CHAPTER 1: STATUS OF SOLID WASTE MANAGEMENT IN TASK MEMBER COUNTRIES

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Executive summary

This chapter details the solid waste management practices in the IEA Task 36 member countries in terms of policy, actual practice, and trends for the future (to 2020). The country specific reports include details on:

- national policy/strategy on waste management and the recovery of energy from waste;
- data on the historical arisings and management of solid waste;
- factors affecting waste growth, and estimates the solid waste arisings in the future;
- the potential for increasing the amount of energy which is recovered from solid waste.

The summary below draws on data from a wider source (i.e. from more than just the Task 36 Membership) in order to give a more global perspective where relevant and also focuses on the treatment of the residual waste stream for energy recovery (energy from waste - EfW).

Definition of MSW

The key for designing waste management systems for countries, regions, or municipalities is knowledge of the amount and quality of waste arising. Data are found in various statistics on all levels, collected by local, regional, national, and international organisations like UNEP, OECD, or Eurostat. The problem with these statistics is the inconsistent basis of the data sources, which makes comparison between regions difficult.

Most national and international statistics contain generation and, rarely, composition data for MSW. Unfortunately, there is no common definition of this type of waste and hence, for example, the OECD statistics are characterised by numerous footnotes indicating which waste fractions are included in the actual data. The following illustrates some of the definitions used for MSW:

OECD: 'In general, municipal waste is waste collected and treated by or for municipalities. It covers waste from households, including bulky waste, similar waste from commerce and trade, office buildings, institutions and small businesses, yard and garden waste, street sweepings, the contents of litter containers, and market cleansing waste. The definition excludes waste from municipal sewage networks and treatment, as well as municipal construction and demolition waste.'

'Household waste is waste generated by the domestic activity installations of households. It includes garbage, bulky waste and separately collected waste.' [OECD 2002].

U.S. EPA: 'EPA includes those materials that historically have been handled in the municipal solid waste stream and sent to municipal landfills. MSW includes wastes such as product packaging, newspapers, office and classroom papers, bottles and cans, boxes, wood pallets, food scraps, grass clippings, clothing, furniture, appliances, automobile tires, consumer electronics, and batteries.' [U.S. EPA 2004]

'Household Waste (Domestic Waste): Solid waste, composed of garbage and rubbish, which normally originates in a private home or apartment house. Domestic waste may contain a significant amount of toxic or hazardous waste.' [U.S. EPA 1997]

'Residential Waste: Waste generated in single and multi-family homes, including newspapers, clothing, disposable tableware, food packaging, cans, bottles, food scraps, and yard trimmings other than those that are diverted to backyard composting.' [U.S. EPA 1997]

From the definitions it is obvious that household waste and domestic waste are the same material. Another synonym is often 'residential waste', but the EPA definition makes no clear statement in that case.

'Commercial Waste: All solid waste emanating from business establishments such as stores, markets, office buildings, restaurants, shopping centers, and theaters.' [U.S. EPA 1997]

IEA: For the IEA, waste is only of interest in view of its energy inventory and - for IEA Bioenergy - also for its biogenic energy fraction. The definition for MSW is: 'Municipal waste consists of products that are combusted directly to produce heat and/or power and comprises wastes produced by the residential, commercial and public services sectors that are collected by local authorities for disposal in a central location. Hospital waste is included in this category.' [IEA 2007]. Here again, the last waste type is excluded in most definitions.

EU: The European Commission issued a waste list in 2000 which defines under code 20 'Municipal wastes and similar commercial, industrial and institutional wastes including separately collected fractions.' Code 20 01 'Separately collected fractions' lists paper, wood, textiles, glass, metals, and organic kitchen waste and also hazardous fractions like acids, photo chemicals and others. The latter ones, however, are typically summarised as hazardous household waste in Eurostat or OECD statistics. Code 20 02 'Garden and park waste' comprises compostable waste, soil and stones, and other non-compostable waste. 20 03 'Other municipal waste' covers mixed municipal waste, often called 'residual waste', and waste from markets, street cleaning, and septic tanks. [European Commission 2000]

Eurostat, the statistical office of the European Commission, and the national statistical offices of the EU member states compile annual statistics on MSW and household waste, but do not always indicate which waste fractions are separately collected. Commercial waste is only included as long as the material is similar to household waste. Such waste is under the regime of the public waste management system, other waste from commerce, trade, and industry has to be taken care of by the producer himself.

According to the above listed definitions, MSW comprises waste from various sources. Some of these waste streams, like yard and garden waste, are more uniform in composition than others such as waste from commerce and trade or from office buildings. From this perspective, residential waste, the waste generated in private homes, should be the most inhomogeneous and hence, for the purposes of treatment, probably the most difficult type of waste to manage.

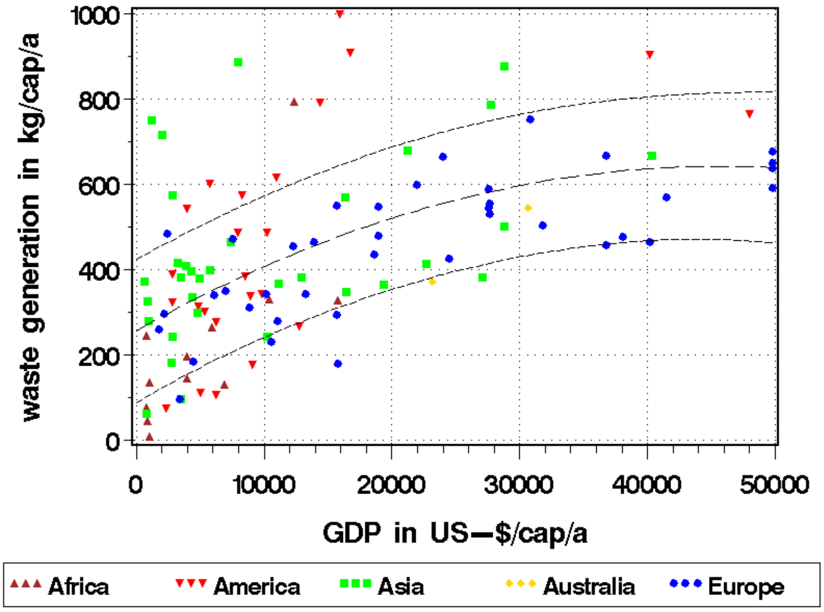
Our focus in this report has been on examining the management of MSW and more specifically on *residual* MSW. MSW is the waste typically collected and managed by local municipalities, i.e. it is predominantly the waste generated by households and collected from households or from areas to which households have access to deposit their waste. It also includes wastes of a similar nature derived from the commercial and industrial waste sector. Residual MSW is the waste remaining after recyclable materials have been extracted - typically by the householder taking part in source segregated collections.

Generation and composition of MSW

The huge variation of waste data at local level does not mean that regional and national statistics should be regarded as pure guesses. In evaluating the available information, it would appear that the single (MSW) statistics do bear some correlation with other parameters - particularly with the economic situation of a country. On a global level, a good correlation appears to exist between the generation of MSW and the gross domestic product

(GDP) of a country. The data plotted in Figure 1 have been collected from several public statistics and scientific publications. European figures date from 2006 or 2007; those from other industrialised countries may go back to 2000 - 2005 and, for some developing countries, data before 2000 are included.

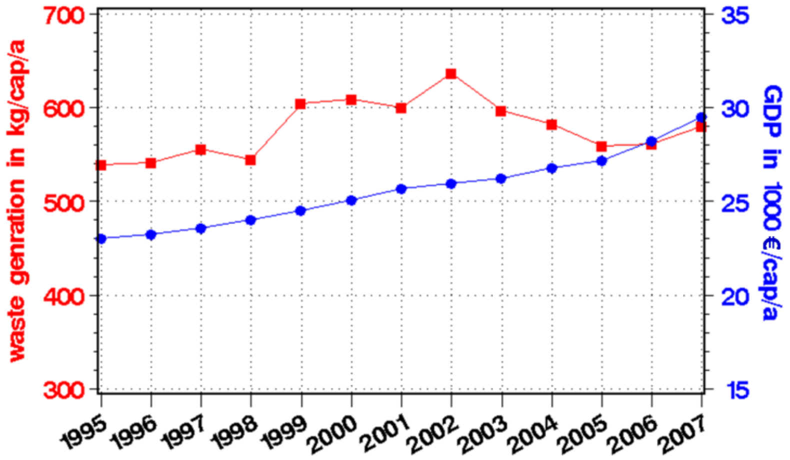
Figure 1: Waste generation versus GDP in 111 countries (fit with 70% confidence limit)



The calculated correlation between the waste generation data and GDP is surprisingly good. This positive correlation leads to the conclusion that economic growth changes consumption patterns and results in higher rates of per capita waste generation.

Decoupling of economic development and waste generation is a major objective in industrialised countries. Policy is driven towards the aims of reducing the amount of waste and diverting reactive waste from landfill. The EU with its many Directives regulating waste disposal is a forerunner towards such goals. Some successes can be noted in terms of reducing landfill, but few countries have been successful at reducing or at least to keeping their waste generation figures constant over the past years. One example where waste reduction has been achieved is Germany (Figure 2).

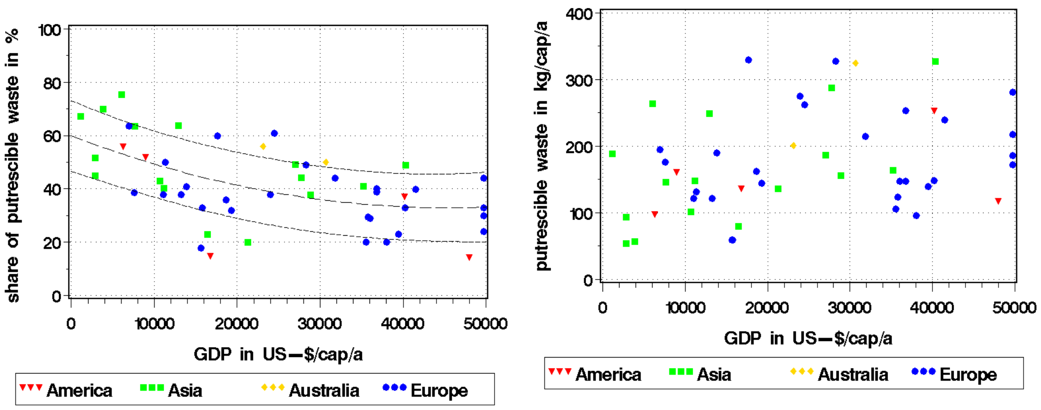
Figure 2: Decoupling of waste generation from economic output in Germany [Umweltbundesamt 2008 - data from Statistisches Bundesamt Deutschland]



A rather good correlation with the GDP is also reflected in the share of food or biodegradable waste in MSW as can be seen in the left hand graph of Figure 3. This correlation is usually explained by reference to the different ways of preparing food: poorer countries live less on prefabricated food and prepare their meals more from fresh food, which causes higher amounts of waste in residential homes. However, keeping in mind that MSW usually also comprises waste from restaurants, small businesses (including food preparing enterprises), canteens, etc. this argument is not necessarily convincing.

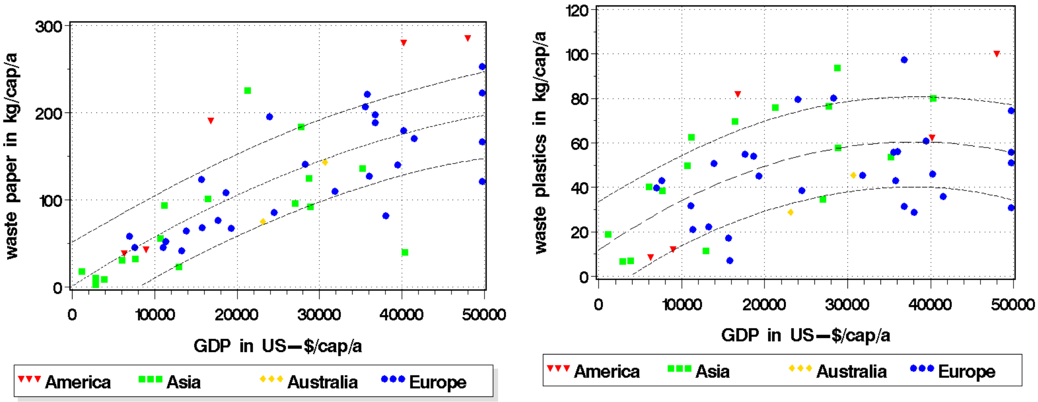
In reality, this explanation does not hold if the absolute amount of this waste is considered. The right hand graph in Figure 3 shows the per capita generation of food and other biodegradable waste plotted against the GDP for 52 countries. The result is a broad scattering of values without any discernable trends. The data for all countries from all continents seem to vary in the same broad range which means that the poor countries do not discard more food waste, but - and this makes much more sense - have not much else to throw away.

Figure 3: Percentage of biodegradable waste fraction versus GDP (left) and per capita generation of biodegradable waste (right) for 52 countries



This fact is underlined by the characteristics of paper and plastic generation data which are depicted again against GDP in Figure 4. The amount of paper correlates rather well with the GDP whereas the correlation for waste plastics is much weaker. The almost uniform distribution of plastics indicates the extent of their use across the globe.

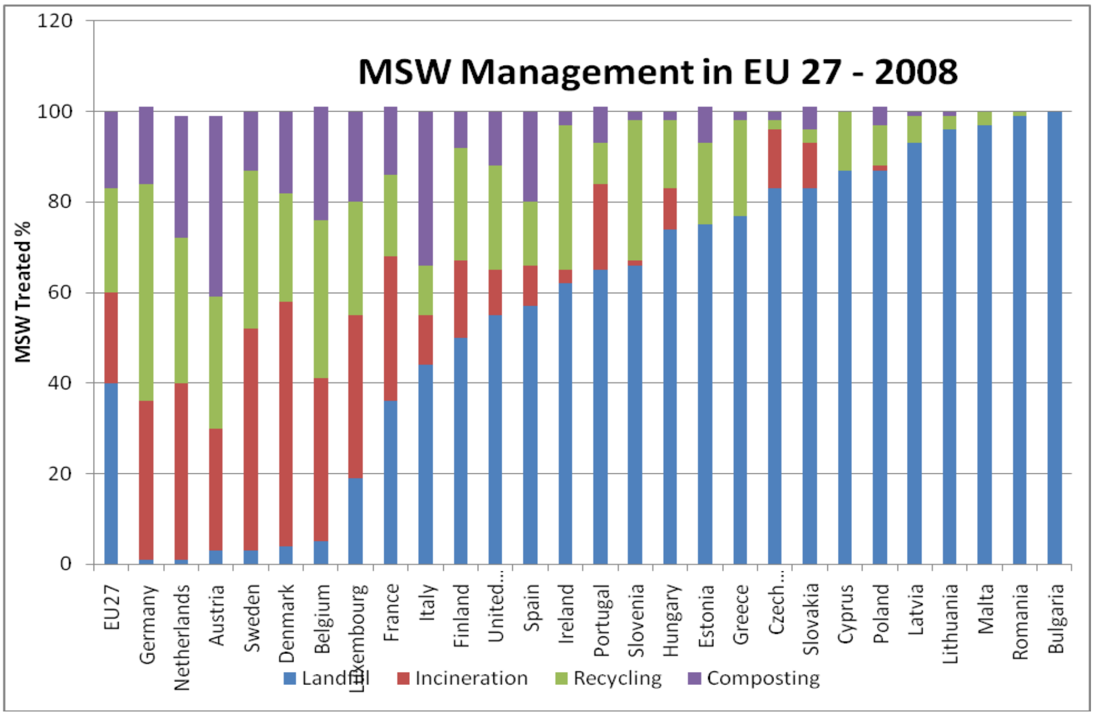
Figure 4: Per capita generation of waste paper (left) and waste plastics (right) versus GDP for 52 countries



Management of MSW

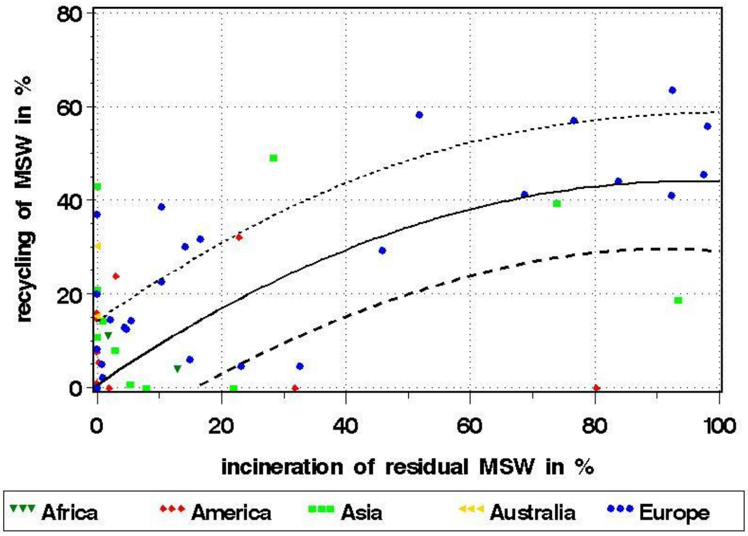
Figure 5 collates (Eurostat) 2008 data for EU27 and shows the destination of MSW to either recycling/composting (or similarly recovered), incineration (energy recovery) and landfill. The EU27 countries are ordered in terms of increasing landfill usage and show Germany at the top with the least tonnage to landfill and Bulgaria at the bottom with virtually all waste consigned to landfill. Norway and Canada are of course not included in these statistics but with landfill levels of approximately 25% and 80% they would appear above France and the Czech Republic respectively.

Figure 5: MSW management in EU27 (2008)



The level of incineration in EU27 was approximately 20% with the highest level recorded by Denmark (50%). Some have argued that waste incineration impedes recycling. However, an evaluation of data in Figure 5 and other wider statistical data does not support such arguments. Figure 6 correlates the incinerated fraction of residual waste - that waste which is left over after all material recovery activities - with the recycled and composted fraction of the total MSW stream. It is evident that most countries with high recycling also tend to have high levels of waste incineration (in almost all cases with energy recovery) for their residual waste prior to its final disposal.

Figure 6: Recycling and incineration of MSW

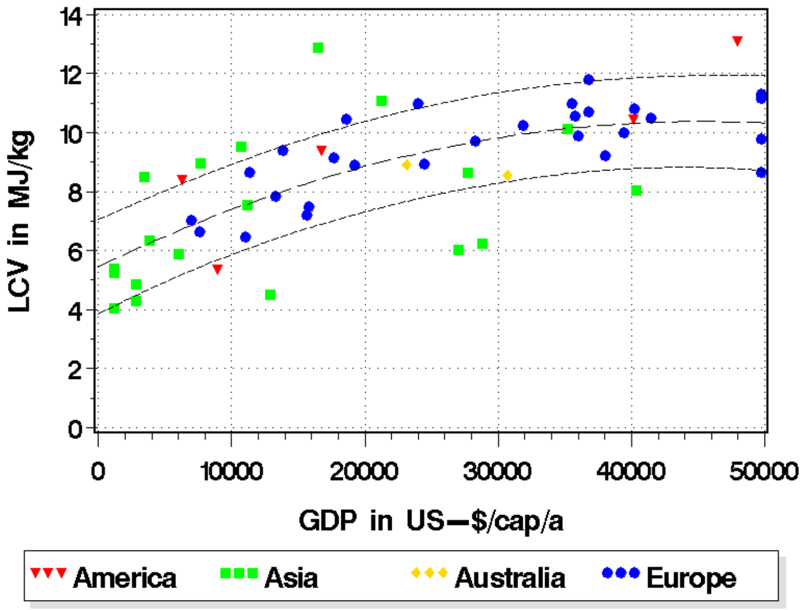


Energy recovery

Feedstock

The feedstock for thermal EfW systems can be the residual MSW as received or a processed product (SRF - Solid Recovered Fuel - meaning waste treated to produce a fuel fraction that can be transported to an off-site user) derived from residual MSW. The energy content of the feedstock is expressed as the lower calorific value (LCV) and covers a wide range. For residual MSW, in developing countries, it is of the order of 2 - 5 MJ/kg and in industrialised countries of the order of 8 - 12 MJ/kg. A good correlation exists between the LCV of MSW and the GDP of a country (Figure 7). A LCV of 6 MJ/kg is needed for the safe operation of thermal EfW systems and this is a level that is reached in many countries.

Figure 7: Correlation between LCV and GDP



SRF is characterised by higher LCV, lower contamination, and better homogeneity. SRF is produced in a number of industrialised countries to substitute fossil fuel in industrial furnaces, or for use in other high efficiency combustion systems. SRF is mainly produced in mechanical biological treatment (MBT) or mechanical treatment (MT) plants: metals are separated for recycling, organics are diverted for composting or anaerobic digestion, the high calorific fraction is separated for SRF, and residual inert materials are consigned to landfill or used in low value recovery processes such as landfill cover.

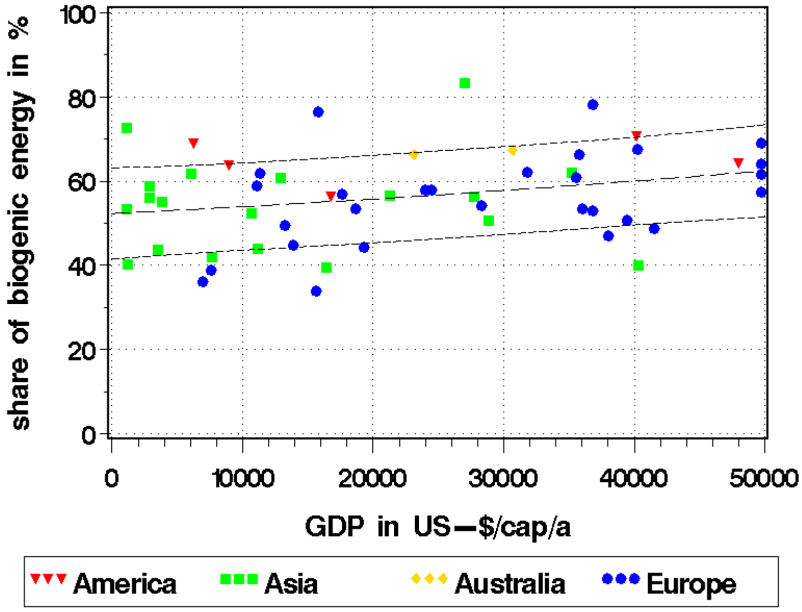
Various types of SRF are on the market to comply with process requirements and applicable legislative requirements. The conversion rate from MSW to SRF is typically 20 - 55% depending on product quality. Some plants produce a high-grade SRF together with a low calorific combustible residue, which is destined for waste incineration. In some countries, quality labels for special SRF types have been established, and on an EU level, EN-standards are under development. The main problem in utilisation of SRF from mixed MSW is the presence of pollutants, especially chlorine and heavy metals. Hence SRF, is mainly produced in countries with well developed MSW source separation and recycling.

The LCV of SRF from MSW is of the order of <15 - 20 MJ/kg. SRF/RDF with LCV >20 MJ/kg is virtually only produced from well-defined residue streams from trade and industry. SRF production and utilisation figures are vague in many countries due to rapid on-going changes in the waste management industries. In the US, approximately 6 Mt out of 30 Mt of incinerated MSW is SRF. Japan operates approximately 50 MBT or SRF plants with a capacity of 4.2 Mt/a. The exported material for incineration is of the order of only 0.4 Mt/a. In the EU, 3 - 4 Mt/a SRF is produced in more than 50 plants with a total capacity of >6 Mt/a.

Biogenic content

A significant fraction of the municipal solid waste stream is of biogenic origin: food and garden waste, wood, paper and to a certain extent, also textiles and diapers. Assessing the waste composition data with the amount of biogenic energy per waste fraction allows an approximate calculation of the share of biogenic energy in the waste. The results of such calculations are depicted in Figure 8. For most EU countries (and all of the Task 36 countries) the biogenic energy content is about 50%.

Figure 8: Share of biogenic energy in waste as a function of GDP (quadratic fit, 70% confidence limit)

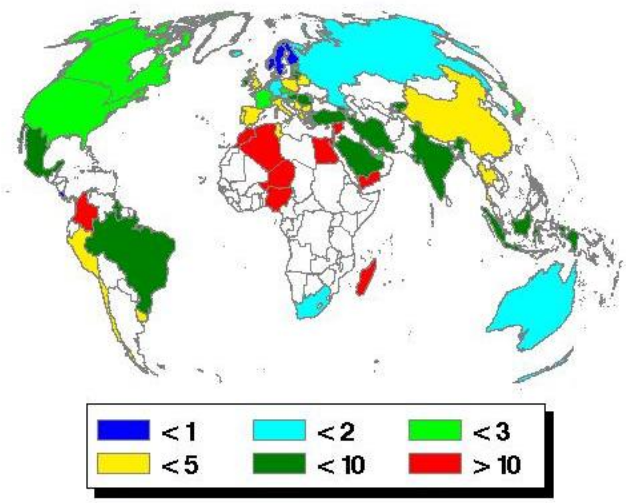


The fact that a certain fraction of the energy in waste is of biogenic origin has been acknowledged by some European countries, such as the Netherlands, Denmark and Finland. In these countries, power generated in waste incineration plants is rewarded by tariffs partly subsidised according to the national renewable energy acts. In other countries (e.g. UK, France, Sweden, Italy, Canada, Norway and Germany) even if the energy generated from waste is not supported by such tariffs, it is acknowledged in the collation of national and EU statistics for renewable energy.

Apart from the revenue support that may flow from the recognition of the biogenic energy inventory in MSW there is also beneficial consequence of the fact that the CO_2 emitted during combustion of this fraction is climate neutral.

The potential for MSW to replace fossil fuel in the power market for selected countries is shown in Figure 9. Even in highly industrialised countries, MSW can supply 1 - 2% of the power demand, a share that should not be underestimated. For the time being, this potential is far from being exhausted in any country. The actual number for Germany is in the order of 0.7% [CEWEP 2008], but it has to be expected that here, and at least in other EU countries, much higher values will be reached in the near future.

Figure 9: Potential of residual MSW to replace fossil fuel in the power market for selected countries, given in % of power supply



Task 36 member country reports

From the individual country reports, a number of common themes can be identified:

1. All countries are guided by a waste hierarchy in their policy - in broad terms, this is waste prevention, reuse, material recovery, material recycling and energy recovery, all of which take priority above final disposal (landfill). The waste hierarchy informs policy development aimed at decreasing waste to landfill and setting out the role of energy recovery (energy from waste).

2. In line with the waste hierarchy, the principal waste management policies are built around the desire to decrease landfill and improve resource recovery - whether materials and/or energy. These policy measures include a combination of fiscal incentives, such as taxes on materials destined for disposal to landfill, and regulatory measures, such as landfill bans on specific waste streams, for example biodegradable (food) and combustible and/or recyclable wastes.

3. At both national and local level, waste policy is frequently targeted at supporting separation, recycling and recovery activities. All of the IEA T36 Member countries have set targets for recycling and all (except Canada) have reported declining levels of waste to landfill and progressively increasing rates of recycling. Some countries (Germany, Netherlands) have clearly managed to break the link between GDP and waste growth.

4. Public perception of incineration (energy from waste) remains a concern in many countries. However, where there is a proactive programme of communications and public participation in decision making, much of the negative perception of EfW (and residual treatment technologies in general) can be mitigated. There has been a strong policy emphasis in response to public concern by, for example, applying more stringent emissions regulations and also to improving energy utilisation, i.e. improving energy efficiency through the generation of electricity and/or heat (combined heat and power).

5. Energy from waste makes a significant contribution to renewable energy in many countries. Increasingly, renewable policy is designed to encourage the recovery of energy from biodegradable wastes that cannot be recycled, composted or digested

and to encourage efficient recovery of this energy. Hence the utilisation of heat should be promoted wherever possible, although negative public perception sometimes results in facilities being sited away from urban areas where there is the demand for heat.

6. There is an increasing trend towards the use of separation technologies for mixed waste followed by composting or anaerobic digestion of the biodegradable fractions - sometimes driven by public opposition to direct combustion of waste. Pre-treatment of residual waste often results in a final fraction of waste that is usually not recyclable/reusable but nevertheless contains residual energy value. Pre-treatment can also produce a paper/plastic combustible fraction sometimes referred to as solid recovered fuel (SRF). Increasingly, waste management systems are required to treat this waste; options include co-incineration in cement kilns, co-firing in power stations (this option depends on the design of the power station) or incineration in a dedicated facility.

7. The European nations are obliged to comply with various EU Directives, e.g. the Waste Framework Directive and the Waste Incineration Directive. These Directives provide a common framework for the EU nations, but when transposed to national policy, there remain wide diversions in the way in which that national policy has developed and in the management of waste in each country. Perhaps, not surprisingly, it is the local conditions, policy priorities and economics that determine the development of the waste management systems and the uptake, in particular, of energy from waste technology.

In terms of future trends, it is possible to conclude that:

- There will be less biodegradable (and combustible?) waste consigned to landfill in the future.
- Most Member countries project that waste production will continue at current or slightly increased levels, indicating that measures to reduce waste arisings are starting to make a gradual impact.
- For those countries that currently rely on landfill, it is likely that the utilisation of energy from waste will expand but that the final deployment rate achieved is uncertain as there are still significant barriers to overcome, e.g. cost effectiveness, public concern, development timescales and planning/facility location issues.
- The utilisation of heat (for heating or cooling purposes) is likely to play a greater role in the future, but this potential will depend on siting issues (developing plants close to heat users) and overcoming other barriers, such as developing infrastructure (heat networks) and cost.
- Anaerobic digestion (AD) is likely to play a greater role in the future as many countries look to segregate this waste stream (food waste) at source.
- Further debate on the biogenic nature of MSW is likely to influence policy making and have practical consequences, for example, in the measurement and monitoring of wastes for this parameter.

Canada

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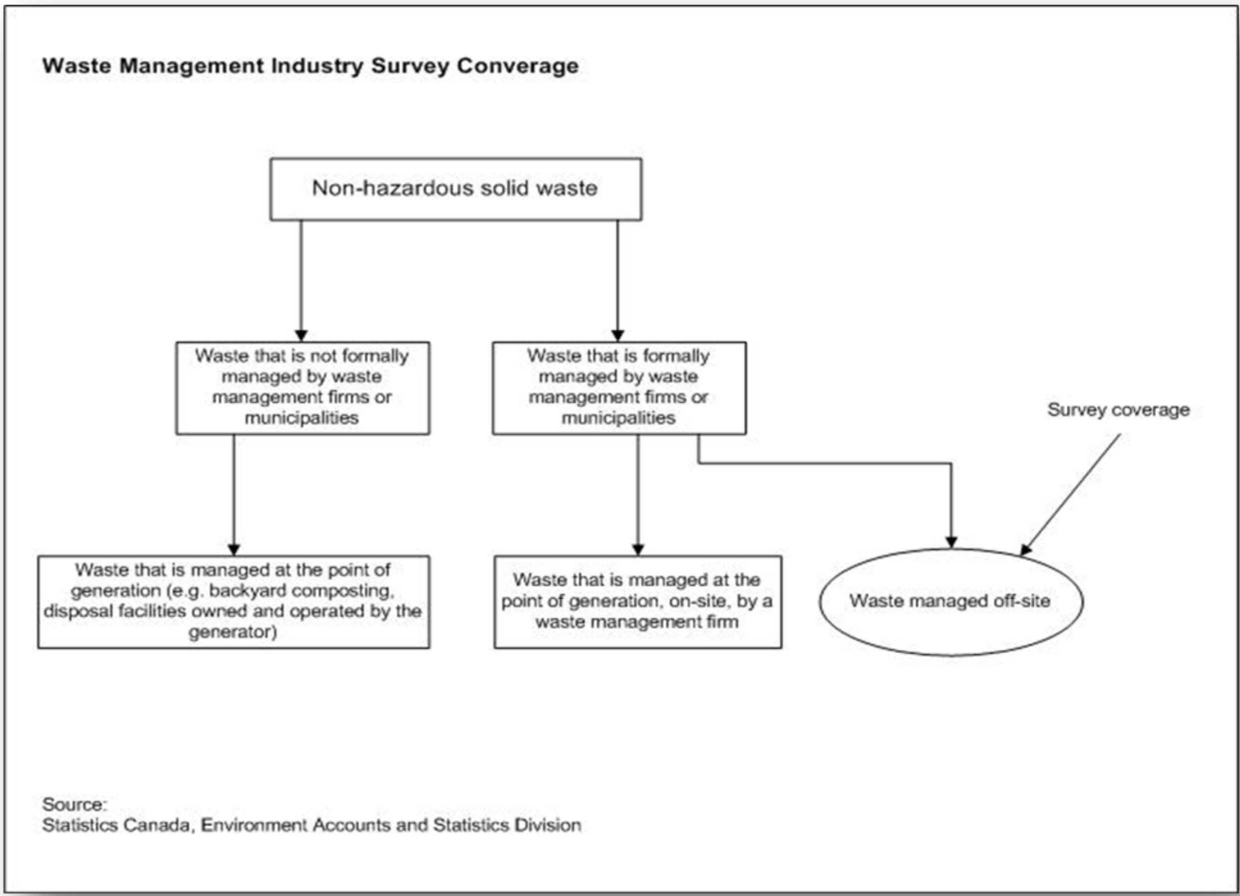
Definition

The definition of waste in Canada is still evolving. The common thread among definitions developed over the last years is that a waste is a material that is unwanted by its producer. Canada identifies municipal solid waste in two sectors, residential and non-residential.

- Residential waste is solid waste that is produced from residential sources (households) and that is either picked up by municipalities or brought to depots and landfills by the generators.
- Non-residential waste consists of non-hazardous waste generated by industrial, commercial and institutional sources as well as waste generated by construction and demolition activities. In more detail:
  - Industrial waste is generated by manufacturing, primary and secondary industries, and is managed off-site from the production operation.
  - Commercial waste is generated by commercial operations (such as shopping centres, restaurants, offices, etc).
  - Institutional waste is generated by facilities such as schools, hospitals, government facilities, etc.
  - Construction and demolition waste is waste that is generated by construction, renovation and demolition activities.

Figure 10: Waste management industry survey coverage



National waste policy

The responsibility for municipal solid waste (MSW) management in Canada is shared among the municipal, provincial/territorial and federal governments. The daily MSW management activities such as collection, diversion (recycling and composting) and disposal operations are the responsibility of municipal governments, while the provinces and territories are responsible for approvals, licensing and monitoring of operations. The federal government is involved in management issues related to sustainable development, toxic substances, trans-boundary movement (inter-provincial and international) of hazardous waste, hazardous recyclable material, federal lands and operations, air emissions including greenhouse gas emissions and the Fisheries Act.

All three levels of government cooperate in developing national initiatives, collecting statistics and disseminating the information to the public. Due to the lack of a centralized regulatory body however, regulations vary on a provincial basis based on regional and political dissimilarities. To address this concern, the Canadian Council of Ministers of the Environment was created in the 1980s to provide a forum for a national effort on environmental and resource related issues. It is made up of environment ministers from each province and territories as well as from the federal government. It developed and issued guidelines for MSW incinerators, established waste diversion targets and developed a National Packaging Protocol. The waste diversion targets of 50% diversion of waste from landfill by 2000 were based on the 4Rs approach of reduction, reuse, recycling and recovery. The National Packaging Protocol set a 50% reduction target on packaging sent for disposal by the year 2000 based on source reduction and reuse. The objective of those initiatives was to significantly reduce the reliance of Canadians on landfill. While a few communities have reached this goal, Canada as a whole still disposes of more than 78% of its waste to landfill.

