes obligatory, which is always linked with a reduction in quantity, this will increase. This provides an opportunity to prematurely shut down sites which fail to comply with the TI Si while maintaining adequate disposal capacity. This would be obligatorily regulated by both of the AbfAblV and the Landfill Ordinances. Sites which do not comply with the ordinances were to be shut down in line with this by 1 June 2005 and under certain conditions by 2009 at the latest. This will result in significant relief to the soil, groundwater, and atmosphere.

In addition, this will bring an end to the competition between landfill sites erected in an effort to meet TI Si requirements, and those which do not fulfil those requirements.

Like the TI Si, Part 1 of the Technical Guidelines on Waste (TI So, covering hazardous waste) requires that hazardous waste be treated before being sent to final disposal. Strict assignment criteria for landfill disposal apply to all sites, even old ones. Amendments to the KrW-/AbfG (2001) and the Landfill Ordinance (2002) made the requirements of the TI So and the TI Si legally binding. The requirements of the EU Landfill Directive will be integrated into the Landfill Ordinance. Alongside existing technical, operational and site requirements, in TI Si and TI So, new requirements will be introduced, such as requiring a level of expertise and competence for landfill operators and sufficient financing to ensure safe and proper after-care for 30 years, or a payment scheme to cover all costs (Fig. X 3.3.-2).

Fig. X 3.3.-2: *Distribution of class II landfills (formerly: domestic waste landfills) across the Länder*



Source: *Federal Environment Agency 2005*

Climate-compatible waste management

Scientific findings in recent years have clearly shown that the pre-treatment of waste implemented under the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities (AbfAblV, 2001) protects not only soils and waters from contaminant inputs, but also makes a significant contribution to climate protection through utilisation of its energy potential and substitution of primary fuel.

The treatment of waste prior to storage leads directly to a sharp decline in methane emissions from landfills. Waste treatment is already obtaining considerable CO_2 credits through careful management and is thereby contributing to attainment of the ambitious national goal of reducing greenhouse gases within the framework of the Kyoto Protocol.

According to recent calculations by the Federal Environment Agency [1], methane emissions from landfill sites will fall from at least 1.5 Mt in 1990 by around two thirds to 0.5 Mt in 2004. This is synonymous with a decrease of around 21 Mt CO_2 equivalents. This fulfils the goal set under the October 2000 German Climate Protection Programme, to reduce methane emissions from landfills to around 0.5 Mt by 2005. This is achieved by reducing stored amounts of degradable waste and through improved thermal pre-treatment in waste incineration plants (MVAs) as well as through extensive landfill gas collection in accordance with the standards under either the Technical Instruction on Municipal Waste or the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities.

The complete cessation of storage of untreated biologically degradable waste since 1 July 2005 will lead to a further 0.1 Mt decrease in methane emissions from landfills by 2008, 0.4 Mt by 2012, synonymous with 2.1 Mt and 8.4 Mt CO2 equivalents. Compared to 1990, this corresponds to a reduction of over 90 % in methane emissions from landfills in Germany.

Pre-treatment measures also contribute to climate protection themselves: since 50 % of municipal waste has biogenous origins, its use for energy is climate neutral. In addition, larger amounts of fossil fuels can be substituted through the efficient use of energy from the remaining organic components rich in caloric value. Direct use of waste in MVAs and co-incineration waste, which is separated or separately collected in MBAs (RDF = refuse derived fuel) are considerations. According to Federal Environment Agency calculations, besides the effects of the landfilling ban for organically degradable waste, at least a further 3.7 Mt CO_2 a year can be saved through the utilisation of waste for energy.

Of this amount, around 2.2 Mt is accounted for by the co-incineration of waste components rich in caloric value as replacement fuel in industrial plants and power stations (RDF) and around 1.5 Mt by the incineration in MVAs of approximately 3 Mt of waste, landfilled to date. The expected lessening effect from co-incineration is around 22 %, related to the 10 Mt CO_2, must be saved by energy and industrial sector in line with the emission trading by 2012. The lessening effect attributable to incineration in MVAs is around 17 % of the CO_2 reduction the additional remaining sectors like private households, trade, transport etc. have to realize by 2012.

