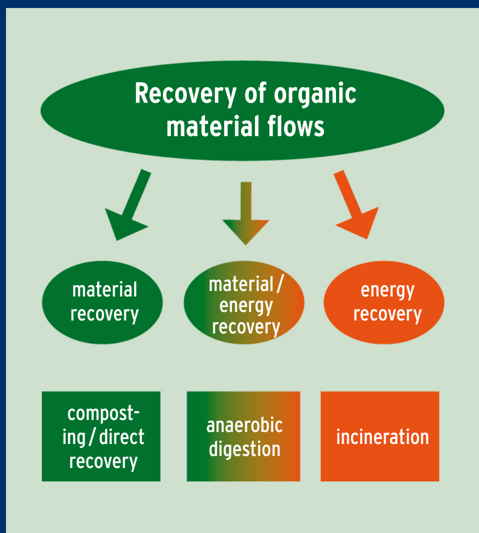
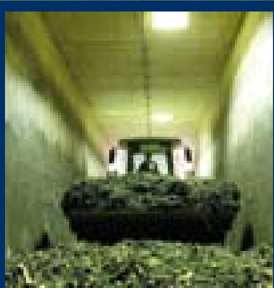
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

Umwelt Bundes Amt
For our Environment

Ecologically sustainable recovery of bio-waste

Suggestions for policy-makers at local authorities





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1 PREFACE

Germany already excels in the separate collection of bio-waste and its recovery: on average more than 100 kg of bio-waste and green waste are collected separately per person and year, which translates into a total annual amount of around nine million metric tons.

Until a few years ago, large quantities of these materials were still deposited in landfills as part of the residual unsorted waste. However, biodegradable waste at landfill sites was the key factor in the generation of greenhouse gases attributable to waste management. The turning point with regard to the waste management sector's climate impacts was reached with the separate collection of bio-waste and the removal of the remaining biodegradable elements in the residual waste through pre-treatment: the annual emissions of greenhouse gases, expressed in CO_2 equivalents, have been reduced by approximately 56 million metric tons compared with 1990 levels. That represented almost 25 percent of the total reduction in emissions of greenhouse gases achieved in Germany until 2006.

In addition, composts made from separately collected bio-waste and digestates provide an excellent opportunity to stabilise or improve the humus content of soils and to promote biological activity. Composts or composted digestates also make superb peat substitutes.

Environmental life-cycle assessments conducted in recent years have shown that optimised recovery of bio-waste can contribute yet further to protecting the climate and conserving resources.

Rotting tunnel at a composting facility

The future consequence will be that suitable bio-waste will be more used for producing energy. The new German Renewable Energy Sources Act (EEG 2012) is supporting this development with its Section 27a, which establishes specific regulations governing bio-waste. Under the Act, if electricity is generated by facilities using biogas produced by anaerobic digestion of bio-waste this electricity attracts a higher subsidy rate than if the biogas is produced by digesting other types of biomass. The precondition to this preferential treatment is that the anaerobic digestion facility is connected to a following composting stage. However, not all bio-waste is suited for anaerobic digestion or incineration, so that the exclusive composting of bio-waste without energy recovery will also continue to play an important role in the future.

In order to provide guidance in optimising bio-waste collection and use especially for local policy-makers, this booklet sets out the potential in bio-waste and the technical processes currently available for using the various categories of bio-waste. Furthermore, with the aid of a checklist local policy-makers can estimate whether optimising bio-waste recovery is practical in terms of increasing the amounts collected or the quantity of energy generated on site.

This booklet is partly based on the results of a study commissioned by the German Federal Ministry for the Environment (BMU) and the Federal Environment Agency (UBA). Although the booklet is aimed predominantly at users in Germany, it should be pointed out that the Ministry for the Environment has also set itself the task of boosting the concept of ecologically sustainable recovery of bio-waste in other countries. Also for this reason the ministry has strenuously pursued the aim of an EU bio-waste directive.

Already in May 2006 the political debate about the need for an EU bio-waste directive was restarted on Germany's initiative. The drive towards a discrete regulation for bio-waste gained strong political support from several Member States.

As a result of this alliance, a discrete Article of the EU Waste Directive 2008/98/EC commits Member States to promote the separate collection and recovery of bio-waste. The European Parliament also recognised the opportunities provided by bio-waste earlier on and is supporting EU-wide regulation of the recovery of separately collected bio-waste. Although there are hardly any other fields of climate and environmental policy where so much climate and environmental benefit can be achieved with relatively little expense, the European Commission still has no plans to formulate a specific EU bio-waste directive. Nonetheless, the Commission is actually moving ahead in this important sector of waste management. In its "Communication to the Council and the European Parliament on future steps in bio-waste management in the European Union" of May 18th 2010 it has set out an ambitious vision for the optimisation of bio-waste collection and recovery.

2 INTRODUCTION

The German government is aiming to reduce emissions of greenhouse gases in Germany, until 2020 at the latest by 40 percent against 1990 levels. This is a target that can only be reached by means of a sustainable energy sector – based on energy reduction, renewable energy generation and efficient energy use. In view of this ambitious target it is important to examine how waste management and within it also bio-waste can provide a further contribution to meeting the targets of resources, energy and climate in the future.

Waste management is already providing a substantial annual contribution to meeting climate targets with a reduction in emissions by approximately 56 million metric tons of CO_2 equivalents per year compared to 1990 levels. This has also been achieved by the waste separation in households that has been established more than two decades ago. The system of separate collection and treatment of bio-waste and green waste is one of the most advanced in Europe.

In the context of further efforts to produce renewable energy, for example from energy plants, whose cultivation is sometimes in competition with food and fodder production, combined material and energy recovery from bio-waste and green waste is now of particular interest.

Sustainable management of biogenic material flows combines material and energy recovery paths with the aim of optimising the integration of nutrients and carbon recycling, energy production, CO_2 reduction by replacing fossil fuels and cutting the demand for peat, as well as lower treatment costs with the expansion of local value added. What form optimised collection and recovery of bio-waste can take, what additional potential exists, the investments required

Whether energy crop or bio-waste, the material and energy recovery paths are similar.

Lawn cuttings as source material for compost of high quality

and how the benefits relate to the costs have become key questions for waste management, which are presented in this document.

It is not a question of seeking to promote particular processes such as composting, anaerobic digestion or thermal treatment, but of tapping the potential for use of each bio-waste type as far as possible and to that end employing the optimum combination of processes in each case.

In 2007 the German Advisory Council on the Environment (SRU) established that every year around 100 million metric tons of "biomass residues", i.e. bio-waste and similar materials are generated in Germany from areas such as forestry, agriculture or sewage and waste management. Of this about 65 percent could be technically and ecologically useful. This has a potential of four to five percent of the country's primary energy requirement. High priority should be given to exploiting this potential, a major proportion of which falls within the sphere of responsibility of local authorities.

The Federal Ministry for the Environment (BMU) already stressed in its discussion paper on ecological industrial policy (2008) the importance of expanding bio-waste collection and the use of this resource as a tool in the interest of climate change.

The EU Waste Framework Directive of December 2008 also underscores the need to make better use of bio-waste. The Directive prescribes in Article 22 that Member States shall take appropriate measures to encourage the separate collection of bio-waste with a view to their composting and anaerobic digestion.

The BMU has turned the EU Waste Directive 2008/98/EC into German law by means of the amended Closed Substance Cycle and Waste Management Act (KrWG) of February 24th 2012. The pivotal element of the new Act is the five-tier waste hierarchy given by the EU Waste Framework Directive: prevention; preparing for re-use; recycling; other recovery, e.g. energy recovery; and disposal. In future German waste management legislation will give more priority to recycling. In addition, the Act provides various measures designed to boost material recovery overall.

To that end, Article 11 (1) KrWG stipulates that, as a matter of principle, separate collection of bio-waste is to be mandatory from January 1st 2015 onwards. Further provisions can be established by statutory ordinance. These can determine, for instance, which wastes are to be considered bio-waste, which standards are to apply to separate collection and to treatment, and which criteria are to govern bio-waste recovery. Furthermore Article 12 KrWG establishes further quality assurance requirements applicable to bio-waste recovery processes, in order to ensure that such recovery follows proper procedures and causes no harmful impacts.

Anaerobic digestion plants

CASE STUDY: MUNICH WASTE MANAGEMENT COMPANY

Since the early 1990s AWM, the Munich municipal waste management company has led the field in sustainability and climate protection with an environmentally oriented concept for reducing and recovering waste.

Central to this is the universal separate collection of bio-waste. Since the introduction of the bio-waste bin the amounts collected have risen steadily, partly as a result of intensive publicity, to around 42,000 metric tons in 2011. Furthermore roughly 15,000 metric tons of garden waste can be added that has been deposited at citizens' recycling centres.

From compost heap to hi-tech facility

In the early years the main recovery path for bio-waste was via conventional composting plants. In 2003 an anaerobic digestion stage (dry fermentation by batch process) was added, which was expanded to a recovery capacity for around 25,000 metric tons of bio-waste by 2008. The aim was to have an ultra-modern process for the production of biogas as a climate-friendly fuel prior to the composting facility.

Clean energy for 1,000 households in Munich

The biogas obtained is used in the integrated cogeneration plant to produce electricity and process heat and is sufficient to provide electricity to 1,000 Munich homes all year round.

Premium potting soil for everyone in Munich

AWM uses the digestates – around 18,000 metric tons a year – to make 8,800 metric tons of compost, which is used in horticulture and to manufacture seed compost and premium potting soil. What is especially pleasing about the introduction of premium potting soil from Munich is the realisation of a cycle concept: the people of Munich bring their garden waste to the recycling centre and can take ready-made potting soil home with them.

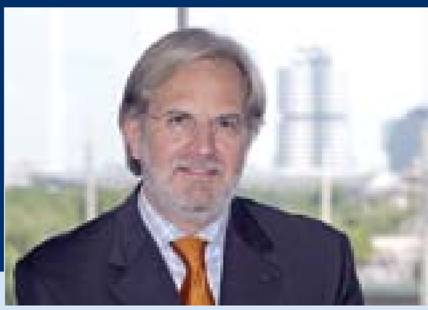
AWM's overall contribution to climate protection

The dry anaerobic digestion plant in Munich is an example of the use of innovative technologies in the recovery of bio-waste.

With the subsequent implementation of the environmental waste management plan AWM has in the last ten years succeeded in making a significant contribution to CO_2 reduction and thus to cutting greenhouse gases. The encouraging outcome of this is that municipal waste management in Munich is contributing to greenhouse gas limitation with 822,000 metric tons of CO_2 equivalents annually. That equates roughly to the global warming potential caused by around 62,000 residents in one year.

Municipal waste management and sustainability

"With this result AWM proves beyond doubt that the environment and the economy complement each other admirably, and precisely in municipal waste management. Through long-term investment in new environmental technologies the public-sector waste management entities are not only guarantors of safe waste management, but also of targeted development in waste management towards sustainability and climate protection," declares Helmut Schmidt, deputy works manager at AWM.



Advanced strategies mean lower charges

Despite major investment in new technologies AWM was able to reduce the waste collection fees three times in succession in recent years. That means that ambitious environmental schemes and innovative plant technology can be very successfully combined with economic efficiency and socially acceptable charges.

3 QUANTITIES AND QUALITIES OF ORGANIC WASTE

3.1 Collection and quantities of organic waste

Every year considerable quantities of bio-waste from various sources are accumulated across Germany. The most important of these are discussed briefly here.

3.1.1 Bio-waste and green waste

Public-sector waste management entities, i.e. local authorities and waste disposal associations, have direct access to

- bio-waste from bio-waste bins and
- green waste (from parks and gardens)[1].

Separate collection of bio-waste and green waste from households is carried out in various ways. Typically they are collected in a bio-waste bin at the resident's home. In addition the separate collection of green waste, for example at citizens' recycling centres or by kerbside collection, is widespread.

However, despite a great deal of willingness on the part of residents to separate their bio-waste and green waste, the collection systems have not been introduced universally throughout the country.

There are 96 municipalities (out of a total of 405) which do not provide their residents with any bio-waste bin at all. This affects around 14.3 million people. 67.5 million people live in regions where bio-waste bins have been introduced. However, the actual level of affiliation is around 56 percent on average in these regions, so that approximately another 30 million Germans have no access to a bio-waste bin.

Therefore, in total almost 44 million citizens across Germany, that is more than half the people in the country, do not use a bio-waste bin.

