EN

EUROPEAN COMMISSION

Brussels, 18.5.2010
SEC(2010) 577 final

COMMISSION STAFF WORKING DOCUMENT

Accompanying the Communication from the Commission On future steps in bio-waste management in the European Union

{COM(2010) 235 final}

COMMISSION STAFF WORKING DOCUMENT

Accompanying the Communication from the Commission
On future steps in bio-waste management in the European Union

Assessment of the management of bio-waste

Table of contents

List of the Annexes

Contents of figures:

List of acronyms and abbreviations

AD: Anaerobic Digestion

AQ: Air Quality

CH4: Methane

CHP: Combined Heat and Power

CO_2: Carbon dioxide

CO_{2e}: CO_2 equivalent

ETS: Green house gas emission trading scheme

EU-27: Current Member States

EU-15: European Union countries prior to 1st May 2004

EU-12: New Member States after 1st May 2004

GHG: Greenhouse Gases

ISG: Inter Service Group

IVC: In-vessel composting

IPCC: Intergovernmental panel on climate change

MBT: Mechanical-biological treatment

MSW: Municipal solid waste

Mt: Million tonnes

NGO's: Non Governmental Organisations

N_2O: Nitrous oxide

NO_x: Nitrogen oxides

NPV: Net Present Value

QAS: Quality Assurance Schemes

WFD: Waste Framework Directive (1998/2008/EC)

1. PROCEDURAL ISSUES AND CONSULTATION OF INTERESTED PARTIES

This assessment aims at assessing the management of bio-waste as requested by Article 22 of the Waste Framework Directive[1].

1.1. Background study

Background data and information for this report were developed by a consortium of consultants - Arcadis and Eunomia - from January to November 2009. Interim results and draft reports were made available to stakeholders for comments and published online. The study is further referred to in this Assessment as the "Arcadis/Eunomia report[2]". All data mentioned in this Assessment originate from this study, unless mentioned otherwise.

1.2. Internal consultation

An Interservice Steering Group (ISG) was created to follow the preparation of the Assessment. It was a continuation of the ISG established for the purposes of the Green Paper on the Management of Bio-waste in the EU. The ISG met twice: first to comment on the outline and policy scenarios of the Assessment and a second time to discuss the structure and the main messages from the Assessment. The following Commission services were engaged in the preparation of this Assessment: DG ECFIN, TREN, ENTR, RTD, AGRI, SANCO, JRC, SJ, and SG. Minutes from the last ISG meeting form the Annex 1 to this Assessment.

1.3. External consultation

DG ENV carried out a broad stakeholder consultation throughout the process of preparation of this IA. On 3 December 2008, the Commission's Green Paper on bio-waste management was adopted and published. A first round of consultation on this issue ended mid-March 2009. In this process, the stakeholders were asked questions concerning various policy and technology options and expected future developments in the area of bio-waste management.

Almost 150 comments were received and made public on a specific CIRCA website[3]. A summary of the comments is given in Annex 2. This website was also used to host deliverables from the Arcadis/Eunomia study and comments thereto. From spring 2009, interested stakeholders were regularly informed via a website dedicated to the issue of biodegradable waste management[4].

On 9-10 July 2009, DG ENV together with 3 Member States (Belgium, the Czech Republic and Germany) co-organised a conference on bio-waste which gave the stakeholders an opportunity to further comment on the issue.

---

1 Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste, OJ L 312, 22.11.2008, p.3

2 "Assessment of the options to improve the management of bio-waste in the European Union", Arcadis/Eunomia, December 2009

3 http://circa.europa.eu/Public/irc/env/biowaste_prop/home All references to CIRCA in the text refer to this website

4 http://ec.europa.eu/environment/waste/compost/index.htm

The conference was open to the public and around 200 participants actively attended the meeting[5]. Several Member States, environmental NGO's and a majority of waste related industries expressed strong support for a standalone legislation on bio-waste while another group of Member States and representatives of regional and local authorities voiced reservations.

On 25 June 2009, the Environment Council adopted its conclusions on the Commission's Green Paper on bio-waste management[6]. The Council expressed concerns about the increasing volume of biodegradable waste and the linked greenhouse gas emissions and other pollution - especially when such waste is landfilled. It was also agreed that improved bio-waste management could contribute to fighting climate change and help to improve soil quality via the application of compost.

The Council urged the Commission to take into account local conditions when weighing up policy options to improve the management of bio-waste in the EU and invited the Commission to present an EU legislative proposal on biodegradable waste by 2010, "if appropriate". The conclusions have been adopted unanimously; however, negotiations over the text were intense and demonstrated significant differences in the views of Member States with regards to this issue.

A targeted stakeholder consultation of Member States and key stakeholders was conducted in May-June 2009 to allow stakeholders to verify and comment on the baseline scenario developed for the Assessment. Another targeted consultation was conducted in October 2009 on the results of the scenario developed to assess the possible impacts of various options on improved bio-waste management. Main comments are summarized in Annex1.

Box 1: What is bio-waste?

"Bio-waste" is defined in the Waste Framework Directive (WFD) as "*biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises, and comparable waste from food processing plants*". It does not include forestry or agricultural residues, manure, sewage sludge, or other biodegradable waste (natural textiles, paper or processed wood).

"Biodegradable waste" is a broader concept defined in the Landfill Directive as any waste that is capable of undergoing anaerobic or aerobic decomposition, such as food and garden waste, and paper and paperboard. All biodegradable waste can have negative impacts on the environment when improperly managed, notably in landfills. Environmentally preferable options can include composting (notably food and garden waste), recycling or use as renewable energy sources (for example paper, paperboard, treated wood). The WFD defined bio-waste more precisely and focused on this fraction.

The total yearly production of bio-waste in the EU amounts to 118 to 138 Mt of which around 88 Mt originate from municipal waste and between 30 to 50 Mt from industrial sources such as food processing[7]. In the EU, bio-waste usually constitutes between 30% and 40% - but can range from 18% up to 60% - of municipal solid waste (MSW). The bio-waste part of MSW comprises two major streams: green waste from parks, gardens etc. and kitchen waste. The former usually includes 50-60% water and more wood (lignocellulosis), the latter contains no wood and up to 80% water.

5 Proceedings are published on the http://www.biowaste.eu
6 2953rd Environment Council meeting, Luxembourg, 25 June 2009
7 Data based on data on municipal waste from EUROSTAT, source : Arcadis/Eunomia report 2009

2. POLICY CONTEXT

Since 1999, the issue of specific legislation on biodegradable waste and bio-waste was subject to intensive political debate. Many stakeholders including several Member States and European Parliament directly formulated calls for such legislation. The idea was also supported by environmental NGO's and the waste management services. At that time, the legislation was supposed to supplement other legislations concerning the management of municipal waste, namely the Landfill Directive[8] and the Waste Incineration Directive[9].

The issue of bio-waste management was further addressed in the Thematic Strategy on the Prevention and Recycling of Waste[10]. The Strategy stated that, since there is no single environmentally best option for the management of bio-waste diverted from landfills, bio-waste management options should be determined by Member States using life-cycle thinking. In parallel, the Commission would continue its work on preparing guidelines on the application of life-cycle thinking and address standards for waste recycling. This work has progressed substantially and guidance documents are being published[11].

Beyond non-binding guidance, the new end-of-waste mechanism of the revised Waste Framework Directive (WFD) now provides a legislative tool for binding EU standards on waste management processes and the quality of recycled materials, including compost. Article 22 specifically calls upon the Commission to carry out "*an assessment of the management of bio-waste, with a view to submitting a proposal, if appropriate*", and to analyze "*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*".

The European Parliament in its resolution on the proposal for a Soil Framework Directive[12] also called for a European initiative on bio-waste management. Accordingly, the Commission in 2008 started to re-examine the issue and published a Green Paper on the Management of bio-waste in the EU. The foregoing discussions have already given valuable indication for the scope of possible policy options. This Assessment is intended to up-date the debate, using new information and data available after enlargement by 12 new Member States.

3. PROBLEM DEFINITION

3.1. The nature of the problem

About 30 to 40% of the mass of the municipal solid waste produced in the European Union is bio-waste, equivalent to 88 million tonnes annually (around 170 kilograms per inhabitant annually, respectively 0.5 kilograms per day). Without additional action, this amount is projected to increase by 10% by 2020.

---

8 Council Directive 1999/31/EC of 26 April 1999 on the Landfill of waste, OJ L 182, 16.7.1999, p. 1

9 Directive 2000/76/EC on the incineration of waste, OJ L 332, 28.12.2000, p. 91

10 COM (2005) 666 final

11 JRC is finalising the International Reference Life Cycle Data System (ILCD) handbook which contains a series of technical guidance documents that provide the basis for consistent and quality-assured life cycle data, methods and assessments. In parallel, JRC is also developing the "ILCD Data Network" which supports access to quality assured life cycle data, worldwide, building on the ILCD Handbook. More information is available from: http://lct.jrc.ec.europa.eu/eplca/deliverables/international-reference-life-cycle-data-system-ilcd-handbook

12 European Parliament legislative resolution of 14 November 2007 on the proposal for a Directive of the European Parliament and of the Council establishing a framework for the protection of soil

Box 2: Bio-waste treatment methods – technologies in use and potential

Today's most common bio-waste management options include, in addition to prevention at source, its collection - separately or with mixed waste, anaerobic digestion and composting, incineration, and landfilling. The environmental and economic benefits of different treatment methods depend partly on local conditions such as population density, infrastructure and climate as well as on the existence of markets for associated products - energy and compost. The two most important methods of biological treatment of bio-waste are composting and anaerobic digestion (AD).

Composting is a process which turns biomass into compost with the use of oxygen and certain microorganisms. There are two forms of composting: windrow composting conducted in open air and in-vessel composting (IVC) carried out in closed containers. Windrow composting is the most used method of treating green waste today, mostly due to very low investments costs, but it is not suited to treat food waste. IVC is more adapted for treating food waste and causes less nuisances to the neighbourhood, but is more costly. Home composting or "backyard composting" refers to composting by citizen at home using simple methods. During composting around 50% of the mass of waste (mostly water) is lost. The rest turns into compost. Separate collection of bio-waste is one of the conditions required to guarantee the high quality of the compost produced.

Anaerobic digestion (AD) is a process in which wet waste degrades in enclosed tanks without oxygen using the activity of other types of microorganisms than those active in the composting process. During this process large amounts of methane are generated which can easily be collected and used for energy generation purposes: either directly to power gas engines or as a vehicle fuel (CNG). Another promising option for the bio-methane produced would be its injection into the natural gas distribution grid. Moreover, grid injection would have the economic advantage of relying on an already existing distribution infrastructure. Solid residues from the process - a "digestate" - can be used in agriculture (mostly after composting). In this Assessment the term "compost" refers to both compost and digestate, unless stated otherwise and the term "biological treatment" covers composting and anaerobic digestion of separately collected bio-waste and home composting.

Bio-waste can also be used as a source of carbon neutral energy[13] during incineration or via production of biogas during anaerobic digestion. In the near future, bio-waste may also be used on a wider scale as a resource for the production of second generation of bio-fuels.

The range of technologies used to treat mixed municipal waste using biological treatment is often referred to as Mechanical-Biological Treatment (MBT). This method is usually used to only pre-treat biodegradable waste in order to stabilise it before its final disposal and to sort recyclable fractions from the mixed waste. Some MBT facilities produce compost from mixed waste but the quality of such material is very low.

Finally, landfilled bio-waste undergoes a process similar to AD: it decomposes in landfills to produce large amount of greenhouse gases (especially methane) which needs to be captured and leachate which may contaminate the soil and groundwater if the landfill is not operated in

[13] As bio-mass during its growth removes CO2 from atmosphere via photosynthesis – emission of GHG is regarded by Intergovernmental Panel on Climate Change (IPCC) as part of natural carbon cycle. As a result, biogenic CO2 is not taken into account when greenhouse gas emissions are calculated

conformity with the provisions of the Landfill Directive. Also, landfilling means an irrecoverable loss of resources.

Food waste disposers[14] could constitute an alternative method, especially in places where separate collection of food waste is not possible or feasible and where an individual sewer system and waste water treatment installations allows for their use. However they do not solve the problem of food waste but transfer it to the waste water treatment plant. As their feasibility depends on local conditions the decision of promoting/banning should not be taken at the EU level but left to national/regional or even local authorities. Therefore they are not covered by this analysis.

In a number of Member States, the management practices for bio-waste are not optimal: EU-wide, 36 million tonnes (40%) of this waste are still landfilled[15]; in some Member States this amount still exceeds 90%. The massive use of landfilling for bio-waste management violates the "hierarchy" of waste management options which is a binding legal requirement for national waste management policies[16] as it disregards better alternatives such as prevention and recycling.

It also represents a risk of non compliance with the Landfill Directive, notably its provisions for diverting biodegradable waste and managing landfill gas. EU legislation indeed already bans landfilling of an increasing part of biodegradable waste (Box 3).

While the Landfill Directive does not impose specific treatment on bio-waste diverted from landfills, Member States are obliged according to the requirements of the Waste Framework Directive to optimise treatment with a view to sustainable resource use, avoiding negative impacts on the environment and human health according to their specific conditions. This includes notably the requirement to develop national policies in support of waste prevention and recycling.

Failure by many Member States to respect in practice the "waste hierarchy" principles leads to significant losses of material and energy resources, unnecessary greenhouse gas emissions and other environmental impacts, e.g. on groundwater quality.

The EU as a whole is therefore missing out on the economic and environmental opportunities offered by directing bio-waste to the most appropriate management techniques[17]. For example, recycling of bio-waste accounts for only 1/3 of its overall potential[18], although seemingly cheaper alternatives have been shown to be more expensive when taking into account their financial, environmental and social costs.

It is estimated that by improving bio-waste management and make it conform to the principle of the "waste hierarchy" notably by increasing prevention and recycling efforts:

- Significant financial savings could be made by citizens. For example, one third of food bought by UK households (approximate value of €19 billions) becomes waste[19]. Up to 60% of this waste

14 Device, usually electrically-powered, installed under a kitchen sink which shreds food waste into small pieces to pass through plumbing.

15 Data for the year 2008 - source: Arcadis/Eunomia report

16 Article 4 of the WFD includes a precise definition of the waste management hierarchy: the prevention of waste is defined as the best option, followed by re-use, recycling and energy recovery. Disposal (landfilling, incineration with low-energy recovery) is defined as the worst environmental option

17 Box 2 outlines the bio-waste management options

18 Source: Orbit/ECN

19 Source: "The Food We Waste" report for the "Waste Resources Action Programme (WRAP) – UK" – April 2008

could theoretically be avoided. Other sources[20] suggest that 5% of food waste can be saved by smarter consumption (avoid food wasting) and a similar amount of garden waste by improved gardening practises;

- The market for quality compost could be increased by a factor of 2.6 to reach about 28 million tonnes[21]. This could help to improve the quality of 3% to 7% of depleted agricultural soils in the EU[22] and to address the problem of degrading soil quality in Europe[23];

- Maximising composting could also substitute 10% of phosphate fertilizers, 9% of potassium fertilizers and 8% of lime fertilizers[24];

- About one-third of the 2020 EU target to use renewable energy in transport[25] could be met by using the biogas produced from bio-waste as vehicle fuel. If all the bio-waste produced in the EU in 2020 was treated by anaerobic digestion and the gas used by public vehicle fleets, the potential gain would be around 13 Mt CO_2-equivalent[26]. In terms of the achievement of the 10% biofuel target this would represent an average contribution ranging from 6% in Luxembourg up to 85% in Romania;

- Emissions of between 10 Mt[27] to a maximum of 50 Mt[28] CO_2-equivalent could be avoided by more prevention and biological treatment, representing between 0.4 % and 2.3 % of the EU 2005 GHG emissions (not covered by ETS)[29] in 2005[30]. This could represent between 4% to a maximum of 23% of the 2020 EU target (10% reduction compared to 2005 emissions) for the non ETS GHG emissions[31].

In summary, the EU is missing out on significant environmental, social and economic opportunities as bio-waste management options are not optimal and EU legislation on the prevention and management of bio-waste is insufficiently implemented in many Member States.

The waste sector has been steadily developing in the EU for over a decade with high growth rates driven by the implementation of EU and national waste policies. It includes two sub-sectors: specialised waste management companies (collection, incineration, landfill, composting, etc.) and

---

20 Source: Association for Cities Recycling (ACR+) - presentation at the biowaste conference, June 2009

21 Source: ORBIT/ECN, 2008, Compost production and use in the EU, Final report. The production of compost from bio-waste in 2005 was estimated at 10,5 million tonnes

22 Source: ORBIT/ECN, based on the assumption of an application of 10 tons/ha/year of compost repeated every year

23 Around 45% of EU soils lack humus – prerequisite of soil fertility

24 Example of Germany, source Orbit/ECN

25 As outlined in Directive 2009/28/EC on the promotion of the use of energy from renewable sources

26 Detailed calculation are given in Annex 3

27 Calculation based on Sander, K. (2008) "Climate protection potentials of EU recycling targets", Ökopol GmbH, Germany - http://www.eeb.org/publication/documents/RecyclingClimateChangePotentials.pdf

28 Details of the calculation are given in section 8

29 This scheme covers over 11.500 energy-intensive installations across the EU, which represent close to half of Europe's emissions of CO_2. These installations include combustion plants, oil refineries, coke ovens, iron and steel plants, and factories making cement, glass, lime, brick, ceramics, pulp and paper

30 Source: Decision N° 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the efforts of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020, OJ L 140/136, 5.6.2009, the EU 27 target is a reduction of around 10% of the non ETS EU GHG's emissions by 2020 compared to 2005 emissions

31 These data are purely indicative as it will depend in reality on the calculation methods under the non ETS directive

businesses recovering and recycling materials (composting, paper, glass, metals, etc.). Solid Waste Management and Recycling Industries have a turnover of €137 billion which is just over 1.1% of EU GDP. These areas together represent over 2 million jobs[32].

3.2. The issue of bio-waste in EU legislation and policy to date

The management of bio-waste is covered by several pieces of EU legislation. The revised WFD requires Member States to develop waste management policies that protect the environmental and human health and ensure a sustainable use of natural resources. Member States are thus legally bound to optimize the treatment of bio-waste according to their specific conditions.

Article 4 on the "waste management hierarchy" defines this approach more precisely: the prevention of waste is defined as the best option, followed by re-use, recycling and energy recovery. Disposal (landfilling, incineration with low-energy recovery) is defined as the worst environmental option (emissions, loss of resources).

The WFD also encourages Member States to separately collect and recycle bio-waste. For example, Member States can include bio-waste when calculating the legally binding recycling target for municipal waste.

Furthermore, it enables the setting of EU minimum criteria for the quality of compost from bio-waste, including requirements on the origin of the waste and the treatment processes. Such criteria have been called for by many Member States and other stakeholders in order to enhance user confidence in compost, thus strengthening the market and supporting the EU's policy towards a material efficient economy. The revised WFD also sets binding efficiency levels for the recovery of energy from direct incineration of municipal waste. It thus could discourage the incineration of bio-waste with low calorific value due to high water content.

Landfilling of bio-waste is addressed in the Landfill Directive (See Box 3) which requires the diversion of biodegradable municipal waste from landfills. The directive also contains stringent provisions towards the avoidance of GHG emissions from landfilled biodegradable waste.

Improved management of bio-waste is in line with EU policies concerning environment and sustainability. It fits into the EU's Sustainable Development Strategy which sets particular emphasis on avoiding the generation of waste and enhancing the efficient use of natural resources by applying life-cycle thinking and promoting re-use and recycling.

It would also contribute positively to Sustainable Consumption and Production policy and to the EU policy on Climate Change and notably to meet the EU targets of reducing by 10% (by 2020 compared to 2005) the green house gas emission not covered by ETS[33].

There are very clear synergies to be exploited between the management of bio-waste and the production of bio-fuels and renewable energy. Renewable Energy Directive[34] sets ambitious targets for 2020 to which bio-waste management could contribute.

---

[32] Source: Study on the Competitiveness of the EU eco-industry, ENTR/06/054 Final Report. Directorate-General Enterprise & Industry and Thematic Strategy on the Prevention and Recycling of Waste COM(2005) 666

[33] Refer to note 16

[34] Directive 2009/28/EC on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC OJ L 140, 5.6.2009, p. 16–62

Box 3: Bio-waste and the Landfill Directive

The Landfill Directive requires Member States to set up a National strategy for the reduction of biodegradable waste going to landfills. This strategy should ensure that by mid 2006 biodegradable municipal waste going to landfills is reduced to 75 % of the total amount of biodegradable municipal waste produced in 1995. By mid 2009 this must be reduced to 50 % of this amount, and by mid 2016 to 35%. The main objective of these targets and measures is to reduce the production of methane in landfills in order to reduce GHG emissions.

Member States which relied heavily on landfilling in 1995 - for more than 80% of municipal waste - were given a four year extension period. They must achieve a 25% reduction by 2010, then meet the 50% target by 2013 and finally meet 65% in 2020[35].

The targets set in the Landfill Directive refer to the diversion of biodegradable waste from landfills, but do not prescribe specific treatment options. In practice, Member States are often inclined to choose the seemingly easiest and cheapest option disregarding the actual environmental benefits and costs.

3.3. What are the underlying drivers of sub optimal bio-waste management?

As detailed in section 3.1, optimized management of bio-waste is still not achieved by many Member States. Notably, waste prevention is nearly inexistent while biological treatment remains underused and the potential market for quality compost remains underdeveloped. The reasons for this sub-optimal management can be summarized as follows:

1. **Waste prevention**: programs to prevent the generation of bio-waste require a combination of policy instruments that need to address a variety of actors and need to complement each other over many years to be successful:

- a "chain" of actors should be involved in reducing the generation of bio-waste - households, producers, retailers, and public authorities;
- more specifically, waste prevention programs may require politically sensitive messages towards a modification of the current consumption habits, which requires time to be absorbed;
- a variety of instruments such as economic, legal and information should be combined in a consistent manner in order to achieve significant results;
- these instruments should be defined and applied at various competence levels from European and National to regional and up to very local levels.

In summary, successful prevention programs require the mobilization of several actors, various instruments and at different levels of competence. The financial, social and environmental potential benefits of prevention are largely underestimated by most Member States. This could explain why so far no significant efforts have been undertaken at large scale to enhance prevention, even if at the local level promising results are progressively emerging.

35 Member States concerned are: Bulgaria, Cyprus, Czech Republic, Estonia, Greece, Ireland, Latvia, Lithuania, Malta, Poland, Portugal, Romania, Slovakia and the UK

2. Concerning increased bio-waste separate collection: there are different obstacles for the development of large scale separate collection programs and biological treatment for bio-waste:

- Participation of citizens: inhabitants need to be informed and convinced to participate in separation collection schemes;

- Logistics issues: in many areas, especially densely populated, separate collection could be difficult to set up due to logistics constraints such as insufficient space for sorting. This could affect the acceptance of introducing separate collection. However, some of the most densely populated Member States have established very advanced separate collection schemes like in the NL , DK or BE;

- Uncertainties over expected quantities/quality of the material: this depends largely on the efforts of the citizens to sort bio-waste in an appropriate way, but also on the capability of the authorities in charge of waste collection and treatment to motivate and inform correctly the population and implement effective monitoring – or if needed enforcement schemes;

- These uncertainties could complicate planning and the design of the necessary investments. Some experts see this problem as a "vicious circle" as regards composting – the lack of separate collection does not justify the construction of composting plants, whilst the lack of treatment capacity affects the setting up of separate collection;

- Lack of sufficient incentives for the development of biomethanisation at larger scale: although separate collection and composting or home composting could in general be beneficial from the financial point of view[36], this is not the case for biomethanisation which still needs additional financial incentives in most of the Member States as demonstrated in section 7.

In summary, even if separate collection followed by biological treatment could represent a less expensive option for the competent authorities while presenting larger environmental benefits, it is not yet sufficiently developed. It indeed requires additional efforts from the authorities and the citizens notably in terms of organization and participation in selective collection systems. The uncertainties linked with the setting up of such programs complicate the planning work of local authorities who have to ensure the permanent affordability of the service.

There are differences between Member States in terms of development of separate collection and biological treatment which will be discussed in section 5.3.3. These differences are linked to various factors including differentiated levels of citizen and authority's environmental awareness and differences in availability of space notably for landfills.

3. Concerning the development of a market for compost: in order to ensure that the additional compost produced will find its market, new initiatives are required. The development of such market is indeed currently limited for the following reasons:

- Absence of common European standards for compost which limits intra EU trade and could increase the risk of soil contamination due to the use of compost of low quality;

---

36 See section 7.3

- Lack of confidence from the potential end-users: this is the case particularly in agriculture as it could take time to convince farmers to use compost originating from waste.

As the place of origin of bio-waste is often in large urban centers while the main use would be in agricultural areas, facilitating intra-EU trade would be important. It is therefore indispensable to ensure a common approach at EU level in order to harmonize the existing national standards and to offer new market perspectives for compost of good quality.

In summary, for all these reasons the efforts achieved by Member States to implement in practice the "waste hierarchy" in the case of bio-waste management are generally insufficient. The absence of clear guidance possibly including targets for the Member States to implement this hierarchy could also explain why these efforts have been so far too limited.

3.4. The right of the EU to act, subsidiarity

The Union competence to take action on bio-waste management derives from the articles of the Lisbon Treaty related to the protection of the environment.

Under Article 191 of the Treaty, Union policy on the environment shall contribute, among other things, to protecting and improving the quality of the environment, protecting human health, ensuring prudent and rational utilisation of natural resources, and combating climate change. Under Article 194 of the Treaty, Union policy on energy shall aim to promote the development of new and renewable forms of energy.

In the revised WFD the legislator has re-iterated several of these objectives and explicitly called on the Commission to identify ways of improving bio-waste management by means of additional initiatives (Article 22).

More specifically, the WFD calls upon the Commission to "carry out an assessment on the management of bio-waste" examining "the opportunity of setting minimum requirements for bio-waste management and quality criteria for compost and digestate in order to guarantee a high level of protection for human health and the environment".

In accordance with the requirement of the WFD, different policy options are assessed in this Assessment, including new initiatives to improve bio-waste management in line with the waste hierarchy principles (more prevention and more separate collection and recycling) and setting common compost standards at European level. The respect of the subsidiarity principle is analyzed for each of these options.

Concerning **prevention**, the analysis carried out to build the baseline scenario (section 5), indicates that in the vast majority of the Member States no clear and measurable steps to increase bio-waste prevention have been so far taken, although prevention has been shown to be an extremely effective option. This is partly due to the lack of clear guidance including measurable quantitative targets. As will be explained in section 7.6, at this moment, due to the uncertainties linked with the cost and effectives of prevention actions the impacts of setting a common quantitative target at European level cannot be assessed.

Therefore, in line with the subsidiarity principle, a first immediate step could be for Member States to further investigate the opportunity of setting indicative targets at national level for bio-waste prevention. In addition, the Commission could provide specific guidance on bio-waste prevention to be included in the National prevention plans to be drafted according to the WFD. This combination of actions at European and Member States levels should provide the necessary incentive to move towards increased prevention while ensuring enough flexibility in its application.

Concerning the introduction of a **minimum quantitative targets for biological treatment,** the analysis of the baseline scenario (section 5) indicates that a number of Member States representing together around a quarter of the EU population have already or are expected to dramatically reduce landfilling of bio-waste and increase its biological treatment. However, the baseline scenario also shows that even for these "advanced" Member States the opportunities of improved bio-waste management could be better exploited.

As shown in section 5.3, without EU level incentives, it is improbable that the less advanced Member States alone will take steps in the foreseeable future to increase converting bio-waste into bio-fuel and compost, the options which are environmentally and economically most beneficial. Instead, they will continue choosing the seemingly easiest option disregarding the actual environmental benefits and costs. This also explains why for so many years some Member States and stakeholders continued to press the Commission to initiate action in this area.

In order to better take into account these differences of actual performances between the Member States but also to leave an appropriate level of flexibility, the feasibility of introducing an EU minimum target for biological treatment needs further analysis while already at present it can be recommended that Member States pursue their national efforts to increase biological treatment.

The cost/benefit analysis detailed in section 8 shows that some flexibility should also be introduced for what concerns the type of biological treatment to be promoted. The choice of the best option (centralised or de-centralised composting, energy production by digestion and various ways of using the energy produced - transport, electricity heat production) is depending on local conditions (energy mix, possible synergies with other policies) and should be left to the Member States.

The present knowledge base indicates that a future EU target, if any, for biological treatment should remain moderate to allow Member States to choose the zones in which the organization of separate collection is most relevant. For instance, it seems that separate collection should be set up as a matter of priority in semi-rural or semi-urban zones in which more space is available in the houses.

In summary, Member States should be encouraged to increase biological treatment for bio-waste and the added value of fixing a minimum target at EU level should be further investigated.

The **compost market** of the EU shows a huge variety in terms of quality parameters, assessment criteria and quality assurance systems. Compost quality refers to the overall state of the compost with regard to physical, chemical and biological characteristics. These parameters are indicators of the ultimate impact of the compost on the environment. In particular, the most important parameters from the point of view of environment protection standards, public health and the soil are those related to pathogens, inorganic and organic potentially toxic compounds (heavy metals, phthalates, and polycyclic aromatic hydrocarbons) and stability.

Within the EU, the limit values adopted by the Member states vary widely, with the north being generally more stringent than the south. A recent study[37] has recently evaluated the quality profile of compost products in Greece, and examined their compliance with the Greek standards. They also examined how the compost complied with more stringent limit values valid in other countries of the

[37] Lasaridi et al (2006) « Quality assessment of compost in the Greek market: The need for standards and quality assurance”, Journal of Environmental Management 80: 58-65.

EU. A total of 28 compost products available on the Greek market were identified and analysed. The scientists measured the physical and chemical parameters (moisture, organic mater, electrical conductivity, pH and heavy metals), stability indicators (self-heating potential), and biological parameters (microbial population, pathogen indicators and selected pathogens) to determine the quality of the compost products.

The results showed that there were wide variations in the quality of the study products, even within the same group of products. This is an interesting finding as the studied parameters are directly related to environmental protection and public health. For example, the content of heavy metals ranged from levels exceeding the fairly tolerant limits of the Greek legislation to below the stringent Austria limits for compost. The authors noted that approximately 25% of the compost examined met the heavy metals limits for the EU-ecolabel award. The study concludes that the diversity of limit values within the EU countries highlights the need to develop homogenous standards within Europe in order to harmonise the compost market.

In addition, the quality assurance systems for compost demonstrate significant differences across the EU. Depending on intention, philosophy, political or functional approach, the quality assurance systems for compost comprise different elements[38].

Efforts to ensure systematic quality assurance varies from Member State to Member State ranging from no efforts (eg FI; EL; IE, PT) to advanced quality check systems (eg AT, BE, DE, NL).[39]

There are clear advantages of fixing **common compost standards**, notably from the market point of view and to ensure that increase compost production will be achieved without risks for the environment. As confirmed by stakeholders, to guarantee the quality and safety of compost across the EU and to boost the compost markets (which in turn will encourage more recycling) harmonised standards need to be adopted, also to stand the competition on the market with peat-, earth- and bark products. Such standards will address the obstacles in trade and secure the same minimum level of environmental and health protection. Several Member States have already developed their own legislation in this area which fragments the EU compost market. Union action will level out these differences.

