Costs for Municipal Waste Management in the EU

Final Report to

Directorate General Environment, European Commission

eunomia
research & consulting

on behalf of

ECOTEC
RESEARCH & CONSULTING

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Preface

Eunomia Research & Consulting would like to thank Christopher Allen of the European Commission for helpful guidance in the development of this report. We would also like to thank all the team members, who have carried out significant pieces of work with limited resources.

The study also benefited from helpful comments received both during and after a review meeting held in Brussels in October 2001. We would like to thank those who participated at that meeting.

1.0 INTRODUCTION

Eunomia Research & Consulting Limited, on behalf of ECOTEC Research & Consulting (ECOTEC), and in association with;

⇒ Eunomia Research and Consulting (UK)
⇒ GUA (Austria)
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⇒ Scuola Agraria del Parco di Monza (Italy)
⇒ TECNOMA (Spain) and
⇒ Swedish Environmental Research Institute (IVL) (Sweden),

is pleased to present a Final Report for the study on *The Financing of Municipal Solid Waste Management*. This is an important study given that to date, no comprehensive analysis has been undertaken to give an overview of the costs of different waste management options at local and national levels for all 15 EU member states. There is also a lack of information concerning the variety of financing systems. The study constitutes an attempt on the part of the Commission to generate baseline data for the costs of future policy changes.

1.1 This Report

The report continues as follows:

⇒ Section 2: Aims and objectives, tasks and scope;
⇒ Section 3: Approach and programme of work;
⇒ Section 4: Roles and responsibilities for waste management;
⇒ Section 5: Costs of collection and treatment: introduction;
⇒ Section 6: Collection;
⇒ Section 7: Treatment; and
⇒ Section 8: Concluding remarks and recommendations.

The report synthesises information provided by the whole team which can be found in the Annexes to this report.

A companion report also exists. That report, *'Financing and Incentive Schemes for Municipal Waste Management'*, was carried under the same contract and outlines some interesting schemes used in Member States to encourage more sustainable management of municipal waste.

2.0 AIMS AND OBJECTIVES, TASKS AND SCOPE

2.1 Objectives

The main objectives of the study, as set out in the Technical Annex were

1. To complete existing data sets on prices and costs of waste management which are needed to undertake economic analysis; and

2. To collate information on various financing models used by local authorities and national Member States with a view to diffusing best practices including an evaluation of the experiences with such systems.

The scope of the second of these objectives was expanded to include both financing and incentive based measures during the course of this study. This has been addressed in a separate report covering a number of case studies in the European Union (*'Financing and Incentive Schemes for Municipal Waste Management – Case Studies'*).

2.2 Tasks

The specific tasks, as originally specified, were:

1. To give an overview of typical costs and prices paid for the various waste treatment options for municipal solid waste (MSW) in EU15. For this purpose, the data of European Commission 1997[1] as regards total net financial cost of standard operations of MSW treatment shall be systematically updated. The data shall be refined according to the various material sub-fractions where significant cost differences exist (e.g. plastics, aluminium, etc). Additionally to these standardised operations, typical prices paid according to locally applied conditions (legislation, norms, administrative practice, etc) shall be identified. These conditions shall be described, including an analysis on the choices of various collection methods (performance and costs of bring systems, commingled versus selective kerbside collection etc). If assumptions are used, they shall be mentioned and discussed. On this basis as well as taking into account other existing information, overall figures on expenditure on municipal solid waste management, including the various fractions thereof, shall be given for the 15 EU Member States.

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[1] European Commission (1997) *Cost-benefit analysis of the different municipal solid waste management systems: Objectives and instruments for the year 2000*. Luxembourg: Office for the Official Publications of the European Communities.

2. To describe the distribution of competences, prevailing operational structures and typical financing systems for waste management in the Member States. The study shall describe the degree to which fees, charges, taxes etc, cover costs. It shall discuss issues of cross-subsidisation and the degree to which the polluter-pays-principle is applied. Schemes based on producer responsibility concept shall be described.

Estimations were to be used in the absence of available data provided that they were clearly stated as such, and based on thorough research as regards the underlying assumptions.

2.3 Scope of the Analysis

At an early stage, it was agreed that a 'systematic' approach along the lines of the earlier study was unlikely to generate meaningful results. Consequently, it was agreed that the study should seek to obtain information on 'actual' costs as far as possible. Furthermore, the study concentrates on costs, not prices (see Section 3.3 below).

The study covers all 15 EU Member States and is limited to municipal solid waste**,** including separately collected and treated waste. The focus is on collection and treatment, and principally on *household* (as opposed to *municipal*) waste. With respect to treatments, where 'recycling' is concerned, the reprocessing of materials per se has not been examined. The focus is on the collection of materials and, where possible, their preparation for delivery to reprocessors. Consideration has also been given to:

- ⇒ the costs of operating bring schemes; and
- ⇒ the costs of running civic amenity sites / containerpark schemes.

Regarding the decision to concentrate on collection of household waste, the definition of municipal waste varies across Member States. Different countries include different elements. France, for example, includes sewage sludge in the definition. For all municipalities in Denmark (which does not specifically define 'municipal waste'), all wastes are the responsibility of the municipality. Elsewhere, such as in Austria and Ireland, relatively large quantities of non-household waste are collected in the municipal fraction. The one thing common to all countries' definition of municipal waste is household waste. Concentrating on this fraction facilitates cross-country comparisons. Clearly, there may be cross-subsidising of different waste fractions collected. Where this occurs, an attempt has been made to establish this in addressing the roles and responsibilities of the different bodies in the municipal waste management system (though this is not always easy to discern).

The project asks for a statement of the situation in the 15 EU Member States. It does not specifically ask for a detailed comparative investigation of the reasons for variations in costs from one country to another. Despite this, and despite the lack of resources available for such a comparative analysis, an attempt has been made to make some comparative analysis, especially in respect of the key treatment options. This will aim to examine the hypothesis that, as regulatory standards become harmonised across Member States, the costs of certain key end of pipe treatments should converge.

3.0 APPROACH AND PROGRAMME OF WORK

The whole study was sub-divided into two tasks:

1. Information gathering (according to an established pro-forma) concerning roles and responsibilities for collection and treatment in Member States; and

2. Data gathering concerning costs of collection and treatment in Member States.

These are described below.

Towards the end of the process of data gathering, a Peer Review Meeting, attended by consultants, industry representatives and Commission officials (from various Directorates) was held in Brussels. The aim was to encourage feedback on the report as it then stood. We are grateful to those who responded with critical comments, and their contributions are acknowledged where relevant.

We have focused on the present situation. Of course, future orientations are useful to know, and to this end, members of the team were asked to comment on the factors most likely to influence future costs for the different options. It should be recognised that for specific treatments in specific countries, a good deal of upheaval is likely. This is particularly likely in respect of those countries for whom the Landfill Directive will imply significant changes in current practice.

3.1 Roles and Responsibilities

For each of the EU15 Member States, information concerning the roles and responsibilities of different organisations within Member States were sought through the completion of a pro-forma for all countries concerned.

The information sought concerned, for example:

1. Who (e.g., local authority, private sector companies, regional authority, public company, etc.) is responsible for various aspects of waste management (collection, disposal, recycling etc.)

2. Who effectively pays for each service?

3. To what extent (if any) are local authorities free to charge householders directly for waste management services? To what extent does this occur through more general municipal taxation?

The pro-forma was agreed with the team members and the Commission prior to its completion.

3.2 Cost Data

The acquisition of detailed cost data is a task altogether more difficult than that of seeking to characterise the different agents and their responsibilities in the process of waste management. It was always expected that the degree to which detailed data of this nature could be obtained would be highly variable. Hence, it was not considered appropriate to generate a pro-forma for this aspect of the work. Instead, a set of broad guidelines for the development of cost data was established.

Sub-consultants were given flexibility to generate their own information, though with emphasis on the following features:

a) Concentrate on the most commonly found collection approaches;

b) Generate the most detailed breakdown of costs possible; and

c) Especially where detailed breakdowns are not available, be completely specific as to what the cost data refers to (for instance, is this a gate fee, and if it is a 'private sector' gate fee, does it incorporate profit margins? etc.).

As will become clear, the detail in which cost breakdowns are presented varies widely across countries. In particular, we have had difficulties generating much meaningful data for Portugal, whilst in some other countries, what is reported in some cases is more akin to a gate fee than a true cost.

3.3 Gate Fees and Costs

Most studies undertaken for the European Commission have tended to seek estimates of 'gate fees' since data on the costs of different options is typically not available in any other form.[2] The gate fee paid represents a unit (usually per tonne) payment made by the local authority to the service provider to generate a stream of revenue.

It may or may not be the case that the payment made by a local authority covers the costs of treating the waste delivered by the local authority. In some cases, the local authority may pay a gate fee that is lower than the costs of service provision. This situation can emerge, for example, where:

1. the treatment facility accepts other wastes as well as municipal wastes. This presents possibilities for cross-subsidisation. Some landfills, for example, may (today) have permits (licences) which enable them to accept more problematic wastes contingent upon there being enough municipal waste material to 'buffer' the more hazardous materials. To the extent that the latter are likely to attract higher disposal fees, the more municipal waste that is accepted, the greater will be the revenue derived from the more hazardous fractions. Subject to local market conditions, this may lead to a lowering of gate fees for municipal waste below that required to cover costs;

2. in the case of 'stock' treatments (as opposed to 'throughput' treatments) such as landfills, impending legislation threatens to increase costs, and the viability of the plant beyond a specific date. In such cases, the filling of void may become a priority. This may lead to reduce gate fees so as to attract more material;

3. in the case of 'constant throughput' treatments (such as incinerators), the waste delivered under contract and in the spot market is well below the capacity of the facility. In these circumstances, especially given the capital costs of the facility, the incremental costs of additional tonnages may be close to zero. It may make sense, therefore, from the operator's point of view, to attract waste into the facility. To the extent that this requires gate fees to be adjusted downwards to reflect the increased transport costs of delivering wastes from within a larger radius, the gate fees may have to fall to reflect this; and

4. in the case where subsidies support the construction of the plant (so that effectively, the costs net of subsidies are below what they would otherwise be).

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[2] See, for example, A. Smith et al (2001) *Waste Management Options and Climate Change*, Final Report to the European Commission, July 2001; D. Hogg et al (2002, forthcoming) *Economic Analysis of Options for Managing Biodegradable Waste*, Final Report to Directorate General Environment, European Commission.

This is by no means an extensive list. The lifetime of a facility, the stage at which it finds itself in its investment cycle and the corporate strategy of the company or body owning the facility can each act either independently, or in conjunction with other factors affecting the market for waste treatment services, to encourage a reduction of gate fees below the level at which costs are covered.

Equally, gate fees may lie well above costs. Of course, operating profits are to be expected. Indeed, these are desirable for the functioning of a healthy market where the private sector is encouraged to be involved. One could go further and remark that ideally, these profits would be more aligned with the waste management hierarchy than perhaps they are. However, in certain cases, the profits generated may tend towards the super-normal variety owing to a variety of factors.

The costs of different waste management services do not form a continuum. It is still the case in many countries that landfill constitutes the cheapest waste management option (with the exception of home composting where one considers this as a management option rather than waste minimisation). Landfills tend not to exist in abundance in a given area. Indeed, as the regulation of landfills improves, they have tended to increase in size to benefit from considerable scale economies. Landfills have the potential, therefore, to act as local monopolies. Note that this characteristic of the landfill industry is made more prominent as taxes on fuel increase the costs of haulage to ‘next-nearest’ landfills. Duties on fuel are widespread in EU Member States and Applicant Countries.