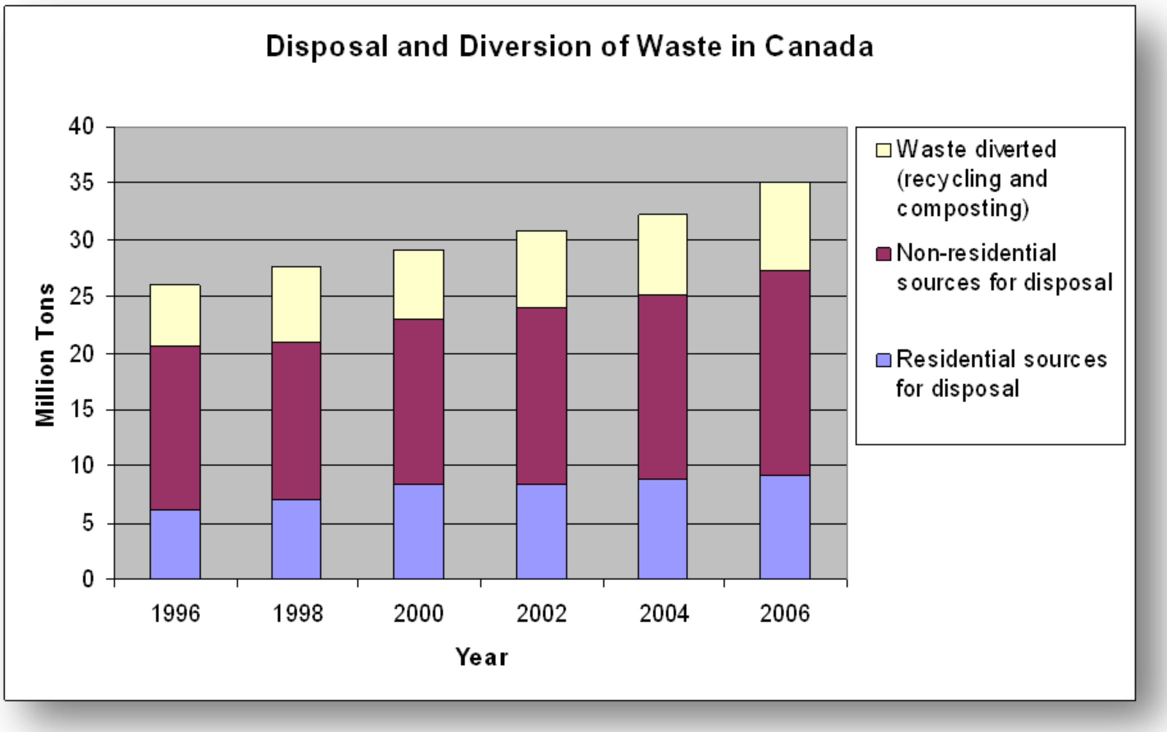
Quantities of waste generated

Waste generation in Canada in 2006 reached 35 million tonnes (Mt), an 8% increase over 2004 figures. Of this 35 Mt, 27 Mt were landfilled or incinerated while 8 Mt were diverted to material recovery or centralized composting facilities. Landfills have been to this day the preferred method of disposal in Canada where nearly 97% of the wastes have been sent; the balance represents the incinerated portion. The non-residential wastes made up approximately 22 Mt of the total while the remaining 13 Mt came from residential sources. There was no change in the residential (1/3) to non-residential (2/3) ratio of waste for disposal from 2004 to 2006.

The result is a per-person waste generation of 1,072 kg in 2006, up 8% from 2004. The portion disposed of was 835 kg and the diverted portion was 237 kg.

Many factors such as population growth, rising incomes and increased economic activity can influence the production of waste. Not only the goods themselves but their packaging must be disposed of, recycled or reused. During the period 2004-2006 the national GDP increased by 6% while the population of Canada increased by 2%.

Figure 11: Disposal and diversion of waste in Canada



The average waste disposed of per Canadian was 835 kg in 2006. Across the country the range spreads from a low of 430 kg/capita (kg/cap) in Nova Scotia to a high of 1133 kg/cap in Alberta. The population increased by 5% in Alberta since 2004 and the waste disposal increased by 24% over the same period. This was largely influenced by the non-residential portion which increased by 33% in 2006 while the residential portion increased by 3%. The residential portion is on par with a national increase of 3% while in comparison, the national non-residential waste generation increased by approximately 11%.

Figure 12: Disposal of residential and non-residential waste per capita

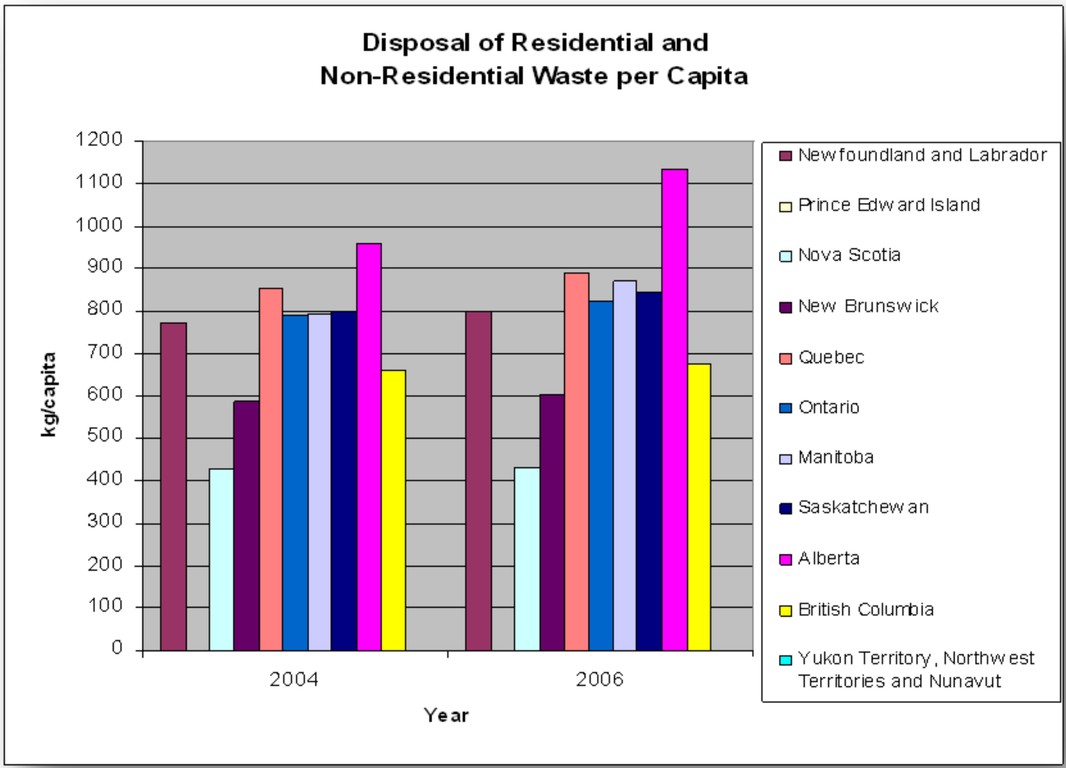


Table 1: Disposal of waste material in Canada in 2006

Disposal of Waste Material (Residential and Non-Residential) in 2006			
Region	**Population**	**Waste Managed (Mtons)**	**Waste per capita (kg/cap)**
Alberta	3,370,600	3.82	1,133
British Columbia	4,320,255	2.92	675
Manitoba	1,178,492	1.02	869
New Brunswick	749,225	0.45	600
Newfoundland and Labrador	509,940	0.41	799
Nova Scotia	935,050	0.40	429
Ontario	12,705,328	10.44	821
Prince Edward Island	138,027	na	na
Quebec	7,651,033	6.81	889
Saskatchewan	987,520	0.83	844
Yukon Territory, Northwest Territories and Nunavut	104,012	na	na
Canada	**32,649,482**	**27.1**	**834**

Waste diversion – recycling and composting

The national diversion rate from landfill remained constant at 22% from 2004 to 2006; a few provinces exceeded the average as can be observed in table 2.

Table 2: Waste diverted from landfill in Canada

Waste Diverted (Residential and Non-Residential) in 2006				
Region	Population	Waste Managed (Mtons)	Diverted Material (Mtons)	Diversion Rate (%)
Newfoundland and Labrador	509,940	0.41	na	na
Prince Edward Island	138,027	na	na	na
Nova Scotia	935,050	0.40	0.28	40.72
New Brunswick	749,225	0.45	0.25	35.90
Quebec	7,651,033	6.81	2.46	26.51
Ontario	12,705,328	10.44	2.40	18.67
Manitoba	1,178,492	1.02	0.15	12.98
Saskatchewan	987,520	0.83	0.11	11.36
Alberta	3,370,600	3.82	0.65	14.59
British Columbia	4,320,255	2.92	1.37	31.89
Yukon Territory, Northwest Territories and Nunavut	104,012	na	na	na
Canada	**32,649,482**	**27.25**	**7.75**	**22.14**

Overall the materials processed for recycling increased 9% to just over 7.7 Mt in 2006. There has been a steady increase in the quantity of materials processed since 2002 especially with organics and plastics. Paper fibres are still the main contributor to diverted materials with 44% of the share, while organics made up 26% of the total in 2006.

Figure 13: Diverted waste by type

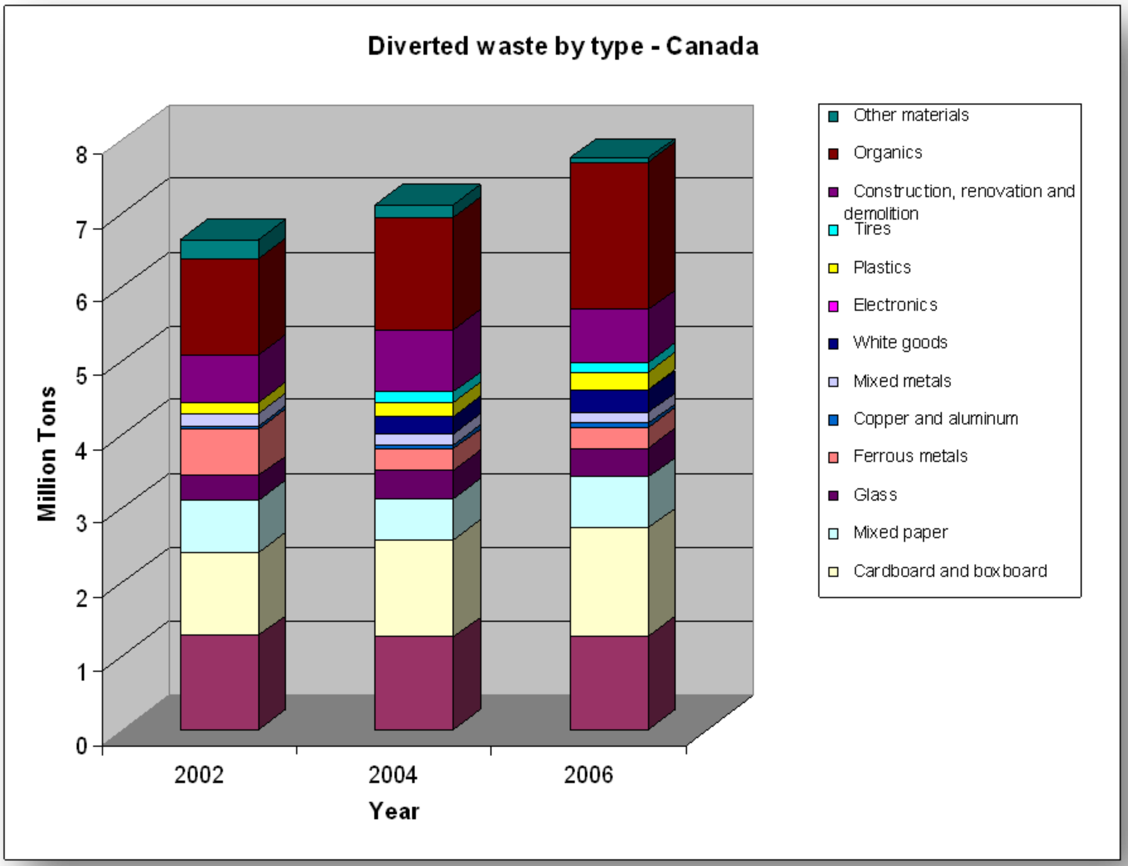
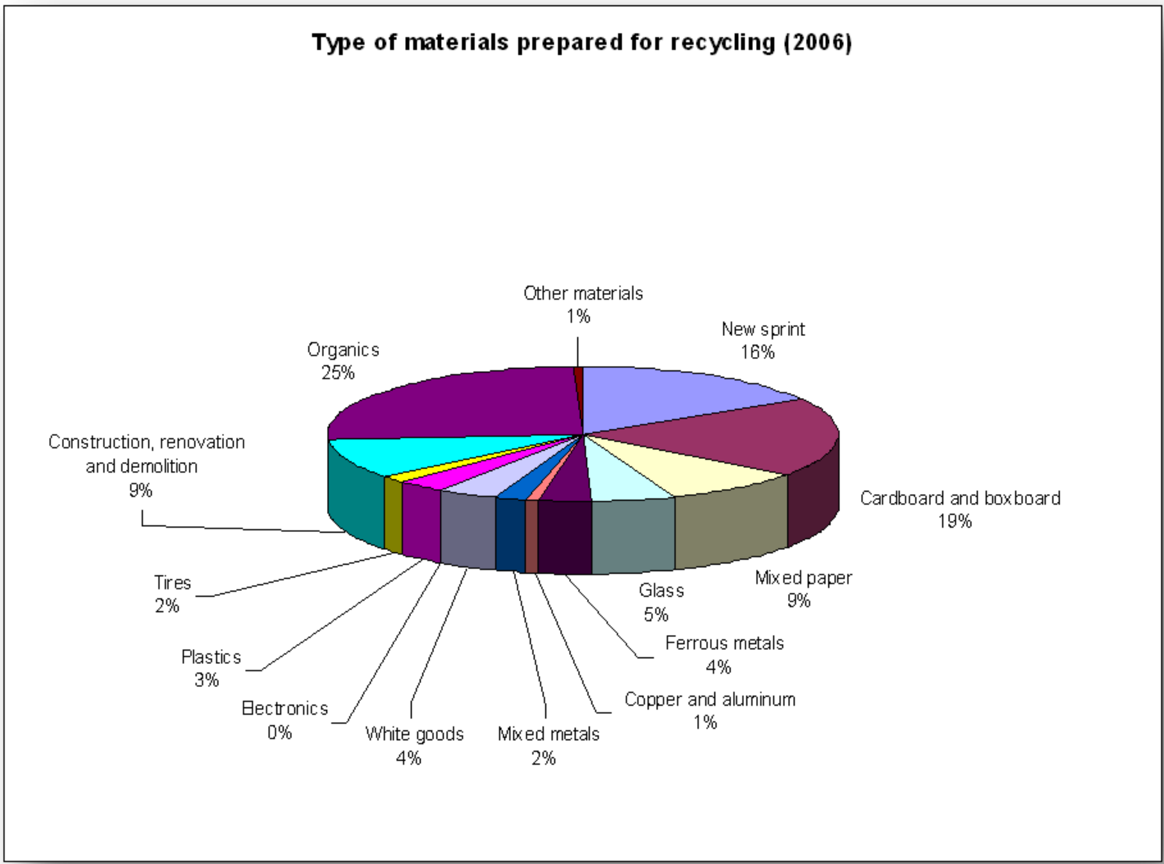


Figure 14: Type of materials prepared for recycling in Canada (2006)



Thermal conversion facilities in Canada

There are seven main thermal treatment facilities currently in operation in Canada that have a waste processing capacity of more than 25 t/day. Four of those facilities use mass burn technologies while the other three use a modular multi-stage technology. In 2006 nearly 773,000 t (up from 761,000 t in 2005) were thermally processed to produce 5.23 PJ of energy, of which 2.75 PJ were sold in the form of electricity, steam and hot water.

Table 3: Major thermal conversion facilities in Canada 2006

Major Thermal Conversion Facilities in Canada in 2006					
Installation	**Capacity (kton/y)**	**Energy Product**	**Energy Generated (GJ)**	**Energy Exported (GJ)**	**Date Commissioned**
Greater Vancouver Regional District Waste to Energy Facility	263	Steam & electricity	2,756,638	867,429	1988
Algonquin Power Peel Energy-From-Waste Facility	166	Electricity	214,600	151,528	1992
L'incinérateur de la Ville de Québec	336	Steam	1,725,870	1,150,115	1974
PEI Energy Systems EFW Facility	361	Steam and hot water	531,655	474,802	1983
Ville de Lévis, Incinérateur	292	None	-	-	1976
MRC des Iles de la Madeleine	113	None	-	-	1995
Wainright Energy From Waste Facility	99	Steam	na	115,023	1994
TOTAL	**1,630**		**5,228,763**	**2,758,897**	

There is currently one thermal processing facility planned for the York-Durham region near Toronto, Ontario. The plan is for an initial design capacity of 140,000 t/yr with a scale-up plan to 400,000 t/yr. The project is now in Phase 1 where advanced architectural designs must be submitted and environmental approvals must be obtained. The stack emissions will have to meet EU2000/76/EC and MOE A-7 guidelines. The Final Draft EA document was submitted to the Regional Council in June 2009. The RFP process which was started in June 2007 was expected to reach project approval status by June 2009.

Landfill gas

Landfill gas is produced from the anaerobic decomposition of organic waste in a landfill and is mainly composed of methane and carbon dioxide. Both these gases are greenhouse gases although methane is deemed to possess a global warming potential 23 times that of carbon dioxide.

It is estimated that 24 MT in carbon dioxide (CO_2) equivalent (eq) were emitted from municipal solid waste landfills in Canada in 2005, accounting for 22% of the total national man-made methane emissions. The most recent data (2005) shows there are 47 landfills involved in capturing landfill gas throughout Canada for a total quantity of 6.4 Mt CO_2eq. From this amount, 52% (3.3 Mt CO_2eq) was utilized and 48% (3.1 Mt CO_2eq) was flared. Of the 47 sites, 8 utilized the captured methane, 26 flared it, and 13 both utilized and flared the gas. Table 4 below shows the breakdown of use and output for the use of captured methane.

Table 4: Breakdown of use and output for captured methane from landfill sites in Canada

No of facilities	Methane Utilization	Facility Output
26	Flared	Nil
13	Utilized and flared	67 MWe
8	Utilized	• Space & hot water heating • Fuel for gypsum manufacturing plant, steel refinery, greenhouse and recycling plant

Landfill gas capture and combustion increased by 50% over the 1990-2005 period, however landfill gas emissions from MSW landfills increased by 24% over the same period.

The European Union policy landscape

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In the EU, the policy on waste management has been rationalised and consolidated over the last five years and new legislation has come into force since 2006. In addition to specific waste management policy and legislation, new energy and climate change policies have assumed a growing role in waste management practices. The major components of the EU legislative portfolio with an impact on waste management are described below.

Direct waste legislation

The directive 75/442/EEC (1975) was the EU first waste framework legislation that defined categories of waste and approaches to waste treatment. In the years following, a number of directives were introduced to cope with specific waste streams. These included, amongst others, waste electrical and electronic equipment, packaging waste, waste oils and end of life vehicles. During the early stages of this century there were a number of legal cases involving transport of waste and classifications of waste for recovery and disposal. The final opinions of the judge in two cases in particular in 2002, involving waste sent for recovery to cement kilns and waste exported for waste incineration, led to a complete overall of waste policy and to the formulation of the new waste framework directive (WFD): **Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste.** Introduction of the new WFD resulted in repeal of a number of obsolete directives, including 2006/12/EC on waste. One directive that remains in place is the **Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste**, which has probably had the biggest single impact on waste management practices over the last 35 years. The landfill directive requires major reductions in the disposal of biodegradable municipal waste, which accounts for approximately 70% of the mass of MSW. The reductions are given as:

- By 2006, a reduction to 75% of the amount of biodegradable municipal waste landfilled in 1995.
- By 2009, a reduction to 50% of the amount of biodegradable municipal waste landfilled in 1995.
- By 2016, a reduction to 35% of the amount of biodegradable municipal waste landfilled in 1995

  (These dates can be extended by up to four years for Member States which landfilled over 80% of their municipal waste in 1995)

The landfill directive (Article 16) is supplemented by **COUNCIL DECISION of 19 December 2002 establishing criteria and procedures for the acceptance of waste at landfills.** Until the start of implementation of the landfill directive, there were great differences in the proportion of biodegradable waste landfilled in different member states. These differences were in large part due to how well developed recycling and energy recovery practices are across the EU. Countries like Sweden, Denmark, Germany and the Netherlands made large scale efforts in the 1990s to implement recycling and waste-to-energy into national waste management strategies. As a consequence, landfilling in those countries was already low on implementation of the landfill directive. On the other hand, countries like Greece, Ireland and the UK relied heavily on landfilling of all waste. The new member states that joined the EU in 2004 (10 countries) and 2007 (2 countries) were granted prolongations until 2020; their targets will be reviewed in 2014.

The Waste Framework Directive reinforces the five-step waste hierarchy (Article 4) that had been established previously. The waste hierarchy applies as a priority order in waste prevention and management legislation and policy:

a) prevention;
b) preparing for reuse;

c) recycling;
d) other recovery, e.g. energy recovery;
e) disposal.

The WFD takes a fresh look at waste prevention (Article 29 of 2008/98/EC) and requires member states to set up programmes to address waste prevention in order to stem the seemingly endless rate of increase in waste creation. At the same time, the directive sets new recycling targets (Article 11) as follows:

a) by 2020, reuse and recycling of waste materials such as paper, metal, plastic and glass from households and possibly from other origins similar to waste from households, will be increased to a minimum of overall 50% by weight;

b) by 2020, reuse, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste excluding naturally occurring material will be increased to a minimum of 70% by weight.

Concerning recovery operations, there are two key issues that could have a significant impact on waste management practices in the future. These are end-of-waste and energy recovery efficiency of waste-to-energy plants.

End-of-waste criteria are addressed in Article 6 of the WFD. The Article states that when something (a material/substance) is recovered from Municipal Solid Waste (MSW) and:

- the material/substance is commonly used for specific purposes;
- a market or demand exists for such material/substance;
- the material/substance fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products;
- the use of the material/substance will not lead to overall adverse environmental or human health impacts,

the material/substance shall cease to be classified as waste. As a consequence, a waste license and transport restrictions will no longer apply. The situation concerning Solid Recovered Fuel (SRF) or Refuse Derived Fuel (RDF) could change in the future as a consequence of this rule. Application of the end-of-waste criteria should be considered, among others, for aggregates, paper, glass, metal, tyres and textiles.

Energy efficiency is now considered as the key parameter to determine whether a waste-to-energy plant can claim recovery status, or whether combustion of the waste will be classified as disposal. A number of calculation methods for efficiency of energy recovery were considered in the Waste Incineration BREF [2006]. One of these methods, after modification, was selected for inclusion in the WFD; the equation is to be found in Annex II of the Directive. The equation does not give energy conversion efficiency in the true physical sense, but energy conversion performance. Thresholds are set for waste-to-energy plants, where a performance level of 0.6 (for installation permitted and in operation before end 2008) and 0.65 (for installations permitted and in operation after 2008) to claim 'recovery' status. A rough evaluation of operating plants in the EU suggests that about one-third will exceed the threshold immediately, but that hardly any of those exporting only electricity will be included in the recovery group. Allowances are available to account for climate factors so that plants operating in warm regions will not be penalised.

Emissions from waste incinerators (waste-to-energy plants) continue to be covered by **DIRECTIVE 2000/76/EC of the European Parliament and of the Council** of 4 December 2000. However, this directive is in the process of review (expected date of completion is mid-2010) and there is a possibility of changes to emissions limits. The proposal, contained in Commission Communication, COM(2007) (of 21.12.2007), is to combine seven industrial emissions directives into one 'recast' directive [EC 2007] based on the requirements of the**Integrated Pollution Prevention and Control (IPPC) directive, 96/61/EC** of 24-09-1996 and its associated best available techniques documents (BREFS) from the seven industries concerned.

The WFD also requires (in Article 22) the Commission to address specific issues related to bio-waste from households, restaurants, etc; that means:

a) the separate collection of bio-waste with a view to composting and digestion;
b) the treatment of bio-waste in a way that fulfils a high level of environmental protection;
c) the use of environmentally safe materials produced from bio-waste.

As a consequence, DG Environment produced a **'green paper' (COM(2008) 811, on the management of bio-waste in the European Union**, 3.12.2008) and in 2009 is carrying out life cycle assessment work on different bio-waste treatment pathways. The assessment is examining the opportunity of setting minimum requirements for bio-waste management and quality criteria for compost and digestate from bio-waste, in order to guarantee a high level of protection for human health and the environment. A separate directive is one possible option for dealing with bio-waste in the future.

Legislation with indirect impact on waste management

The biodegradable fraction of waste, about 70% of the weight or 50% of the energy content of municipal solid waste, is counted as biomass according to new renewable energy directive [EC 2009] of the EU. The definition of biomass in the new EU renewables directive is given as:

> 'biomass' means the biodegradable fraction of products, waste and residues from biological origin from agriculture (including vegetal and animal substances), forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste".

As a consequence, energy recovered from the biodegradable component of waste can be considered as renewable energy and counted towards renewable energy targets. Since 2005 the European Commission has been promoting energy from biomass according to the **Biomass Action Plan (Commission Communication COM(2005) 628,** of 7.12.2005). The new renewable energy directive also focuses on sustainability of biomass production and its conversion to energy. While the criteria for sustainable biomass have yet to be established, criteria are included in the new directive for biofuels for transport. Importantly, as far as waste materials and residues are concerned, CO_2 emissions associated with production of wastes and residues are given as zero in any life cycle assessment. This means that only emissions produced during the energy conversion process, and in the disposal of residues such as ashes, will be counted so that CO_2 savings from energy from waste should be high enough to safely exceed any future threshold. The WFD energy efficiency criterion should nevertheless push waste incinerator operators to maximise the efficiency of energy recovery.

References

BREF(2006) Waste Incineration Best Available Techniques Reference Document (BREF), August 2006, http://eippcb.jrc.es/reference/
EC (2007) Proposal for a Directive of the European Parliament and of the Council on industrial emissions (integrated pollution prevention and control) (Recast), COM(2007) 844, of 21.12.2007
EC (2009) DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 on the promotion of the use of energy from renewable sources

France

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National Policy/strategy

Fundamentals on waste strategy

First waste management acts

The first waste management act in France came into force on July 15th 1975. This was driven by sanitary rather than environmental considerations. However the act encouraged recovery over disposal and required that strategies were put in place for the disposal of hazardous and non-hazardous waste. Waste could only be treated in permitted facilities. Waste collection was also extended to all householders (at this time only 50% of the population was covered by waste collection).

A new act came into force in 1992, with the purpose of achieving sound environmental waste management and improving the sustainability of waste management. The Act established the waste hierarchy (prevention, reuse, recycling, recovery and disposal). Recycling and recovery were strongly encouraged. Landfill was restricted to 'ultimate' waste, meaning waste that cannot be technically and economically recovered for the time being. This act showed a voluntary approach by establishing tools: waste management plans, tax regulation, and waste fund. The act set up the landfill tax regulation for Municipal Solid Waste (MSW).

Waste fund

From 1993 to 2003, part of the landfill tax was dedicated to the improvement of waste management, in particular for increasing the recycling rate and for diverting waste from landfill. The fund was managed by ADEME. Subsidies were allocated to help the investment in separate collections, drop off centres, sorting units and recycling units. Energy from waste units received grants for pilot schemes and for combined heat and power investment. Research related to waste management processes, sanitary and heath impact, waste recovery schemes and pilot scale projects was funded.

Table 5: Evolution of waste management from 1993 to 2002

	1993		2002	
	%	Mt	%	Mt
Separate collection for packaging and paper	6	1.3	13	3.4
Separate collection for organics	6	1.3	6	1.6
Energy from waste plant	28	6.2	33	8.6
Incineration without energy recovery	12	2.6	3	0.8
Landfill	48	10.6	45	11.7
Total		22		26

Table 5 above shows the developments in waste management in France from 1993 to 2002. By 2002, there was an increase in material recycling and energy recovery, a slight decrease in materials sent ton landfill, a significant reduction in incineration without energy recovery and a stabilisation of biodegradable recycling. The developments were partly due to the subsidies received for increasing the recycling rate. The level of the landfill tax was not high enough to divert waste from landfill. Also no landfill ban was issued. Stricter regulation on emission limits led to the closure of many small, obsolete incinerators.

The 'Grenelle'

A national strategy for France was drafted in 2003. The strategy promoted waste minimisation (waste prevention, home composting), and public acceptance. One of the key drivers of the strategy was to divert waste from landfill and in 2007 the 'Grenelle' was put in place to speed up the process.

The 'Grenelle' was a multi-stakeholder forum of environmentalists, business representatives, trade unions, local authorities and state bodies which gathered together to discuss environmental causes. The aim was to reach an agreement on the ways of tackling climate change and to draw a roadmap for sustainable management and development. Several working groups were organised (health, energy, governance). The waste strategy group presented its conclusions in December 2007. The conclusions were related to France's commitment to fight climate change and to preserve resources and to decrease greenhouse gas emissions fourfold by 2050. Of the 268 'Grenelle' measures, 25 were concerning waste. On 3 August 2009, the first Grenelle law was adopted by the parliament, setting up the Grenelle requirements and allowing implementation of the decisions.

Grenelle waste objectives

To achieve the objective of minimizing the impact of waste on climate change and on resource depletion, the following main actions were proposed:

Strengthening waste prevention

- Waste prevention was put at the top of the list of priorities in compliance with the Framework Directive 2008/98/EC. Besides resource and energy saving, waste prevention impacts the overall cost of waste management. Waste management was estimated to have cost €11.6 billion in 2006 of which €7.4 billion was dedicated for household waste management, meaning €116 per inhabitant. These costs have doubled in the last ten years (data from MEEDDAT/IFEN). Part of this increase is due to more sophisticated technology in order to get better environmental and sanitary protection, but part of it is due to the increase in the amount of waste produced.
- Developing organic and material waste recycling. ADEME assessed that, in 2005, waste recycling (municipal solid waste and non-hazardous industrial waste) avoided the consumption of 17 million tons of raw material and reduced CO_2 emissions by 15 million tons. Recycling stimulates more jobs - ten times more than landfilling.
- Increasing diversion from landfill and incineration. Today 75% of the household and assimilated waste is going to landfill or incineration. To promote recycling, this waste route should be limited.

National targets were set up for each of those objectives

To show a voluntary approach, targets were set up. A national committee with all main actor representatives will monitor yearly achievement of the objectives.

- Waste prevention. Households should reduce their waste by 5 kg/h each year over five years to achieve 25 kg reduction by 2014 (decrease of 7% per capita over the next five years).

- Waste recycling.

    - 35% of municipal solid waste should be recycled or composted by 2012 (24% in 2006) rising to 45% in 2015;

- increase recycling from 60% in 2006 to 75% by 2012 for household packaging waste;
- increase recycling from 68% to 75% by 2012 for industrial waste.

- Organic waste. The amount of organic waste treated by composting or anaerobic digestion should double in the future.

- Landfill and incineration. To reduce the amount of waste landfilled and incinerated by 15% by 2012. To promote these targets, regulations are being introduced to limit the capacity of any new incinerator, thus allowing the recycling target to be reached.

Main measures

- Tax regulation on landfill and incineration.
  Currently the tax level on landfill is too low to be an incentive to divert waste from landfill. At €10/t, the tax in France is one of the lowest in EU. The average cost of landfill of €53/t (€63 with tax) can be compared with €70 to €90 for composting and incineration.
  - The Landfill Tax will increase from €15/t in 2009 to €40/t in 2015. The tax is lower when the site carries out high efficiency recovery of the collected landfill gas (> 75%) and has been awarded an environmental certificate.
  - A new tax will be set up for incineration with a level depending on the energy efficiency from €7/tonne in 2009 to €14/tonne by 2013. The tax is lower (from €2/tonne in 2009 to €4/tonne in 2013) when two of the following criteria have been satisfied: (a) the plants have been awarded an environmental certificate, (b) the energy efficiency is high (in accordance with the French formula calculation), or (c) the NOx emission is less than 80 mg/Nm3.

The level and the scope of the tax is still being debated within parliament.

- Local prevention plan

  In 2004 the Environment Ministry adopted a National Waste Prevention Plan, with three major lines of action:
  - mobilising stakeholders;
  - implementing action over the long term;
  - ensuring follow-up on measures taken.

  This plan aims to “raise awareness of waste prevention to the same level as for recycling”, with the prime objective of holding down waste generation and achieving growth in GDP without increasing waste.

  This law calls for:
  - across-the-board application of rate incentives;
  - development of green fiscal measures to tax products that generate large quantities of waste, provided alternate products with the same functional properties are available;
  - country-wide application of Local Waste Prevention Plans;
  - general implementation of Extended Producer Responsibility.

Financial assistance should help to draft and implement the Local waste prevention Plan. Considering that implementing the plan will cost an average of €2/h/a, a grant of €1/h/a could be attributed if the objectives have been reached. 80% of the population should be covered by such a plan by 2015.

- Develop the principle for extended producer responsibility (EPR) to more products.

Stewardship, or responsible management based on environment and resource, requires industry to assume a greater responsibility for ensuring that its products have a minimum impact on environment during their lifetime. Grenelle emphasizes this concept strongly and promotes the extension of the principle for more of the waste stream. In the first place, the EPR will be applied to hospital waste, furniture and household hazardous waste stream.

- Generalize the pay as you throw tax by 2020

A pay as you throw tax (PAYT) or at least an incentive tax should be established for householders within ten years. To improve the recycling record, the PAYT seems to be a valuable concept. Traditionally, residents pay for waste collection through property taxes regardless of how much — or how little — trash they generate. Pay as you throw breaks with tradition by treating trash services just like electricity, gas, and other utilities. Households pay a variable rate depending on the amount of service they use. Currently, as an experimental measure, 25 municipalities have set up a pay as you throw tax. They charge residents a fee for each bag or can of waste they generate or on the weight of their trash. Despite administrative difficulties and a little non civic behaviour, the results are positive. To avoid illegal tipping a fixed amount will be charged for an amount of waste at first then a fee will be charged depending of the amount collected.

Transversal measure

Waste management remains a concern among the population. To improve public acceptance, transparency and public involvement needs to increase. The Grenelle proposed the following measures to tackle this problem:

- Draw an environmental and sanitary impact assessment of the different waste treatment options.
- Set up a more ambitious research, information and monitoring policy.
- Strengthen waste management planning.
- A new national campaign for information on environmental issues.

Measures concerning waste incineration

At the beginning of the debate, some participants wanted a moratorium on waste incineration. They argued that incineration is a sink for waste and slows down waste minimisation and recovery. They agreed to reconsider their point of view due to prevention and recycling considerations within the Grenelle but also due to a limitation on waste incineration development.

As the EU waste directive 2008/98/EC requires, the residual waste stream will be treated only in waste to energy (WtE) plants with high environmental standards and high energy efficiency. Modernisation of the WtE plant will be encouraged. Within a territory, the capacity of the WtE plants and landfill will be capped at a maximum of 60% of the relevant waste production.

To try to improve heat recovery rate a fiscal measure is proposed. Municipalities applying their own tax system could exempt buildings (using the heat from the WtE plant) from the requirement to pay property tax for a period of five years. The amount of heat used should be a significant part of the energy produced by the unit.

Fundamentals on renewable energy policy

Objectives

Energy was the centre of the Grenelle debate as the major source of climate change.

- The first measured trends concern energy efficiency on new construction, on refurbishment of existing buildings and on transport by increasing the role of railways and public transport and by decreasing vehicle consumption.
- The second measured trend is related to renewable energy. The French commitment goes beyond the EU energy-climate package and targets 23% renewable energy by 2020, instead of 20%. A rise of 20 Mtep production from renewable energy is mandatory. Biomass and wind power will be the main source of renewable energy with a contribution of 16 Mtep. Energy from waste from incineration, co-combustion or anaerobic digestion will be included within this.

Tariffs for energy from biomass

Since 2000 (law 2000-108 of the 10/02/2000) EDF has the obligation to buy electricity from renewable energy.

In 2001 (law of the 02/10/2001), the tariffs were fixed for MSW plant as incineration. For new units, the tariff is established to a level of c€4.6/kWh with a prime of c€0.3/kWh for high efficiency units (>60% calculated on the basis of the R1 formula). For existing units the tariff is set up to c€3.9/kWh.