Concerning **industrial waste**, this Assessment (section 5.2.3) indicates that the added value of a European initiative would be too limited. The quality of this waste is more stable than municipal waste and most of it is already either re-used or recycled. It is also to be assumed that direct financial interest of the industries concerned are strong incentives for them to reduce as far as possible their bio-waste production.

In summary, a good balance between what is needed at EU level and what could be done at national or local levels is indispensable to improve bio-waste management in a cost effective way, taking into account the local constraints and conditions. At national level, Member States can already revisit their national waste management planning related to bio-waste, for example by setting up separate collection systems and planning of infrastructure for the treatment of the collected bio-waste. They can also develop ambitious waste prevention programmes where already today they

---

38 Including Raw material, intake control, limits for harmful substances, quality criteria for the valuable constituents in the compost, composting production, external control (product and/or production), in-house monitoring, quality label for the product, certificate for the plant and/or the product, declaration of the properties of compost, recommendations for use and application, training and qualification of the operator, management and operation of plants (plant assessment), annual certificates

39 http://www.compostnetwork.info/index.php?id=10.

can set national benchmarks, targets and indicators. The present knowledge base seems to indicate potential for additional benefits from setting EU level standards for the quality of compost, for applying compost to soil, and minimum levels of ambition for recycling/prevention. However, investigations are needed to better underpin the feasibility of such measures. The final recommendations of this Assessment (see section 8.5) have been scrutinized in order to reach an optimal combination of EU, national and local actions.

3.5. Who is affected, in what ways, and to what extent?

All citizens are at least indirectly affected by threats related to inadequate management of bio-waste, as those threats are of a general nature – climate change, public health, possible air, water and soil pollution due e.g. inadequate landfilling, incineration and spreading of poor quality composted waste on soil.

Citizens are the main producers of bio-waste and at the same time they could provide a part of the solution through more efforts for preventing the generation of bio-waste and participation in separate collection schemes. They also bear the financial consequences of bio-waste management.

Also, waste related industries which deal with composting, anaerobic digestion and production of bio-fuels are affected by the opportunities of adequate bio-waste management.

4. OBJECTIVES OF AN EU INITIATIVE

The main objective of an EU action is to ensure that existing legislation is better implemented in practical terms by the Member States. Only improved practical application of legislation will ensure that the opportunities of an appropriate management of bio-waste - in terms of environmental protection, energy and resource savings, improved quality of EU soils and cost efficient waste management - will be better exploited in the European Union.

More specifically and in line with the "waste hierarchy", the objectives should be as follows:

- Create optimal conditions for reducing the generation of garden and especially food waste to avoid environmental impacts of unnecessary food production and related waste management;
- Optimise conditions for the recycling of bio-waste to marketable products, thus saving primary materials (peat moss, mineral fertilizer) and contributing to a material efficient economy;
- Optimize the recovery of renewable energy from bio-waste in support of EU energy policy targets;
- Optimize the use of bio-waste as soil improver (contribution to EU soil policy) and limit emissions of GHG from sub-optimal bio-waste management (contribution to EU climate policy).

The means for achieving these objectives could include actions aiming at increasing prevention of bio-waste, encouraging recycling and energy recovery by facilitating the use and trade of products made from bio-waste, including enhancing customers' confidence, regulating the use of recycled bio-waste on soil, setting minimum quantitative targets for prevention and biological treatment.

Therefore, the objective of this Assessment is to analyze the main environmental, social and economic impacts of different policy options to move towards optimal bio-waste management at EU level.

Various levels of ambition of the application of the waste hierarchy will be assessed and compared to a "baseline scenario" (without additional action at EU level) in order to identify EU targets for bio-waste management minimizing costs while maximizing benefits. As far as possible environmental impacts will be monetized and compared to the costs of the analyzed options. In order to meet EU objectives for bio-waste management, the use of different possible policy instruments will be assessed.

5. BASELINE SCENARIO

A baseline scenario was constructed in order to assess the expected consequences of already decided and planned policies without additional European initiative. The analysis has been limited to the "foreseeable future", i.e. until 2020.

5.1. Main assumptions

Even if the issue of bio-waste management cuts across many policy areas the legislation which will have a predominant impact on bio-waste management up to 2020 are the Landfill Directive and the revised Waste Framework Directive. The potential impacts of both pieces of legislations should be clearly distinguished.

The Landfill Directive has potential important consequences, especially for Member States which have heavily relied upon landfilling as a method of waste disposal. Its implementation in these Member States will require significant diversions of waste flows combined with an upgrading of alternative waste management systems in line with the WFD within the coming years.

The question whether the countries which still rely heavily on landfilling will meet the landfill diversion targets within the deadlines set by the Directive was raised during the consultation processes. It was however seen as a separate issue of non-compliance with the existing acquis that may need to be addressed eventually by the appropriate means of enforcement.

In the framework of the present Assessment, it was assumed that all Member States will comply with the Landfill Directive for the following reasons:

- The first reduction target for mid-2006 (25% of reduction of biodegradable waste landfilled) has been met by the relevant Member States;

- During the stakeholder consultation, no Member State reported that it expected delays with meeting the targets;

- Furthermore, no Member State has signalled to the Commission difficulties in achieving the 2009/2010 targets in response to a recent enquiry[40];

- The enforcement of the existing legislation is already a matter of priority for the Commission and additional new initiatives with the aim to further promote proper implementation are under way;

- The objective of this Assessment is to assess the added value and the opportunity of a <u>new</u> EU initiative in addition to existing policies.

40 Response from the Member States to a Commission enquire in July 2009 regarding the Landfill Directive biodegradable waste diversion targets

Concerning the application of the **Waste Framework Directive**, the efforts of the Member States to apply in practice the "waste hierarchy" principles are supposed to be reflected in their National waste management plans. These plans have been used as a source of information for the construction of the baseline scenario (section 5.2.2).

It was assumed that no major technological breakthrough will occur in the next 10 years and that the composition of municipal waste as well as bio-waste will remain stable over the period of the exercise which is in line with the results of the stakeholder consultations.

In order to construct the baseline and the alternative scenarios, it was necessary to make assumptions on several parameters not or insufficiently known. These uncertainties and their potential implications in terms of policy development are presented and discussed in section 8.1.2.4.

5.2. Construction of the baseline scenario

For the construction of the baseline scenario information on the generation and composition of municipal waste as well as on the household waste collection and treatment was gathered.

5.2.1. Bio-waste generation and composition

For each Member State, an estimate of the future generation of municipal waste was made on the basis of the actual (2006) generation and demographic and economic development evolutions[41]. Some degree of decoupling between GDP and waste generation was introduced depending on the economic welfare. A summary of the assumptions taken is given in Annex 4.

5.2.2. Collection coverage, needed and planned treatment capacities

For each Member State, the projections of waste generation were compared to the planned treatment capacities and to the Landfill Directive targets.

The possible needs for additional capacities were calculated in such a way that the targets of the Landfill Directive are met. For Member States for which the collection is not ensured for the entire population, additional assumptions were made on the collection coverage rate and its evolution (Annex 5, Table A5-1).

The planned bio-waste treatment capacities were identified on the basis of the available official reports such as the national waste management plans and national strategies for the implementation of the reduction of biodegradable waste going to landfills which have to be submitted to the Commission in line with the requirements of the WFD and the Landfill Directive.

However, these strategies date back to 2005 and do not cover the EU-12. In addition, the existing harmonised reporting requirements are not adapted to the data needs of this assessment. It was therefore necessary for some Member States to make hypotheses on the evolution of bio-waste treatment capacities. This was achieved taking into account policy preferences of these Member States on the basis of additional sources of information[42]. In case of conflicting figures, choices were often made on the basis of judgement from the involved experts.

---

[41] In order to ensure consistency with other Commission scenarios, economic and demographic projections used are based on the "European Energy and Transport – Trends to 2030 – 2007 Update" as published by DG TREN

[42] Country Fact Sheets of the European Topic Centre on Sustainable Consumption and Production ETC/SCP, reports from national Environment Ministries, waste management Agencies and statistical Agencies

The first draft baseline scenario was sent for consultation to the Member States and the most relevant stakeholders (Annex 1). Fourteen Member States answered and their comments and suggestions were taken into account as far as possible. Some countries contested the assumptions concerning shares of treatment methods until 2020, however no evidence or alternative data were provided. The main results in terms of projected type of bio-waste treatment for each Member State are presented in Table 1, Figures 1 and 2, and discussed in section 5.3.

5.2.3. Industrial waste

The baseline scenario does not include bio-waste from industrial sources such as food processing as it was not possible to gather reliable information on industrial bio-waste at EU level. While there are some general estimations on the amounts of industrial bio-waste (between 30 Mt to 50 Mt), the data is generally scarce and of low quality. The analysis of case studies[43] demonstrated that this waste is usually reused or recycled within agriculture and related industries e.g. as animal feed. The case studies are showing that the quality of this waste is stable which allows its re-use or recycling in good economic and safety conditions. The interest of the concerned industries is to reduce and re-use or recycle as far as possible their bio-waste.

For these reasons, bio-waste from industrial sources was excluded from all detailed scenarios with the exception of setting compost/digestate standards.

5.3. Analysis of the baseline scenario

5.3.1. Bio-waste generation

Figure 1 show the expected evolution of bio-waste generation within the next 10 years. The amount of bio-waste generated is expected to rise rather slowly - from 87.7 Mt to 96.4 Mt, a 10% increase. The growth in EU-12 will be more pronounced - from 12.9 to 18 Mt, a 40% growth, but in 2020 the EU-12 will still be responsible for only a small part of bio-waste generated in the EU (18.5%). Projected bio-waste generation per Member State is given in Annex 4, Table A4-3. Differences are expected between Member States which is mainly due to socio-economic parameters.

[43] Notably in Belgium and Lithuania, source: Arcadis/Eunomia

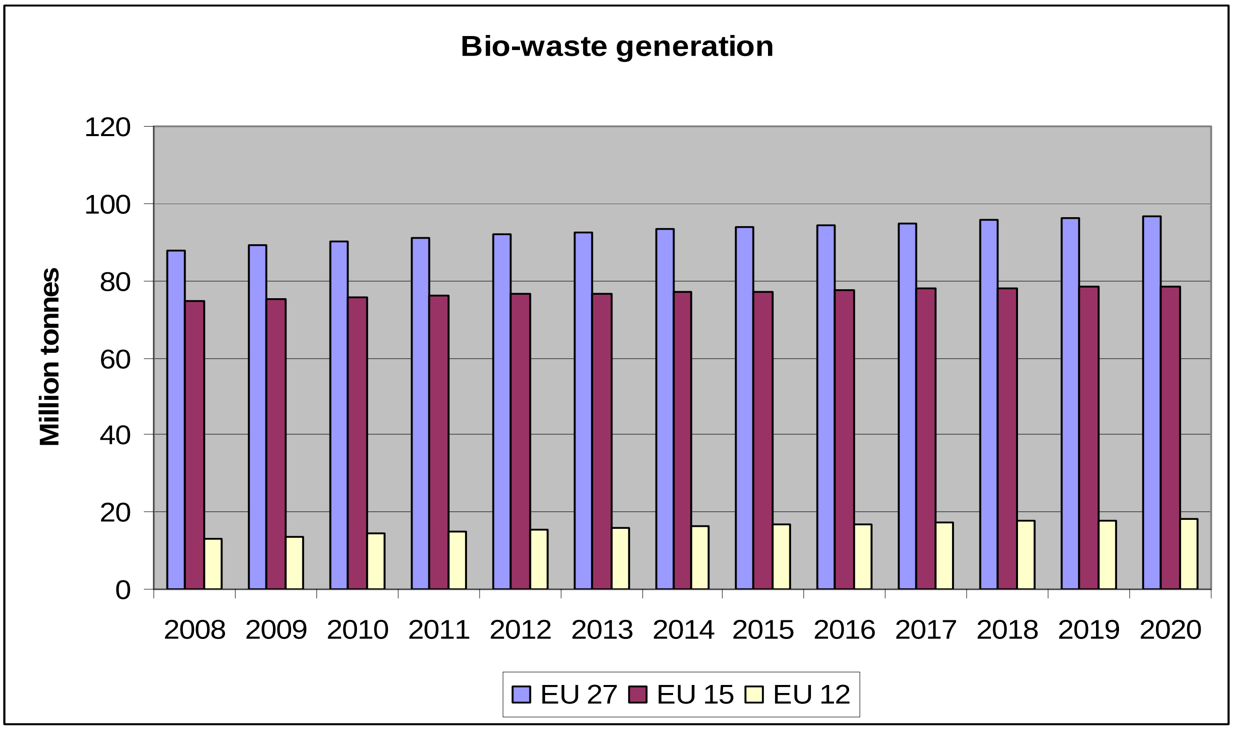


Figure 1: Baseline scenario – projected bio-waste generation 2008 - 2020

5.3.2. Bio-waste management

Concerning bio-waste management, as shown in Figure 2, the amounts of landfilled bio-waste are expected to drop considerably - from 35.7 Mt in 2008 to 15.1 Mt in 2020 – a reduction of 38%. By 2020 bio-waste is expected to be diverted from landfills to the following treatment techniques:

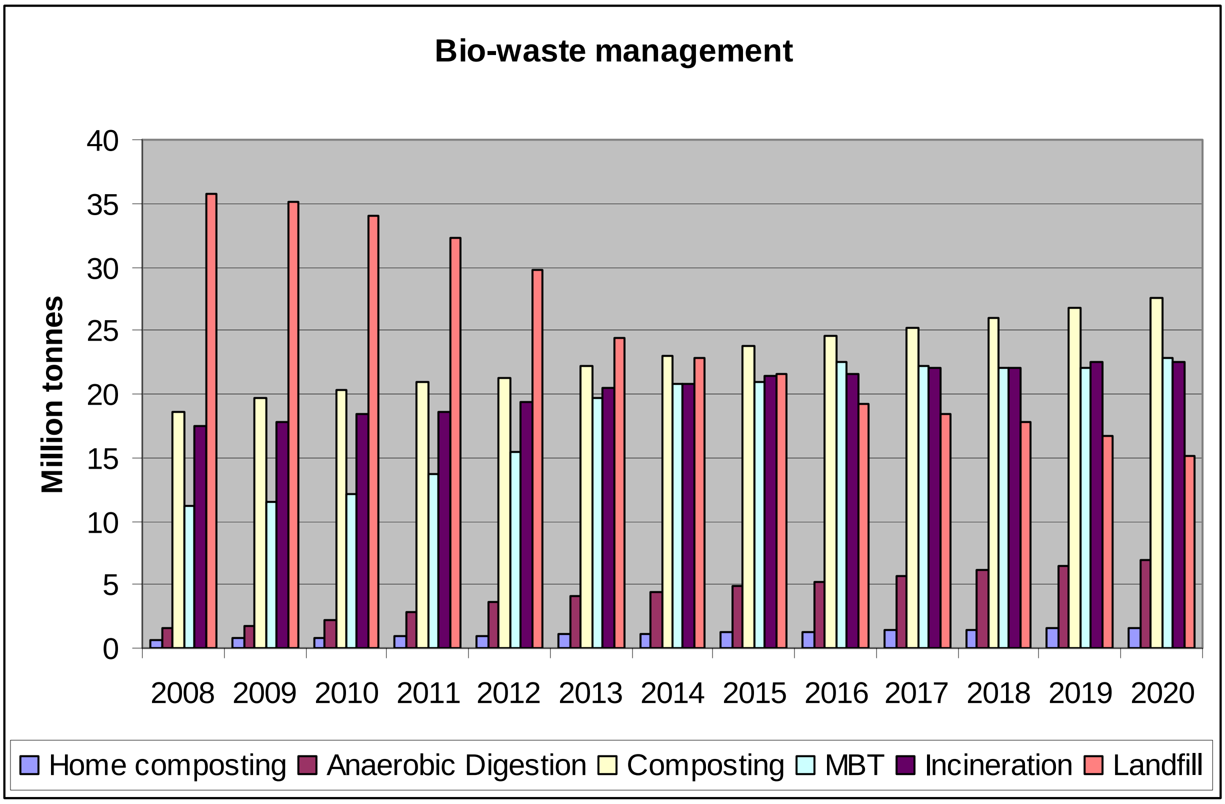
Composting: from 18.7 Mt in 2008 to 27.6 Mt in 2020, expected increase of 48%;

Incineration: from 17.4 Mt in 2008 to 22.6 Mt in 2020, expected increase of 29.5%;

Mechanical and biological treatment (MBT): from 11.2 Mt in 2008 to 22.8 Mt in 2020, expected increase of 103%;

Anaerobic digestion (AD): from 1.5 Mt in 2008 to 6.9 Mt in 2020, increase of 349%;

Home composting: from 0.7 Mt in 2008 to 1.6 Mt in 2020, increase of 148%.



I

Figure 2: Baseline scenario – projected evolution of bio-waste treatment 2008-2020 (EU-27)

5.3.3. Implementation of existing legislation

As detailed in section 5.1, the baseline scenario has been constructed assuming that all Member States will comply with the diversion targets of the Landfill Directive. The targets set in the Landfill Directive refer to the diversion of biodegradable waste from landfills but do not prescribe specific treatment options. In practice, for various reasons, Member States are often inclined to choose the seemingly easiest and cheapest option of landfilling disregarding the actual environmental benefits and costs.

Table 1 clearly shows that for some Member States this will require either no effort or limited effort although for other Member States significant actions have to be taken in the coming years. For example, Member States such as AT, DK, DE and SE will landfill no bio-waste waste by 2020 whereas other Member States such as PL, BU, CY, CZ; EE and FR will have to make significant efforts to divert bio-waste into options other than incineration and landfill.

Table 1: Baseline scenario – projected evolution of bio-waste treatment 2008-2020 (Tonnes - EU-27)

	Landfill		**Incineration**		**MBT**		**Composting**		**Anaerobic Digestion**		**Home composting**		**Not collected**	
	2008	**2020**	**2008**	**2020**	**2008**	**2020**	**2008**	**2020**	**2008**	**2020**	**2008**	**2020**	**2008**	**2020**
AT	0	0	514.419	513.565	210.115	180.442	432.432	498.932	136.136	195.660	232.232	283.707	0	0
BG	818.810	374.145	0	427.595	0	267.247	27.976	142.532	0	0	6.141	61.085	54.442	0
BE	239.055	0	624.020	741.061	26.508	21.940	1.034.898	992.451	78.603	216.759	95.410	192.586	0	0
CY	129.975	32.904	0	59.825	0	56.834	0	25.070	0	0	0	3.419	0	0
CZ	1.086.967	298.450	120.774	373.062	0	572.028	63.565	602.638	0	66.960	0	0	0	0
DK	0	0	712.731	849.407	0	0	554.403	634.021	0	0	5.600	33.370	0	0
EE	263.860	22.400	0	88.580	0	130.055	31.277	90.852	0	0	26.643	38.936	27.981	0
FI	722.931	400.466	30.122	197.244	0	0	193.284	195.252	19.116	183.298	0	19.924	0	0
FR	6.574.986	3.511.501	4.542.718	4.389.376	836.816	3.072.563	498.105	2.090.179	0	0	0	0	0	0
DE	0	0	5.263.551	5.282.749	3.226.048	3.237.814	7.640.639	6.816.450	848.960	1.704.113	0	0	0	0
EL	1.733.523	402.417	8.755	10.318	8.755	1.650.943	0	229.298	0	0	0	0	152.264	0
HU	770.547	557.651	107.095	123.087	77.485	417.009	493.353	763.986	0	0	143.399	233.440	0	0
IE	429.847	32.107	0	288.966	20.255	321.073	84.950	333.916	0	192.644	34.698	115.586	142.437	0
IT	3.492.523	1.353.146	825.505	579.920	2.032.013	1.288.711	1.508.135	3.382.866	79.376	1.449.800	0	0	0	0
LV	171.885	89.318	0	0	0	165.876	0	96.245	0	0	0	13.124	96.686	3.682
LT	404.444	165.987	0	105.628	0	105.628	88.780	142.275	0	0	0	19.401	0	0
LU	30.938	32.282	0	1.699	0	0	47.689	52.380	9.768	10.728	0	0	0	0
MT	60.852	7.502	0	0	0	67.518	0	0	0	0	0	14.289	0	0
NL	220.527	206.474	1.019.937	954.944	137.829	129.047	1.258.030	1.214.471	66.212	362.764	0	0	0	0
PL	2.560.373	852.096	14.800	1.503.699	384.796	2.656.535	0	954.729	0	0	0	0	0	0
PT	1.236.964	260.066	436.576	715.182	145.525	650.165	46.133	216.722	10.127	46.440	0	46.440	0	0
RO	1.870.129	915.135	0	0	0	2.353.203	93.000	547.836	0	0	0	74.705	2.043.257	0
SK	405.908	156.607	117.844	202.284	0	293.638	21.823	223.724	0	0	0	55.931	0	0
SI	228.225	63.793	37.991	81.655	11.092	109.724	30.812	137.401	0	0	0	0	0	0
ES	4.643.828	3.437.250	928.766	1.580.633	3.715.062	3.345.256	259.077	1.379.918	219.971	418.157	9.776	292.710	0	0
SE	38.300	0	1.212.825	1.177.910	25.533	24.039	465.313	512.832	62.880	160.260	100.608	128.208	0	0
UK	7.603.448	1.949.870	884.122	2.304.391	353.649	1.654.435	3.785.305	5.344.087	3.789	1.877.652	0	0	0	0
EU	35.738.844	15.121.568	17.402.551	22.552.781	11.211.481	22.771.721	18.658.979	27.621.062	1.534.937	6.885.235	654.508	1.626.861	2.517.066	3.682

As follows from table 1 such Member States have very little composting or anaerobic digestion and instead heavily reply on landfill and incineration. This may require significant changes in the national waste management systems related to bio-waste, including setting up separate collection schemes or sorting systems, developing infrastructure for incineration, composting and anaerobic digestion. For example, to implement the diversion targets of the Landfill Directive, Poland will have to divert almost 5 million tonnes of bio-waste generated in 2020 from landfills. This includes directing 1.5 million tonnes of bio-waste to incineration, mechanical-biological treatment of 2.5 million tonnes of bio-waste and composting of around 1 million tonnes.

However, there is no systematic need to build new waste management facility at national level: Member States are allowed to cooperate with other Member States to establish a network of municipal (including bio- waste disposal or recovery operations (Art. 16 of the Waste Framework Directive).

The preferred options for each Member State assumed in the baseline scenario are supposed to represent the plans of the Member States for future bio-waste management. These choices which were broadly confirmed during the stakeholder consultation (section 5.3.2) are not necessarily the least cost or the easiest option to follow: for instance the expected increase in composting and anaerobic digestion implies the organization of additional separate collection and the construction of new infrastructures.

As regards the application of the waste hierarchy by the Member States, as there are no quantitative objectives for the concrete application of the hierarchy, it is not possible to assess the impact of the full application of the hierarchy by each Member State. Nevertheless, Table 1 gives some indications on how the hierarchy can be reasonably expected to be applied by 2020.

In summary, a group of more advanced Member States are expected to apply the hierarchy to a large extent: landfill is already either abandoned (AT, DE, DK) or will be abandoned by 2020 (BE, SE), recycling by composting or digestion is expected to increase in a significant proportion. On the contrary, some Member States are still heavily relying on landfills for the management of bio-waste. For those countries no additional progresses in the application of the hierarchy are expected beyond what is strictly necessary to meet the Landfill Directive targets.

The projections on bio-waste generation are mainly linked with socio-economic parameters. It has indeed not been possible to identify national ambitious and effective strategies to prevent municipal bio-waste production. This means that the first “pillar” of the waste hierarchy (prevention) is not expected to be applied by most of the Member States. Therefore a part of the expected gains will be off-set by a rising amount of bio-waste generated.

5.3.4. Conclusions

In conclusion, the baseline scenario shows that the proper implementation of the Landfill Directive is expected to improve significantly bio-waste management at European level. This will require different levels of effort from the Member States (from significant to no efforts). A clear margin of progress towards the application of the waste hierarchy still remains unexploited for all Member States notably as more efforts on prevention and recycling of good quality (composting and digestion of bio-waste) could be done. These margins will be further analysed through the development of alternative scenarios (section 6.2). The projected increase of compost production also shows the necessity to set up compost standards which will increase confidence in the product and the development of the related market.

6. POLICY OPTIONS

A first comprehensive attempt to analyse and set up policy options for biodegradable waste management was made in 2004[44]. The recommended policy option included setting quality criteria for compost and allowing Member States to set their own national recycling targets. Compared to 2004, the present analysis includes the assessment of the situation in the new Member States and an update of the EU-15 situation.

6.1. Rejected options

6.1.1. Proportionality

This analysis is limited to options directly linked with bio-waste management. On the basis of the principle of proportionality, possible changes in the following policies were not considered:

- climate change policies e.g. by the introduction of waste management into ETS;
- taxation policies e.g. by taxation of landfill or other disposal of bio-waste;
- renewable energy policies.

In all the abovementioned options, as the issue of bio-waste management would account for a relatively limited part of the changes, it seems disproportionate to modify these instruments in order to meet part the objectives detailed in section 4.

For instance, bio-waste is a limited fraction from the point of view of the ETS. Therefore the additional costs – notably the administrative costs - of introducing bio-waste into ETS appeared disproportionate compared to the potential benefits.

As explained in section 3.1, improving bio-waste management could contribute to meeting the targets defined in other European policies such as renewable energy and non ETS emissions.

Landfill related taxes are used in many European countries today, but are very country-specific. Experience shows that the harmonisation of these taxes at EU level is very likely to result in low level of taxes adjusted to different national contexts and priorities.

6.1.2. Other rejected options

The options below were analysed but were not shortlisted for a detailed Assessment.

- **Introduction of a total ban on landfilling of bio-waste or extension of the current limitations**. Such a ban is considered as disproportionate compared to the objectives detailed in section 4. The current targets in the Landfill Directive still allow landfilling of 35% of biodegradable waste after 2016 which would allow the Member States still heavily

44 "Preliminary Impact Assessment for an Initiative on the Biological Treatment of Biodegradable Waste" http://ec.europa.eu/environment/waste/compost/pdf/ia_biowaste_Directive_report.pdf

relying on landfills to meet the targets progressively. Moreover, as shown by experience and in the analysis of the baseline scenario (section 5) such a ban alone is unlikely to direct diverted waste to optimal treatment.

- **Setting a limit for the amount of bio-waste in municipal residual waste.** This option was suggested during the stakeholder consultation[45]. Even if potentially interesting it was rejected as it will require costly monitoring and enforcement systems. Targets on separate collection or recycling seem to offer similar results but perform better as they allow for more flexibility.

- **Voluntary agreements** would need to be concluded with counterpart organisations representing the relevant market actors and which can enter into long-term commitments on their behalf. As currently there is no such agreement or organisation able to guarantee self-regulation on that issue, the option has been abandoned.

6.1.3. Options analysed but not developed into scenarios

The options listed below have not been developed into scenarios due to challenges with setting clear and measurable objectives.

- **Introduction of differentiated recycling targets**. This option proposed setting national recycling targets which would take into account differences between Member States, e.g. their soil situation, demand on quality compost, geographical and climatic conditions, population density. However, it was concluded that setting acceptable and objective criteria for such differentiation would require disproportionate efforts in practice.

- Differentiation according to a time schedule (derogation for specific countries) was also rejected as a standalone option as it was not expected to deliver significantly different results than the options pre-selected for full assessment.

- **Setting GHG targets instead of recycling targets**. While this option seemed to be attractive, especially as it enables a more flexible approach, it was rejected since the setting of a GHG based target could lead to disregarding other environmental benefits of the treatment of bio-waste. This option should be further reviewed in the future, starting with the definition of appropriate specific objectives. Nevertheless, it has been decided to include certain elements of this option in a variant of the scenario analyzed in this Assessment with the aim of assessing solutions maximizing GHG savings.

6.1.4. Non-regulatory measures

- **Awareness raising instruments** and **public procurement policy** were both regarded as necessary but insufficient as standalone measures to meet the objectives as defined in section 4. Meeting these objectives will indeed require a modification of the current and foreseen bio-waste management practices which could not be achieved only with these instruments. Nevertheless these instruments should be considered at local level when implementing potential legislation.

[45] By European Environmental Bureau (association of environmental NGOs)

- **National targets** (i.e. set nationally by Member States) could also offer a positive contribution to improved bio-waste management. Such national targets would ensure that a certain fraction of bio-waste is biologically treated. Compared to EU mandatory separate collection or recycling targets, the setting of national targets would offer a more flexible approach for individual Member States in framing their specific strategies for bio-waste management. However, the achievement of such targets would be uncertain and rely on Member States willingness. Parts of this option are already included in the baseline scenario as possible elements of national implementation strategies of the Landfill and Waste Framework Directives.

Non-inclusion of non-regulatory measures in the detailed assessment does not exclude their future use as they may effectively support other legislative instruments. For example, regulatory measure could be successfully accompanied by awareness raising measures.

6.2. Options shortlisted for scenario analysis

Any EU initiative on bio-waste should take into account local/regional specific conditions as much as possible. The options selected for further analysis therefore meet the following criteria:

- Allow Member States as much flexibility as possible in the selection of waste management systems;
- Do not hinder further technological development in bio-waste treatment.

6.2.1. General assumptions for all scenarios

Taking into account that bio-waste management strategies are quite different from one Member State to another, the following assumptions have been made:

- No modifications compared to the baseline scenario will occur before 2013;
- Each scenario assumes an interim target corresponding to 40% of the final target by 2017. Progress towards the targets will be linear;
- 10%[46] of the separately collected waste sent to anaerobic digestion and 5% of the waste sent to composting becomes a residue and is landfilled;
- Green waste separately collected in addition to the baseline will be treated by in-vessel composting;
- The setting of compost standards is an element of each scenario and implies in practice the organisation of separate collection to ensure the quality of the compost/digestate produced;
- In cases where for some "advanced" Member States the baseline scenario performs better than an alternative scenario, the baseline scenario is maintained for the calculation of the impacts.

46 Average ratio in the EU composting and AD plants – source: Arcadis/Eunomia

The necessity of organizing separate collection of bio-waste to ensure the quality of the compost produced has been confirmed during the stakeholder consultation and by the "return" on experiences from projects on composting based on mixed collection. Separate collection is therefore considered a pre-requisite before envisaging more ambitious objectives in terms of biological treatment. Four scenarios representing an increased level of ambition in the application of the waste hierarchy principles were analysed in detail, the main assumptions used are summarised in Table 2. Figure 3 illustrates the gradation of the different scenarios in term of environmental ambition. In addition to these four scenarios, another qualitative scenario has been analysed in order to assess the added value of EU common compost standards (scenario 1).

The selection of the boundary conditions for scenarios has been done on the basis of the experiences of Member States with separate collection.

The levels set in scenarios 2 and 2A reflect the most advanced performance of projects in the leading Member States. It corresponds to the separate collection and biological treatment of 90% of garden waste and 60% of kitchen waste – or an average of 66% of all bio-waste.