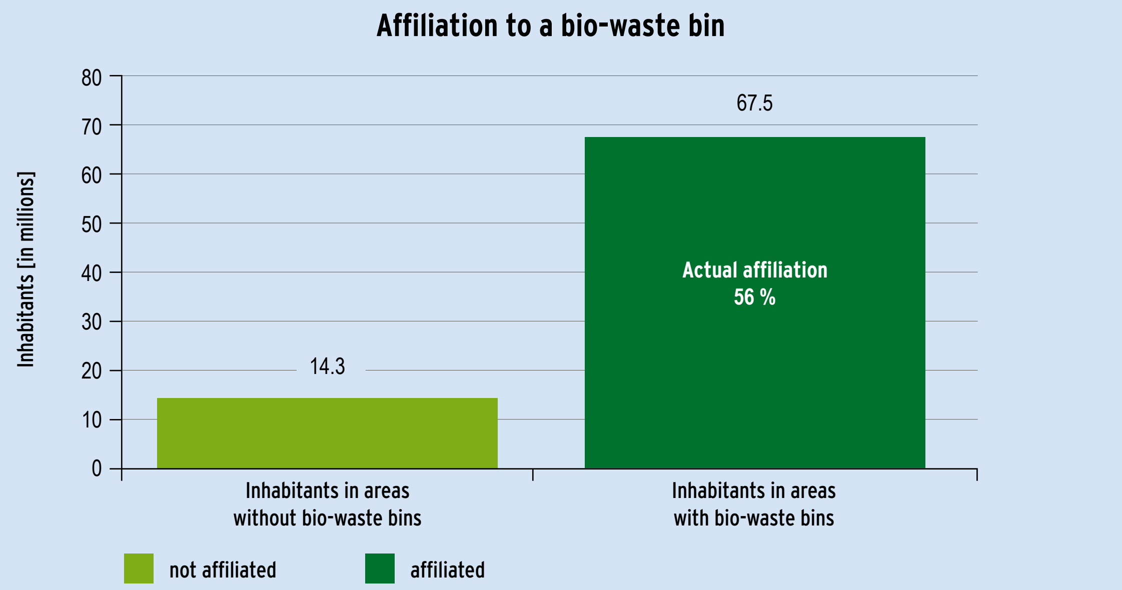
This means that a considerable proportion of bio-waste is still disposed of via residual unsorted waste treatment and thus is only used inadequately or not at all. The resulting destruction of resource and energy potential contradicts the aims of sustainable resource use.

Analyses of municipal residual waste show that bio-waste and green waste in the order of 4 to 5 million metric tons can still be found in the German domestic residual waste, of which almost two million metric tons per year could be extracted by suitable methods.

1 A precise definition of types of waste can be found in the glossary at the back of the booklet.

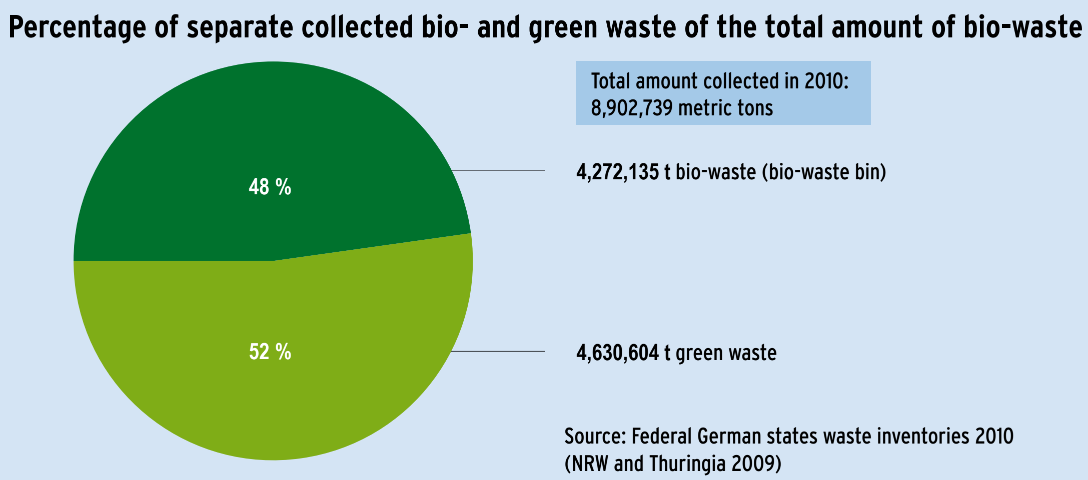
Green waste collected selectively

Bio-waste from a bio-waste bin



Source: Federal German states waste inventories 2010 (NRW and Thuringia 2009)

Public-sector waste management municipalities without bin or ≤ 5kg /res*a organic waste are regarded as not affiliated



Source: Federal German states waste inventories 2010 (NRW and Thuringia 2009)

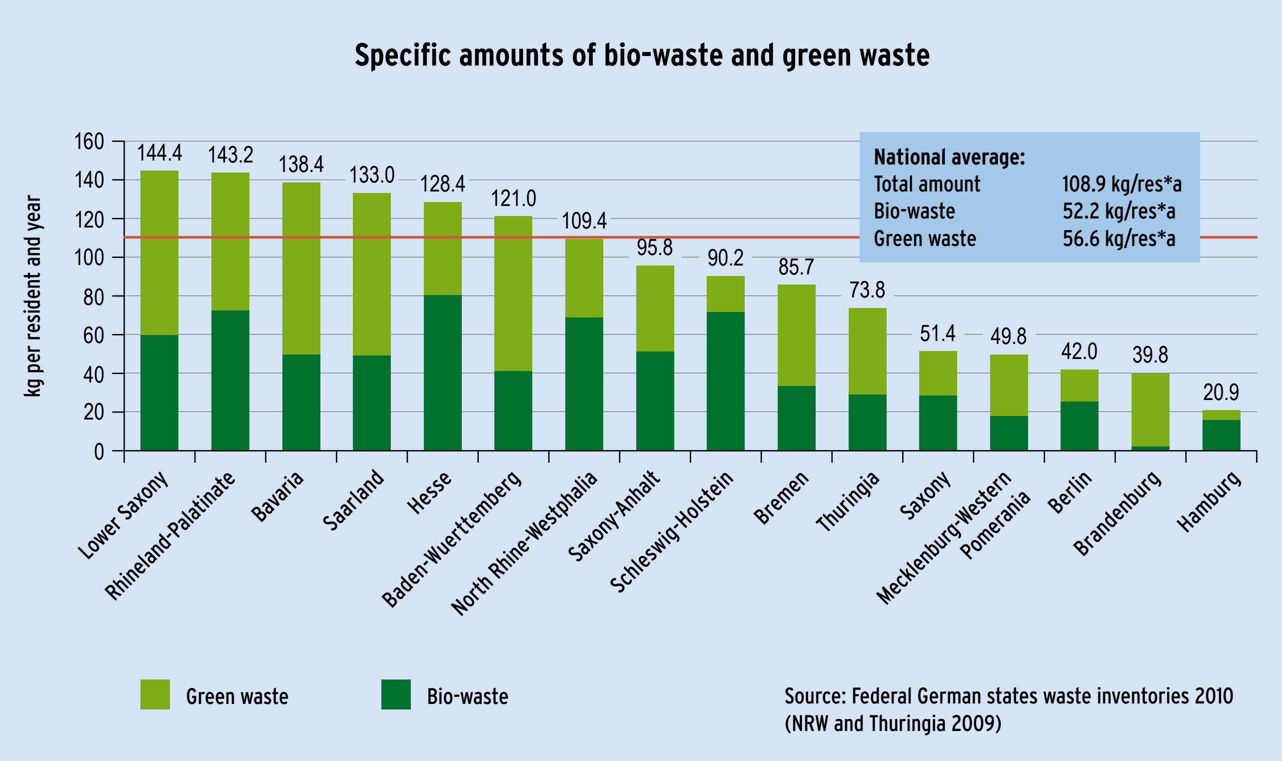
Bio-waste sorted out from a residual waste bin

Despite the optimisation potential described, around 8.9 million metric tons of bio-waste and green waste are already collected from households annually and taken for material and/or energy recovery. That equates to approx. 21 percent of the household waste generated in Germany in 2010, which totalled approx. 43 million metric tons (Federal Statistical Office, 2012).

Public-sector waste management municipalities providing a bio-waste bin in Germany in 2010

Baden-Württemberg = Baden-Wuerttemberg
Bayern = Bavaria
Hessen = Hesse
Mecklenburg-Vorpommern = Mecklenburg-Western Pomerania
Niedersachsen = Lower Saxony
Nordrhein-Westfalen = North Rhine-Westphalia
Rheinland-Pfalz = Rhineland-Palatinate
Sachsen-Anhalt = Saxony-Anhalt
Sachsen = Saxony
Thüringen = Thuringia

Source: Witzenhausen-Institut



3.1.2 Landscape maintenance material

The data situation for landscape maintenance material appears somewhat less certain. Nevertheless, one can assume that between one and three million metric tons of herbaceous and ligneous material are generated annually in Germany from maintenance work along roads and railway lines and around water bodies. The materials emerging from maintenance work performed for nature conservation purposes cannot be quantified at present.

Potential of landscape management residues

Maintenance waste materials	theoretical potential [t solid matter per year]		technical potential [t solid matter per year]	
	ligneous	herbaceous	ligneous	herbaceous
Roadside vegetation	900,000	1,100,000	250,000–550,000	100,000–150,000
Vegetation beside railways*	580,000	150,000	23,000–35,000	figures not available
Riparian vegetation	figures not available	figures not available	20,000	figures not available
Driftwood**	50,000		25,000	
Total	1,530,000	1,250,000	318,000–630,000	100,000–150,000

*) Annual amount until the end of 2014, from then onwards theoretical potential < 200,000 t solid matter per year
**) Extrapolation: water content 60 %

3.1.3 Other organic waste from industry and commerce

Apart from the waste mentioned other organic substances occur in industry, commerce, trade or agriculture which are used by recovery plants. These include for example leftover food from restaurants and large kitchens (e.g. canteens, hospitals and refectories), waste from the grocery trade, and production residues from food manufactures. Common to all of these is that they do not have to be collected by public-sector waste entities. Their collection and recovery is organised mainly by private-sector companies and will not be considered in further detail in this booklet.

Résumé:

- Currently, for each person in Germany, approximately 52 kilograms (kg) of bio-waste and 57 kg of green waste from parks and gardens are collected separately each year, with many regions collecting considerably larger amounts.

- In a number of regions biobins are not provided or only made available in some areas, which means that more than half of the citizens of Germany have no biobin.

- Further extraction of almost two million metric tons bio-waste and green waste from the residual waste is possible using appropriate methods.

- Expansion of separate collection of bio-waste and green waste, together with the materials coming from landscape maintenance, provides an opportunity to conserve fossil fuels and produce fertilisers and soil improvers.

3.2 Composition and qualities of bio-waste and green waste

Composition of waste from biobins

The composition of waste from biobins alters during the year: for one thing, the different elements of green waste from private gardens are reflected in the bins, and for another, people's consumer behaviour can be "read" from them. Whereas for example in summer more bones occur in the waste bin (barbecue waste), in winter there are more quantities of citrus fruit peel.

In winter the relative proportion of impurities in the biobin is larger, as the diluting effects of green waste are less evident than in the vegetation period. The occasional piece of plastic film that is particularly noticeable only represents a minute proportion of the total weight and can be filtered out relatively easily. However, the entry of this sort of impurity can be an indication of inadequate separation and sorting habits.

For this reason information for residents about the correct separation of materials is of considerable importance – moreover, the publicity must be adapted to the target groups. Many local authorities have had positive experiences with information geared to target groups. Examples of this are special campaign days, collaboration with the local press and also foreign language brochures.

Impurities in bio-waste

Ligneous green waste

Furthermore, the way waste collection is organised and the provision of targeted public information can considerably reduce the occasionally discussed issues of odours, flies and maggots.

Composition of green waste

The quantity of green waste and its composition is also subject to seasonal variation: the largest amounts are recorded during the vegetation period into autumn. Herbaceous material such as grass cuttings and "weeds" forms a relatively constant part of it during the growing season, while ligneous materials such as shrub and tree prunings occur mainly in winter and spring.

The same applies to waste materials from landscape maintenance.

Qualities of separately collected bio-waste and green waste

Whether the quality of separately collected bio-waste and green waste is more suitable for recovery by composting, anaerobic digestion or incineration depends, apart from the input material, on the collection system, the size of container and the regional structure. Thus for example biobins in high-rise buildings contain mainly damp or wet kitchen waste, whereas the proportion of green waste rises with the drop in housing density and the corresponding increase in garden size.

In the case of waste from parks and gardens, it is possible to produce wood fuel from the ligneous material collected in winter. The fine material and the material collected in summer should be composted and/or anaerobically digested.

Résumé:

- The composition and quality of the biogenic waste flows varies according to the season.
- Targeted and sustained public awareness-raising work is absolutely essential in order to increase the amounts that can be collected, guarantee and improve quality and reduce the proportion of impurities.
- Bio-waste and green waste as well as materials coming from landscape maintenance are often suitable for material and/or energy use. From an energy and climate perspective the combination of different recovery paths mostly makes sense.

3.3 Possible ways of increasing the collection rate

This has already been referred to: theoretically there is still much untapped potential in bio-waste and green waste in household residual waste. Why should one consider the separate collection and use of the largest possible parts of this potential?

Two essential reasons

1. The separately collected organic waste can be used well for material and energy recovery and therefore can contribute to the conservation of mineral fertiliser reserves, peat and fossil fuels.

2. The amount of residual waste with comparatively higher treatment costs will be reduced.

The introduction or expansion of separate collections in regions without or with only limited access to biobins is fundamental. In areas with separate collections there is scope for introducing measures to raise the collection quotas and improve the quality of the material flows.