New tariffs were established in 2006 for biogas from landfill and aerobic digestion: c€7.5-9/kWh, with a bonus of c€2/kWh for aerobic digestion and up to circa €3/kWh for high efficiency. But for incineration the tariffs did not change. The French government clearly wants to support anaerobic digestion rather than incineration.

Current situation on MSW management

MSW Production in 2006

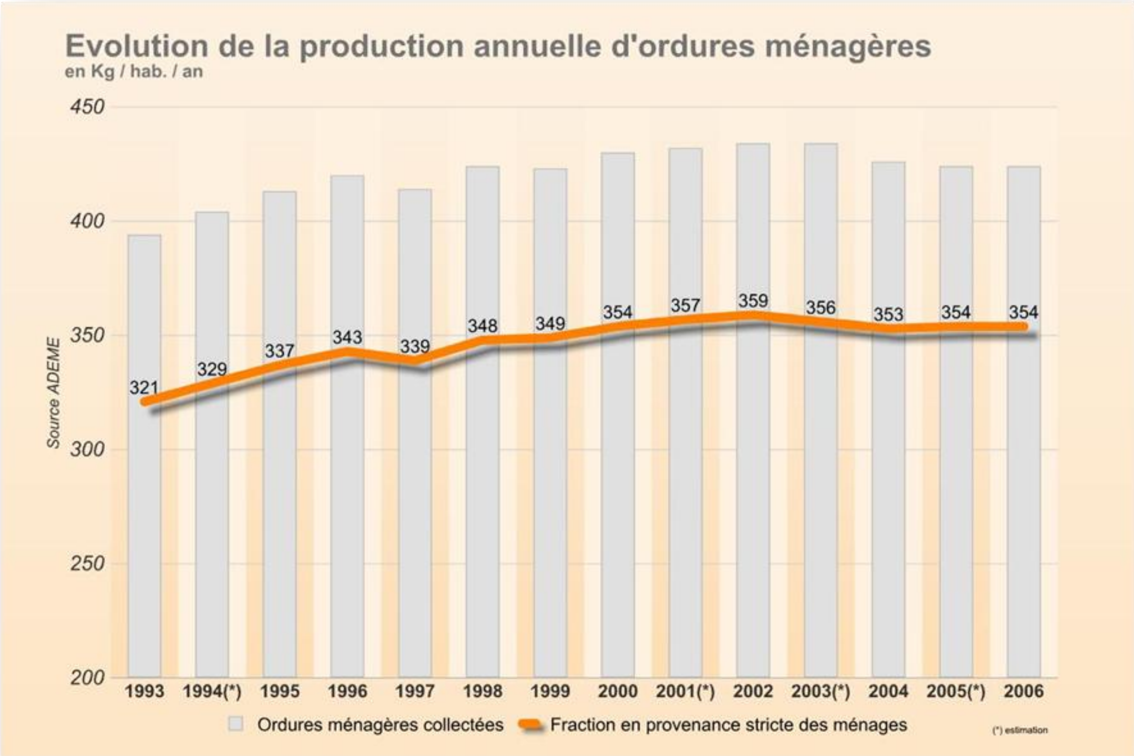
In 2006, the total production of waste was estimated at 849 Mt, of which 28 Mt (3%) was produced by householders.

Table 6: Waste production in 2006 in Mt (ADEME-IFEN)

<table>
<tr><td>Waste from municipalities</td><td colspan="2">Household waste</td><td colspan="3">Industrial waste :
Factories & industrial plants</td><td>Agriculture and forestry waste</td><td>Infectious waste</td><td colspan="2">Construction and demolition waste</td></tr>
<tr><td>14 Mt</td><td colspan="2">31 Mt</td><td colspan="3">90 Mt</td><td>374 Mt</td><td>0.2 Mt</td><td colspan="2">359Mt</td></tr>
<tr><td rowspan="4">Street sweeping, garden waste, waste water treatment sludge</td><td>Bulky waste, garden waste</td><td>Household Collection rounds</td><td colspan="2">Non hazardous</td><td>Hazard-ous</td><td rowspan="4"></td><td rowspan="4"></td><td>Non hazard-ous</td><td>Hazard-ous</td></tr>
<tr><td rowspan="3">11</td><td rowspan="3">20</td><td colspan="2">84</td><td>6</td><td rowspan="3">356</td><td rowspan="3">3</td></tr>
<tr><td>Collected with household</td><td>Private collect</td><td></td></tr>
<tr><td>5</td><td>79</td><td></td></tr>
</table>

In 2006, the production of household waste was estimated at 354 kg/h/a. The production doubled in the last forty years but started to have a smaller increase since the 1990s with an average rate of growth of 4% a year. However, since 2002 there has been a slight decrease (1%), but the trend is weak.

Figure 15: Evolution of household waste production (ADEME)



MSW management in 2006

ITOM is a survey of household and assimilated waste treatment facilities carried out by ADEME every two years. It considers all types of treatment and all throughput of waste; including waste from waste treatment plants as bottom ash going to landfill or sorting refuse into an incinerator. As is common with such statistics, the quantity treated appears to be greater than the quantities collected at times. This is due to discrepancies in the statistics due to collection techniques.

Table 7: Quantity of waste treated in waste treatment units managed by the public waste management system in 2006 (ADEME, ITOM 2006)

Treatment type	Number of plants	Waste treated kt/a	Percentage %
Sorting units	320	6 438	13.4
Composting	511	5 051	10.7
Anaerobic digestion	3	147	0.3
Energy from waste facilities	110	12 372	26.0
Incineration without energy recovery	18	579	1.2
Landfill	303	22 938	48.3
Total	**1 263**	**47 526**	
Bottom ash treatment facilities	50	2 006	

The MSW units treat 46% of household waste collected on kerbside and 21% of non-hazardous waste coming from retail and small enterprises. Incineration and landfill together represented 80% of the treatment, a stable position since 2003.

Table 8: Waste treated in waste treatment units managed by the public waste management system (ADEME, ITOM 2006)

Waste treated by the MSW units	Percentage %
Household strict	46
Waste from retail and small business	21
Dry waste from separate collection	9
Organic waste	8
Refuse from sorting unit	5
Rubble	2
Waste water treatment sludge	3
Hazardous waste	1

Role of EfW Plants

In December 2008, 116 energy from waste plants were in operation. Over the past 20 years the number of incinerators has decreased from 300 in 1993 to 113 today, but the quantity of waste treated has increased slightly.

The average capacity of a new unit is 110,000 t/a, for a population of 260,000 inhabitants.

France used to have a lot of small incinerators without energy recovery. The new regulations led to the closure of several units of less than one t/h.
Several reasons can explain the shut downs:

- the drafting of departmental plans with the objective of optimising the waste management options;
- the establishment of inter-municipal bodies with centralised units instead of one small unit per municipality;
- the strengthening of regulations that were difficult to apply technically and economically for small units;
- the problem of public acceptability and the perceived threat of toxic emissions.

Table 9: Thermal waste treatment plants with energy recovery in France in July 2008 (ADEME, Sinoe, www.sinoe.org)
Note: The capacity is calculated by multiplying the hourly capacity by 8,000 hours. Sometimes the permits given by the authority is for less than the real capacity. This could explain some of the discrepancies between the two numbers.

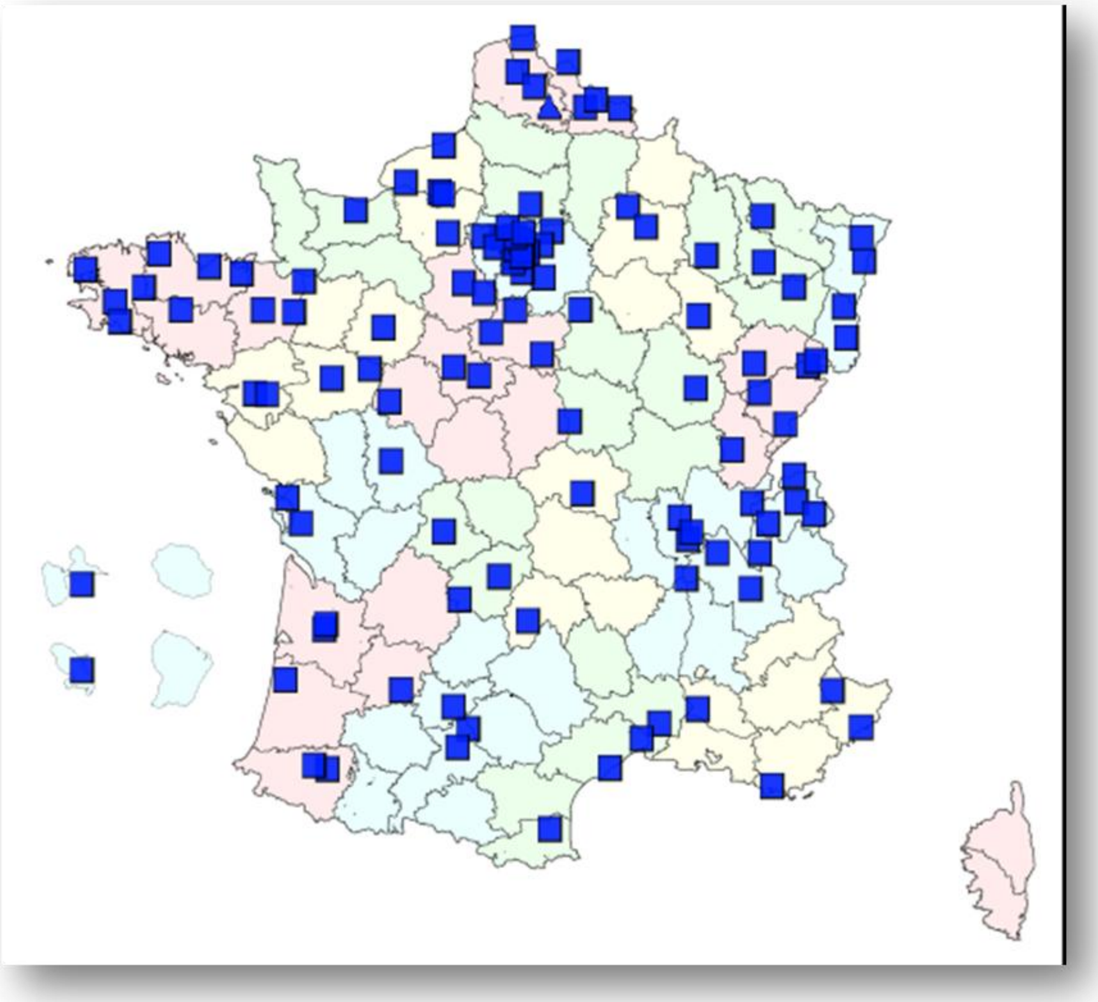
Dpt	Location	Opening date	Units	Capacity Mg/a	Treated quantity
		(last authorisation)			2007/*2006**
1	BELLEGARDE SUR VALSERINE	1998 (2003)	2x8	128,000	113,944
3	BAYET	1982 (2005)	1x4+1x5	72,000	50,056
6	NICE	1977 (2005)	3x12+1x18	432,000	309,091
14	CAEN	1972	2x8	128,000	98,768
15	AURILLAC	1990 (2004)	<1	5,100	4,666
16	ANGOULEME/ La Couronne	1986 (2004)	1x5	40,000	*36,640*
17	LA ROCHELLE	1988 (2004)	2x4	64,000	57,573
17	ROCHEFORT/Echillais	1990 (2004)	2x2.5	32,000	33,953
19	BRIVE LA GAILLARDE	1973 (2005)	3x3.5	84,500	62,000
19	ROZIERS D'EGLETON	1997 (2005)	1x5.3	42,000	*40,000*
21	DIJON	1974 (2004)	2x11.6	140,000	*124,274*
22	DINAN/Taden	1998 (2006)	2 x7	96,000	*95,147*
22	LAMBALLE	1993 (2007)	1x5.9	47,200	40,665
22	PLUZUNET	1997 (2006)	1x7	56,000	22,424
25	BESANCON	1971 (2005)	1x3+1x4	56,000	50,000
25	MONTBELIARD	1987 (2005)	2x4	64,000	43,849
25	PONTARLIER	1989 (2004)	1x5	40,000	34,408
27	EVREUX/Guichainville	2003	2x5.6	90,000	90,101
28	CHARTRES	1999 (2004)	2x7.5	120,000	118,390
28	RAMBOUILLET/Ouarville	2000 (2004)	2x8	128,000	114,161
29	BREST	1988 (2006)	2x9	144,000	124,699
29	CARHAIX-PLOUGUER	1995 (2006)	1x4	32,000	29,153
29	CONCARNEAU	1989 (2006)	2x3.9	62,400	45,773
29	QUIMPER/Briec	1996 (2006)	2x4	64,000	*30,408*
30	NIMES	2004	1x14	112,000	101,026
31	BESSIERE	2000 (2007)	2x11.4	182,000	158,497
31	TOULOUSE	1969 (2006)	3x8+1x14	304,000	250,995
33	BORDEAUX/Bègle	1998 (2007)	3x11	264,000	245,181
33	BORDEAUX/Cenon	1985(2006)	2x8	128,000	123,063
34	LUNEL-VIEL	1999 (2007)	2x8	128,000	127,434
34	SETE	1992 (2005)	1x5.6	44,800	40,435
35	RENNES	1968 (2005)	2x5+1x8	144,000	124,914
35	VITRE	1998 (2005)	1x4	32,000	24,594
37	CHINON/St Benoit la foret	1984 (2004)	1x2.8	22,400	19,000
38	BOURGOIN JALLIEU	1986 (2007)	1x5 +1x6	88,000	80,256
38	GRENOBLE/La Tronche	1972	3x8.25	198,000	168,972
38	SALAISE SUR SANNE	1985		100,000	*92,400*
39	LONS LE SAUNIER	1994 (2004)	1x5	40,000	36,563
40	PONTENX Les Forges	1997 (2007)	1x5.3	40,600	40,148
41	BLOIS	1971 (2007)	2x5.5	88,000	91,157
41	VERNOU EN SOLOGNE	1987 (2004)	1x2.3	18,400	*7,154*
44	NANTES Arc en Ciel	1994 (2004)	2x7	112,000	89,284

44	NANTES Valorena	1987 (2003)	2x9.5	152,000	129,374
45	GIEN	1999 (2005)	2x5	80,000	26,443
45	ORLEANS	1995 (2004)	2x7	112,000	98,470
45	PITHIVIERS	1985 (2004)	1x3.25	26,000	23,800
47	AGEN	1983 (2001)	1x4.2	33,600	30,882
49	ANGERS	1974 (2004)	3x5	120,000	77,738
49	LASSE	2004	1x12.5	100,000	100,496
51	CHALONS-EN-CHAMPAGNE	1996 (2004)	1x12.5	100,000	149,062
51	REIMS	1989 (2004)	2x6.5	104,000	67,069
52	CHAUMONT	1984 (2006)	2x5	80,000	76,599
53	LAVAL/Pontivy	1984	1x4.5	36,000	*26,234*
53	PONTMAIN	1984(2004)	1x3.2+1x4	57,600	61,000
54	NANCY/Ludres	1995 (2006)	2x7	112,000	97,810
55	TRONVILLE EN BAROIS	1983 (2005)	1x3.5	30,000	23,488
56	PONTIVY LE SOURN	1989 (1997)	1x4	32,000	30,503
57	METZ - BORNY	2001 (2006)	2x8	128,000	*92,160*
58	DUNKERQUE	2007		86,000	
58	NEVERS	2002	1x6	48,000	38,106
59	DOUCHY-LES-MINES	1977 (2005)	2x5	80,000	90,526
59	LILLE /Halluin	2000 (2006)	3x14.5	348,000	344,993
59	MAUBEUGE	1981(2003)	2x5.5	88,000	83,092
59	VALENCIENNE/St Saulve	1977 (2003)	3x5	140,000	116,353
60	COMPIEGNE/Villers St Paul	2004 (2006)	2x10.8	172,500	*172,500*
62	ARRAS (pyrolysis)	2004	2x3.3	52,800	*35,000*
62	BETHUNE/Labeuvrière	1979 (2006)	2x5+1x10	160,000	*58,716*
64	MOURENX	1990	1x2	16,000	*9,362*
64	PAU	1975 (2005)	1x5+1X6	88,000	79,440
64	VALBERG	2005	1x0.5	4,000	*470*
66	PERPIGNAN/Calce	2000 (2007)	2 X11	176,000	180,644
67	HAGUENEAU	1990 (2006)	2x5	80,000	76,483
67	STRASBOURG	1974 (2006)	4 X 11	352,000	267,718
68	COLMAR	1988 (2005)	2x6.2	99,200	*81,102*
68	MULHOUSE	1999 (2006)	2x10.5	168,000	149,862
69	LYON NORD/Rilleux le pape	1989 (2004)	2x12	192,000	141,519
69	LYON SUD/Gerlan	1990 (2004)	3x12	288,000	*227,025*
69	VILLEFRANCHE	1984 (2005)	1x4.5+1x6.5	88,000	79,751
70	NOIDANS-LE-FERROUX	2007	1x5.2	41,000	
72	LE MANS	1975 (2008)	1x9+1x12	168,000	120,954
73	CHAMBERY	1977 (2005)	2x4+1x6	112,000	*80,649*
74	CRAN GEVRIER/Annecy	1984 (1993)	2x6+1x4.2	129,600	*135,298*
74	MARIGNER	1991	1x5	40,000	44,557
74	PASSY	1995 (1997)	1x7.5	60,000	44,129
74	THONON LES BAINS	1988 (2004)	1x5	40,000	39,000
76	DIEPPE	1971 (2002)	2x2.5	40,000	20,000
76	LE HAVRE/St Jean de Folleville	2003	2x12	192,000	172,760
76	ROUEN	2000 (2008)	3x14.5	348,000	296,922
77	LAGNY SUR MARNE	1985 (2005)	1x8+1x12	160,000	150,086
77	MONTHYON	1998 (2004)	2x7+1x4	144,000	117,760
77	VAUX-LE-PENIL	2003 (2005)	2x8	140,000	141,667
78	CARRIERE SOUS POISSY	1998 (2003)	2x7.5	120,000	115,258
78	CARRIERES SUR SEINE	1977 (2003)	2x10	160,000	117,683

78	MANTES:guerville	1997 (2004)	3x4	96,000	59,881
78	THIVERVAL GRIGNON/Behoust	1974 (2006)	2x10.1+ 1x14.7	280,000	188,113
82	MONTAUBAN	1986 (1992)	5	40,000	29,119
83	TOULON	1984 (2005)	2x12+1x14	304,000	250,931
84	AVIGNON/Vedenne	1995 (2005)	3x6	144,000	136,733
86	POITIERS	1984 (2004)	2x4	64,000	44,962
87	LIMOGES	1989 (1997)	3x5	120,000	90,680
88	EPINAL/ Rambervillers	1983 (2005)	2x3.5+1x6	104,000	90,493
89	SENS	1988 (2005)	1x3	24,000	16,927
90	BELFORT/Bourogne	2002 (2004)	2x6.2	99,000	72,269
91	MASSY	1987 (2004)	2x5.5	88,000	*67,255*
91	ULIS/villejust	1984 (2005)	1x6+1x8	112,000	*73,549*
91	VERT-LE-GRAND	1999	2x14	224,000	*152,652*
92	PARIS/ Issy les Moulineaux	2008	2x30.5	460,000	12,872
93	PARIS/ St Ouen	1990	3x28	672,000	607,819
94	CRETEIL	1978 (2003)	2x15	240,000	227,337
94	PARIS/Ivry sur Seine	1969 (2004)	2x50	800,000	669,339
94	RUNGIS	1985 (2004)	2x8.5	130,000	121,476
95	ARGENTEUIL	1975 (2004)	2x7.5+1x9	192,000	189,068
95	CERGY/St Ouen L'Aumone	1996 (2005)	2x10.5	168,000	*145,961*
95	SARCELLES	1978 (2005)	2x10	160,000	121,062
97	FORT-DE-FRANCE	2002	2x7	112,000	113,026
971	SAINT-BARTHELEMY	2001	1x1.5	12,000	9,501
		Total capacity		**14,782,700**	**12,022,754**

*source 2007: SVDU, 2006 : ITOM

Figure 16: Location of French waste incineration plants (ADEME, ITOM 2006)



Recent developments in energy recovery

Due to the difficulty faced in building new plants in urban areas, most of the plants are built outside these areas, making it almost impossible to recover the heat. For this reason electricity generation is increasing and heat valorisation is decreasing. By proposing that buildings using a significant amount of heat from an incinerator are exempt from tax, the state is trying to change this trend.

Table 10: Evolution of type of energy from waste

	2000	2002	2004	2006
Waste reated quantity t/y	11 782	12 598	13 630	12 950
Electricity, GWh	2 041	2 900	3 242	3 206
Heat, GWh	7 601	9 057	8 231	6 700*
Number of waste to energy plants	109	116	112	110
% units with energy recovery	51	69	84	93
% quantity of waste incinerated with energy valorisation	88	90	95	99
% MSW incinerated	27.3	29	28.2	27.1

* this decrease is due to the closure of one unit in Paris. A new unit has been in operation since June 2008

Waste as a renewable energy

Energy from MSW is the second highest renewable energy, after hydropower for electricity and wood for heat. Consequently one can say that energy from waste plays a significant role in renewable energy. In addition, estimates indicate that energy from waste plants avoids the emission of 2 Mt of CO_2.

Table 11: Place of energy from waste in 2004

2004	Electricity GWhe	Heat ktep
Hydropower	61 369	
Waste biogenic fraction of waste = 50%	1621 (total 3242)	358 (716)
wood	1 332	8 780
wind	629	
Geothermic near surface		316
Biogaz	446	55
Crop residue	366	190
Geothermic	29	130
Photovoltaic	26	
Solar heat		32
Total renewable energy	65 817	10 281
Total renewable energy in ktep	15 964	

Future of EfW

Today in France incineration still plays a key role in the waste strategy. However, the few new projects have to fight against a lack of public acceptance. Each time a plant is proposed it is strongly opposed and often the municipality propose another solution (e.g. MBT, anaerobic digestion). A symbolic fight for the 'association against incineration' is the Marseille incinerator. The construction was stopped following a court appeal by the opposition. An agreement was reached by building an MBT plant with anaerobic digestion on the spot to divert waste from the incineration unit.

The waste strategy has to follow the Grenelle objectives that limit incineration and landfill. The new revised department plans will have to justify each new waste to energy plan and to limit its capacity. The tax will add a small burden, but for incineration the level of tax will stay low compared to the treatment cost. Also few new incineration plants will be commissioned in the next ten years. As landfill and incineration are considered to be on the same level in France (no landfill ban, no obligation to recover combustible waste), the future of incineration is uncertain.

New grants will be allowed to promote waste recycling and recovery. Anaerobic digestion also has the advantage of being popular. Six units are in operation today, two to three new units should be built per year until 2012.

Many mechanical biological treatments have been built. Some will produce a solid recovered fuel that could be processed in a boiler or furnace. But few industrial plants are able to process this kind of product without too much change. The cement industry is currently undertaking a survey to look at the possibility to use it by feeding the fuel into main burner. Of course the utilisation of such fuel will depend on its quality and on the energy market price.

Germany

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Legislative regulations on waste management

The German Government started activities to develop an integrated waste management strategy in the early 1990s. The principles are the same as those of the EU Waste Framework Directive on Waste Disposal 75/442/EEC.

In this section the most important acts, ordinances, guidelines and memoranda will be described briefly. In this context only regulations affecting the management of non-hazardous waste will be considered.

Waste Disposal Act and Waste Avoidance and Management Act

The first **Waste Disposal Act** [**Bundesminister des Inneren 1972**] was enacted in 1972, three years before the EU Waste Framework Directive. It replaced approximately 50,000 landfill sites with 300 controlled landfills. This was accomplished within a few years; however, issues with logistics and shortages in capacity caused local crises and public opposition. To cope with the permanently increasing waste generation the **Waste Avoidance and Management Act** [**Bundesminister des Inneren 1986a**] was adopted in 1986. It set the principle of giving avoidance and recycling preference over disposal.

Air Emission Regulations

Along with the reorganisation of landfills, the number and capacity of waste incineration plants was extended. This technology was soon blamed for unacceptable air emissions, particularly after dioxins had been detected in the fly ashes of Dutch waste incinerators [Olie 1977]. Declining public acceptance in the early 1980s was the driver for the release of the **Technical Guideline Clean Air** (**TA Luft 86**) in 1986 [Bundesminister des Inneren 1986b]. Its limits were strengthened five years later by the **17. Federal Emmission Control Ordinance (17. BImSchV) [Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit 1990**]. This ordinance is one of the sources of the later EU Waste Incineration Directive 2000/76/EC (WID) and is (with a number of minor changes) still in power today.

The 17. BImSchV regulates the entire waste incineration process. For the combustion process a minimum temperature of 850°C is required, but if the concentration of organic chlorine (Cl) exceeds 1 wt% in the fuel this temperature has to be increased to 1,100 °C. The combustion temperature has to be measured after a flue gas residence time of >2 s downstream of the last air injection.

The grate ashes have to reach a Total Organic Carbon (TOC) < 3 wt% and detailed provisions are provided for co-incineration. Safety measures for different operation modes are also included.

The limits set for air emissions are of especial importance. Gaseous components, including fly ash, have to be monitored continuously. Heavy metals, Benzo(a)pyrene, and PCDD/F have to be sampled and analysed every two months during the first year of operation and later once per year. The sampling has to be performed over three days. The sampling time for heavy metals and Benzo(a)pyrene is restricted to 0.5 – 2 h, for PCDD/F the sampling time is 6 – 8 h. Details for monitoring methods, measuring time intervals, and analytical methods are also included.

The actual daily and half-hourly emission standards of gas carried components for Germany are compiled in Table 12.

Table 12: Emission limits in the 17. BImSchV in mg/m^3 (273 K, 101.3 kPa, 11 vol% O_2, dry)

Parameter	*Daily limit*	*Half-hourly limit*
Dust	10	30
CO	50	100
TOC	10	20
HCl	10	60
HF	1	4
SO_2	50	200
NO_x (as NO_2)	200	400
Hg	0.03	0.05

The limits for the annual surveillance measurements are shown in Table 13.

Table 13: Emission limits for heavy metals and Benzo(a)pyrene in mg/m^3, for PCDD/F in ng(I-TE)/m^3 (273 K, 101.3 kPa, 11 vol.-% O_2, dry)

Parameter	*Limit*
Cd+Tl	0.05
Sb+As+Pb+Cr+Co+Cu+Mn+Ni+V+Sn	0.5
As+Benzo(a)pyrene+Cd+Co(water sol.)+Cr[1]	0.05
PCDD/F	0,1

[1]) alternatively Cr^{6+} compounds with the exception of $BaCr_2O_7$ and $PbCr_2O_7$

These stringent safety standards helped to reduce the public opposition against thermal waste treatment to a great extent.

Packaging Ordinance

Approximately 50 % of the volume of waste from households is packaging material. For this reason, regulations on the disposal of this waste stream were introduced in the **Packaging Ordinance [Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit 1991**], by shifting the responsibility for its adequate management to the manufacturers and retailers. As a consequence of this ordinance the **Dual System Germany (DSD**) was established. This collects packaging material free of charge for the householder and organises the recycling of fractions such as glass, paper, or plastics. The system is financed by the 'Green Dot' licence fee which the manufacturer - but in fact the customer - pays. Meanwhile the DSD lost its exclusivity and a number of dual systems are in operation.

Technical Ordinance on Waste from Human Settlements (TASi)

For mixed residential waste the government issued the **Technical Ordinance on Waste from Human Settlements (TASi**) in 1993 [**Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit 1993**]. The core target of the ordinance was the prevention of direct disposal of reactive waste. Its main objectives are

- restriction of direct disposal of biodegradable waste on landfills;
- instructions for design, operation and allocation of future landfills;
- priority for material recovery including composting and anaerobic digestion; and

finally

- thermal treatment of residual waste with energy recovery and - as far as possible - residue utilisation prior to final disposal.

The waste management hierarchy outlined above did not have to be followed strictly if technical or economic aspects were in favour of other strategies.

Two types of landfills were foreseen for the disposal of mixed municipal solid waste; their acceptance criteria are compiled in 0. The most important parameter is the residual content of organic matter, analysed as TOC, which is 1 wt% in the case of landfill class 1 or at the highest 3 wt% for landfill class 2.

Table 14: Acceptance criteria for German landfills as laid down in the TASi (landfill class 1 and 2) and in the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities (landfill class 3)

Parameter	*Unit*	*Landfill class 1*	*Landfill class 2*	*Landfill class 3*
vane shear strength	kN/m^2	≥25	≥25	≥25
axial deformation	%	≤20	≤20	≤20
uniaxial compressive strength	kN/m^2	≥50	≥50	≥50
LOI	wt%	≤3	≤7	-
TOC	wt%	≤1	≤3	≤18
extractable lithophilic substances	wt%	≤0.4	≤0.8	≤0.8
pH		5.5 - 13	5.5 - 13	5.5 - 13
el. conductivity	µS/cm	≤10,000	≤ 50,000	≤ 50,000
TOC	mg/l	≤20	≤100	≤250
phenols	mg/l	≤0.2	≤50	≤50
As	mg/l	≤0.2	≤0.5	≤0.5
Pb	mg/l	≤0.2	≤1	≤1
Cd	mg/l	≤0.05	≤0.1	≤0.1
Cr-VI	mg/l	≤0.05	≤0.1	≤0.1
Cu	mg/l	≤1	≤5	≤5
Ni	mg/l	≤0.2	≤1	≤1
Hg	mg/l	≤0.005	≤0.02	≤0.02
Zn	mg/l	≤2	≤5	≤5
F	mg/l	≤5	≤25	≤25
ammonium-N	mg/l	≤4	≤200	≤200
cyanide	mg/l	≤0.1	≤0.5	≤0.5
AOX	mg/l	≤0.3	≤1.5	≤1.5
soluble fraction	wt%	≤3	≤6	≤6
as breathing activity (AT_4)	mg/g			≤5[1]
or as gas formation rate in fermentation test (GB_{21})	l/kg			≤20[2]
upper thermal value (H_0)	kJ/kg			≤6,000

(1) mg O_2 with respect to dry weight, (2) standard litre of gas with respect to dry weight

The TASi - its full enaction was stipulated for 1 June, 2005 - could have been a strong instrument to promote waste incineration with energy recovery. However, it had no legally binding power, since it was solely requesting the establishment of an integrated waste management system from the relevant administrative bodies. Hence the federal government could not enforce its immediate application and the strong opposition to waste incineration made it difficult to site new plants. As a consequence almost all federal states and all local bodies made excessive use of permits which allowed the continuation of the status quo.

The principles and requirements laid down already in the TASi have later been used as the basis of the EU Landfill Directive. In that way this ordinance – although not really effective in

Germany - resembled at least an important input for the waste management strategies in the EU.

Closed Substance Cycle Act (KrW-/AbfG)

In the early 1990s the German government chose to fight the ever increasing waste generation by introducing a landfill tax. This attempt failed due to heavy resistance, especially from various industry sectors that had to deal with high amounts of production residues. Another reason was the unclear constitutional situation, since a high fraction of the tax was not used to serve common interests in the waste disposal area but was allocated for other purposes.

At the same time Germany was sued at the European Court of Justice for not having fully adopted the Waste Framework Directive. Whereas the German legislative label 'waste' addressed only materials for disposal, in the EU Directive, materials diverted for recycling were also regarded as waste. A further promotion to enact new regulations originated from the World Summit in Rio de Janeiro which brought the term 'sustainability' on stage.

Hence in 1994 the **Act for Promoting Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal (KrW-/AbfG) [Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit 1994**] was issued to adopt the waste classification of the EU Waste Framework Directive; the KrW-/AbfG reinforced the fundamentals of the former TASi and set a series of new rules including:

- the establishment of a waste management hierarchy based on avoidance, utilisation, treatment, and disposal;
- the request for low-waste design of products and closed-cycle management of substances within plants;
- the introduction of the 'polluter pays' principle (producer and holder of waste is responsible for its disposal according to the principles laid down);
- the definition of environmental compatibility as the basic principle to decide upon priority between recycling and energy recovery.

For waste incinerators the KrW-/AbfG set criteria to distinguish between disposal and energy recovery. The latter operation mode is accepted if:

- the lower heating value of the material exceeds 11 MJ/kg;
- the combustion efficiency of the combustion plant exceeds 75%;
- the energy released by the process has to be used as heat or power; and
- the residues meet the landfill acceptance criteria of the TASi without further treatment.

The KrW-/AbfG also stated clearly that energy recovery will not be accepted for municipal waste, regardless of the compliance with the above cited acceptance parameters.

Regulation of Biological Treatment Processes for Waste

To open an alternative treatment route other than waste incineration, the 30. Federal Emmission Control Ordinance [Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit 2001a] was issued in 2001. This ordinance regulates the operation and environmental requirements for mechanical-biological waste treatment plants. Such plants have to meet air emission standards which are similar to those for waste incineration plants with the consequence that these plants have to control their emissions and have to be equipped with air pollution control systems.

Since mechanical and/or biological processes are not able to meet the landfill class 1 or class 2 criteria, the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities (AbfAblV) [Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit 2001b] opened an outlet for the residues of such facilities by defining acceptance criteria for another landfill category, the landfill class 3. The standards are included in 0. Instead of 1 or 3 wt% the TOC has been set to 18 wt%. This standard is accomplished by the limitation of the upper heating value of the material to 6 MJ/kg and a restriction of the amount of extractable organic matter to 0.8 wt%.

Ordinance on Landfills and Long-Term Storage (DepV)

The EU Landfill Directive was adopted by German law in July 2001 with the **Ordinance on Landfills and Long-Term Storage Facilities and Amending the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and Biological Waste-Treatment Facilities (DepV)** [Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit 2002b]. This ordinance finally converted the principles of the TASi into a legally binding regulation. The direct disposal of untreated reactive waste in landfills was now definitely prohibited after 1 June 2005. After this date all standards for design, operation and aftercare of all landfill classes for municipal waste, commercial waste and waste requiring special surveillance (hazardous waste) came in force as they had been laid down already in the TASi. Any exemptions that had been granted expired.

Act on Commercial, Construction and Demolition Wastes

In 2002 the German government released new rules for the disposal of commercial as well as construction and demolition waste with the **Ordinance on the Management of Municipal Wastes of Commercial Origin and Certain Construction and Demolition Wastes** [Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit 2002a]. The disposal of these waste streams must be taken care of by their producers. The new ordinance defines pre-treatment and recovery requirements.

Energy consumption

Primary energy

Primary energy consumption in Germany in 2006 was 14,565 PJ and in 2007 it was 13,842 PJ. A breakdown into the different energy sources is shown in Table 15 [Bundesministerium für Wirtschaft und Technologie 2008].

Table 15: Primary energy consumption in Germany and the contribution of the different energy sources (absolute data in PJ, share in %)

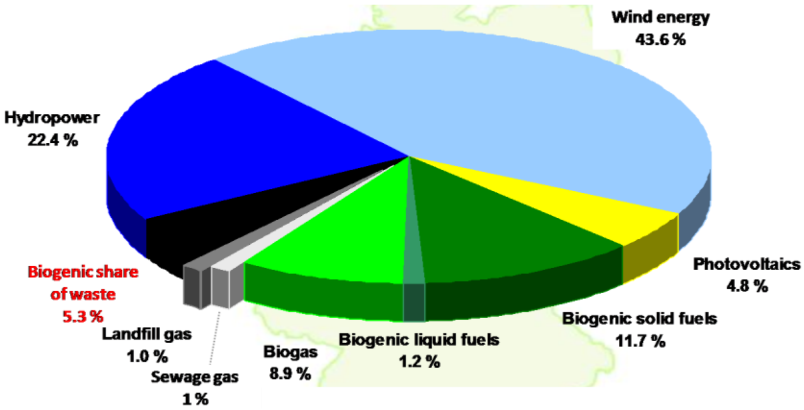
	2006 [PJ]	***2007 [PJ]***	***2006 [%]***	***2007 [%]***
mineral oil	5 179	4 678	35.6	33.8
natural gas	3 286	3 136	22.6	22.7
hard coal	1 923	1 952	13.2	14.1
lignite	1 574	1 618	10.8	11.7
nuclear	1 826	1 533	12.5	11.1
hydro	71	72	0.5	0.5
wind	111	146	0.8	1.1
other renewables	603	691	401	5.0
others	-7	16	0.0	0.1
total	14 565	13 842	100	100
renewables	785	909	5.4	6.6

The table shows that the primary energy consumption decreased from 2006 to 2007 by almost 10%. This is in line with a long term trend, which added up to a total reduction of almost 30% since 1990. The major energy sources are still oil, gas, and coal, but the contribution of renewable sources is permanently and rapidly growing, reaching 5.4% in 2006 and even 6.6% in 2007.