In the absence of other treatment facilities, and as long as landfills are not made more numerous, the landfill may be able to charge a gate fee which is above costs as long as it is not so high as to attract new entrants (i.e. different treatment options). The discontinuity in costs of waste treatments (i.e. the ‘gap’ between the costs of landfills and the costs ‘next cheapest’ treatments) makes this possible. Note, however, that the next cheapest treatment – likely to be windrow composting of garden wastes – will not cope with all wastes. The problem might only be eliminated completely when alternative treatments exist for all wastes.

Wherever there is a capacity constraint of one or other form, similar issues may arise. This is particularly likely where the only options are ‘constant throughput’ options, and where additional capacity is required. Under such circumstances, either the treatment for which the incremental cost of developing capacity, or a more distant landfill, might be able to charge gate fees well above costs (reflecting a local ‘waste crisis’).

3.3.1 Costs or Gate Fees?

What emerges from this discussion is that although gate fees may (depending upon the nature of contractual relationships and so forth) be the factor that determines what demand is made upon the local authority budget, the degree to which one can know what this will be from one period to the next is somewhat limited. The introduction, locally, of a new facility can perturb the local market for waste management such that yesterday's gate fees are irrelevant today. The gate fee, therefore, has a greater potential to vary over time than the cost of a specific facility. This is not to say that costs do not vary across different facilities of the same type, merely that gate fees for a given facility can vary over time, even as underlying costs remain broadly constant.

In the Peer Review Meeting at which this study was presented, the issue of whether or not to make use of gate fees or costs was discussed. Several commentators felt that the gate fee was the more appropriate measure to use.

Probably, the measure one prefers depends upon what it is one seeks from the information gathered. From the point of view of determining the best options for waste management policy at the EU level, costs are the appropriate measure. This is because they more accurately reflect the resources which are required in the implementation of new waste management policies. This gives a more appropriate guide as to the resource costs to Member States of policy changes. It is not in the Commission's gift to understand the impacts in terms of gate fees, which would require understanding of what are often quite local market dynamics. Local market structures, which determine the relationship between gate fees and prices, are best dealt with by Member States.

The other merit of seeking good cost data is that the buyers of waste management services – the local authorities – frequently have little experience in making such investments. This applies especially to the more capital intense investments, which are unlikely to be made by a given municipality more than once over a period of more than a decade. It is to be hoped that the cost data in this report also helps municipalities in their quest for value for money procurement of facilities, and implementation of strategies.

This is not to say that gate fees are useless measures. On the contrary. Gate fees reveal much about market structures. But the only way to understand the significance of local market structures on prices is to understand the degree to which these prices, or gate fees, actually deviate from underlying costs. Hence, gate fee information on its own is not so revealing. Gate fees and costs, taken together, reveal a great deal about the way in which the market for waste management services behaves (or misbehaves) in the local context.

It should be recognised, however, that another problem with gate fees is that they do not always cover the same thing. For example, the way in which capital is financed varies across different treatments and Member States. If large capital items are effectively financed from central government (as, for example, under the Private Finance Initiative in the UK, or for a proportion of the costs of compost facilities in Flanders) or through, for example, the Structural Funds, the local authority may be exposed in a more limited way (if at all) to the capital expenditure required to establish and operate a plant. Gate fees in such cases might then represent only the payment required to cover operating expenditure and profit with the bill for capital effectively picked up by other bodies.

3.3.2 Costs Represented

Costs for collection and treatment would ideally be readily comparable. Detailed breakdowns across countries would allow a 'common accounting framework' to be applied, so allowing a comparison once agreement had been generated on this framework.

For financial comparisons, there was broad agreement that an interest rate of the order 5-7% was adequate (7% was used), and that depreciation periods should reflect the 'technical life' of the components being costed. As such, where detailed breakdowns are presented, the unit costs as presented here are not necessarily in line with those which might be quoted by private sector operators. They do, however, reflect the resources required to implement specific waste management options.

It is well-known amongst those close to the industry that investments can be 'written-down' much quicker by private sector operators (reflecting required rates of return on capital). Periods of 4-5 years are not unusual even for capital items with a considerable working life (20 years or so). From this perspective, the way in which private sector companies seek to recoup capital costs might even be said to be linked to wider institutional factors such as the expectations of shareholders in private sector companies in different EU Member States.

This means that:

a) Where processes are more capital-intense;

b) Where they are operated by the private sector; and

c) Where the lifetime of the capital equipment is extended,

the financial costs generated through the 'common accounting framework' discussed are likely to deviate from those which are actually quoted to Local Authorities (they will typically be lower than such quotes).

Similar issues arise in the context of land. All processes need land, and the way in which this is accounted for was anticipated to vary enormously, especially for landfill (where site acquisition may reflect strategic / historic investments), depending upon which source was being quoted.

3.4 Verification of Data Generated

Another issue raised at the Peer Review Meeting was the degree to which the data could be readily verified. This is an important question. One of the reasons for choosing to handle this project through an international team was precisely the fact that frequently, costs are not well established, and are not in the public domain. Commercial confidentiality is also frequently cited by private companies as a reason for not revealing detailed costs.

Most of those involved in the study have been working day-to-day in country on various aspects of waste management. Every attempt has been made to ensure an accurate reflection of costs. Furthermore, the Peer Review Meeting encouraged participants to comment on the work and provide more accurate figures.

That having been said, the fact remains that within a given country, facilities of similar type vary in scale, and in detailed design. As such, it is not possible to give 'unique' values for the unit costs of specific facilities. That is why readers are encouraged to look at the detailed information provided in the Annexes rather than relying on the summary Tables provided in this Main Report. Indeed, it is perhaps worth noting that to the extent that the cost data reported here might be used in future cost-benefit analyses, the following problems obviously arise in seeking to make such an attempt:

1. EU Directives, both those recently implemented, and those likely to emerge in future, will inevitably affect the costs of different treatments. Note that the relevant Directives include those affecting the energy market (especially renewable energy) and the ongoing implementation of the IPPC Directive;

2. Member State policies are also liable to change (partly due to the need to implement EU Directives);

3. The influence of scale on the costs of certain facilities is known to be highly significant. Without knowing the scale of facility likely to enter into operation, one can only estimate unit costs within certain ranges; and

4. For certain treatments, the differences in process types can itself affect the underlying costs. For example, a range of different anaerobic digestion

processes exist. The detailed cost implications of the choice of equipment are not well established (and they are certainly not made clear in this work). The same applies to compost facilities, and thermal treatment plants, though arguably less so to mass-burn incinerators.

All of these factors imply that care must be taken when using the information contained in this report and its Annexes.

4.0 ROLES AND RESPONSIBILITIES FOR WASTE MANAGEMENT

4.1 Introduction

As discussed above, all members of the team were asked to fill out a pro-forma concerning the roles and responsibilities for waste management in the Member States for which they took responsibility. The completed pro-formas are given in full in Annex 1.

4.2 Key Observations

Table 1 summarises some key aspects of the roles and responsibilities work. It is notable that in several countries, municipalities are grouping together in intermunicipalities or waste associations to approach waste management on a joint basis. It is important to recognise that the size of local authorities varies considerably across Europe. France has 35,000 communes whilst the UK, with roughly the same population, has around 400 local authorities. On average, the commune would be one-hundredth the size of the average local authority. As such, the ‘need’ to collaborate in larger units varies across countries.

It is also quite clear that private sector involvement differs across countries. At the European level, it can probably be said to be increasing, but there is no firm one-way trend in all countries.

It is quite clear that the way in which Member States implement Producer Responsibility legislation affects local authorities in different ways. In some countries, responsibility for the different fractions is given over completely to specific organisations (Austria, Belgium, Finland, France, Germany, Luxembourg and Sweden) so that the municipalities are not paying for this collection. In others (France, Ireland, Italy and Spain), the local authority receives a payment but this does not cover the total collection cost.

In other countries (Denmark, Greece, Netherlands and the UK), there is no direct funding of the collection of packaging fractions. In Denmark, however, all municipalities are required to instigate either kerbside or bring collections for paper and glass. The agreement between VNG (the association representing municipalities) and the AOO (the Waste Management Council of the Netherlands) requires local authorities in the Netherlands to seek to meet high rates of recycling for packaging. In the UK and Greece, however, there are no such compulsions, although in England, statutory recycling targets for each local authority have been established.

The arguments concerning the relative merits of different approaches is somewhat complex, but the question of who actually collects the material and how is an important one. Where collection systems become fragmented (through introducing responsibilities upon specific actors for specific material), this can increase the costs of collection systems.

Table 1: Summary of Key Aspects of Roles and Responsibilities

Country	Key Municipal Actors	Extent of Private Sector Involvement	Examples of Fees Which are Not Paid by Municipalities	Variable Charging
AU	Municipalities Waste associations	Residual waste collection – 50% Recycling 80% Composting – 50% Increasing in residual waste management	Packaging collection	Widespread, usually on basis of volume emptied
BE	Municipalities Intermunicipal waste associations Net Brussels	Collection and / or treatment frequently contracted out to private sector. In Brussels, the activity is carried out by a public sector body, 'Net Brussels'	Packaging Batteries WEEE	Widespread and increasing
DEN	Municipalities Intermunicipal waste associations	Collection – 80% Landfills – and most incinerators are in public hands	None	10% of authorities, usually weight-based Some others charge for 'additional bags' Some reduce fees for home composting
FIN	Municipalities and co-operative municipal waste management companies	Municipalities are the more dominant in collection Private sector industry owns co-incineration and some other treatment plants	Kerbside paper Bring scheme bottles and cans	Volume-based charging on residual waste
FRA	Communes (and groupings) Départements Sometimes, is the responsibility of the former, treatment with the latter	Opex and capex for 28% of treatment Opex only for 50% collection, 54% treatment	Payments from Eco-emballages and Adelphe for packaging (and for courier non-addressé mail	14% of population on waste related fees in 1996. Mostly volume based, some weight based
GER	Municipalities	No split on collection Few landfills Some incinerators Contracts through DUALES system	Packaging (Green Dot) Batteries	Widespread – by volume, or amount of waste and sometimes also on chosen frequency of collection
GRE	Municipalities Association of municipalities	Limited role in collection and transport No recycling	None	No variable charging
IRE	Municpalities	Swift movement from public to private sector in collection and treatment Most recycling schemes Collection – 40%	Packaging (part subsidised by REPAK)	Variable charging being piloted Tagged bags, volume and weight based systems though without recycling infrastructure
ITA	Municipality Ambito Territoriale Ottimale	Collection – estimated 46% of municipalities (lower in South, higher in North) Treatment mostly in public hands	Payments from CONAI for packaging waste (though not covering all costs)	Will be compulsory - becoming more widespread – sometimes tags, sometimes 'average weight'.
LUX	Municipalities Intercommunal Syndicates	Some involvement in an incinerator and in composting Some involvement in collection	Valorlux carries out packaging collection	Compulsory – mostly volume-based, some weight based
NL	Municipalities Independent publicly owned companies	Collection – 33% Little involvement in treatment for residual waste More involvement in biological treatment	None	21% of authorities involved in DIFTAR schemes. Volume and volume / frequency are most common
POR	Municipalities	Involvement in treatment especially (level not known)	Payments from SPV to cover multi-materials collection	None
SP	Municipalities Autonomous regions Public companies	Involved in recycling collection (usually from bring sites) No clear split on collection	Glass and paper from bring sites	None
SWE	Municipality	Collection – 60%	Packaging materials	About 5% of municipalities, mainly based on size / amount of containers, some based on weight
UK	Municipalities (divided into waste collection authorities and waste disposal authorities)	Collection – approaching 50% private (some recycling in 'not for profit' companies) Treatment – almost all private sector (some community	None	Not permitted by law

Country	Key Municipal Actors	Extent of Private Sector Involvement	Examples of Fees Which are Not Paid by Municipalities	Variable Charging
		level composting, and some landfills still owned and run by public sector)		

Variable charging also varies in its extent across countries. There is a clear trend for this to increase in most countries. The only exception as regards countries which have implemented such systems appears to be Denmark (for weight-based systems for residual waste).