Goals to achieve

- ▶ Extraction of bio-waste and green waste from residual waste as far as possible

- ▶ Optimisation of the material and energy recovery potential by separation of the bio-waste flows for the most appropriate recovery procedure in each case.

Besides uncontrollable factors like seasonal variations, success depends amongst other things on the following specific circumstances:

Structure of the collection district
The lower the population density, the larger is the amount of generally good quality material collected. However, it should also be noted that in rural districts a comparatively high proportion of residents make their own compost.

Compulsory affiliation and use
Higher affiliation quotas result in higher collection quotas. However, the compulsory introduction of biobins involves the risk of larger amounts of impurities, especially in very dense settlement structures (town centres). In more rural areas it makes sense to permit controlled exceptions, such as home composting. In contrast, in very built-up areas it is important to examine whether the amount of impurities in the collection containers does not increase disproportionately with rising population density and whether certain areas ought to be excluded from separate collections.

There are, however, also positive examples such as that of the city of Munich, which show that with appropriate measures the quantity and quality of collected material can be increased in large residential areas as well.

Successful separate collection of bio-waste requires intensive publicity, especially in big cities.

Charging system
The most important way to achieve an increase in the amounts of bio-waste and green waste collected is through the charging system. If there is no compulsion to provide biobins, direct or indirect financial incentives to use the bins voluntarily should be considered. For example, these can be a reduction in residual waste charges for participating in bio-waste collection or the creation of a standard refuse charge without additional costs for the biobin. Various studies have shown that waste charges tailored to the specific types of waste producer can influence behaviour.

Charges based on the amount generated can be calculated using stamp or identification systems where the quantity to be disposed of is logged for each individual household and the costs are based on the actual amount of waste produced. Through such a use-based charge for emptying the unsorted residual waste bin, these systems contribute to the conscious use of the biobin for organic waste. In addition, if the collection of bio-waste is also charged by quantity, this can lead to less ligneous material being deposited in the biobin. In this case a good green waste service is a requirement, such as cluster collections of garden waste or the provision of local collection points.

However, there are no patent solutions for all types of district structure; too attractive financial incentives for biobins can also result in an increase of impurities.

Increasing the amount of green waste collection
In the case of kerbside collections of green waste from households the frequency of service can be increased and possibly the restrictions on quantities reduced. Where collection points or citizens' recycling centres are in operation, the number and accessibility of these and the opening hours are key to unlocking the potential held by green waste.

The necessity for local "bonfire days", i. e. days when burning garden waste is permitted on one's own land, should be examined critically. Restricting the burning of garden rubbish in places where it is still allowed can lead to an increase in the quantity of waste collected and can furthermore contribute to clean air and climate protection.

Public awareness-raising
Common to all these steps is that they must be accompanied by targeted publicity, aimed at specific demographic groups such as children and teenagers or foreign residents. Key elements of public awareness-raising work may include

- An explanation of the purpose of separate collection and correct waste separation
- Information about recovery paths
- Advertisements for using locally produced compost
- Information about possible uses of compost and composted digestates
- Getting people and institutions to spread the message

Résumé

- The introduction of the biobin and the provision of bins to households who previously had no access to them is generally environmentally and economically beneficial.
- The creation of a charging system appropriate to the collection structure of each district is useful, preferably with the introduction of charges for unsorted waste and biobins which fairly reflect usage.
- A broad-based green waste collection system should be established, accompanied by a bonfire ban where appropriate.
- Exceptions to the separate collection of bio-waste should only be permitted in justified cases.
- Targeted awareness-raising is an essential tool for increasing the quantity and quality of separately collected bio-waste and green waste.

Biobins

4 RECOVERY METHODS OF THE COLLECTED MATERIAL FLOWS

What happens to the separately collected bio-waste and green waste? Since the 1980s mechanical composting facilities have operated successfully in Germany for bio-waste and green waste. Not long afterwards the first anaerobic digestion plants came in operation as well, although not in the same large number. Recently, as energy prices have risen, ligneous material has been extracted from green waste to make into fuel.

4.1 Composting processes

Composting is a biological decomposition process for organic waste, in which the material is broken down by microbes and micro-organisms under aerobic conditions. The end product is compost, an organic plant nutrient and humus supplier.

Originally practised by amateur gardeners in their own gardens, composting has been used as a method of bio-waste treatment on a large industrial scale in Germany since the middle of the 1980s.

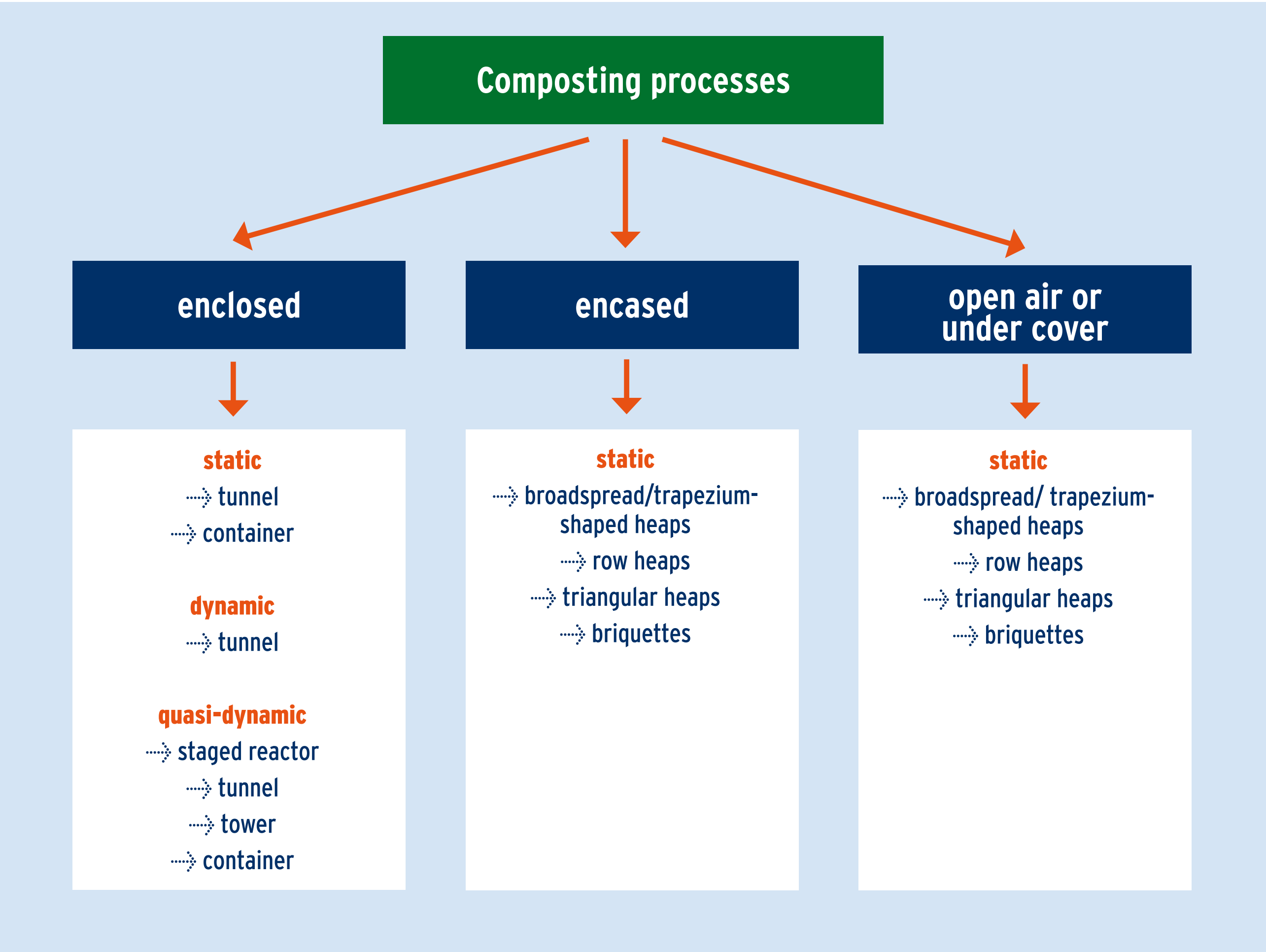
A thermo composter

The mechanical composting processes applied can be divided into various categories:

- composting in heaps (triangular, trapezium-shaped or flat stacks)
- composting in bunkers/containers
- row/tunnel composting
- composting as briquettes
- other systems

The processes differ in the way the heaps are constructed (open, covered, in containers), the type of ventilation and also the duration of the intensive rotting stage and the maturity of compost desired. If the intensive rotting system is set up for mature compost, the main and subsequent rotting phases are integrated. If the intensive rotting results in sanitized fresh compost, a second rotting stage can follow to achieve a higher degree of decomposition. In composting facilities the second stage is carried out predominantly in flat or triangular heaps.

The following diagram provides an overview of possible processes:




Intensive rotting under a semi-permeable membrane


View inside a composting container

At present nearly one thousand composting plants (of more than 1,000 metric tons throughput per year) are operating in Germany, with a total capacity of more than ten million metric tons. Of these, half are plants processing exclusively green waste and half treating both bio-waste and green waste.

The amount of bio-waste and green waste collected at present totals 9 million metric tons. This compares with the approximately ten million metric tons' processing capacity, so that even if the collection network is expanded, recovery of the additional quantities is guaranteed.

Composts are eminently suitable for use as soil improver in agriculture and recultivation but also for producing substrates and ready-to-use blended soils.


Processing the finished compost

CASE STUDY: WITZENHAUSEN COMPOSTING PLANT

"The composting plant at Witzenhausen is especially important to us," stresses Dirk Hesse, managing director for the operator Vogteier Kompost GmbH.

Firstly, the composting plant at Witzenhausen shows that even with a fairly small input capacity of 5,000 metric tons per year high-grade compost can profitably be produced. Secondly, this plant is more or less the birthplace of mechanical composting in Germany and Europe. From 1983 onwards the first attempts at composting on an industrial scale in the country were carried out at this site by the University of Kassel at Witzenhausen.

The collected bio-waste is mixed with structural material, i.e. shredded green waste, prior to composting. This mixture is put on a covered rotting surface in triangular heaps about two metres high and thirty metres long. These are then turned twice a week with a mobile turning device. Regular temperature checks ensure a rotting process which guarantees complete pathogen reduction of the finished products. After seven or eight weeks of rotting the material is sifted and ready to use. What remains after sifting is returned to the biological process. The superior composts with the RAL quality guarantee produced in this manner are mainly distributed to agriculture in the region, but are also bought in fairly large quantities by amateur gardeners. In addition, bark mulch and high-grade potting composts are available at the plant for sale to the public.

Capacity:	5,000 t bio-waste and green waste
Start-up date:	1991
Processing technology:	Composting in covered heaps, mobile turner, sifting machine, mechanical shredder, wheel loader
Employees:	2
Duration of intensive rotting:	7–8 weeks
Products manufactured:	Fresh and mature compost
Customer base/market:	Soil and compost suppliers, amateur gardeners, agriculture, local authorities
Contact:	Vogteier Kompost GmbH Kompostanlage Witzenhausen Am Burgberg | D-37213 Witzenhausen Tel.: +49 5542 71320 | Fax: +49 5542 71490 | Email: vogteier-kompost@tupag.de

CASE STUDY: WESTHEIM COMPOSTING PLANT

"We believe in quality, that's why our products don't just sell well to amateur gardeners, but to horticulturalists and landscapers too, as well as soil suppliers, fruit-growers and the local winegrowers. On top of that our composts appear in the list of products for use in organic farming," declares sales manager Ralf Schöppenthau with satisfaction.

Westheim composting plant started operating in 1999. 28,000 metric tons of bio-waste and green waste can be recovered annually into superior quality-assured compost suitable for organic farming.

In order to aerate the bio-waste properly, it should as far as possible have a loose homogeneous structure and be free from impurities. For this reason it undergoes mechanical pre-treatment in the preparation hall. After shredding and mixing the waste, sifting and removal of metals and other impurities takes place. The air in this hall is constantly extracted (negative pressure). This air stream is pumped through the floor of the rotting hall and aerates the waste. The bio filter minimises emissions from the air extracted from the rotting hall.

The intensive rotting process takes place in the rotting hall. Composting is carried out on ten heap areas, each 27 m wide and 6.5 m long, using a heap moving system. The "Wendelin" ("rotator"), the heart of the plant, turns the waste completely automatically. As the waste is turned it is watered. The rotting process is controlled by aerating and watering as necessary.

A well-developed water management system does not require connection to the public fresh and waste water system. The compost produced is removed from the rotting hall by wheel loader after eight to ten weeks and sifted to 10 mm.

Capacity:	28,000 t bio-waste and green waste
Start-up date:	1999
Process technology:	Bühler Wendelin, encased
Employees:	4
Duration of intensive rotting:	8–10 weeks
Product manufactured:	Quality controlled, 10 mm fresh and mature compost approved for use in organic farming, green waste 30 mm
Customer base/market:	Soil and compost suppliers, vegetable and wine growers, arable farming, landscaping, amateur gardeners, organic farming
Contact:	SITA Kompostwerk Westheim Zeiskamer Schneise | D-67368 Westheim Tel.: +49 7274 70290 | Fax: +49 7274 702920 Email: info@kompostwerk-westheim.de | Website: www.kompostwerk-westheim.de

CASE STUDY: RATINGEN-LINTORF COMPOSTING PLANT

All operational conditions have been created by the plant's operating company, KDM, to process organic waste from biobins, separate green waste collections and waste from gardening, landscaping and cemeteries etc. into high-quality, RAL-labelled compost.