The levels set in scenarios 3 and 3A represent the midpoint between the current EU 27 weighted average of biological treatment (19%) and the rate in the most advanced Member State (DK with 54% of separate collection). This calculated midpoint amounts to 36.5%, meaning in practice that all Member States currently below this target are supposed to meet it by 2020. For the other Member States which are expected to exceed this minimum target in 2020, no modification has been introduced compared to the baseline scenario.

	Baseline scenario	Scenario 3 : moderate biological treatment	Scenario 2: prevention and high biological treatment
Prevention - waste generation 2008-2020	10% increase of waste generation between 2008 and 2020	No prevention - same amount of waste generated as in the baseline	Compared to the baseline, reduction of 3% by 2017 and 7,5% by 2020
Compost standards	No EU standards	New EU standards	New EU standards
Biological treatment in 2020	37.5% (average at EU 27 level – no minimum target per MS)	36,5% as minimum in all Member States	66% (90% garden waste and 60% food waste)
Interim target in 2017		40% of 2020 target	40% of 2020 target
Variant - scenario 2A and 3A		*Kitchen waste separately collected treated in AD*	*Kitchen waste separately collected treated in AD*

Table 2: Comparison of the main assumptions used for each scenario

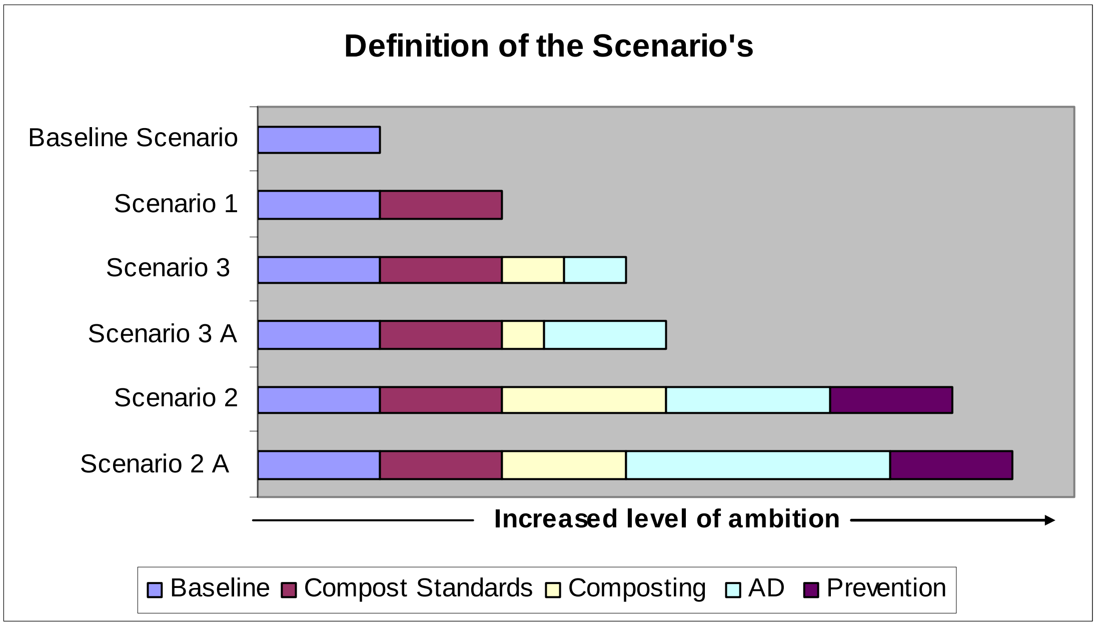


Figure 3[47]: Scenario definition and level of ambition

6.2.2. Scenario 1: Set compost standards only

This option includes setting quality standards for compost produced from bio-waste in order to facilitate trade, eliminate potential risks of soil contamination, improve compost markets and enhance customers' confidence. Compost standards represent a valuable quality framework within which other policy measures can more successfully be enacted.

6.2.3. Scenarios 2 and 2A: Compost standards + high biological treatment rates + waste prevention

These two scenarios assume setting ambitious prevention and biological treatment for bio-waste. Successful implementation of these targets necessitates efforts to promote prevention and the implementation of comprehensive systems for separate collection of bio-waste from both household and commercial sources on the national level.

Separate collection schemes and further composting or anaerobic digestion of bio-waste would cover a majority of households and be organised either through kerbside door-to-door collection, a bring-in system on communal amenity sites, or through access to tools for monitored and structured home composting.

Only composting or digestion of source separated bio-waste as well as "controlled home composting" is considered as "biological treatment" in these scenarios in order to guarantee the quality of compost. Practical capture rates would be around 60% of food waste and 90% of garden waste (average of 66% for all bio-waste). A target for prevention of 7.5%[48] is defined for 2020 with an interim objective of 3% in 2017.

---

47 This graphic is illustrative based on a qualitative approach. It aims at summarizing the scenario which were assessed in the Assessment

48 This target has been fixed on the basis of the results of existing prevention programmes launched at local level – references: WRAP and ACR+

Scenario 2A is based on almost identical assumptions as scenario 2. The sole difference is that while scenario 2 maximizes the overall total benefit for society, scenario 2A maximizes environmental gains by choosing the system leading to the greatest reduction in GHG emissions. In practice, it means that in scenario 2A food waste is subject to anaerobic digestion even in countries for which the more economic solution would be an in-vessel composting.

6.2.4. Scenarios 3 and 3A: Compost standards + moderate biological treatment rates

The main difference between these scenarios and scenarios 2 and 2A is the absence of waste prevention targets and a much less ambitious level of obligatory separate collection and biological treatment - separate collection and biological treatment at 30% for food waste and 70% for garden waste (average of 45% on all bio-waste).

Scenario 3A is based on almost identical assumptions as scenario 3 but while in scenario 3 the total benefits for society are maximized, in scenario 3A the GHG emission reduction are maximized. This is similar as for scenarios 2 and 2A.

6.3. Scenarios comparison and modelling

Taking into account the above assumptions, a model was developed in order to assess the impacts of each scenario. The results of this comparison are presented in section 8.

The model used for assessing the impacts of the scenarios is based on a "optimal" approach at society level: in order to meet a certain ambition level in terms of biological treatment, the solution offering the best cost/benefit ratio at society level for the treatment of bio-waste is searched country by country. On this basis, an analysis of how the waste streams will change in comparison to the baseline scenario was conducted. It allowed making estimations on how much waste has to be diverted from landfilling, incineration and MBT in order to meet the pre-defined targets as fixed in the different scenarios. It is assumed that, for each country a switch will be made into the most effective biological treatment option which depends on country specific data.

The environmental and economic impacts were calculated for each treatment method in each Member State. As detailed in section 7, the impacts of the treatment methods were estimated in detail, including energy used and produced, direct emissions to air and GHG, avoided emissions linked with energy and compost used. Knowing the amount of waste moved into biological treatment as well as the differences between the costs and benefits per technology, the result of the “technology switch” were calculated per country for each scenario and expressed both in costs and benefits (including a monetization of the environmental impacts) and in tonnes of GHG emissions avoided.

As explained above, it was not possible to take into account specific local conditions, e.g. outlets for compost, available city heating or gas grids etc. Country averages were used instead. Therefore, the modelling gives general answers which are valid at the EU-27 level but could not be used as the main tool for selecting waste management systems at a local level.

7. ANALYSIS OF IMPACTS

7.1. General description of impacts

The main impacts of the policy options identified in section 6 are linked to the modification of the amount of waste generated and the way it is treated. The impacts are summarized below.

7.2. Environmental impacts

The main environmental impacts are linked to the emissions of GHG, other emissions into the air affecting air quality and soil improvement.

Each treatment method and waste collection system was assessed against environmental impacts which, where possible, were quantified. This evaluation considers direct emissions as well as how much emission could be avoided by using the energy and compost/digestate produced.

The environmental impacts were assessed assuming that all installations are in compliance with the existing relevant Directives and notably the Landfill, the Waste Incineration and the Industrial Emissions Directives[49].

7.2.1. Direct emissions into the air

The main emissions for the analysed bio-waste treatment methods are summarised below:

- Emissions from composting include GHG from the decomposition of organic matter (however a significant part of this gas remains bound in organic matter), nitrous oxide and methane;

- Emissions from anaerobic digestion include mainly small amounts of fugitive emissions of methane from the installation and emissions of GHG and nitrogen oxide in the process of combustion of biogas to generate energy;

- Emissions from landfilling include significant amounts of gases consisting of methane, carbon dioxide, nitrogen oxide and ammonia. About 1% of landfill gas is made up of trace substances which may include up to 150 often harmful substances. Flaring or combusting landfill gas results in carbon dioxide and nitrogen oxide emissions;

- Incineration generates significant emissions of biogenic (i.e. regarded as carbon neutral) CO_2[50] as well as a variety of harmful air pollutants including dust and particulate matters, dioxins, nitrogen oxide, sulphur dioxide, acids, carbon monoxide, organic volatile compounds and heavy metals. These emissions are assumed to be below the limit values of the Incineration Directive.

---

49 Directive on Industrial Pollution Prevention and Control (IPPC) 1996/61/EC. This directive will be replaced by directive of Industrial Emissions (currently in co-decision process) which will set up operational requirements for large biological treatment plant (above 50t/day)

50 see box 2

As detailed in Annex 6, in quantitative terms, the majority of air pollutants and GHG emissions are emitted by landfills, followed by incineration and composting. The least emitting technology is anaerobic digestion.

7.2.2. Production and consumption of energy

As detailed in Annex 7, the emissions linked to energy consumed and/or produced by each process, were also included in the calculation of the impacts:

- For composting, no energy generation is envisaged and energy used in the process is rather low - electricity and Diesel fuel;

- Anaerobic digestion requires electricity to run the process; however generation of biogas delivers a surplus of energy. Biogas can be used as an energy source in four different ways:

– combusted on the site of the facility in a gas engine and used to generate electricity only;

– combusted on the site of the facility in a gas engine and used to generate electricity and heat;

– upgraded (cleaned) and used as a vehicle fuel (e.g. for buses as is currently the case in some Member States), replacing Diesel fuel;

– upgraded biogas injected into the gas grid, where it replaces natural gas;

- Incineration uses energy in the process within the air pollution control system and to start the combustion process. This however is by far offset by the use of energy generated. Depending on the type of incinerator, it can produce only electricity, only heat, or both (CHP process).

- Landfilling requires some electricity to run the plant and Diesel fuel to operate the landfill equipment. As capturing of landfill gas is compulsory, it was assumed that 50% of the gas is captured on site of which 60% is used to generate electricity.

The energy generated at a waste treatment facility is regarded as renewable according to the methodology used by the IPCC and also laid down in numerous community legislation, such as the Renewable Energy Directive, which states that the waste with biological origin can be used for producing renewable energy. It is assumed that the energy produced from bio-waste replaces the energy which would have been produced from other sources in the given country.

As detailed in Annex 8 (Table A.8-1 and A.8-2), the energy mix for each country was defined on the basis of ESTAT data for heat and electricity generation. On the basis of the country specific energy mix and the related emission factors, the air emissions were estimated.

In practice it means that electricity produced from waste will allow avoiding a larger amount of air pollutants in countries like Poland or Estonia where more than 90% of electricity originates from solid fuels combustion emitting significant amounts of air pollutants. The situation would be different in Austria which generates 62% of electricity from renewable sources or Sweden where 47% of energy originates from nuclear sources and 50% from renewable sources. The energy mixes has been prepared based on country's averages. It could be argued that in case marginal source of electricity would be used instead of average - fossil fired power plant would be substituted first - as these plants generally have the highest variable cost. No Member State would reduce the production of e.g. hydropower because of increased incineration, but rather export (if possible) this surplus electricity abroad. However if demand for electricity would rise the electricity for bio-waste would rather supplement than substituted existing plants. Nevertheless changing this assumption would improve the performances of solutions that substitute electricity, such as incineration and electricity from biogas, in the countries relying on fossil fuels.

7.2.3. Use of compost/digestate on soil

Environmental advantages of using compost on soil are quite difficult to quantify. Due to a loss of water and gases during composting the mass of compost produced is equal to 50% of bio-waste collected and slightly lower for anaerobic digestion. Similarly as in the case of energy, most of these environmental impacts were re-calculated into avoided air and GHG emissions (Annex 9).

This is for instance the case for benefits from the use of compost on soil linked to the substitution of alternative nutrient sources otherwise applied through the use of synthetic fertilisers, including the avoided external costs of fertiliser manufacture and the avoided associated energy use.

7.2.4. Environmental impacts not quantified

In the framework of this assessment, it was not possible to quantify the following impacts:

- The production of leachate and waste water from all the processes - composting, landfilling, landfilling of incineration residues;
- Odour and bio-aerosols from landfilling and composting process as well as other nuisances such as insects and vermin;
- Estimation of the financial disamenities linked with living in the vicinity of waste treatment facilities.

While the data on both the magnitude of disamenities and their possible valuation are inadequate, it is assumed that these impacts are likely to be relatively small as it has been assumed that all plants are supposed to respect the EU relevant legislation. The risk for soil from the presence of harmful substances in compost was not quantified either, even though this issue has been recognised by experts e.g. the problem of an accumulation of heavy metals in soil[51].

However, the application of source segregated bio-waste as well as setting standards for compost and limit values for soils to which it can be applied should adequately address this issue.

---

[51] Amlinger, E. Favoino, M. Pollak, S. Peyr, M. Centemero and V. Caimi (2004) *Heavy metals and organic compounds from wastes used as organic fertilisers*, Study on behalf of the European Commission, Directorate-General Environment, ENV .A.2, http://europa.eu.int/comm/environment/waste/compost/index.htm

7.2.5. Environmental impacts from changes in waste collection

The impacts from waste collection are linked to the issues of transport and the related impacts like noise, congestion, air pollution, climate change. A comparison of collection of mixed waste with separate collection of waste demonstrated that the differences of the environmental impacts between various separate collection schemes and a mixed collection system are very limited and not relevant in the framework of this analysis[52]. Therefore, the impacts from waste collection have not been taken into account as they have negligible influence on the results.

7.2.6. Monetization of environmental impacts

In order to compare environmental impacts between themselves as well to enable comparison with economic impacts they were monetized. Basic data used for the monetisation as well as an example of monetisation of the environmental impacts for each treatment method for the Czech Republic are included in Annex 12.

Most emissions into air - such as nitrous oxide, sulphur dioxide, particulate matters, ammonia, organic volatile compounds - were monetised, using the "CAFE" (Clean Air for Europe) benefits database for country specific damage cost (re-calculated into 2009 prices – details are give in Annex 12). For some pollutants like CO_2, dioxins, mercury, arsenic and lead, unit damage costs are supposed to be constant across the Member States. For instance, the unit damage cost for CO_2 recalculated for 2009 amounts to 23 €/tonne.

As a result it was identified that landfilling is environmentally the least favourable option, especially due to related GHG emissions (mostly methane). Incineration performs much better than landfilling but usually worse than biological treatment. Composting performs slightly better or similar to incineration - also in that case climate change related emissions offset the gains from the use of compost. Anaerobic digestion performs best, due to limited emissions combined with production of renewable energy and the possibility of beneficial use of the digestate on land.

It could be noted that while best available data and assumptions has been used, all monetisation models include unavoidable uncertainties in both the modelling structure and the input data, as well as in the issue of the appropriateness of the monetization of the impacts. Therefore these conclusions should be treated with care.

7.3. Economic impacts

7.3.1. Financial cost of waste treatment technologies

In order to assess the financial impact of the different scenarios, the costs of each treatment technology were assessed. Since many factors influencing the financial cost are specific to the national or even local conditions (cost of electricity, cost of labour, etc.), unit costs were evaluated for each Member State and for each technique.

---

52 Source: Arcadis/Eunomia – based on the comparison of the results of several cases studies notably in Italy, Slovakia, UK, Germany

A summary of the results of the calculations is given in Annex 10[53]. The unit cost includes annualized capital expenditure (capex), operational expenditure (opex) and maintenance expenditures as well as other specific costs or revenues (e.g. revenues from sale of the energy). The costs calculated do not include taxes (e.g. landfill taxes) or subsidies (e.g. subsidies to renewable energies) as the objective is to compare the real cost for the society of the various options.

Figure 4 shows an example of the financial costs breakdown for anaerobic digestion where biogas is used as vehicle fuel. From the sum of costs - disposal, maintenance, opex and capex - the revenues from the sale of energy are subtracted. The financial cost of anaerobic digestion with biogas used as vehicle fuel varies from 47.6 €/tonne in Slovakia to 107 €/tonne in Denmark. The financial costs for anaerobic digestion with different uses of biogas remain within the same range.

As detailed in Annex 10, financial costs of landfilling range from17.2 €/tonne in Cyprus to over 38.5 €/tonne in France. France has the highest net cost of landfilling because it has a low wholesale price of electricity and high labour costs, whereas in Cyprus the low net cost of landfilling is a result of low labour costs and a significantly higher wholesale electricity price.

The same factors affect the costs of incineration. The financial cost of incineration ranges between 57.9 €/tonne in Cyprus to 104.3 €/tonne in France. For in-vessel composting, the differences between financial costs in various Member States are much lower than for the other waste treatment methods and vary between 30 €/tonne in Bulgaria and 41 €/tonne in Denmark.

53 Source: Arcadis/Eunomia. The calculations have been achieved on the basis of an in-depth literature review, an analysis of various case studies and when needed, on expert judgment

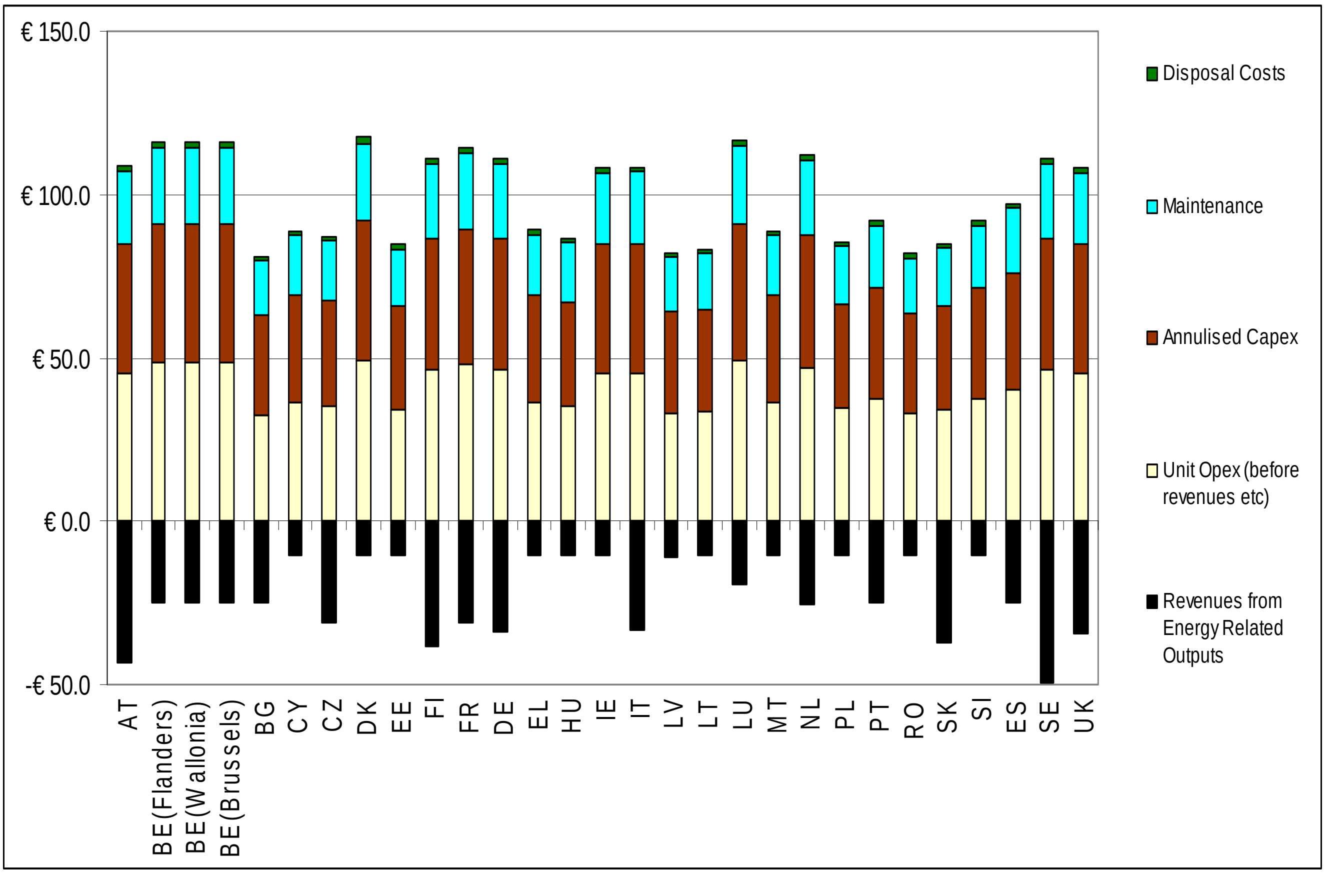


Figure 4: Example of breakdown of financial costs (€/tonne): anaerobic digestion with biogas used as a vehicle fuel

7.3.2. *Cost of separate collection*

The introduction of new schemes involves the planning of new systems, their design, and possibly a tender for a new collection service. This planning phase may incur upfront costs. Such costs should not exceed the order of €1 per household, and this would be a one-off cost. New services generally require additional communication efforts in the preparatory phase for the change.

These might be of the order of €1-2 per household over and above the ongoing communication efforts. As these costs are very low compared to other costs and cannot be effectively attributed to scenarios they were not included in the calculations behind the scenario.

In the context of the preparation of the present Assessment, a review of the available information on the running costs of separate collection has been undertaken[54]. Different studies on the costs of separate collection of several municipalities – including rural, semi-rural and urban areas, spread in representative Member States - have been compared in order to try to draw general conclusions for the EU level. The analysis shows that running costs of separate collection are mainly influenced by local conditions. According to the analysis, the difference in financial costs between separate collection of bio-waste and the collection of

[54] Arcadis/Eunomia, main report, pages 96 to 113

mixed waste can, if the transition in collection systems is well engineered, be a net reduction in costs for separate collection, even taking into account that separate collection is more labour intensive.

The potential savings are linked with the reduction of the needed collection frequency for the remaining waste which requires expensive compacting truck. Even in cases where separate collection may be more expensive than mixed waste collection, the savings on waste treatment should offset this difference. In this Assessment it was assumed that running costs of separate collection do not differ from the cost of mixed waste collection.

7.3.3. Administrative cost

In comparison to the baseline scenario, no additional significant administrative costs have been identified. As detailed in section 8.1, some additional administrative cost could be expected if compost standards are applied but these costs are expected to be low and not directly linked with the implementation of alternative scenarios.

7.3.4. Cost comparison of treatment techniques

An analysis of the costs and benefits of switching from landfill and incineration into biological treatment for the management of bio-waste shows significant potential savings. These savings result either from a reduction of the financial costs when switching from incineration into composting, or an increase of environmental benefits when switching from landfills into composting or incineration into anaerobic digestion. Tables showing the costs and benefits of such switches on country-by-country basis are included in the Annex 11.

7.4. Social impacts

7.4.1. Involvements of households

The implementation of the analyzed scenarios will require an increased involvement of households in prevention and separate collection of bio-waste. The number of inhabitants who will be affected will directly depend on the extent of separate collection requirements.

No reliable method to monetise or even quantify this impact is available due to the large number of factors to be taken into consideration and the lack of generally accepted methodologies. Factors like the need of space for additional waste bins for kitchen waste or time spent on waste separation may be valued very differently. Also, the willingness of inhabitants to participate in separate collection is difficult to assess even if it is a key issue for ensuring the success of separate collection schemes.

7.4.2. Effects on employment

Although data on employment in relation to various waste collection and treatment techniques are rather scarce, it can be assumed that separate collection and biological treatment will generally be more labour intensive.

It was not possible to quantify the differences in terms of job creation between the analyzed scenarios due to a lack of detailed data on the labour intensity of each collection and treatment method. Nevertheless, a positive impact on job creation is expected from the scenarios requiring more separate collection and more biological treatment.

7.4.3. Effects on workers and neighbours health of bio-waste treatment plants

Information about the impacts on the health of workers involved in waste collection and treatment is limited. Available studies deliver contradictory results on the possible degradation of health conditions of workers dealing with municipal waste collection and treatment[55]. Therefore, no firm conclusion on such impacts can be made based on the current state of knowledge.

The analysis performed for this Assessment is focused on the issue whether separate collection and treatment of bio-waste can increase health risks in comparison to collection and treatment of mixed waste. The information found suggests that no significant change in terms of health risks for workers as a result of the increased separate collection of the bio-waste fraction[56] could be expected. Larger composting and digestion plants will be covered by the new Directive on Industrial Emissions[57], meaning that they will be operated on the basis of the "best available techniques" concept.

7.5. Impacts on the specific group of stakeholders

It is expected that the Member States potentially most affected by a possible new initiative favouring the biological treatment of bio-waste will be those heavily relying on landfilling (UK, GR, ES, IE, PT, EU-12) or those meeting the targets of the Landfill Directive with operations other than recycling and recovery (FR, DK, SE).

The groups most intensely affected by a potential new initiative favouring biological treatment would include:

- Administration from local to national level especially the authorities responsible for waste management as increasing the biological treatment of bio-waste would require an adaptation of the collection and treatment systems;
- Citizens who would be required to make additional prevention and waste separation efforts and depending on the results of these efforts, make savings or pay more for waste management;
- Compost users such as farmers who would be offered compost of good quality in larger quantities;
- Landfill operators as new obligations on the management of bio-waste may further divert this waste from landfilling (i.e. beyond the diversion targets of the Landfill Directive);
- Bio-waste management companies in terms of business opportunities, new jobs and increased market share;

---

55 Harrison, E. Z., 2007. Compost Air Emissions Health Studies - A Summary of the literature, Cornell Waste Management Institute, US, http://cwmi.css.cornell.edu/composthealth.pdf

56 See e.g. Neumann, H.-D., 1999. Arbeitschutz bei Müllwerkern unter dem Aspekt von Schimmelpilz- und Gefahrstoffbelastung, In: Gallenkemper, B. et al (Hrsg): 6. Münsteraner Abfalltage. Münsteraner Schriften zur Abfallwirtschaft Band 2, Münster 1999. *"The biowaste collection personal is exposed to the same low level microorganisms (1*104 to 5*105 Colony Forming Units CFU/m³) like for mixed waste collection (3*104 to 2*105 CFU/m³). No special risk can be concluded"* (Neumann 1999).

57 Replacing current IPPC directive (1996/61/EC)

- Waste incinerators: the removal of bio-waste which could have been incinerated may negatively influence the income of the sector. On the other hand, the elimination of the wet fraction with low energy value should increase the energy efficiency of incineration. Therefore, it can be expected that the incinerators designed to treat low calorific waste will be forced to reduce the amounts of waste treated while incinerators able to treat high calorific fuel will be in a favourable position.

- In the longer term it should lead to higher energy efficiency on the incineration market. In Member States with a high incineration capacity, it is expected that the liberated capacity will draw other waste streams towards incineration. In order to counter this trend, it may be necessary to limit the incineration capacity e.g. by not replacing incinerators which have reached the end of their lifetime;

- The waste collection and treatment industry should generally benefit from new business opportunities related to new or widened collection systems and broadening of the recovery market. The more ambitious separate collection targets are set (scenarios 2 and 2A), the wider market possibilities will be for the waste management sector;

- Equipment makers will profit from increased demand.

Due to the comparatively small amount of compost produced, no major loss of business is expected for producers of materials which may be partly replaced by compost - peat, mineral fertilizers, soil improver and growing media[58] even if the exact scope of influence on these markets cannot be precisely assessed.

7.6. Cost of prevention and possible impacts from waste prevention

A potential for preventing bio-waste exists mainly in the area of food waste. It is crucial to encourage households to see the potential savings. For instance, in the UK households typically loose around €500 annually on *avoidable* food waste[59]. This financial loss is coupled with the costs to municipalities (and hence to households) of collecting and treating this waste.

Waste prevention could imply a modification in consumer behaviour. Important changes could include a better “management” of food in households, better targeted purchasing decisions ("buy what is needed"), more attention and better information about to the periods of product validity. Such measures would clearly not aim at reducing the Consumer's freedom of choice.

It is difficult to precisely estimate the costs of activities which could lead to waste prevention. While the examples of possible actions are available (e.g. information campaigns, food banks, etc[60]), it is problematic to attribute the cost to the results. In any case, it seems prudent to assume that education campaigns aiming at food waste reduction or improving the gardening will cost only a small percentage (10% according to expert judgement[61]) of the potential savings resulting from prevented waste.

58 "Growing media" is material used to culture plants as a replacement of soil (especially in horticulture)
59 Source: "The Food We Waste" report for the "Waste Resources Action Programme (WRAP) – UK" – April 2008
60 More information is available at: http://ec.europa.eu/environment/waste/prevention/practices.htm
61 Source: Arcadis/Eunomia – page 85, main report

Therefore, in the context of the present Assessment, knowing that there are uncertainties around the precise costs and benefits of prevention actions, it has been assumed that no direct financial benefits could be attributed to prevention actions except those strictly due to the reduction of the quantities of waste to be treated.

Given the significant potential savings for households that have been established by some national investigations, the present approach of considering neither costs nor direct benefits for prevention actions is assumed to be very prudent in the context of this global analysis. It therefore appears reasonable to assume on the basis of available data that prevention actions should be favoured.

8. COMPARISONS OF SCENARIOS

8.1. Assessment of impacts of the different scenarios

8.1.1. Scenario 1 - only compost standards

On the basis of the results of the stakeholder consultation, it has been concluded that the optimal approach would aim at setting two standards: one to define the minimum quality for compost that has completed the recovery process and can be traded as a product, and another one setting minimum requirements for the spreading of not completely recovered material on soil. The advantages of setting standards include:

- Strengthening the market by setting a level playing field for compost and related products - soil improvers, growing media - in the EU: cross boarder trade of compost is limited in the EU (e.g. export from Belgium and the Netherlands accounted for around 4.5% of the annual production of compost in these countries[62]). However this trade faces obstacles resulting from different compost standards. Most Member States have set their own standards for high quality compost to distinguish it from waste. To the contrary, in some Member States like Germany, quality compost is legally considered as "waste" until it is actually used on soil.

This leads to additional administrative burdens related to the waste status e.g. notifications[63]. Based on the experiences from Belgium and Netherlands, the potential of intra-EU trade of compost resulting from harmonising national approaches could be about 1.8 Mt per year[64] equivalent to around € 12.6 M [65];

- **Improving consumers' confidence and enhancing the recycling markets:** experience of several countries suggests that the development of markets for products resulting from bio-waste treatment will be made easier through a combination of standards, supported by voluntary quality assurance schemes (QAS), now operated in many Member States. The expected growth of the market from the introduction of standards cannot be effectively quantified. However, it is expected to be most visible in the countries which have low or no compost standards[66].

---

62 For 2005 and 2006, source Orbit/ECN

63 Another example of problems related to differing compost perception is the lack of ability to export specialized seaweed compost from Greece to Denmark. Source Orbit/ECN

64 Source: Orbit/ECN

65 Assuming an averaged revenue of 7€ per tonne of compost sold – source: Arcadis/Eunomia

66 BG, CY, GR, EE, LV, SK, PT, MT

Based on the experiences of countries which have successfully implemented quality compost policies, it seems that standards and QAS increase the level of demand for compost through a better appreciation of the potential benefits of their use among key end-users. This effect is particularly relevant in agriculture, which constitutes the major end-use market for compost.