In other countries where variable charging has been implemented, it would appear that any disadvantages of the system are perceives to be outweighed by the advantages. Hence, the approach is to become compulsory in Italy. The UK appears to be exceptional in effectively forbidding variable charging by law.

5.0 COSTS OF COLLECTION AND TREATMENT: INTRODUCTION

To the extent that this analysis is intended to be of utility to those carrying out economic analyses for the Commission in future, there are reasons to believe that some sort of ‘road map’ is required to help to understand the significance and applicability of what is being reported here. In addition, although no resources were made available for this purpose in this project, we have sought to undertake some comparative analysis through summary Tables for key treatments. These are intended to help provide an overview of the Section which follows, which provides more detailed estimates of the costs of different collection / treatment options across countries.

Waste management operations should be viewed as ‘more-or-less integrated’ systems of collection and treatment. Within the considerably varied spectrum of systems in existence, however, one finds varying degrees of fragmentation in the collection system, and for obvious reasons, this has implications for the manner in which waste is treated following its collection. Key questions are:

- **Which materials are collected separately?** Relevant issues here include, for example:

    a. the manner of Member State implementation of the Packaging Directive[3] (does this ‘fragment’ collection efforts?);

    b. the extent of Member State Producer Responsibility initiatives / mandating of Local Authorities;

    c. the treatment options available for residual waste. Some Member States (Netherlands, Flanders and Denmark) have banned the landfilling of most municipal wastes whilst others are implementing such bans (Finland) and Austria and Germany require landfilled waste to be pre-treated through stabilisation (mechanical biological treatment) prior to landfilling. The locally available capacity for incineration may also influence decisions as to what materials to collect and how; and

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[3] Argus, ACR and Carl Bro (2001) *European Packaging Waste Management Systems*, Final Report to European Commission DG XI.E3, February 2001.

d. the relative costs of different treatment options available (where residual waste treatments are more expensive, the incentive to collect fractions separately for reprocessing will be greater). Waste taxes and landfill taxes, and schemes such as the Wallonia residual waste levy will clearly have an influence here;

- **How are they collected, and how does this affect collection of residual waste?** Relevant issues concern:

  a. the selection of the collection approach (bring or doorstep / kerbside collection);

  b. the degree to which vehicle choice is matched to the relative bulk densities of different materials;

  c. the degree to which the frequencies for collection of the different fractions can be altered in a new, cost-optimised scheme (especially likely in the context of collections of kitchen and garden waste); and

  d. the degree to which one can capitalise on the cost-optimising possibilities afforded by diversification of vehicle fleets.

- **How effective are schemes at capturing the targeted materials?** Relevant issues here are:

  a. the convenience of the collection scheme for householders to participate in;

  b. the role played by education / scheme promotion in encouraging householder participation;

  c. the role of mandating (of householder participation); and

  d. incentives such as pay-as-you-throw, or variable charging schemes in encouraging householder participation.

The diversity of collection strategies still in existence across Europe, and the range of performance in separately collecting fractions of municipal waste, suggests that collection systems are likely to enter a period of considerable change as separate collection of waste begins to be pursued more vigorously.

Local circumstances clearly influence the strategy adopted (as indeed, they should) but the difference in approach and performance regarding the quantity of separately collected material suggests that a number of factors influence the degree to which local authorities provide services enabling separate collection, and the intensity with which local authorities seek to encourage householders to separate their wastes (reflected partly in the convenience of the systems implemented). For example, whilst Flanders separately collects 62% of its municipal waste, other Member States are either still in, or only just out of, single figures in this regard.

As collection systems change, so will the treatment options. The challenge for those just beginning separate collection strategies is to ensure that treatment options are sufficiently flexible to allow the development of separate collection without compromising the value of fixed investments. In this context, landfill (as a ‘stock’ treatment, rather than a fixed throughput treatment) has strategic value and it may be that Member States seek to make use of remaining void space in this way (possibly, in conjunction with mechanical biological pre-treatment to reduce potential for methanogenesis and preserve void space). Specifically, landfill does not suffer from the same inflexibilities as incineration.

For those Member States / regions who are further advanced, the issue is becoming one of how best to treat residual wastes in an environmentally friendly way, possibly using different treatments for different fractions according to their physical / chemical / biological properties. In future, this is likely to result in separated fractions being recycled (metals in residual waste), biologically treated (subjected to composting or anaerobic digestion processes), and sent for thermal valorisation (RDF, pyrolysis, gasification).

For all Member States, the key lies in matching the development of collection systems to the treatments for separated and residual fractions. This is what must be implied by integrated waste management (rather than simply reference to the end treatments). It is the potential of the system as a whole – collection and treatment – to retain flexibility to dynamic changes in system performance, changing waste composition and changing treatment costs.

It is important to recognise that this piece of work cannot capture all the workings of the dynamics. It can shed light upon some of the component costs when such systems are implemented. It could be argued that it makes more sense, in seeking to understand waste management costs (and how these ‘build up’), to make reference to specific systems rather than to system, components. On the other hand, this probably makes any comparative analysis less straightforward.

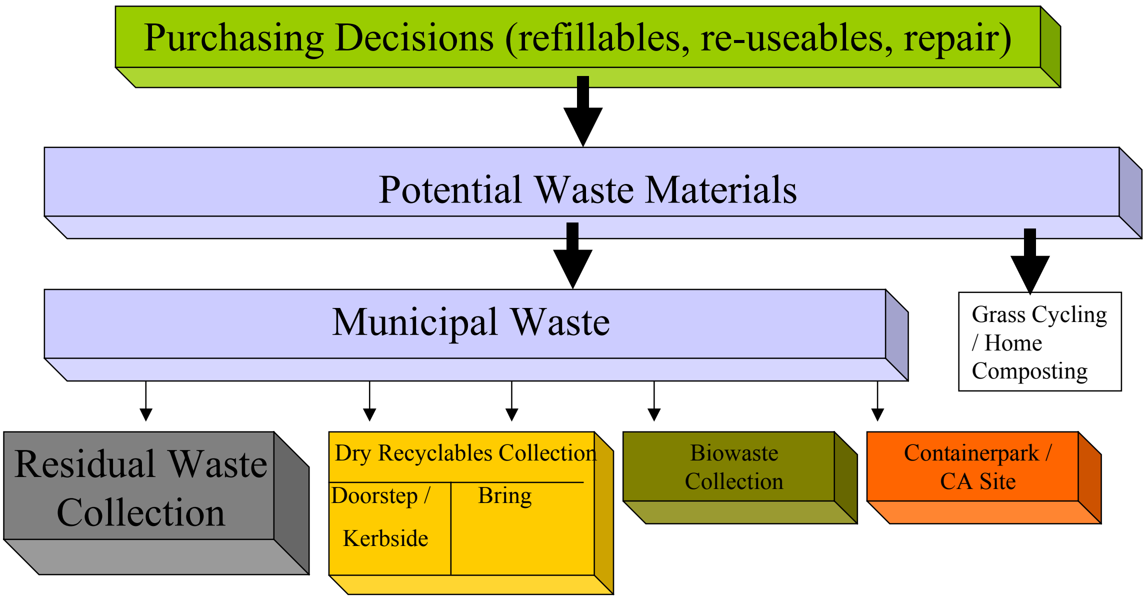
6.0 COLLECTION

6.1 Introduction

The costs of waste collection have typically been reported in the past in terms of a per tonne cost for residual waste and / or for different materials. Very little work has been undertaken in seeking to establish cross-country data for the costs of separate collection of biowastes. It is important to have in mind the observations made in the preceding section as one seeks to understand the significance of the different components of a waste collection system.

Waste collection should be considered as ***a system***. What happens in one part of the system affects not only what happens at the treatment end, but also, other components of waste collection. Consider a stylised representation of waste collection systems in Figure 1 below.

Figure 1 Stylised Representation of Collection System



There are a number of issues that arise when different components of the system are in place:

1. Collection of dry recyclables reduces the quantity of residual waste collected. This should reduce total costs for residual waste collections as rounds are re-optimised (to reflect lower quantities collected per

household). In pay-as-you-throw schemes based upon payments for a specific number of 'emptyings', the frequency at which waste is set out, or the size of the container chosen, may fall. Variable charging can assist in the monitoring of this process. There are also savings on residual waste treatment. Variable charging / education / promotion increases materials capture so increasing the potential savings. Whether this reduces the costs of supplying the total service will depend (for reasons discussed in the previous Section) on which additional materials are being captured and in which proportions. The frequency of residual collection is likely to remain as before where only dry recyclables are being collected. The same is true where garden wastes are separately collected at bring schemes / CA sites / containerparks since the most fermentable fraction – kitchen waste – is not being collected separately.

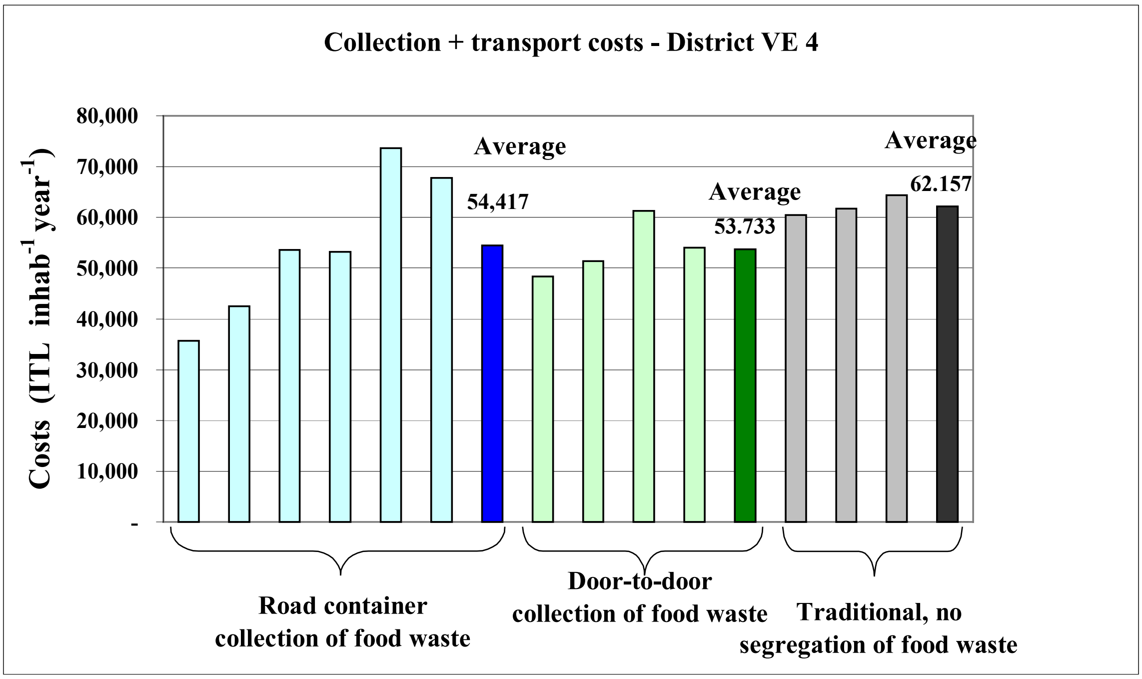
2. Collection of biowastes also reduces the quantity of residual waste. However, in addition, collection of biowastes, and specifically, kitchen wastes, reduces the potential for odour and nuisance in the residual waste stream and facilitates a reduction in the frequency of residual waste collection. Hence, the costs of residual waste collection can fall significantly where kitchen wastes are collected (especially where frequency of residual waste collection is high as in Southern Member States). However, collection of garden wastes (as well as kitchen wastes) may reduce grass-cycling and home composting whilst also reducing use of CA sites / containerparks. The most efficient schemes will tend to target kitchen waste only, making use of compactors unnecessary (because of high bulk density of kitchen waste) and thereby not discouraging home composting / grass cycling. This, as well as reduced frequency of residual waste collection, makes it possible to introduce separate collection of biowastes at no additional cost to the total collection system (see Figure 2 below).