In addition a modern composting plant with completely enclosed fully automated row composting has been constructed at the Ratingen-Lintorf site, where up to 50,000 metric tons of organic residues are processed annually into marketable composts. For preparation and production the material is shredded and sifted, metals are removed with an iron separator and finally it is sorted by hand (impurities > 60mm). Fresh and mature composts are produced.

To market the products a comprehensive network has been set up at a number of sites in the Mettmann district near Dusseldorf. This network consists of local sales points, garden centres and the company's own sites and is being constantly expanded.

"Our principal aims in recycling are a guaranteed high-quality end product for the consumer and on top of this an optimum method of dealing with organic material flows in the interests of sustainable climate protection and resource conservation," says managing director Dietmar Steinhaus. *"With this in mind we are currently considering whether to extend the composting plant to include an anaerobic digestion stage, in order to use the energy as well as the material potential of bio-waste."*

Furthermore, KDM has concentrated its activity in recent years on the processing and marketing of materials recovered from green waste and on timber as feedstock for energy production in biomass-fired combined heat and power plants. Woodchips, unseasoned wood, off-cuts etc. are used by KDM to produce high-grade fuels for woodchip-fired heating systems.

Capacity:	50,000 t (composting plant) bio-waste and green waste, 60,000 t (wood facility) seasoned and unseasoned wood
Start-up date:	1997/2009
Process technology:	Completely enclosed, automated row composting with automated turning
Employees:	16
Duration of intensive rotting:	approx. 4–5 weeks
Product manufactured:	Fresh and mature compost
Customer base/market:	Soil and compost suppliers, private gardeners, agriculture, local authorities
Contact:	KDM – Kompostierungs- und Vermarktungsgesellschaft für Stadt Düsseldorf/Kreis Mettmann GmbH Lintorfer Weg 83 | D-40885 Ratingen Tel.: +49 2102 30 22-0 | Fax: +49 2102 30 22-222 Email: info@kdm-gmbh.com | Website: kdm-gmbh.com

4.2 Anaerobic digestion processes

In contrast to composting facilities, bio-waste anaerobic digestion plants can also recycle liquids and paste-like material.

Unlike composting, the biological decomposition processes occur in the absence of oxygen. The most important end product of anaerobic digestion, besides a nutrient-rich digestate that can be used as a digestate product in liquid or solid form in agriculture and related areas, is biogas. Biogas can be used mainly in electricity and heat production.

Wood and other ligneous materials such as hay or straw are unsuitable for this recovery path, as the anaerobic micro-organisms hardly break these down in the anaerobic digesters.

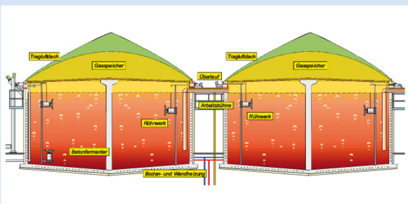
Separately collected bio-waste as well as food scraps and the herbaceous parts of green waste, on the other hand, are generally well-suited to anaerobic digestion.

Fermenter plus biofilter

Anaerobic digestion processes

continuous processes | **discontinuous processes**

wet fermentation
dry matter < 12-15 %



Source: Biogas Nord

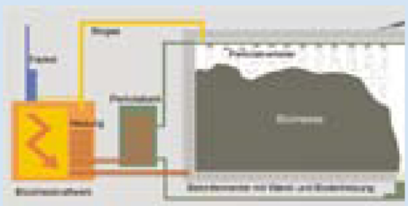
dry matter
digestate: 5-10 %

dry fermentation
dry matter > 20-30 %
continuous

Source: Strabag/Linde

dry matter
digestate: 10-20 %

dry fermentation
dry matter > 30-40 %
percolation process



Source: BeKON

dry matter
digestate: 20-30 %

There are several thousand anaerobic digestion plants in Germany, although most are mainly intended as agricultural facilities for fermenting liquid manure and energy crops.

Digestion capacity for bio-waste is still being built up. By early 2012 around 100 sheer bio-waste digestion plants were in operation in Germany.

An important feature for distinguishing between anaerobic digestion processes is the method of operation. There are continuous and discontinuous processes.

In the continuous process bio-waste is automatically fed at regular intervals into the anaerobic digestion reactor (fermenter). This process promotes continuous biogas production of consistent quality.

In the discontinuous process the digesters are filled by wheel loader, then after several weeks they are emptied and refilled (batch operation). Biogas production is not continuous, but parallel connection of several digesters working on a staggered system can largely compensate this.

Discontinuous processes have advantages over continuous methods because of their simpler mechanical reactor systems. On the other hand, the latter require a smaller reactor volume because of their higher space-time yield and can usually be automated better than discontinuous processes.

Per metric ton of bio-waste, depending on the input quality and process, between 80 and 140 cubic metres (m^3) of biogas with a methane content of 50–65 percent is produced. The energy from this equates to 50–80 m^3 of natural gas.

In most cases the biogas is converted directly into electricity (200–300 kilowatt-hours per metric ton [kWh/t] input) and heat (likewise approximately 200–300 kWh/t input) via a cogeneration plant. As an example, an input of 20,000 metric tons of bio-waste per year suffices to operate a cogeneration plant with a rated electrical capacity of 600 kW, producing enough electricity for 1,000 to 1,500 homes. It is also possible to refine biogas to natural gas quality and feed it into the natural gas grid.

The digestates can be used directly in agriculture in liquid form or marketed as a solid digestate product after composting.

A cogeneration unit for energy production at an anaerobic digestion plant

CASE STUDY: DEISSLINGEN ANAEROBIC DIGESTION PLANT

The anaerobic digestion plant in Deisslingen recycles the separately collected bio-waste from the Schwarzwald-Baar-Heuberg region, which is made up of the districts of Rottweil, Schwarzwald-Baar-Kreis and Tuttlingen. The project is an example of successful cooperation between local authorities. The preferred anaerobic digestion technology was only economically viable on the basis of the wastes from all three districts.

The plant was constructed next to the Upper Neckar Joint Waste Water Board sewage treatment works. It is situated conveniently for vehicle access in the middle of the waste management area close to the A 81 motorway to Lake Constance. Anaerobic digestion started in 2005. Each year around 25,000 metric tons of bio-waste are processed. The biogas produced is converted into electricity in a cogeneration plant and fed into the public electricity grid. The surplus heat from the cogeneration plant is used on site to dry municipal sewage sludge. In this way almost the entire energy is used. Waste water can be discharged the short distance into the neighbouring treatment works.

All the materials to be used for anaerobic digestion are pasteurised by heat treatment. The solid digestates are sold as high-grade, quality-controlled fertilisers to farmers in the region.

"More than 2,000 homes can be supplied with electricity from our plant," says managing director Eberhard Ludwig.

Capacity:	25,000 t bio-waste
Start-up date:	2005
System provider:	1) Schwarting Umwelt GmbH i.I. 2004; 2) RosRoca Internacional, S.L., Ostfildern-Nellingen
Electrical output:	950 kW_{el}
Biogas production:	~ 3,300,000 Nm^3/a
Electricity production:	~ 5,700,000 kWh/a
Energy use:	Fed into public electricity grid; drying sewage sludge
Use of digestates:	Agricultural fertiliser
Contact:	BRS Bioenergie GmbH Eberhard Ludwig Tel.: +49 7721 92820 | Fax: +49 7721 928272 Email: ewl@brs-recycling.de

CASE STUDY: ERFURT DRY FERMENTATION PLANT

In 2009 a modern organic recycling plant was brought into service at the Erfurt-Schwerborn landfill site. Annually 18,200 metric tons of bio-waste can be converted in the dry fermentation plant into clean energy for more than a thousand homes.

Bio-waste with a high content of dry material can only be added in small quantities in conventional wet digestion plants. The process known as “dry fermentation” on the other hand allows the methanisation of bulky biomass from farming, bio-waste and local amenity sites without having to convert the materials into a pumpable liquid substrate. This makes the digester resistant to impurities such as plastic film and ligneous and fibrous components.

Certified compost for the farmers of Thuringia is produced from the digestates. The biogas plant is not only a sustainable waste management measure, but also makes an important contribution to climate protection with the energy generated. The new organic recycling plant replaces the open composting of Erfurt’s bio-waste.

“Our company’s extensive provision for environmentally sustainable waste management is being expanded further through the new organic recycling plant in the interests of creating a closed cycle,” reports managing director Andreas Jahn. *“By embracing this biogas technology the Erfurt city works group is leading the way in the use of alternative energies.”*

Capacity:	23,500 t bio-waste
Start-up date:	2009 (2008 trial operation)
System provider:	BEKON Energy Technologies GmbH & Co. KG
Electrical output:	660 kW_{el} (2 engines of 330 kW)
Thermal output (utilisable):	800 kW (2 engines of 400 kW)
Biogas production:	1,761,714 Nm^3/a (2011)
Electricity production:	3,424,772 kWh/a (2011)
Heat production:	4,305,630 kWh/a (2011); of which extracted from cogeneration: 3,104,270 kWh/a (2011)
Energy use:	Fed into Erfurt’s electricity grid
Use of digestates:	Production of certified compost (2 post-rotting phases after dry fermentation, sifted to remove impurities)
Contact:	B & R Bioverwertung & Recycling GmbH | Herr Gutjahr Magdeburger Allee 34 | D-99086 Erfurt Tel.: +49 361 5644430 | Tel.: +49 361 5644430 | Email: detlef.gutjahr@stadtwerke-erfurt.de

CASE STUDY: NIDDATAL-ILBENSTADT HUMUS AND SOIL SUPPLIERS

The central composting plant for the Wetterau district, with intensive rotting, was extended in 2007 to include an anaerobic digestion stage. The motivation for this was the current climate debate, a desired increase in capacity, further reduction of odour emission and the long-term assurance of acceptance in the community. It was possible to expand the previous composting procedure involving preparation and intensive rotting in an enclosed system for a throughput of 22,000 metric tons to include anaerobic digestion without any major alterations to the existing buildings.

Now up to 29,500 metric tons of bio-waste and green waste can be processed in the plant each year. The solid digestate undergoes a further process to turn it into compost. As well as being recycled in agriculture and horticulture, it is used to manufacture soil-based composts and potting composts. The liquid digestate is used by farmers as a compound fertiliser.

Each year more than 4.5 million kWh of electricity are produced from the biogas in a cogeneration plant. The electricity, for which payment is made under the Renewable Energy Sources Act (EEG), is fed into the public grid and supplies around 1,500 homes. The heat is used for the thermophilic digestion process, heating the site buildings, providing hot water and drying woodchips. There are plans for a further external use. Through the addition of the anaerobic digestion stage an annual reduction of 3 million kg of CO_2 is being achieved – an amount that corresponds to the CO_2 sequestered by thirty hectares of forest.

Operator:	Wetterau Composting Ltd Wetterau district waste management company
System supplier:	Kompogas
Capacity:	29,500 t/a, digester 18,500 t/a
Biogas production:	120 Nm^3/t digester input
Electrical output:	625 kW_{el}
Electricity production:	4.5 million kWh/a
Energy use:	Public electricity grid, space heat and hot water, woodchip drying
Use of digestates	Agricultural use and further processing into compost, with some subsequent soil production
Contact:	Abfallwirtschaftsbetrieb des Wetteraukreises Kurt Schäfer | Dr. Jürgen Roth Bismarckstr. 13 | D-61169 Friedberg Tel.: +49 6031 90660 | Email: j.roth@awb-wetterau.de

CASE STUDY: KIRCHSTOCKACH ANAEROBIC DIGESTION PLANT

Kirchstockach's anaerobic digestion plant in Munich district came into operation in 1997. Whereas at first bio-waste recovery was the priority, now, with the improvements undertaken to the plant, optimal material and energy recovery is most important for the district. The plant, which works with a wet fermentation principle, achieves an annual throughput of over 30,000 metric tons.

After early attempts to store the energy using aluminium silicate, the dominant achievement of 2009 was the supplying of heat to nearby industrial premises. The electricity produced in the facility's own cogeneration plants is fed into the public grid.

Tests are currently being carried out to see whether the recovering of digestates could be improved. Part of it is recovered into compost and substrates in the green waste composting facility on site.

"For us operators the advantages of the wet procedure lie in the thorough removal of impurities prior to digestion. The digestion process is considerably more stable on account of the hydrolysis which takes place prior and separately from the methanisation," says operations manager Ulrich Niefnecker.