- **More clarity between "waste" and "product":** most Member States allow compost production and use only if it originated from separately collected bio-waste. Other countries allow the production of compost from mixed waste. The definition of compost standards will allow a clear distinction between compost of high quality considered as a "product" and material of lower quality which could still be used as soil improver, albeit for well specified purposes and under clearly defined waste management rules. As supported by most stakeholders, the use of compost material derived from mixed waste should remain under control of the waste regime.

Conclusion of scenario 1

Setting standards and using QAS has already proved effective in creating confidence on the part of consumers. Standards, therefore, play a dual role:

- Help protecting health and the environment through regulating the physical and chemical properties of compost and its application on soil; and

- Contribute to developing a better market for compost/digestate producers by improving the public perception of compost and trust of end-users in this material.

Table A.13-1 in Annex 13 compares the impacts of a scenario with and without compost standards. No specific standards have been proposed in this Assessment as they need to be developed via appropriate scientific studies and additional stakeholder consultations. According to previous studies[67] and on the basis of the existing national legislations and the information gathered during the stakeholder consultation, compost standards should at least include the following parameters: heavy metals, pathogens, organic contents and unwanted residues.

Minimum requirements for compost that can circulate freely on the internal market as a product (i.e. having completed a recovery operation according to EU waste law) would be set by the Waste Framework Directive (end-of-waste criteria). The additional administrative cost of EU standards for Member States is expected to be low. Investments in collection and treatment infrastructure will have to be made swiftly in many Member States to meet the Landfill Directive targets.

Accordingly, the baseline scenario assumes that Member States will fairly rapidly develop source separation and composting even without new EU legislation. However, standards would allow making informed decisions regarding the appropriate balance of separate

[67] EU Commission, DG Environment 2001. Working Document (WD), 2nd draft: "Biological treatment of bio-waste"; J. Barth, F. Amlinger, E. Favoino, S. Siebert, B. Kehres, R. Gottschall, M. Bieker, A, Löbig and W. Bidlingmaier (2008). *Compost Production and Use in the EU*. Report for the European Commission DG/JRC; Amlinger, E. Favoino, M. Pollak, S. Peyr, M. Centemero and V. Caimi (2004) *Heavy metals and organic compounds from wastes used as organic fertilisers*, Study on behalf of the European Commission, Directorate-General Environment, ENV .A.2, http://europa.eu.int/comm/environment/waste/compost/index.htm;

collection and dedicated bio-waste treatment infrastructure or mixed waste treatment through MBT. Member States may therefore need to apply a (national) system of standards to help marketing the end product in any case. Operational costs for biological treatment plants include the cost of monitoring and quality assurance of waste at the plant level. For waste from food production and catering waste subject to animal by product regulation (ABPR)[68] standards relating to compost should be in line with relevant safety and hygiene requirements to prevent potential risks for human health which may be caused by improper management of such bio-waste.

8.1.2. Scenarios 2 and 3

8.1.2.1. Mass-flow changes resulting from each scenario

The main changes of mass-flows between treatment methods are summarised in Figure 5 and in Annex 14. The management of bio-waste anticipated to take place under scenario 2 leads to significant changes relative to the baseline scenario. Between 2013 and 2020, a total of 117 Mt of waste is estimated to be removed from residual waste treatment facilities. Approximately 80% of the source-separated waste removed from these facilities is assumed to be treated biologically. The remainder is entirely removed from the treatment system as a result of enhanced waste prevention.

For scenario 2A, the mass flows are effectively the same as under scenario 2, but it is assumed that progressively more bio-waste is treated in anaerobic digestion and less through composting – 17 Mt per year as from 2020. Unlike scenarios 2 and 2A, there is no enhanced waste prevention under scenario 3 and 3A. As a result, between 2013 and 2020 only approximately 31 Mt of waste is removed from residual waste treatment and directed to organic treatment facilities. The mass flows under scenario 3A are the same as under scenario 3 but it is expected that progressively more bio-waste will be treated by anaerobic digestion and less by composting (2 Mt each year as from 2020). In scenarios 3 and 3A the global rate of biological treatment at EU 27 level increases from 37.5% (baseline scenario – 2020) to 45% on average.

[68] Regulation 1774/2002/EC of the European Parliament and of the Council of 3 October 2002 laying down health rules concerning animal by-products not intended for human consumption

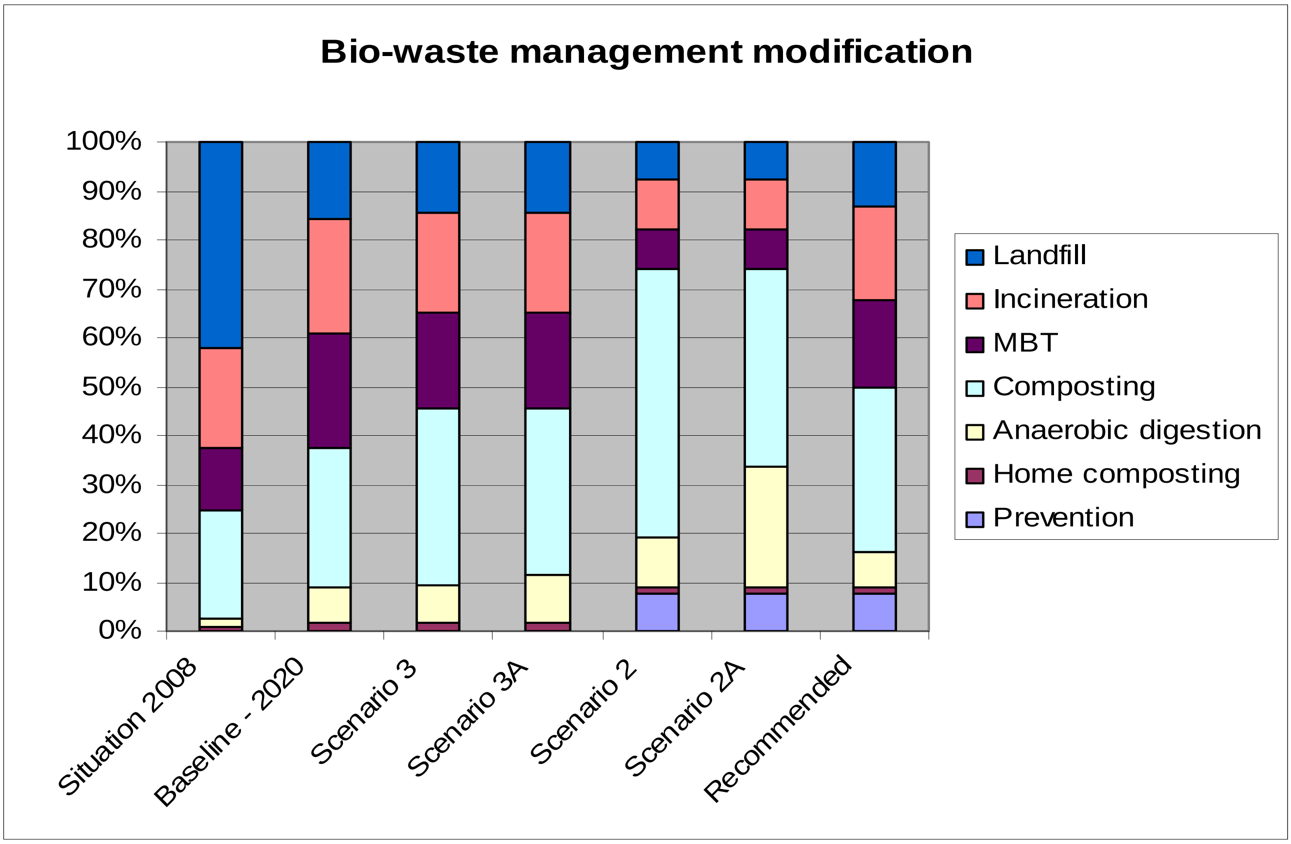


Figure 5: Mass flow modifications of treatment flows by 2008 and 2020 for each analysed scenario

8.1.2.2. Trade offs

Figure 5 shows that there are trade-offs between various options for bio-waste management. More prevention for instance will imply a reduction of the quantities of waste to be treated and therefore a reduction of the possibilities to produce biogas and/or compost.

The alternative scenarios have been constructed in order to take into account these possible trade-offs. For instance, in scenario 2 quantitative prevention targets have been introduced and therefore the total amount of bio-waste to be treated has been decreased (by 7,5% in 2020 compared to the baseline).

Consequently, the total amount of compost and/or biogas produced has been decreased compared to a solution without prevention. Similarly, in scenario 2B and 3B, anaerobic digestion has been promoted and therefore, as indicated in Figure 5, the quantities composted have been decreased accordingly. The costs and benefits as well as the main impacts have been assessed taking these trade-offs into account.

8.1.2.3. Changes in Greenhouse Gas Emissions

The main modifications between the scenarios in terms of GHG emissions are summarised in Figures 5 and 6. Detailed calculations for Member States are given in Annex 15 (Table A.15-1).

Compared to the baseline scenario, a significant reduction in overall GHG emissions is expected under scenario 2. The main expected effects come from waste prevention and avoided landfilling. The expected total GHG emission reduction is of 48.8 Mt CO_2-equivalent. Scenario 2A results in additional savings of 2.7 Mt CO_2-equivalent over scenario 2 (total reduction of 51.5 Mt CO_2-equivalent). The larger reduction is associated with the choice of bio-waste treatment options. The difference between scenario 2 and 2A is not large in relative terms – 2.7 Mt CO_2-equivalent.

Scenario 3 and 3A shows a far less significant expected reduction in overall GHG emissions than scenario 2 and 2A. A smaller amount of waste is expected to be diverted from landfills, no waste prevention effects are included and for many Member States composting instead of anaerobic digestion is expected to bring better results in terms of net cost for the society.

In many Member States, there is a small difference of costs between composting and AD, with composting being slightly cheaper, but having less environmental benefits. The total benefit in Scenario 3 is a reduction of 4.3 Mt CO_{2e} which is comparable with the reduction of 4.8 Mt CO_{2e} under Scenario 3A.

Figure 6 and 7 show the results using different methodologies of counting CO_2 of biological origin. Figure 6 shows the results using the approach followed in the Assessment - which is better suited to compare the impacts in terms of GHG emissions between the different waste treatment techniques (but not in line with IPCC methodology). Due to accounting delaying of emissions of from compost and digestate used on soil, it gives slightly more favourable results for biological treatment in comparison to waste incineration.

Figure 7 is given for comparison and shows the result using the methodology used for IPCC inventories (which normally neglects the effects of slower release of carbon from compost) – so this figure should be used when discussing performance against policy targets. The IPCC methodology is widely used in both the Commission and in inventories of global warming emissions. The differences between the two methods are nevertheless not significant in the context of the present Assessment and its possible policy implications.

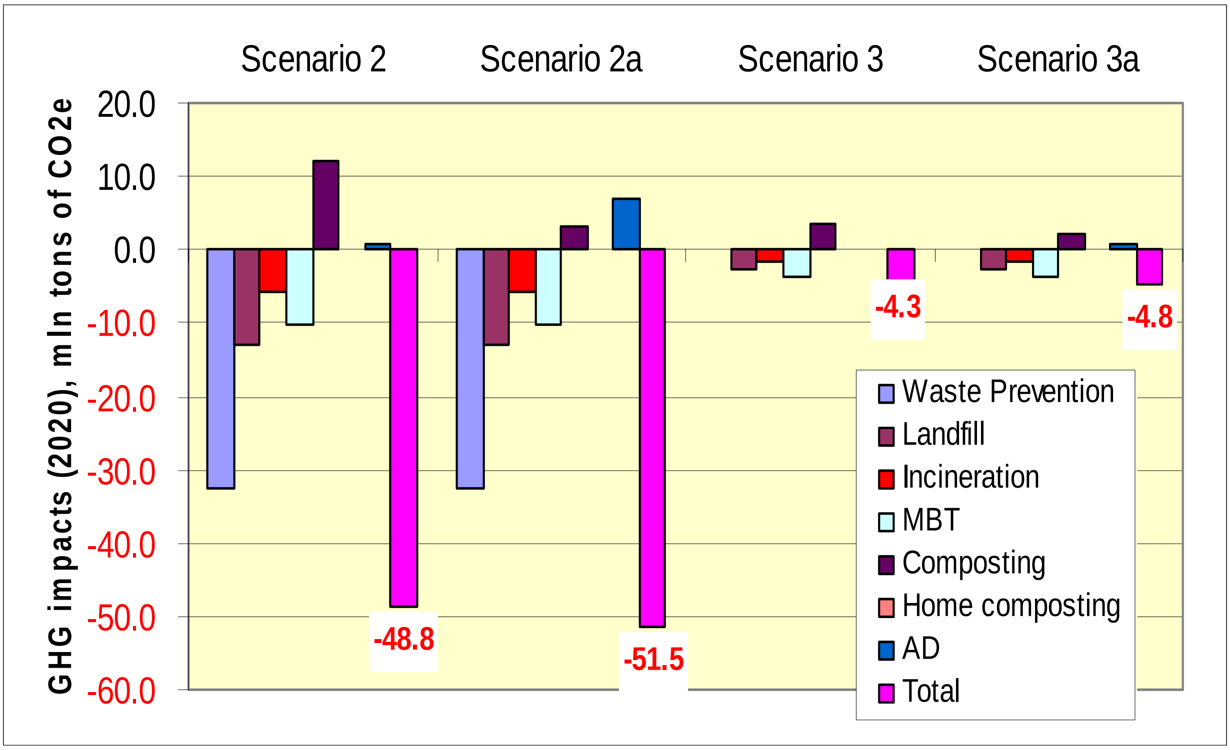


Figure 6: GHG emission relative to the baseline Scenario (year 2020) including biogenic carbon

.

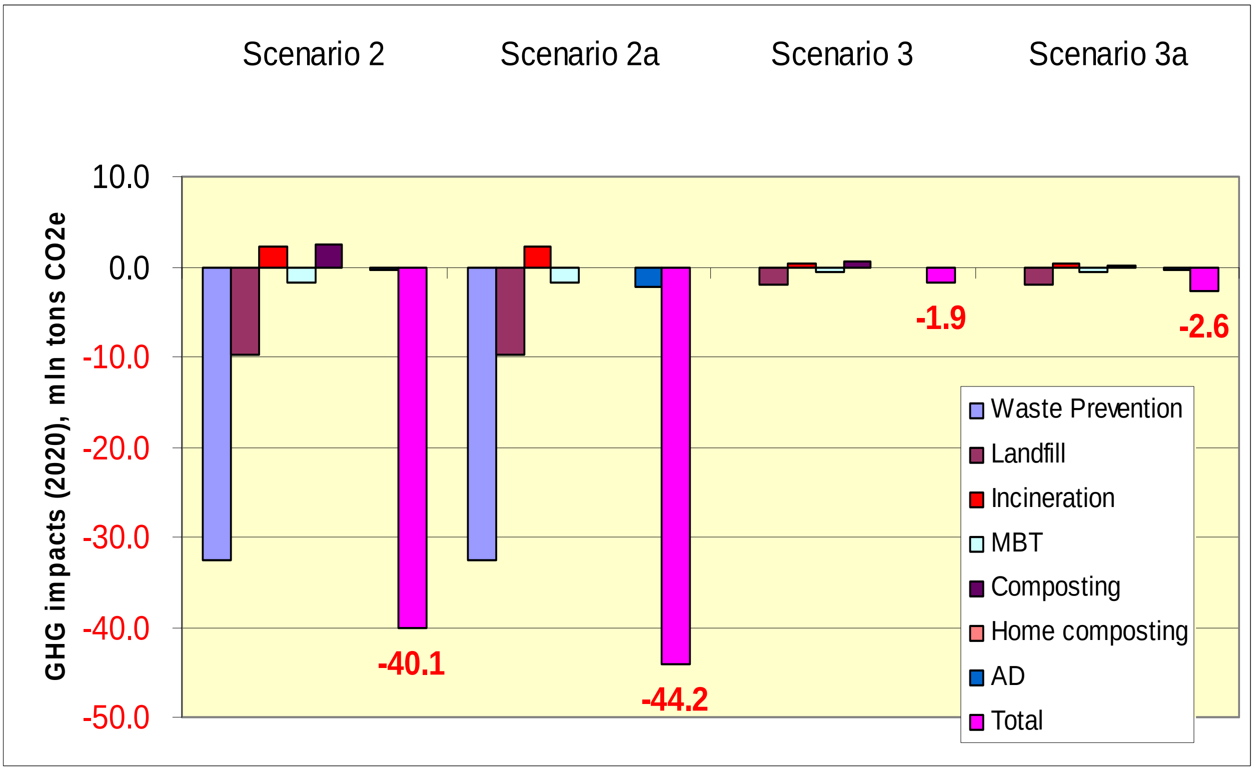


Figure 7: GHG emission relative to the baseline Scenario (year 2020) excluding biogenic carbon

8.1.2.4. Financial and environmental costs

Figure 8 shows the financial and environmental costs and benefits associated with each scenario in comparison to the baseline scenario. Detailed calculations for Member States are given in Annex 15 (Table A.15-2). Compared to the baseline scenario, scenario 2 demonstrates a significant net benefit to the society, calculated from cost savings and from additional environmental benefits. This is due to a significant reduction in overall GHG emissions mainly from enhanced waste prevention and avoided landfilling. The net benefit to the society from the introduction of scenario 2 amounts to € 7.088 million over the period 2013-2020 (in net present value – NPV – discount rate at 4%).

Scenario 2A also results in a significant net benefit to the society, but this benefit is lower by 11% than scenario 2 (€ 6.395 NPV for the 2013-2020 period). The expected benefits of scenario 2A (linked with larger avoided environmental damages) are higher compared to scenario 2. However, the expected costs are much higher for scenario 2A compared to scenario 2 and these higher costs do not compensate the higher benefits. This is due to the choice of a more costly treatment method for food wastes (biomethanisation for all kitchen waste and all Member States, section 6.2.3).

Compared to the baseline scenario, scenario 3 results in a significant net benefit to the society but this benefit is much lower than in scenario 2 (€ 1.448 million under scenario 3 as compared to € 7.088 million under scenario 2). Under this scenario, the quantity of bio-waste diverted from landfills is less than a quarter of the amount considered under scenario 2, and there is no waste prevention impact. As a result, the substantial reduction in environmental damage costs seen under scenario 2 does not occur to the same degree under scenario 3.

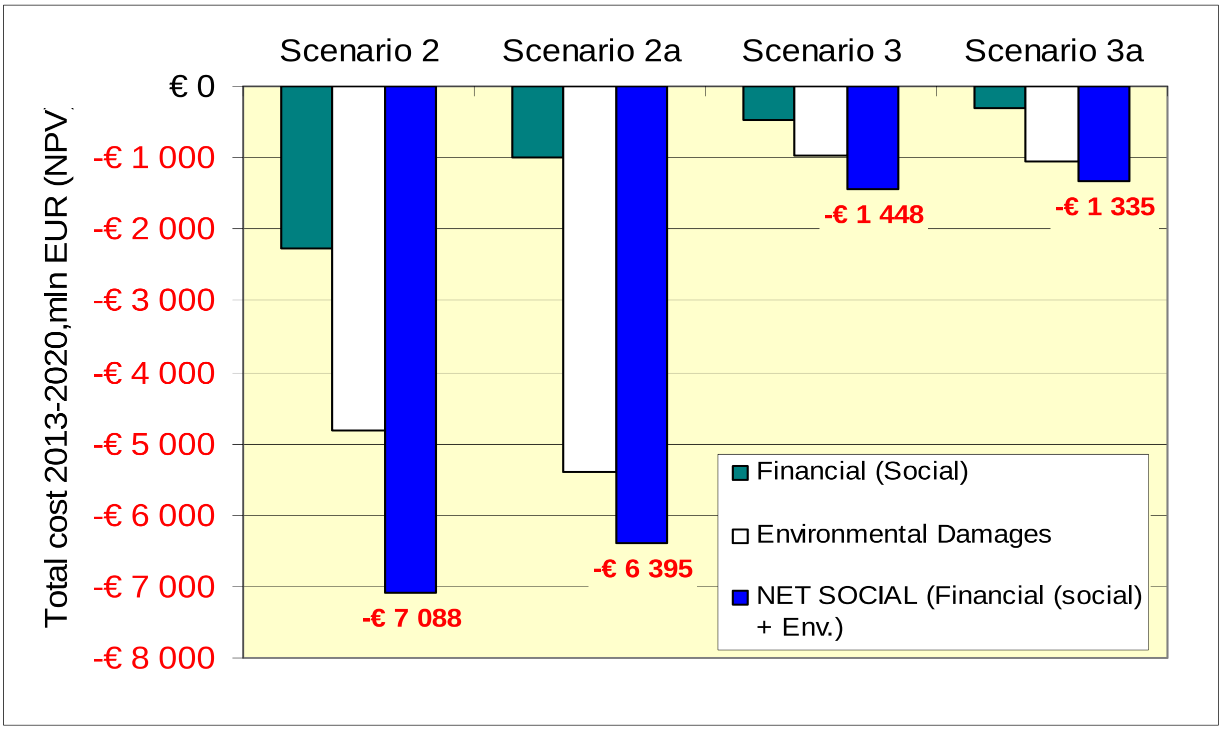


Figure 8: Total Financial and Environmental Costs of each scenario for the EU-27 over the period 2013-2020 (NPV)[69]

There are, however, some reductions in the quantities of waste treated by both incineration and MBT facilities. These types of treatment typically result in higher financial costs per tonne of waste treated in comparison to the cost of sending the material to landfill or composting organic wastes. Thus there is still a reduction in the financial cost associated with scenario 3 - albeit less than half of what could be achieved under scenario 2 owing to smaller changes in tonnage directed to residual waste treatment facilities.

The differences between scenario 3 and scenario 3A are similar to those between scenario 2 and scenario 2A. Under scenario 3A, there is a significant increase in environmental benefits; however, this is more than offset by a worse financial performance.

Tables in Annex 14 and 15 demonstrate that for some Member States the expected modifications implied by scenario 3 are either limited or even zero[70] as the objectives of scenario 3 are expected to be met in the baseline scenario. Therefore, compared to the baseline scenario, no additional benefits at society level are expected for these countries by applying scenario 3. Scenario 2 implies modifications for all Member States demonstrating that increased prevention is beneficial at society level for the whole EU 27.

The net effect is that the net societal costs are higher than under scenario 3 (there is a reduced benefit to society) and the net benefit to society is the lowest of all the analysed scenarios compared to the baseline scenario.

The contribution to the environmental benefits of each impact is shown in Figure 9. The dominating impacts are linked to the reduction of GHG emissions and air pollutant emissions (AQ). This is partly due to the fact that it was not possible to monetize all impacts but also simply because the expected reduction of air pollutants and GHG emissions are the dominating environmental impacts.

[69] Scenario 1 was not added into the graph as it was unable to monetize the expected costs and benefits. Negative figures imply a net saving

[70] This is the case for 11 Member States including AT, DE, DK, FI, HU, IE, IT, LU, NL, SE and UK

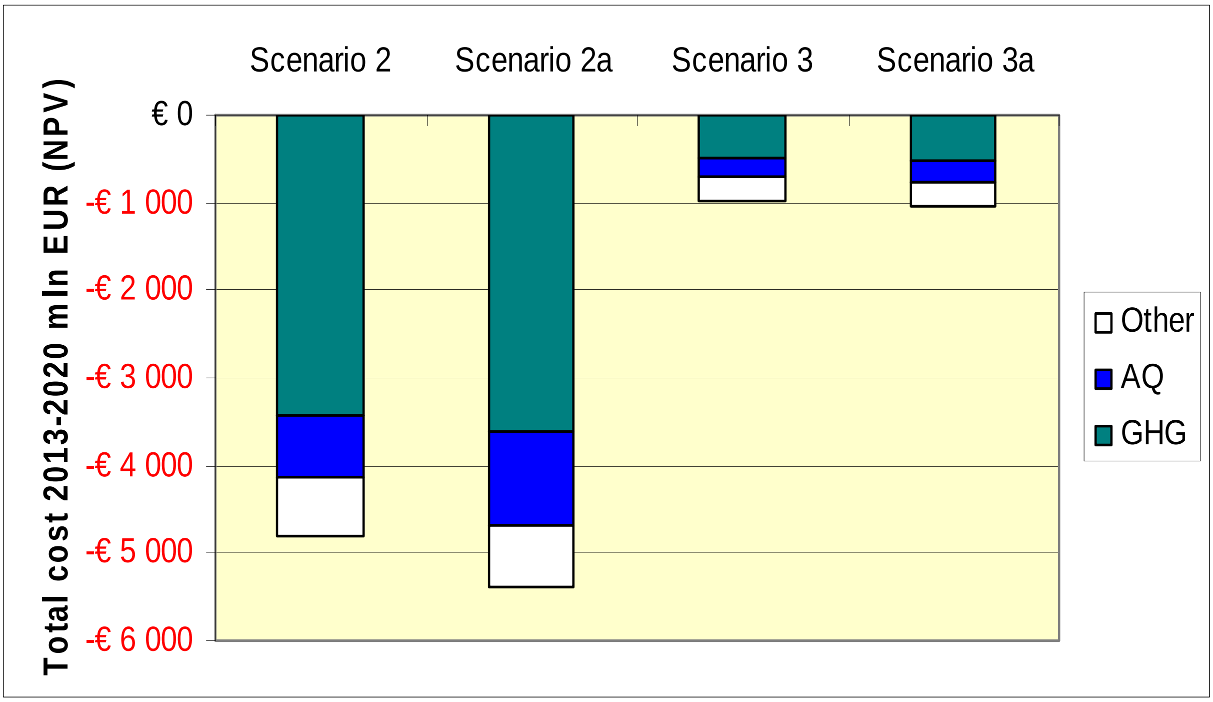


Figure 9: Total Environmental Benefits of each scenario for the EU-27 (2013-2020) (NPV)

8.1.2.5. Uncertainties and policy implications

An assessment of the main uncertainties as well as their potential implications in terms of policy development is given in Annex 16. In summary, main uncertainties are:

- Bio-waste generation: estimations were made on bio-waste generation on the basis of the assumptions on GDP and demographic growth and specific patterns of relation between GDP and waste generation;

- Compliance with the Landfill Directive: it was assumed existing law will be implemented - this might not be the case in a limited number of Member States heavily depending on landfilling;

- The expected treatment methods in the baseline and the alternative scenarios: the choice of the treatment methods is based on maximised benefit for the society. In practice, other practical parameters could influence the choices of the treatment methods such as planning capacity at local level, citizen participation in separate collection schemes, etc.;

- Prevention: costs and benefits of the prevention actions are very difficult to assess as the "return on experience" is rather limited; available information comes from a restricted number of experiences at local level which makes difficult an extrapolation to an EU level. The same applies for home composting for which available information is also limited;

- Cost and benefit assessments: numerous hypotheses were made as the costs depend on local factors (salaries, energy mix); numerous assumptions were also made on the "physical" environmental impacts of each treatment method and related emissions (GHG and air pollutants) which are all based on average emission factors;

- Monetization of the impacts: the most accurate information was used in order to monetize the environmental impacts but the information was often incomplete, missing or collected in other contexts and for other purposes (for instance Clean Air for Europe data were collected in the framework of the air quality policies);

- Local/EU level: Overall, the main messages coming from the comparison of the scenarios are valid at EU-27 level. However, as regional or local conditions - including local or regional demand for compost or energy - may differ from the average values assumed in this Assessment, more caution is needed when applying the results at national, regional or local levels.

Based on expert judgement, a tentative estimation of the range of each of these uncertainties is given in Annex 16. Efforts were made to limit as far as possible these uncertainties, including an in-depth analysis of the existing reports, the analysis of historic data, a comparison of the performances of Member States, etc. An in-depth stakeholder consultation also contributed to limiting uncertainties and more confidence in the data used in the context of this Assessment.

These uncertainties were taken into account for the definition of the proposals linked to the present Assessment, notably by recommending flexibility in the way of encouraging Member States to move towards more prevention and biological treatment of bio-waste.

8.2. Comparison of policy scenarios and recommended scenario

The comparison of all scenarios with the baseline scenario demonstrates an unexploited potential for improved bio-waste management in the EU. The most visible and significant benefits include avoided emissions to air, including large amounts of GHG. At the same time, good quality compost can be produced which can contribute to the improvement of EU soils and the protection of primary resources.

Scenarios 2 and 2A perform better than scenarios 3 and 3A in terms of financial costs and environmental benefits. A major part of this performance is due to the large effect of waste prevention under scenarios 2 and 2A, the cost of which was impossible to estimate and assumed to be zero. Compared to scenarios 2 and 3, scenarios 2A and 3A are more promising in terms of environmental benefits but are more costly.

However, scenarios 2A and 3A can contribute better to achieving other EU policy targets, most notably the renewable energy targets and renewable energy in transport target. This may render them attractive to some Member States despite their higher costs.

The comparison of the results of the cost and benefit analysis of the different analysed scenarios indicates that a combination of scenarios would deliver the most eco-efficient solution to meet the objectives as defined in section 4. This "optimal" combination consists in promoting a moderate targets for prevention (similar to the scenario 2) and another target for biological treatment (minimum of 36.5% as proposed in scenario 3).

More advanced Member States should be encouraged to further pursue their efforts in terms of increased biological treatment. In addition, work should commence towards a possible proposal for compost standards at European level as analyzed in scenario 1.

8.3. Impacts of the recommended scenario

An estimation of the impacts of the recommended scenario has been prepared on the basis of the results of the alternative scenarios.

The mass flows of the recommended scenario are presented in Figure 5 and detailed in Annex 14 – Table A.14.3. They are similar to scenario 3 but include the impact of prevention (global reduction of waste to be treated by 7.5% compared to the baseline scenario). Generally as in scenario 3, landfilling, incineration and MBT are decreasing compared to the baseline scenario whereas composting and to a lesser extent anaerobic digestion are increasing.

The recommended scenario is expected to lead to a reduction between 34,3 (excluding biogenic emissions) and 36.6 Mt CO_{2e} (including biogenic emissions) compared to the baseline scenario. Similarly to scenario 2 and 3, 80 to 90% of this potential reduction would be achieved by prevention.

The net benefit for society of the recommended scenario is estimated to amount to € 5.449 million over the period 2013-2020[71]. This represents the net benefit of scenario 3 adjusted to take into account the impact of prevention (€ 1.339 million), to which the net benefit of prevention of scenario 2 is added (€ 4.110 million). The net benefit to the society of the recommended scenario is higher compared to scenario 3 but lower than expected with scenario 2 as biological treatment is less developed. Nevertheless, as explained in section 8.2, this scenario appears as the most cost effective while ensuring a certain level of feasibility.

8.4. Possible EU initiatives to implement the recommended policy scenario

In order to move towards the recommended scenario and to fully benefit from the opportunities offered by better bio-waste management, new initiatives should be taken at EU level in order to:

- Enhance prevention by encouraging and supporting additional actions of the Member States;

- Progressively increase the biological treatment of high quality bio-waste by encouraging Member States to ensure that a minimum proportion of bio-waste is separately collected and treated or treated by adequate home composting;

- Ensure the quality of composted bio-waste and improve markets by defining standards for its application notably in agriculture, and criteria for compost that is allowed to circulate freely on the market as a product.