This last point is especially important when seeking to make use of the results of this work. The degree to which collection costs are 'additive' has to be considered in the context of the specific system and the actions being undertaken.

One approach which would potentially make these issues more transparent when considering policy changes and / or the cost implications of changes in waste strategies would be to look at the incremental costs of specific interventions in specific systems. However, to do this across all Member States would require considerable resources. To do so in the hypothetical sense would merely reinforce the points that have already been made.

To summarise, there is no straightforward way of understanding the costs of collection systems other than in the local context in which they apply. This is perhaps an explanation for, as much as it is a consequence of, the variety of collection approaches adopted across Member States. Indeed, this is one of the most significant observations in this study – that the diversity of approaches in place (with respect to the presence of separate collection facilities, the prevalence of kerbside / doorstep collections relative to bring schemes, the approaches to capturing different materials, etc.) is still enormous. There would appear to be considerable scope for optimisation of system costs. This could generate significant reductions in cost to municipalities, and hence, householders.

Figure 2 Collection Costs for Different Systems in One Italian District



Source: E. Favoino (2001) The Optimisation of Source Separation Schemes for Food Waste in Mediterranean Districts, Paper presented to the Lisbon Conference, March 2001.

On a pessimistic note, one could make the point that many Member States are simply not following the most basic prescriptions for the development of municipal waste strategies in the EU. Frequently, cost is sited as an obstacle to such development (especially where treatment costs are low). On the positive side, there is evidence of rapid development of source separation both at the level of individual municipalities and at the regional level. Many Italian communities have rapidly developed rates of source separation in excess of 50% (some above 70%). Flanders, in Belgium, progressed from 18% in the early 1990s to 62% in 2000.

6.2 What is the Best Measure of Costs?

At the Peer Review Meeting, one view put forward by the team in this study was that the typical indicator of costs for collection – 'costs per tonne' – was misleading. This is especially true in the case of residual waste collections.

Consider the following: it is cheaper to collect residual waste where it arises in larger quantities per collection point than in cases where each collection point delivers only a small quantity of the same material. The costs per tonne will be far lower in the former case where more of the same material is collected more quickly and in moving a shorter distance.

Where collection schemes look to separately collect materials dry recyclables and materials for composting, and where they also seek (through charging mechanisms, encouraging home composting etc.) to reduce the overall quantity of material collected, it is highly likely that the amount of residual waste collected per household will fall, often quite dramatically over short periods of time.

The per tonne costs for residual waste collection in such cases may be higher than in the case where no attempt is made to reduce the residual waste collected per household.

Similarly, in terms of total collection system costs, per tonne costs can mask the benefits of certain approaches which deliberately set out to ensure that the waste collected in the collection system is kept to a minimum. The per tonne costs may well be lower in cases where more waste is collected per household.

6.3 Residual Waste

The costs for collecting residual waste exhibit some variation across countries. This is shown in Table 2. Detailed breakdowns are given in Annex 3. Variation is likely to reflect:

- Variations in the typical situation in respect of the number of passes (collection points passed) per unit of time (the higher this is, the lower the cost - this is not simply an issue of population density, though this has an effect, since it is affected by factors such as traffic);

- The nature of the setting out of residual waste and the costs of containers used (in some systems, resident purchase bags / bins, in others, these are included in scheme costs);

- Variation in the quantity of residual waste collected per collection point (the lower the collection, the higher the per tonne cost), which, is affected by:

    - as discussed above, the rate of source separation (effective source separation reduces the residual waste set out);

    - the nature of containers used for collection; and

    - what householders are 'allowed' to put in the container for collection (e.g. is garden waste excluded? Is 'side waste' collected?).

- The vehicles used (and their maximum payload – as long as vehicles are not completing rounds half-empty, larger vehicles can reduce costs);

Table 2 Comparative Costs of Residual Waste Collection in Different Member States (€/tonne)

	Costs (€/tonne)			**Costs (€/hhld)**			**Frequency**
	Low	**High**	**Best Est.**	**Low**	**High**	**Best Est.**	
AU			70				Every two weeks, sometimes more frequent in summer
BE F Br	58	92	75 56	14	22	18	Mostly every two weeks, sometimes weekly
DK			126			62	Weekly
FI	15 (urb)	32 (rur)		17 (urban)	37 (rural)		Weekly, biweekly or monthly per household depending route or area (excludes container costs at household)
FR	54 (urb) 63 (rur)	65 (urb) 74 (rur)	60 (urb) 70 (rur)				e.g. Five times a week in urban areas e.g. Twice a week in rural areas
GE	39 (urb) 48 (rur)	81 (urb) 91 (rur)	67 (urb) 71 (rur)			30 (urb) 40 (rur)	May be every two weeks, weekly in summer months. Lower costs likely to be for biweekly collections
GR	25 (urb) 40 (rur)	36 (urb) 67 (rur)	30 (urb) 55 (rur)			32 (urb) 57 (rur)	Ranging from daily for some urban areas, weekly for some rural. Lower per tonne cost for larger settlements
IR	60	70	65	70	80	75	Weekly
IT	48	255	75	15	45	25	Varies – weekly or twice weekly in cost optimised systems collecting food waste (costed here), may be three or four times daily in some areas with no food waste collection
LUX	85	104	85				Every two weeks
NL	75	123	100				Weekly
PO			45[e]				
SP	19	91	60	10	43	25	Likely to be daily in urban areas
SW	59	80	65				Every two weeks in single family houses, weekly in urban areas with multi-occupancy buildings
UK	32 (urb) 50 (rur)	50 (urb) 80 (rur)	42 (urb) 60 (rur)	24 (urb) 38 (rur)	38 (urb) 60 (rur)	31 (urb) 45 (rur)	Usually weekly – a few local authorities alternate residual waste collection with collection of biowaste (fortnightly)

[e] *Estimate*

- Labour costs (these vary with the number of operatives, itself affected by the nature of the are in which collection takes place, and with unit labour costs in country). Note that labour is an important component of collection costs, but relatively much less so in the case of treatments;

- The frequency of collection, related to the nature of the housing stock, the collection mechanism, the climate, and most significantly, the presence or absence of food waste / biowaste collections; and

- The sophistication of the collection equipment (for example, are vehicles equipped with on-vehicle weighing systems, or other computational equipment designed to record emptyings of containers?).[4] It is not clear to what extent this has been captured in the reporting of costs.

The reported costs do not generally include transport other than for returns to a depot, or similar movements (Annexes 11 and 12 contain some information regarding transfer stations and bulking and baling facilities). This means that where the ultimate destination of material is some distance from the point of the collection, costs for collection *and* transport may be somewhat higher. It seems likely that this will be more likely where landfill is the main outlet for residual waste (since where incinerators are concerned, the 'depot' is sometimes also the site of the facility).

There is no obvious pattern in the costs which emerges. Certain countries have lower costs per tonne, but these are not necessarily a reflection of low labour costs for the reasons discussed earlier. It should be pointed out, however, that labour costs are typically a substantial fraction of collection costs (frequently of the order 50%). On closer inspection, there does seem to be some confirmation of the thesis which was posited above. That is to say, the variation in per tonne costs is somewhat less than the variation in costs per household. Those countries with lowest per tonne costs are likely to be those which collect higher quantities of residual waste per household. Hence, the per tonne and per household figures are more similar than in cases where the per tonne cost may be higher due to lower deliveries of residual waste per household.

Both per tonne and per household measures are useful, but concentrating on the one without the other (as has been done in the past) gives an entirely false respresentation of the situation. To claim that those with lower per tonne costs are performing better is tantamount to condemning separate collection systems which are likely to increase the per tonne costs of residual collection. This is clearly

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[4] It is, perhaps, debatable as to whether one should attribute such costs to the residual waste collection system. The rationale for such equipment is actually to minimise the delivery of material into this part of the collection system. This serves to highlight the systemic nature of collection systems.

shown in a comparison between Brescia and Monza in Italy in Tables 3-5. In the former, as a comparison of Tables 3 and 4 reveals, the road container scheme leads to high captures of waste, especially residual waste, and lower specific costs for the residual waste fraction. However, this lower specific costs for residual waste is higher when expressed in 'per inhabitant' terms. Indeed, as Table 5 shows, the Monza system, with much higher rates of source separation, costs less when expressed in terms of the cost per inhabitant.

Table 3: Collection Schemes and Costs in Brescia, 1999

Collection scheme	Residual waste	Food & Yard Waste	Paper & Board	Glass & Cans	Plastics	Wood
Road containers (2.4- 3.2 cu.m)	X	X	X	X	X	
Doorstep collection		X	X	X		
Civic amenity site			X			X
Collection Frequency (times per week)	6	3	1	1	3	-
Specific capture kg/inh/yr	466	38.20	58.73	21.06	1.01	15.78
Collection cost €/inh.yr	31.37	9.78	4.21	2.03	0.56	0.54
Collection cost €/kg	0.07	0.26	0.07	0.10	0.55	0.03
Treatment costs - incomes €/inh.yr	25.33	2.98	-0.61	-0.33	-0.11	-
Treatment costs - incomes €/kg	0.05	0.08	-0.01	-0.02	-0.11	-

Source: ASM Brescia. Not including road sweepings

Table 4: Collection Schemes and Costs in Monza, 1999

Collection Scheme	Residual waste	Food Waste	Paper & Board	Glass & Cans	Plastics	Wood & Yard Waste
Bagged or packed at the doorstep	X				X	
bins or buckets at the doorstep		X	X			
Road containers				X		
Civic amenity site			X	X	X	X
Collection Frequency (times per week)	2	2	1	1	1	-
Specific capture kg/inh/yr	228	63.13	51.46	33.39	9.33	38.16
Collection cost €/inh.yr	18.53	7.86	13.02			
Collection cost €/kg	0.08	0.12	0.01			
Treatment costs - incomes €/inh.yr	33.04	6.70	-0.35	-0.09	-	0.38
Treatment costs - incomes €/kg	0.14	0.11	-0.01	0.00	-	0.01

Source: Ufficio Ecologia Comune di Monza. Not including road sweepings

Ironically, if the whole system costs were expressed in ‘per tonne’ terms, the Monza scheme would appear more expensive (€89 per tonne of material collected as opposed to €75 per tonne in Brescia). Few would disagree that the Monza scheme is far superior on virtually every count ***except*** cost per tonne.

Significantly, a growing number of countries appear to be seeking to reduce the frequency of residual waste collection. This is especially true of those situations where putrescible wastes are collected separately, either in a highly targeted way as in some Italian municipalities, or in a more general biowaste collection as in much of Central Europe (Au, Be (Fla), Lux, NL, Ger).