Capacity:	30,000 t bio-waste
Start-up date:	1997
System supplier:	BTA International GmbH
Electrical output:	1 MW
Biogas production:	2.3 million Nm³/a
Electricity production:	5.0 million kWh/a
Energy use:	Own use and feed-in to grid
Use of digestates:	Compost and substrate production
Contact:	U. Niefnecker | Fa. Ganser GmbH & Co. KG Taufkirchner Str. 1 | D-85649 Kirchstockach | Email: niefnecker@ganser-gruppe.de
	M. Kischenhofer | Landkreis München Mariahilfplatz 17 | D-81541 München | Email: matthaeus.kirschenhofer@lra-m.bayern.de

CASE STUDY: BÜTZBERG BIOGAS AND COMPOSTING FACILITY

"With its facility in Bützberg, SRH, the public cleansing utility of Hamburg, is implementing a dual strategy designed to recover organic kitchen and garden waste with maximum climate and environmental benefit. SRH is capturing the value of bio-waste in a two-tier cascade: first biogas production, then compost production. This gives Hamburg's households access to clean and low-carbon energy generated from their own kitchen and garden wastes," says SRH works manager Bernd Töllner.

On December 1st 2011, SRH (Stadtreinigung Hamburg), the public cleansing utility of Hamburg, brought on stream a biogas facility at the site of its Bützberg composting plant that has the capacity to treat up to 70,000 metric tons of bio-waste collected via the more than 100,000 biobins in the city. With 21 digesters and a batch process, the combined treatment system generates some 2.5 million cubic metres of pure bio-methane each year.

The cleaned and upgraded bio-methane is fed directly into the natural gas grid that supplies Hamburg's private households. The digestates from the dry fermentation system are processed in the associated composting plant, delivering around 35,000 metric tons of high-grade compost – a much sought-after substitute for mineral fertilisers in regional agriculture and horticulture.

In addition to its comprehensive exhaust air management designed to minimise odour nuisance, the scheme for reducing methane emissions is a special feature of the dry fermentation system. The exhaust from digester shutdown, which can still contain biogas traces, is conveyed to a furnace fired with woodchips gained on site, partly from garden waste. Heat extracted from the furnace is used to raise digester temperatures to the optimal level of 38°C.

The annual output of SRH's new biogas facility saves 7,800 metric tons of carbon dioxide emissions that would otherwise arise from fossil fuel combustion. The Bützberg biogas and composting facility proves that biogas from organic waste is a clean source of energy with a bright outlook – even for a major city such as Hamburg.

Annual capacity:	70,000 t/a
Start-up date:	1st December 2011
System supplier:	Kompoferm
Biogas production:	25 million Nm^3
Energy use:	Upgrade to bio-methane and feed-in into regional main gas line
Use of digestates:	Composting
Contact:	Stadtreinigung Hamburg | Biogas- und Kompostwerk Bützberg Dr. Anke Boisch Bullerdeich 19 | D-20537 Hamburg Email: info@srhh.de

4.3 Material and energy recovery of green waste

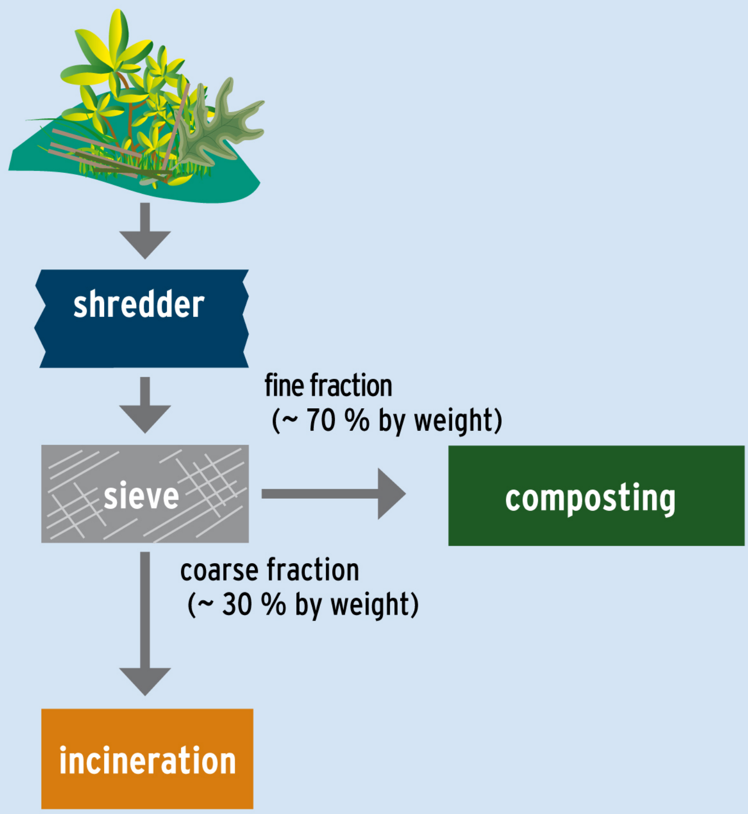
Energy recovery from unprocessed green waste is relatively difficult owing to the seasonally variable proportion of herbaceous and therefore damp waste. For this reason material recovery through the production of green waste composts is suitable for unprocessed material flows. This is especially useful given the importance of green waste composts as peat substitutes and their consequent contribution to CO_2 reduction.

If green waste is prepared before use by suitable procedures such as shredding and sifting, there is also the option of energy recovery for part of the material flow. This is done through incineration and also using the finer parts for anaerobic digestion followed by composting.

Sifting shredded green waste

The heat produced can be used, in particular for heating buildings. In addition it is conceivable that electricity and heat production could be achieved simultaneously, in order to increase overall system efficiency.

Preparation stages for separating partial streams from tree and shrub prunings for energy recovery



Around a third of green waste, especially the material generated in the winter months, can be filtered out for fuel. However, it is important to leave a sufficient amount of structural material for composting, as this is essential for aerobic decomposition to take place. If these materials are absent, higher emissions of greenhouse gases can result from the composting process or the aerobic post-treatment of digestates.

In the winter months green waste consists – to a certain extent depending on the collection system and the structures – primarily of ligneous tree and shrub prunings while in summer it is made up of the green parts of plants. This is why measurements show widely varying calorific values between 2.2 and 12.8 megajoule per kilogram (MJ/kg) for unprepared green waste from season to season. Mostly ligneous green waste with only a small amount of green parts, which can be generated through appropriate processing, has an estimated calorific value of more than twelve MJ/kg. This makes it comparable with slightly dried firewood.

Firewood from processed green waste collected in the winter months can only be used in normal woodchip combustion systems with certain limitations. The following adjustments have proved worthwhile for problem-free operation:

Incineration

- long water-cooled rack for pre-drying of material and to prevent clinker forming
- optimised primary air supply to the individual zones of the rack to ensure complete combustion

Conveyor technology

- avoidance of screw conveyors for input supply and ash removal by exclusive use of hydraulic or mechanical machinery such as scraper chain conveyors.

Résumé:

Combined energy and material recovery from organic waste flows

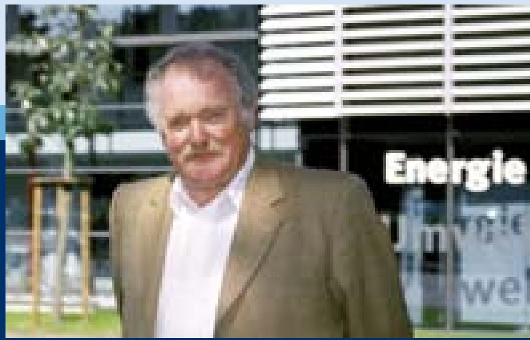
Material flows	Form of energy recovery	Form of material recovery
Bio-waste – separate collection	Biogas	Compost or digestates
Green waste – (30 % ligneous material)	Heat recovery**	Ash*
Green waste – (70 % herbaceous material)	Biogas	Compost or digestates
Landscape maintenance waste – herbaceous	(Biogas)	Compost or digestates
Landscape maintenance waste – ligneous	Heat recovery**	Ash*
Sifting residue from composting process	Heat recovery**	Structural material for compost

* Wood ash can be recycled as fertiliser since it contains plant nutrients. Statutory requirements must be met.

** Heat recovery can refer to heat generation or combined heat and power generation, depending on the design of the facility

CASE STUDY: ORC FACILITY IN OERLINGHAUSEN

Green waste is used to produce electricity and district heating



"We wanted to supplement this system with renewable energies from the region," is how Dipl.-Ing. Peter Blome, the managing director of Oerlinghausen public utilities, sums up the motivation for the construction of a biomass power plant with ORC technology. From the initial plans untill feeding in the first electricity took just under two years. The utilities' collaboration with a private financial investor and a local horticulture and landscaping business, which agreed to provide the input, proved invaluable in achieving this result.

Oerlinghausen public utilities have been generating their own electricity and heat for a long time, e.g. with a natural gas-fired combined heat and power plant. The heat is used via the utilities' district heating network.

What is unusual about the first ORC power station in North-Rhine-Westphalia is that the vast majority of the fuel is obtained by processing local tree and shrub prunings. When combined with other natural waste wood, this produces a cheap, good-quality fuel. The fuel generates an annual net revenue of around 500,000 euros. The fine material left after processing the wood is composted.

Rated thermal input:	4,605 kW
Net thermal output:	3,900 kW
Electrical output:	600 kW
Fuel:	13,000 t/a untreated wood, including 50 % wood from green waste
Investment:	approx. 4 million euros
Start-up date:	December 2005
Electricity production:	4.5 million kWh/a – fed into electricity grid
Net heat production:	24.5 million kWh/a – fed into Oerlinghausen public utilities' district heating network
Climate effects:	CO_2 reduction of 7,900 t/a
Contact:	Holzheizkraftwerk Oerlinghausen GmbH An der Bleiche 21 | D-33813 Oerlinghausen Website: www.stadtwerke-oerlinghausen.de

CASE STUDY: HEATING SCHOOL COMPLEXES WITH GREEN WASTE FROM HOUSEHOLDS IN THE RHEIN-HUNSRÜCK DISTRICT

"Thanks to the large quantities of tree and shrub cuttings that are collected, it became possible to implement the idea of using this material as fuel. As a result, we have made an important contribution to achieving the goal the Rhein-Hunsrück district has set itself: to become a showcase region for climate change mitigation and innovative energy strategies" explains technical director Klaus-Peter Hildenbrand.

Heat for school complexes from green waste

Since the 1990s the Rhein-Hunsrück district has done some innovative approaches to the heat supply of public buildings. In autumn 2009 the district's waste management utility (Rhein-Hunsrück-Entsorgung) started to run central heating stations in three of the district's school complexes. What makes these systems special is that they are fired exclusively with shrub and green cuttings delivered by private households. Most recently, the third of these systems began supplying heat to the Emmelshausen school complex in December 2011.

Local residents deliver tree and shrub cuttings to 120 collection points run by the district authority. This results in 130,000 cubic metres of material each year, of which around 60 percent is processed for energy recovery and about 40 percent is shredded and then used for soil improvement and erosion control in agriculture, viticulture and landscaping. Thermal energy recovery in the three biomass-fired heating stations substitutes approx. 650,000 litres of heating oil per year in the district. The Emmelshausen facility alone accounts for 220,000 litres.

This prevents a capital outflow from the region for heating costs amounting to some 600,000 euros annually. The pre-processing of the heating material is performed at a central facility at the site of the district landfill. From here the material goes to storage halls at the central heating stations and to a joint interim storage facility. Because the material contains coarse wood fractions it is not free-flowing – the technology had to be adapted accordingly. The ash proportion amounts to approx. 10–15 percent. This made it essential to design the facilities to have capacities above 550 kW and to procure robust conveyor systems. Peak-load periods are supplemented by a gas-fired boiler of a capacity of 1,040 kW. In Simmern and Kirchberg, the roofs of the central heating stations and storage halls support photovoltaic arrays totalling 64 kWp.

The three biomass-fired heating stations are a pivotal element of the Rhein-Hunsrück district's plan of action to make the transition from net energy importer to exporter – a plan that has already been fulfilled in many respects.

	Simmern station	Kirchberg station	Emmelshausen station
Net energy produced:	3,395,840 KWh/a	2,212,000 KWh/a	no data
Energy supplied:	2,870,000 KWh/a	1,715,000 KWh/a	approx. 2,618,610 KWh/a
Solid fuel boiler capacity:	850 kW	650 kW	750 kW
Peak-load boiler capacity:	1,400 kW (oil)	1,050 kW (gas)	1,040 kW (gas)
Fuel storage capacity:	2,500 m^3	1,700 m^3	2,500 m^3
Buffer storage:	30 m^3	20 m^3	28 m^3
Fuel quantity (wood):	800–1,000 t/a	500–800 t/a	700–1,000 t/a
Heating oil equivalent savings:	273,500 litres	180,000 litres	220,000 litres
CO_2 savings:	465 t	330 t	400 t
Max. distance heat grid to heating system:	600 m	500 m	300 m
Overall efficiency:	75–80 %	75–80 %	75–80 %
Investment cost incl. grid:	2.1 million euros	2.45 million euros	2.14 million euros
Buildings connected:	5 schools, 3 sports halls	3 sports halls, indoor/ outdoor swimming pool, 4 schools	4 schools + lunch room area, 2 sports halls
Contact:	Rhein-Hunsrück-Entsorgung | Hr. Günter Hackländer | Weitersheck | D-55481 Kirchberg | Email: g.hacklaender@rh-entsorgung.de		

5 ENVIRONMENTAL ASPECTS OF COMPOSTING AND ANAEROBIC DIGESTION

The just under nine million metric tons of bio-waste and green waste collected annually through segregated systems represent an important resource for energy, nutrients and humus recovery. The costs involved in collection and treatment must be set against this potential.