The three above mentioned actions in bio-waste policy - enhanced prevention, increased biological treatment, and setting EU standards for compost - can be implemented through a combination of policy measures, ranging from voluntary to legislative actions. The table in Annex 17 summarizes the benefits and drawbacks of using different measures to introduce the selected policy actions.

The Assessment demonstrates that a better management of bio-waste would result in environmental and economic advantages for the EU. Waste policy at EU and Member State

---

[71] Extrapolation of the results of scenario 2 and 3

levels should therefore make full use of these opportunities as a matter of priority. As a first step, Member States should be encouraged to better use the existing instruments at their disposal to improve the bio-waste management at national level, and the Commission should support the widest possible up-take of best practices. This could be done in the form of a Communication from the Commission.

Existing legislation such as the Landfill Directive provides supporting means. Together with the waste hierarchy, the new legal provisions of the Waste Framework Directive [72]on waste Prevention Programmes are powerful instruments if used well by the Member States. In fact, zero landfilling of untreated waste and high-quality biological treatment has been achieved nowadays by Member States who already took the appropriate national initiatives.

In view of this evidence and in line with the "better regulation principle" priority should be given to making best use of the already existing instruments. It is therefore proposed to use as far as possible existing instruments to "translate" the three main orientations detailed above into actions at EU level.

8.4.1. Waste prevention

Waste prevention offers the largest single means of improvement: full use should therefore be made urgently of the revised WFD which includes clear provisions for Member States to draw up and implement waste prevention plans.

The present investigations seem to indicate that promoting prevention would likely require coordinated actions at all competence levels from the European, through national and regional, to local levels. It appears that it would also require the involvement of the whole chain of actors from producers, through retailers, to citizens. As detailed in section 3.4, EU level initiatives might be appropriate for encouraging and supporting action by Member States. However, it is considered that the evidence base for these assumptions needs to be further developed before any policy proposals can be presented.

Setting a binding bio-waste prevention target at EU level does not seem realistic at this stage. Clearly, there is still insufficient experience for proposing any binding prevention targets as policies and indicators have just begun to be developed. The level of ambition for such a target would be very difficult to fix at EU level given the strong link between waste generation and economic growth and vastly different national economic circumstances and due to the fact that it is difficult to link precise policy actions to potential results in terms of reduction of the amount of waste generated.

However, rough estimates of the potential effects of prevention policies on the overall amounts of bio-waste generated are as follows: according to the baseline scenario (section 5), an increase in waste generation is expected at EU level (10%). Scenario 2 assumes a reduction of this growth of 7.5%, meaning that compared to 2008 additional waste generation would be limited at EU level to around 2% by 2020, which seems reasonable at EU 27 level. Depending on the specific Member States, this global objective could imply an absolute decrease of waste generation in some countries while in other cases it would only mean a reduction of the expected increase[73].

---

[72] Directive 2008/98/EC of 19 November 2008

[73] Waste generation per country is summarized in Annex 4 – Table A4-3

As an alternative, it is suggested to further analyze the possibility of requiring Member States to set a national prevention target similar to those pertaining to the recommended scenario.

Guidance under development by the Commission through Comitology should be extended to include specific provisions for bio-waste including the definition of the contents of the prevention plans for bio-waste. In addition, the possibility of introducing indicative quantitative reduction targets at national level should be further assessed.

In addition, the Commission should make best use of its possibilities to encourage and support, at EU level, the exchange of good practice and assess any possibilities for EU-wide awareness rising initiatives.

8.4.2. Increasing the biological treatment of bio-waste

Increasing the biological treatment of bio-waste coupled with avoidance of landfilling, offers the second largest potential for improvement. The present investigations point to increased biological treatment of bio-waste as an important factor which might contribute to overall societal gains. Member States should be strongly encouraged to fully comply with the "waste hierarchy" in national waste management policies. Legal action in case of failure should be considered at an early stage.

It is however not possible at this stage to decide in general terms whether composting, anaerobic digestion or adequate home composting should be preferred at EU level, since the choice will depend on local conditions linked with the energy mix and the efforts already achieved to reduce GHG emissions from other sources.

Indications from the present Assessment are that any Member States aiming at moderate collection/recycling rates similar to the scenario 3 target (minimum of 36.5%) would most likely retain sufficient flexibility to decide in which geographical areas it is more relevant to organize separate collection and biological treatment of bio-waste in response to national and local circumstances..

Present data suggest that higher rates could lead to greater environmental and financial savings. From the data available it could be interpreted that even in already advanced Member States an increase of biological treatment by 5 to 10% by 2020 seems feasible up to a maximum around 60%- 70% (corresponding to the ambitious scenario 2 target of 66%). However, a stepwise approach may be recommendable to allow Member States to gain the necessary experience and build markets for compost and digestate.

As a preliminary working hypothesis it could thus be assumed that a minimum aspiration similar to scenario 3, accompanied by a strive to higher levels for more advanced Member States would seem to be to most eco-efficient solution. However, further assessments would be needed to investigate if EU level initiatives would be opportune, also in light of the subsidiarity principle.

The more advanced countries having met this target should be encouraged to pursue their efforts. This could be done via the introduction of a recommendation in the Commission Communication.

Such targets should be met in principle by separate collection of waste followed by composting or anaerobic digestion or by properly managed home composting programs.

Mixed collection of bio-waste could be possibly considered as long as high compost quality is ensured and adequately monitored with quality assurance systems in place.

If the added value from defining a common target at EU level would be demonstrated notably from the subsidiarity point of view the introduction of such target could be achieved through the review of the new WFD recycling targets for Municipal Solid Waste as these targets can include bio-waste.

A review of the recycling targets is foreseen by 31 December 2014 at the latest, but a limited amendment of the WFD could also introduce this recycling target at an earlier date. New self-standing legislation to set targets is another option but it is uncertain if it would become effective sooner than reviewing the WFD targets. Full coherence between two parallel pieces of legislation would have to be ensured also with a view to future developments under the WFD.

8.4.3. Demand-orientated measures to encourage the use of biologically treated bio-waste

The present Assessment indicates that standards for compost and digestate according to different possible uses could facilitate Member States' progress towards better management of bio-waste. Demand-orientated measures to encourage the use of biologically treated bio-waste should be introduced to complement the measures discussed above. Notably the existing possibilities under the revised WFD (setting end-of-waste criteria by Comitology) should be used as a matter of urgency to define legally binding criteria for the production and quality of compost that can circulate freely as a product.

This should lead to a clear distinction between compost that is marketable as a product versus other treated bio-waste which would remain subject to waste legislation. Legally binding criteria for the use of the latter, e.g. in agriculture, should also be established as a matter of urgency. Most likely, as a minimum the following criteria should be considered when compost standards will be defined: heavy metals, pathogens, organic contents, unwanted residues.

This could be done through the extension of the scope of the Sewage Sludge Directive fixing criteria for the use of sludge in agriculture and which is currently under review.

The feasibility and potential impacts of any EU initiatives would have to be further assessed notably concerning the type of parameters to be considered, the level of the possible standards and their potential impacts.

8.5. Recommendation for next steps, proposed timing

In summary and in practice, the following package of initiatives to be launched in parallel is recommended:

1. A (chapeau) **Communication from the Commission** explaining the strategy of the Commission for an optimal management of bio-waste in the EU, for the coming years. It will explain the main lines of action as indicated in 8.4 above. The Communication will also reiterate the possibilities lying in existing legislation particularly by applying the principles included in the waste hierarchy, giving guidance on how to use them best. The Communication should be based on the results of the present report and include a work program along the lines described in

section 2 below. This Communication from the Commission should be prepared and adopted still in 2010.

2. In line with the "better regulation principle" and to avoid unnecessary duplication, it is proposed to also announce in the Communication the preferential use, for as far as possible, of existing instruments to translate the main courses of action proposed in the Communication, into new initiatives at EU level, namely:

- First, in line with the conclusions of scenario 2, the Comitology procedure under the Waste Framework Directive would be used to require the MS that when drawing their waste prevention programmes (required under article 29, by December 2013) that those programmes include specific measures for bio-waste prevention. The preparatory work has already been launched and the objective is an adoption by end 2010.

- Second, in the light of the conclusions of the recommended scenario, the various ways of encouraging Member States to move towards more prevention and more biological treatment for instance by a better implementation of existing legislation and/or through the introduction of quantitative targets should be further assessed before any policy initiatives are can be suggested. The analysis will be launched in 2010.

- Third, quality criteria for the production of compost (as analysed in scenario 1) that can circulate freely as a product can also be set under the Comitology procedure under the WFD (end-of-waste criteria – Article 6) according to an established process. The objective is an adoption of the criteria in 2011.

- It is also proposed to take advantage of the ongoing review of the sewage-sludge Directive to define minimum quality standards for compost used in agriculture (that is bio-waste that would not have obtained an "end-of waste" status and would need to remain subject to waste legislation, e.g. when being applied to agricultural soil). The impact assessment should be finalised in 2010 and should be followed by a proposal in 2011.

3. On the basis of the results of the analysis achieved in this report demonstrating the potential benefits of ensuring the full implementation of existing legislation, the Commission should make renewed and enhanced efforts to monitor and assess the proper implementation of EU waste policy. This concern notably, but not exclusively, the proper implementation of the Landfill Directive, application of the "waste hierarchy" in national waste management policies, including in national Waste Management Plans, and the development of waste management infrastructure.

9. MONITORING AND EVALUATION

9.1. Indicators of progress towards meeting the objectives

The core indicators of progress would be the amounts of bio-waste prevented and directed to high quality treatment, the amount of quality compost/digestate produced from bio-waste, and the amount of renewable energy produced from bio-waste. A good indicator could be related to GHG emissions and savings from waste management. However, it would have to be constructed in a way which prevents focusing on the GHG objectives at the expense of other environmental gains.

9.2. Broad outline for possible monitoring and evaluation arrangements

Monitoring of the bio-waste stream directed to a specific treatment option can be ensured by using the data from the Waste Statistic Regulation (which may require adaptations to this role) or by the general monitoring of the implementation of the waste acquis by Member States.

The Commission has most recently stepped-up its detailed assessment of national Waste Management Plans and is seriously assessing possibilities for further intensifying its controls on proper enforcement of EU waste legislation in the Member States. The assessment and monitoring of future Waste Prevention Plans should be given high priority in this context.

In EU waste legislation, 3-years implementation reports and annual reporting on specific targets are typically required, coupled with ad hoc checks of compliance by the Commission. Regular progress reports to the Council, the European Parliament, the Committee of the Regions and the European social and Economic Committee are prepared on the basis of national reports on implementation. These reports are made available online and are used by the Commission to identify possible needs for policy initiatives, including legal action where appropriate.

ANNEX

Annex 1: Minutes of last ISG meeting

The ISG meeting had place on 21 October 2009 in DG ENV premises in Brussels.

List of participants:

Alexandre MARGHELIS (SJ)

Stefan MOSER (SG)

Rene L'HER (AGRI)

Emese KOTTASZ (TREN)

Andrea TILCHE (RTD)

Bartosz ZAMBRZYCKI (ENV)

Klaus KOEGLER (ENV)

Michel SPONAR (ENV)

Malgorzata KICIA (ENV)

Luca MARMO (ENV)

Thomas STRASSBURGER (ENV)

ENV presented the issue, providing additional explanations questions about the settings of baseline, methodology and assumptions taken.

TREN raised questions to what extend policies on renewable energy (biofuel directive, RES directive) has been included in the baseline. It has also stressed that potential proposal should be technology neutral, bearing in mind the need to reach renewable energy targets, and where energy recovery by incineration is justified as an environmentally beneficial option.

ENV explanation was landfill directive targets has been identified as major driver and it could be assumed it already "include" input from other EU policies.

RTD discussed objections raised few days before the meeting. There were as follows

– the methodology which includes emissions of biogenic carbon is not in line with IPCC methodology for GHG inventories and is favourable for composting while underestimates potential of savings from anaerobic digestion and especially incineration. Therefore additional analysis (calculations) is necessary for comparison

– the RTD data shows much higher GHG savings potential, that presented by ENV

– in the opinion of RTD one of policy option should be based on performance criteria as to avoid preferring any specific technologies.

As the result of the discussions it was agreed that those issue will be dealt with on technical level (verification of calculation and explain differences of methodologies) by cooperation of RTD and ENV.

The policy option based on performance criteria could be acceptable, however no adequate criteria has been yet developed. While this option has not been analysed as the scenario it should be reviewed when performance criteria would be identified. The environmental, economic and social effects should be very similar to options discussed in the IA, while setting performance target would give more Member States and enterprises more flexibility and avoid promotion of any specific technology. It was agreed to flag this issue in IA but discuss in details when concrete proposals would be available (also possible at later stage of possible legislative process).

However ENV stressed that proposed approach of promotion of separate collection is already to large extent "technology neutral" as it gives freedom as for further use of collected waste.

Final item discussed was the timeline for possible future police developments based on this IA, taking into account the start-up of new Commission.

In parallel to ISG meeting ENV has received a written input from JRC and TREN.

These contributions pointed out that the CO2 calculation methodology counts biomass carbon as "fossil" carbon and by including a discount factor skews the result in favour of composting. JRC and TREN also reflected on the methodology of calculation of environmental impact from the energy replaced by energy from bio-waste.

The final text has been modified to more clearly show the differences concerning methodology of carbon calculations (figures in chapter 8.1.2). The comment on calculation of marginal energy has not been included due to data problems.

Further actions:

As the comments received during and after IASG meeting implied considerable further work on the IA draft before submission to the IAB, additional written round of comments was held in December - resulting with set of remarks regarding structure of IA in general and proposal of improvement and clarifications in the text (ECFIN). Additional comments concerned need of better visibility in the text the issue that methodology could favour composting over incineration (TREN) and provided IA with additional data on potential of bio-fuels from bio-waste (RTD).

Annex 2: Stakeholder consultation on bio-waste management – Summary of comments

1. Green paper on management of bio-waste in the EU (COM (2008) 811 Final)

Main problem of the Green Paper: Are we losing an opportunity created by the Landfill Directive? Diverting the waste from landfill into other disposal operations (low grade incineration or low grade MBT) may result in lost of potential for soil improvement and renewable energy generation.

– The Commission received 149 comments, including 22 Member States, 24 regional and local authorities (and their associations), 24 EU level NGOs (of various character), 38 national level NGOs, 8 academic institutions and think tanks, 26 companies, and 5 individual persons and 3 EU institutions (Council, CoR, EESC). All comments are available at: http://circa.europa.eu/Public/irc/env/biowaste_prop/home (enter CIRCA and look for: Bio-waste – Impact Assessment).

Content of the Green Paper:

– Description of existing legislation;
– Description of existing bio-waste management practises and their impacts environmental economic and social impacts;
– Presentation of several alternatives for additional measures supporting recycling;
– Presentation of possible approach to the issue of compost;
– Need for standards.

– The Green Paper was presented as a set of 8 main questions, the answers to which are summarised below. The spectrum of comments was very broad and often contradicting points of view were expressed.

– **Increased bio-waste prevention**: All stakeholders generally supported measures increasing prevention of bio-waste generation. The most popular prevention methods included home composting, information and awareness rising campaigns, improved industrial processes and logistics, programmes for the distribution of products for the poor, smart gardening, and about 8 other proposals.
– **Further limiting of landfilling**: most stakeholder against, Member States and regional administrations split, European NGOs in favour. Most common argument against – it is too early for such a decision since a lot of implementation efforts are needed to meet the current requirements.
– **Bio-waste management options to be strengthened**: stakeholders opted for the following, in descending order of popularity: anaerobic digestion, incineration, composting, separate collection of bio-waste, combination of methods, production of biofuels, Mechanical Biological Treatment (MBT).
– **Increased use of LCA**. Stakeholders were divided on the idea of a wider and more consistent use of life cycle assessments in choosing the best options for treatment of bio-waste diverted from landfills, with Member States and regional administrations split, European NGOs in favour, companies and academic institutions mostly against.

– They have however pointed to several shortcomings of LCAs: lack of evaluation of social and economic impacts, dependence of LCA results on the parameters considered, difficulty to quantify many positive impacts such as carbon sinks, soil impacts.

- **Acceptance for incineration**: National and EU NGOs were generally against incineration of bio-waste, most Member States were in favour. Many stakeholders preferred anaerobic digestion to incineration. The main arguments in favour of incinerations included no need for compost in northern Europe or in big cities, basic requirements for high efficiency of energy recovered. The arguments against included negative impacts of the wet fraction of bio-waste on the calorific value of mixed waste and the loss of nutrients and organic matter contained in bio-waste.
- **Further promotion of bio-waste recycling:** All stakeholders strongly supported further promotion of bio-waste recycling. For many, such promotion would mean an obligation of selective collection of bio-waste, some proposed introducing a cap on the maximum amount of bio-waste in residual waste. The main arguments in favour included the application of the waste hierarchy, providing investment security for the recycling industry. The main arguments against included Subsidiarity in deciding on bio-waste management and doubts that a single best treatment option for bio-waste exists.
- **Levels of quality standards**: Stakeholders generally agreed that standards were needed and proposed from one to three groups of such standards for different types of compost.
- **Rules on compost application and soil quality**: A number of countries and organisations do support EU minimum requirements for compost and its use in the EU such as limits on load applied and the quality of soil to which compost is applied. There is no clear view which applications should be covered but most stakeholders mentioned agriculture and/or food production. Some preferred to leave the detailed rules on the use of compost to the Member States due to the differences in soil, climate and customer needs across Europe.
- **Use of compost from mixed waste**: Most stakeholders were against such practice. The main arguments against were related to the potential for contamination and limited applications. Some arguments in favour included carbon capture opportunities. All stakeholders (including those in favour) stressed that such use requires more stringent quality and application control measures, the use of appropriate Quality Management Systems and better equipment.
- **Additional operational standards for small bio-waste treatment plants** were favoured by companies and NGOs, while generally considered unnecessary by the Member States and regional authorities. Some stakeholders proposed s simplified version of IPPC requirements for plants treating less than 50 tons per day. Other argued that the current legislative provisions are sufficient and that environmental effects of small treatment installations are local and need to be addressed locally.
- **Emerging technologies**: A repeated message from all stakeholders was that further research was necessary. The most frequently mentioned technologies included biochar, gasification, pyrolisis. The main obstacles to their development as perceived by the stakeholders include lack of legal clarity and certainty at European level, lack of EU promotion activities (e.g. targets), extensive regulatory demands on smaller plants (e.g. by Animal By-Products Regulation or IPPC).

2. Targeted stakeholders consultation during preparation of Arcadis/Eunomia report

Background data and information for this assessment were developed by a consortium of consultants - Arcadis and Eunomia. During preparation of the report two targeted stakeholder consultations have been conducted in order to verify background data and content of the report.

First phase of targeted consultations took place in May/June 2009. The baseline scenario has been sent to all Member States and major stakeholders to verify the data sets used. The baseline scenario has also been presented at conference "Biowaste – need for EU legislation?" on 10 June 2009.

10 Member States have responded providing update or corrections of data (BE, DE, DK, ES, LT, MT, PL, P, SI, SE).

In October/November 2009 the draft final report of Arcadis/Eunomia (which included basic calculation and assumptions to be used in this assessment) has been sent for consultation to Member States, major stakeholders as well as to all stakeholders who requested to be notified (in a call publish on relevant ENV website).

18 comments have been received to this report. In general, most of the comments were related to general approach, rather than to specific assumptions and calculations behind environmental impacts. Several stakeholders pointed out that the given time was insufficient taking into account the size and the level of details of the report. Also clarity and transparency of draft final report has been criticised.

The most contested part was the assumption taken in the baseline scenario that Member States will meet the targets of Landfill directive. Some stakeholders called such assumption very optimistic or even unrealistic and criticised that the Commission has not considered the biowaste directive as a measure to meet the Landfill directive targets (Germany, Belgium, EEB, BGK, ECN)

Other more frequent comments included:

- call to include sewage sludge and other biodegradable waste streams in potential future legislation (e.g. EUREAU, EBA, SUEZ);
- problems with calculations concerning home composting (EEB, BDE);
- criticism of assumption that quality compost can be produced only from source separated bio-waste (FNADE, SUEZ);
- criticism of assumption behind some scenarios chosen – i.e. that scenarios included assumption of total switch into one of biological treatment method in the country.

Several countries (including DE, FIN, CZ, NL, RO, BE) provided further modification of data to be used in the baseline scenario.

The raised issues has been better addressed in the final report and better explained in the text of Assessment itself.

Annex 3: Potential contribution of bio-waste to the 2020 bio-fuel target – assumptions, calculation method and results per Member State

The RES Directive provisions on waste-derive biofuels

The anaerobic conversion of bio-waste into biogas and its further purification into bio-methane is considered as production of second generation biofuels according to the Renewable Energy Sources Directive. Once purified this bio-methane could be used as biofuel for private cars, buses, trucks, or directly injected into the natural gas distribution grids. Focusing the discussion on biofuels, the RES Directive set up a 10% target, meaning that by 2020 a mandatory 10 % minimum target has to be achieved by all Member States for the share of biofuels in transport petrol and diesel consumption[74].

The Directive identifies three important provisions concerning biofuels produced from waste:

– Wastes […] shall be considered to have zero life cycle greenhouse gas emissions up to the process of collection;

– Emissions from the fuel in use shall be taken to be zero for biofuels and other bioliquids.

– the contribution made by biofuels produced from wastes […] shall be considered to be twice that made by other biofuels.

Methodological assumptions

In order to calculate the potential contribution of bio-waste generated in each Member State to the achievement of their respective 2020 biofuel target, a life cycle approach has been used[75].

The basic assumptions used for the calculation are the following:

– All the bio-waste available in 2020 is processed via anaerobic digestion for the production of bio-methane[76].

– The quantity of bio-waste produced in 2008 and 2020 are taken from the Arcadis and Eunomia supporting study.

– Energy consumption data for 2020 are taken from the DG TREN report on future energy trends[77].

– The biogas purification energy penalty (i.e. the amount of energy necessary to upgrade the biogas to bio-methane) is generally reported in the range 3-6% of the bio-methane energy content. The Arcadis and Eunomia supporting study used the 3% value whilst in our evaluation the more conservative 6% values have been used.

– Bus fuel consumptions are taken from VTT study (same source as in the Arcadis and Eunomia supporting study).

---

74 The RES Directive specifies that the mandatory 10 % minimum target for transport to be achieved by all Member States should be defined as that share of final energy consumed in transport which is to be achieved from renewable sources as a whole, and not from biofuels alone. Moreover, only petrol, diesel, biofuels consumed in land road and rail transport, and electricity shall be taken into account. However, in this calculation, the contribution of electric cars in 2020 has not been taken into consideration.

75 Even if the bio-methane could be used both for private cars and public transportation fleets (like buses and trucks for waste collection), the data mentioned in the Assessment only refers to the use for buses.

76 The potential contribution to the biofuel target (but also to other relevant targets like the Kyoto or the renewable energy production one) could be higher if also other potential sources of bio-methane are considered (e.g. manure, wastewater sludges and existing landfills).

77 2008 - European energy and transport: Trends to 2030 : update 2007

– Life cycle data for diesel production are taken from the EU Life Cycle Data Network (ELCD)[78].

– CO2 emissions in 2007 are those reported by each Member State and presented in the Annex I reporting to the Kyoto protocol[79].

In Table A.3-1 are reported some other technical parameters used for the calculation. The values are taken from the sources already mentioned above.

Parameter	**Unit of measure**	**Value**
Methane content in biogas	%	60
Biogas density	kg / m^3	1.2
Energy content in biogas	MJ/kg	27
Bio-methane energy content	MJ / kg	45
Efficiency of CHP (electricity and heat)	[%]	85
Life cycle emissions for the production of 1 kg of diesel	kg $CO_{2\text{-eq}}$ kg CO kg CH_4 kg N_2O	3,02E-01 4,16E-04 3,36E-03 8,78E-04
Consumption of a bus using diesel as fuel	kg / km	3,57E-01
Consumption of a bus using bio-methane as fuel	kg / km	7,80E-01
CO_2 emissions from a diesel bus	kg / km	1,22E+00

Table A.3-1: main assumptions used to calculate energy potential from bio-waste

Calculation procedure

The first step consists in the calculation of the quantity of bio-methane that could be potentially produced in each Member State based on the bio-waste available. When doing this calculation the plant internal energy use (about 25% according to average existing techniques) and the energy required for the bio-methane upgrade (6% energy penalty) have been deducted. What remains is the bio-methane available for use as biofuel (expressed in MJ).

78 http://lca.jrc.ec.europa.eu/lcainfohub/datasetArea.vm
79 http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/4303.php

The next step consists in the calculation of the equivalent amount of diesel fuel that the bio-methane could displace. This is done by computing the average consumption of a diesel bus with that of a bio-methane fuelled one. In this way it is also possible to know how many kilometres could be covered by the bio-methane fuelled bus per year. Knowing the quantity of diesel that could be substituted is necessary to calculate the amount of GHG emissions "saved" due to the diesel non-production.

The last step consists in the calculation of the potential contribution towards the specific biofuel target. In order to obtain this information, it is necessary first to identify the expected final energy consumption for land (road and rail) transports in 2020. These values have been calculated from those reported in the previously mentioned DG TREN report.

The share of bio-methane contribution to the 10% 2020 biofuel target is then calculated by dividing the total energy content of the bio-methane available in 2020 by the total energy demand for transport in the same year[80].

The maximum available bio-waste in the EU in 2020 is 8800 million ton, which is equivalent to around 5.7 MToe of biogas. On average this is enough to supply almost one third of the renewable energy target of the Renewable Energy Directive (taking into account double-counting as prescribed by article 21(2) of the Renewable Energy Directive. The same gas used in CHPs (Combined Heat and Power) for electricity and heat would supply around 2% of the overall renewable target.

The main results country by country are presented in Tables A.3-2 and A.3-3.

	CO2-eq avoided emissions (electricity from biogas)			**CO2-eq potentially avoided by using bio-methane in buses**		
	min (kg)	***max (kg)***	***average (Mt)***	***min (kg)***	***max (kg)***	***average (Mt)***
AT	1,85E+08	2,62E+08	2,24E-01	1,90E+08	2,69E+08	2,29E-01
BE	3,61E+08	5,12E+08	4,36E-01	2,46E+08	3,48E+08	2,97E-01
BG	6,02E+08	8,53E+08	7,27E-01	1,44E+08	2,04E+08	1,74E-01
CY	7,21E+07	1,02E+08	8,72E-02	2,02E+07	2,86E+07	2,44E-02
CZ	7,10E+08	1,01E+09	8,58E-01	2,17E+08	3,07E+08	2,62E-01
DK	3,75E+08	5,32E+08	4,53E-01	1,44E+08	2,04E+08	1,74E-01
EE	2,68E+08	3,80E+08	3,24E-01	4,21E+07	5,96E+07	5,08E-02
FI	1,96E+08	2,78E+08	2,37E-01	1,13E+08	1,60E+08	1,37E-01
FR	8,14E+08	1,15E+09	9,83E-01	1,48E+09	2,10E+09	1,79E+00
DE	4,04E+09	5,72E+09	4,88E+00	1,93E+09	2,74E+09	2,34E+00
EL	1,11E+09	1,57E+09	1,34E+00	2,60E+08	3,68E+08	3,14E-01
HU	5,83E+08	8,26E+08	7,05E-01	2,34E+08	3,32E+08	2,83E-01
IE	4,57E+08	6,48E+08	5,53E-01	1,46E+08	2,06E+08	1,76E-01
IT	2,29E+09	3,24E+09	2,76E+00	9,14E+08	1,29E+09	1,10E+00

80 It is important to remember, when doing this calculation, that the contribution of bio-methane coming from waste can be counted twice according to the RES Directive provisions.

LV	9,79E+07	1,39E+08	1,18E-01	4,18E+07	5,92E+07	5,05E-02
LT	4,61E+07	6,52E+07	5,57E-02	6,11E+07	8,66E+07	7,39E-02
LU	1,92E+07	2,72E+07	2,32E-02	1,10E+07	1,56E+07	1,33E-02
MT	3,99E+07	5,66E+07	4,83E-02	1,01E+07	1,44E+07	1,22E-02
NL	7,20E+08	1,02E+09	8,70E-01	3,25E+08	4,61E+08	3,93E-01
PL	3,31E+09	4,69E+09	4,00E+00	6,77E+08	9,59E+08	8,18E-01
PT	7,51E+08	1,06E+09	9,07E-01	2,19E+08	3,11E+08	2,65E-01
RO	2,01E+09	2,84E+09	2,42E+00	4,41E+08	6,25E+08	5,33E-01
SK	1,44E+08	2,05E+08	1,75E-01	1,06E+08	1,50E+08	1,28E-01
SL	1,05E+08	1,48E+08	1,26E-01	4,45E+07	6,31E+07	5,38E-02
ES	3,11E+09	4,41E+09	3,76E+00	1,19E+09	1,68E+09	1,43E+00
SE	8,04E+07	1,14E+08	9,72E-02	2,27E+08	3,22E+08	2,75E-01
UK	3,67E+09	5,20E+09	4,43E+00	1,49E+09	2,11E+09	1,80E+00

Table A3.2: CO2 equivalent avoided in 2020 when electricity is produced from biogas and using bio-methane in buses

	Potential contribution to 2020 RES target (%) - electricity			**Potential contribution to 2020 bio-fuel target (%)**		
	min	***max***	***average***	***min***	***max***	***average***
AT	0,4%	0,5%	0,4%	26,4%	37,4%	31,9%
BE	1,0%	1,4%	1,2%	30,2%	42,8%	36,5%
BG	1,4%	2,0%	1,7%	44,2%	62,6%	53,4%
CY	1,5%	2,1%	1,8%	29,8%	42,2%	36,0%
CZ	1,1%	1,5%	1,3%	29,9%	42,4%	36,1%
DK	0,6%	0,8%	0,7%	36,3%	51,5%	43,9%
EE	0,9%	1,3%	1,1%	48,4%	68,5%	58,4%
FI	0,2%	0,3%	0,3%	29,7%	42,1%	35,9%
FR	0,7%	1,1%	0,9%	35,3%	50,0%	42,7%
DE	0,9%	1,3%	1,1%	40,5%	57,3%	48,9%
EL	1,1%	1,6%	1,4%	37,2%	52,7%	44,9%
HU	1,7%	2,3%	2,0%	51,7%	73,3%	62,5%
IE	1,2%	1,7%	1,5%	33,2%	47,1%	40,2%
IT	0,7%	0,9%	0,8%	22,7%	32,2%	27,4%
LV	0,3%	0,5%	0,4%	29,0%	41,1%	35,0%
LT	0,9%	1,2%	1,0%	36,5%	51,7%	44,1%
LU	0,4%	0,5%	0,5%	4,7%	6,6%	5,6%
MT	2,8%	4,0%	3,4%	37,7%	53,4%	45,6%
NL	0,8%	1,2%	1,0%	29,5%	41,9%	35,7%

PL	1,2%	1,7%	1,4%	41,1%	58,2%	49,6%
PT	0,6%	0,9%	0,7%	34,7%	49,2%	42,0%
RO	1,0%	1,5%	1,2%	70,1%	99,3%	84,7%
SK	1,1%	1,6%	1,4%	50,5%	71,6%	61,0%
SL	0,5%	0,8%	0,6%	21,2%	30,1%	25,7%
ES	1,0%	1,4%	1,2%	33,0%	46,8%	39,9%
SE	0,2%	0,3%	0,3%	30,6%	43,3%	37,0%
UK	1,3%	1,8%	1,5%	39,5%	55,9%	47,7%

TableA3.3: Potential contribution to RES and Bio-fuel targets in 2020

Annex 4: Bio-waste generation assessment and collection coverage – main assumptions results per Member State

Three patterns of relation between economic growth and waste generation were defined and applied to each Member State in order to calculate the future waste generation:

Pattern 1: In a first phase, due to quick economic growth and a catch up operation in a context with less environmental awareness or pressure, a negative decoupling takes place and waste generation grows more quickly than the economy. This first phase is followed by stabilisation:

First fifth of period	Growth of waste production = GDP growth * 2
Second fifth of period	Growth of waste production = GDP growth * 3/2
Third fifth of period	Growth of waste production = GDP growth
Fourth fifth of period	Growth of waste production = GDP growth * 1/2
Fifth fifth of period	Growth of waste production = 0

Table A4-1: Growth of waste production under pattern 1

Pattern 2: No decoupling takes place and the environmental impact evolves at the same speed as economic activity;

First fifth of period	Growth of waste production = GDP growth * 1,3
Second fifth of period	Growth of waste production = GDP growth * 1,3
Third fifth of period	Growth of waste production = GDP growth * 1,3
Fourth fifth of period	Growth of waste production = GDP growth * 0,85
Fifth fifth of period	Growth of waste production = GDP growth * 0,3

Table A4-2: Growth of waste production under pattern 2

Pattern 3: Waste generation is decoupled from the economic growth (relative decoupling) and tends to stabilise around a maximum value. The only factor influencing the waste quantity is the demographic growth.