Table 5: MSW Management in Different Italian Towns, Key Statistics

Town	Pop.	Overall MSW Production kg	Specific MSW Production Kg/inh.yr	Source Separation Rate kg/inh.yr	% Source Separation Rate	Collection & Transportation Cost €/inh.yr
Monza	**119,172**	**55,249,541**	**464**	**236**	**50.91***	**41.61**
Mantova	48,288	29,898,808	632	198	31.27*	60.40
Brescia	**190,909**	**126,350,000**	**656**	**189**	**28.81***	**49.47**
Modena	176,022	97,757,000	555	126	22.70*	35.96
Parma	168,717	88,711,000	526	71	13.45*	37.15

Source: Uff. Ecol. Comune di Monza, TEA Mantova, Ass. Ambiente Comune di Brescia e Parma, META Spa Modena

6.4 Dry Recyclables

The wisdom of reporting the costs of collection per material is questionable. The costs of separately collecting dry recyclables in a given location depends upon:

- **The approach used (for obvious reasons).** Typically, bring schemes involve lower outlays than doorstep ones, though it is generally accepted that the implied inconvenience makes it impossible to achieve such high captures as with doorstep schemes. Furthermore, greater problems of contamination are likely. Further distinctions, among the kerbside / doorstep schemes, can be made according to the range of materials collected, the vehicle used for collection (is it collected on the same collection vehicle as residual waste, and if so, is collection at the same time?), the degree of separation required post-collection etc., as well as collection frequency;

- **The composition of the municipal waste stream and the relative capture rates of the different materials targeted.** For example, in a scheme where paper was being collected along with plastics and other materials, one would expect collection costs to be especially high where the composition and capture rate for plastics was relatively high, whilst the capture of the more dense materials was relatively low. Whatever the rate of vehicle compaction (where compaction was used), this would lead to smaller collection weights per vehicle and higher costs. Equally, where materials are collected as individual fractions, the costs of collecting fractions with lower bulk density (such as plastic and cardboard) and/or which account for small proportions of the waste stream (such as plastics and cans) will tend to be much higher than those for paper and glass.

As such, the costs of collecting different fractions of the waste stream in a given location depend upon how they are being collected, what is being collected along with them, and the relative capture of the different materials in the collection approach. The last two of these are likely to change over time so in truth, what is reported is really a snapshot of what is a dynamically changing picture. Across locations, other factors, such as the number of vehicle passes achievable per day (which is related to local population density), also have an impact.

It is generally not the case that collection of dry recyclables affects the collection frequency of residual waste, although its presence can ensure that the residual waste and kitchen / yard waste fractions are of similar magnitude (in some cases, removing the need for re-design of collection logistics). As such, the collection costs of dry recyclables are more likely to be additional to the costs of residual waste collection. On the other hand, some collection approaches use the same vehicle to collect co-mingled dry recyclables and residual waste on the same collection round. This can reduce any additional costs associated with collection. However, it typically limits the range of materials which can be collected and makes post-collection handling and separation potentially more costly and less efficient (reject rates for materials may be quite high).

It should also be recognised that reporting collection costs independently of the required costs of sorting (related to the collection approach adopted) is likely to be misleading. For example, in the UK, the debate continues around whether collection of dry recyclables in co-mingled form for separation at a MRF is superior to those systems in which in which separation takes place on vehicle (requiring no subsequent sorting).

Clearly, comparing the total costs of only the collection favours one system rather than the other (since the former requires sorting equipment). Furthermore, the approach to collection may affect materials quality, as well as the proportion of each tonne of material collected which is delivered to reprocessors. Consequently, net revenue from materials sales / treatment of rejects depends upon collection approach.

Table 6 shows a summary of costs. More detail is given in Annex 4 (kerbside schemes) and Annex 6 (bring schemes). It should be pointed out that the term ‘bring schemes’ covers a range of possibilities. It could imply road-container schemes for waste collection, or small numbers of discrete collection vessels aimed at capturing materials, through to recycling parks and container parks / civic amenity sites. All of these are 'bring' schemes. They have differing cost profiles. Furthermore, the relative significance of kerbside to bring schemes in collecting recyclables varies considerably across the EU.

The cost figures do not include revenues.

Table 6 Comparative Costs of Dry Recyclables Collection in Different Member States (excl. revenue)

	Approach	All Paper	News/Mags	Card	Glass	Textiles	Cans	Plastics	Packaging
AU	Centrally/ kerbside	€74/t							
	Central depots (separated)				€48/t				
	Bring / containerpark					€190/t			
	Central depots						€296/t		
	Central depots / kerbside								€298/t
BE	Door-to-door	€44/t (all BE, from FOST Plus)			€97-194/t				€169-184 /t (from FOST Plus)
	Door-to-door	€61/t (Fl), €100/t (Bru)[5], €61/t (W)							€194-359/t (Fl)
	Door-to-door								€100/t (Bl)
	Door-to-door								
	Door to Door								
	Bring				€48/t (FOST Plus)				
DK	Door-to-door	€21.50/hhld for monthly dry recyclables collection in plastic bags, estimate €100-180 / t (depending upon capture rates); €15/hhld for paper							
	Recycling centres								
	Bring banks	**Glass €3.4 per hhld, €91/t; Paper €4.7/hhld, €74/t**							
FI	Co-collection with residual	Incremental costs of collection small w.r.t residual waste collection (weekly to monthly)							
	Separate door to door	Weekly to monthly collection of co-mingled dry recyclables estimated at €78/t							
	Drop-off centres	€108/tonne for mixed recyclables (incl. profit of operator)							
FR	Door-to-door (urb)	All materials except glass and textiles – twice weekly - €111-133 / t @96kg/hhld/yr or €12 - €14 / hhld							
	Door-to-door (rur)	All materials except glass and textiles – weekly - €171-202 / t @ 144 kg/hhld/yr or €24-29 / hhld							
	Bring	€30-35/t for glass containers							
GE	Door-to-door	€125/t for packaging paper[1]			€70/t[1]				€250-300/t €575/t for lightweight packaging [1]
GR	Road containers (voluntary)	Mixed recyclables €59/t							
IR	Kerbside, box scheme	Packaging and glass €19/hhld (incl cost of sorting at MRF)							
	Kerbside wheeled bin	Non-plastic packaging and newsprint €51 /hhld (incl cost of sorting at MRF and subsidy from REPAK)							
	Kerbside clear bags	Packaging and newsprint €38-51 /hhld (incl cost of sorting at MRF)							
	Kerbside box	Packaging and newsprint €65-96/hhld (sorted on vehicle)							
	Bring	Estimate for collecting glass and aluminium from banks €63.5/t							

5 The figure of 100€ for collection of paper in the Brussels Region is based on a calculation that takes into account only the labour cost for doing the collection. The collection cost of packaging waste in the Brussels Region was calculated in the same way.

	Approach	All Paper	News/Mags	Card	Glass	Textiles	Cans	Plastics	Packaging
IT	Door-to-door Road containers	€30-125/t €2.5-4/hhld €90-150/t €1.5-3/hhld			With cans €50-70/t €1.7-3/hhld €20-40 €.4-1.3/hhld		With glass €50-70/t €1.7-3/hhld €20-40/t €.4-1.3/hhld	€300-750/t €1.5-6/hhld €230-500/t €1-2.5/hhld	
LUX	Door-to-door Containers Recycling centre	€139-146/t €82/t €60/t			€139 €32 €7			€81	
NL	Door-to-door Bring Post-incineration recovery	€40/t[2]			€27/t		€73/t (steel)		
PO[3]	Road Containers	€60/t (packaging)			€39/t		Steel €125/t Alu €964/t	€803/t	
SP[3]	Road Containers, Urban Road Containers, Semi-urban Road Containers, Rural	€40-60/t €50-70/t (paper and card packaging only)			€30/t €40-50				€180/t €200/t €270/t (light packaging)
SW									
UK	Door-to-door, on-vehicle sep Door-to-door, co-mingled Bring	€130-200 for mixed recyclables, higher end represents systems collecting plastics Incremental costs low w.r.t. residual waste (costs of bags equivalent to approx €20 per tonne annum) €50-80 / t for paper / glass							

Notes:

[1] The figures reported are those from the Duales system and include sorting

[2]This figure is from Stichting PRN, the body established in the wake of the agreement of the paper and fibre sub-covenant of the Netherlands Packaging Covenant.

[3]These are not the full costs but represent payments made by packaging bodies (Pont Verde in Portugal and Ecoembes and Ecovidrio in Spain)

There is not much that one can say in terms of generalisations regarding the Table above that was not already known. Less dense fractions are cheaper to collect, and generally, kerbside / door-to-door systems are more expensive to run than bring schemes / road containers. However, it is generally accepted that the potential to deliver high rates of diversion from the residual waste stream is reduced where the scheme is reliant upon bring approaches, with glass being the exception in some countries. Furthermore, kerbside schemes would appear to reduce the likelihood of evasion (through dumping / fly-tipping) when pay-as-you-throw schemes are introduced (because the means to reduce exposure to waste charges is readily available).

The collection costs for fractions such as glass, paper and textiles are typically in the same area as those for residual waste. Light packaging materials – plastics and cans - are typically much more costly to collect although for some UK schemes and for Brussels, the costs are not so high (of the order €100 and below). The UK system to which this cost estimate applies would certainly require investment in post-collection sorting, implying additional costs. Elsewhere, the costs vary between €200-300 for the packaging and plastics fractions.

6.5 Sorting Facilities

The degree to which sorting facilities are required, and the complexity of their design, depends upon the nature of the collection system in place. There is considerable variation in approaches to the collection of materials separated at source, and so, the requirement for sorting varies across, and within countries. Further complicating matters is the fact that for a given operation, facilities of differing capital intensities can be designed.

The requirement for sorting facilities linked to collection increases as:

1. The number of materials co-collected in any one round increases;

2. One seeks to direct more materials to higher quality markets. So, for example, if ‘paper and card’, including packaging papers, newsprint, magazines, graphic papers and cardboard are all collected together, it may make sense to deliver this ready-sorted to reprocessors to capture added value through separation into different paper grades. On the other hand, certain uses of mixed (colour) cullet are now emerging (e.g. road surfacing) which require less separation of glass fractions;

3. The ability of end-users to segregate materials is more limited. For example, it may make sense to co-collect cans and plastic if plastics reprocessors are able to sort metals from the mix. Effectively, this will

reduce the value of the materials delivered by the local authority as the materials separation is undertaken by reprocessors. The same type of process may occur for mixed cans (e.g. aluminium and steel);

The second and third points reflect the fact that in some cases, there is not so much a reduced requirement to sort per se, more that the point at which sorting is undertaken depends upon the market for materials and the equipment of the reprocessors.

Clearly, those countries relying heavily on bring schemes / recycling parks / containerparks and civic amenity sites will have less requirement for sorting. Similarly, door-to-door approaches which either target specific materials (or small ranges) on each collection round, or which separate materials on-vehicle, have little or no requirement for separation equipment. Indeed, the desire to avoid such investments may be important in determining the collection approach.

Information obtained is given in Table 7 (further details are given in Annex 9). Note that in some cases, costs are for mixed fractions. This reflects the fact that disaggregation by material is difficult. However, typically, the costs of sorting equipment depend upon volume. Thus, materials with a higher bulk density incur lower costs per tonne for separation. It tends to be mixed, light packaging fractions which incur highest costs. For this reason, in some countries (e.g. the Netherlands, where this is reflected in the paper and fibre sub-covenant of the packaging covenant), the approach to collecting paper packaging is to collect all paper together (packaging as well as other paper and card fractions) in a single collection rather than mixing this with other packaging materials.