Power market

The total power supply in Germany in 2008 was approx. 616 TWh, which is equivalent to approximately 2217 PJ. The share of electricity from renewable sources was 15.1% or 93 TWh respectively 335 PJ [Working Group on Renewable Energies 2009]. The contribution of the different renewable sources is shown in Figure 17.

Figure 17: Renewable sources in the German power market in 2008

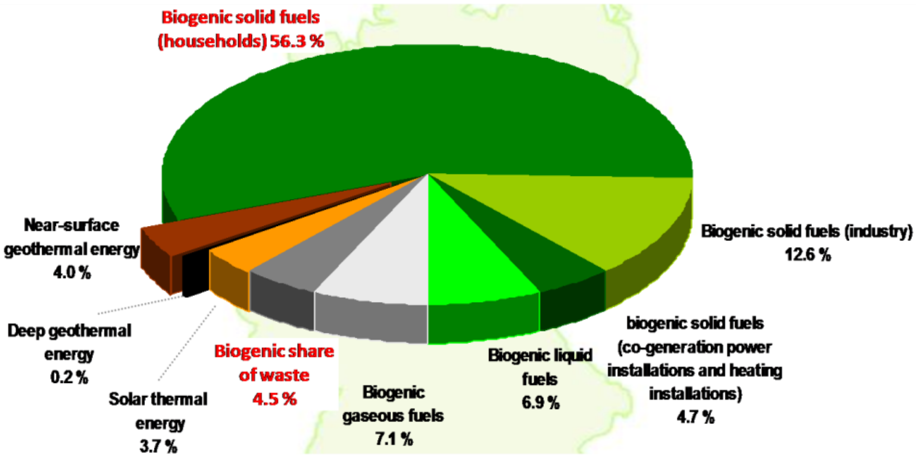


The pie chart shows that the main sources were wind and hydro power. However, the various types of biomass had a share of approx. 29% and this figure has rapidly increased over the past 15 years. The biogenic waste fraction accounted for 4.9 TWh or 17.7 PJ which represents approximately 5.3% of all renewable sources.

Heat market

The total heat demand in Germany in 2008 was approximately 5,170 PJ; renewable sources supplied 7.7% or 400 PJ to this figure [Working Group on Renewable Energies 2009]. The contribution of the single renewable sources is depicted in Figure 18. The main heat source is solid biomass for house heating. Biogenic waste has with 4.9%, a slightly lower share in the power market.

Figure 18: Renewable sources in the German heat market in 2008



Waste generation

Municipal solid waste

In Germany municipal solid waste (MSW) is managed by the public waste management system, which is partly operated by public bodies, partly by private companies owned by private bodies, or in private-public partnership. This is why there are good statistics for this waste category. The situation is different for waste from commerce and light industry. The statistics do only present that fraction which is taken care of by the public waste management system. Reliable data on the share which is disposed of by the private sector – in any case following the legislative regulations of waste treatment – are hard to find.

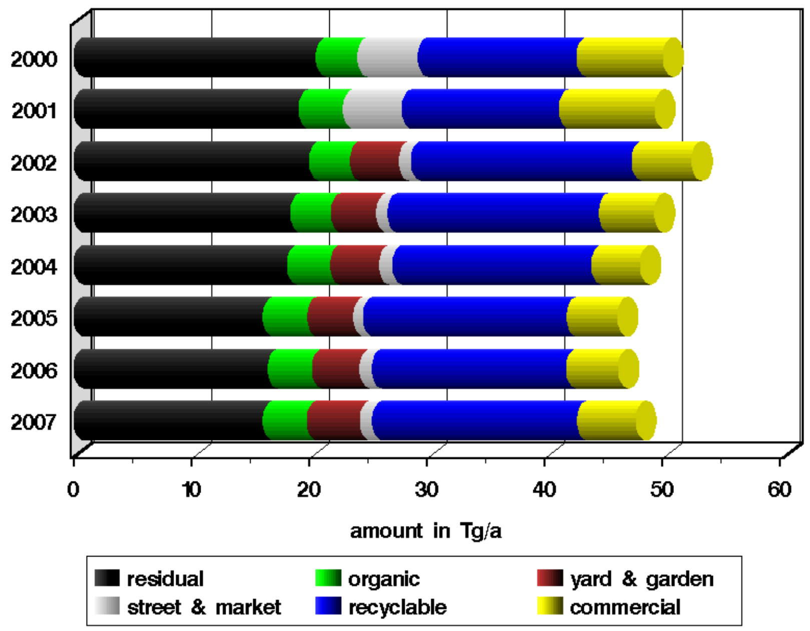
According to data published by the German Federal Office of Statistics (Statistisches Bundesamt) the total annual amount of residential waste was during the years 2000 to 2007 slightly reduced from 50 mill. Mg to 47.7 mill. Mg. The respective figure for commercial waste decreased from 7.3 mill. Mg in 2000 to 5 mill. Mg in 2007. This tendency, however, might not reflect a real decrease but rather a change to cheaper disposal routes in the private sector.

A breakdown into residual mixed MSW and separately collected organic or bio-waste and waste for recycling is compiled in Table 16 and visualised in Figure 19.

Table 16: Total residential waste, separately collected organic, recyclable, and residual household waste, and commercial waste between 2000 and 2007 in mill. Mg [Statistisches Bundesamt 2009]

Year	*Total residential waste*	*Residual & bulky waste*	*Organic waste*	*Yard & garden waste*	*Street & market waste*	*Recyclable waste*	*Commercial waste*
2000	50.015	20.598	3.531	0	5.060	13.491	7.335
2001	49.301	19.142	3.753	0	4.933	13.364	8.109
2002	52.455	20.023	3.465	4.163	943	18.769	5.092
2003	49.265	18.432	3.447	3.845	879	17.944	4.718
2004	48.048	18.147	3.661	4.172	1026	16.899	4.143
2005	46.130	16.079	3.776	3.924	728	17.313	4.310
2006	46.019	16.507	3.757	4.044	967	16.520	4.224
2007	47.704	16.088	3.743	4.509	973	17.410	4.981

Figure 19: Separately collected household waste fractions and commercial waste in Germany between 2000 and 2007 (Tg=mill. Mg)



Solid recovered fuel

There are two reasons to produce fuel from waste or waste fractions, so-called solid recovered fuel (SRF) which is in Germany called EBS (Ersatzbrennstoff, alternative fuel) or SBS (Sekundärbrennstoff, secondary fuel). Originally it was a product of mechanical-biological treatment (MBT) of waste, which became popular in Germany in the 1980s and 1990s as an alternative to waste incineration. An actual driver is the need of industry for cheap fuel, especially in times of exploding oil prices.

SRF is typically a mix of paper, wood, and plastics. Its heating value varies between 11 and >20 MJ/kg. The lower limit is set to comply with the German legislative regulation for energy recovery from waste derived fuels.

The utilisation of this SRF depends on one hand on its market price, on the other hand on its quality. The latter is mainly determined by its inventory of unwanted ingredients like halogens, heavy metals, and alkali metal compounds. The most critical component in that respect is chlorine (Cl). Municipal solid waste has a Cl concentration of 0.5 – 1 wt-%, whereas the respective figure for SRF is typically in the order of 1 or even >2 wt-%. Standards have been developed for the production of SRF, however, the quality assurance is still the major problem with SRF from MBT plants treating residual MSW. A number of such plants have been shut down for this reason since their product found no market. Good quality is more or less solely to be derived from well defined waste fractions, mainly from the commercial and industrial sector.

According to 2006 data from the Federal Statistical Office there were 64 MBT or similar plants for MSW in existence in Germany out of which only 52 were in operation. The theoretical capacity was 6.1 Mt of waste and the amount of produced SRF was approximately 2.4 Mt. There is an additional SRF stream of 4.2 Mt, produced from commercial and light industrial waste. The potential for SRF production from industrial waste is expected to exceed 9 Mt.

Energy from waste

Drivers and barriers

There are different types of drivers for energy from waste in Germany:

- The main legal driver is the above mentioned Ordinance on Landfills and Long-Term Storage (DepV), which resulted in a landfill ban for reactive waste and requires waste to be rendered inert prior to final disposal. For the time being only waste incineration can meet the standards set for access to German landfill sites class 1 or class 2. The second important legal driver is the 17. Federal Emission Control Ordinance, the 17. BImSchV, which calls for recovery of the released energy.
- An economic driver is the demand of cheap energy for industry. Since treatment and disposal of MSW are taken care of by the public waste management system (the costs of which are paid by the citizen) this energy, especially in the case of SRF utilisation, is subsidised and is offered at low cost.
- Finally, policy is, to a certain extent, promoting energy from waste since the biogenic fraction of waste is in the statistics categorised as renewable energy and the calculated saved CO_2 emissions can contribute to the reduction targets endorsed for the Kyoto Protocol.
- There are also some barriers to energy from waste:
- Although the situation is by far more relaxed than during the 1980s and 1990s, waste incineration is still looked upon critically by part of the population. Perhaps surprisingly, in areas where waste incineration does not yet exist, interest groups have support in their fight against the siting of new plants; whereas in areas where there is experience with this technology the opposition is much lower.
- The energy efficiency for power generation in a waste incinerator is low compared to utility boilers and the need for gas cleaning makes the generation of power expensive.
- A factor which is at least not in favour of waste incineration is the non-application of the Renewable Energy Act on waste incineration. Its partly biogenic character is acknowledged for the statistics but the respective subsidies for the energy are not paid.

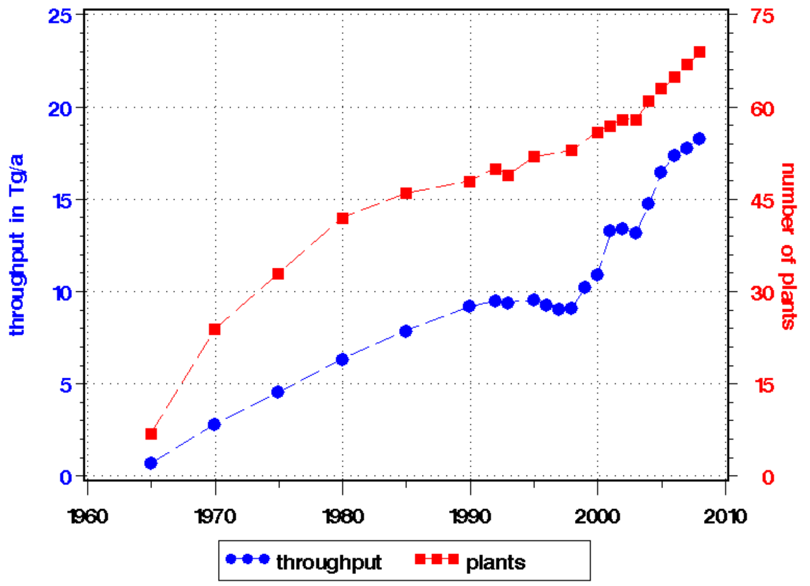
- The potential risk of contaminants in waste based fuels is limiting an extensive utilisation of SRF in high efficiency processes.
- Another limitation of extending the number of dedicated SRF power plants is the lack of a long term stable market for such fuel.

Waste incineration

Germany has extended its waste incineration capacity significantly over the past years. Figure 20 visualises the development of waste incineration in Germany, starting in 1965. The figure documents the steady increase in the number of plants as well as in their throughput. The growing public opposition against this technology caused a kind of moratorium after 1990. Although there was a slight further increase in the number of plants the throughput stayed almost constant.

This changed after the EU Landfill Directive was issued and it became evident that its adoption into German law would indeed bring the targets of the TASi into reality in a short space of time. As can be seen, the throughput of the German waste incineration plants was almost doubled between 1998 and 2008.

Figure 20: development of waste incineration in Germany between 1985 and 2008



In 2008 there were 68 waste incineration plants in operation with a total capacity of approx. 18 Mt. The map in Figure 21 shows the location of all plants for thermal treatment of MSW. The name of the location and theoretical capacity of the single plants can be looked up under the respective green numbers in Table 17 [Umweltbundesamt 2008]. The plants are ordered according to the federal state they are located in. It has to be mentioned that the total number given in Table 17 is not in line with the 69 operating plants published by ITAD, the association of German waste incineration plants [ITAD 2009]. The plants in Landshut, Rostock and Weißenhorn were obviously not in operation.

From 1986 on the municipality of Burgau in Bavaria operates a small pyrolysis plant for MSW with a capacity of 25,000 t. New technologies have been tested in Germany but did not enter the market. For the Siemens Thermal Recycling Process a plant was erected in Fürth but never got a permanent license and the Thermoselect plant in Karlsruhe was shut down due to economic problems after few years of operation.

Figure 21: Location of German waste incineration plants (green numbers) [Umweltbundesamt 2008]

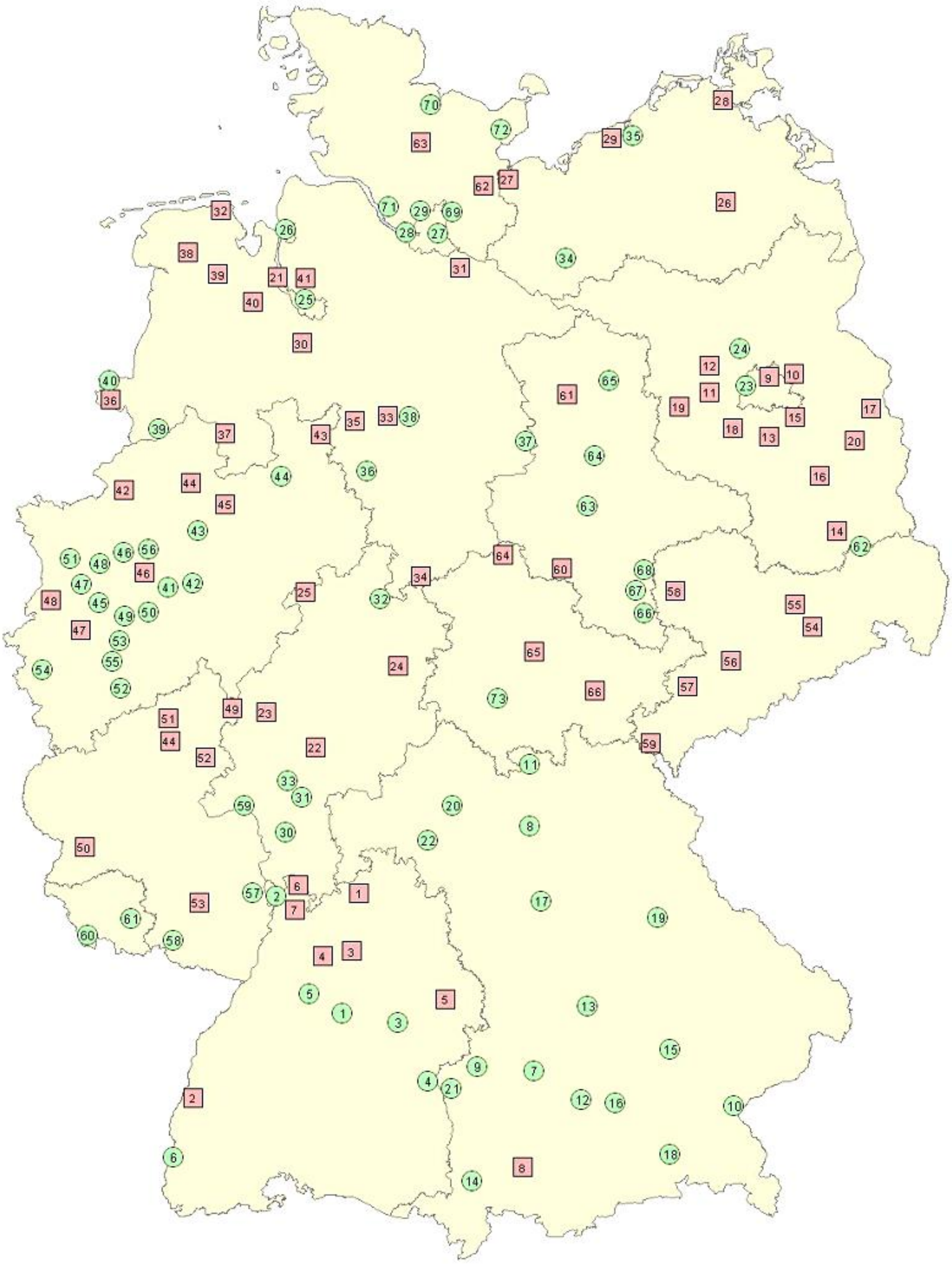


Table 17: Thermal waste treatment plants in Germany: state, location, and capacity

no	state	location	capacity [Mg/a]
1	BW	Stuttgart	420,000
2	BW	Mannheim	380,000
3	BW	Göppingen	140,000
4	BW	Ulm	120,000
5	BW	Böblingen	140,000
6	BW	Eschbach	150,000
7	BY	Augsburg	200,000
8	BY	Bamberg	125,000
9	BY	Burgau (pyrolysis)	25,000
10	BY	Burgkirchen	200,000
11	BY	Coburg	115,000
12	BY	Geiselbullach	85,000
13	BY	Ingolstadt	197,000
14	BY	Kempten	70,000
15	BY	Landshut	45,000
16	BY	München	700,000
17	BY	Nürnberg	200,000
18	BY	Rosenheim	60,000
19	BY	Schwandorf	450,000
20	BY	Schweinfurt	145,000
21	BY	Weißenhorn	89,000
22	BY	Würzburg	170,000
23	BE	Ruhleben	520,000
24	BB	Germendorf	80,000
25	HB	Bremen	468,000
26	HB	Bremerhaven	315,000
27	HH	Borsigstraße	320,000
28	HH	Rugenberger Damm	320,000
29	HH	Stellinger Moor	160,000
30	HE	Darmstadt	212,000
31	HE	Offenbach	225,000
32	HE	Kassel	150,000
33	HE	Frankfurt	525,000
34	MV	Ludwigslust	50,000
35	MV	Rostock	166,000
36	NI	Hameln	300,000
37	NI	Buschhaus	525,000
38	NI	Lahe	230,000
39	NI	Salzbergen	120,000
40	NI	Emlichheim	200,000
41	NW	Hagen	120,000
42	NW	Iserlohn	230,000
43	NW	Hamm	245,000
44	NW	Bielefeld-Herford	330,000
45	NW	Düsseldorf	450,000
46	NW	Essen-Karnap	622,000
47	NW	Krefeld	350,000
48	NW	Oberhausen	510,000
49	NW	Solingen	100,000
50	NW	Wuppertal	385,000
51	NW	Asdonkshof	234,000
52	NW	Bonn	240,000
53	NW	Leverkusen	210,000
54	NW	Weisweiler	360,000
55	NW	Köln	569,000
56	NW	Herten	260,000
57	RP	Ludwigshafen	180,000
58	RP	Pirmasens	189,000
59	RP	Mainz	237,000
60	SL	Velsen	210,000
61	SL	Neunkirchen	150,000
62	SN	Lauta	225,000
63	ST	Staßfurt	300,000
64	ST	Magdeburg	300,000
65	ST	Stendal	300,000
66	ST	Zorbau	300,000
67	ST	Leuna	195,000
68	ST	Lochau	80,000
69	SH	Stapelfeld	350,000
70	SH	Kiel	140,000
71	SH	Tornesch-Ahrenlohe	80,000
72	SH	Neustadt	56,000
73	TH	Zella-Mehlis	160,000
Total capacity			**17,779,000**

All waste incineration plants recover energy and utilise it by exporting power, process steam, heat or a combination of these energy forms. The energy efficiency of the single plants varies to a great extent. Some plants built during the 1980s and 1990s were located outside residential and industrial areas for public acceptance reasons and only convert their recovered energy to power. Although the Air Pollution Control (APC) systems of all plants were regularly upgraded, this was not the case for the energy recovery system. On the other hand, even some older plants are characterised by optimum energy use. The Schwandorf waste incinerator, for example, delivers high temperature steam to an aluminium smelter, serves a small district heating grid, and operates a turbine. Other plants like those in Mannheim have their steam cycle coupled with a close-by power plant and are equipped with an external oil fired super heater. The Mainz plant has its boiler coupled with a combined cycle natural gas turbine and achieves in this coupled state an energy efficiency exceeding 40 %.

The efficient utilisation of energy only recently became a major objective in thermal waste treatment. Hence the calculation of a mean efficiency for heat or power of all German incineration plants is misleading. It can be estimated that new plants have primary or boiler efficiencies in the order of 80 – 85%. Conventional plants, which are mainly operated for power export, achieve an efficiency of 23 – 24% with an internal consumption which reduces this number by few per cent. For CHP plants the respective efficiencies depend on the operation mode and the respective demand.

Instead of calculating mean efficiencies it is more convincing to use the actual global data on generated heat and power and the respective exported quantities.

According to the German Federal Statistical Office [Statistisches Bundesamt 2008] the amount of residual household waste in 2006 was approximately. 16.7 Tg. CEWEP published in its Annual Report on Germany 2006 a total throughput in German waste incineration plants of

$$M_{waste} = 16.5\ Tg$$

Estimating a mean lower heating value of

$$H_u \approx 10\ MJ/kg$$

which is close to the value published by Umweltbundesamt during the last years [Johnke 2007] the total energy input into the incineration plants was approximately

$$E_{in} \approx 165\ PJ$$

For the recovered energy CEWEP published estimates of approx. 16.37 TWh including a self-demand of 3.3 TWh or

$$H_{out,\ total} \approx 59\ PJ$$
$$H_{out,\ self} \approx 12\ PJ$$
$$H_{out,\ net} \approx 47\ PJ.$$

This indicates a recovery of energy in terms of heat which is equivalent to

$$R_{heat} \approx 35.8\ \%$$

of the energy fed into all incinerators. The exported heat represents

$$U_{heat} \approx 28.5\ \%$$

of the initial energy inventory of the waste.

The same publication indicates a power generation of approximately 6.8 TWh and an internal demand of 2.13 TWh. These data are equivalent to

$$P_{out,\ total} \approx 24.5\ PJ$$
$$P_{out,\ self} \approx 7.7\ PJ$$
$$P_{out,\ net} \approx 16.8\ PJ.$$

The recovery of energy in terms of power can be calculated to

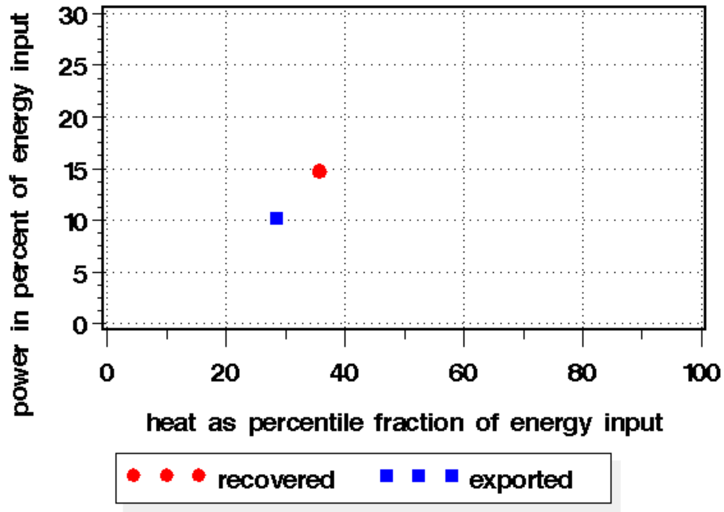
$$R_{power} \approx 14.84\ \%$$

and the respective export to

$$U_{power} \approx 10.2\ \%.$$

The graph shown in Figure 22 visualises the 2006 average power and heat numbers reported above, on one hand as generated energy, on the other hand as exported energy, given as a fraction of the overall energy input into all German incineration plants.

Figure 22: Average figures of recovered respectively exported power and heat of all German waste incineration plants in 2006



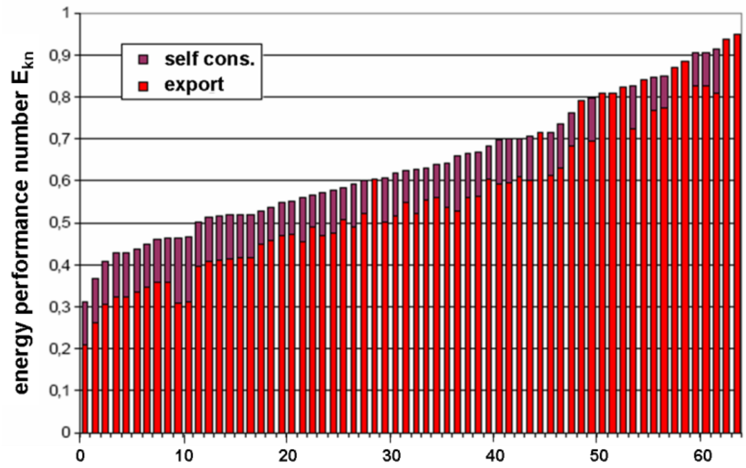
The revised EU Waste Framework Directive contains a formula to calculate a so-called 'energy efficiency' which will here be referred to as energy performance figure E_{kn} since it is not efficiency in a physical sense [Beckmann et al. 2007]. Using this formula which multiplies the power generation by a factor of 2.6 and the exported heat by a factor of 1.1 and divides the sum of both by the energy fed into the system results in

$$E_{kn} \approx 0.7$$

which means that the accumulated energy recovery of all German waste incineration plants complies well with the energy performance figure thresholds set in the revised Waste Framework Directive for the acceptance of an energy recovery status of 0.6 for old and 0.65 for new waste incineration plants.

In a report for the Umweltbundesamt this formula has been applied to 64 German waste incineration plants [Fehrenbach et al. 2007]. The bar plot shown in Figure 23 indicates the wide spread of the energy performance figure for individual plants between 0.31 and 0.95. 28 out of the 64 plants exceed 0.65, the threshold for new plants and 36 the limit of 0.6 for old plants.

Figure 23: Energy performance figure of 64 German waste incineration plants calculated using the R1 formula of the new EU Waste Framework Directive [Fehrenbach 2007]



Energy from SRF

SRF is in most cases used together with other fuels. Main users of SRF for co-combustion are power plants, cement and lime kilns, paper and steel industry. An overview of the co-combustion practice in 2006 is compiled in Table 18.

Table 18: Co-combustion in various industry furnaces in 2006

	SRT throughput in mill. Mg
Power plants	0.5
Cement kilns	2.0
Paper industry	1.4
Steel industry	0.1
Lime kilns	0.2
Total	4.2

The future of co-combustion is not clear due to the difficulties in quality control and the (for that reason) unstable market of SRF. An example illustrating this situation is the co-combustion in power plants. The high chlorine (Cl) content limits the utilisation of SRF due to the risk of Cl induced boiler corrosion. In 2006 co-combustion was practised in 8 hard coal and also in 8 lignite fired power plants. In 2007 only 6 hard coal and 2 lignite boilers continued co-combustion [Thiel 2007].

Cement kilns, too, cannot cope with high halogen levels in their fuel. They have a typical acceptance standard of <1 wt-% Cl which may also limit the utilisation of SRF in this industry sector. The total capacity for co-combustion in the cement industry in Germany is assumed to be in the order of 2 Mt, which means this potential sink for SRF is already more or less exhausted (Schu 2007).

Table 19: Dedicated SRF plants in Germany (CFB: circulating fluidised bed)

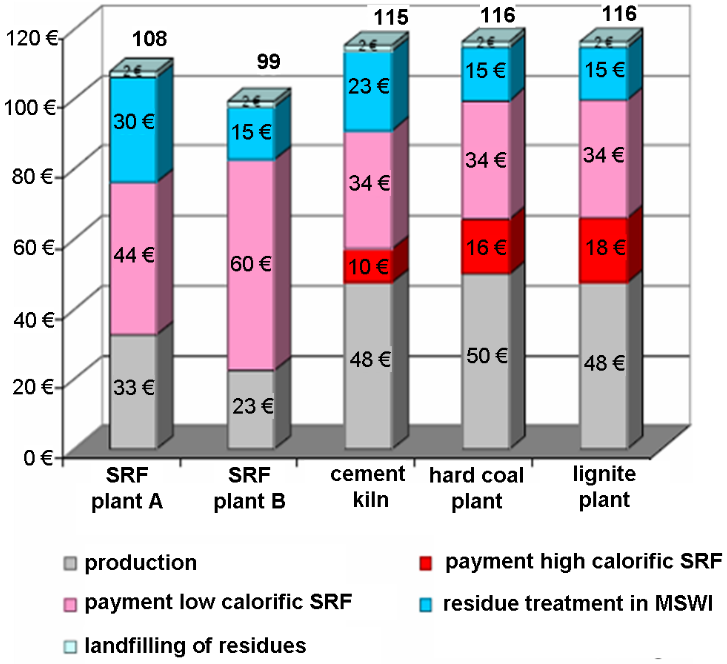
Location	Technology	Capacity in Mg/a	
		in operation	planned
Amsdorf	grate	60,000	
Andernach/Rasselstein			100,000
Aßlar	grate	15,000	
Bremen-Blumenthal	grate	60,000	
Degussa			
Erfurt-Ost	grate		64,000
Frankfurt			500,000
Großräschen/Freienhufen	grate		200,000
Hagenow			80,000
Heringen	grate		270,000
Hürth	grate		240,000
Meuselwitz-Licka	grate	50,000	
Minden Industriehafen	grate	35,000	
Neumünster	CFB	150,000	
Premnitz (former Polyamid 2000 AG)	CFB	100,000	
Premnitz	grate / CFB		130,000
Rheinberg	grate		300,000
Rostock	grate		136,000
Rüdersdorf	grate		200,000
Rudolstadt-Schwarza	grate		14,000
Schwedt	CFB		200,000
Sottrum			150,000
Stavenhagen	grate		90,000
Witzenhausen			250,000
Sum		**470,000**	**2,924,000**

As an alternative there are a number of dedicated combustion plants for heat and/or power in operation and a much higher number of such plants is in planning. An overview of the situation in 2006 is shown in Table 19. These plants are either using grate or circulating fluidised bed technology and are equipped with a flue-gas cleaning system which allows the compliance with the 17. BImSchV, the German regulation for air emissions from waste incineration plants.

The table shows that approximately 2.9 Mt of capacity were in the design or construction phase, but only 7 plants, with a total throughput of 0.47 MT, were in operation in 2006. How many of these projects will be realised is hard to predict at present. It can be assumed that some projects are rather theoretical ones and are only published by companies to give them a better standing in the negotiations with the respective power supplier. For example, a large project was announced by a copper refinery in Hamburg to take (initially) 750,000 t/y of SRF, but was cancelled after the copper refinery was given a good contract for power from the local energy supplier.

The main actual barrier for a full exploitation of waste for SRF production is the cost situation. Full SRF costs have to include a significant extra payment to the customer depending on the type of thermal process. A survey published by Prognos lists total costs for production, extra payments for utilisation and additional costs for residue treatment or disposal for the year 2006 [Alwast 2007]. The study compared the utilisation of SRF especially produced for utilisation in different plants. The results of the study are shown in Figure 24.

Figure 24: Costs of production and utilisation of 1 Mg of SRF in 2006 (adapted from [Alwast 2007])



According to these figures the total cost of SRF utilisation covers a range between 100 and 120 €/Mg, depending on the utilisation scenario.

Conclusions and outlook

Evaluating the actual situation in the waste-to-energy area in Germany, it can be concluded that the legal framework is in principle in line with the regulations on the EU level. In terms of landfilling Germany took stronger action than laid down in the EU Landfill Directive. This measure was a strong driver for waste incineration and at the moment the amount of residual MSW can be easily taken care of in existing waste incineration plants. Approximately 50% of these plants already comply with the energy performance threshold set in the revised EU Waste Framework Directive.

Further efforts for waste minimisation and improved recovery of special waste fractions will reduce the MSW that has to be incinerated in future. Extension of anaerobic digestion for separately collected organic household waste could play a major role here. This may not necessarily mean a surplus in waste incineration capacity since old plants can be taken out of operation.

Furthermore this free capacity may be used for commercial and light industrial waste treatment. In this sector there is a lack of reliable data describing the current situation and even less for future expectations.

The actual oversupply of SRF is assumed to range between 1 and 2 Mt and if co-combustion capacity is not increased and/or extension of dedicated plants does not progress, there may be increasing problems with the disposal of SRF over the next few years.

SRF will have a brighter future if the quality control of production can be improved. An extension of the number of dedicated SRF plants, preferentially for CHP, needs both successful planning applications and a long-term calculable and stable market.

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Italy

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The waste resource in Italy

Current national policy and regulations on waste in Italy

In 2006 the Italian Parliament replaced the previous regulation on waste – **based on the D.lgs. 22/1997**[2] which took in the Directives 91/156/CE_[3], 91/689/CE [4] and 94/62/CE_[5] – by adopting the **D.Lgs. n.152/2006** [6], which was integrated in **D.Lgs. n. 4/ 2008** [7] two years later. The general regulations were based on criteria of caution, prevention, responsibility and co-operation between all subjects at national and local level (i.e.: private and public producers; private and public administrations involved in waste management and treatment) and with the aim of ensuring that waste management (recovery, recycling, discharge) can offer an adequate protection of people and environment and meet with criteria of effectiveness, efficiency, transparency other than economical. With regard to these aims, priority criteria are considered to be:

- development of clean technologies;
- use of commercial products with no or minimum impact on waste production;
- improvement of technologies able to eliminate/reduce pollutants in waste;
- prevention of waste production;
- stimulation, on a national and local level, of a more active role of public administrations for waste control, recycling and recovering of both material and thermal and electrical energy.

The current national legislation on waste seems to be heading in the direction now proposed by the revised EU Waste Framework Directive.

Regarding separately collected Municipal Solid Waste (MSW), the **D.Lgs. n.152/2006** [6] fixed targets (percentage of the total waste produced) to be reached in Italy by the end of December 2006 (almost 35%), December 2008 (almost 45%) and December 2012 (65%). A national regulation on the general structure and activity of local systems for a separate collection of MSW was then introduced in Italy in 2008 through the specific **DM 8 April 2008** [8] of the Italian Ministry of the Environment. Due to a lack of legislation for some aspects (mainly methodological aspects related to the quantitative assessment of system performance), the separate collection of MSW is currently regulated in Italy by local regulations set out on a regional basis. Industrial wastes generated by healthcare activities are currently classified and regulated through a specific legislative rule, the **DPR n. 254/2003** [9] not amended by the_**D.Lgs. n.152/2006_** [6]. The European Directives 2006/66/CE[10]and 2006/21/CE [11] have been incorporated in the Italian regulation in 2008 by the **Dlgs. n.188/2008** [12] and the **D.Lgs. n. 117/2008** [13] respectively. While the European Directives 2000/76/CE[14] (on waste incineration) and 1999/31/CE [15] (on waste landfilling) have been adopted as national rules through the **D.Lgs. n. 133/2005** [16] and the_**D.Lgs. n.36/2003** [17], respectively. The above mentioned **D.Lgs. n.152/2006** [6] also define regulations on waste planning, monitoring and reporting actions, which local and national authorities have to adhere to. Any company (private or not) involved in the activities of collection, transport, recovery, discharge of waste as hazardous waste producers, or public administration involved in the municipal waste management, are requested to qualify (CER code) and quantify, annually, the waste produced/managed according to the MUD (*Modello Unico di Dichiarazione ambientale*) reporting system as introduced by the **D.Lgs. n. 70/1994** [18]. On this matter, the **D.Lgs. n. 4/ 2008** [7] amended the **D.Lgs. n.152/2006,** [6] which allow all producers of non-hazardous industrial waste to qualify and quantify annually their waste through the MUD reporting system. A national *Waste Report* is published annually by the

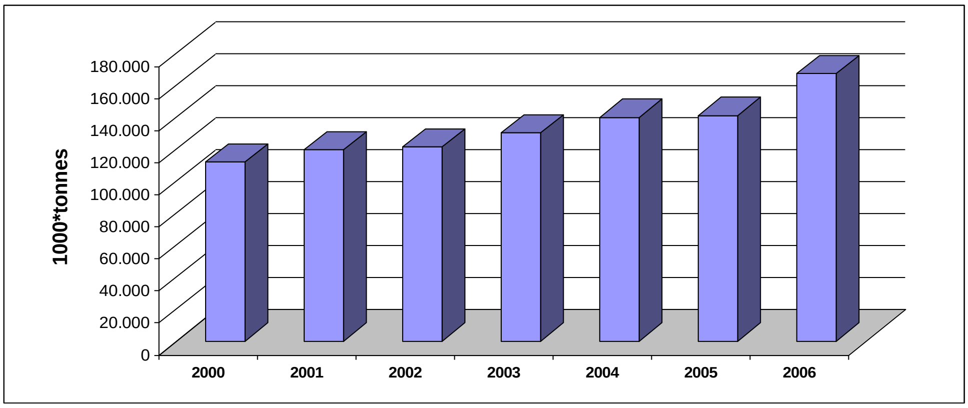
Italian Agency for the protection of the Environment (APAT, now named ISPRA), which offers an overview of the whole waste production and management in Italy; details of local waste production and management is also given by the reporting activity of regional authorities.