The assumptions taken to calculate bio-waste future generation are summarised in Table A4-3. Results country by country are shown in the last columns.

	Municipal waste generated in 2006 (kg/inhab)	**Pattern [81]**	**Population Million inhabitant)**	**Population growth (% per year)**	**GDP growth (% 2000 - 2020)**	**% Bio-waste in municipal waste**	**Biowaste generated in 2008 (M Tonnes)**	**Biowaste generated in 2020 (M Tonnes)**
AT	449	2	8,2	0,35	1,94	41,3	1,525	1,672
BE	470 -555	3	10,52	0,22-0,38	1,96	33,7 -37,7	2,099	2,166
BG	285	1	7,719	0,76	5,49	33,5	0,907	1,273
CY	345	1	0,75	1,66	3,53	46	0,13	0,178
CZ	390	1	10,2	-0,16	2,65	26	1,271	1,913
DK	533	2	5,4	0,26	2,1	34	1,034	1,271
EE	439	1	1,35	0,83	5,97	54,6	0,35	0,371
FI	505	3	5,3	0,27	2,22	35,9	0,965	0,996
FR	560	3	59	0,41	2,11	36,9	12,453	13,064
DE	563	3	82,3	0,03	1,59	36,6	16,979	17,041
EL	418	1	11	0,43	3,04	36,75	1,903	2,293
HU	464	2	10	0,22	3,66	27,6	1,591	2,095
IE	460	2	4	1,24	5,23	25,3	0,712	1,284
IT	546	3	57	0,12	1,56	36,4	7,938	8,054
LV	311	1	2,3	0,74	6,69	31,9	0,2969	0,368
LT	396	1	3,4	0,45	5,9	23,5	0,493	0,539
LU	555	3	0,45	0,83	4,54	37,3	0,088	0,097
MT	345	2	0,4	0,83	3,29	38,7	0,061	0,089
NL	557	3	16,4	0,51	2,4	29,3	2,703	2,868
PL	235	1	38,2	0,21	4,02	26,2	2,96	5,967
PT	480	3	10,3	0,27	2,47	37,5	1,875	1,935
RO	410	1	21,61	0,42	5,78	43,7	4,006	3,9
SK	301	2	5,4	0	3,67	29,7	0,546	0,932
SI	431	2	2	0	2,73	32,5	0,308	0,393
ES	521	3	45,2	0,58	3,05	44,8	9,776	10,454
SE	495	3	9,1	0,43	2,38	41,8	1,905	2,003
UK	591	3	60	0,33	2,42	35,4	12,63	13,13
EU-27	**454**		**487,499**	**0,45**	**3,32**	**35,53**	**87,5049**	**96,346**

[81] The pattern for each country has been choosen on the basis of existing data and expert judgement – source: Arcadis/Eunomia

Table A4-3: Biowaste Generation – Main assumptions and results country per country

Annex 5: Collection coverage per Member State

On the basis of the information gathered during the stakeholder consultation and on the basis of studies and reports achieved at national level, a collection coverage rate of 100% has been assumed for all the countries except for the following countries: GR, ES, BG, RO, IE, LV. For those countries additional assumptions have been made as summarised in Table A.5-1.

	Bulgaria	Estonia	Greece	Ireland	Latvia	Romania
2008	94	92	92	80	64	49
2009	96	94	92	80	67	49
2010	98	96	94	82	70	55
2011	100	98	96	86	73	65
2012	100	100	98	90	76	75
2013	100	100	100	94	80	85
2014	100	100	100	98	84	95
2015	100	100	100	99	87	100
2016	100	100	100	100	90	100
2017	100	100	100	100	93	100
2018	100	100	100	100	96	100
2019	100	100	100	100	98	100
2020	100	100	100	100	99	100

Table A.5-1: Collection coverage[82] *(%)*

[82] Source: Arcadis/Eunomia

Annex 6: GHG and air pollutant emissions of bio-waste treatment methods[83]

1. Composting:

Two composting techniques have been assessed in calculations**:** Open Air Windrow composting facilities and In vessel (Enclosed) composting facilities.

Direct Climate Change Emissions to Air

CO_2 Emissions

It is assumed that the quantity of emissions of CO_2 is not dependent upon the nature of the facility. However, it is assumed that the mineralization of CO_2 may occur more quickly or more slowly depending upon the process type and the operating parameters. Generally over an extended period of time, the CO_2 emissions for the combined process 'compost plus land application' are very similar. The emissions from land applied materials are modelled in time so as to facilitate the use of appropriate discounting methods in the economic evaluation.

CO2 Emissions after Application of Compost to Soil

The pace for conversion of the carbon contained in compost into carbon dioxide has been assessed as follows:

(1) The carbon can be converted from the readily available organic matter into stable organic matter (at rate x);

(2) The carbon in the readily available organic matter can be mineralised into carbon dioxide (at rate y); and

(3) The carbon in the stable organic matter can also be mineralised into carbon dioxide (a rate z).

Following figures has been assumed for the analysis: x = 25%, y = 20%, z = 1%. (Arcadis/Eunomia estimates). These figures generate profiles for carbon dioxide emissions. The external costs from these emissions, discounted over time, are then assessed and included in the modelling.

Methane Emissions

For enclosed facilities emissions of 700 g of CH_4 per tonne of waste to facility has been assumed, whilst the figure for open (windrow) processes is taken to be 50 g of CH_4 per tonne.

[83] Unless mentioned otherwise, all the data are extracted from the Arcadis/Eunomia report. . Data used are based on combination of literature review, cases studies and expert judgement

Nitrous Oxide Emissions

The ammonia emissions are based on assumption that 9% of the input nitrogen is converted to ammonia, 1% is converted to N_2O, resulting in emissions of 116 g N_2O per tonne of waste treated at a windrow facility. For enclosed facilities, the operation of the biofilter is assumed to result in emissions of 360 g N_2O per tonne of garden waste (the figure for a mixed food / garden waste feedstock is slightly higher at 478 g per tonne).

Air Quality Impacts

Emissions of VOCs[84]

Compounds Detected	Grams per tonne of MSW
m,p Xylene [108-38-3; 106-42-3]	0.81
Nonane [111-84-2]	0.44
o Xylene [95-47-6]	0.54
Beta.-Pinene [127-91-3]	3.7
Ocimene [13877-91-3]	3.0
D-Limonene [5989-27-5]	10.5
Undecane [1120-21-4]	2.4
Dodecane [112-40-3]	1.2
Methyl-(methylethyl)-Cyclohexane [99-82-1]	1.5
TOTAL	*24.0*

Table A6-1: Emissions of VOCs from Monitoring of Compost Facilities[85]

It has been further assumed that the use of biofilters reduces the emissions by 80% in the case of in-vessel facilities. The use of biofilters is assumed to result in zero damage cost for the remaining 20% of VOC emission (i.e. the biofilter is assumed to remove those pollutants that result in the health effects).No emission of carbon monoxide has been assumed.

2. Anaerobic Digestion

Direct Climate Change Emissions to Air

CO_2 emissions resulting from the AD of source-separated organic waste are based on the carbon content of the input waste, assumed to 100% food waste for the purposes of this study. The carbon content is calculated on the basis of the total organic content of the waste and its volatile solids (VS) content. A proportion of the total carbon content will be converted to CO_2 as a result of biogas combustion for energy generation (in whatever form this takes).

84 Assessment of emissions of VOCs has been based on the results of the measurements by UK Environment Agency

85 Source: Environment Agency (2000) Life Cycle Inventory Development for Waste Management Operations: Composting and Anaerobic Digestion, R&D Project Record P1/392/4

Parameter	Assumption
Dry matter content of food waste	30%
Organic matter content of VS	93%
Carbon content of VS	45%
VS content of organic matter	45%
VS loss during digestion	70%
Methane content of biogas	60%
Fugitive CH_4 emissions from digester (% carbon converted to CH_4)[86]	1.5%
CO_2 emissions from the process (kg CO_2 per tonne of waste input)	276

Table A6-2: Assumptions Relating to AD Process and Generation of Biogas

Air Quality Impacts

Pollutant	Example emissions data	
	Value	**Unit**
CO	72.3	g / tonne
NOx	10-72.3	g / tonne
NH_3	Fugitive	
SOx	2.5-30	g / tonne
H_2S	284-289	mg/Nm^3
TOC (VOC)	0.0023	g / tonne
Odour	626	GE/Nm^3
Dioxins/furans	10-8	g / tonne
Total chlorine	1.5	$\mu g/Nm^3$
HCl	0.011	g / tonne
HF	0.0021	g / tonne
Cd	9.4E-07	g / tonne
Cr	1.1E-07	g / tonne
Hg	6.9E-07	g / tonne
Pb	8.5E-07	g / tonne
Zn	1.3E-07	g / tonne

Table A6-3: Emissions Data from Anaerobic Plants[87]

86 Equivalent to 900 g of CH_4 per tonne of waste to process

87 Source: European Commission (2006) Integrated Pollution Prevention and Control: Reference Document on Best Available Techniques for the Waste Treatment Industries, August 2006

Although fugitive emissions of H_2S may occur in digestion plants, no damage cost is associated with this pollutant. The model therefore attributes no external cost to air quality impacts occurring during the digestion phase.

It is further assumed that the VOC emissions associated with this part of the process will be negligible in a well managed facility, due to the enclosed nature of the process. Therefore, direct air quality emissions from the process principally relate to NOx emissions as the biogas is burnt. These are lower for the gas to grid option as biogas goes through an additional cleaning process prior to grid injection.

The cleaning process removes the NH_3 and H_2S which are a principal cause of NOx and SOx emissions when the biogas is combusted onsite in a gas engine.

3. Landfilling

Direct Climate Change Emissions to Air

Climate Change Impacts – landfill gas generation

The generation of landfill gas has been made using IPCC default model[88] - time-dependent 'first order decay' functions. Emissions of methane from landfill are allocated to specific years over a 150 year period.

Therefore all the emissions and damage cost related are discounted using a declining long-term discount rate as recommended in the UK Treasury's Green Book. Table shows the rates at which damage costs are discounted for the relevant time periods.

Period of years	**0-30**	**31-75**	**76-125**	**126-200**	**201-300**	**301+**
Discount rate	3.5%	3.0%	2.5%	2.0%	1.5%	1.0%

Table A6-4: Declining Long-Term Discount Rate as Applied to Landfill Emission Damage Costs[89]

For waste that has not been pre-treated, it is assumed that 50% of the landfill gas is captured by the landfill gas management system, and that a further 10% is oxidised through the cover of the landfill.

Air Quality Impacts

Whilst landfill gas is principally comprised of methane and carbon dioxide, approximately 1% of the volume of the gas is made up of trace elements. This can include up to 150 substances including halogenated organics, organo-sulphur compounds and aromatic hydrocarbons depending on the nature of the waste.[90]

88 Land Quality Management (2003) *Methane Emissions from Landfill Sites in the UK*, Report for Defra, January 2003; IPCC (2006) Guidelines for National Greenhouse Gas Inventories: Chapter 3 – Solid Waste Disposal

89 Source: The UK Treasury Green Book

90 Komex (2002) Investigation of the Composition and Emissions of Trace Components in Landfill Gas, R&D Technical Report P1-438/TR for the Environment Agency, Bristol

The gases which are emitted in any one year are assumed to be related to the quantity of methane or CO_2 produced, depending upon whether one is considering raw gas or gas once combusted (table A6-5).

Methane emissions to the atmosphere and methane emissions captured are both used to estimate, on a proportional basis, emissions of different trace gases in a given year using the relative composition of gas outlined in below. The way this is done is to normalise the concentrations (by weight) so that:

- Where gas is flared, the emissions of other gases are calculated with reference to the studies by Enviros et al and White et al. The way this is done is by calculating the CO2 content of flared gas and calculating the emissions of other gases through the quantities relative to CO_2 as specified in the two studies mentioned;

- A similar approach is used to calculate fugitive emissions, but in this case, the other emissions are calculated relative to the calculated quantity of methane emissions; and

- For gas which is emitted from the gas engine, the emissions of other gases are calculated using the quantities estimated in other studies relative to calculated CO_2 emissions.

	Fugitive Ratio to CH_4	Flaring Ratio to CO_2	Energy Generation Ratio to CO_2	Source
Methane	1	0.001818	0.005714	Enviros
Carbon dioxide	1.733333	1	1	Enviros
Carbon monoxide	3.03E-05	4.09E-04	4.09E-04	White et al
Hydrogen sulphide	4.66E-04	1.69E-08	1.69E-08	White et al
Hydrogen chloride	2.67E-06	8.64E-05	1.14E-05	Enviros
Hydrogen fluoride	5.33E-07	1.82E-05	1.14E-05	Enviros
Chlorinated HC	8.10E-05	5.10E-06	5.10E-06	Enviros
Dioxins and furans	0	3.36E-13	5.43E-13	Enviros
Total Particulates	0	3.64E-05	0.00002	Enviros
Nitrogen oxides	0	0.000455	0.002571	Enviros
Sulphur dioxide	0	0.000545	0.0002	Enviros
Cadmium	0	0	2.86E-07	Enviros
Chromium	7.12E-08	1.25E-08	1.25E-08	White et al
Lead	2.00E-08	2.49E-09	2.49E-09	White et al
Mercury	1.41E-08	2.49E-09	4.57E-09	Enviros
Zinc	1.68E-07	6.64E-11	6.64E-11	White et al
Nickel	0	0	3.71E-08	Enviros
Arsenic	0	0	4.57E-09	Enviros
Total VOCs	0.000333	7.73E-06	0	Enviros
Non-methane VOCs	0	8.64E-06	8.57E-05	Enviros
1,1-dichloroethane	0.000036	0	0	Enviros
Chloroethane	1.33E-05	0	0	Enviros
Chloroethene	1.47E-05	0	0	Enviros
Chlorobenzene	0.000032	0	0	Enviros
Tetrachloroethene	0.000044	3.64E-08	5.71E-07	Enviros
PCBs	0	0	0	White et al
Benzene	3.2E-06	0	0	Enviros

Table A6-5: Non Greenhouse Gas Emissions to Air from Landfilling[91]

4. Incineration

Direct Climate Change Emissions to Air

Carbon Content of Waste Materials

Greenhouse gas emissions occurring as a result of the incineration of waste will be dependent upon the carbon content of the dry material, along with the overall efficiency of energy generation that results from the combustion of that material.

Error! Reference source not found. Table A6-6 details the carbon content of waste components together with their energy and moisture content.

	Total C (% fm)	**Proportion of C that is non fossil**	**Energy content (lower heating value as received) MJ per kg**	**Typical moisture content**
Paper	41%	100%	13	10%
Card	32%	100%	12	24%
Dense plastic	77%		35	10%
Plastic film	72%		33	15%
Textiles	49%	50%	15	19%
Glass	0%		0	2%
Ferrous metal	0%		0	3%
Non ferrous metal	0%		0	5%
Wood	32%	100%	12	30%
Garden waste	**26%**	**100%**	**8**	**45%**
Food waste	**14%**	**100%**	**4**	**70%**
Misc. combustibles	40%	50%	15	41%
Misc. non combustibles	7%		0	6%
Fines	30%	100%	5	41%

91 Source: Adapted from White P R, Franke M and Hindle P (1995) Integrated Solid Waste Management: A Lifecycle Inventory, Blackie Academic & Professional, Chapman and Hall; Enviros, University of Birmingham, RPA Ltd., Open University and Thurgood M (2004) Review of Environmental and Health Effects of Waste Management: Municipal Solid Waste and Similar Wastes, Final Report to Defra, March 2004

Table A6-6: Carbon Contents and Energy Content for Materials in the Waste Stream

The EU BREF note provided a range of 5.5 – 66 g N_2O per tonne of waste treated by the facility. The mid point of these values has been used within the current analysis. CH_4 emissions are negligible from incineration facilities.

Air Quality Impacts

In the analysis two types of incinerator are considered:

- A facility that meets the Waste Incineration Directive (WID), typical of those that have installed SNCR to reduce NOx emissions;

- A facility that significantly out-performs the requirements of the WID through the installation of SCR and wet scrubbing techniques.

Emissions are based on data obtained from plant operating in the Belgium with this type of equipment installed. Such installation has been assumed for Germany, the Netherlands, Belgium and Austria. Emissions data for the facilities are detailed in Table A6-7.

	WID compliant facility		**Significantly out-performs WID**[92]	
	mg/Nm	**g / t waste**[93]	**mg/Nm**	**g / t waste**
PM10 / dust[94]	10.0	61.0	0.5	3.0
Dioxin (ng ITEQ/Nm^3)	0.1	0.0	0.0	0.0
NOx	200.0	1,220.0	45.0	274.5
SO_2	50.0	305.0	1.0	4.8
HF	10.0	6.1	0.0	0.0
HCl	1.0	61.0	0.5	1.2
CO	50.0	305.0	10.0	55.2
NMVOC	10.0	61.0	0.5	3.0
Total heavy metal	0.5	3.0	0.0	0.2

Table A6-7: Emissions from Incineration Facilities[95]

92 Assumes the use of SCR and wet scrubbing techniques to reduce emissions

93 Assumes an exhaust gas exit volume of 140 Nm^3/s, based on data provided by a 650,000 tonne per annum incinerator located in Paris (Source: ExternE)

94 70% of PM10 is assumed to be PM2.5 (Source: Chang et al)

95 Sources: Information Centre for Environmental Licensing (2002) Dutch Notes on BAT for the Incineration of Waste, Report for the Ministry of Housing, Spatial Planning and the Environment, The Netherlands, February 2002; European Commission (2006) Integrated Pollution Prevention and Control: Reference Document on Best Available Techniques for the Waste Treatment Industries, August 2006; ExternE (1999) Externalities of Energy, Vol 10: National Implementation, prepared by CIEMAT for the European Commission, Belgium; Chang M B, Huang C K, Wu J J, and Chang S H (2000) Characteristics of heavy metals on particles with different sizes from municipal solid waste incineration, Journal of Hazardous Materials 79(3): pp229-239

The principal determinant of air quality impacts associated with incineration facilities relates to the NOx emissions – both with respect to direct emissions from the treatment process and emissions generated through the use of diesel in the facility.

Annex 7: Energy consumed/produced for each bio-waste treatment method[96]

1. Compost

Energy Used at Facilities

Following energy use has been assumed at composting facilities

- For windrow facilities: 1 litre of diesel and 0 kWh of electricity;
- For enclosed facilities: 0.3 litres of diesel and 40 kWh of electricity.

Energy Used to Spread Compost

The following figures has been taken into account for diesel use: 0.54 litres per tonne for a mixed food / garden compost, or 0.41 litres per tonne assuming the feedstock is garden waste.

2. Anaerobic digestion

Energy Used at Facilities

Unlike composting plant, AD facilities can potentially utilise some of the energy generated within the process to meet their requirements. AD facilities typically use both electricity and heat, discussed in the two sections that follow.

It is assumed that the AD process utilises 30 kWh of electricity and 118 kWh of heat per tonne of input to the process, equivalent to 10% of electricity generated, and 33% of the heat generation. The additional electricity requirement for upgrading is assumed to be 28 kWh of electricity (equivalent to 0.2 kWh per Nm^3 of biogas).

These energy requirements are assumed to be supplied by the AD process itself – i.e. a smaller CHP unit is assumed to fuel the vehicle fuel and gas to grid applications. The energy content of the biogas that is assumed to be available for the upgrading process is therefore reduced accordingly.

No emissions are directly attributed to these energy requirements, as they are included within the total emissions attributed to the AD process.

Energy Generation

The present Assessment considers the following uses for the biogas produced from the AD process:

---

96 Unless mentioned otherwise, all the data are extracted from the Arcadis/Eunomia report. Data used are based on combination of literature review, cases studies and expert judgement

- to generate electricity or heat on site using a gas engine;
- upgraded biogas used to power vehicles;
- upgraded biogas injected into the natural gas grid.

Each will result in emissions from the utilisation process itself, as well as offsetting emissions associated with the energy generation that would have otherwise taken place. The ultimate emissions to atmosphere, and indeed, the emissions associated with the compensatory system, will be different depending upon the utilisation route. Avoided emissions are also dependent upon the energy mix of the country.

On-site Combustion of Biogas

It has been assumed that biogenic CO_2 emissions of 276 kg CO_2 per tonne of waste result from the combustion of the biogas in the gas engine. Further, it is assumes that emissions are of 30 g CO_2 equivalent per kWh of electricity from the non-combusted biogas resulting in 8 kg CO_2 equivalent emissions from one tonne of waste to the process.

Other assumptions are outlined in Table A.7-1.

	Emissions from biogas combustion (g / tonne of waste)
CO	200
Dust	20
NOx	250
Hydrocarbons	40
SO_2	20

Table A.7-1: Emissions from the Combustion of Biogas

Use of Upgraded Biogas as a Vehicle Fuel

The assessment assumes that the upgraded biogas is used to fuel heavy goods vehicles such as a bus or a waste collection vehicle, as is the case in Sweden, France and the UK. Comparisons are made on the basis of emissions reductions per km of travel, assuming the same type of engine is used for both the diesel and gas fuelled vehicles. It is assumed that the use of biogas results in emissions reductions of:

- 15% for the greenhouse gases (in terms of CO2 equivalent emissions);
- 75% for the NMHC;
- 46% for NOx; and
- 90% for particulates.

It is also assumed that 2% of the CH_4 in the biogas is emitted during the upgrading process.

Injection of Upgraded Biogas into the Gas Grid

Cleaned and upgraded biogas (biomethane) can also be injected into the gas distribution grid as a substitute for natural gas. Biogas injected into the gas network is assumed to offset emissions associated with a similar quantity of natural gas on a calorie for calorie basis.

The plant is assumed to produce 2,114 MJ or 587 kWh of compressed biogas per tonne of food waste to the facility (excluding the biogas required by the process for energy generation purposes).

Offset emissions for climate change impacts are based on the calorific value of natural gas, assumed to be 0.238 kg CO_2 per kWh (including emissions associated with extraction and transport). Biogas injected into the grid is also assumed to offset the air quality impacts associated with the pre-combustion emissions for natural gas such as those relating to transport and extraction. These are shown in Table A.7-2.

	Pre-combustion emissions, g / MJ
NMVOC	0.025
NOx	0.022
SOx	0.027
PM2.5	0.001

Table A.7-2: Pre-combustion Emissions Associated With the Use of Natural Gas[97]

3. Landfilling

Energy Used at Facilities

Landfills typically use both electricity and diesel. Diesel use is assumed to be 1.65 litres per tonne of material sent to landfill, whilst the electricity requirement is taken to be 1% of that generated. These assumptions are taken from a recent report produced in the UK by ERM which investigated the greenhouse gas emissions associated with a range of waste treatment facilities.[98]

Energy Generation

It is assumed that 60% of the captured methane is used for energy generation, with the remainder being flared. The gross efficiency of the gas engine at the landfill is assumed to be the same as that used to generate energy from biogas, i.e., 37%. The emissions assumed to be offset by this generation are dependent upon the energy mix of the country.

4. Incineration

---

97 Source: ecoinvent (2004) ecoinvent Data v1.1, Final Reports ecoinvent 2000, No. 1-15, Swiss Centre for Life Cycle Inventories, Dubendorf, 2004

98 ERM (2006) *Carbon Balances and Energy Impacts of the Management of UK Wastes*, Final Report to Defra, December 2006

Energy Used at Facilities

Following energy consumption has been assumed:

78 kWh per tonne of waste input in SNCR facilities (CEWEP)

85 kWh per tonne of waste input in SCR facilities (VITO)

Oil: 4 kg per tonne (or 4.7 litres per tonne)

Energy generated at the facilities

The assumptions on energy efficiency of incinerators re based on the survey data provided by CEWEP and summarized in the table A.7-3 below.

Parameter		Assumption[99]
Electricity	Gross electrical generation efficiency	27%
CHP	Gross electrical generation efficiency	10%
	Gross heat generation efficiency	56%
Heat	Gross heat generation efficiency	85%

Table A.7-3: Summary of Energy Generation Efficiencies – Incineration Facilities

The emissions offsets associated with this generation are, in turn, dependent upon the energy mix of the country for both electricity and heat. Green waste is assumed to generate 864 kWh of useful heat in a facility generating only heat. Offset greenhouse gas emissions associated with this electricity generation range from 180 – 279 kg CO_2 equivalent, depending upon the energy mix of the country. Facilities generating only electricity are assumed to generate 474 kWh of electricity, which results in avoided emissions of 9 – 474 kg CO_2 equivalent.

99 60% of the heat generated by incineration facilities is assumed to be utilised.

Annex 8: Energy mix per Member State and monetisation of related environmental impacts

1. Energy Use by Member States

Electricity Mix1: Table AA.8-1[100] presents the 2006 electricity mix in the 27 Member States.

	Oil	Gas	Nuclear	Renewables	Solid fuel	Other
Austria	3%	19%	0%	62%	11%	5%
Belgium	2%	30%	54%	4%	8%	2%
Bulgaria	1%	5%	42%	9%	42%	1%
Cyprus	100%	0%	0%	0%	0%	0%
Czech Rep.	0%	5%	31%	4%	59%	1%
Denmark	4%	21%	0%	22%	53%	0%
Estonia	0%	8%	0%	1%	90%	0%
Finland	1%	16%	28%	27%	27%	1%
France	1%	4%	79%	11%	4%	1%
Germany	2%	12%	26%	12%	42%	6%
Greece	16%	17%	0%	13%	53%	1%
Hungary	2%	37%	38%	4%	20%	0%
Ireland	10%	51%	0%	9%	29%	1%
Italy	15%	52%	0%	17%	14%	2%
Latvia	0%	43%	0%	57%	0%	0%
Lithuania	3%	20%	69%	3%	0%	5%
Luxembourg	0%	75%	0%	25%	0%	0%
Malta	100%	0%	0%	0%	0%	0%
Netherlands	2%	60%	4%	10%	24%	0%
Poland	2%	3%	0%	3%	91%	1%
Portugal	11%	25%	0%	32%	31%	1%
Romania	3%	19%	9%	29%	40%	0%
Slovenia	0%	3%	37%	25%	36%	0%
Spain	8%	30%	20%	17%	22%	3%
Sweden	1%	1%	47%	50%	1%	0%
UK	1%	36%	19%	5%	38%	1%

Table A.8-1: Electricity Generation Mix – EU Member States

Heat Mix

Table A8-2 presents the heat mix for each of the 27 Member States in 2006 developed from data provided by Eurostat.

[100] Source: Commission of the European Communities (2008) Second Strategic Energy Review: Europe's Current and Future Energy Position, Part B - Statistical Annex, Report to the European Parliament

	Oil	Gas	Renewables	Solid fuel
Austria	35%	29%	21%	15%
Belgium	47%	35%	5%	13%
Bulgaria	26%	28%	9%	38%
Cyprus	89%	0%	6%	5%
Czech Rep.	16%	29%	7%	48%
Denmark	31%	32%	28%	9%
Estonia	10%	23%	18%	48%
Finland	35%	8%	39%	18%
France	42%	36%	12%	9%
Germany	36%	37%	9%	18%
Greece	66%	6%	9%	19%
Hungary	20%	60%	8%	12%
Ireland	51%	27%	4%	18%
Italy	36%	44%	10%	10%
Latvia	12%	39%	46%	3%
Lithuania	28%	48%	18%	6%
Luxembourg	33%	53%	5%	10%
Malta	100%	0%	0%	0%
Netherlands	37%	51%	5%	7%
Poland	19%	21%	8%	52%
Portugal	53%	13%	29%	5%
Romania	24%	47%	12%	18%
Slovak Rep.	17%	47%	4%	32%
Slovenia	38%	28%	16%	18%
Spain	51%	28%	10%	11%
Sweden	33%	4%	49%	14%
UK	28%	56%	3%	13%

Table A8-2: Heat Generation Mix – EU Member States[101]

101 Source: Commission of the European Communities (2008) Second Strategic Energy Review: Europe's Current and Future Energy Position, Part B - Statistical Annex, Report to the European Parliament

2. Environmental Impacts of Energy Use

There can be considerable variation in the environmental impacts of energy generation. Much of the variation is associated with the choice of fuel – for example, the impacts (in terms of emissions to air per kWh of electricity generated) associated with the use of renewable sources of electricity and nuclear are typically far less than those associated with oil and coal.

However there is also variation between emissions resulting from use of the same fuel to generate the same type of energy in different circumstances e.g. coal quality or sulphur content).

Given such a diverse sources of variation, it is difficult to develop country specific emissions factors. Nevertheless the approach has been to develop "typical" emissions factors and use these factors across all Member States.

Electricity

Table *A*A8-3 confirms the emissions factors used to estimate the impacts of electricity generation for the different generation sources considered within the current analysis.

	Emissions factors, kg / kWh electricity[102]				
	CO2e	NMVOC	$PM_{2.5}$	SOx	NOx
Gas	0.4	2.70E-04	1.40E-05	2.20E-04	7.20E-04
Oil	0.8	4.05E-04	2.44E-04	6.86E-03	2.35E-03
Coal	0.9	1.21E-04	2.81E-04	4.52E-03	2.82E-03
Nuclear	0.0	2.58E-03	1.58E-05	3.67E-05	3.98E-05
Renewables	0.0	5.65E-06	1.30E-05	1.58E-05	3.26E-05

Table A8-3: Emissions Factors for Electricity Generation[103]

Heat

Table A.8-4 confirms the emissions factors used to estimate the impacts of heat generation for the different generation sources considered within the current analysis.