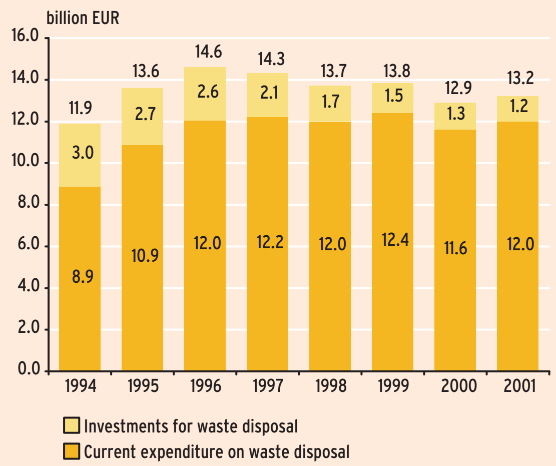
[1] Federal Environment Agency, German Greenhouse Gas Inventory 1990–2002, National Inventory Report 2004. Report presented under the United Nations Framework Convention on Climate Change, Berlin 2004

X 4 Environmental protection expenditure on waste management by manufacturing industry, government and privatised public companies

The Federal Statistical Office records what the public sector and private industry spend on environmental protection. Further information, e.g., the combined sum spent by all sectors, is available in Chapter V 2 “Environmental protection expenditure on air quality management by manufacturing industry, government and privatised public companies”.

42 % of overall expenditure on environmental protection in 2001 (13.2 billion EUR) was spent on waste management. Investments constituted approximately 9 % of this expenditure. In 1994 it was still 25 %. 91 % went towards current expenditure (Fig. X 4-1).

Fig. X 4-1: *Investments and current expenditure for waste disposal in the production industry[1], in the public sector and privatised public companies in current prices*



1) Current expenditure in the production industry: Excl. fees and charges for disposal services by third parties

Source: *Federal Statistical Office 2004 b*

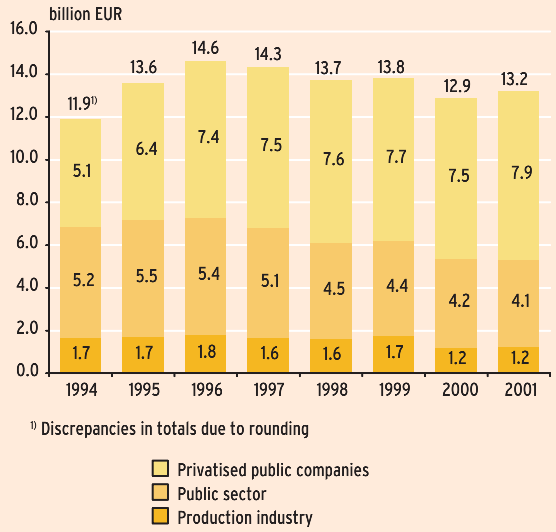
The vast majority of expenditure (about 60 %) was supplied by privatised public companies in 2001, mainly owner-operators of the waste disposal plants. Government supplied a further 31 % for waste disposal. The remaining 9 % came from manufacturing industry companies (Fig. X 4-2).

X 5 Transboundary movements of waste

Legal framework

After many years of effort to bring some order to the transboundary movement of waste, primarily

Fig. X 4-2: *Environmental protection expenditure for waste disposal in the production industry, in the public sector and privatised public companies in current prices*



[1)] Discrepancies in totals due to rounding

Production industry: Excludes construction industry and expenditure for integrated environmental protection measures Privatised public companies: Waste disposal companies outside public budget, where government funds provide at least 50 %

Source: *Federal Statistical Office 2004 b*

waste exports from industrialised countries to the developing world, a complex system of regulations has recently been developed. The most important regulations are:

- the international Basel Convention, now with more than 160 signatory states,
- The OECD Council Decision on the control of transboundary movements of waste for recovery,
- the EC Waste Shipment Regulation, which applies directly with the force of law in all EU countries,
- the German Waste Movement Act.