Table 7: Unit Costs for Sorting Waste Materials

<table>
<tr><th>Country</th><th>Austria</th><th>Belgium</th><th>Finland</th><th>France</th><th>Germany</th><th>Ireland</th><th>United Kingdom</th></tr>
<tr><td>Material</td><td></td><td></td><td></td><td rowspan="5">For mixed recyclables excl. glass €183-€229/t</td><td></td><td rowspan="5">€127/t</td><td rowspan="5">€30-66/t excl. glass</td></tr>
<tr><td>Paper</td><td>€28/t</td><td></td><td></td><td></td></tr>
<tr><td>Plastics</td><td>€272/t</td><td></td><td></td><td></td></tr>
<tr><td>Glass</td><td>€14/t</td><td></td><td></td><td></td></tr>
<tr><td>PMD</td><td></td><td>€193</td><td></td><td>Light packaging €250/t</td></tr>
<tr><td>Optical sorting - separation of energy bags or compost bags from residual waste</td><td></td><td></td><td>€8/t</td><td></td><td></td><td></td><td></td></tr>
</table>

6.6 Revenues for Materials Collected

In theory, one would expect revenues received for collection and delivery of materials to be relatively homogeneous across the EU (with adjustments for quality). Markets for secondary materials are increasingly globalised. This has long been the case for paper and aluminium, and it is becoming more true of steel and plastics. The situation regarding glass cullet is perhaps more one which is affected by local market conditions.

Yet the way in which municipalities (or those acting on their behalf) are remunerated for the service they carry out is now intimately affected by the implementation of the producer responsibility aspect of the Packaging Directive within Member States, as well as other producer responsibility agreements in specific Member States.

In Table 1 above, it was noted that the costs of collecting certain materials are not borne by municipalities in all countries either because the collection itself is taken over by third parties, or because payments are made to municipalities in respect of their undertaking collection. Hence, for those countries where producer responsibility has a more ‘direct’ application (i.e. third parties take over parts of waste collection, as in Germany), the issue of ‘revenue’ from materials collected does not arise as an issue for municipalities. In intermediate cases too (such as Spain, France, Italy and Portugal), the revenues from material sales are made less relevant since municipalities are paid a sum for their role in collection (so the payments from the packaging bodies become important). The exceptions are paper and textiles. The countries where materials revenue remain most important are those such as the UK and the Netherlands where collection costs are still born directly by municipalities with no direct support from packaging bodies.

Some limited details concerning materials revenue are given in Annex 10.

6.7 Compostables

The collection of compostables is likely to lead to more fundamental changes in collection systems. We noted in Table 2 that those countries where biowaste was being collected separately (though not only these) were moving to less frequent collections of residual waste. This is important, especially (though not only) in Southern Member States where the frequency of residual waste collection has had to be high (often three times a week or more), and also, where soil organic matter status makes the collection of biowastes especially important from the perspective of seeking to maintain or increase soil organic carbon levels without excessive loading with heavy metals and organic pollutants.

We have, for this reason, sought to comment (in some cases) on the effect on total 'system' costs so that the unit costs of collecting compostables (as shown in Table 8) do not mislead. More detail is given in Annex 5. Italian systems targeting food waste may be especially efficient by this measure even though the unit costs can appear very high (see Table 8).

Table 8 Comparative Costs of Collecting Biowastes in Different Member States

	Nature of Compostables Collected	Frequency	Estimated Cost
AU	Both	Weekly in summer, every two weeks outside summer	€82/tonne (biowaste) - home composting widely promoted
BE (Fl)	VFG Green	Weekly / every two weeks but approx 40% 'emptied' in PAYT (Gent)	€45-146/tonne, average €111/tonne (VFG waste) €16 /hhld €38/tonne (Green waste) €3.7 /hhld
DK	Garden and green kitchen	Dual collection (every 14 days)	Collection system costs increase 25% relative to standard weekly residual collection
FI	Both	Weekly / every two weeks	€63/tonne
FR	Both	Rural, weekly Urban, twice weekly (split-bodied)	€120-142/tonne €36-45 / tonne
GE	Both	Alternate weeks with residual, sometimes weekly (e.g. summer)	€67-159/tonne (best est. €100/tonne) - home composting plays an important role
GR	N/a	N/a	N/a
IR	Both	Alternating with residual waste collection Fortnightly biowaste alongside weekly collection	No increase relative to 'residual only' except €6-8/hhld/annum in respect of investments (containers and bags) Approx €33 per hhld (this is an estimate).
IT	Kitchen waste only	Once or twice weekly	€54-302/tonne, €4.4-9.3/hhld - collection system increases in cost by zero, or thereabouts, owing to reduced frequency of residual waste collection
LUX			
NL			
PO			
SP	Wet-dry schemes Kitchen waste collections		€40/tonne Incremental cost over simple refuse collection was zero in trials
SW			
UK	Both	Alternating with residual (every two weeks) Weekly co-collection (split bodied)	Costs for collection system increase by order €11/tonne collected of €3.5 per household @ 350kg / hhld Costs for collection system increase by order €11 – 33 per tonne biowaste collected depending upon capture rate

Clearly, capture rates play a role in determining costs. The higher captures in ‘kitchen and garden waste’ collection systems may lead to lower costs per tonne, but they increase total system costs by drawing more waste into the system (their convenience makes home composting less likely), leading to higher costs per household.

However, even where collection is of all biowastes, the impact on total collection costs need not enormous. Indeed, the major impact on total costs may be masked by estimates of costs per tonne in that cost increases may arise through the tendency to ‘pull out’ of the waste stream material which otherwise might not have to be collected at all (grass clippings, small soft prunings etc.) or would have been delivered to containerparks / CA sites / recycling centres. Increasingly, countries with biowaste collections, notably Flanders (Belgium), Austria and Germany, recognise this and promote home composting quite strongly (see Box 1). It is recognised in parts of Austria, for example, that the costs of chipping machinery can enhance participation in home composting, thereby reducing collection and treatment costs (and so paying for the chipping system). This also happens in community composting schemes in parts of the UK. As mentioned above, in Italy, and also in parts of Catalunya, appreciation of this experience has led to the design of collection systems to specifically target kitchen waste only.

These considerations are transferable to all countries. They suggest that those municipalities who embark upon strategies for the collection of garden (and kitchen waste) in the absence of measures to promote home composting might expect to see quantities of waste collected increasing considerably, with implications for the overall waste management budget. Indeed, this is precisely why many Italian systems target kitchen waste only in their door-to-door collection schemes. The objective should be to target the more problematic, fermentable food waste fractions. This material is wet, and has high bulk density. This implies that compactors are not required for the collection of this material, which can be collected in (smaller) vehicles which are far less expensive than those with compacting mechanisms.

6.8 Other Collections

Different Member States collect differing proportions of municipal waste through various collection approaches. Civic amenity sites of containerparks may be very important outlets in some areas, and they may be more so where these are well designed to collect materials separately, and where the door-to-door collections are charged for directly. Waste data for Member States is not good enough for any estimates of the breakdown to be presented.

Furthermore, some Member States collect bulky wastes at the doorstep, and others collect household hazardous wastes also. Some data has been obtained for these collections (Annex 7), but clearly, per tonne costs become relatively meaningless in both contexts since the collection system, once provided, will almost certainly have minimal 'truly variable' costs. As such, the cost per tonne is derived from the total cost of provision divided by the tonnes delivered.

Table 9: Costs for Bulky Waste and Household Hazardous Waste Collection

Material	Austria	Belgium	Belgium	Denmark	Germany[1]	Ireland	Lux
	€/t	€/t	€/hhld	€/t	€/t	€/t	€/t
Bulky Waste	95.52	142.41	95.52	107	43-128		97-104
Hazardous	217.58		217.58		377-749	2300[2]	2840[2]

[1] These figures are for transport and collection

[2] The figure includes the costs of information campaigns, sorting and logistics centre.

6.9 Information Provision

It is well understood that in order for collection systems to function well, the users have to be provided with appropriate information promoting the schemes, and encouraging householders to participate, as well as informing them of charging regimes. Furthermore, promotion of positive behaviour through home composting and through encouraging waste minimisation increasingly forms part of such information / education campaigns. These can be highly effective investments, either through increasing per household capture of materials separated at source, or through increasing uptake of home composting in an effective manner (possibly using compost experts / doctors to diffuse best practice). Both of these will tend to reduce system costs.

It has not, of course, been possible to trace all expenditure, from the national level, to the local level, on such information provision. What was sought was some understanding of the expenditure per household made by local authorities (or other bodies) in this area. The information obtained is shown in Table 10 (see Annex 8).

Table 10: Costs for Information Provision / Education in Context of Collection Schemes

	Denmark	France[2]	Ireland[3]	Italy[4]	UK[5]
Expenditure (€)					
Start-up		1.5-6/inh	9/hhld		
Ongoing	7 / hhld[1]	0.8/inh	5-7/hhld	1/inh	1.6/hhld

Notes:
[1] Estimated average;
[2] Information from 9 schemes;
[3] Information from 1 scheme;
[4] 'Consensus' requirement

[5] Estimated minimum requirement

It can be seen that there appears to be a minimum requirement of the order €1.6-2 per household per annum on an ongoing basis, with greater expenditure required in start-up phases. It might be reasonable to think that in cases where costs of dealing with residual waste are higher, the benefits of information provision will be increased. This could explain the relatively high estimate for expenditure in Denmark. On the other, expenditure on information provision and scheme provision can cover a range of activities so some variation in costs should be expected.

6.10 Conclusions

There are some important points to be carried forward from this Section. They are:

1. That measuring costs per tonne gives a partial picture of the relative performance of collection systems. This is most true in the case of residual waste. The more of this that is collected, other things being equal, the lower the costs per tonne will be;

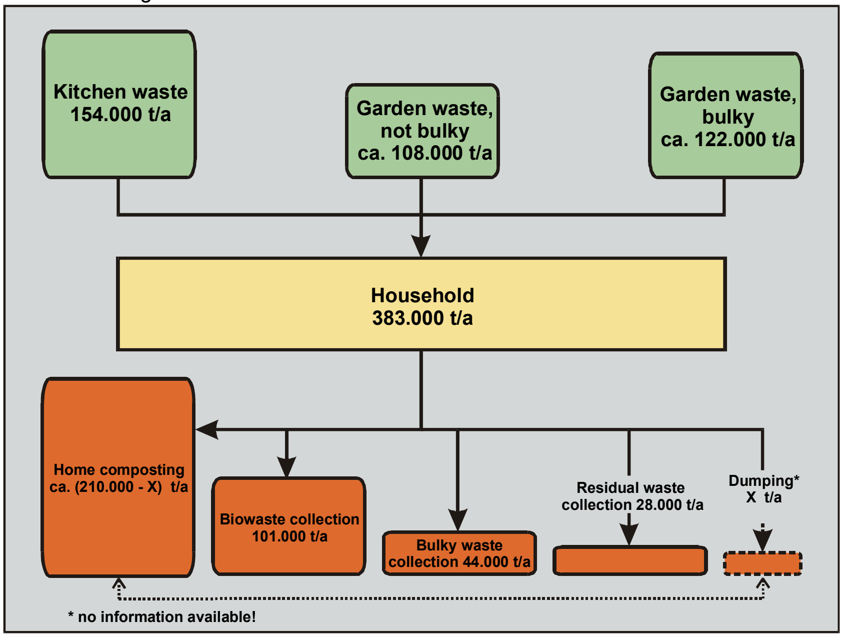
2. To some extent, the same comments can be applied to other waste streams. If the decision is made to collect both kitchen and garden waste, this 'intercepts' more waste than a 'kitchen waste only' scheme. Costs per tonne may appear lower, but total costs will increase because of the greater quantity of material collected. Costs per tonne for kerbside collection of recyclables will fall as participants use make greater use of the system. There are some exceptions to this rule. If, where materials collected for recycling are co-mingled, households become much better at sorting low density fractions, they may increase collection costs. This highlights the need to match the bulk density of materials to the specific collection approach;

3. Because of the previously mentioned factors, in schemes which collect more than one material, the specific costs for collecting individual materials are not straightforward to calculate. They vary with the relative quantities of the different materials which are collected by the scheme;

4. For dry recyclables, as expected, bring schemes are usually cheaper than kerbside, or door-to-door schemes. Materials of lower bulk density are more expensive to collect; and

5. For compostable materials, the implications of their collection for total costs of the collection system depend upon the degree to which the collection is 'separate from' other aspects of the collection system, or integrated within it. Where the latter is the case, the incremental costs for the collection system can be very low.