102 Includes pre-combustion emissions for the fossil fuels and nuclear (e.g. emissions associated with fuel extraction), electricity from renewables is assumed to be 80% hydro-electricity and 20% wind

103 Sources: Eurostat (2009) Panorama of Energy: Energy Statistics to Support EU Policies and Solutions; ecoinvent (2004) ecoinvent Data v1.1, Final Reports ecoinvent 2000, No. 1-15, Swiss Centre for Life Cycle Inventories, Dubendorf, 2004; D. Weisser (2007) A Guide to Life-cycle Greenhouse Gas Emissions from Electric Supply Technologies, Energy, 32, pp1543-1559

	Emissions factors, kg / MJ heat[104]				
	CO2e	**NMVOC**	**$PM_{2.5}$**	**SOx**	**NOx**
Gas	0.2	3.63E-05	1.61E-06	3.16E-05	4.51E-05
Oil	0.3	1.00E-05	1.00E-05	3.29E-04	1.50E-04
Coal	0.4	6.10E-05	3.48E-05	6.59E-04	2.14E-04
Renewables	0.1	3.47E-05	5.40E-05	1.03E-05	2.15E-04

Table A8-4: Emissions Factors for Heat Generation[105]

Heat generation from waste management facilities is generated continuously and would not always be capable of being utilised. A heat load factor of 60% has been used in this report.

Diesel

It has been assumed a figure of 3.26 kg CO_2 equivalent per litre of diesel (including 0.46 kg CO_2 equivalent pre-combustion emissions). Data regarding the air quality impacts associated with the use of diesel within waste management facilities is taken from the BUWAL life-cycle inventory database produced by the Federal Office for the Environment in Switzerland.[106] The major air quality impacts are emissions of NOx (estimated to be 105 g per litre of diesel combusted), SOx (5 g per litre) and PM_{10} (2 g per litre).

Summary of Impacts for the Different Member States

Table A8-5 shows the external costs for the utilisation of energy for each Member State, taking into account both the generation mix for electricity and heat (previously shown in Table *A*A8-1 and A8-2) and the external costs associated with the pollutants for each country (Annex 12 – Table A12-1).

104 Includes pre-combustion emissions for the fossil fuels (e.g. emissions associated with fuel extraction)The factor for renewables is based on the emissions factor for wood fuel and assumes two thirds of the fuel was sustainably produced (with regard to the CO_2 emissions)

105 Sources: Eurostat (2009) Panorama of Energy: Energy Statistics to Support EU Policies and Solutions; ecoinvent (2004) ecoinvent Data v1.1, Final Reports ecoinvent 2000, No. 1-15, Swiss Centre for Life Cycle Inventories, Dubendorf, 2004

106 Available from http://www.bafu.admin.ch

	External costs for electricity, € / MW		External costs for heat, € / GJ	
	Climate change	**Air Quality**	**Climate change**	**Air Quality**
Austria	€ 4.99	€ 33.67	€ 1.78	€ 9.03
Belgium	€ 4.70	€ 31.15	€ 1.72	€ 9.04
Bulgaria	€ 9.49	€ 77.93	€ 1.97	€ 1.58
Cyprus	€ 18.63	€ 224.34	€ 1.83	€ 1.47
Czech Republic	€ 12.89	€ 28.04	€ 2.06	€ 10.30
Denmark	€ 13.71	€ 31.06	€ 1.48	€ 3.80
Estonia	€ 19.79	€ 149.02	€ 1.96	€ 2.20
Finland	€ 7.45	€ 37.15	€ 1.57	€ 1.67
France	€ 1.41	€ 5.10	€ 1.68	€ 6.46
Germany	€ 10.35	€ 25.57	€ 1.80	€ 9.72
Greece	€ 15.79	€ 124.27	€ 1.88	€ 1.60
Hungary	€ 8.07	€ 62.81	€ 1.75	€ 3.23
Ireland	€ 12.81	€ 31.04	€ 1.85	€ 4.83
Italy	€ 11.18	€ 53.56	€ 1.80	€ 4.59
Latvia	€ 4.31	€ 15.11	€ 1.34	€ 1.12
Lithuania	€ 2.56	€ 13.77	€ 1.63	€ 1.56
Luxembourg	€ 8.38	€ 20.77	€ 1.95	€ 6.52
Malta	€ 18.63	€ 71.74	€ 1.86	€ 2.08
Netherlands	€ 10.71	€ 75.16	€ 1.61	€ 7.63
Poland	€ 19.75	€ 50.40	€ 2.09	€ 7.25
Portugal	€ 11.05	€ 106.35	€ 1.57	€ 2.46
Romania	€ 10.62	€ 55.05	€ 1.62	€ 1.05
Slovak Republic	€ 4.64	€ 16.95	€ 1.95	€ 4.99
Slovenia	€ 7.85	€ 17.63	€ 1.77	€ 6.20
Spain	€ 9.04	€ 46.16	€ 1.76	€ 3.55
Sweden	€ 0.44	€ 5.08	€ 1.45	€ 2.71
UK	€ 11.25	€ 46.52	€ 1.60	€ 4.05

Table 8-5: External Costs for Energy Utilisation (Average Energy Mix)

Annex 9: Use of Compost/Digestate: benefits and monetisation[107]

The current analysis assumes the following:

- 65% of the compost produced from IVC and windrow facilities is used in agriculture, with the remainder used in horticultural / amateur gardening applications;

- 90% of the compost/digestate produced from AD facilities is used in agricultural applications with the remainder used in horticulture and amateur gardening.

Where compost is used in agriculture it is assumed to displace the use of synthetic fertilisers whilst that used in horticulture and amateur gardening is assumed to displace the use of peat.

The modelling assumes the production of relatively mature compost that would not be required for most agricultural applications, though it would be essential in higher quality and value uses such as in potting mixes.

1. The use of compost/digestate in agriculture

Principal benefits associated with the use of compost in agriculture are:

- A reduction in the use of fertilisers. The following environmental impacts are assumed to be offset:

    - The manufacture of fertiliser (an energy intensive process);

    - The use of fertiliser itself (principally nitrous oxide emissions to air, and the leaching of nitrate to water from soil);

- A reduction in pesticide use;

- A reduction in water use.

For further explanation compost cover both compost from aerobic processes as well as digestate from anaerobic digestion, regardless if it has been composted afterwards.

Replacement for Mineral Fertiliser

Unlike mineral fertilisers, the use of compost does not provide a specific amount of N, P or K that will be immediately available to the growing plant. Compared to mineral fertilisers, composts provide low levels of N, P and K. However, the addition of compost can provide essential trace minerals to the soil (calcium, sulphur, iron, boron, molybdenum and zinc) that are not supplied when mineral fertilisers are added.

Modelling the Amount of Nutrient Displaced and the Rate of Application

The nutrient values we have used for composts are shown in Table A9-1.

[107] Unless mentioned otherwise, all the data are extracted from the Arcadis/Eunomia report

Mix	N	P	K
Garden Only	1.07%	0.47%	0.42%
Mainly Garden	1.31%	0.77%	0.70%
Kitchen and Garden	1.79%	1.38%	1.26%

Table A9-1: Nutrient Content of Composts with Different Biowaste Components

In the assessment an application rate of 10 tonnes per hectare of dry matter is taken. The mineralisation rate of the nutrients is assumed to be 30%. This determines the time profile of the displacement effect (which in turn affects the external benefits associated with displacement via the discounting mechanism).

For synthetic fertilisers, a loss rate of 23% is assumed for nitrogenous fertilisers[108]. The nitrogen in compost is assumed to be 100% available to plants over time, with the mineralisation rate determining the rate at which the nutrient is made available. This means that more nutrients have to be applied in a given year in the synthetic form than would be available in mineralised form from the composted materials.

For an application of 10 tonnes dry matter per hectare in one year, the N displacement would follow the evolution set out in Table A9-2 and Figure 9-3 below. Equivalent projections for P and K displacement have been calculated using mineralization rates of 70% for both.

Year	Displacement of N (kg)	Cumulative Displacement
1	50.9	50.9
2	35.7	86.6
3	25.0	111.6
4	17.5	129.0
5	12.2	141.3
6	8.6	149.8
7	6.0	155.8
8	4.2	160.0
9	2.9	163.0
10	2.1	165.0

Table A9-2: Evolution in N Displacement Associated with 10 tonnes Dry Matter of Composting Applied to Farmland, Southern Member State Case

108 This is the loss rate from Hydro Agri Europe (1995) *Important Questions on Fertilizer and the Environment*, Brussels: Hydro Agri Europe.

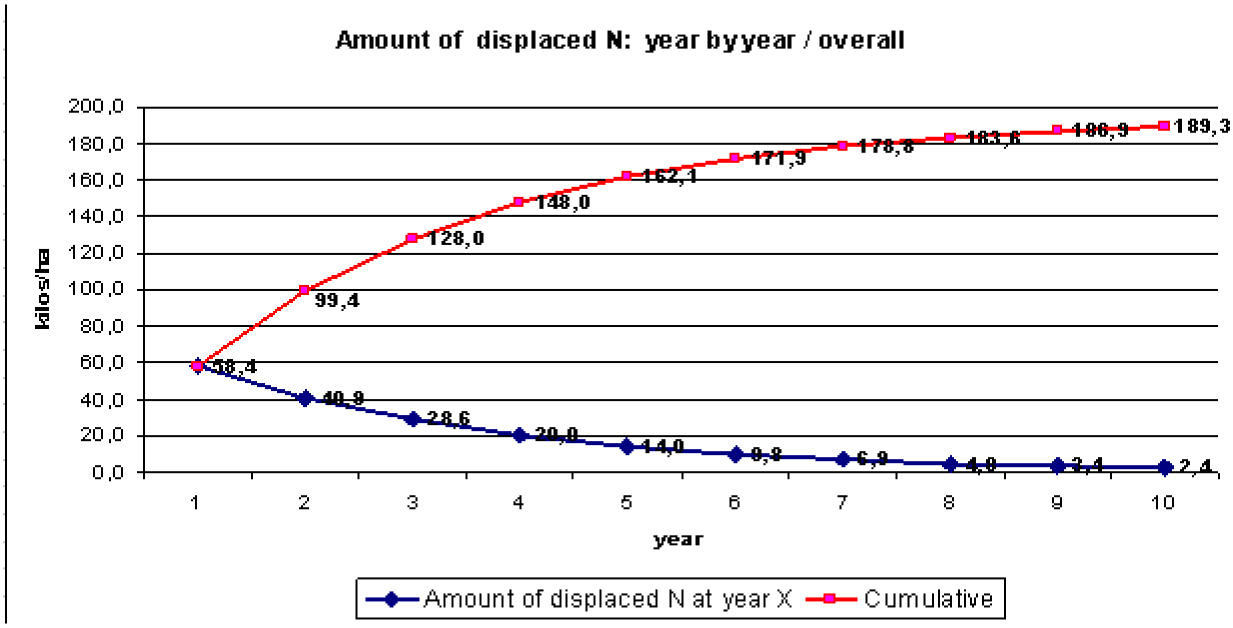


Figure A9-3: Evolution of Nitrogen Displacement over Time from Single Compost Application

Impacts Resulting from the Manufacture of Fertiliser

There are a number of different routes to NPK fertiliser production. The most widespread are the mixed acid and nitrophosphate routes. This assessment is based on two sources of data, the first on Best Available Technologies from EFMA (European Fertilisers Manufacturing Association), the second from Davies and Haglund.[109] The first of these sources refers to production via the mixed acid route. There are three further distinctions within this route (granulation with a pipe reactor system, drum granulation with ammoniation and digestion). The data concerning emissions have been taken from those for the 'digestion' process because it is the only process for which this Assessmenthas obtained data associated with all the required raw materials. The EFMA booklets suggest that these three processes cover the majority of NPK fertiliser production in Europe. The data from Davies and Haglund are calculated from, separately, production of ammonium nitrate, Triple Superphosphate and (for potassium), PK fertiliser (22% P_2O_5, 22% K_2O).

Avoided Phosphate Rock Extraction

Mining phosphate rock is an energy intensive activity and approximately 3.3 tonnes of phosphate rock are required to produce one tonne of phosphorous pentoxide (P_2O_5) (100%)[110].

Avoided Process Wastewater Disposal Phosphate Fertiliser

---

109 J. Davies and C. Haglund (1999) *Life Cycle Inventory (LCI) of Fertiliser Production – Fertiliser Products Used in Sweden and Western Europe*, SIKreport, No 654 1999, SIK The Swedish Institute for food and biotechnology, Gothernburg, Sweden.

110 B. Bocoum and W. C. Labys (1993) Modelling the Economic Impacts of Further Mineral Processing: the Case of Zambia and Morocco. *Resources Policy*, **19**, (4), pp.247-63.

Estimate of the externalities associated with P_2O_5 production (which may be avoided when compost is applied) has been assumed at €58.24 per tonne of, P_2O_5 .The estimated damages associated with phosphate rock extraction from Nolan-ITU have been used[111].

Modelling Approach Taken in this Assessment

The EFMA[112] booklets provide gaseous emissions and energy consumption data associated with sulphuric acid, nitric acid, phosphoric acid and ammonia production, the base acids used in mixed acid production of NPK (15:15:15). The data also quotes the raw material requirement for the mixed acid route, in terms of sulphuric acid, nitric acid, phosphoric acid, ammonia and phosphate rock. Having derived the emissions and energy requirement associated with the production of each of these materials (e.g. extraction in terms of phosphate rock), these were factored according to the relative proportions used in the NPK (15:15:15) fertiliser. It was then assumed that for each of the nutrient components, that one-third of the processing requirement was attributable to the manufacture of 150 kg N, one-third to the manufacture of 150kg K_2O portion and 150kg P_2O_5. Hence, through this attribution process, the levels from the mixed acid route itself are apportioned to the different nutrients (for the purpose of displacement calculations).

Using the two data sources described, the calculations has been done for emissions associated with N, P and K production. These figures are multiplied by unit damage costs to estimate the external costs of production. These are, in turn, multiplied by avoided N, P and K quantities to arrive at a benefit per tonne of compost.

<u>Impacts Resulting from the Use of Fertiliser</u>

Two environmental impacts have been calculated when considering the use of fertilisers:

(1) Leaching of nitrate to water from soil;

(2) N2O emissions to air.

Nitrate Contamination from Fertiliser Use

Based on application rate of 10 tonnes per hectare of dry matter applied in year one displace a quantity of N from commercial fertiliser in line with the schedule set out in Table A9-2. Assuming that the 23% of nitrate lost is leached to groundwater, this would imply that the quantity of N being leached into groundwater follows the schedule outlined in Figure A9-1.

A figure of €3.20 per kg N, based on the average shadow price of nitrogen quoted by Pretty et al [113] has been used.

Impact of Nitrogenous Fertilisers on Soil N2O Emissions

---

111 Nolan-ITU (2004) *TBL Assessment of Garden Organics Management*, Final Report to the NSW Dept of Environment and Conservation, Sustainability Programs Division, May 2004.

112 European Fertilizer Manufacturers Association

113 *Znaor D, Pretty J, Morrison, J and Todorovic S K (2005) Environmental and Macroeconomic Impact Assessment of Different Development Scenarios to Organic and Low-input Farming in Croatia, Report for the Republic Government of Croatia published by University of Essex*

In the analysis, it has been assumed that relative to compost, 0.5% of nitrogen applied as fertiliser is lost as N_2O. This is combined with the time profile of N replacement for the compost. Hence, the externality also depends upon the mineralisation rate.

Reduced Pesticide Use

It has been shown that compost can help to control plant diseases and subsequently reduce crop losses in both agriculture and horticulture.

In this study, it is assumed that where compost is applied at 10 tonnes dry matter per hectare, the use of pesticides falls by 20%. The external costs of pesticide use have been assumed at €13 per kg of active ingredient used, while average use was assumed at 6 kg active ingredient per hectare. It should be stressed that those estimates are subject to considerable uncertainty.

Avoided Water Use

Studies have indicated that the application of composted products can enhance the water use efficiency by improving infiltration and storage in the root zone and reducing deep drainage, run-off, and evaporation, and water use by weeds. The beneficial effects of compost application arise from improvements in soil physical and chemical properties.[114]

In this study, it has been assumed reduced water requirement of 5% (i.e. 61 m^3 of water per hectare is saved as a result of the application of compost). The total economic value of water was assumed at €1.07 per m^3.

2. The Use of Compost in Horticulture and Amateur Gardening

The use of compost in horticulture and amateur gardening is assumed to avoid pesticide use, as was previously discussed with reference to the use of compost in agriculture. Benefits are also attributed to the avoidance of peat extraction.

Avoided Pesticide Use:

The savings due to avoided pesticide use in horticulture have been assumed as the same as in agricultural sector.

Avoided Peat Extraction

Emissions associated with the extraction and utilisation of peat are estimated on the basis of the annual 5% decay rate of peat when used on soils. The behaviour of peatland prior or after

114 A. Shiralipour, D. B. McConnel and W. H. Smith (1992) Physical and Chemical Properties of Soils as Affected by Municipal Solid Waste Compost Application, Biomass and Bioenergy 3(3-4): 261-266; S.A.R. Movahedi Naeini and H. F. Cook (2000) Influence of Municipal Compost on Temperature, Water, Nutrient Status and the Yield of Maize in a Temperate Soil. Soil Use and Management 16:215-221; L. M Bresson, C. Koch, Y. Le Bissonnais, E. Barriuso and V. Lecomte (2001) Soil Surface Structure Stabilization by Municipal Waste Compost Application. Soil Sci. Soc. Am. J. 65:1804-1811; J. Albaladejo, V. Castillo and E. Diaz (2000) Soil Loss and Runoff on Semiarid Land as Amended with Urban Solid Refuse, Land Degradation & Development 11: 363-373; M. Agassi, A. Hadas, Y. Benyamini, G. J. Levy, L. Kautsky, L. Avrahamov and H. Zhevelev (1998) Mulching Effect of Composted MSW on Water Percolation and Compost Degradation Rate. Comp. Sci. Util. 6(3): 34-41

removal has not been assessed. The gaseous emissions associated with peat decompostion are used as the basis for the external cost savings from compost use where it displaces peat. Peat is replaced by compost more on the basis of volume than on weight. The density of peat is low, estimated here at 200 kg/m^3. The density of compost, is of the order 500 kg/m^3 for a compost with dry matter content 60%. This implies that to replace one tonne of peat would require compost resulting from 7.14 tonnes of waste material.

Annex 10: Financial cost of bio-waste treatment methods (€ per ton treated)

	IVC	AD - electricity	AD - CHP	AD - vehicle	AD - grid	Incineration (electricity)	Incineration (CHP)	Incineration (heat only)	Landfilling
AT	€38.30	€80.00	€89.70	€65.10	€86.90	€93.00	€93.40	€75.80	€33.40
BE	€40.60	€87.50	€99.50	€91.40	€98.70	€99.80	€106.10	€92.70	€37.40
BG	€30.00	€61.20	€70.60	€56.20	€66.30	€83.10	€93.30	€86.40	€23.60
CY	€32.40	€50.40	€63.50	€78.00	€88.60	€57.90	€93.20	€111.20	€17.20
CZ	€31.80	€60.00	€68.70	€55.70	€65.90	€76.00	€84.60	€76.90	€22.70
DK	€41.00	€85.80	€95.70	€107.00	€100.40	€95.70	€93.80	€73.60	€36.40
EE	€31.10	€65.80	€75.80	€74.10	€68.30	€88.00	€97.50	€89.30	€26.10
FI	€39.00	€85.20	€97.80	€72.70	€93.10	€100.00	€110.20	€100.20	€36.20
FR	€40.00	€89.30	€101.00	€83.30	€94.50	€104.30	€107.40	€90.60	€38.50
DE	€39.00	€81.60	€92.00	€76.80	€89.20	€93.90	€96.70	€81.00	€34.20
EL	€32.40	€64.60	€77.70	€78.40	€89.00	€82.30	€106.90	€112.50	€25.30
HU	€31.60	€58.90	€67.80	€75.70	€64.80	€74.70	€84.80	€78.60	€22.10
IE	€38.30	€75.50	€88.50	€97.80	€89.20	€85.30	€104.00	€103.40	€30.80
IT	€38.30	€76.20	€85.20	€75.00	€86.80	€86.40	€86.60	€69.50	€31.20
LV	€30.40	€58.60	€67.20	€71.10	€59.90	€77.40	€86.10	€78.30	€22.00
LT	€30.70	€58.70	€67.30	€72.60	€60.60	€76.90	€85.20	€77.10	€22.10
LU	€40.70	€86.40	€97.60	€97.10	€94.90	€97.50	€100.90	€85.10	€36.80
MT	€32.40	€53.80	€66.90	€78.10	€88.70	€63.70	€96.50	€111.50	€19.10
NL	€39.30	€81.60	€93.10	€86.80	€93.30	€92.80	€100.70	€89.60	€34.20
PL	€31.40	€61.70	€71.20	€75.00	€68.10	€80.10	€90.60	€84.10	€23.70
PT	€33.30	€69.50	€82.90	€67.10	€76.50	€88.60	€111.40	€114.70	€28.00
RO	€30.30	€60.40	€70.10	€71.20	€68.30	€80.90	€92.90	€87.70	€23.10
SK	€31.20	€56.50	€65.50	€47.60	€59.40	€71.90	€83.90	€79.70	€20.80
SI	€33.30	€65.80	€75.60	€81.30	€69.00	€82.00	€91.70	€84.00	€25.80
ES	€34.90	€71.20	€85.40	€72.60	€79.50	€87.00	€112.60	€118.30	€28.70
SE	€39.00	€83.80	€94.30	€61.50	€88.60	€97.70	€99.30	€82.00	€35.50
UK	€38.30	€76.10	€89.10	€73.70	€91.50	€86.40	€104.60	€103.50	€31.20

Annex 11: Comparison of the costs of switch between treatment techniques, country by country (€ per ton)

	Incineration to AD: on-site biogas use (electricity)			**Incineration to AD: on-site biogas use + CHP**			**Incineration to AD: compressed biogas used in**			**Incineration to AD: biogas injected to gas grid**			**Incineration to IVC + biofilter**		
	From	To	**Net Cost of Switch**	From	To	**Net Cost of Switch**	From	To	**Net Cost of Switch**	From	To	**Net Cost of Switch**	From	To	**Net Cost of Switch**
AT	€95.00	€71.80	-€23.14	€94.97	€74.30	-€20.60	€94.97	€48.70	-€46.30	€94.97	€56.50	-€38.50	€94.97	€53.20	-€41.80
BE	€90.90	€74.50	-€16.49	€90.94	€78.50	-€12.50	€90.94	€71.80	-€19.10	€90.94	€63.60	-€27.40	€90.94	€56.20	-€34.70
BG	€80.30	€53.40	-€26.89	€80.32	€58.70	-€21.70	€80.32	€48.20	-€32.10	€80.32	€53.90	-€26.40	€80.32	€44.00	-€36.30
CY	€53.20	€39.50	-€13.75	€53.22	€47.40	-€5.80	€53.22	€65.60	€12.40	€53.22	€71.90	€18.70	€53.22	€46.90	-€6.40
CZ	€77.80	€37.60	-€40.17	€77.77	€38.50	-€39.20	€77.77	€41.10	-€36.60	€77.77	€32.70	-€45.10	€77.77	€45.70	-€32.10
DK	€92.00	€66.20	-€25.81	€91.98	€70.50	-€21.50	€91.98	€85.90	-€6.10	€91.98	€76.80	-€15.10	€91.98	€56.70	-€35.20
EE	€75.60	€51.20	-€24.33	€75.56	€56.60	-€19.00	€75.56	€62.00	-€13.60	€75.56	€54.30	-€21.20	€75.56	€45.20	-€30.30
FI	€96.80	€75.40	-€21.41	€96.81	€82.80	-€14.00	€96	€62.80	-€34.00	€96.81	€76.20	-€20.60	€96.81	€54.70	-€42.10
FR	€134.90	€83.00	-€51.86	€134.91	€87.50	-€47.40	€134.91	€63.90	-€71.00	€134.91	€65.00	-€69.90	€134.91	€55.30	-€79.60
DE	€69.20	€56.90	-€12.32	€69.23	€59.10	-€10.10	€69.23	€56.30	-€12.90	€69.23	€53.40	-€15.90	€69.23	€53.80	-€15.40
EL	€75.50	€53.30	-€22.25	€75.53	€61.10	-€14.40	€75.53	€65.70	-€9.80	€75.53	€71.50	-€4.00	€75.53	€46.90	-€28.60
HU	€90.10	€50.40	-€39.74	€90.14	€54.40	-€35.70	€90.14	€58.70	-€31.40	€90.14	€48.90	-€41.30	€90.14	€45.70	-€44.40
IE	€87.10	€60.30	-€26.78	€87.07	€66.70	-€20.40	€87.07	€78.70	-€8.40	€87.07	€66.00	-€21.10	€87.07	€53.40	-€33.70
IT	€94.70	€60.30	-€34.46	€94.74	€63.50	-€31.30	€94.74	€58.90	-€35.80	€94.74	€63.70	-€31.10	€94.74	€53.50	-€41.30
LV	€84.60	€54.90	-€29.67	€84.57	€59.70	-€24.80	€84.57	€59.00	-€25.60	€84.57	€49.50	-€35.10	€84.57	€44.50	-€40.10
LT	€86.90	€55.60	-€31.38	€86.95	€60.10	-€26.80	€86.95	€59.70	-€27.20	€86.95	€49.60	-€37.40	€86.95	€44.80	-€42.20
LU	€128.00	€76.20	-€51.86	€128.03	€80.20	-€47.80	€128.03	€73.60	-€54.50	€128.03	€66.40	-€61.70	€128.03	€56.20	-€71.90

	Incineration to AD: on-site biogas use (electricity)			Incineration to AD: on-site biogas use + CHP			Incineration to AD: compressed biogas used in			Incineration to AD: biogas injected to gas grid			Incineration to IVC + biofilter		
	From	To	Net Cost of Switch	From	To	Net Cost of Switch	From	To	Net Cost of Switch	From	To	Net Cost of Switch	From	To	Net Cost of Switch
MT	€52.70	€38.70	-€14.05	€52.71	€46.40	-€6.30	€52.71	€65.40	€12.70	€52.71	€70.40	€17.70	€52.71	€46.90	-€5.80
NL	€67.80	€58.00	-€9.81	€67.84	€62.00	-€5.80	€67.84	€66.30	-€1.50	€67.84	€60.80	-€7.00	€67.84	€54.30	-€13.60
PL	€61.20	€34.90	-€26.26	€61.20	€37.60	-€23.60	€61.20	€59.30	-€1.90	€61.20	€40.40	-€20.80	€61.20	€45.30	-€15.90
PT	€82.50	€56.70	-€25.83	€82.50	€64.30	-€18.20	€82.50	€56.30	-€26.20	€82.50	€58.40	-€24.10	€82.50	€47.70	-€34.80
RO	€78.20	€52.50	-€25.74	€78.24	€58.20	-€20.00	€78.24	€59.80	-€18.40	€78.24	€56.70	-€21.60	€78.24	€44.30	-€33.90
SK	€92.00	€51.30	-€40.73	€92.02	€54.70	-€37.40	€92.02	€37.20	-€54.80	€92.02	€40.70	-€51.30	€92.02	€45.20	-€46.80
SI	€97.20	€53.50	-€43.75	€97.24	€57.00	-€40.30	€97.24	€62.00	-€35.30	€97.24	€45.70	-€51.50	€97.24	€47.50	-€49.70
ES	€89.30	€59.80	-€29.51	€89.33	€67.70	-€21.60	€89.33	€59.60	-€29.80	€89.33	€60.00	-€29.40	€89.33	€49.60	-€39.70
SE	€107.30	€78.60	-€28.66	€107.28	€83.90	-€23.40	€107.28	€52.80	-€54.50	€107.28	€69.60	-€37.70	€107.28	€54.90	-€52.40
UK	€85.90	€58.70	-€27.19	€85.87	€65.30	-€20.60	€85.87	€59.80	-€26.10	€85.87	€68.20	-€17.70	€85.87	€53.60	-€32.30

Table A.11-1: Average cost of switch from incineration into biological treatment

Technology	Landfill to AD: on-site biogas use (electricity)			Landfill to AD: on-site biogas use (CHP)			Landfill to AD: compressed biogas used in vehicles			Landfill to AD: biogas injected to gas grid			Landfill to IVC		
Cost	From	To	Net Cost of	From	To	Net Cost of	From	To	Net Cost of	From	To	Net Cost of	From	To	Net Cost of Switch
AT	€97.20	€71.80	-€25.36	€97.19	€74.30	-€22.90	€97.19	€48.70	-€48.50	€97.19	€56.50	-€40.70	€97.19	€53.20	-€44.00
BE	€109.10	€74.50	-€34.69	€109.15	€78.50	-€30.70	€109.15	€71.80	-€37.30	€109.15	€63.60	-€45.60	€109.15	€56.20	-€52.90
BG	€74.70	€53.40	-€21.25	€74.68	€58.70	-€16.00	€74.68	€48.20	-€26.50	€74.68	€53.90	-€20.80	€74.68	€44.00	-€30.70
CY	€68.00	€39.50	-€28.52	€67.98	€47.40	-€20.50	€67.98	€65.60	-€2.40	€67.98	€71.90	€4.00	€67.98	€46.90	-€21.10
CZ	€92.80	€37.60	-€55.20	€92.79	€38.50	-€54.20	€92.79	€41.10	-€51.60	€92.79	€32.70	-€60.10	€92.79	€45.70	-€47.10
DK	€90.70	€66.20	-€24.50	€90.68	€70.50	-€20.20	€90.68	€85.90	-€4.80	€90.68	€76.80	-€13.80	€90.68	€56.70	-€33.90
EE	€76.30	€51.20	-€25.09	€76.32	€56.60	-€19.70	€76.32	€62.00	-€14.30	€76.32	€54.30	-€22.00	€76.32	€45.20	-€31.10
FI	€83.60	€75.40	-€8.21	€83.61	€82.80	-€0.80	€83.61	€62.80	-€20.80	€83.61	€76.20	-€7.40	€83.61	€54.70	-€28.90
FR	€100.00	€83.00	-€16.96	€100.00	€87.50	-€12.50	€100.00	€63.90	-€36.10	€100.00	€65.00	-€35.00	€100.00	€55.30	-€44.70
DE	€102.40	€56.90	-€45.51	€102.41	€59.10	-€43.30	€102.41	€56.30	-€46.10	€102.41	€53.40	-€49.10	€102.41	€53.80	-€48.60
EL	€76.00	€53.30	-€22.68	€75.96	€61.10	-€14.80	€75.96	€65.70	-€10.20	€75.96	€71.50	-€4.40	€75.96	€46.90	-€29.10
HU	€84.80	€50.40	-€34.41	€84.81	€54.40	-€30.40	€84.81	€58.70	-€26.10	€84.81	€48.90	-€35.90	€84.81	€45.70	-€39.10
IE	€82.80	€60.30	-€22.47	€82.75	€66.70	-€16.00	€82.75	€78.70	-€4.10	€82.75	€66.00	-€16.70	€82.75	€53.40	-€29.30
IT	€91.20	€60.30	-€30.93	€91.22	€63.50	-€27.70	€91.22	€58.90	-€32.30	€91.22	€63.70	-€27.60	€91.22	€53.50	-€37.80
LV	€75.60	€54.90	-€20.71	€75.62	€59.70	-€15.90	€75.62	€59.00	-€16.60	€75.62	€49.50	-€26.10	€75.62	€44.50	-€31.10
LT	€75.50	€55.60	-€19.90	€75.47	€60.10	-€15.40	€75.47	€59.70	-€15.70	€75.47	€49.60	-€25.90	€75.47	€44.80	-€30.70

Technology	**Landfill** to **AD: on-site biogas use (electricity)**			**Landfill** to **AD: on-site biogas use (CHP)**			**Landfill to AD: compressed biogas used in vehicles**			**Landfill** to **AD: biogas injected to gas grid**			**Landfill** to **IVC**		
Cost	From	To	**Net Cost of**	From	To	**Net Cost of**	From	To	**Net Cost of**	From	To	**Net Cost of**	From	To	**Net Cost of Switch**
LU	€108.10	€76.20	-€31.92	€108.08	€80.20	-€27.90	€108.08	€73.60	-€34.50	€108.08	€66.40	-€41.70	€108.08	€56.20	-€51.90
MT	€74.00	€38.70	-€35.31	€73.98	€46.40	-€27.60	€73.98	€65.40	-€8.50	€73.98	€70.40	-€3.60	€73.98	€46.90	-€27.00
NL	€102.50	€58.00	-€44.47	€102.49	€62.00	-€40.50	€102.49	€66.30	-€36.20	€102.49	€60.80	-€41.70	€102.49	€54.30	-€48.20
PL	€82.90	€34.90	-€47.97	€82.91	€37.60	-€45.30	€82.91	€59.30	-€23.60	€82.91	€40.40	-€42.50	€82.91	€45.30	-€37.60
PT	€79.70	€56.70	-€23.07	€79.73	€64.30	-€15.50	€79.73	€56.30	-€23.40	€79.73	€58.40	-€21.40	€79.73	€47.70	-€32.00
RO	€74.10	€52.50	-€21.59	€74.09	€58.20	-€15.90	€74.09	€59.80	-€14.30	€74.09	€56.70	-€17.40	€74.09	€44.30	-€29.80
SK	€85.90	€51.30	-€34.62	€85.91	€54.70	-€31.20	€85.91	€37.20	-€48.70	€85.91	€40.70	-€45.20	€85.91	€45.20	-€40.70
SI	€90.20	€53.50	-€36.75	€90.24	€57.00	-€33.30	€90.24	€62.00	-€28.30	€90.24	€45.70	-€44.50	€90.24	€47.50	-€42.70
ES	€82.10	€59.80	-€22.31	€82.13	€67.70	-€14.40	€82.13	€59.60	-€22.60	€82.13	€60.00	-€22.20	€82.13	€49.60	-€32.50
SE	€87.90	€78.60	-€9.24	€87.86	€83.90	-€4.00	€87.86	€52.80	-€35.10	€87.86	€69.60	-€18.30	€87.86	€54.90	-€33.00
UK	€93.00	€58.70	-€34.36	€93.04	€65.30	-€27.70	€93.04	€59.80	-€33.30	€93.04	€68.20	-€24.80	€93.04	€53.60	-€39.40

Table A.11-2. Average cost of switch from landfilling into biological treatment

Annex 12: Monetisation of environmental impacts: basic data, case study (Czech Republic)

1. Unit damage costs for air pollutants and GHG emissions:

In order to enable comparison between scenarios as well as enable to include environmental effect into analysis it was necessary to monetize to them to the extent possible. The set of data used has been extracted from the Clean Air for Europe (CAFÉ) programme and the Benefits Table (BeTa) database[115]. This dataset coves a wide range of pollutants (see Table 2), and uses country specific damage costs for non-GHG.