5.1 Quality requirements and quality assurance of the recovery of composts and digestates

Strict quality requirements are laid down for composts and digestates with regard to their impurity and contaminant content.

The statutory framework for this is provided by the German Ordinance on Bio-waste (*Bioabfallverordnung BioAbfV*), which regulates the recycling of bio-waste on soils used for agriculture, forestry or horticulture with regard to their treatment and application. For example, specifications for bio-waste suitable for material recovery, regulations on pathogen reduction and limit values for contaminant content can be found there.

The Ordinance on Bio-waste also guarantees that composts and digestates from mixed household waste are not recycled as fertilisers or soil improvers. Numerous studies have shown that bio-waste composts produced from bio-waste collected separately are of far superior quality to composts based on mixed household waste.

In order to guarantee consistent quality to consumers of the products, most composting plants and also increasingly digestion plants undergo regular and independent quality checks by a product quality association.

Product quality associations guarantee that only appropriate and safe feedstock is used for recovery.

Also they guarantee that the requirements concerning treatment, the quality of the produced fertilisers and soil improvers and their proper use are met.

Precisely for products recovered from bio-waste and green waste it is of particular importance that proof of an impartial quality control and a label to identify a quality product is given, in order to gain acceptance by customers and to strengthen the regional sales structure.

Conclusion:

Owing to statutory requirements and voluntary quality assurance of the vast majority of plants, compost and digestate products made from bio-waste and green waste are in every respect of high quality.

5.2 Composts and digestates: providers of nutrients and humus for our soils

As they contain essential plant nutrients, composts and digestion products are good organic fertilisers and excellent soil improvers. Compost and composted solid digestates are especially suitable for humus reproduction. Both solid and liquid digestates contain nutrients that are directly available to plants, whereas compost releases them gradually. This should be considered for fertiliser planning.

Composts and digestates made from bio-waste and green waste

- contribute to reduce consumption of energy-intensive synthetic mineral fertilisers, conserve resources and have a positive effect on the CO_2 balance,
- make an important contribution to humus reproduction in the soil and
- have a regulating effect on the water balance.

According to calculations by the German waste management association (*Bundesverband der Deutschen Entsorgungswirtschaft, BDE*), the potential to reduce CO_2 by using compost instead of mineral fertiliser across the whole country is almost 300,000 metric tons a year.

Increasingly compost is used by soil producers as ingredient in the manufacturing of potting composts and growing media. This also contributes to a reduction in peat use in these areas and thus also to a cut in CO_2-emission

Conclusion:

Composted bio-waste and digestates contribute to improving humus balances. Composts supply plant nutrients such as phosphor and nitrogen. Whereas nitrogen in liquid digestates is rapidly available to crops, composts release the nutrients gradually.

Energy recovery from bio-waste, combined with material recovery of the plant nutrients contained in the waste, can be regarded as a “high grade cascade utilisation”.

Utility of bio-waste in the different recovery paths

Recovery paths	Composting	Anaerobic Digestion	
Product	material – solid –	energy/material – solid –[1)]	energy/material – liquid –
Humus reproduction	+ + +	+ + +	0
Peat substitution	+ +	+ +	0
Plant nutrients [2)]:			
- nitrogen	+	+	++
- phosphor	++	++	++
- other nutrients	+	++	++
Energy, heat	(+)[3]	+ +	+ +

1) Composted digestates
2) Short- and medium-term availability
3) In energy recovery from sifting residue

Source: BUNDESGÜTEGEMEINSCHAFT KOMPOST 2008, modified

5.3 Energy balances of composting and anaerobic digestion

An important criterion for assessing biological recovery paths is the energy balance of the plant technology used, which in the final analysis has an important influence on the climatic relevance of the process.

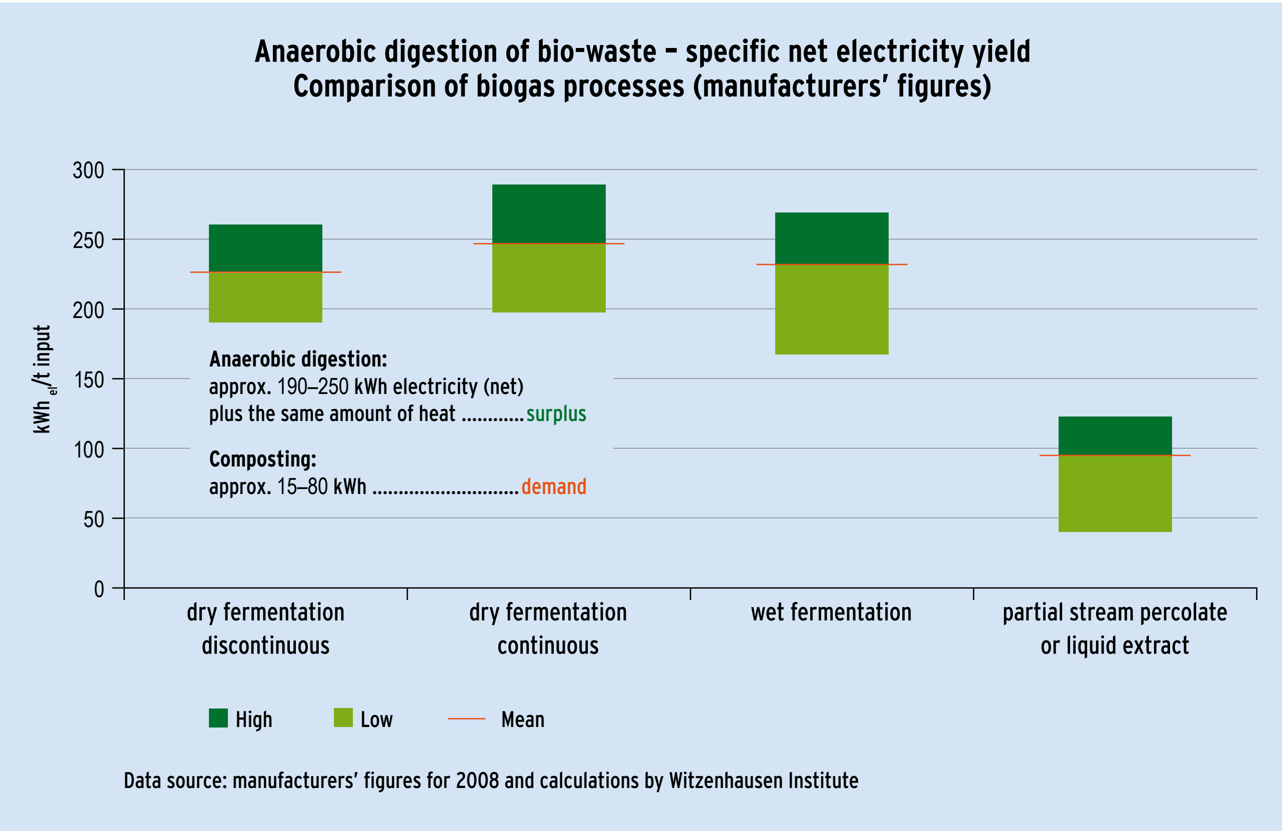
In the case of composting the energy required to recover one metric ton of input materials depends on the complexity of the installation. Thus the energy required varies between 15 and 80 kWh (electricity and fuel) per metric ton of input according to the system type. By-products of composting and anaerobic digestion such as the sifting residue can be used in cogeneration systems and improve the energy balances.

The anaerobic digestion of biological waste also consumes energy, requiring between 30 kWh and 60 kWh of electricity per metric ton of input as well as heat for the digestion process. However, by using the emerging biogas to produce electricity and heat, specific energy credits in the order of 200 kWh for both electricity and heat offset this consumption, with the result that the whole process has a clear energy surplus.

The diagram shows how the removal of suitable ligneous material from green waste combined with the composting of the herbaceous material results in a clearly positive energy balance for this recovery path.

Conclusion:

In the case of composting alone, the recovery process requires an input of energy, whereas anaerobic digestion with subsequent composting of the digestates produces energy. If efficient thermal recovery of sifted residues is carried out when composting, this recovery path can also deliver a net energy surplus.



5.4 Greenhouse gas balances of composting and anaerobic digestion

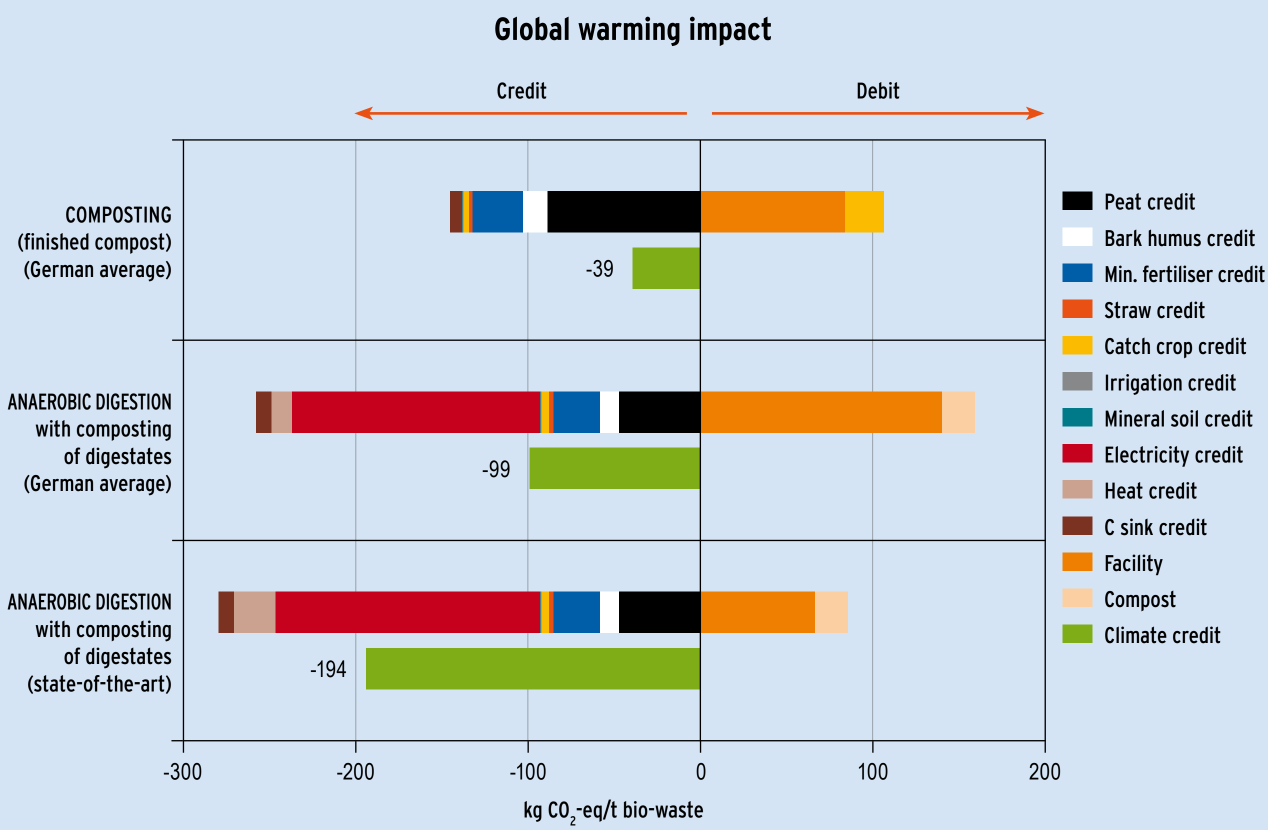
CO_2 emissions emerge from the use of fossil fuels to operate the facility and distribute composts and digestates. Although substantial amounts of carbon dioxide are released by the decomposition of organic matter during the composting of bio-waste and solid digestates, this is assessed as climate-neutral, since it was previously taken up by the plants.

Nevertheless, as a result of both composting and anaerobic digestion, depending on the processes used in the facility and the distribution of the composts and digestates, some other emissions (methane, nitrous oxide, ammonia) emerge, which must be taken into account in the greenhouse gas balance. These emissions can be offset by various types of CO_2 credit, e.g. for products substituted, such as peat and mineral fertiliser, and by direct energy credits for the electricity and heat generated.

These emissions and savings (credits), considering also the carbon sink, sum up for composting (finished compost product) in a climate credit of 39 kg CO_2 equivalents per metric ton bio-waste.

Anaerobic digestion prior composting reduces overall CO_2 emissions thanks to a substantial energy (electricity and heat) credit from biogas recovery. In this way a climate credit of approximately 99 kg CO_2 equivalents can be obtained per metric ton of bio-waste (average of all bio-waste digestion facilities in Germany). State-of-the-art bio-waste digestion technology with reduced greenhouse gas emissions even achieves a credit of approx. 194 kg CO_2 equivalents (with carbon sink).

The following diagram shows the main debits and credits from composting and anaerobic digestion in terms of CO_2 equivalents (average values, state-of-the-art). It should be noted that this diagram does not show a comprehensive environmental life-cycle analysis, but only a greenhouse gas balance.