Box 1: The Case of Lower Austria
The Figure below shows the biowaste system and the quantities following different routes in Lower Austria. Inputs in the system are kitchen waste and garden waste. The flows of these fractions varies across seasons.
Only a minor part of the biowaste is collected, namely the fractions collected as biowaste, bulky and residual waste collection. Home composting and illegal dumping never appear in formal collection systems. As interventions in the biowaste collection system may have important effects on these two routes, they have to be integrated in consideration of waste strategies.



Sources of biowaste include:
Kitchen waste: The quantity per capita varies only in a moderate magnitude. The quality (composition, water content, etc.) is known, but problematic (e.g. odorous, highly fermentable). It has a high bulk density.
Garden waste: As a rule the information about this fraction is poor. In Lower Austria (and many other parts of Austria), only small fractions of the garden waste potential appears in the formal collection systems. The consistency of this fraction is rather unproblematic. It has a lower bulk density than kitchen waste.
The main problem in rural regions is the promotion of home composting. Cutting bulk waste (bushes, etc.) as well as large amounts of grass cuttings are often a problem for private households. Support from a shredding service (with or without removal) is very important. Ignoring this fact leads to illegal dumping and higher quantities in residual and biogenic waste collection. This has ecological disadvantages and also leads to much higher costs for the biowaste (and overall waste) management budget.
The following considerations appear to be very important in the Lower Austrian context.
Home composting: The most important treatment route in the Lower Austrian system is home composting. This is true for most regions in Austria, except cities. Home composting is not part of the public collection system and therefore is not often considered in waste management plans.
Biowaste collection: The separate collection of biowaste is an important factor in Austria and Lower Austria. It has enabled a strong reduction in the biogenic fraction of residual waste. Of course, material was also attracted from that which might otherwise have been used in home composting. Yet the kerbside collection of biowaste concentrates on regions with high population density (little amount of garden waste). Therefore only relatively small amounts of garden waste are included.
Bulky waste collection: In some regions garden waste can be brought to collection centres or it is collected once a year. This is again only a minor part of the whole garden waste potential.
Residual waste collection: The remaining biogenic waste, principally kitchen waste, remains in the residual waste collection system and is collected in the grey bin. It is an important goal to minimise this fraction by targeting kitchen waste.
Illegal dumping: Illegal dumping, which is, of course, the worst solution cannot be controlled easily. The performance of collection systems has an important influence on this "Output".
The main goals of an effective biowaste strategy are, therefore:

1. Minimising the biogenic fraction in the residual waste stream;
2. Seeking to do this in such a way as not to undermine home composting. This can be done through:
    a. targeting all biowaste in areas with few, or small gardens; and
    b. seeking to target kitchen waste only in less densely populated areas;

One can estimate the savings implied in Lower Austria on the following basis:

- The costs of alternative treatment routes (if this was delivered into the formal collection system) would be either:
    - Collection and recycling of separately collected biogenic waste = approx. 150 Euro (100+50) per tonne.
    - Collection and treatment by collection via residual waste = approx. 180 Euro (70+110) per tonne
- The saved costs by home composting (around 200,000 tonnes per annum) are therefore estimated to be about €30 Million per year (€20 per capita per year).

Given that many of the factors that can lower residual waste collection costs (higher quantities of waste per household, lower recycling / composting rates etc.) poor performers in respect of source separation might be expected to have lower collection costs for residual waste. It is not, therefore, an indicator which should, in any way, be used to rank the 'quality' or 'efficiency' of collection systems, especially not in the absence of reference to the whole of the collection system.

This is a crucial observation for the analysis of the performance of collection systems and one which has tended to be overlooked in the past. It suggests that collection costs ought to pay attention to the degree to which different parts of the collection 'intercept' most waste. The objective should be to not intercept waste unnecessarily (whether this be with the residual, compostable or dry recyclables collections), but to maximise interception through source separation schemes subject to this rule.

7.0 TREATMENTS

Treatments for waste management are not affected by considerations of whether one should consider the costs per tonne or per household. They are characterised on the basis of inputs (in the case of landfill) or throughput (for other treatments).

7.1 Composting

Table 11 shows a breakdown of costs and revenues for a 20,000 tonnes per annum intensive composting plant for food and garden waste in Italy. It illustrates the factors which play a role in determining cost outcomes.

The costs of compost plant are typically affected by:

- Costs of land acquisition;
- The requirements for land per unit of capacity (which are determined by the retention and maturation times, linked to end product quality). Vertical units also reduce land requirements;
- Scale;
- Plant utilisation rate;
- The choice of technology, especially the degree (and technological sophistication) of process control. This may be linked to the input materials / the location;
- The purity of source separation (which will determine the need for screening);
- The nature and length of contracts and the materials received;
- Revenues for sale of product, related to the quality of input material and the maturity of the end product.

Table 12 shows the variation in costs across Member States as reported in this study (details in Annex 13). When one accounts for scale, there is a degree of convergence in the costs, suggesting that in-vessel technologies using biofilters are likely to cost around €40-60 per tonne at scales of the order 20,000 tpa (which are increasingly common). Revenues are typically €0-10 per tonne of waste input so that figures for net costs may fall to €30 per tonne net of revenue or, more unusually, remain at €60 per tonne (which appears to be a high estimate of cost per tonne).

Costs of quality compost plant appear to have fallen in recent years. Controls in in-vessel systems have improved considerably. This is likely to have influenced the costs quoted.

Table 11: Breakdown of Costs and Revenues for Intensive Composting Facility in Italy (20,000tpa)

COSTS

Costs[6]	Investment €	Payback Period yr	Rate %	Annualised cost €/yr	Specific costs €/t	Maint %	Annual Maintainance €/yr	Specific cost €/t
Cost of land[7]	500.000	20	7%	**47.196,46 €**	**2,36 €**			
Civil Works								
Paving, concrete	595.000	20	7%	56.163,79 €	2,81 €	1%	5.950,00 €	0,30 €
Process Buildings	592.500	20	7%	55.927,81 €	2,80 €	1%	5.925,00 €	0,30 €
Pool(s)	20.000	20	7%	1.887,86 €	0,09 €	1%	200,00 €	0,01 €
Biofilter	117.600	5	7%	28.681,55 €	1,43 €	2%	2.352,00 €	0,12 €
Weighing Bridge	30.000	10	7%	4.271,33 €	0,21 €	2%	600,00 €	0,03 €
Offices	90.000	10	7%	12.813,98 €	0,64 €	2%	1.800,00 €	0,09 €
Utilities	300.000	10	7%	42.713,25 €	2,14 €	5%	15.000,00 €	0,75 €
Wall	60.000	20	7%	5.663,58 €	0,28 €	1%	600,00 €	0,03 €
			TOTAL	**208.123,13 €**	**10,41 €**		**32.427,00 €**	**1,62 €**
Equipment								
Shredder	150.000	7	7%	27.832,98 €	1,39 €	5%	7.500,00 €	0,38 €
Screw mixer	100.000	7	7%	18.555,32 €	0,93 €	5%	5.000,00 €	0,25 €
Turning Machine	250.000	7	7%	46.388,30 €	2,32 €	5%	12.500,00 €	0,63 €
Sieve	100.000	7	7%	18.555,32 €	0,93 €	5%	5.000,00 €	0,25 €
Eddy current separator	100.000	7	7%	18.555,32 €	0,93 €	5%	5.000,00 €	0,25 €
Loader	160.000	7	7%	29.688,52 €	1,48 €	5%	8.000,00 €	0,40 €
Hopper	30.000	7	7%	5.566,60 €	0,28 €	5%	1.500,00 €	0,08 €
Blowers, Fans	250.000	7	7%	46.388,30 €	2,32 €	5%	12.500,00 €	0,63 €
			TOTAL	**211.530,67 €**	**10,58 €**		**57.000,00 €**	**2,85 €**
	Quantity	**Unit**	**Unit cost**	**Yearly cost €/yr**	**Specific cost €/t**			
Variable Costs								
Manpower	7	w.u.						
Director	1	w.u.	60.000 €	60.000,00 €	3,00 €			
Accounter	1	w.u.	35.000 €	35.000,00 €	1,75 €			
Workers	6	w.u.	30.000 €	180.000,00 €	9,00 €			
TOTAL Manpower				**275.000,00 €**	**13,75 €**			
Fuels	80.506	litres	0,700 €	56.354,12 €	2,82 €			
Energy	944.813	kWh	0,075 €	70.861,00 €	3,54 €			
Maintenance	considered in fixed costs, as (relatively) independent from throughput							
Analysis	-	-	25.000 €	25.000,00 €	1,25 €			
Disposal of rejects	1.000	tonnes	75 €	75.000,00 €	3,75 €			
			TOTAL	**502.215,12 €**	**25,11 €**			
				1.058.492,38 €				
		TOTAL COSTS			**52,92 €**			

[6] Costs and revenues are considered form the standpoint of an entrepreneur – hence the difference between revenues and costs should constitute the net profit. Most often in such medium-scale facilities entrepreneurs also cover the role as a technical director. Therefore, the net profit adds on the wage as a Director.

[7] Considered as the purchase at a medium price in industrial areas (200.000 € per ha), and no revenue from selling back at the end

REVENUES

Revenues	Quantity	Unit	Unit price €	Yearly revenue €/yr	Specific revenue €/t
Gate fees					
food waste	12.000	tonnes	**60 €**	720.000 €	36,0 €
yard waste	8.000	tonnes	**20 €**	160.000 €	8,0 €
			TOTAL	**880.000 €**	**44,0 €**
Sale of compost[8]	8.000 tpy	= 16.000 cu.m			
field crops	3.200	cu.m	2	6.400 €	0,32 €
gardening, landscaping	8.000	cu.m	6	48.000 €	2,40 €
pot cultivation, once bagged[9]	4.800	cu.m	30	144.000 €	7,20 €
			TOTAL	**198.400 €**	**9,92 €**
			TOTAL REVENUES	**1.078.400 €**	**53,92 €**

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[8] We've considered a typical AVERAGE market share, though the average situation actually gets composed of various marketing attitudes at different composting sites

[9] The calculation of the price should here consider the need for a bagging unit, plus specific marketing costs to enter the sector of gardening centres, supermarkets and so on. In order to simplify assumptions, we've simply considered the displacing value of compost as a substitute for peat materials that would otherwise be purchased to be then blended and bagged

Table 12 Unit Costs for Composting (€/tonne waste)