The latter reported figures of waste production and management in Italy were based only on the certified data published by ISPRA, mainly from the **2008 *Waste Report*** [19] which makes available up-to-date data 2007 and 2006 for municipal and industrial waste respectively. To derive some of the waste trends these data were integrated with data coming from the previous *Waste Reports* [20,21,22] .

Waste production and management in Italy

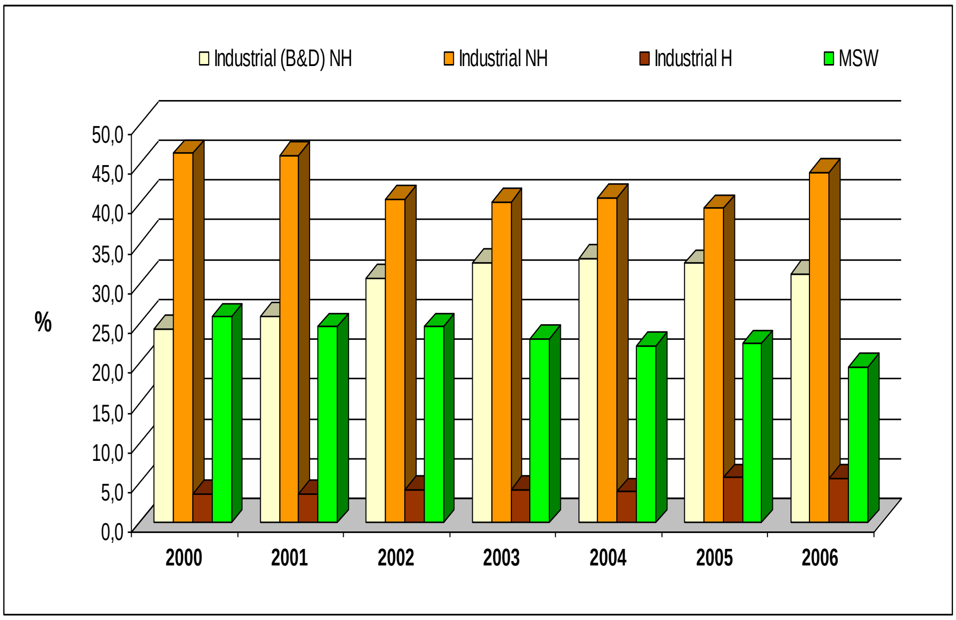
In the year 2006 a total production of waste of about 167 Mt was reached in Italy, corresponding to an increment of about 49% with respect to the year 2000 (Figure 25). Data were used to 2006 only, due to a current unavailability of data on industrial waste production for the year 2007.

Figure 25: Waste production in Italy (trend 2000-2006): total annual amount (1,000*tonnes) produced on a national basis (data source: ISPRA)



An increasing contribution of the industrial non-hazardous waste from Building & Demolition activities and the whole hazardous waste to total waste production is shown in Figure 26. The production of municipal solid waste seems to follow a decreasing trend from 2000 to 2006.

Figure 26: Waste production in Italy (trend 2000-2006): percentage contribution (%) of MSW waste, industrial hazardous (H) and non-hazardous (NH) waste, non-hazardous (NH) from building & demolition activities to the total production of waste on a national basis (data source: ISPRA)

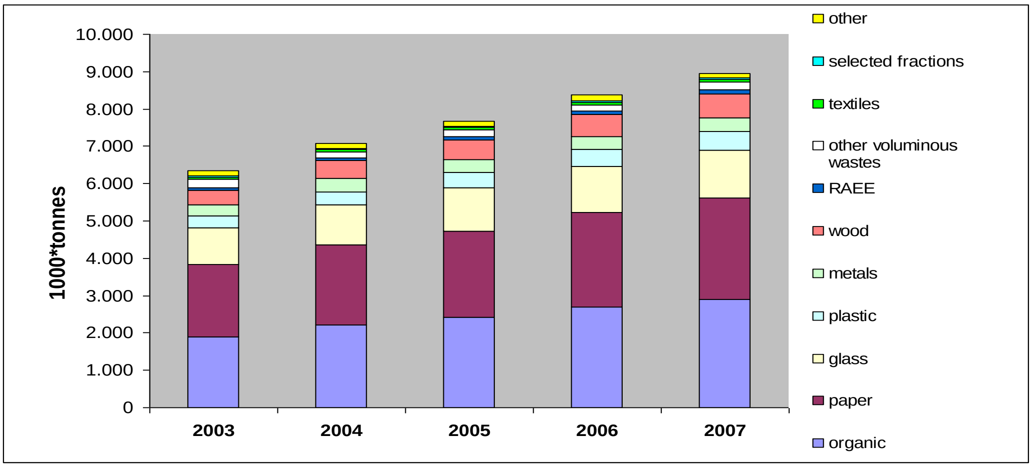


The total production of ***Municipal Solid Waste (MSW)*** in Italy increased during the period 1999-2007 from about 23.8 Mt in 1999 to about 32.5 Mt in 2007, with the main contribution of Northern regions (more industrialised area), even if an increase in production in Southern regions from 2001 can be observed. The highest values of per inhabitant production occurred in Central Italy (reaching 650 kg/cap/y in 2007) with respect to a national average value of 546 kg/cap/y.

The ***separately collected MSW*** accounted for a total of about 8.9 Mt in 2007 (3.6 Mt in 2003), about 27.5 % of the total MSW produced. This value was lower than that expected by the national regulation (35%). By analysing data per macro area, a differential and quite consistent degree of implementation in Italy of separately collected MSW can be observed: only in Northern Italy has the Government target been achieved (since 2004). Central and Southern Italy are still under target: of the total 8.9 Mt of separately collected MSW in 2007, only 1.2 and 1.5 Mt came from Southern and Central Italy, respectively, the main contribution (6.2 Mt) came from the northern regions.

From a qualitative point of view (Figure 27), the share of biodegradable fraction (organic+ paper+wood+textiles) of the total separately collected MSW in 2007 was about 71%, followed by glass (14.5%), plastic (5.6%), metals (4%), voluminous wastes (2.2%), RAEE (1.3%) and other fractions (1.7%).

Figure 27: Separately collected MSW in Italy (trend 2003-2007): total amount (1000*tonnes) of waste collected per merceological fraction (data source: ISPRA)



The amount of ***industrial (hazardous, non-hazardous) waste*** increased by about 63% from 2000 to 2006 (Figure 28), reaching a total amount of 134.7 Mts in 2006, of which 43.4 is non-hazardous wastes, 52.1 is non-hazardous wastes from building and demolition activities and 9.2 is hazardous wastes. Hazardous wastes were mainly produced in Northern (about 5.1 Million tonnes) and Central (about 3.3 Mt) Italy. With regard to 2006 data, note that the legislative regulations introduced in Italy by the **D.Lgs. n.152/2006** [6] allowed all producers of non-hazardous industrial waste to qualify and quantify annually their waste production through the MUD reporting system (a rule now amended by the **D.Lgs. n. 4/ 2008_**[7]). This temporary change in regulation may have affected the real 2006 figure of industrial waste production. The percentage contribution of different economical sectors on the hazardous and non-hazardous waste production (year 2006) is shown in Figure 29.

Figure 28: Trend 2000-2006 of industrial waste production in Italy (1,000*tonnes) (Data source: ISPRA)

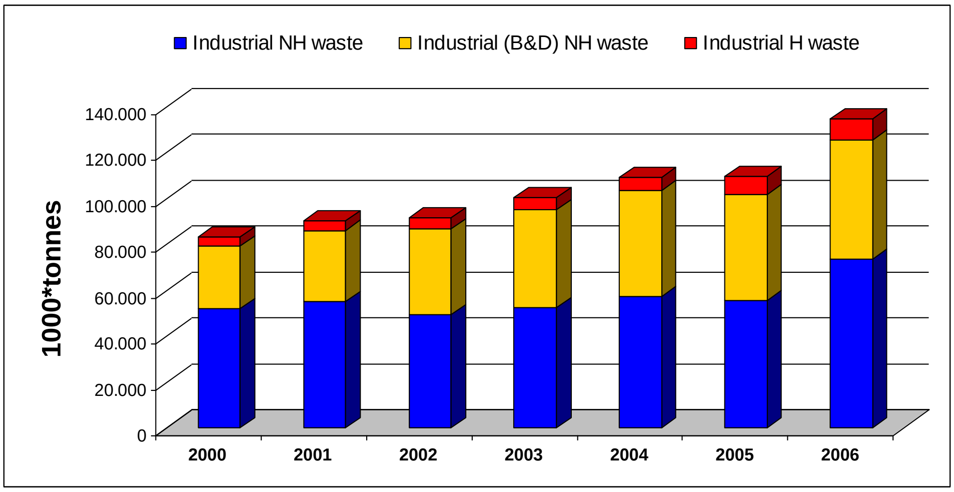
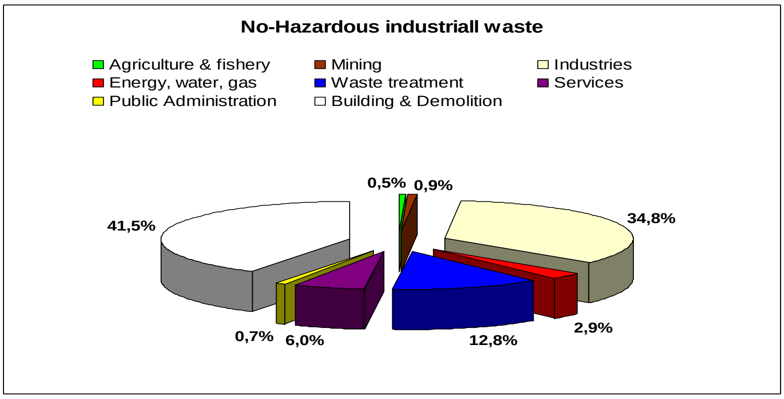
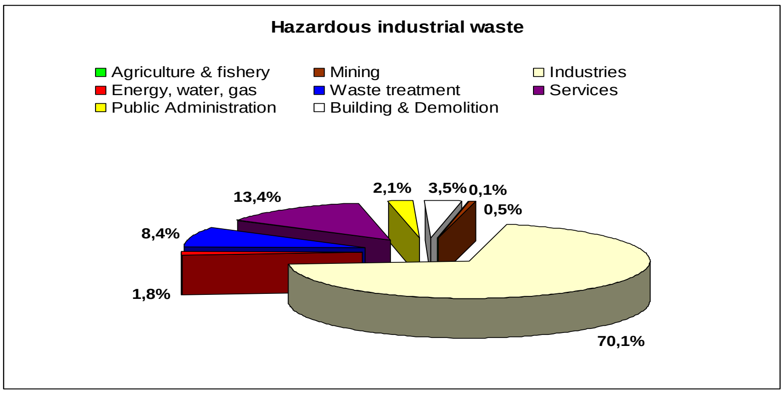


Figure 29: Percentage contribution of Italian economic sectors to the non-hazardous and hazardous industrial waste production (year 2006) (data source: ISPRA)



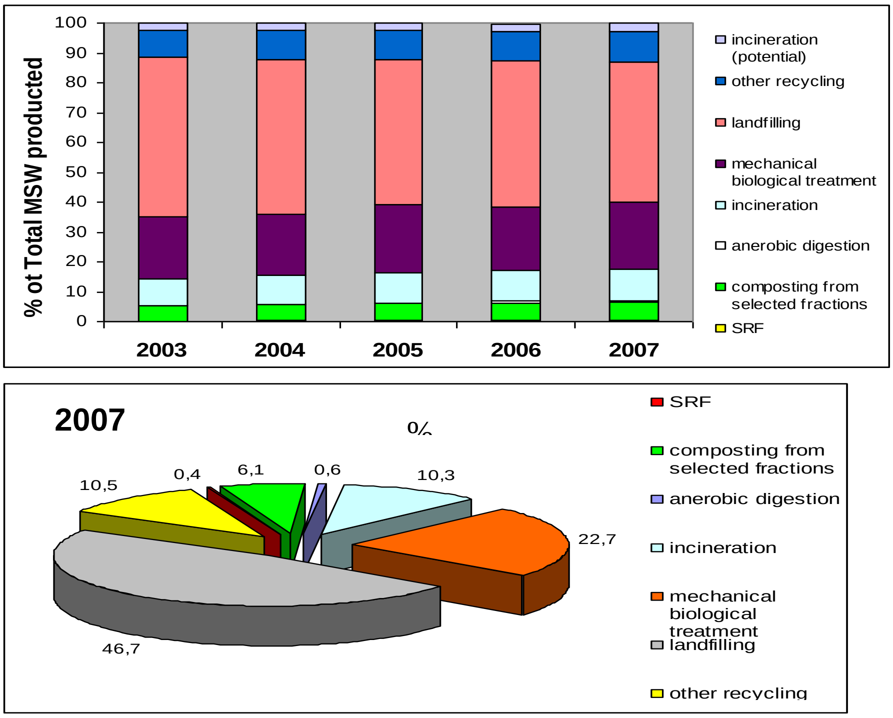


As shown in Figure 30, landfilling of waste and mechanical-biological treatments are the main ways for the management of MSW, their share of total MSW produced ranging from 74.6% (2003) to 69.4% (2007).

About 10% MSW annually produced goes to incineration (excluding the potential incineration of 2.4-2.6% of waste stored annually, most of which comes from the well-publicised issues with the waste collection the Naples area). Composting increased from 5.1% in 2003 to 6.1% in 2006) whereas 9 -10% of total MSW is submitted to recovery/recycling.

The amount of SRF (Solid Recovered Fuel) produced from MSW is low, ranging from 0.1% (2003) to 0.4% (2007).

Figure 30: MSW management in Italy: percentage contribution of different modalities of management. Trend 2003-2007 and situation in the year 2007 (data source: ISPRA)



A total amount of about 8.8 Mt of MSW (2007 data) was managed in the 133 *mechanical & biological treatment plants* (117 working in 2007) operating in Italy (9.6 Mt including waste of other origin).

The 276 *composting*, plants, (237 working in 2007) treated about 3.2 Mt of which MSW comprised 74.5% of the total input, followed by sewage sludge (15.7%) and material of different origin (9.9%). The total plant output production was 1.3 Mt/year, of which 15.3% was classed as green compost and 60.8% as mixed compost.

SFR production from waste in 2007 (41 working plants with a total authorized capacity of 6.5 Million tonnes/year) was 4.3 Mt.

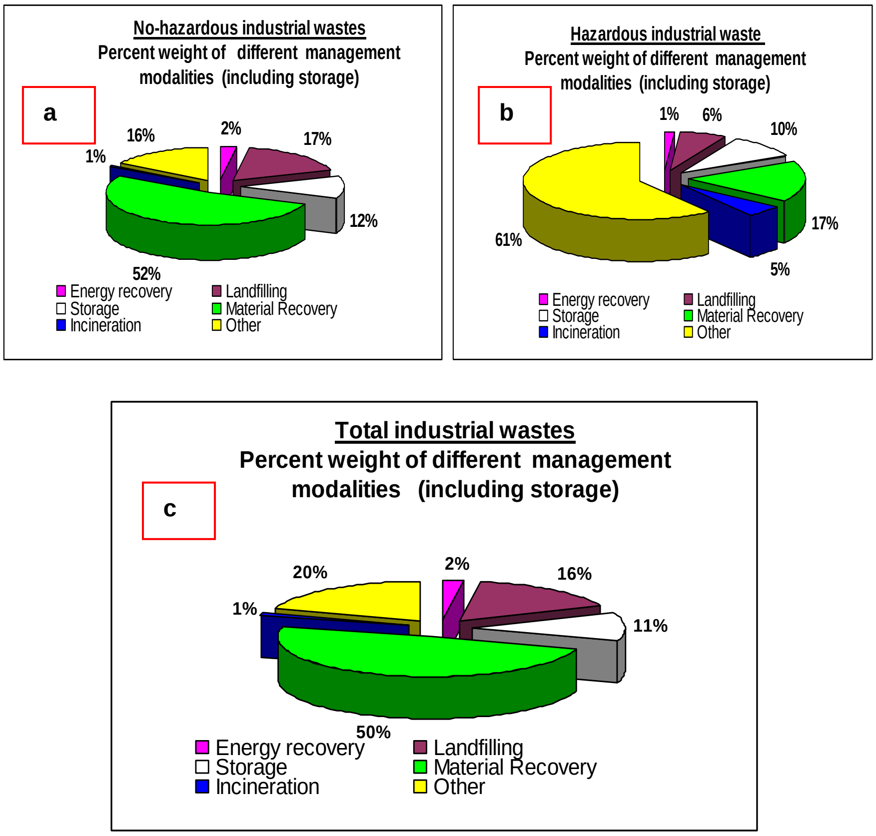
Incineration 2007 - 47 plants, with a total capacity of 4.48 Mt of waste (MSW: 2.98 Mt; dry fraction of CER 191212: 0.32 Mt; SRF: 0.66 Mt; industrial waste: 0.53 Mt, of which 0.07 Mt hazardous waste).

Landfill of waste 2007 - 269 plants, for about the 51.9% (16.9 Mt) of the total yearly production of MSW. Furthermore 0.41 Mt of sewage sludge and 1.8 Mt of industrial waste, for a total of 20.1 Mts were disposed in the same facilities.

The total amount of **industrial waste** produced in 2006 was 134 Mt. 117 Mt (91.6% non-hazardous and 8,4 % hazardous waste) were managed in the Northern regions of Italy (69.4 Mt, against 22.5 and 25.1 Mt treated in Central and Southern Italy, respectively).

Figures 31 a and b show that the material recovery was the main activity in the management of industrial waste (about half of the 117 Mt of industrial waste treated in 2006 (Figure 31 c).

Figure 31: Industrial waste management in Italy (year 2006): percentage incidence of different treatment modalities on the individual management of non-hazardous and hazardous industrial waste and on the whole management of industrial waste (data source: ISPRA)



Landfilling, storage (including temporary storage) and other treatments such as physical-chemical and biological treatment, were the main mode for the treatment of the residual fraction of industrial wastes (Figure 31 c), more significant than incineration and energy recovery. Industrial waste incinerated in dedicated or MSW plants or burned in co-combustion industrial plants amounted to some 3% of the total treated in 2006 (3.9 Mt). In detail, a total amount of 0.5 Mt of industrial wastes were treated in the 66 dedicated plants in operation in 2006, 0.6 Mt in plants also treating MSW, and about 2.8 Mt were co-combusted, the latter being composed of over the 95% of non-hazardous waste. Co-combustion was mainly used for electricity generation (32%), wood & paper industry (27%), treatment plants (14%), cement kilns (7%) and pottery industry (6%). A total number of 650 plants were in operation in 2006 of which 109 supported under the Green Certificate System, the ‘support scheme’ activated in Italy for the promotion of renewable energy.

Based on data published by ISPRA in the *2008 Waste Report*, a preliminary and rough assessment (complete information is not available for all plants) of a total energy recovery of abut 0,42 MkWe (2.696 MkWh) can be estimated for waste treated in co-incineration/co-combustion in the industrial plants in operation in 2006.

Renewable energy in Italy

Renewable energy production

The following figures showing renewable energy production in Italy were based on certified data produced by GSE, the Public Manager for the Electricity Services, as presented in a statistical report published in 2009 [28] and in the last periodical reporting on the Green Certificate System in Italy [29]. Furthermore we referred to data published on the web site of the National Authority for Electric Energy and Gas [30].

Gross electricity production (GWh/year) during the period 1997-2007 is reported in Figure 32. The share of renewable gross energy is under 20% of the total (Figure 33). Renewable gross energy production was about 46,450 GWh in 1997, increased to about 55,000 GWh in 2001 and 2004, while the last available data (2007) was characterized by a lower result (49,411 GWh), corresponding to a 15.7% of the total gross energy production in the same year (about 314,000 GWh).

Figure 32: Total thermal, renewable (all sources) and hydro (pumping only) gross energy production (GWh) in Italy. Trends 1997-2007 (data source:GSE)

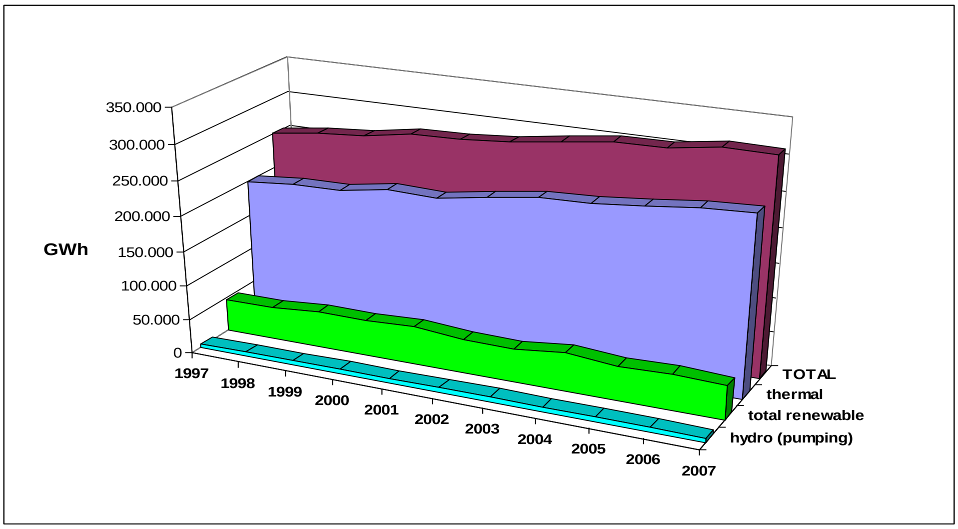
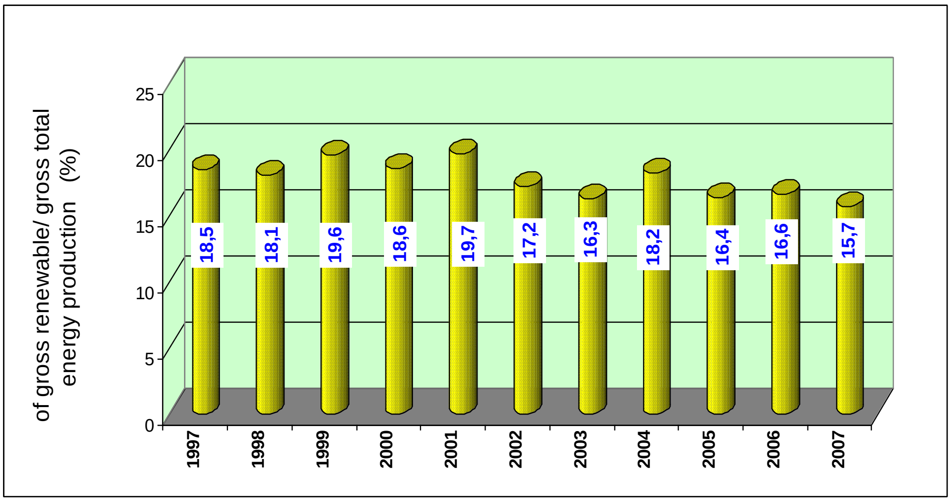


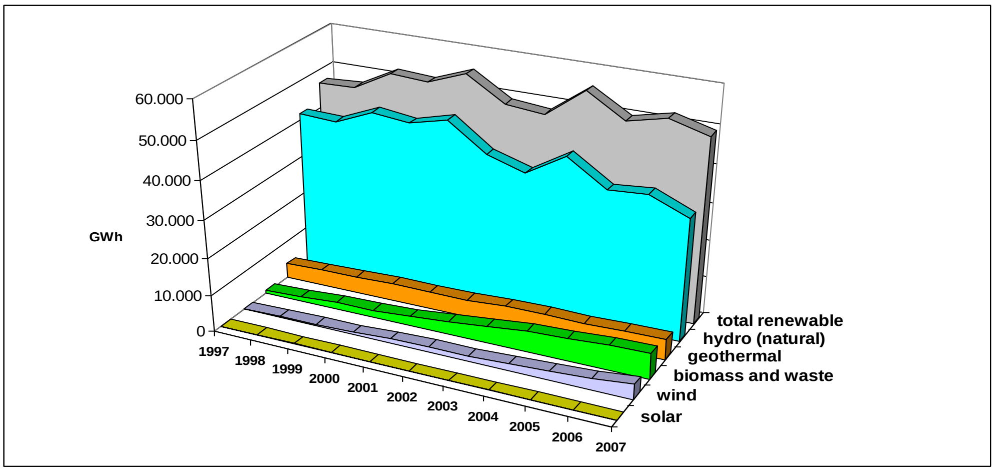
Figure 33: Percentage share of gross renewable production on gross total energy production in Italy. Trend 1997-2007 (data source: GSE)



Considering the Italian renewable gross production in the period (997-2007 (Figure 34), the following remarks can be drawn:

- The dominant role of the natural hydro sector, accounting for from 89% (1997) to 66% of the total renewable production.
- A steady contribution of the geothermal source, which shows an increase from about 3,900 GWh (1997) to about 5,570 GWh (2007).
- A low incidence of solar renewable energy: the related gross production increased from 13.7 GWh (1997) to 39.0 GWh (2007).
- A significant level, increasing with time, of the electricity generated by wind and biomass & waste sources. The wind gross energy accounted for about 118 GWh in 1997 and reached about 4,034 GWh in 2007. The gross energy production obtained from the whole biomass and waste source increased from about 820 GWh (1997) to about 6,950 GWh (2007).

Figure 34: Total and per source (all gross) renewable energy production (GWh) in Italy. Trend 1997-2007 (data source: GSE)



Details about of the gross production per renewable source (2003-2007), are reported in Figure 35.

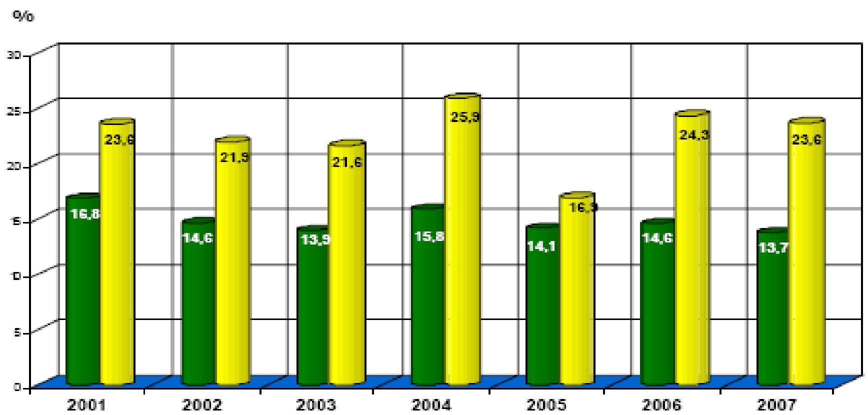
Figure 35: Total and per source gross renewable energy production (GWh) in Italy: detailed trend 2003-2007 (data source GSE)

Gross production of energy from renewable plants in Italy Trend 2003- 2007 (GWh)					
	2003	2004	2005	2006	2007
Hydro (total)	36.670	42.338	36.067	36.994	32.815
0-1 MW plants	*1.455*	*1.731*	*1.526*	*1.521*	*1.416*
1-10 MW plants	*5.732*	*7.218*	*6.091*	*6.354*	*5.684*
>10 MW plants	*29.483*	*33.479*	*28.451*	*29.119*	*25.715*
Wind (total)	1.458	1.847	2.343	2.971	4.034
Solar (total)	23	27	31	35	39
Gethermal (total)	5.341	5.437	5.325	5.527	5.569
Biomass & Waste (total)	**4.493**	**5.637**	**6.155**	**6.745**	**6.954**
Total Solid	**3.460**	**4.467**	**4.957**	**5.408**	**5.506**
MSW	*1.812*	*2.277*	*2.620*	*2.917*	*3.025*
crops & other agro-industrial wastes	*1.648*	*2.190*	*2.337*	*2.492*	*2.482*
Total Biogas	**1.033**	**1.170**	**1.198**	**1.336**	**1.447**
waste landfilling	*911*	*1.038*	*1.052*	*1.177*	*1.247*
sewage sludge	*3*	*1*	*3*	*3*	*9*
animal manure	*13*	*19*	*26*	*45*	*53*
crops & other agro-industrial wastes	*107*	*112*	*117*	*112*	*138*
Renewable (total)	**47984**	**55286**	**49920**	**52272**	**49411**

With regard to the profile of gross renewable energy production for the last reference year (2007) data reported in Figure 35 indicate that about 14% is from the biomass and waste renewable sources with contributions of about 43.5% coming from MSW incineration. About 35.7% can be ascribed to solid biomass from agriculture and other agro-industrial activities, while biogas from waste landfill contributes for about 17.9%.

Figure 36 shows data referred to the internal gross consumption of electricity. The reported data refer to the internal gross production of renewable energy only (green bar) or the whole gross production including renewable imported from abroad.

Figure 36: Trend 2001-2007 of the renewable gross energy production with respect (%) to the internal gross consumption of electric energy (figure extracted and modified from ref. 28)



Green bar:
internal gross renewable production / internal gross energy consumption
Yellow bar:
internal gross renewable production + foreign gross renewable production / internal gross energy consumption

Current national policy on renewable energy, supporting systems and perspectives

The strategies and criteria to reduce greenhouse gas emissions and comply with the Kyoto Protocol mentioned above - control of energy consumption, promotion and support for the use of energy from renewable sources, promotion of energy savings and energy efficiency - were substantially adopted in Italy by the so-called **CIP-6 Resolution** [31] adopted in 1992 by the Italian Inter ministerial Committee on Prices (CIP). Within this, a conventional mechanism aimed to promote and support electricity and co-generation plants fed with renewable sources (solar, wind, hydro, geothermal, waves & tides, biomass) was introduced. Under this mechanism (still in force) GSE - the publicly-owned company promoting and supporting renewable energy sources (RES) in Italy - purchases the electricity generated by these plants at an assured rate and trades it into the energy market. For plants qualified under the CIP 6 mechanism, the trend (from 2008 to all the residual years of validity of the CIP 6 support) regarding the total and per source number of plant/year are reported in Figure 37; and the expected per year production of renewable energy (total and per source) are reported in Figure 38.

Figure 37: Total and per source number of plant/year supported under the CIP 6 mechanism. Trend from 2008 to all the residual years of validity of the CIP 6 support (data source: GSE)

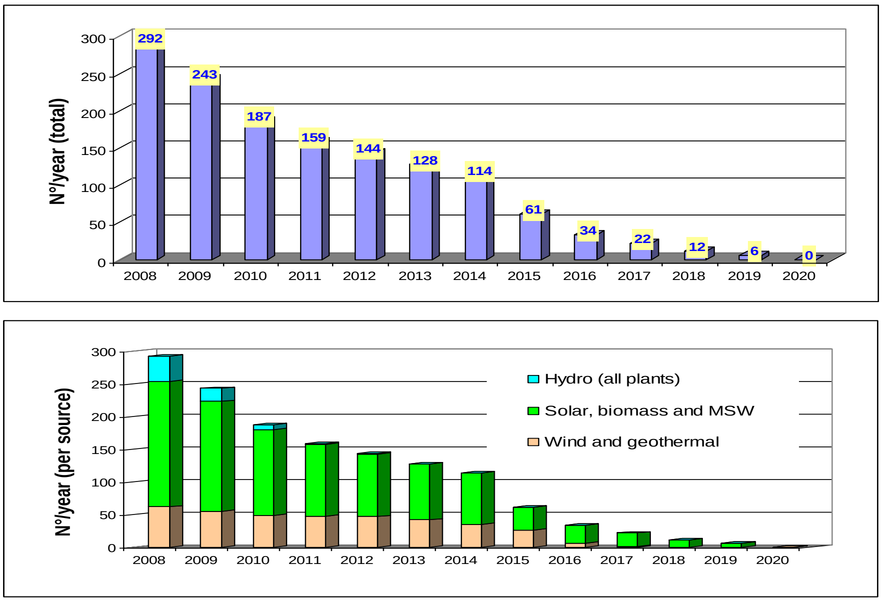
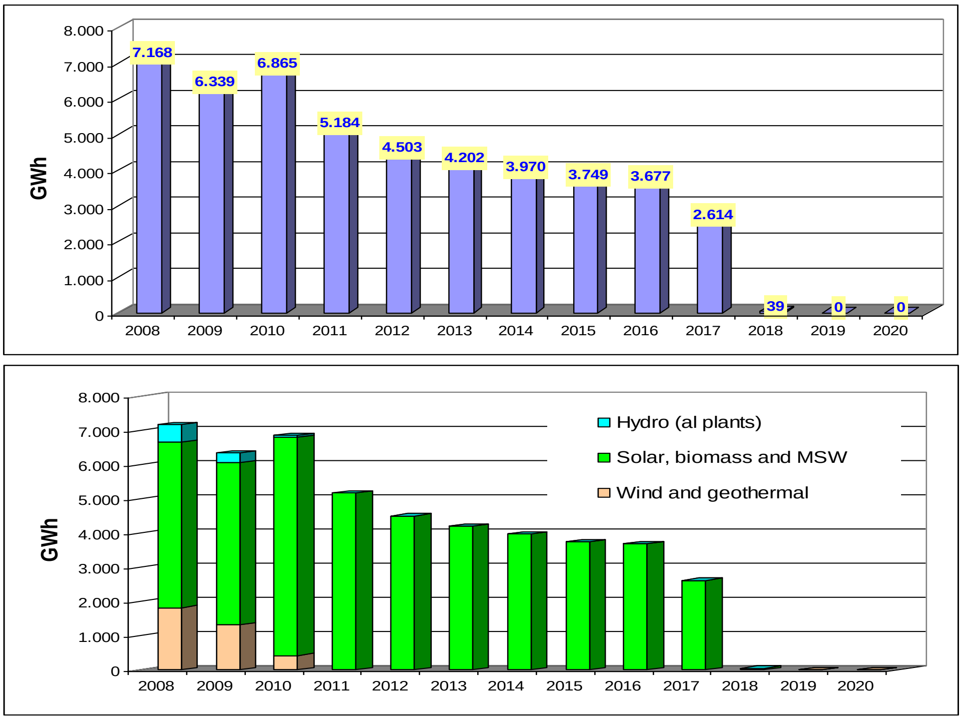
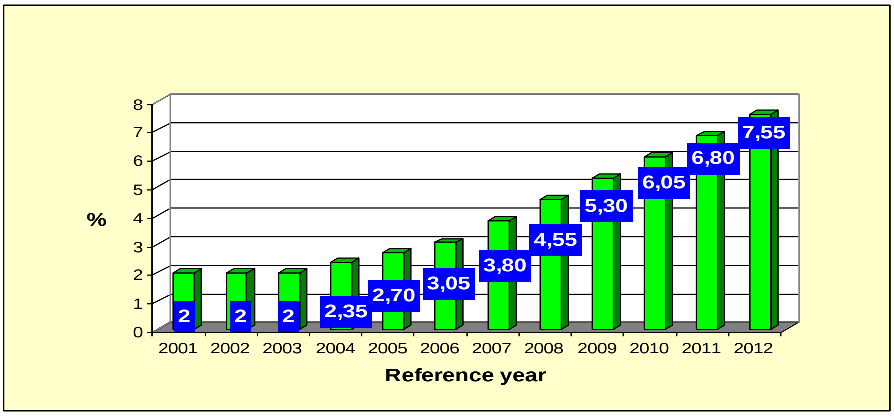


Figure 38: Total and per source expected per year production of renewable energy (GWh) of plants supported under the CIP 6 mechanism. Trend from 2008 to all the residual years of validity of the CIP 6 support (data source: GSE)



According to the European Directive 96/92/CE [33,] the **D.Lgs 79/99** [32] forced producers and importers of non renewable electricity energy to enter, from 2001 on, a minimum share of energy generated by renewable plants in the national energy network, introducing economical supporting mechanisms to promote such a requirement. The current shares of renewable energy to enter the national energy network are reported in Figure 39, for the time period 2001-2012.