Source: ifeu (Institute for Energy and Environmental Research) 2012: Optimising organic waste recovery (UFOPLAN 3709 33 340), modified

Liquid digestate

Dewatered digestate

Résumé:

- If bio-waste and green waste is collected and recovered separately from residual waste, high-quality soil improvers and fertilisers can be produced sustainably by treating it in composting plants or combined anaerobic digestion and composting facilities.
- The material recovery of digestates is an important renewable source of plant nutrients and humus, and is therefore essential for the greenhouse gas balance.
- The statutory framework conditions and quality control guarantee high-grade compost and digestates.
- Anaerobic digestion achieves a positive energy and climate balance due to the emerging biogas and the resulting substitution of fossil fuels.
- Composting can deliver a climate credit of 39 kg CO_2 equivalent saved per metric ton bio-waste. In the case of anaerobic digestion the climate credit amounts to approx. 99 kg (German average) or 194 kg (state-of-the-art facilities).
- Undesirable emissions of trace gases, especially methane, nitrous oxide and ammonia, must be reduced further through technical and operational measures and minimised in the whole process chain.

6 ECONOMIC ASPECTS OF BIOLOGICAL WASTE RECOVERY

Compost heap in autumn

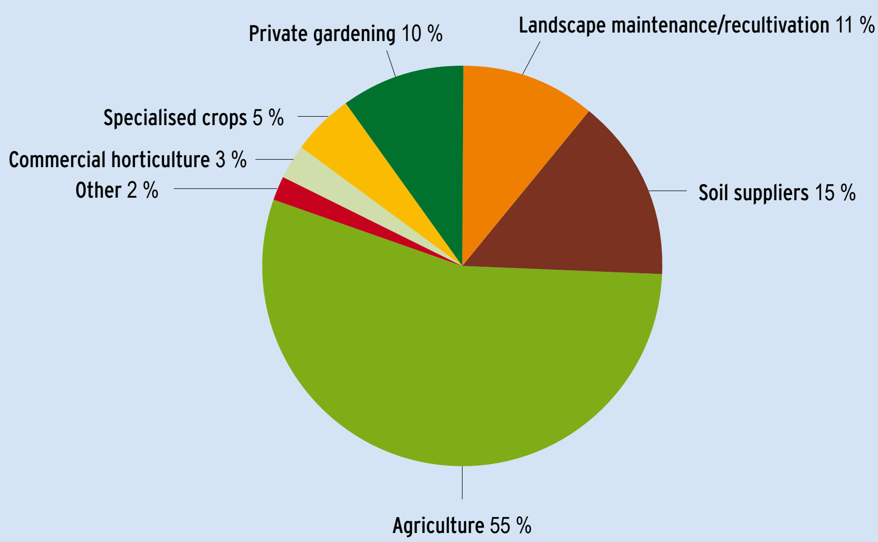
The end product: saleable top-quality compost

Compost has always been a popular soil improver in private gardens, often produced on the compost heap there. Farmers, particularly those farming organically, and market gardeners also recognise the importance of compost in providing nutrients and maintaining the soil's fertility.

6.1 Marketing of compost

Marketing channels for compost can be found in many areas, sometimes characterised by the regional structures.

Compost marketing channels



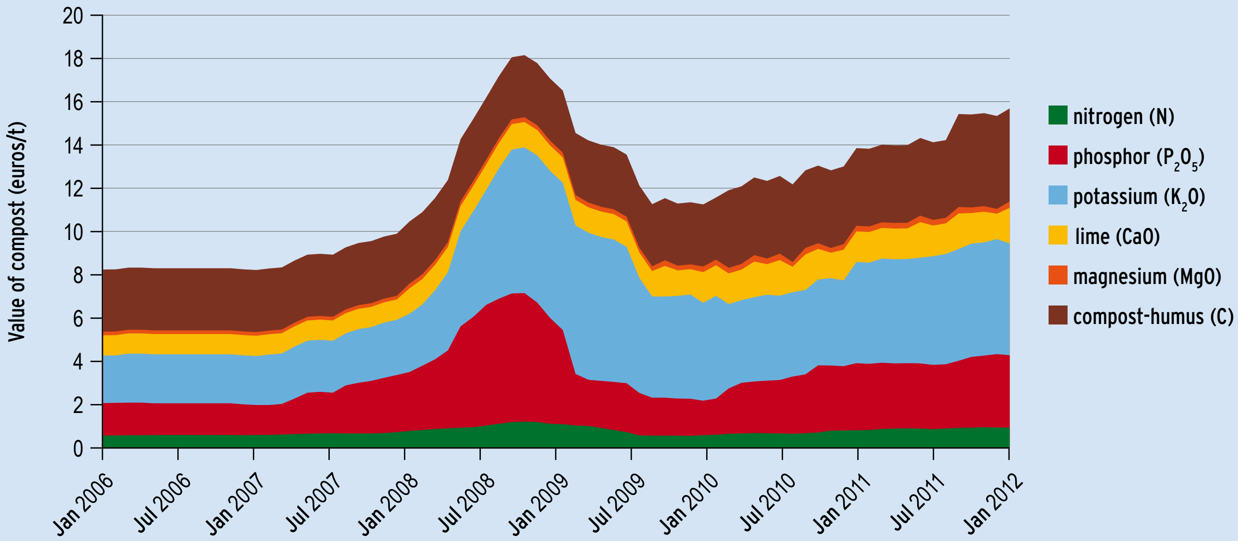
Source: German Quality Association for Compost (BGK), 2011

The economic importance of using composts in agriculture is often underestimated. However, a constantly rising demand shows that compost is rapidly becoming an attractive substitute in the wake of higher mineral fertiliser prices. While until a few years ago farmers were still paid to accept compost and composted digestates, nowadays it is usually a source of revenue.

The use of liquid digestate can be cost-neutral in arable farming areas without a large amount of livestock if transport distances are below ten kilometres.

If one considers just the fertiliser value of compost based on mineral fertiliser prices, a metric ton of compost was worth up to twelve euros in early 2012.

Development of the value of compost
Calculation of the value of compost based on mineral fertiliser prices in Westphalia-Lippe and humus values based on humus reproduction from straw (2006–2012)



Source: Humus and Soil Industry Association (Verband der Humus und Erdenwirtschaft, VHE), February 2012

Sifting composted digestates

Processed compost, ready-to-use soil improver

A successful plan for marketing compost to private and commercial gardeners is being carried out by the Main-Spessart humus works in association with the Würzburg composting plant: quality composts from regional composting facilities are refined on site into high-grade humus products such as topsoil and potting compost and sold locally through a trading partner loose or in bags under the label “Soils from Lower Franconia”.

According to Thomas von der Saal, managing director of Main-Spessart humus works: *“The product reference to the region on our composts and soils strengthens the consumers’ identification with ‘their’ region and contributes to the growing demand for regional products. High-quality regional soils enjoy greater consumer confidence and are bought by preference by a lot of customers.”*

6.2 Composting, anaerobic digestion and combination models (upstream facilities): costs and revenues

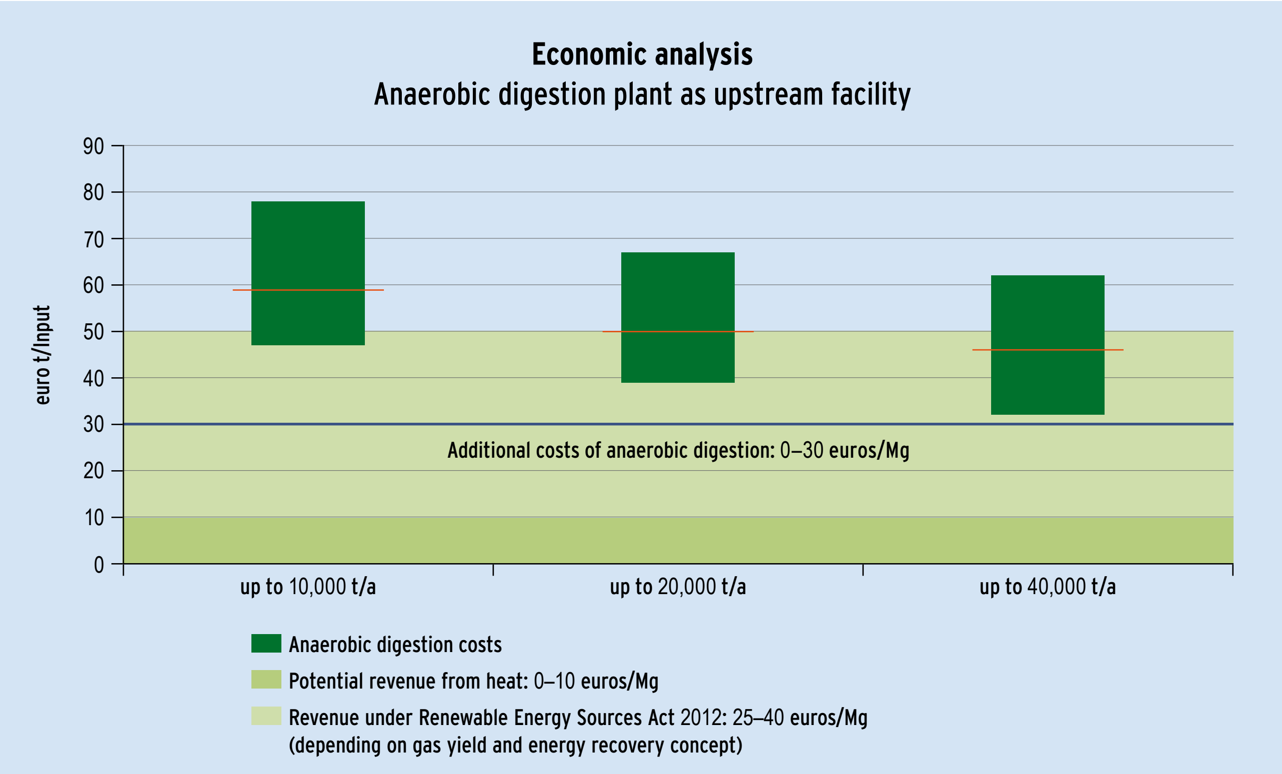
Options for the expansion of the collection of bio-waste have already been mentioned. This is usually economically sound as well, since the cost of a bio-waste composting facility or an anaerobic digester with subsequent composting is still significantly below the cost of treating residual unseparated waste. In 2011 the treatment costs for residual waste were between 70 and 150 euros per metric ton, whereas the treatment of bio-waste (composting or digestion) usually cost between 30 and 80 euros per metric ton. The cost of composting green waste was even significantly lower than that, at between 5 and 30 euros per metric ton.

As most composting facilities came into operation between the early and mid-1990s, it must be assumed that a large number of plants are due for investment in replacements. This raises the question of whether the composting facility should be renovated and optimised or whether an anaerobic digestion stage should be integrated as well.

In addition there is a significant economic incentive (see Section 7), because of the Renewable Energy Sources Act’s support for electricity fed into the grid from the digestion of bio-waste with material recovery of solid digestates.

Plants especially suitable for the integration of a digestion stage would be technically advanced bio-waste composting facilities with a minimum size of 15,000 metric tons per year or more. Ideal conditions are in place if the amount of input can be increased by a third or even half, as the existing compost plant is then used to full capacity when the digestate is processed into compost. However, the existing specific circumstances and options should be examined in each individual case. On average the increase in costs to an existing facility from the addition of a digestion stage comes out at zero to thirty euros per metric ton of bio-waste. This takes into account the revenues from selling electricity and heat. In some cases, especially with the current rising costs of bio-waste treatment, there can even be a reduction in costs. As the solid digestate is also composted, the costs in this area remain the same.

Delivering bio-waste for recovery



Résumé:

- Usually there are profits to be made by marketing composts and digestates as attractive substitutes for mineral fertilisers and soil improvers.
- Regional marketing strategies and the production of high-quality soils and substrates can contribute to an increase in compost sales.
- The increase in costs for the addition of an anaerobic digestion plant to a composting facility amounts around zero to thirty euros per metric ton of bio-waste. In some cases there can even be a reduction in costs.

Bio-waste to energy

7 FUNDING OF BIO-WASTE AND GREEN WASTE ENERGY RECOVERY PROVIDED BY THE GERMAN RENEWABLE ENERGY SOURCES ACT (EEG)

In Germany the recovery of materials and energy from biodegradable waste, is governed by several statutory rules:

- provisions of energy law designed to promote and optimise utilisation processes (such as the Renewable Energy Sources Act [EEG], or the Biomass Ordinance [BioAbfV]),
- facility-related provisions establishing requirements upon the construction and operation of facilities (such as the Federal Immission Control Act [BImSchG] and the ordinances and administrative guidelines adopted on the basis of that Act) and
- substance-related rules and regulations designed to direct material flow into economic cycles in a manner that is efficient and causes no harm (such as the Ordinance on Bio-waste or the Fertiliser Ordinance).

The requirements established by the Ordinance on Bio-waste and by fertiliser law have particular significance for the treatment and use of organic waste. This framework comprehensively regulates the permissible materials, treatment processes and recovery options.