Unit damage costs have been determined from the CAFE data, which is from 2000. In order to model in 2009 prices have been converted into real 2009 figures using the Harmonised Index of Consumer Prices (HICP)[116]. A number of Member States have been omitted from this report and for these countries we have assigned the lowest unit cost for each pollutant. Table A 12-1 shows the costs that have been attributed to each member state for each pollutant. For the remaining pollutants that have been modelled the unit damage cost is constant across all member states. The pollutants and the modelled cost are shown in Table A.12-2.

	NH3	VOCs	PM2.5	SO2	NOx	Cd	Cr	Ni
AT	29 €	5 €	88 €	20 €	20 €	404 €	53 €	6 €
BE	74 €	6 €	147 €	26 €	11 €	674 €	88 €	11 €
BG	4 €	0 €	10 €	3 €	2 €	47 €	6 €	1 €
CY	4 €	0 €	10 €	3 €	2 €	47 €	6 €	1 €
CZ	48 €	3 €	76 €	20 €	17 €	343 €	45 €	6 €
DK	20 €	2 €	40 €	12 €	10 €	184 €	25 €	3 €
EE	7 €	0 €	10 €	4 €	2 €	47 €	6 €	1 €

115 M. Holland and P. Watkiss (2002) Benefits Table Database: Estimates of the Marginal External Costs of Air Pollution in Europe, Database Prepared for European Commission DG Environment; AEAT Environment (2005) Damages per tonne Emission of PM2.5, NH3, SO2, NOx and VOCs from Each EU25 Member State (excluding Cyprus) and Surrounding Seas, Report to DG Environment of the European Commission, March 2005. The figures used reflect the Mean Values of Life Years approach to valuation, including health sensitivity. For CO2e, the central figure €19/tonne in 2000 prices, €23/tonne in 2009 prices was used, source: Be Ta databases: www.methodex.org/BeTa-Methodex%20v2.xls

116 Eurostat (2009) HICP - all items - annual average inflation rate – (tsieb060). Available at http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tsieb060. An index was created using the values from 2000 to 2008, for the row entitled European Union. This gives an overall rate of inflation from 2000 to 2009 of 22.57%. Therefore damage costs were uplifted by 22.57% to give 2009 prices

	NH3	VOCs	PM2.5	SO2	NOx	Cd	Cr	Ni
FI	5 €	0 €	13 €	4 €	2 €	60 €	8 €	1 €
FR	28 €	4 €	107 €	20 €	17 €	490 €	64 €	8 €
DE	43 €	5 €	116 €	27 €	22 €	539 €	70 €	8 €
EL	8 €	1 €	21 €	3 €	2 €	94 €	12 €	1 €
HU	27 €	2 €	61 €	12 €	12 €	282 €	37 €	4 €
IE	6 €	2 €	36 €	12 €	9 €	159 €	21 €	3 €
IT	27 €	3 €	81 €	15 €	13 €	368 €	49 €	6 €
LV	7 €	1 €	21 €	5 €	3 €	98 €	12 €	2 €
LT	4 €	1 €	21 €	6 €	5 €	93 €	12 €	1 €
LU	61 €	7 €	99 €	23 €	20 €	454 €	60 €	7 €
MT	20 €	1 €	22 €	5 €	2 €	47 €	6 €	1 €
NL	54 €	5 €	147 €	32 €	15 €	699 €	91 €	11 €
PL	25 €	2 €	70 €	13 €	9 €	319 €	42 €	5 €
PT	9 €	1 €	54 €	8 €	3 €	245 €	32 €	4 €
RO	4 €	0 €	10 €	3 €	2 €	47 €	6 €	1 €
SK	34 €	2 €	49 €	12 €	12 €	221 €	29 €	4 €
SI	31 €	4 €	54 €	15 €	16 €	245 €	32 €	4 €
ES	11 €	1 €	45 €	10 €	6 €	208 €	27 €	3 €
SE	15 €	1 €	28 €	7 €	5 €	135 €	17 €	2 €
UK	42 €	3 €	89 €	16 €	8 €	417 €	54 €	6 €

Table A.12-1: Variable CAFE Unit Damage Costs (€ 000's/tonne) in 2009 Prices

Cost per Tonne	Dioxin	Pb	Hg	CO2e
€/tonne	€ 45,350,900,000	€ 735,420	€ 7,354,200	€ 23

Table A.12-2: Unit Damage Cost, Constant in 2009 Prices

2. Example of monetisation of the environmental impacts:

An example of monetisation of the environmental impacts for all treatment techniques in the case of Czech Republic is given below. For all bio-waste management techniques and for all Member States, similar tables have been constructed on the basis of the data as detailed in Annexes 6, 7, 8, 9 and 12.1.

Landfill	Climate change	Air quality	Other impacts	Totals
Process				
Direct emissions (non energy)	€48.45	€18.06		€66.51
Energy use (electricity & diesel)	€0.15	€3.63		€3.78
Avoided emissions, energy generation				
Electricity	- €0.90	- €7.30		- €8.20
FINAL TOTALS	€47.70	€14.39		€62.09

Table A.12-3: Indicative External Damage Costs for the Landfill – Czech Republic

	Incineration	Climate change	Air quality	Other impact	Totals
ELECTRICITY ONLY	Process				
	Direct emissions	€11.28	€30.02		€41.30
	Energy use (electricity & diesel)	€1.95	€17.58		€19.53
	Avoided emissions, energy generation				
	Electricity	- €5.75	- €43.88		- €49.63
	FINAL TOTALS	€7.48	€3.72		€11.20
C H P	Process				
	Direct emissions	€11.28	€30.02		€41.30
	Energy use (electricity & diesel)	€1.95	€17.58		€19.53
	Avoided emissions, energy generation				
	Electricity	- €3.08	- €23.50		- €26.58
	Heat	- €3.17	- €18.45		- €21.62
	FINAL TOTALS	€6.98	€5.65		€12.63
HEAT ONY	Process				
	Direct emissions	€11.28	€30.02		€41.30
	Energy use (electricity & diesel)	€1.95	€17.58		€19.53
	Avoided emissions, energy generation				
	Heat	- €6.03	- €34.85		- €40.88
	FINAL TOTALS	€7.20	€12.75		€19.95

Table A.12-4: Indicative External Damage Costs for Incineration Facilities– Czech Republic

	Anaerobic Digestion	Climate change	Air quality	Other impacts	Totals[117]
ELECTRICITY ONLY	Process				
	Direct emissions	€10.25	€6.50		€16.75
	Energy use (electricity & diesel)	€0.00	€0.00		€0.00
	Avoided emissions, energy generation				
	Electricity	- €3.24	- €26.19		- €29.43
	Use of compost			- €10.01	- €10.01
	FINAL TOTALS	€5.60	- €18.17	- €10.01	- €22.58
C H P	Process				
	Direct emissions	€10.25	€6.50		€16.75
	Energy use (electricity & diesel)	€0.00	€0.00		€0.00
	Avoided emissions, energy generation				
	Electricity	- €3.24	- €26.19		- €29.43
	Heat	- €0.43	- €5.28		- €5.71
	Use of compost			- €10.01	- €10.01
	FINAL TOTALS	€5.17	- €20.69	- €10.01	- €22.24
AS VEHICLE FUEL	Process				
	Direct emissions	€10.40	€7.06		€17.46
	Energy use (electricity & diesel)	€0.00	€0.00		€0.00
	Avoided emissions, energy generation				
	Diesel	- €3.03	- €13.62		- €16.65
	Use of compost			- €10.01	- €10.01
	FINAL TOTALS	€2.28	- €5.14	- €10.01	- €12.87
INJECTION TO GAS GRID	Process				
	Direct emissions	€10.61	€2.66		€13.27
	Energy use (electricity & diesel)	€0.00	€0.00		€0.00
	Avoided emissions, energy generation				
	Heat	- €3.03	- €32.04		- €35.07
	Use of compost			- €10.01	- €10.01
	FINAL TOTALS	€6.40	- €20.81	- €10.01	- €24.42

Table A.12-5: Indicative External Damage Costs for Anaerobic Digestion – Czech Republic

[117] Direct emissions include those associated with the combustion of the biogas to generate energy, and those associated with the burning of the gas in a bus (where it is used as a vehicle fuel)

Composting	Climate change	Air quality	Other impacts	Totals
PROCESS				
Direct emissions (non energy)	€9.94	€0.49		€10.57
Energy use (electricity & diesel)	€0.44	€4.57		€5.11
USE OF COMPOST				
CO_2 emissions from soil	€1.87			€1.87
Diesel used to spread compost	€0.02	€0.58		€0.60
Reduction in pesticide use			- €3.29	- €3.29
Nutrient displacement impacts			- €1.96	- €1.96
Avoided energy, fertiliser production	- €0.09	- €0.25		- €0.34
Avoided phosphate rock extraction			- €0.69	- €0.69
Avoided water use			- €0.82	- €0.82
Avoided nitrogen leaching			- €1.61	- €1.61
Avoided N_2O emissions			- €0.13	- €0.13
Avoided peat extraction			- €0.65	- €0.65
FINAL TOTALS	€12.18	€5.39	- €9.15	€8.66

Table A.12-6: Indicative External Damage Costs for In-Vessel Composting– Czech Republic

Annex 13: Summary of the potential impacts of compost standards (Scenario 1)

No EU standards scenario	**EU standards including quality assurance systems** **"No need for a standard without its control"**
None of the countries with low or no compost standards can show a sustainable large compost market until now.	Avoiding a period of "trial and error" in the countries which have not yet introduced standards, including candidate countries.
Lack of standards poses problems and uncertainty with investments and planning of infrastructure for further management of bio-waste.	A high quality and controlled compost standard creates customers' and controlling authorities' confidence in compost and composting and stimulates the organics' recycling.
All investments in mixed waste composting failed in the past because of a lack of markets and were limited to building facilities pre-treating waste before its final disposal.	Compost customers act on the European level (certified food production chains, producers of growing media and soil improvers) and need a uniform and ambitious European compost standard in the long run as this allows exploring the full market potential for recycled organics, nationally and internationally.
No standards or low ambition standards affect high quality composting approaches because of enhancing the already suspicious image of a waste derived product.	Environmental impacts do not stop at borders. European compost standard can reflect the Commission's soil protection strategy.
Summary: The No Standards Scenario" delays the developments for organic waste treatment and hampers diversion of biodegradable waste from landfills, promotes incineration, increases MSW treatment costs and leads to more environmental damages in the Member States.	**Summary:** A controlled high quality standard facilitates composting and introduces compost as an element of the intended EU Recycling Society. A European definition of harmonised ambitious quality standard will help the whole bio-waste sector and establish compost markets sustainably.

Annex 14: Mass flow modification per Member State- Scenarios 2, 3 and recommended scenario

	Scenario 2							Scenario 2A[118]	
	Prevention	Landfill	Incineration	MBT	Home Composting	Compos-ting	Anaerobic Digestion	Compos-ting	Anaerobic Digestion
AT	-125.423	0	-189.617	-66.622	-21.278	-37.420	189.514	-37.420	189.514
BG	-95.445	-253.840	-290.103	-181.314	-4.581	634.393	0	201.199	433.194
BE	-162.360	0	-232.935	-1.646	-14.444	102.922	-16.257	-33.482	120.147
CY	-13.354	-17.515	-40.589	-43.368	-256	26.579	61.794	26.579	61.794
CZ	-143.485	-106.442	-235.914	-352.591	0	60.981	490.481	60.981	490.481
DK	-113.760	0	-509.170	0	-2.503	397.913	0	-47.552	445.464
EE	-27.812	-9.720	-49.503	-75.479	-2.920	109.810	0	13.767	96.043
FI	-74.714	-225.746	-111.188	0	-1.494	277.462	-13.747	39.262	224.452
FR	-979.771	-2.143.609	-3.021.484	-2.388.617	0	6.573.939	0	2.435.222	4.138.717
DE	-1.278.084	0	-2.692.881	-1.650.476	0	3.193.081	-127.808	198.103	2.867.169
EL	-171.973	-246.099	-7.476	-1.241.674	0	1.323.276	0	636.072	687.205
HU	-157.138	-269.942	-58.982	-197.103	-17.508	386.396	0	-57.299	443.695
IE	-96.322	-15.298	-137.678	-152.975	-8.669	232.746	-14.448	21.287	197.010
IT	-604.083	-430.047	-184.306	-409.568	0	528.573	-108.735	267.810	152.028
LV	-27.342	-39.140	0	-111.516	-984	124.298	0	-7.218	131.516
LT	-40.419	-101.940	-64.871	-64.871	-1.455	192.718	0	16.248	176.469
LU	-7.282	-11.593	-610	0	0	5.726	-805	-3.929	8.850
MT	-6.698	-5.090	0	-45.807	-1.072	13.680	31.590	13.680	31.590
NL	-215.078	-94.003	-434.765	-58.752	0	399.650	-27.207	-91.085	463.528
PL	-447.529	0	-1.181.358	-2.219.269	0	921.911	2.031.187	921.911	2.031.187
PT	-145.126	-176.442	-485.217	-441.106	-3.483	964.605	-3.483	293.039	668.084
RO	-291.816	-463.236	0	-1.754.175	-5.603	1.931.198	0	580.830	1.350.368
SK	-69.914	-83.590	-124.231	-192.925	-4.195	45.304	289.723	45.304	289.723
SI	-29.443	-37.285	-47.724	-64.130	0	119.696	0	15.840	103.855
ES	-784.044	-2.276.749	-1.046.972	-2.215.814	-21.953	4.808.805	-31.362	1.985.200	2.792.243
SE	-150.244	0	-663.998	-13.551	-9.616	142.206	394.715	142.206	394.715
UK	-984.783	-815.587	-963.876	-692.013	0	1.627.517	-140.824	72.874	1.413.820
EU 27	-7.243.442	-7.822.911	-12.775.447	-14.635.363	-122.015	25.107.966	3.004.328	7.709.430	20.402.863

118 The mass flow modifications of Scenarios 2 and 2A relative to the baseline Scenario are the same except for what concerns anaerobic digestion and composting (less composting and more anaerobic digestion)

Table A.14-1: Mass modifications of Scenario 2 and 2A relative to the baseline Scenario

	Scenario 3					Scenario 3A[119]	
	Landfill	Incineration	MBT	Compos- Ting	Anaerobic Digestion	Compos- ting	Anaerobic Digestion
AT	0	0	0	0	0	0	0
BG	-91.309	-104.353	-65.221	260.884	0	137.441	123.442
BE	0	-40.678	0	40.678	0	29.515	11.163
CY	-8.030	-14.600	-13.870	17.948	18.553	17.948	18.553
CZ	-6.887	-8.609	-13.201	0	28.697	0	28.697
DK	0	0	0	0	0	0	0
EE	0	-2.044	-3.518	5.562	0	0	5.562
FI	0	0	0	0	0	0	0
FR	-525.157	-1.071.217	-1.081.668	2.678.042	0	1.783.184	894.858
DE	0	0	0	0	0	0	0
EL	-2.006	-3.038	-602.594	607.639	0	504.455	103.184
HU	0	0	0	0	0	0	0
IE	0	0	0	0	0	0	0
IT	0	0	0	0	0	0	0
LV	503	0	-24.200	23.697	0	0	23.697
LT	-15.413	-9.808	-9.808	35.030	0	0	35.030
LU	0	0	0	0	0	0	0
MT	-1.831	0	-16.478	8.359	9.949	8.359	9.949
NL	0	0	0	0	0	0	0
PL	0	-745.882	-477.365	644.442	578.805	644.442	578.805
PT	-63.469	-174.538	-158.671	396.678	0	195.050	201.629
RO	147.270	0	-944.900	797.630	0	392.201	405.429
SK	15.055	-18.784	-56.863	0	60.592	0	60.592
SI	-1.472	-1.884	-2.532	5.889	0	0	5.889
ES	-708.933	-326.006	-689.959	1.724.897	0	1.505.365	219.532
SE	0	0	0	0	0	0	0
UK	0	0	0	0	0	0	0
EU 27	-1.261.680	-2.521.442	-4.160.847	7.247.374	696.596	5.217.959	2.726.011

Table A.14-2: Mass modifications of Scenario 3 and 3A relative to the baseline Scenario

[119] The mass flow modifications of Scenarios 3 and 3A relative to the baseline Scenario are the same except for what concerns anaerobic digestion and composting (less composting and more anaerobic digestion). Home composting and prevention are the same as in the baseline scenario

	Recommended Scenario[120]						
	Prevention	Landfill	Incineration	MBT	Home Composting	Compos-ting	Anaerobic Digestion
AT	-125.423	0	-38.517	-13.533	-37.420	-37.420	-14.674
BG	-95.445	-112.522	-128.597	-80.373	230.627	230.627	0
BE	-162.360	0	-93.206	-1.646	-36.807	-36.807	-16.257
CY	-13.354	-9.896	-17.992	-17.092	14.721	14.721	17.161
CZ	-143.485	-28.754	-35.943	-55.113	-45.198	-45.198	21.523
DK	-113.760	0	-63.705	0	-47.552	-47.552	0
EE	-27.812	-1.680	-8.534	-13.008	-1.669	-1.669	0
FI	-74.714	-30.035	-14.793	0	-14.644	-14.644	-13.747
FR	-979.771	-749.133	-1.320.079	-1.230.985	2.320.425	2.320.425	0
DE	-1.278.084	0	-396.206	-242.836	-511.234	-511.234	-127.808
EL	-171.973	-32.037	-3.584	-681.220	544.868	544.868	0
HU	-157.138	-41.824	-9.231	-31.276	-57.299	-57.299	0
IE	-96.322	-2.408	-21.672	-24.080	-25.044	-25.044	-14.448
IT	-604.083	-101.486	-43.494	-96.653	-253.715	-253.715	-108.735
LV	-27.342	-6.233	0	-34.825	14.701	14.701	0
LT	-40.419	-26.706	-16.995	-16.995	21.732	21.732	0
LU	-7.282	-2.421	-127	0	-3.929	-3.929	-805
MT	-6.698	-2.256	0	-20.306	7.732	7.732	9.203
NL	-215.078	-15.486	-71.621	-9.678	-91.085	-91.085	-27.207
PL	-447.529	-63.907	-802.719	-640.802	524.504	524.504	535.394
PT	-145.126	-78.213	-215.087	-195.533	350.673	350.673	-3.483
RO	-291.816	67.589	0	-1.050.522	696.720	696.720	0
SK	-69.914	2.180	-32.546	-74.621	-16.779	-16.779	56.048
SI	-29.443	-6.146	-7.867	-10.572	-4.858	-4.858	0
ES	-784.044	-913.557	-420.103	-889.106	1.493.604	1.493.604	-31.362
SE	-150.244	0	-88.343	-1.803	-38.462	-38.462	-12.019
UK	-984.783	-146.240	-172.829	-124.083	-400.807	-400.807	-140.824
EU 27	-7.243.442	-2.301.172	-4.023.793	-5.556.663	4.633.809	4.633.809	127.958

Table A.14-3: Mass modifications of the recommended scenario relative to the baseline Scenario

120 It is assumed that the reduction of waste generation compared to the baseline scenario will not change the repartition between the various bio-waste management options

Annex 15: GHG emission and cost/benefits implications - Scenarios 2 and 3

	Including biogenic CO2		Excluding biogenic CO2		Including biogenic CO2		Excluding biogenic CO2	
	Scenario 2	Scenario 2A	Scenario 2	Scenario 2A	Scenario 3	Scenario 3A	Scenario 3	Scenario 3A
AT	-637	-636	-555	-555	0	0	0	0
BG	-787	-849	-633	-731	-156	-177	-91	-125
BE	-817	-833	-695	-721	-10	-12	8	4
CY	-104	-109	-85	-91	-20	-20	-12	-12
CZ	-839	-866	-763	-790	-5	-6	-7	-9
DK	-501	-571	-379	-481	0	0	0	0
EE	-152	-176	-121	-152	0	-1	1	-1
FI	-587	-618	-537	-586	0	0	0	0
FR	-8.609	-9.227	-6.761	-7.735	-1.616	-1.796	-728	-1.025
DE	-6.490	-6.879	-5.056	-5.685	0	0	0	0
EL	-1.610	-1.764	-1.184	-1.410	-335	-373	-83	-145
HU	-1.039	-1.094	-954	-1.038	0	0	0	0
IE	-512	-545	-414	-465	0	0	0	0
IT	-3.672	-3.719	-3.254	-3.333	0	0	0	0
LV	-182	-199	-161	-186	-2	-5	1	-4
LT	-305	-328	-271	-306	-12	-16	-11	-18
LU	-48	-49	-45	-46	0	0	0	0
MT	-47	-47	-44	-45	-7	-7	-5	-5
NL	-1.100	-1.160	-934	-1.028	0	0	0	0
PL	-2.602	-2.666	-2.154	-2.217	-194	-212	100	82
PT	-997	-1.096	-729	-889	-152	-186	-40	-96
RO	-2.418	-2.611	-1.930	-2.245	-153	-219	113	4
SK	-495	-495	-441	-441	1	1	6	6
SI	-190	-204	-160	-181	-1	-2	-1	-2
ES	-7.445	-7.877	-6.168	-6.854	-1.671	-1.755	-1.113	-1.259
SE	-758	-758	-567	-567	0	0	0	0
UK	-5.885	-6.097	-5.105	-5.442	0	0	0	0
EU 27	**-48.825**	**-51.472**	**-40.102**	**-44.222**	**-4.331**	**-4.786**	**-1.864**	**-2.605**

Table A.15-1: GHG emission modification per country relative to the baseline Scenario – Scenarios 2, 2A, 3 and 3A, including and excluding biogenic emissions

(Thousand Tons CO2e, year 2020)

	Scenario 2	Scenario 2A	Scenario 3	Scenario 3A
AT	-86	-86	0	0
BG	-116	-107	-41	-39
BE	-101	-94	-8	-7
CY	-16	-14	-6	-5
CZ	-150	-142	-6	-5
DE	-1.058	-975	0	0
DK	-93	-70	0	0
EE	-21	-17	-1	-0
EL	-180	-143	-78	-72
ES	-890	-787	-318	-307
FI	-67	-61	0	0
FR	-1.721	-1.585	-661	-627
HU	-99	-78	0	0
IE	-70	-60	0	-0
IT	-388	-384	0	0
LT	-35	-25	-3	-1
LU	-5	-4	0	0
LV	-16	-9	-1	1
MT	-7	-6	-2	-2
NL	-145	-129	0	0
PL	-525	-496	-185	-175
PT	-162	-120	-56	-41
RO	-252	-181	-76	-51
SE	-135	-135	-0	-0
SI	-28	-22	-1	-0
SK	-64	-64	-6	-6
UK	-657	-602	0	0
EU	-7.088	-6.395	-1.449	-1.336

Table A.15-2: Cost/benefit analysis – Modification relative to the baseline Scenario – Scenarios 2, 2A, 3 and 3A (Net social - Million €, NPV for the period 2013-2020)

Annex 16: Summary of the main uncertainties and their possible impacts on policy options

	Nature of the uncertainty	Range	Efforts made to reduce the uncertainty	Possible influence on Scenario results interpretation	Possible implication in terms of policy development
Waste generation	Not verified hypothesis on demography, GDP growth and relation between GDP and waste generation	1 to 10% per MS/ or for specific years	Comparison to historical data, consultation of the stakeholder including MS	limited at EU 27 level, possibly more important at specific country level and/or for a specific year	No implication at EU 27 level for a multi annual approach
Respect of the landfill Directive target	Not sure that all Member States will meet the targets meaning more waste landfilled in 2020 than foreseen	Mainly relevant in MS heavily dependant on landfilling	Comparison with existing implementation of the Directive, consultation of the stakeholder	More important diversion from landfill in the alternative Scenario, increased cost but not linked with a new initiative on bio-waste	Need to ensure an appropriate enforcement of the Landfill Directive, no implication for additional initiative on bio-waste
Projected treatment methods in the baseline	Deviation from the expected treatment methods	Between 5 to 20% of different treatment method per Member State	Information based on Member States plans and intentions, consultation of the Member States on the baseline Scenario	Different mass movement between treatment methods, should be compensated between them at EU 27 level	Limited at EU 27 level
Costs and benefits - Prevention	No reliable estimation of the cost of prevention actions		Compilation of existing information on prevention even if limited	Advantageous presentation of the cost-benefit ratio of prevention	Difficult to fix a binding target for prevention
Costs - collection	No differences of costs between separate and mixed collection systems have been assumed	0 to 20% of additional cost	Compilation and comparison of several studies	Additional or less cost of separate collection of biowaste leading to different costs and benefit analysis	
Emissions of GHG's	Biogenic emissions taken into account or not in the calculation of the GHG's emissions	around 10%	Sensitivity analysis comparing the results for both calculations	About 10% more or less GHG's emission, no modification of best treatment option for the society	Limited - benefits of all Scenarios including or not Biogenic emission are greater than the costs
Monetization of the impacts - soil	Impossible to monetize the impacts linked with improvement of soil organic contents	Not available	Estimation made on mineral fertiliser avoided in terms of GHG's emissions but not on soil organic content improvements	Possibly more benefits for all alternative Scenarios particularly when more compost is produced and in MS facing a deficit of organic	Could justify a diffenciated approach between MS

	Nature of the uncertainty	Range	Efforts made to reduce the uncertainty	Possible influence on Scenario results interpretation	Possible implication in terms of policy development
				contents in their soil	
Method of choice of the preferred treatment method	Preferred treatment method to meet the targets of the alternative scenarios is based on a comparison of costs and benefits for society - real decisions could be based on other parameters	Potentially significant on a country basis	Consultation of the interested stakeholder on the results of the alternative Scenarios	Possible different repartition of the treatment methods mainly between anaerobic digestion and composting	Limited as the intention is to fix a global target for the biological treatment not distinguishing AD from composting
Quality compost only possible with separate collection	No compost of quality is admitted in the Scenarios without being coupled with separate collection	Maximum 15 to 20% of the compost		Neutral - possible reduction of collection cost compensated by increased treatment cost	

Annex 17: Benefits/drawbacks of different measures to introduce selected policy actions

Instrument	Expected costs	Practicability and enforceability	Impact on subsidiarity	Expected environmental effects
Prevention measures				
EU Information campaign	Not known	Easy	Synergies with national campaign to be checked	Low – difficult to measure
Binding prevention target	Not known	Complicate to control	Moderate impact	If controllable, potentially high
Non-binding or indicative targets	Not known	Easy to moderate	Leaves more flexibility to Member States	Low to high depending on Member States
Tackling food and garden waste in waste prevention plans	Not known	Easy	Flexibility left to the Member States	Low to high depending on Member States
Improve compost market and soil protection measures				
Product standards only ("End of waste")	Low	Easy	Moderate. Could imply the revision of existing standards	Low if the market remains limited
2-tier system (product standards and minimum standards for use notably in agriculture)	Low to moderate, costs could be higher in countries not having standards	Easy	Moderate. Could imply the revision of existing standards	Low to moderate, improvements expected in countries without standards
Support for recycling				
High separate collection or biological treatment obligation	Higher start-up costs but high savings in the future	Moderate – this implies setting up reliable reporting obligations	High – this implies a modification of the waste collection and treatment systems	Moderate to high depending on country situation
Low separate collection or biological treatment obligation	Low start-up cost, moderate savings in the future	Moderate (see above)	Moderate – to high where separate collections are not yet introduced	Moderate to high impacts, depending on country situation