Figure 39: Minimum share per year (2001-2012) of energy generated by renewable plants to enter on the national energy system according to D.Lgs 79/99 (data source: GSE)



The target share of energy generated by renewable plants can be reached through a direct production of renewable energy or by buying the corresponding amount of obligations (Green Certificate) from other qualified producers of renewable energy. This supporting mechanism was confirmed and detailed by later regulations, the **D.Lgs n. 387/2003** [34], taking in the national legislation the European Directive 2001/77/EC [23], the **DM 24/10/2005_** [35] of the Italian Ministry of Economic Development, the **Law n. 244/2007_** [36] for assessing the national economic budget for the years 2008 and the **DM 18/12/2008_** [37] of the Italian Ministry of Economic Development.

Another supporting mechanism - the all-inclusive feed-in tariff – was also made available by the **DM 18 dic 2008_** [37] for plants meeting specific requirements, as later discussed.

To benefit from the *all-inclusive feed-in tariff* or the Green Certificate Supporting Systems, plants should obtain the qualification of RES-E ('IAFR') released by GSE, according to specific procedures (**DM 21/12/ 2007** [38] of the Italian Ministry of Economic Development) which allow calculation of the amount of electricity energy generated that meets the renewable criteria. Note that regulations introduced by the above mentioned D.Lgs n. 387/2003 [34] changed the previous definition of renewable energy sources, considering as renewable the energy from non-fossil sources (wind, solar, geothermal, wave & tidal, hydro, biomass, landfill gas, biogas and gas from waste water treatment), including the biodegradable fraction of products, wastes and residues (both from plants and animals) from agricultural activities, forestry management and related industrial activities, as the biodegradable fraction of municipal and industrial wastes.

Hybrid plants (fed with both renewable and non–renewable fuels, including waste) can be supported for renewable source only, after qualification by GSE.

The on demand all-inclusive feed-in tariff scheme is applicable to plant upgraded/repowered, total or partial renovation, reactivation or new plants (IAFR qualified), only if it meets the following requirements:

a) use of RES (excluding the solar source);

b) nominal power not exceeding 1 MW (200 kW for on-shore wind plants);

c) commissioned after 31 December 2007.

This scheme represents an alternative to the Green Certificate; the flat rates (Eurocent/kWh) fixed by the **Law n. 244/2007** [35] depend on the source of renewable energy.

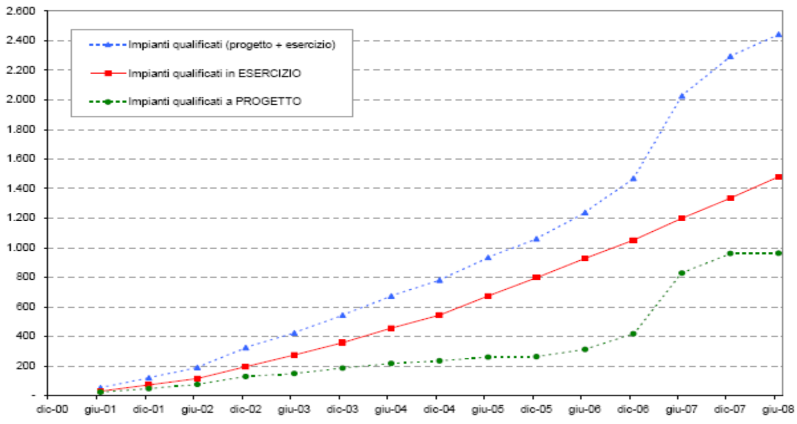
The Green Certificate scheme applies to larger plants (>1 MW). Based on regulations introduced by the Law n. 244/2007 [36] a Green Certificate size of 1 MWh from January 01, 2008 is currently in force. The period of time covered by the Green Certificate System is 15 years for plants, including hybrid, operating after 12/31/2007. It becomes 12 years for plants operating before 12/31/2007 and 8 years for the non renewable energy from co-generation plants and for the non renewable energy from plants (even hybrid) treating not-biodegradable wastes which comply with the CV requisition.

For plants starting after 12/31/2007 with an annual average nominal power >1 MW (>0.2 MW for wind plants), GSE releases Green Certificates calculated by multiplying the net energy production of the plant for a specific coefficient. The economic value of the supporting scheme (Green Certificate) is basically defined by the energy market according to the offer/bid low. Before the Law n. 244/2007 [36] came into force, the reference bid price was calculated by GSE as the difference between the purchase price of energy from CIP 6 plants and the revenue obtained by selling the electricity on the energy market.

According to the new method introduced by n. 244/2007, [6] the 2008 bid reference price was set at 112.88 €/MWh, which results from the difference between the reference value of 180.00 €/MWh; and the 2007 annual average market price of electricity (67.12 €/MWh), as fixed by the National Authority for Electric Energy and Gas at the end of each year.

Figure 40 shows the trend of plants admitted to the Green Certificate support system in the period 2000-1008.

Figure 40: Number of plants qualified by GSE as IAFR energy plant and admitted to the Green Certificate Supporting System from 2000 to 2008: total number of IAFR plants, number of certificated operating plants or certificated but not operating (planned) plants per year (Figure extracted and modified from ref 29)



Blue line: all plants (expected)
Red line: operating plants (actual)
Green line: planned plants

An overview of the current status of the Green Certificate mechanism in Italy is presented in the following figures. In particular Figure 41 reports the amount (GWh) and percentage of the renewable energy supported by the Green Certificate System on the total renewable energy produced in Italy in the year 2007.

Figure 42 reports the amount (GWh) the relative contribution of the specific source of renewable energy supported by the Green Certificate expected from IAFR qualified plants in operation at the end of June 2008.

Figure 41: Amount (GWh) and percentage share of renewable energy supported by the Green Certificate System on the total renewable energy produced in Italy in the year 2007 (data source: GSE)

	Energy gross production from all renewable plants in 2007 (GWh)	Renewable Energy supported by the Green Certificate System	
		GWh	% of Energy gross production
hydro	32.815	2.876	8,8
wind	5.569	866	15,5
biomass and waste	5.506	553	10,0
biogas	4.034	2.645	65,6
geothermal	1.447	716	4,9
solar	39	2	5,4
Total renewable sources	**49.411**	**7.658**	**15,5**

Figure 42: GWh of renewable energy in Italy supported by the Green Certificate expected from IAFR qualified operating plants at the end of June 2008 (data source: GSE)

Working renewable plants - Status at June 30, 2008			
	N° of plants	Nominal Power (MW)	Theorical productivity from qualified plants supported by Green Certificates (GWh)
hydro	873	5.032	5.058
wind	182	2.094	4.980
biomass	76	1.456	2.416
biogas	255	267	1.618
geothermal	13	440	972
solar	47	5	6
waste	35	909	824
Total renewable sources	**1.481**	**10.024**	**15.873**

The Guarantee of Origin (GO) certificate for electricity generated by RES-E or high-efficiency co-generation plants (released by GSE), is an on-demand certificate which does not give economic support to producers but allows them to prove that all or a share of their energy is produced from renewable sources, according to Italian national regulation (**D.Lgs n. 387/2003** [34]).

In the case of hybrid plants, the Guarantee of Origin refers only to the electricity generated by the renewable source, including the biodegradable fraction of the waste.

In 2007, GSE released the Guarantee of Origin for 3,062 GWh or renewable energy. The number of plants complying with GO rules are shown in Figure 43.

Figure 43: Renewable energy plants identified by GSE as meeting requirements for the Guarantee of Origin at the end of June 2008 (data source: GSE)

Source	GO qualified plants (n°)	Nominal Power (MW)	Expected energy production (GWh)
Hydro	78	1.476	4.177
Biomass	3	30	187
Winf	2	40	85
Biogas	5	7	39
Total	**88**	**1.552**	**4.488**

A preliminary assessment of the maximum theoretical potential level of renewable energy production in Italy to 2020, expressed in terms of primary energy replaced, can be derived by the Position Paper [39] of the Italian Government. This Paper takes into account many aspects, such as the potential, availability and possible alternative use of each renewable source as well as the environmental constrains related to landscape impact, the socio-economic sustainability of these policies, including incentives, and the effects of the promotion of renewable energy on the electricity market prices for consumers and industry. It also takes into account the need for investments in the transmission grid, to accommodate for small scale distributed power generation resources that need to be interconnected like an internet network and in the form of two-way interacting infrastructures.

Compared with 6.71 MTOE (Million Tons of Oil Equivalent) in 2005, the total maximum theoretical potential for renewable energy at 2020 could increase to 20.97 MTOE, of which 8.96 would be electricity, 11.40 heating & cooling and 0.61 biofuels.

As regards the 'biomass', a total potential at 2020 of 14.50 TWh for electricity (Figure 44) was estimated. In particular it was assumed that the potential energy coming from the exploitation of industrial waste could be 5 TWh/year, with an expected efficiency of 25%. For MSW, the biodegradable part is assumed to be the 40% of total, with a potential of 4TWh. For landfills, the expected 3.2 TWh includes the annual potential of 1.7 TWh from the exploitation of gas generated by anaerobic digestion, and 1.5 TWh from landfill gas, subject to an improvement in gas capture technologies and to a reduction of the waste treatment system. For dedicated energy crops, it is necessary to assume high levels of incentives. Total potential at 2020 would be 14.50 TWh, compared with 6.16 TWh of 2005.

Figure 44: Theoretical national potentials for the production of renewable energy at 2020. Details for Electricity (data source: ref 39)

	State of implementation 31 december 2005		Total potential energy available by 2020	
	Power (MW)	Energy (TWh)	Power (MW)	Energy (TWh)
Hydro power plants > 10MW	14.920	28,50	16.000	30,72
Hydro power plants < 10MW	2.405	7,50	4.200	12,43
TOTAL HYDRO SOURCE	**17.325**	**36,00**	**20.200**	**43,15**
Wind plants on-shore	1.718	2,35	10.000	18,40
Wind plants off-shore	0	0,00	2.000	4,20
TOTAL WIND SOURCE	**1.718**	**2,35**	**12.000**	**22,60**
Building integrated PV plants	27	0,03	7.500	9,00
Power PV plants	7	0,01	1.000	1,20
Solar thermodynamic	0	0,00	1.000	3,00
TOTAL SOLAR SOURCE	**34**	**0,04**	**9.500**	**13,20**
Traditional geothermic	711	5,32	1.000	7,48
New generation geothermic	0	0,00	300	2,24
TOTAL GEOTHERMIC SOURCE	**711**	**5,32**	**1.300**	**9,73**
Plants using biomass coming from crops and other agro-industry waste	389	2,34	769	5,00
Plants using biodegradable part RSU	527	2,62	800	4,00
Plants using landfill gas, sewage treatment plant gas and biogas	285	1,20	492	3,20
Plants using dedicated energy crops	0	0,00	354	2,30
TOTAL BIOMASS, LANDFILL GAS AND BIOLOGICAL PURIFICATION	**1.201**	**6,16**	**2.415**	**14,50**
Wave and tidal energy	0	0,00	800	1,00
TOTAL WAVE AND TIDAL ENERGY	**0,00**	**0,00**	**800**	**1,00**
TOTAL	20.989	49,87	46.215	104,18
TOTAL PRIMARY ENERGY REPLACED	4,29 MTOE		8,96 MTOE	

For heating/cooling (Figure 45) a total of 389,933 TJ, or 9.32 MTOE was assessed as potential from the biomass source, assuming that a 5% will be used in civil heating with an average efficiency of 50% and that 50% of the new power capacity is co-generative with an average yield of 70%.

Figure 45: Theoretical national potentials for the production of renewable energy at 2020. Details for heating & cooling and biofuels (data source ref 39)

	State of implementation 31 december 2005		Total potential energy available by 2020	
	Power (TJ)	Energy (MTOE)	Power (TJ)	Energy (MTOE)
Geothermal	8.916	0,21	40.193	0,96
TOTAL GEOTHERMAL SOURCE	**8.916**	**0,21**	**40.193**	**0,96**
Solar heating	1.300	0,03	47.000	1,12
TOTAL SOLAR SOURCE	**1.300**	**0,03**	**47.000**	**1,12**
Biomass for civil sector	57.820	1,38	233.333	5,57
Cogeneration (+district heating)	21.000	0,50	156.600	3,74
TOTAL BIOMASS	**78.820**	**1,88**	**389.933**	**9,32**
Biofuels	12.600	0,30	25.600	0,61
Biofuels for import			150.400	3,59
TOTAL BIOFUELS	**12.600**	**0,30**	**176.000**	**4,20**
TOTAL	101.636	2,4	653.127	15,6

With regard to biofuels (Figure 45), the Position Paper [39] accounted for a total internal potential of 25,600 TJ, or 0.61 MTOE, assuming a consumption of 40 Mt by 2020 (based on the present growth rate of gas oil consumption for transportation) and that, in order to produce the 5.5 Mt necessary to cover the 10% of energy from biofuels (assuming 2nd generation biofuels are introduced), it would be necessary to cover an agricultural area of 5 Mha, equal to 16.7% of the area of the country and about 60% of the cropped arable land.

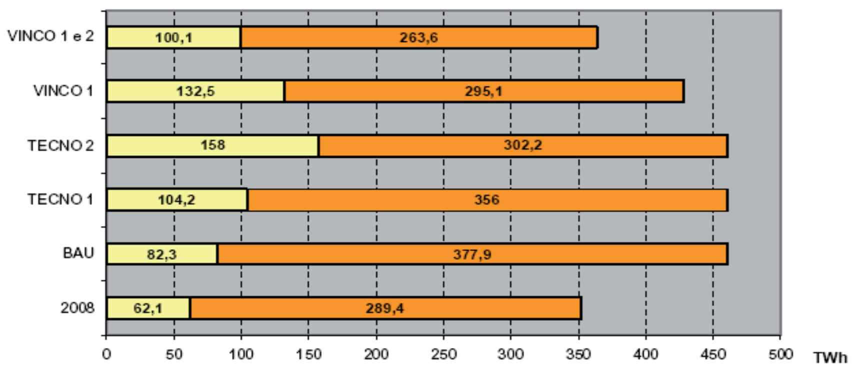
Considering that Italy could produce at most 800,000 – 1,000,000 tons a year, using an agricultural area of approximately 600,000 hectares, instead of the current 260,000 (equivalent to 25,600 Tj or 0.61 MTOE), resorting to import is considered unavoidable to reach the above mentioned target of 10% of fuel consumption.

As pointed out in a report recently presented by GSE to the Italian Parliament,[40] the energy market seems to be currently interested in the electrical energy generation from renewable sources. This trend is expected to continue in the near term, even if influenced by the future national and European choices on energy and environmental policy. This is because of the capability of the Italian government and the Italian energy industrial sector to plan, support and promote technological development and innovation in the field of renewable energy and to cover the need for annual investment to develop new renewable plants. It was estimated[40] that the sustainable European climate and energy policy (the so called 'Environment-Energy 20-20') could result in a business and occupational opportunity for Italy by 2020, more or less consistent with the capacity to stimulate and economically support internal development and implementation of renewable technologies in Italy, rather than importing renewable energy.

The report mentioned above[40] points out that Italy, within the Law n. 244/2007[36] enhances, for the time period 2007-2012, the minimum share of the electrical energy derived from renewable sources that each year has to be generated within the national energy system, from the value of 0.35% fixed by the D.Lgs 387/2003[34] to 0.75%. Furthermore, Italy has declared annual national targets for the period to 2015 to achieve a minimum level of 25% of internal gross consumption of electrical energy from renewable energy. The EU Renewable Energy Directive, (RED) assigns a share of 17% of the gross total internal consumption of energy (electricity, heat, fuels for transport) used in 2020 should be from renewable sources (including 10% of transport fuels as biofuels) and a reduction in greenhouse gas emission of 14% (with respect to 2005) in Italy.

This means that a share of 25-30% of renewable energy on internal electrical energy consumption has to be achieved in Italy by 2020, depending on the target of GHG reduction (25% or 30%). An additional amount of renewable energy can be added to its actual level depending on the medium-term potential of renewable production in Italy. Estimates of the renewable energy production (TWh) for 2020, for various final gross energy consumption estimates calculated from different models, were taken into account and compared in the GSE report [40] (Figure 46): the provisional potential declared in the 2007 National Position Paper[39] previously described (labelled Tecno 1); the national scenario assessed by European Commission and IEA (labelled Tecno 2); a Business As Usual scenario (labelled BAU); two scenarios (labelled Vinco 1 and Vinco 2) based on national targets for renewable energy and GHG reduction as defined in the Energy and Climate Change Package of the European Commission (approved on 23 /01/2008), where the Vinco 2 scenario referred to a situation of both the renewable energy and the GHG target are included, while in the Vinco 1 the target of GHG reduction is excluded.

Figure 46: Scenarios at 2020. Renewable energy production to cover the final gross energy consumption. Renewable energy (yellow bar) and residual gross energy consumption (red bar) (Figure extracted from ref 40)



The renewable energies potential (104.2 TWh) to cover the final gross consumption at 2020 assessed by the Italian Government (Tecno 1 scenario) seems to be lower (-54 TWh) than that predicted by the European Commission and the IEA (Tecno 2 scenario). The Vinco 1 +2 scenario shows that if the national renewable target is set with respect to the GHG targets at the same time, the renewable potential is lower. While, under the business-as-usual model, a much lower renewable production relative to the gross final consumption at 2020 would be obtained.

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Netherlands

The municipal solid waste resource in the Netherlands

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This report:

- summarises national policy/strategy on waste management and the recovery of energy from waste;
- provides data on the historical arisings and management of MSW;
- briefly discusses the factors affecting waste growth, and estimates the MSW arisings in 2020;
- assesses the potential for increasing the amount of energy which is recovered from MSW in NL.

National policy/strategy

Waste policy

The second waste management plan of the Netherlands was published on 14 December 2009 and came into force one month later. The plan was sub-titled: towards a material chain policy, which clearly states the focus on material recycling within current waste policy. The plan contains the next objectives for waste policy:

- Limitation of the production of waste. This means that the growth in total waste production must be decoupled from economic growth.
- Limitation of the environmental impact of the activity 'waste management'. This means in principle that as much waste as possible must be recovered, that only waste which cannot be recovered may be disposed of, and that only incombustible waste may go to landfill.
- The limitation from a chain-oriented waste policy viewpoint of the environmental impact of production chains (raw material extraction, production, usage and waste management, including reuse). This means, among other things, that for the reduction of the environmental impact in the waste phase, the whole chain must be taken into account, and that the efforts to reduce the environmental impact in the waste phase may not result in shifting the environmental impact to other phases in the chain.

Quantitative objectives relevant for waste-to-energy

The general waste objectives in the previous section result in the following quantitative and measurable objectives. A selection of objectives relevant for waste-to-energy is made.

1. Promotion of prevention of waste, such that the decoupling between the Gross Domestic Product (GDP) achieved in the period 1985-2006, and the development in total waste production is strengthened. This means that the total waste production in 2015 may not be greater than 68 Mton, and in 2021 may not be greater than 73 Mton.
2. Increase in recovery from 83% of all waste in 2006 to 85% in 2015. This can mainly be achieved by promotion of waste separation at source, and post-separation of waste streams. By this means, it becomes easier to achieve product reuse, material use and reuse.
3. Increase in recovery from 51% of all household waste in 2006 to 60% in 2015. Objectives are included in various Directives for the percentages of recovery to be achieved for different waste substances, such as packaging, batteries and electrical

and electronic equipment. No other objectives for separate waste substances are stipulated in addition to these legislatively stipulated objectives. This means that municipalities have a limited degree of freedom in implementing the achievement of the objective of 60%.

4. Reduce the deposition of combustible residual waste from 1.7 Mton in 2007 to 0 Mton in 2012.

Qualitative objectives

5. Optimal usage of the energy content of waste that cannot be reused. To this end, more usage of waste as fuel in plants with a high energy efficiency, and improvement of the energy efficiency of the existing waste incineration plants (WIPs), are aimed at.

6. Better usage of residual heat from waste incineration. Within the context of the Ministry of Economic Affairs' 'Plan of Approach for Heat' (Aanvalsplan warmte), it will be investigated together with the Ministry of Economic Affairs and Commerce how the potential for the usage of waste heat can be better realised in local situations.

7. Contribute to the following specific ambitions of the Balkenende IV cabinet, in the context of the integral chain approach to waste materials policy:

   - by 2020, in comparison to 1990 levels, a reduction of CO_2 emissions by 30%. (theme 'climate change');

   - by 2020, - no risk to man or environment due to the distribution of hazardous substances (theme 'distribution');

   - in 2010, the loss of biodiversity to be stopped (theme 'land usage').

Capacity planning and D10/R1-status

The new plan, although still not in force, is already under debate and as a result a proposal for change is in progress. The proposal is a result of the emerging overcapacity for incineration in the Netherlands, leading to a political consensus that capacity should be stabilised and a willingness to ensure waste incinerators already in operation achieve good energy performance (R1-status), before the rest of the Waste Framework Directive is implemented in the Netherlands. This led to a gentlemen's agreement which was signed on 2 December 2009. (in Dutch http://www.lap2.nl/nieuwsbericht.asp?i=33).

The companies involved in waste incineration agreed on a cap on new capacity up to 2020. The minister of the environment will investigate the possibility of changing the status of waste incinerators with high energy efficiency to recovery (R1) in advance of the implementation of the new European waste framework directive. A list of incinerators and their proposed future status is given in Table 20 (http://www.lap2.nl/uitvoering.asp?i=55)

The status is based on calculation made by SenterNovem. The interpretation of the D10/R1-formula is made by SenterNovem since no European guidance exists so far. The EU is expecting to formulate guidance in 2010. In case this diverges from the Dutch method it will be seen if and how the Dutch method will be changed.

Table 20: Incinerators, capacity and energy efficiency according to the new WFD

Waste Incinerator	Existing or new.	capacity (kton)	Energy Eff. (1)	Status	capacity R1 per 1-1-2010 (kton)	capacity R1 per 2011 / 2012 (2) (kton)
AEC Amsterdam	Existing	800	0,63	R1	800	800
HRC Amsterdam	Existing	500	0,78	R1	500	500
ARN	Existing	310	0,67	R1	310	310
AVR Duiven	Existing	400	0,39	D10		
AVR Rozenburg	Existing	1.300	0,59	R1 (3)	1300	1300
AVR Rotterdam, will close 1-1-2010						
AZN lijnen 1-3	Existing	715	0,90	R1	715	715
AZN lijn 4	Existing	275	1,15	R1	275	275
E.ON Delfzijl	New	275	0,96	R1	275	275
GAVI Wijster	Existing	630	0,49	D10		
HCV Alkmaar	Existing	675	0,55	D10		
HCV Dordrecht lijnen 1-4	Excisting	240	0,21	D10		
HVC Dordrecht lijnen 1,4,5	Excisting/ New	396	0,61	R1		396
Omrin Harlingen	New	228	0,95	R1		228
Sita bestaand, geen aanvraag ingediend						
Sita BAVIRO (4)	New	224	0,63	R1		224
Twence lijnen 1, 2	Existing	300	0,41	D10		
Twence lijn 3	Existing	216	0,67	R1	216	216
Totaal (kton)		**7.311**			**4.391**	**5.239**

Overcapacity

The overcapacity on the waste incineration market leads to:

- Decrease in waste treatment prices. Recently the municipalities of the Utrecht Province signed a contract with AVR for 40 EURO/ton residual MSW. This is less than half the price a couple of years ago.
- Some plans were stopped. Essent decided not to increase their capacity in Wijster.
- First closure of a waste incinerator in years. The AVR Rotterdam waste incinerator will close next month.

Renewable energy policy

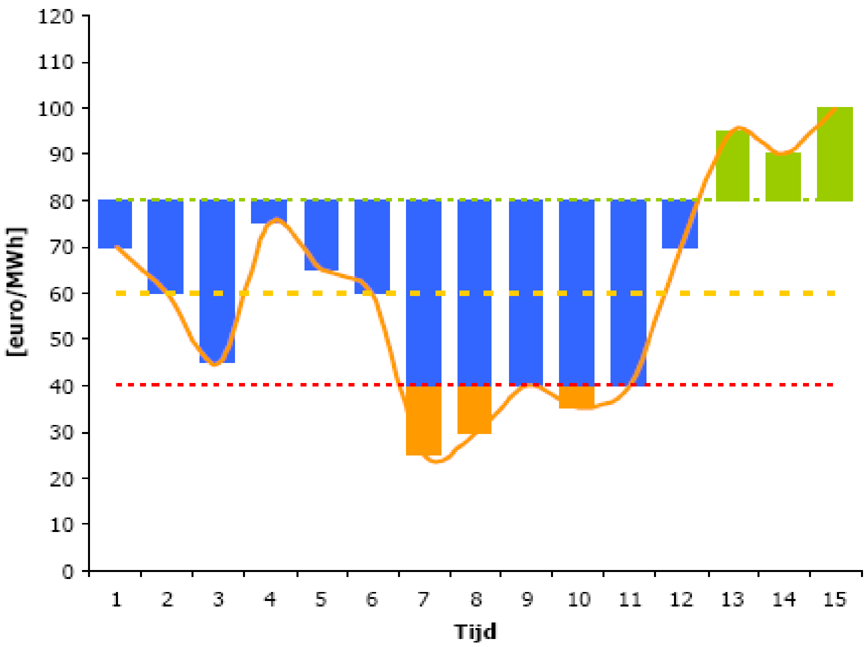
A new strategy was introduced by the Government in 2007 entitled '*clean and efficient'.* The main targets set out in this strategy are the reduction of the greenhouse gases by 30%, 20% renewable energy in 2020 and an annual efficiency improvement of 2%.

SDE (subsidy renewable electricity)

The main instrument in stimulating renewable energy is the SDE. This subsidy scheme is designed to stimulate investment in the production of renewable energy. The SDE is not an investment grant; it is a utilisation subsidy, for renewable energy generated. The SDE subsidizes the lack of profit of a production unit of renewable energy.

For this purpose for each technology a basic price is determined. This is the average production costs of renewable energy per production system. These prices are calculated for e.g. offshore wind, co-combustion of biomass, and also for (the biomass fraction of) waste incineration. Based on a basic market price the subsidy level is defined as the difference between the basic price and the market price. Every year the market price is estimated and after a subsidy year the subsidy paid is corrected for the actual electricity prices. This means that in case of high electricity prices the subsidy might be zero. (Green bars in Figure 47 indicate profit, not negative subsidy).

Figure 47: Example of how SDE-subsidy is calculated.
Green line: basis price; red line: basic electricity price; orange line: developing price through time. Blue bars are the subsidy required, green bars, not subsidy but profit.



SDE for waste incineration

For waste incineration the cost calculation is difficult because the cost structure is dominated by income from waste. Furthermore, a minimum energy recovery is obliged for all waste incineration due to environmental legislation (e.g. BBT). Therefore only electricity generation above 22% efficiency is granted within the SDE. The basic prices are 5.5 €ct/kWh for 23% efficiency up to 6.6€ct/kWh for efficiencies over 30%.[1] According to the market this is too low for a profitable benefit.

[1] The efficiency is electricity + 2/3 of the heat produced. However the subsidy is only granted for the electricity part.

Heat

The ambitious targets for efficiency improvement and renewable energy require the use of all energy systems, including heat. Therefore this year a plan for heat (aanvalsplan warmte) has been introduced by the ministry. The plan is not official, so the details are not available however the most important points are:

- subsidising CHP by the SDE;
- mapping heat demand and supply in industrial regions, in this way to decrease the discharge of heat;
- support to the agreements with different sectors (e.g. agro sector).

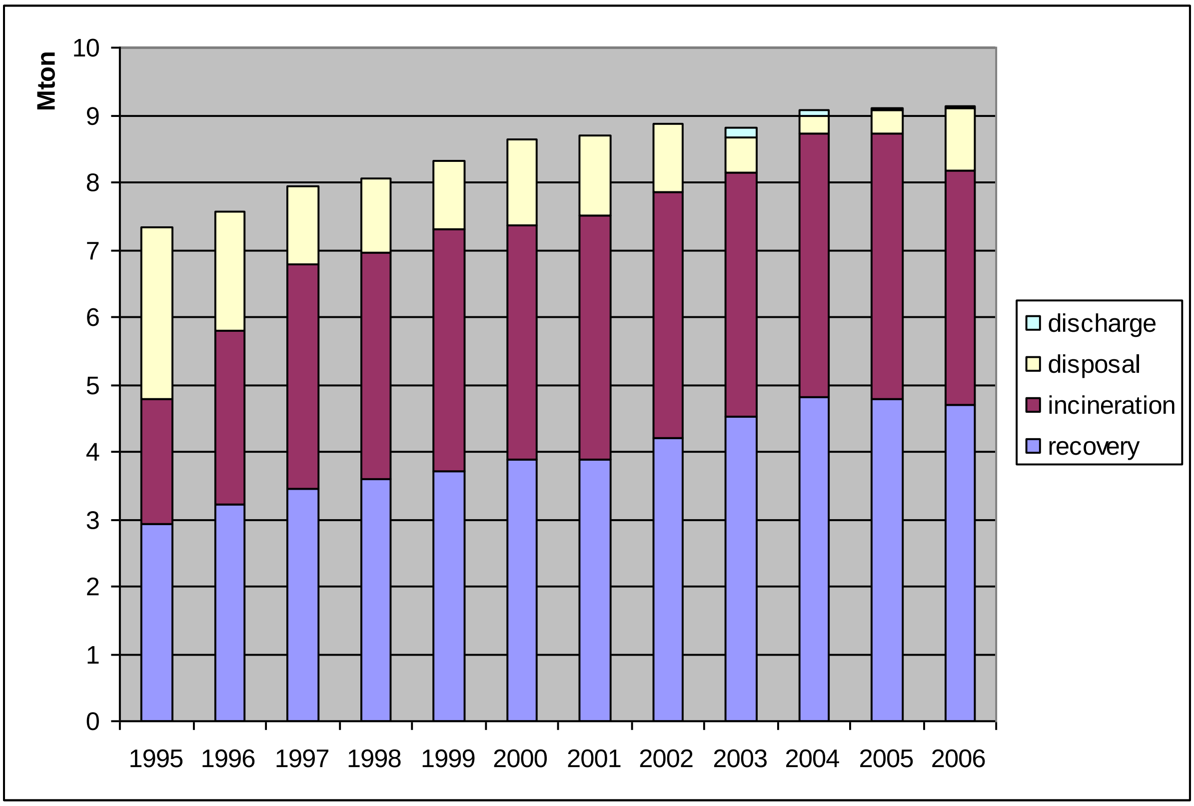
Current situation

Household waste

Dutch statistics use a distinction between different sectors for waste. For household waste the total production of waste increased over the last 13 years from 7.3 Mt in 1995 to over 9 Mt in 2006. In this period recovery increased from 40% in 1995 to 53% in 2006, mainly due to increasing separate collection of paper and a better recovery of bulky waste.

From the non-recyclable waste a clear shift from landfilling to incineration is seen in the period 1995-2005. However, in the period 2003-2005 part of the recovery and incineration took place in Germany. After the landfill ban in Germany on 1 June 2005 this export decreased dramatically leading to a capacity shortage in the Netherlands. The surplus of waste of approximately 1 Mt is landfilled.

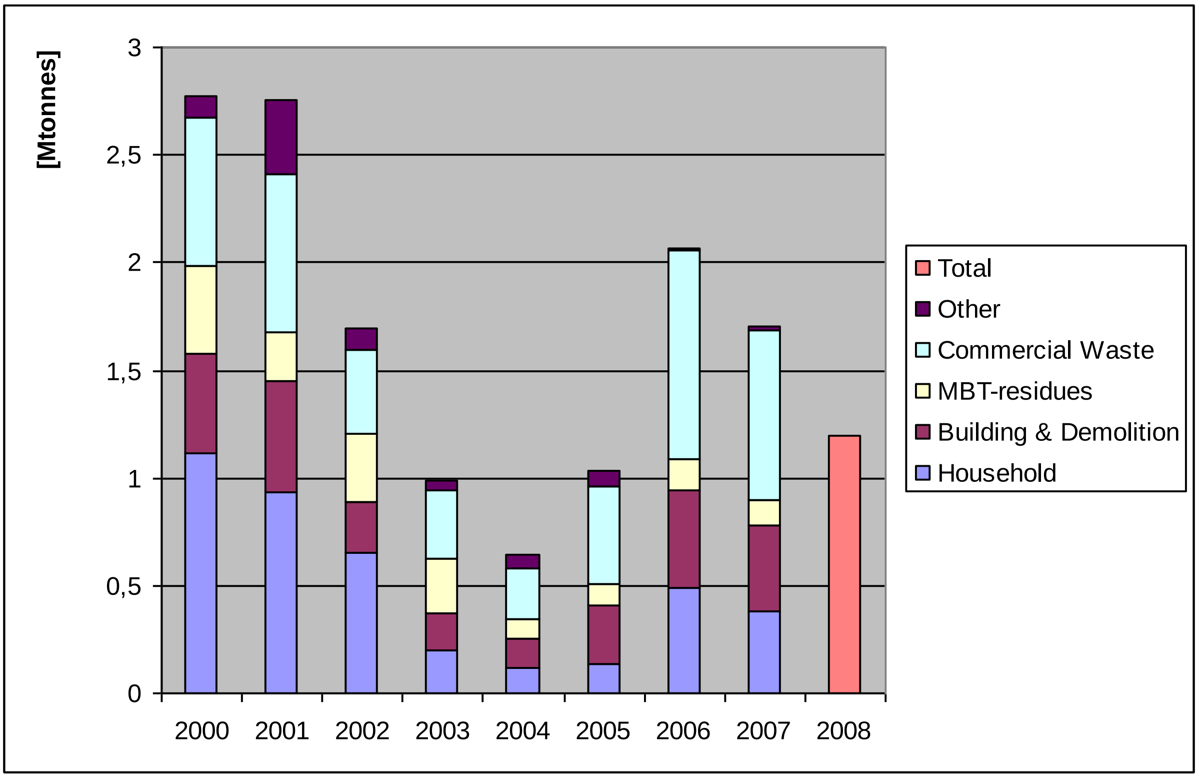
Figure 48: Treatment of household waste in the Netherlands 1995-2006)



As earlier, an important aspect of the capacity planning is to enable the incineration of all non-recyclable combustible waste. For this purpose, this waste is monitored for the period of the first waste management plan.

The amount is stable for the last eight years around 10 Mt, which contains 4.7 Mt waste from household, 2.2 Mt waste from commercial premises, 1.8 Mt combustible mixed demolition waste and approximately 2 Mt other waste (mainly sludge). Here we see the same development as for household waste - an increase in the landfill of combustible waste due to a lack of incineration capacity. In recent years the landfill decreased again, now leading to an overcapacity and a stop to landfilling of combustible waste.