The Act on granting priority to renewable energy sources

The Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz – EEG), in its amended version that became law on 1st January 2012, is particularly important in relation to energy recovery from bio-waste and green waste. The Act's purpose is the funding and development of renewable electricity production in Germany.

The EEG guarantees that electricity generated from renewable sources can be fed into the electricity grid.

Digester of a biogas facility

Payments [cent/kWh] for electricity generated from bio-waste made under the Renewable Energy Sources Act (EEG, 2012)

	Electricity generated from ...		
Electric capacity class	Anaerobic digestion of defined types of bio-waste (Art. 27a)	Anaerobic digestion of other types of bio-waste (Art. 27)	Thermal energy recovery from ligneous green waste (Art. 27)
≤ 150 kW	16.00	14.30	14.30
151–500 kW	16.00	12.30	12.30
501 kW–5 MW	14.00	11.00	11.00
5,001 MW–20 MW	14.00	6.00	6.00

It further establishes a system of fees that grid operators must pay at fixed rates to renewable electricity producers. The new Section 27a EEG has now established special provisions allowing for slightly increased payments for the digestion of certain types of bio-waste.

The main preconditions to receiving a payment under the EEG are that

(1) at least 90 percent by mass of the input materials within a calendar year consist of separately collected bio-waste of the following waste code types:
- 200201 (Garden and park waste)
- 200301 (Biobin)
- 200302 (Market waste)

(2) the installations used for anaerobic digestion of bio-waste are linked directly to an installation for composting the solid digestates and

(3) the composted digestates are used for material recovery.

If these conditions and a number of further technical specifications of the facility are met, electricity attracts a payment of 16 cents/kWh_{el} up to an annual electricity output of 4.38 million kWh_{el} (500 kWh_{el} capacity class). Electricity generated beyond that output attracts a payment of 14 cents/kWh_{el} (up to max. 20 MW capacity class).

Upgrading biogas to natural gas quality and feeding it into the natural gas grid attracts a further payment. Depending on the capacity class of the biogas upgrading facility, this can amount to an additional 1 to 3 cents/kWh_{el} (Article 27c EEG).

Under Article 27 electricity from the anaerobic digestion of other types of biogenic waste attracts payments between 6 and 14.3 cents/kWh_{el}. If bio-waste and green waste are used in wood-fired cogeneration units, the same payments for the electricity generated by such units is realized.

If certain types of biogenic waste are used, notably slurry substrate, further payment can be added to the basic level; this can amount up to 8 cents/kWh_{el} according to the type of material. In order to determine the payment class for each type of input material, the Biomass Ordinance establishes substance tariff classes defined according to their material-specific energy yields.

Résumé:

The EEG has created a system ensuring that electricity generated from renewable sources can be fed into the grid. It also establishes a financial incentive system to promote innovative use of energy concepts such as the material and energy recovery bio- and green waste.

8 GUIDELINES FOR POLICY-MAKERS OF LOCAL AUTHORITIES

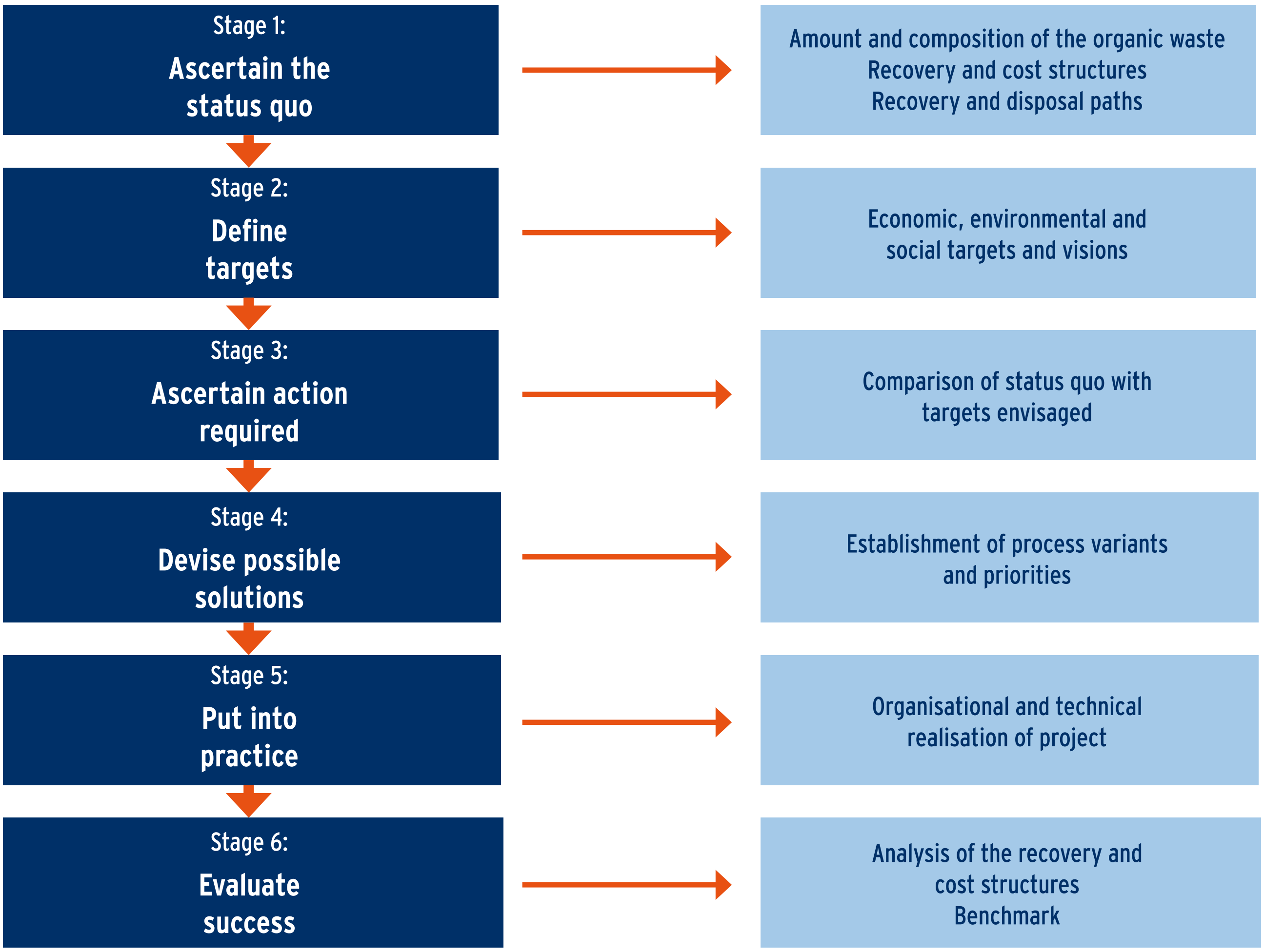
This brochure shows, with the help of case studies, that the separate collection of bio-waste and green waste and its use as a material and energy resource can make a considerable contribution towards climate protection and renewable energies. The following checklists are intended to help public-sector waste management entities to examine their

- current collection of bio-waste and green waste
- and its recovery,

and – where appropriate – to identify the need for action and improvement.

The figures used here are based on practical experience and targets.

The evaluation diagram should encourage intensive discussion on the subject of bio-waste, with the aim of optimising the recovery of bio-waste and green waste. Even where the target amounts quoted in the individual questions for bio-waste and green waste have already been achieved, further improvements in recovery can of course be considered.



Waste wood for energy recovery

TARGET:
Bio-waste and green waste are used for high-grade material and/or energy recovery

1. The recycling of bio-waste and green waste is mainly carried out locally.
2. High-grade compost or digestate is produced, making high-value material recovery possible in accordance with good professional practice.
3. Materials particularly suitable for anaerobic digestion are taken to an anaerobic digestion plant (upstream facility) and the biogas is used for electricity and heat production or processed for feeding into the natural gas grid.
4. The ligneous parts of bio-waste and green waste is separated and used as an energy resource in a biomass-fired power plant or for heat generation. In the case of bio-waste, green waste and digestates left for composting, it is important, that enough ligneous material is left to provide the structure for a low-emission aerobic decomposition.

Existing separate collection for bio-waste (biobin)

YES	NO
1. Specific amounts collected exceed 60 kg/res*a.	1. There are comprehensible reasons for not introducing a separate collection system for bio-waste (for example, because of the settlement structure).
2. More than two thirds of households are covered by the system.	2. More than two thirds of households have their own well-functioning composting systems (verified by inspection).
3. The quality of the material collected is sufficiently good (less than 5 percent impurities)	3. Very high specific collection of green waste (more than 100 kg/res*a).
4. Financial incentives for separate collection are included in the waste and charges statutes.	4. The biodegradable content of residual household refuse is less than one third (residual household refuse analysis).
5. Home composting is encouraged, but also regulated.	
6. The biodegradable content of residual household refuse is less than one third (residual household refuse analysis).	
7. The waste advisory service and publicity regularly addresses the subject of bio-waste (foreign language information sheets where necessary).	

EVALUATION

The lower the number of boxes ticked, the more thoroughly optimisation potential in bio-waste collection should be examined.	The lower the number of boxes ticked, the more thoroughly the introduction of biobins should be examined.

Existing separate collection for green waste

YES	NO
1. The green waste collection is carried out in combination with the bio-waste collection. The specific quantities collected (bio-waste and green waste) are together more than 110 kg/res*a.	1. There are comprehensible reasons for not introducing a separate collection system for green wastes.
2. Green waste (tree and shrub prunings, Christmas trees) is collected at least twice a year from residents.	2. Very high specific collection of bio-waste (biobin) (more than 100 kg/res*a) with a high green waste content.
3. All residents can take their green waste to a collection point.	3. The biodegradable content of residual household refuse is less than one third (residual household refuse analysis).
4. The collection point is easily accessible.	
5. Home composting is encouraged, but also regulated.	
6. The biodegradable content of residual household refuse is less than one third (residual household refuse analysis).	
7. The waste advisory service and publicity regularly addresses the subject of green waste (foreign language information sheets where necessary).	

EVALUATION

YES	NO
The lower the number of boxes ticked, the more thoroughly optimisation potential in green waste collection should be examined.	The lower the number of boxes ticked, the more thoroughly the introduction of a separate green waste collection should be examined.

9 SOURCES OF FURTHER INFORMATION

Further information can be found on the following websites:

- www.bmu.de
  Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
- www.uba.de
  Federal Environment Agency
- www.witzenhausen-institut.de
  Witzenhausen Institute (University of Kassel Faculty of Organic Agricultural Sciences at Witzenhausen)
- www.ask.eu.de
  Information portal
- www.kompost.de
  Bundesgütegemeinschaft Kompost e. V. (registered association of compost producers and suppliers)
- www.biogas.org
  German Biogas Association
- www.vhe.de
  Verband der Humus- und Erdenwirtschaft e. V. (Association of the humus and soil industry)

10 GLOSSARY

Biogas: Biogas is formed through the bacterial digestion of organic matter (biomass) under anaerobic conditions. Methane is the principal component of biogas. Biogas is found in, for instance, swamps and mires or in the digestive tract of ruminants, and can be produced from biomass in technical installations (digesters).

Bio-waste: Kitchen waste collected via the biobin, with a proportion of garden waste (Federal Statistical Office waste code number 20030104: "Biobin waste").

Digestate: Digestion residues emerging in the anaerobic phase of the digestion process.

Digestate product: Final products emerging from the separation of digestates, which are either consigned directly to reuse in agriculture as liquid digestion products or are returned to the materials cycle as a solid digestate following a composting process.

Dry fermentation[1]: Dry fermentation is a process used to produce biomass through anaerobic digestion in which the feedstock consists exclusively of solid substrates with high dry matter contents (generally above 20 percent). The fermenter content is no longer pumpable. However, it is generally stackable. The substrate is not diluted with liquids.

Green waste: Garden waste and shrub prunings (with no admixture of wet kitchen waste) collected by segregated systems (pick-up at source, and/or drop-off at recovery facility) (waste code number 200201: "Biodegradable waste from garden and park waste").

Landscape maintenance material[2]: Garden and park waste, waste emerging from landscape maintenance activities, tree and shrub clearing residues, and the plant-based component of coastal and watercourse maintenance material that fall under waste code number 200201 (Biodegradable waste).

Specific waste amount: This term refers to the untreated mass of a waste substance that arises per citizen and year. It is usually stated in kilograms per resident and year (kg/res*a).

Technical potential[1]: The technical potential is that part of the theoretical potential that can actually be tapped under the restrictions applying.

Theoretical potential[1]: The theoretical potential refers to the quantity of available energy that could theoretically be tapped in physical terms within a given period (e.g. the energy stored in plant biomass) in a region. Due to insurmountable barriers (technical, ecological, structural, administrative limits) the theoretical potential can usually only be tapped in part.

Wet fermentation[1]: Wet fermentation processes can be used to digest both liquids (generally with dry matter contents below 3 percent) and solid substrates. A defining feature is that the fermenter content is always pumpable. This state can be achieved by admixing liquids such as water.

1 Definition based on Kaltschmitt, M. et al. (2009): Energie aus Biomasse. 2nd edition, Berlin.
2 Definition based on the Bio-waste Ordinance.

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