Distinctions must be drawn, not only between imports and exports, but also between hazardous and non-hazardous waste. The most important regulations applicable to waste for disposal are:

- within the EU, there is a preference for self-sufficiency in waste disposal at EU and national levels, as well as for waste disposal close to the point of origin.
- movements between EU states are only permitted after obtaining written permission.
- exports of waste to non-EU countries, with the exception of Iceland, Liechtenstein, Norway, and Switzerland (EFTA-countries), are prohibited.
- waste imports for disposal to EU member states require a licence if the exporting country is a member of EFTA, signatory to the Basel Convention, or if bilateral agreements exist between the countries in question. Imports from any other country are prohibited.

Waste transferred for recovery is subject to significantly less restrictions – primarily to ensure transport safety and to verify the plausibility of the recovery method. The most important regulations applicable to waste for recovery are:

- movement of waste between EU states is subject to notification if the waste is hazardous. Most non-hazardous waste may be transported without notification with the exception of a transition period in the case of some new Member States.
- Exporting hazardous waste from the EU for recovery requires notification, providing the importing country is an OECD member. Exporting to other countries is prohibited. Exporting non-hazardous waste does not generally require notification unless any one state requires that certain types of waste be handled as hazardous waste.
- waste imports for disposal within the EU require a licence if the exporting country is a member of EFTA, signatory to the Basel Convention, or if bilateral agreements exist between the countries in question. Non-hazardous waste can be shipped without notification.

Environmental goals in transboundary movement of waste

Both German and EU law require that waste be avoided, and that recycling or re-use be given priority over disposal, and this should also apply to transboundary movement of waste.

Under EU law, wastes are considered as goods, and therefore enjoy the right to freedom of movement within the EU. The free movement of goods, including transboundary movement of waste, may not be restricted unless it fails to meet certain essential (e.g., environmental) requirements.

Recycling waste can help conserve limited resources of raw materials if conducted in an economically and environmentally acceptable form. Waste must be allowed to be moved across national borders for this purpose.

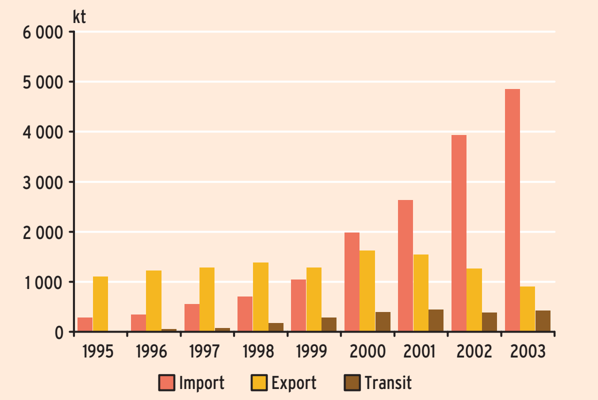
On the other hand, transboundary shipment of waste for disposal is only practical when, for example, the cross-border route to disposal facilities is significantly shorter, or there are no adequate disposal facilities in the state where it was generated.

Transhipment of waste into states which do not possess the technical means to treat it without risk to the environment and their citizens must be prevented. The prohibition on exporting hazardous waste in non-OECD countries has been enforced by law since January 1998.

Trends in waste quantities

In recent years, the levels of imported waste requiring notification have experienced a sharp increase (Fig. X 5-1). It amounted to 4.9 Mt in 2003. It was 3.9 Mt the year before. The majority of the imports went to North-Rhine-Westphalia. Exports only continued to outweigh imports in Baden-Württemberg and the Saarland (Fig. X 5-2). Over half of the waste came from the Netherlands, where disposal fees have experienced a sharp increase. The export of waste requiring notification decreased in recent years and came to around 900 000 t in 2003. More waste requiring notification has been imported than exported since 2000.

Fig. X 5-1: *Import, export, and transit of waste requiring notification 1995–2003*