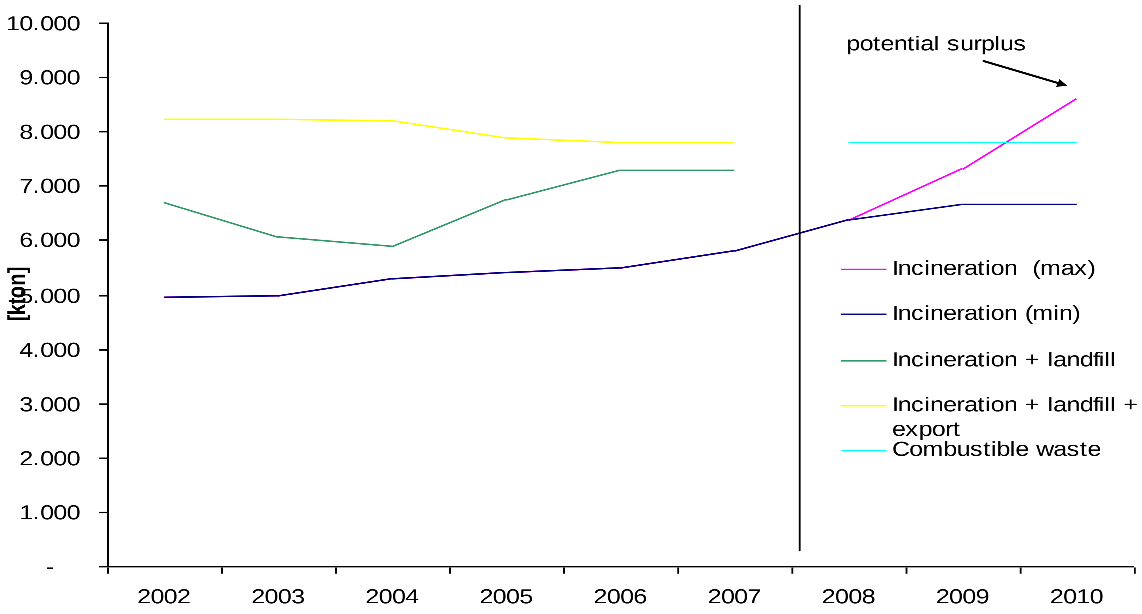
Figure 49: Landfilling of combustible waste in the Netherlands (SenterNovem 2009)



Incineration capacity

The 10 Mt combustible, non-recyclable waste contains approx 2 Mt of waste not suitable for waste incineration. This is the high calorific part of building and demolition waste and the sludge. Thus, around 8 Mt of incineration capacity is needed for the amount of waste produced over the last few years (see yellow line in Figure 50). The plans for increase of incineration capacity show enough development to treat all combustible waste produced today. There was a surplus of capacity in 2009 due to a decrease in waste due to the economic crisis and the availability of new waste incineration capacity. As a result, the Waste Incinerator of AVR in Rotterdam will close in January 2010.

Figure 50: Incineration capacity and planned (status October 2008)



Future energy recovery potential

The current focus on energy production, especially on heat production, has led to the consideration of heat production in all new initiatives. At three locations the integration of waste incineration with industrial heat demand leads to an efficient coupling of systems. On most sites where the capacity is increased new capacity leads to more heat delivery. Development of electricity production is relatively straightforward, and, due to the subsidies available for the renewable part, it is proposed for all new non-industrial coupled installations.

The electricity power capacity increased in 2007 to 506 MW producing 2900 GWh of electricity in 2008. The net production was 2204 GWh and the total heat production 10.5 PJ. With a waste input of 6.1 Mton (61 PJ), the average efficiency was 13% and heat efficiency 17%. The total capacity will be 7.3 Mton within a couple of years. It is assumed that there will be an increase in particular in the heat production since the new waste incinerators all use heat delivery.

Norway

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Waste policy

Overall waste policy

The regulation on recovery and treatment of waste (Avfallsforskriften)

The Avfallsforskriften (the Norwegian version of the Waste Incineration Directive) is a document covering the collection and treatment of electrical and electronic products, batteries, vehicles and tyres and the regulation for waste landfilling and incineration of waste. This regulation forbids the landfilling of wet organic waste (sludge, food waste), although there are exemptions where consent has been granted.

Hazardous wastes and export/import of waste are also covered by this regulation. About 300,000 t of waste are exported every year, mostly to Sweden. The current trans-boundary transport regulations concerning waste do not allow any ban/restriction (market-regulated). However the Norwegian authorities stress that their ultimate goal is that Norwegian produced waste should be treated in Norway, mostly to assure proper treatments and because waste is seen as a resource for material and energy recovery. The authorities are committed to closely watch export/import of waste.

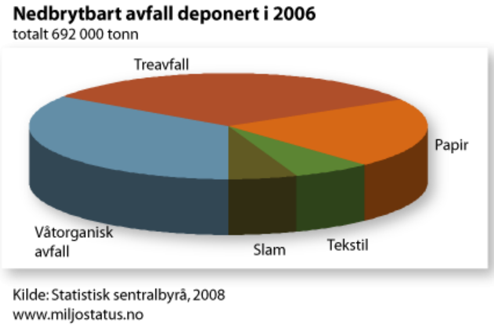
The 'final treatment' fee (Sluttbehandlingsavgift)

This tax system was established in order to reflect the environmental impacts imposed by the waste 'final treatment' techniques. Landfilling and combustion without energy recovery are considered as 'final treatments' and are subject to this fee, which is meant to stimulate the use of 'non-final' treatments such as recovery or combustion with energy recovery. The cost for landfilling varies with the quality of the landfill and was between 434 and 566 NOK/t in 2008.

Ban on the landfilling of biologically degradable waste from 01.07.2009

About 4.8 Mt of biologically degradable waste (wood, wet organics, sludge, textiles and paper) were generated in Norway in 2006. About 0.7 Mt were landfilled (see Figure 51). The main basis for this ban is the reduction of GHG emissions and the expected improvement in the material and energy recovery rates. In 2008, emissions from landfills represented about 2.2% of the total Norwegian GHG emissions.

Figure 51: Landfilled biologically degradable waste. 2006



The total amount of waste which will be diverted from landfills to other treatments is estimated to be approximately 1 Mt a year. This is because biologically degradable waste is often mixed with other fractions (plastic, etc). SFT (Norwegian Pollution Control Authority) evaluated that 75% of this stream will go to waste combustion.

More specific EfW

Factors that are relevant to EfW in Norway are:

- There is a district heating network development support scheme (by local authorities).
- Landfilling ban (see previous section).
- Energy recovery rate requirement (50%).
- Subsidy/contribution from Enova. The state-controlled company Enova (created in 2001) manages economic subsidies ('the energy fund') for new or improved energy systems using renewable energy sources.
- Emissions fees (CO_2, SO_2, NOx, dust, HF, HCl, Hg, Cd). Waste incineration installations are subject to fees based on their measured emissions except for CO_2 (fixed fee of 59 NOK/t waste i.e. about 200 NOK/t CO_2).
- Long-term public policies
  - Research programmes (the CenBio research centre, etc)
  - Bio-energy strategy plan 2008 with the overall goal of 14 new TWh bio-energy by 2020 (which includes the bio-fraction of waste)
  - Energy policy
  - Climate policy
  - Waste prevention
  - National (material and energy) recovery rate target (75%).

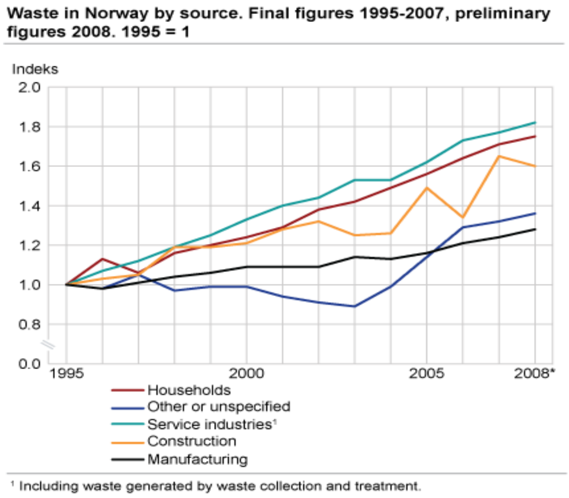
Current situation

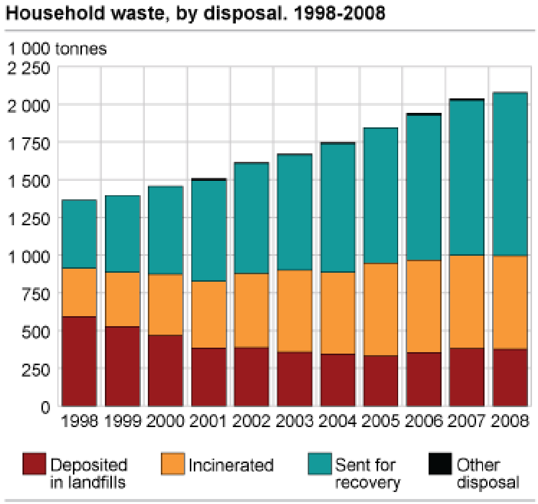
Definition of waste (Statistics Norway, SSB):
Waste/refuse: Discarded objects or materials.
Household waste: Waste from normal household activity, as well as large objects such as furniture.
Hazardous waste: Waste that cannot be treated together with normal waste because it can lead to serious contamination or risk injury to people or animals.

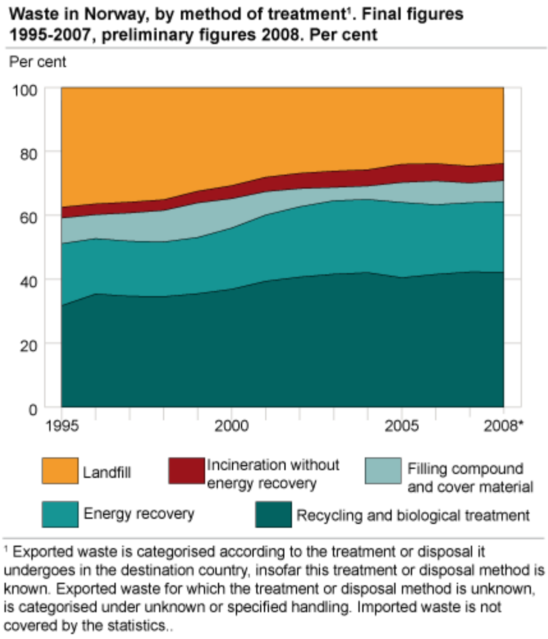
Historical MSW arisings

The three following figures (52-54) summarise the situation.

Figures 52-54: Waste arisings in Norway







(Text adapted from SSB website, www.ssb.no)

During the period 1995-2008, the total amount of waste increased by 48% to 10.9 Mt. In comparison, the GDP increased by 44% in the same period.

- Sharp growth in household waste

The amount of household waste has risen by 75%, exceeding the growth in total waste amounts. One possible explanation for the disproportionate growth in household waste could be a substantial increase in imports of consumption goods, which means that the waste from production is generated abroad. Private households account for 22% of the total waste (including scrapped cars). In comparison, manufacturing industries account for 37% of the total waste, of which 75% is from production processes.

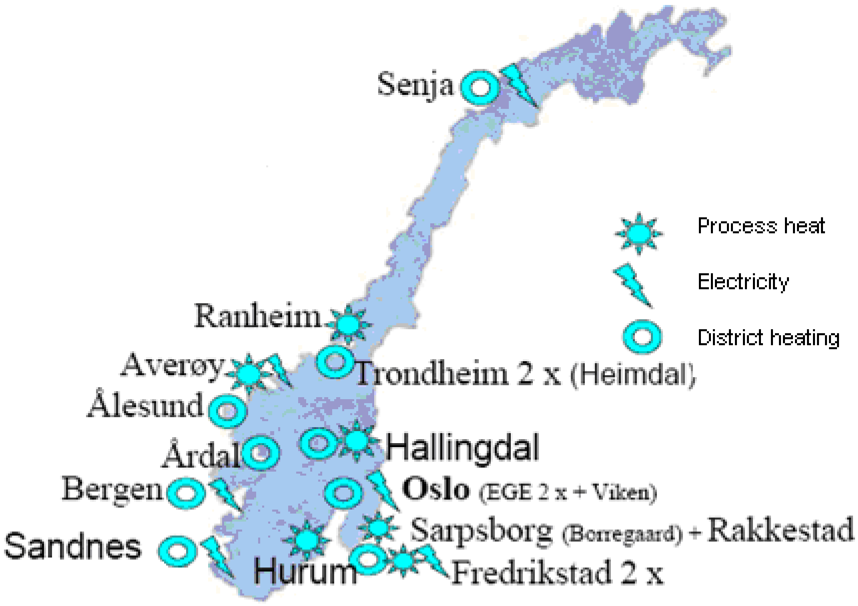
- Getting closer to national target

About 71% of the waste where the waste treatment was known was recovered in 2008 (excluding hazardous waste): about 37% went to recycling (material recovery), 22% to energy recovery and 11% to composting or as filling/cover in landfills. The national target is to increase this figure to 75% by 2010 and to 80% if this is economically and environmentally justifiable.

Recovery has increased by about 70% since 1995, while the amount going to landfill has decreased by 31%. In 2006, about one quarter of the waste going to landfill was biodegradable, compared to one third in 1995.

- We throw more plastic and paper
In 2006, 1.3 Mt of paper and 0.5 Mt of plastic were discarded, an increase of 7 and 6% respectively from the previous year and 41 and 47% from 1995. The plastic and paper go into recovery, leaving the amount for disposal almost constant during the period.

Figure 55: Plants generating energy from waste in Norway, 2009. Source: Rune Dirdal, Avfall Norge



- Waste incineration situation in Norway (2009, Avfall Norge)
  - Ca 1.1 Mt waste is combusted (60% household waste).
  - Current incineration capacity: about 1.1 Mt/y in 19 installations (see Figure 55).
  - New (upcoming) capacity: 800,000 t/y in 10 new installations by 2011 (520,000 under construction or contracted and 300,000 planned).

- Energy production from waste (2009, Avfall Norge, see also Figure 55)
  - 1.26 TWh heat to district heating (about 50% of the total heat production).
  - 0.50 TWh steam to industry.
  - 0.11 TWh electricity to the grid.

Future MSW arisings

Preliminary figures for 2008 show an increase in waste of 2% from 2007, compared to 6% the year before. There is no indication that waste generation could be levelling out.

Future energy recovery potential

It is expected that 0.7-1 Mt (SFT, SSB and Avfall Norge) of waste per year are to be diverted from landfilling after the ban in July 2009. 75% is expected to be combusted (SFT).

The 692,000 tons (Figure 51) represents the amount of biologically degradable waste previously landfilled. However this waste fraction is most often mixed with other fractions, which is why the real amount of diverted waste can therefore be estimated to 1,000,000 tons (Avfall Norge). The required combustion capacity can therefore be estimated to about 750,000 t.

New capacity: 800,000 t/y in 10 'new' installations by 2011 (520,000 under construction or contracted and 300,000 planned).

Sweden

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The municipal solid waste resource in Sweden

Waste management in Sweden has greatly improved over the last fifteen years in terms of its resource efficiency and environmental impact. This is the result of a number of powerful policy instruments, including producer responsibility, restrictions on landfilling, and landfill taxes. Sweden's entry into the EU has also had an impact. The volume of waste, however, has continued to grow.

Waste resources in Sweden

Some 121 Mt, 4.7 as municipal solid waste and 116 Mt as industrial and commercial, non-hazardous waste was generated in Sweden in 2006. Around half of the total amount, or 70 Mt, consists of mining waste and 22 Mt represents wood waste. Approximately 2.8 Mt of hazardous waste were produced in Sweden during 2006. The largest fraction was mineral contaminated waste such as asphalt etc.

Definition of municipal solid waste (MSW)

Municipal solid waste in Sweden is defined as household waste and other equivalent waste produced from other activities. The two categories are defined as:

- Household waste: Waste produced in the household. Waste produced due to business activities is not included within the fraction household waste.
- Waste from other equivalent activities: Waste with a similar complexity and content as waste produced in the household. The waste is produced by the citizens at restaurants, schools etc.

Other waste not included in the MSW definition is commercial, industrial waste and waste covered by the producer responsibility.

National policy/strategy

The Swedish Environmental Protection Agency has produced a national waste management plan '*A Strategy for Sustainable Waste Management*' based on the environmental quality objectives. This plan explains the significance of the objectives and it clarifies the connection between objective and measures taken. It also analyses the effects of various policy instruments and measures, and it points the way to the future by defining five areas given priority within waste management.

The overall aim of the national waste management plan are formulated in the national environmental objectives; "*The total quantity of waste should not increase, and the maximum possible use should be made of the resource that waste represents, while at the same time minimising the impact on, and risk to, health and environment*."

Since 1991, each municipality is obligated to have a waste plan. This plan must cover all types of waste found in the municipal area and identify the actions necessary for their appropriate environmental management and their management as resources. Waste planning has brought about improvements in management by encouraging the establishment of extensive systems for source separation and recycling.

Waste policy
The overall aim of the Swedish environmental policy and protection is to ensure that we can hand on to the next generation a society in which the major environmental problems have been solved. Sixteen national environmental objectives have been adopted by the Swedish Riksdag.

Waste management falls under three environmental objectives viz; ‘A Good Built Environment’, ‘Reduced Climate Impact’ and ‘A Non-Toxic Environment’.

Incineration, landfilling, and hazardous waste management are all governed by EU regulations, while for biological treatment Sweden has national guidance for minimizing impacts on the environment. The EU waste hierarchy is implemented as a guide to the proper management of waste in Sweden. Waste prevention is the highest priority, followed by reuse, recycling, and safe disposal.

MSW management has improved and thus the environmental impact has been reduced greatly over the last 15 years in Sweden. The improvements are the results of implementation of a number of powerful instruments and policies such as:

- 1991 introduction of carbon dioxide tax has given biofuels a favoured position.
- 1994 producer responsibility was used for packaging material to reduce the amount of packaging in the waste stream. Producer responsibility has increased since 1994 and other materials such as cars, tyres, electronic waste etc are now covered as well. The recycling level has constantly increased with time.
- 2000 a landfill tax of 250 SEK[2]/t was launched.
- 2001 implementation of EU’s landfill directive (1999/31/EG) in Swedish legislation (SFS 2001:512). A control program was implemented for all active landfills.
- 2002 a ban on the disposal of sorted combustible waste materials to landfill.
- 2002 implementation of EU’s waste incineration directive (2000/76/EG) in Swedish legislation (SFS 2002:1060 and NFS 2002:28).
- 2003 an increase in landfill tax to 370 SEK/t.
- 2005 a ban on the disposal of organic waste materials to landfill.
- 2005 the new national waste plan was launched.
- 2006 a third increase of the landfill tax to 435 SEK/t.
- 2006 Incineration tax. The use of waste as a fuel is taxed on the organic fossil carbon (12.5 % fossil carbon) content. Per tonne of fossil carbon the tax rates for the two elements are 150 SEK/t as energy tax and 3 374 SEK/t as carbon dioxide tax. CHP plants are excluded from the two new tax elements. The main purpose of the incineration tax is to favour material recycling and biological treatment of waste and if a thermal method is used electricity production is promoted.
- 2008 All active landfills need to fulfil the control program.

Of the listed policies above, the incineration tax, landfill tax and landfill ban are the most powerful tools to make changes to the waste management system.

MSW management in Sweden
Landfilling has decreased and material recovery, biological treatment and incineration for energy recovery have increased as a result of more sorting of waste at source and changes

[2] 10 SEK equal to approximately 1 €

in waste treatment. The quantity of energy and materials recovered has risen dramatically. These measures have also reduced the environmental impact of waste management. Greenhouse gas emissions have fallen and there has also been a general decrease in emissions of hazardous substances such as heavy metals and organic pollutants. But the environmental impact of the waste generated in Sweden could be further reduced by properly applying and reviewing existing rules and policy instruments. Further focus must be put on reducing the hazardous nature and the volume of the waste generated, learning more about toxic pollutants, helping households and enterprises to recycle and separate more of their waste, and increasing our participation in work on waste management within the EU.

MSW treatment methods in Sweden

The most important methods of waste treatment in Sweden are:

1. material recycling of packages, waste paper, tires, scrap metal and electronic waste etc;
2. biological treatment of organic waste fractions;
3. waste-to-energy by incineration;
4. landfilling.

Moreover, it is important that hazardous waste is collected and dealt with in a manner that is environmentally sound. Sweden is working in the long term towards reducing the amounts of hazardous substances that are used in all products that, eventually, become waste.

1. Recycling

A number of specific fractions are collected to be further used in the production of new products. In addition to the traditional material recycling large quantities of waste can be recycled at construction sites. Possible applications include structures at landfill sites, infilling works and road construction. The Swedish EPA is currently working on the development of criteria valid for waste recycling in construction.

2. Biological treatment

Biological treatment refers to the digestion or composting of readily decomposed organic waste, such as food waste, by the action of micro-organisms. Digestion takes place under anaerobic conditions and produces biogas and digestion residues. Composting, in contrast, requires the presence of oxygen and its products are carbon dioxide, water and compost. Compost and digestion residues can be used as fertilisers, soil products, and soil improvers, thus returning plant nutrients and humus to the soil. Biogas can be combusted to produce energy or upgraded for use as vehicle fuel. An increasing amount of waste is processed by digestion and composting, and environmental objectives call for further increases in the recycling of food waste.

The biological treatment of waste can release methane and nitrous oxide, which are greenhouse gases, and ammonia, which contributes to eutrophication and acidification. Leachate, mainly from composting, contains organics and nutrients and its release can cause eutrophication and offensive odours. The Swedish EPA has issued guidance on safety measures to be used in biological treatment to minimise impacts on the environment. Compost and bio-fertiliser plants can gain certification for the quality assurance of their products. Certification rules for compost and digestion residues have been issued by SP Swedish Technical Research Institute, setting standards for the entire waste management chain from waste feed to final use. As of the beginning of 2008, seven biogas plants (of 18) and two composting plants (of 24) had gained certification.

3. Waste-to-energy incineration

Even though growing quantities of waste are incinerated, emissions of dioxins and metals from incineration plants have been greatly reduced due to better cleaning of the flue gases and better incineration conditions. Another factor is the decreasing concentration of metals, including mercury, in the incinerated waste stream. The Swedish EPA is following a number of lines of research to further reduce the environmental impact of incineration.

Incineration, with energy recovery, using modern technology is a good way to recycle (by energy recovery) the combustible, non-recyclable waste. In 2006 the Swedish Riksdag imposed a tax on the incineration of household waste in order to encourage an increase in material recycling.

4. Landfilling

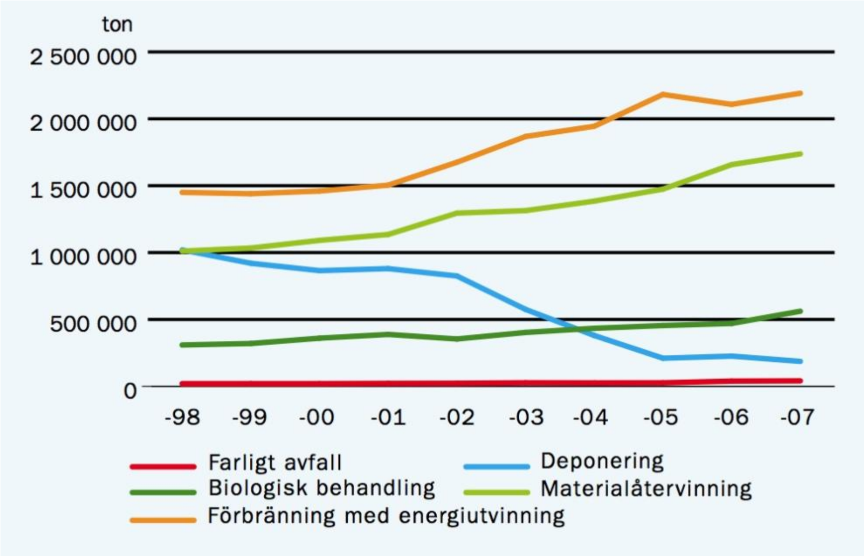
Landfills are required for waste fractions that cannot or should not be recycled or disposed by biological treatment or incineration. Moreover, there are several thousands of landfills in Sweden that are no longer in use. They may contain anything from mining waste to old domestic waste, including many pollutants that are a threat to human health and the environment. New legislation enacted in 2001 has tightened requirements on the landfilling of waste in Sweden.

Waste management today

Waste management today is far more resource-efficient and has less effect on the environment than it did ten years ago. The measures taken since the 1990s to achieve more resource-efficient use of waste have yielded results. More source separation and changes in waste treatment have reduced the amount of waste going to landfill. Of the 121 Mt of non-hazardous waste material produced in Sweden during 2006, 23% was material recycled (53 % if mining waste is excluded), 15% incinerated with energy recovery (35% if mining waste is excluded), 59% was sent to landfill (8% if mining waste is excluded). The majority of the waste material produced within the mining industry was sent to landfill, 62 of 70 Mt.

Figure 56 presents the annual MSW volumes treated by biological methods, incineration with energy recovery, material recycling and landfill between 1998 and 2007. Moreover the amount of collected hazardous waste is also presented in the figure, however the volumes are too low to be presented clearly in Figure 56.

Figure 56: Amount of MSW treated by incineration with energy recovery, material recycling, biological processes, landfill or collected as hazardous waste. Data is reported as annual tons treated between 1998 and to 2007. (Source: Swedish Waste Management Association, 2008)



A distinct increase in waste treated by incineration with energy recovery and material recycling is noticeable since 1998; meanwhile a drastic decrease of waste to landfill is observed at the same time. An increase in waste material recovered by biological methods is also noticeable since 1998, just not in the same quantities as incineration and material recycling.

<u>Some examples of key-figures presenting improvements in the MSW management:</u>

- The volume of MSW going to landfill decreased from 1,380,000 t in 1994 to 186,000 t in 2007.
- Landfilling of waste other than MSW has also decreased. Compared with 1994 the amount landfilled has reduced by 60% by 2006. This waste is now recovered by either material or energy recycling.
- By 2008 Swedish landfills must be converted for long-term safe disposal under EU requirements.
- Incineration with energy recovery produced heat equal to the annual consumption of 810,000 normal homes and electricity equal to 250,000 normal homes in Sweden.
- Emissions from waste incineration have been reduced by more than 90% despite a significant increase in the amount of waste incinerated.
- More than 1.7 Mt of materials were recycled from household waste in 2007, equal to more than double when compared with1996 figures.
- Recycling rates have been increasing continuously since 1994, when the materials recovery rate was around 40%. Recycling of packaging increased from 40% in 1994 to more than 70% in 2006.
- Recycling of paper remains unchanged at a high level of 91% - a level well above the target 0f 70%.
- No tyres are sent to landfill today.
- 85% of used cars are recycled.

- 16 kg/cap of electrical and electronic waste was collected in 2007.

On the other hand, the target of avoiding any increase in the amount of waste is not being met, with the volume of household waste growing by 28% from 1994 to 2006. A reduction in the amount of waste will require measures targeted at the production and consumption of products.

In 2007 totally 4,717,380 t, equal to 514 kg/person, of MSW was treated in Sweden. Table 21 below presents the treated amounts divided in treatment categories as well as the amount of energy recovered (when it is applicable).

Table 21: Treated MSW volumes in Sweden 2007. (Source Swedish Waste Management Association 2008)

Method/Class	Amount totally (tons)	Per person (kg/person)	Energy recovered (MWh)
Hazardous waste	40,880	4.5	-
Material recycling	1,737,720	189	-
Biological treatment	561,300	61.1	Vehicle gas: 112,860 Electricity: 1,230 Heating: 67,960 To natural gas[1]: 36,370
Incineration energy recovery	2,190,980	239	Heat[2]: 12,151,270 Electricity[2]: 1,482,750
Landfill	186,490	20.3	Heat: 267,000 Electricity: 23,000
Total	**4,171,380**	**514**	**14,142,440**

1) Biogas from biological treatment is delivered on the natural gas net.
2) Approximately 50% of the energy originates from incineration of waste material other than MSW such as industrial and imported waste material. This means that the energy from MSW could be estimated to be 5,955,052 MWh heat and 726,661 MWh electricity

In 2007, 30 waste incinerators with energy recovery were in use as well as 18 biogas plants and 24 composts facilities. In addition, 170 landfill sites were in operation in 2007, however 40 of these were closed by the end of the year.

Environmental impacts of MSW management

Waste management today is far more resource-efficient and has less effect on the environment than it did fifteen years ago. The impact of waste management on the environment has been mitigated, with lower emissions of climate-change gases and of generally hazardous substances such as heavy metals and toxic organic pollutants.

The environmental impacts of waste management are directly or indirectly relevant to a number of Sweden's 16 national environmental objectives. Table 22 presents the impact of waste management on the environmental objectives.

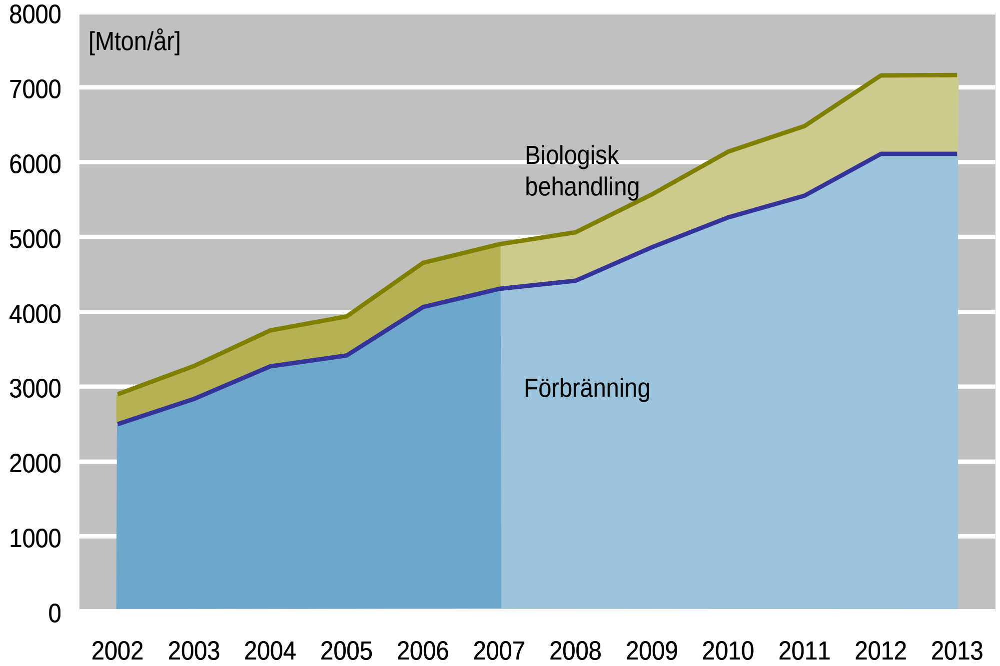
Table 22: Environmental impact of waste management on national environmental objectives, in % of Sweden's total emissions (2002). (Source Swedish EPA 2008)

Environmental objective	Gross contribution from waste management	Net contribution from waste management
Reduced climate impact	3%	No information available
A Non-Toxic Environment (Pb, Cd, Hg, dioxins released to air)	2 – 3%	No information available
Good built environment a. Consumption of energy sources	0.6%	-2.0%
Good built environment b. Consumption of non-renewable energy resources (coal, oil, gas, uranium)	0.8%	-0.1%
Zero Eutrophication (water and soil)	1.7%	0.7%
Natural Acidification Only (including nitrogen oxides and ammonia)	2.4%	0.8%
Clean air a. Nitrogen oxides	1.7%	-0.4%
Clean air b. Volatile organic compounds	1.3%	0.8%

Future MSW management in Sweden

The amount of waste that needs to be recovered in Sweden is unfortunately still increasing. Thus many Swedish communities are considering future investments in biogas plants and/or waste incinerators. Figure 57 below presents the treatment capacity, of today as well as a predicted capacity by 2013, of the two methods biological and thermal treatment.

Figure 57: Total treatment capacity of MSW within the two methods incineration and biological treatment. An estimation of the expansion from today until 2013 is also presented. (Source: Profu 2008)



The National Environmental Objectives state that by 2010, 35 % of food waste should be treated by a biological process. Today the treated amount is equal to only 17 %, thus rather important changes need to take place very soon if the objective is to be achieved. If we reach the goal of 35% biological treatment, and if it is treated in a biogas plant the estimated annual energy recovery is 470,000 MWh, and if 100% of the food waste is recovered in a biogas plant 1,350,000 MWh could be produced annually. These numbers should be compared with the annual production of 220 000 MWh today.

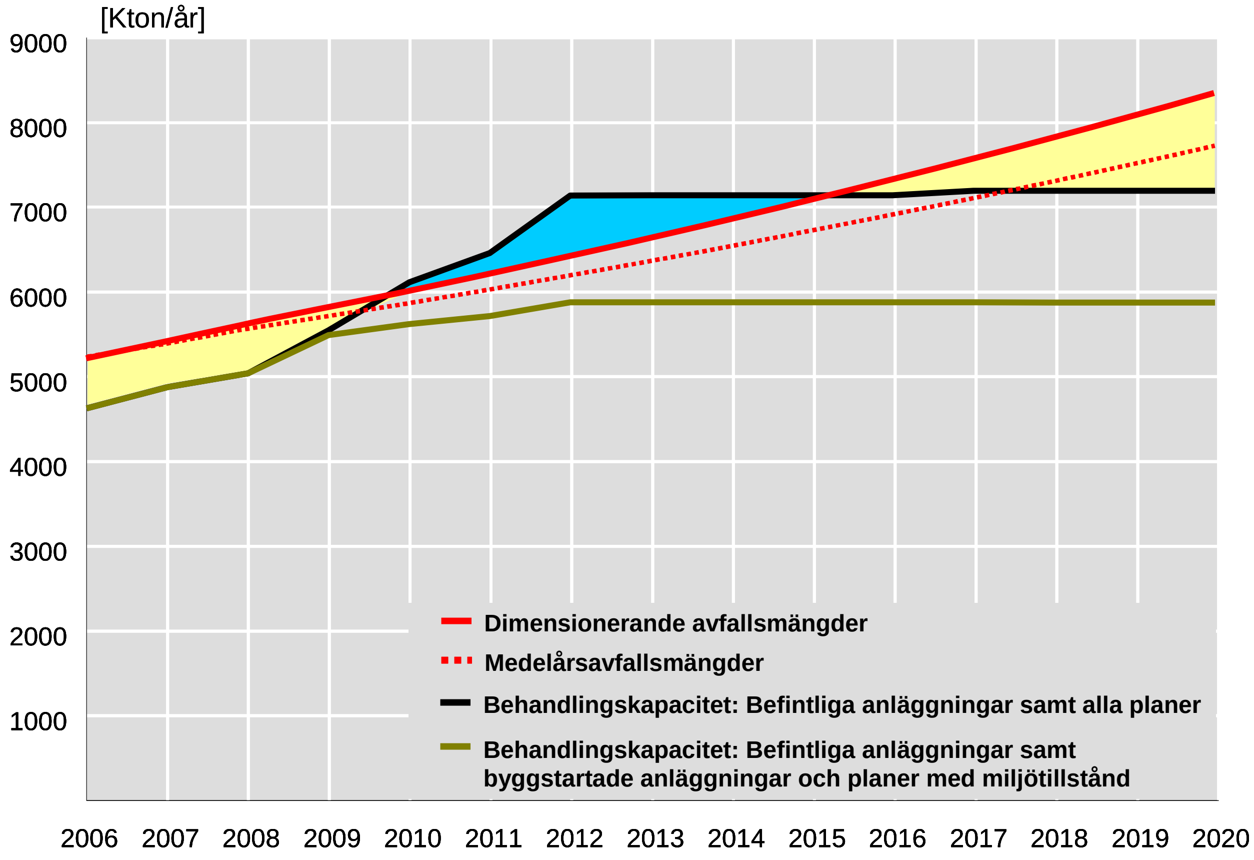
Table 23 below presents the planned expansion in MSW incineration plants in Sweden. In total an expansion of the treatment capacity of more than 2 Mt is planned, equal to approximately an expansion of approximately 50% compared to the treated amount (4.5 Mt) today. If all the planned plants are built, the estimated amount of annual energy production will be approximately 20,000,000 MWh.

Table 23 Existing MSW incineration capacity in Sweden the year of 2007 and the planned for year 2013. The communities marked with yellow have achieved the environmental approval meanwhile the blue is still in the planning process. The total capacity of treated waste is presented in annual tons. (Source: Profu 2008)

	2007	2013
Befintliga		
Avesta	50 000	50 000
Boden	50 000	80 000
Bollnäs	40 000	80 000
Borlänge	40 000	80 000
Borås	90 000	90 000
Eksjö	55 000	55 000
Finspång	30 000	30 000
Göteborg	430 000	520 000
Halmstad	162 000	162 000
Hässleholm	36 000	36 000
Jönköping	165 000	165 000
Karlskoga	43 000	43 000
Karlstad	50 000	50 000
Kiruna	60 000	60 000
Kumla	170 000	170 000
Köping	25 000	25 000
Lidköping	100 000	100 000
Linköping	366 000	380 000
Ljungby	55 000	55 000
Malmö	390 000	535 000
Mora	17 000	17 000
Norrköping	200 000	400 000
Skövde	50 000	50 000
Stockholm	520 000	760 000
Sundsvall	260 000	260 000
Umeå	160 000	160 000
Uppsala	375 000	375 000
Västervik	46 000	46 000
Nya		
Enköping	0	72 000
Helsingborg	0	120 000
Täby/Sörab	0	190 000
Uddevalla	0	98 000
Uddevalla	0	32 000
Åmotfors	0	51 000
Befintliga PTP		
Stockholm, PTP	170 000	170 000
Södertälje, PTP	100 000	175 000
Örebro, PTP	35 000	35 000
Nya PTP		
Västerås, PTP	0	400 000
Landskrona, PTP	0	50 000
Ängelholm, PTP	0	35 000
Örebro, PTP	0	50 000
Tidaholm, PTP	0	40 000
Totalt		
Planerad ny kapacitet med tillstånd		960 000
Planerad ny kapacitet utan tillstånd		1 152 000
Summa alla planer samt befintlig kapacitet		6 352 000

The effect of the expansion of the treatment capacity by incineration is presented in Figure 58. Currently there is a shortage of capacity within the Swedish market (marked with yellow in the figure) and this will continue, even if all the plants with environmental approval (green line in the figure) are built. However, if all plants in planning are built a surplus (marked with blue in the figure) of capacity will be available for some years.

Figure 58: Amount of waste (kt) available for incineration on the Swedish market from today and predicted capacity the year of 2020 (two red lines)



The black line shows the treatment capacity if all existing plants and all planned are built. The dark green line shows the capacity if all existing plants and the one with environmental approval will be built. (Source: Profu 2008).

UK

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The municipal solid waste resource in England

This report:

- provides a summary of the national policy/strategy on waste management and energy from waste;
- summarises the data on the historical arisings and management of MSW;
- briefly discusses the factors affecting waste growth, and estimates the MSW arisings in 2020;
- assesses the potential for increasing the amount of energy which is recovered from MSW in England.

National policy/strategy

The European Union has been the major source of environmental legislation and guidance in relation to the management of waste in the UK, but, following the publication of a report[3] on climate change in 2006, current policy initiatives for both waste management and supply of energy are placing more emphasis on reducing greenhouse gas emissions.

Waste policy

The main area of European legislation that UK waste policy has to meet is the Landfill Directive. This aims to prevent, or minimise, the negative effects on both the environment and human health caused by landfilling of wastes. It will require the amount of biodegradable municipal solid waste sent to landfill in the UK to be reduced:

- to 75% of 1995 levels by 2010 (the UK has a four year derogation);
- to 50% of 1995 levels by 2013; and
- to 35% of 1995 levels by 2020.

Table 24 shows the Landfill Directive targets (tonnes of biodegradable waste) for the UK.

Table 24: Maximum tonnages of biological municipal waste (BMW) that can be landfilled

	2010	2013	2020
UK	13,700,000	9,130,000	6,390,000
England	11,200,000	7,460,000	5,220,000
Scotland	1,320,000	880,000	620,000
Wales	710,000	470,000	330,000
Northern Ireland	470,000	320,000	220,000

England landfilled 9.3 Mt of BMW in 2008/09. This is 40% less than was land filled in 2001/2. England has also increased its MSW recycling rate from 12% in 2000 to 37.6% in 2008/09, and further increases in recycling rates should enable it to meet the 2010 target. Investment is also being made in the additional treatment facilities required to meet the 2013

[3] Stern report - The Economics of Climate Change. October 2006

target, but delays (current economic situation affecting financial approval and obtaining planning approval) may impact on delivery of the 2013 target.

The UK Government has implemented the requirements for landfilling of biodegradable waste through the Waste and Emissions Trading Act 2003. This sets Waste Disposal Authorities annual allowances limiting how much biodegradable municipal waste (BMW) can be landfilled in any particular year, with effect from April 2005. The Government will fine Authorities that do not achieve their annual targets, but this legislation will allow Authorities to buy allowances from other Waste Disposal Authorities if they expect to landfill more than their allocations and sell their surplus if they expect to landfill less than their allowance.

The main area of national legislation is the Landfill Tax Regulations. Landfill Tax is a tax payable for each tonne of waste sent to landfill and was introduced by the Government in 1996 as a way of encouraging more sustainable means of waste management through recognising the hidden financial effects of the environmental impact of landfill. The landfill tax, which is currently £40/t, is increasing at a rate of £8/t each year, and will continue to increase at this rate until 21013/14 when the tax will be £72/tonne. This increase in landfill tax will cause a significant increase in waste disposal costs and will provide a further incentive to move to more sustainable means of waste treatment in the near future.

Although most waste legislation in the UK has been introduced to meet the requirements set by European Directives, the UK Government has also introduced additional legislation, some of which is specifically aimed at encouraging recycling.

Waste strategy

The Government first published a national waste strategy in 2000. The Prime Minister's Strategy Unit reviewed the progress towards the targets set within Waste Strategy 2000 in 2002. The report suggested that 'Waste Strategy 2000' may not be sufficient to move waste onto a more sustainable footing and the Government established the Waste Implementation Programme to address the recommendations made by the Strategy Unit.

An updated waste strategy[4] was published (following consultation during 2006) in May 2007. The aim of the Waste Strategy for England 2007, which sets the Government's vision for sustainable waste management, is to reduce waste by making products with fewer natural resources, breaking the link between economic growth and waste growth. Products should be re-used, their materials recycled, energy from waste recovered, and landfilling of residual waste should occur only where necessary. The key objectives are to:

- decouple waste growth (in all sectors) from economic growth and put more emphasis on waste prevention and re-use;
- meet and exceed the Landfill Directive diversion targets for biodegradable municipal waste in 2010, 2013 and 2020;
- increase diversion from landfill of non-municipal waste and secure better integration of treatment for municipal and non-municipal waste;
- secure the investment in infrastructure needed to divert waste from landfill and for the management of hazardous waste;
- maximise the environmental benefit from that investment through increased recycling of resources and recovery of energy from residual waste using a mix of technologies.

The main points of the waste strategy are:

[4] Waste Strategy for England 2007. Defra, May 2007

- A strong emphasis on waste prevention with householders reducing their waste (for example, through home composting and reducing food waste) and business helping consumers, for example, with less packaging. There will also be a new national target to help measure this.
- More effective incentives for individuals and businesses to recycle waste, leading to at least 40% of household waste recycled or composted by 2010, rising to 45% by 2015 and 50% by 2020. This is a significant increase on the targets (30% by 2010 and 33% by 2015) in the previous waste strategy (which was published in 2000).
- Plastics and aluminium - proposals for higher packaging recycling requirements beyond the 2008 European targets to increase recycling (because of savings in carbon dioxide emissions).
- Increasing the amount of energy produced by a variety of energy from waste schemes, using waste that can't be reused or recycled. It is expected that from 2020 a quarter of municipal waste - waste collected by local authorities, mainly from households - will produce energy, compared to 10% in 2006.
- The Government continues to examine ways in which the diversion of degradable and recyclable materials from landfill can be achieved. It has announced a consultation on the potential ban of certain materials (including combustible materials) from landfill. In addition it is looking at the potential for greater convergence in policy between commercial and industrial waste and MSW and the potential to change the landfill tax to increase the level of tax for some ash materials.

Other measures include:

- Removing the ban on local authorities introducing household financial incentives for waste prevention and recycling, through early legislative change so local authorities would have the option to introduce revenue-neutral schemes (potentially reducing annual residual waste landfilled by up to 15% – equivalent to 1.5 Mt or 130 kg/household).
- Government will work with the Direct Marketing Association to develop a service so that people will be able to opt-out of receiving unaddressed as well as addressed direct mail. The Government is also considering moving towards an approach where people would only get direct mail if they opted in by placing their name on the direct mail register.
- Government will work with retailers to reduce the use of free single use bags. This could involve retailers only selling long-life bags, or retailers charging for disposable bags and using the proceeds to sell long-life bags at a discount.
- Recycling extended from the home and office to public areas by providing recycling facilities in shopping malls, train stations and cinema multiplexes, so that recycling becomes a natural part of everyday life.

The Government has also stated that it intends to consult on the possible introduction of further reductions in the amount of biodegradable waste that is landfilled (this could result in similar legislation to that already existing in a number of European countries, such as Germany and Sweden). It announced in October 2009 that there will be a consultation during 2010 on banning the landfilling of food waste, cans, paper, glass and wood waste.

Renewable energy policy

The UK Government published an updated energy strategy[5] in May 2007. The use of renewables is a key part of this strategy to tackle climate change and deploy cleaner sources of energy. There is currently a target that aims to see renewables grow as a proportion of UK electricity supplies to 10% by 2010, with an aspiration for this level to double by 2020.

[5] Meeting the Energy Challenge. A White Paper on Energy. May 2007

The Renewables Obligation (RO) is the main mechanism for incentivising this growth, and government subsidies (known as renewable obligation certificates (ROCs)) are paid to power generators for every unit of renewable energy produced.

The UK Government recognises that generating energy from that portion of waste that cannot be prevented, reused or recycled has both energy and waste policy benefits. It also recognises that the biodegradable fraction of waste is a renewable resource, and that energy generated either directly from waste or through the use of a refuse-derived fuel has benefits for security of supply.

The white paper proposes making energy-from-waste incineration plants eligible for ROC subsidies if they produce combined heat and power (CHP), rather than electricity only. The biomass element of waste fuel will qualify for one ROC for every unit of energy (MWh) that CHP plants produce. However, established technologies like landfill gas power generation and the co-firing of non-energy crop biomass will see a drop in their ROC subsidies to just 0.25 ROCs per MWh.

The UK Government is supporting emerging technologies for renewable power generation by offering them two ROCs per MWh. This includes 'advanced conversion technologies' such as anaerobic digestion, gasification and pyrolysis plants. The energy white paper highlights the Government's intention to support anaerobic digestion, stating that: "Anaerobic digestion is an emerging technology which is currently under-developed in the UK. It offers the potential to generate renewable energy – not only electricity, but also heat and fuel – from manures and slurries and certain organic wastes such as food waste, whilst at the same time mitigating methane emissions from agriculture and landfill." The Government will also be investing £10 million to support the anaerobic digestion sector.

Other relevant policy initiatives

The aim of the Waste Implementation Programme (WIP) is to drive waste management solutions up the waste hierarchy, and thus improve the sustainability of waste management. Two of the activities in this programme are:

- the new technologies work stream – this focuses on the biodegradable element of municipal waste. It aims to overcome the barriers to the successful development and take-up of proven and near market waste technologies by providing a comprehensive package of support to local authorities and their stakeholders.
- the demonstrator programme – this will provide up to £30 million of assistance to set up new waste treatment technology demonstration projects. The programme is intended to overcome the possible risks of introducing alternative technologies in England through the provision of accurate and impartial technical, environmental and economic information to key decision-makers in local authorities and the waste industry in general.

The Government also provides a financial incentive to energy recovery from waste through the Enhanced Capital Allowances (ECA) scheme. This specifically supports both advanced thermal conversion technologies and technologies for use of secondary recovered fuels (RDF).

Current situation

This section initially discusses the definition of MSW in the UK. It then presents historical data on the arisings and management of MSW in England, and lists (not exhaustively) residual waste facilities (primarily EfW) that are either in operation, under construction or proposed.

Definition of municipal waste in the UK[6]

The principal waste streams are:

- Household waste - includes waste from household collection rounds, dry recyclables collected through banks or kerbside collections, bulky waste collections, hazardous household waste collection, garden waste collections, and waste from services such as street sweeping, litter and civic amenity sites. The definition also covers waste from schools.
- Commercial waste - waste arising from wholesalers, catering establishments, shops and offices.
- Industrial waste - waste arising from factories and industrial plants. The UK definition of industrial waste does not include construction and demolition waste.
- Construction and demolition waste - waste arising from the construction, repair, maintenance and demolition of buildings and structures.

Municipal waste arisings in the UK include all wastes under the control of local authorities or agents acting on their behalf, which means all household waste, municipal parks and garden wastes, and council office waste. It also includes any waste collected by local authorities from businesses.

The Government issued a consultation paper on the definition of municipal waste in 2007, and a further consultation was issued in 2009. Changes to the definition of MSW are likely to be introduced by April 2010, and the main change will be the exclusion of separately collected construction waste

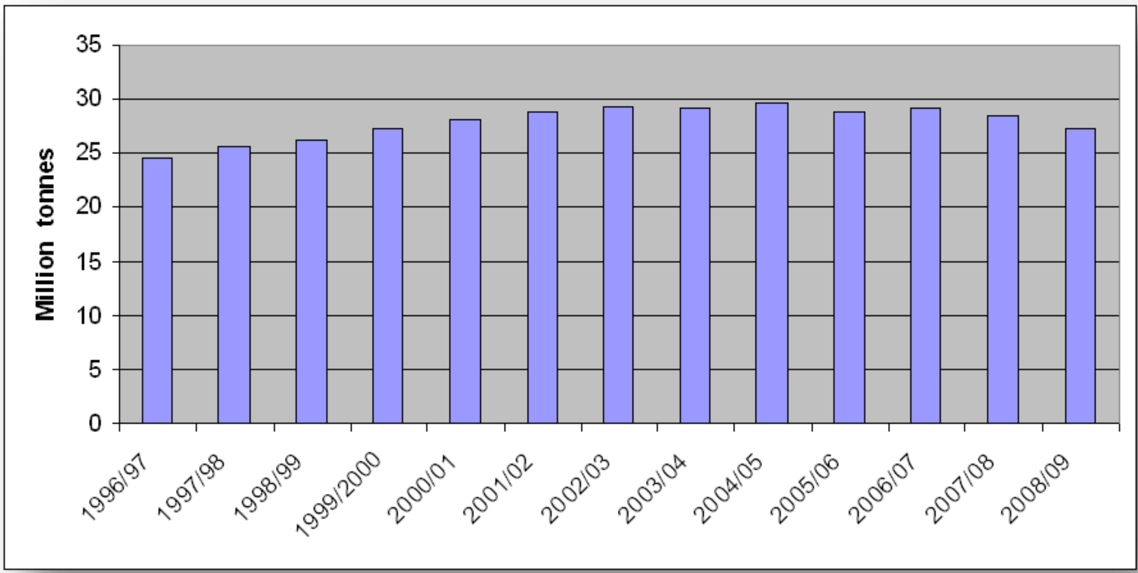
The main difference between the arisings of MSW in the UK and the arisings of MSW in other countries is that the amount of business waste collected as part of the MSW stream is much lower in the UK. In many other countries, the definition of MSW includes commercial and industrial waste of a similar composition to household waste. However, in the UK, businesses are expected to make their own arrangements with private sector waste management companies for the collection, treatment and disposal of their waste. Local authorities in the UK can compete in this sector, but only collect a small fraction of this waste, mainly from smaller shops and trading estates. Some local authorities in the UK are reducing the amount of business waste that they collect because this additional waste can make it more difficult to meet targets for landfilling of biodegradable waste. However, in the light of proposed changes in the definition of MSW mentioned above, this situation may change.

[6] As mentioned above following discussion with the EU the UK is revising its interpretation of the definition of municipal waste. The definition will include all biodegradable waste from commercial, industrial and institutional waste that is similar to municipal waste. (see: http://www.defra.gov.uk/environment/waste/strategy/legislation/landfill/targets.htm). In practice this will mean that the amount of waste classed as MSW will increase significantly.

Historical MSW arisings in England

Figure 59 shows that the arisings of MSW in England increased from 24.6 Mt in 1996/97 to 29.4 Mt in 2002/03. This represents an average growth rate of about 3% per year, which is similar to growth in GDP. However, there has been little growth in arisings since then, and the overall arisings of 27.3 Mt in 2008/09 were lower than the arisings of 28.1 Mt in 2000/01.

Figure 59: MSW arisings (Million t) in England 1996/97 to 2008/09

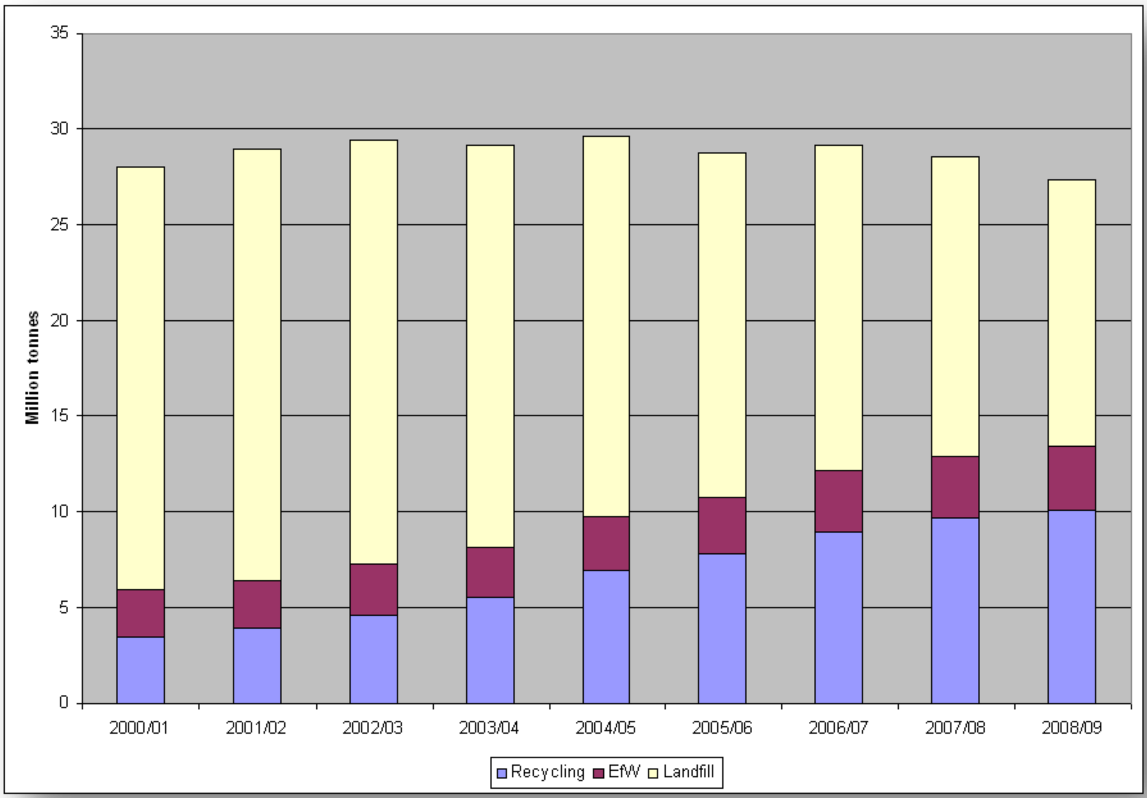


Although MSW arisings grew at an average of 3% per year from 1997/98 to 2000/2001, the average rate of growth since then is now averaging less than 1% per year. There are a number of possible reasons for the lower growth rate since 2002/03:

- Waste minimisation campaigns, but these usually take at least five years to show any noticeable effect.
- Lower arisings of garden waste collected due to a combination of drier summers and an increase in the amount of material that is home composted.
- Restrictions placed on the types of waste taken to the household waste recycling centres.

Figure 60 shows how MSW has been managed in England since 2000/01. The recycling (including composting) rate has increased from 12% in 2000/01 to 37% in 2008/09, and the amount of MSW sent to EfW facilities increased from 2.4 Mt in 2000/01 to 3.32 Mt in 2008/09.

Figure 60: Management of MSW in England



The household waste recycling rate, rather than the MSW recycling rate, is usually reported for the UK. The household waste recycling rate is based on arisings of household waste, and the materials which can be included in the tonnage of household waste which can be recycled exclude both source separated construction & demolition waste arisings at a civic amenity (public recycling and disposal) site, and any bottom ash from EfW facilities which is recycled. A compost product can only be classified as being recycled if it has a beneficial use (a low quality compost used as a soil improver is classified as recovery, but not recycling). The household waste recycling rate achieved in England in 2008/09 was 38%.

Table 25 shows that the MSW arisings of 27.3 Mt in 2008/09 represented an average arising of 532 kg/person/y.

Table 25: MSW arisings in England in 2008/09

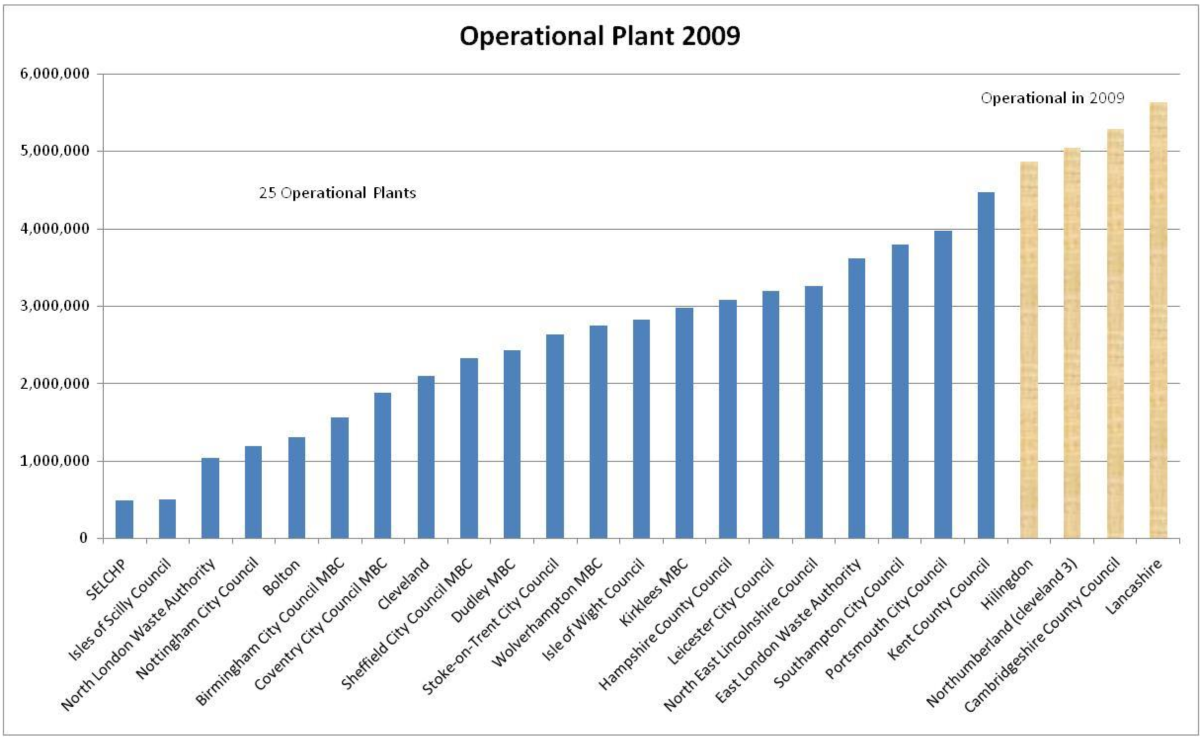
	MSW arisings
Tonnage ('000 tonnes)	27,333
kg/person/year	532
kg/household/year	1,205

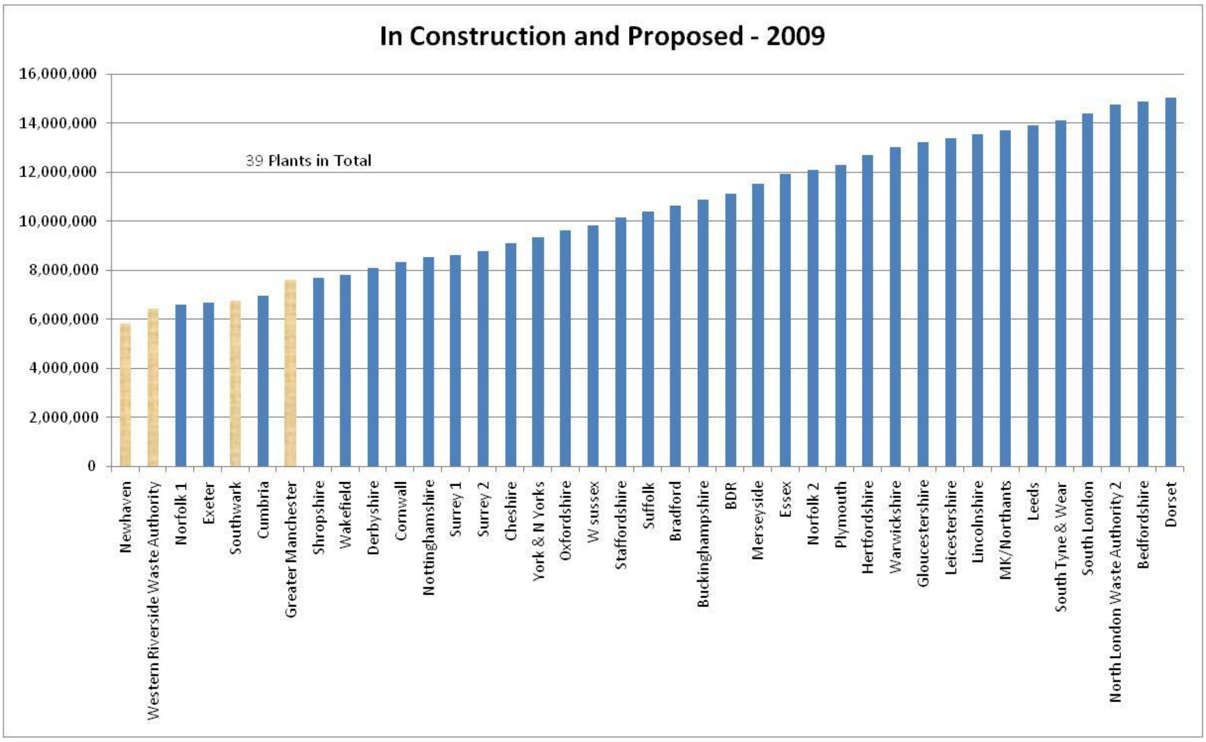
The total MSW recovery (recycling/composting and waste sent to an EfW facility) rate increased from 21% in 2000/01 to 49% in 2008/09. This was mainly due to the increase in the amount of waste which was either recycled or composted.

Figure 61a shows the operational residual waste treatment plants (primarily direct EfW) operational as at 2009; 25 operational facilities with a combined throughput capacity of about 5.5 million tonnes. As Figure 61b shows there are a further 39 facilities at various stages of development – four in construction and the others either progressing planning, in procurement, or in pre-procurement development. Given the difficulties in development (particularly in securing planning) it is unlikely that all of the listed facilities will actually progress to the operational phase but it does demonstrate the total additional capacity that might be developed (in excess of 8 million tonnes) if all of the facilities were delivered.

In terms of energy generating capacity the operational plant equates to about 400 MWe (or assuming 50% renewable component then 200 MWe of renewable energy). There is therefore the potential to increase this to over 1,000 MWe (500 MWe renewable) in the period up to 2020.

Figure 61a & 61b: Energy from waste capacity





A survey[7] of commercial and industrial waste arisings conducted in England in 2002/03 identified that the total arisings were 68 million tonnes (30 million tonnes of commercial waste and 38 million tonnes of industrial waste). 45% was recycled, 44% was landfilled, and less than 5% was sent to an energy recovery facility.

Future MSW arisings

Historically, waste arisings have been shown to grow in line with, or even above, the level of economic growth. Consequently, if this trend continues, a 3% p.a. growth in waste would result a doubling of waste arisings in 20 years. However, the continuation of this trend is now considered to be unsustainable, and thus the sixth Environment Action Programme set an objective to achieve a decoupling of resource use from economic growth through significantly improved resource efficiency, dematerialisation of the economy and waste prevention.

A European study[8] has assessed the factors affecting household consumption, and the effects on the environment (resource use, energy use and waste). Another European study[9] developed a model which assesses the effects of food, recreation, 'infotainment', care, clothing, and housing on waste growth and used this to model four scenarios which all assumed continued economic growth but had different future lifestyles. The results showed that waste continued to grow, with some lifestyles resulting in waste growth rates which could be considerably higher than the GDP growth rate, and other lifestyles resulting in waste growth rates which were lower than GDP growth rates.

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[7] Strategic waste management information 2003. Environment Agency, 2006.
[8] European Environment agency 2005. Household consumption and the environment. European Environment Agency Report 11/2005.
[9] European Commission 2003. Scenarios of household waste generation in 2020. Report by Joint Research Centre for the European Commission, June 2003.

Data[10] on MSW arisings from a number of European countries from 1997 to 2003 indicate that in some countries (e.g. Belgium and the Netherlands) waste arisings are growing more slowly than GDP growth. The data also suggest that countries that have higher MSW recycling rates are also seeing lower growth rates in MSW arisings; this may be because the impacts due to many years of publicity/education information on waste awareness and recycling are now becoming noticeable. However, this trend does not appear to be evident in either France or Germany.

There are a number of predictions for future MSW arisings in England:

- A model[11] which assesses the impact of lifestyle changes on household waste arisings in the UK. This model has a base case scenario in which waste quantities grow at an average of over 2% per year from 2005 to 2020.
- A model[12] which predicts future waste arisings based on national waste strategies and the need to meet various legislative targets. This model has a base case growth rate of over 2% per year from 2005 to 2020.

These models predict average growth rates of between 1% and 2% per year, and Waste Strategy 2007 developed four growth scenarios for MSW in order to assess a range of possible future outcomes to 2020:

1. 2.25% per annum reflecting recent trends in growth in consumer spending;
2. 1.5% per annum in line with national waste growth in the five years to 2004/05;
3. 0.75% per annum, in line with current projections of household growth and reflecting more closely national waste growth in the five years to 2005/06; and
4. 0% growth, representing the possibility that waste growth will be decoupled from household and economic growth.

It is unlikely that scenario 4 (0% growth) will occur due to Government policy regarding future house building, and it is also unlikely that scenario 1 (2.25% growth) will occur due to the emphasis on future waste minimisation in the new national waste strategy. Consequently, an average growth rate of 1% per year is frequently used to predict future waste arisings (this reflects the growth rates used in scenarios 2 and 3).

Figure 62 shows that an average growth rate of 1% per year would increase the arisings of MSW to 33.3 Mt per year by 2020 (an average growth rate of 2% per year would result in MSW arisings of 38.7 Mt by 2020).

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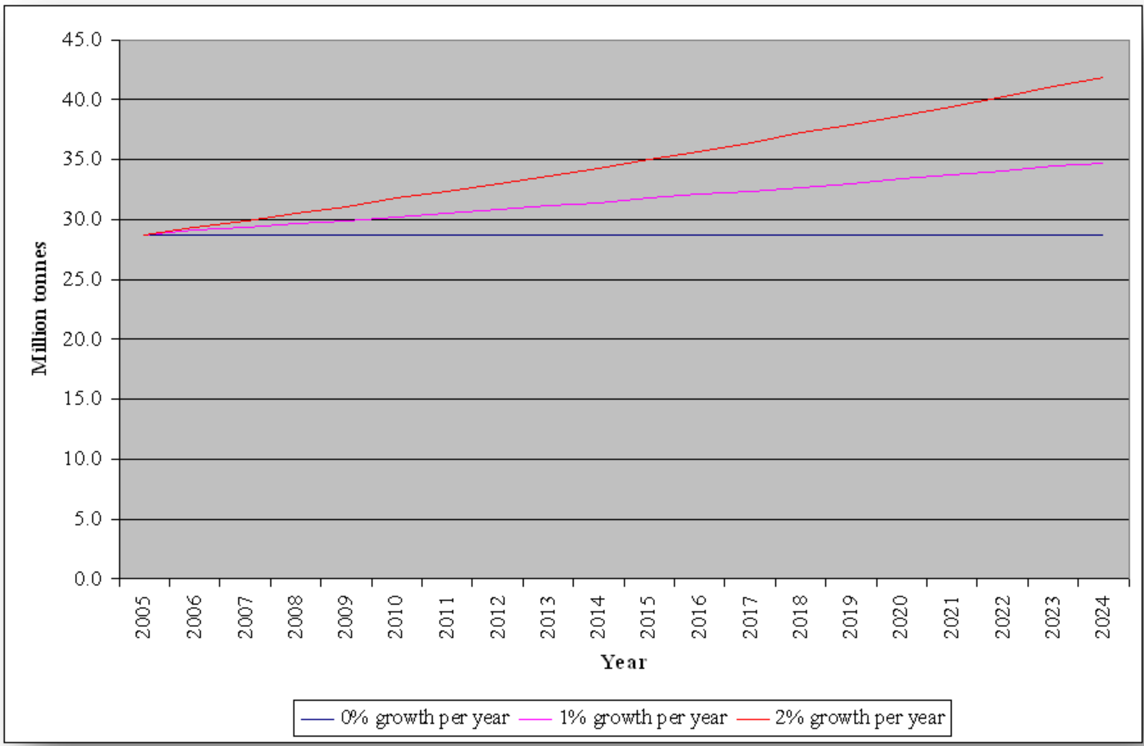
[10] Eurostat - ec.europa.eu/eurostat

[11] Future Foundation 2006. Modelling the impact of lifestyle changes on household waste arisings in the UK. Report by the Future Foundation and Social Marketing Practice for Defra 2006.

[12] Oakdene Hollins 2005. Quantification of the Potential Energy from Residuals (EfR) in the UK. Report by Oakdene Hollins for The Institution of Civil Engineers and The Renewable Power Association, March 2005.

Figure 62: Projected MSW arisings in England



Future energy recovery potential

The Landfill Directive will require England to landfill a maximum of 5.2 Mt of biodegradable waste in 2019/20 (this is equivalent to about 8 Mt of landfilled MSW).

The Waste Strategy sets a target of recycling 50% of household waste by 2020. As household waste represents a high proportion of MSW, it is likely that this will equate to a 50% recycling rate for MSW. The projected arisings of MSW in 2020 are 33 Mt, and if the 50% recycling rate is achieved, the arisings of residual waste in 2020 will be about 17 Mt/y.

The amount of waste that will need to be recycled in order to meet this target will include waste which is composted. The collection of a significant tonnage of food/kitchen waste will be required in order to achieve the 50% recycling target, and whilst the Animal By-Products Regulations (ABPR) require these to be treated using either in-vessel composting or anaerobic digestion (AD), the Government has, through the waste strategy, indicated its preference for AD because of its potential for energy generation. This could result in a minimum of 1 Mt of MSW sourced food/kitchen waste being treated in AD plants.

If 17 Mt are recycled (the 50% recycling rate is achieved), and the maximum permitted tonnage of 8 Mt of MSW is landfilled (this figure includes reject streams from MBT plants), then a further 8 Mt will need to be diverted from landfill. Although this waste could be composted in order to reduce its biodegradable content to a very low value, and thus stabilise it, Government policy initiatives are much more likely to result in energy being recovered from it. This figure of 8 Mt is likely to be a minimum as the amount of waste will continue to grow during the typical 25-year lifetime of a treatment plant, and this suggests that the potential amount of waste in England from which energy would be recovered in 2020 is likely to be between 9 Mt and 10 Mt/y (see Figure 61b).