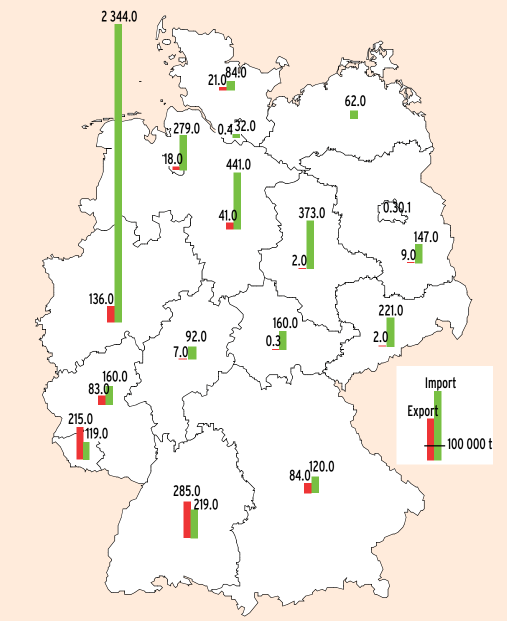
Source: *Federal Environment Agency 2004 b*

To compare: foreign trade statistics reveal import levels of over 10.3 Mt for waste not subject to notification. Exports, on the other hand, come to 15.4 Mt (Fig. X 5-3 and Tab. "Foreign trade of waste not requiring notification in kt 1991–2003"). Here, exports clearly outweigh imports, yet with a decreasing tendency.

The predominant types of disposal for imported waste requiring notification in 2003 were energy recovery (1.2 Mt), thermal treatment in incineration plants (400 000 t), recovery of metals (500 000 t), use as fertiliser in agriculture (340 000 t), landfilling (120 000 t), storage in underground landfills (500 000 t) and use as mining material (190 000 t). Approximately 800 000 t were subjected to pretreatment such as sorting and conditioning.

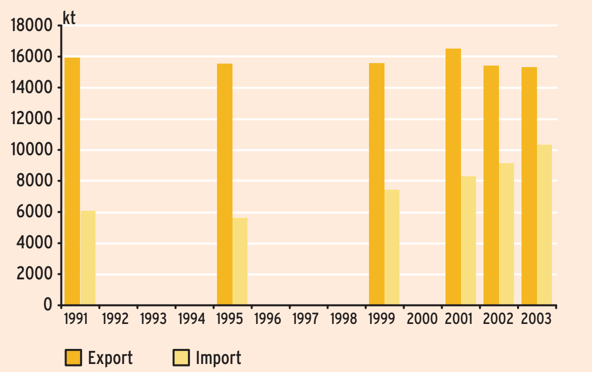
Amounts of metal recovered are an important factor in exports (260 000 t). Dumping on overseas land-

Fig. X 5-2: *Import and export of waste requiring notification 2003 according to Land in kt*



Source: *Federal Environment Agency 2004 c*

Fig. X 5-3: *Foreign trade of waste not requiring notification*



Source: *Federal Statistical Office 2004 c*

fills in contrast is very low (900 t). A total of only 61 000 t were exported for final disposal, all other exported waste was recovered. (Tab. X 5-1)

Monitoring – illegal waste movement

Intensive monitoring of waste exports and clear regulations for offences have resulted in no serious cases of illegal waste export during recent years. Punishments start from fines of up to 50 000 EUR for irregularities to three years' imprisonment for a criminal offence and up to ten years for particularly serious cases.

Tab. X 5-1: *Trends in the transboundary movement of waste (waste requiring notification) according to country categories 1995–2002 in kt*

	Export		
	1995	2000	2003
EU countries	821	1 370	823
EFTA countries	42	53	54
other OECD countries	24	1	2
Poland, Hungary, Czech Reublic [1]	0	1	1
Other countries	3	Export ban since January 1998	
Waste according to Article 17(3) of the EC Waste Incineration Ordinance [2]	208	203	28
Total	**1 099**	**1 628**	**906**
of which recovered	**938**	**1 541**	**843**
of which disposed of	**161**	**87**	**64**
	Import		
	1995	**2000**	**2003**
EU countries	188	1 772	4 555
EFTA countries	82	165	250
other OECD countries	3	3	2
Poland, Hungary, Czech Reublic [1]	5	35	24
Other countries	2	9	15
Total	**281**	**1 985**	**4 854**
of which was recovered	**212**	**555**	**4 223**
of which was disposed of	**69**	**429**	**631**

[1] Poland, Hungary and the Czech Republic have been OECD members since 1996 but did not adopt waste legislation agreements until some time after

[2] Waste which may normally be freely handled but is subject to a licencing obligation due to bilateral agreements with the respective import country

Source: *Federal Environment Agency 2004 d*