	Process	Cost	Comments
AU	High specification plant for biowaste On farm composting	€94/tonne at 20,000 tpa €45-58/tonne at 5,000 – 20,000 tpa	
BE	Green waste composting VFG waste composting	€25-37/tonne €62-74/tonne	 All enclosed with biofilters etc.
DK	Garden waste Kitchen waste	€0-30/tonne €73-77/tonne at 10,000tpa	 Includes revenue est @ €11 / t compost (4.5/t waste) – Revenues vary from €0-11 per tonne
FI	Drum reactor for biowaste Drum and tunnel reactor for biowaste Tunnel reactor	€47/tonne at 6,000 tpa €189/tonne at 1,300tpa €68-76/tonne at 7,000 tpa €37-54/tonne @ 20,000 tpa	Excludes revenue, estimated at 6-10/cubic metre where sold to the public, but more often used in lower value applications
FR	Green waste (open air windrow) Kitchen waste (open air windrow) Kitchen waste (open air, forced aeration no odour treatment) Kitchen waste (enclosed, forced aeration with biofilter)	€50-85/tonne at 6,000 tpa €34-57/tonne at 12,000 tpa €63-95/tonne at 6,000 tpa €41-68/tonne at 12,000 tpa €50-91/tonne at 22,000 tpa	Includes revenues estimated at €0-8 per tonne input waste for garden waste, €0-6 per tonne for kitchen waste Residue assumed to go to incineration in all cases
GE	Kitchen and garden waste, enclosed with odour treatment etc.	€62/tonne at 40,000 tpa €56/tonne at 60,000 tpa	Assumes no revenue for compost and 10% rejects disposed at cost €91per tonne
GR	None from source separated materials		
IR	Food and Green waste composting Green waste	€16/tonne at 6,000tpa (950tpa throughput)) €25/tonne at 5,000tpa €23/tonne at 10,000tpa	Estimates are for operating costs only, no depreciation or revenue
IT	Kitchen and garden waste Garden waste	€53/tonne at 20,000 tpa €34/tonne at 20,000 tpa	Excludes revenues estimated at €10/t input waste Excludes revenues estimated at €9/t input waste. There may be considerable payments to farmers in parts of Italy to enhance use of compost
LUX	Biowaste	€71/tonne at 4,000t	Appears to include operating costs only, excludes revenues
NL	Open-air compost Enclosed biowaste compost Enclosed biowaste compost Buhler systems GICOM systems VAR system VAM system	€30/tonne €80/tonne at 10,000 tpa €30-60/tonne at 50,000 tpa €50-59/tonne €34-55/tonne €38-45/tonne €38-41/tonne	Costs Costs Costs Gate fee Gate fee Gate fee Gate fee
PO		No data	
SP		€18-30/tonne	
SW		€73/tonne at 3,000 tpa €30-45/tonne at 20,000 tpa	
UK	Garden waste, open air windrow In-vessel batch tunnel (biowaste) In vessel batch container (biowaste) In vessel VCU (biowaste)	€22/tonne at 18,000 tpa €40/tonne at 20,000 tpa €47/tonne at 18,000 tpa €31/tonne at 20,000 tpa	

7.2 Incineration

The costs of incineration plant are typically affected by:

- Costs of land acquisition;
- Scale (there are significant diseconomies of small scale);
- Plant utilisation rate;
- The requirements for treatment of flue gas (different Member States have different standards);
- The treatment and disposal / recovery of ash residues. Bottom ash may be used for construction purposes in which case, landfilling is avoided. The costs of treatment for fly ash varies significantly owing to different approaches and regulations regarding the need for treatment prior to disposal, and the nature of the disposal site;
- The efficiency of energy recovery, and the revenue received for energy delivered. The unit price of energy delivered, and whether revenues are received for both heat and electricity are both important determinants of net costs;
- The recovery of metals and the revenues received from this; and
- Taxes on incineration.

A detailed cost breakdown for a 200,000 tonne facility is given in Table 13.

Table 14 shows the variation in costs across Member States as reported in this study. Full details can be found in Annex 16. Comments on this Table are best kept to a discussion as to the key drivers of change in either the reporting of, or actual structure of, costs: These relate to:

- Though not investigated here, the nature and length of contracts, since this determines allocation of risk and the lifetime over which the project can plan with certainty for a given revenue stream;

Table 13: Grate Incinerator Costs, 200,000 tpa, Germany

TOTAL INVESTMENT	Investment €	Payback Period a	Rate %	Annualised cost €/a	Specific costs €/t
Site costs	368,000		7	25,700	0.13
Development of site	341,000	25	7	29,200	0.15
Construction costs	21,629,000	25	7	1,856,000	9.28
Technical installations and machinery	69,740,000	15	7	7,657,100	38.29
Electro technical installations	13,280,000	15	7	1,458,000	7.29
Fees	7,349,000	17	7	752,800	3.76
Prefinancing	9,219,000	17	7	944,200	4.72
TOTAL	121,925,000			12,723,000	63.61
OPERATIONAL COSTS, independent of input	€	Percentage %		Annual costs €/a	Specific costs €/t
Construction	21,970,000	1		219,700	1.10
Technical installations and machinery	69,740,000	4		2,789,600	13.95
Electro technical installations	13,280,000	2.5		332,000	1.66
Taxes and insurances	105,357,000	1		1,053,600	5.27
Management	2,863,000	10		286,300	1.43
Auxiliary materials	3,341,000	5		167,100	0.83
		number	€/person		
Labour		80	35,790	2,863,200	14.32
TOTAL				7,711,500	38.56
OPERATIONAL COSTS, input dependent					
		m3/a	€/m3		
Process water		51,200	0.15	7,900	0.04
Gas		1,381,440	0.20	282,500	1.41
		t/a	€/t		
CaO		1000	79.2	79,200	0.40
Ammonia		400	97.1	38,900	0.19
	kg/t input				
Treatment of slag	334	66,800	28.1	1,878,500	9.39
Treatment of ashes	8	1,600	255.6	409,000	2.05
Treatment of filter dust	22	4,400	255.6	1,124,800	5.62
TOTAL				3,820,800	19.10
	MWh/t input	MWh/a	€/MWh	€/a	€/t
Credits for electricity	0.35	70,700	46.0	3,253,300	16.27
TOTAL Cost Per Annum				21,002,000	105
Cost per tonne input					

Table 14: Comparative Costs of Incineration in Different Member States

	Pre-tax Costs Net of Revenues	Tax (for plant with energy recovery)	Revenues from Energy Supply (per kWh)	Costs of Ash Treatment
AU	326 @ 60ktpa 159 @ 150ktpa 97 @ 300ktpa		Electricity 0.036 Heat 0.018	Bottom ash €63/t Flue gas residues €363/t
BE	€71-75 @ 150ktpa €83 per tonne *[10]	€12.7/tonne (Flanders)	Electricity 0.025	Not available
DK	€30-45/tonne	€44/tonne	Electricity 0.05	Bottom ash €34 /t Flue gas residues €134/t
FI	None		For gasification, Electricity 0.034 Heat 0.017	
FR	€118-129 @ 18.7 ktpa €91-101 @ 37.5ktpa €86-101 @ 37.5ktpa €80-90 @ 75ktpa €67-80 @ 150ktpa		Electricity 0.023	€13-18 per tonne input
GE	€250 (50 ktpa and below) €105 (200ktpa) €65 @ 600ktpa		Electricity €0.046	Bottom ash €28.1 /t Fly ash / air pollution control residues €255.6/t
GR	None		Not known	Not known
IR	€46 (200 kt, est)		Not known	Not known
IT	€41.3 – 93 (350kt, depends on revenues for energy and packaging recovery)		Electricity €0.14 (old) €0.04 (market) €0.05 (green cert.)	Bottom ash €75/t Fly ash and air pollution control residues €129/t
LUX	€97 (120kt)		Electricity €0.025 (est)	Bottom ash €16/t input waste Flue gas residues €8/t input waste
NL	€71-110* (VVAV) €70-134* (OVAM)		Electricity €0.05/t (est)	
PO	€46-76 (est)			No data
SP	€34-56		Electricity €0.036	
SW	€21-53		Electricity €0.03 Heat €0.02	
UK	€69 @ 100ktpa €47 @ 200ktpa		Electricity 0.032	Bottom ash recycled (net cost to operator) Fly ash circa €90/t

** These figures are gate fees, not costs*

- Operating standards, and the technologies used for air pollution control: Historically, countries such as the Netherlands and Germany have had in place standards which exceed those of the latest Incineration Directive. These have required, e.g., selective catalytic reduction (SCR) and wet / semi-wet scrubbers from an earlier date. In some countries, selective non-catalytic reduction (SNCR) is more likely to be used alongside dry scrubbers. These are less costly, but less efficient flue gas treatments. Table 15 shows one attempt to calculate cost differentials related to the

[10] This is the average gate fee for incineration of municipal waste in Flanders. In Brussels Capital Region, 'Net Brussel', which is the operator of the SIOMAB-incineration plant, charges 62€ per tonne for incineration of municipal waste originating from municipalities in the Brussels Region.

choice between SCR and SNCR. The same report suggests that NOx emissions are more than halved in the process;[11]

[11] Note that this cost differential is quite small relative to potential benefits. Certainly, the benefits of NOx reduction are frequently estimated at well above

Table 15: Cost Differentials, SCR v SNCR Incinerator in Flanders

	Grate Incinerator SNCR	Grate Incinerator SCR
COSTS		
Capital Cost per Tonne	€ 34.58	€ 37.08
Operational Cost	€ 38.79	€ 40.00
Fixed	€ 30.54	€ 31.76
Variable	€ 8.24	€ 8.24
Overhead	€ 9.23	€ 9.80
Total	€ 82.57	€ 86.88
REVENUES		
Materials	€ 0.00	€ 0.00
Electricity production	-€ 11.88	-€ 11.76
Total	-€ 11.88	-€ 11.76
NET COST	**€ 70.69**	**€ 75.12**

- Revenues received for energy, in particular, the level of support per kWh for electricity generation heat. In Sweden, gate fees are low because of the revenue gained from sales of thermal energy as well as electricity. Indeed, in Sweden, generation of electricity is often not implemented in the face of considerable revenues for heat recovery. In some other countries, the opposite has tended to be the case, with support for electricity production biasing energy recovery against heat recovery. The UK, Italy, and Spain, amongst others, have supported incineration through elevated prices for electricity generated from incinerators. New incinerators will no longer receive such support in the UK though gasification and pyrolysis will receive an alternative form of support (though a tradable credit scheme designed to encourage electricity production from renewable energy sources). This has led to industry turning its attention quite quickly towards these technologies. Other Member States' structures of incentives for supporting 'renewable energy' may also affect relative prices of different waste treatments;

- Revenues received for recovery of packaging materials: These can also affect relative prices. In Italy and the UK, incinerators are effectively rewarded for the role they play in packaging recovery. The revenues received can cause significant reductions in gate fees;

- Taxes on incineration. In Denmark, the tax is especially high. Hence, although underlying costs tend to be low (owing to scale, and the prices received for energy), the costs net of tax are of the same order as that of several other countries where no tax is in place; and

- The treatment of capital in the 'quotation' of 'unit costs': Without more detailed breakdowns of costs for the countries concerned, it is difficult to ascertain the extent to which one suspects this may be an issue in Portugal and Spain where the capital has frequently been financed through European funds.[12]

The last point makes quite clear the problems which can be experienced in seeking to understand unit costs when the information given is often not the full cost, but effectively, the variable cost only. Some UK authorities, in receipt of so-called PFI credits (from Central Government), effectively pay only the non-capital element of costs so that unit costs from the perspective of the authority are roughly half what they would otherwise be.

7.3 Landfill

Landfill costs can typically be disaggregated into the following components:

- Acquisition costs;

- Capital expenditure and development costs;

- Operating costs;

- Restoration;

- Aftercare costs.

A breakdown for the UK for a new extension of an existing site, excluding energy recovery considerations, is shown in Table 16.

Table 16: Breakdown of Landfill Costs for the UK

	Fill rate	**175,000**		
	Life	**10**	**Years**	
Capital Costs				

[12] For example, the Portuguese Sectorial Strategic Urban Solid Waste Plan suggests that 73% of planned investments in waste management infrastructure (to 2005) will be financed through the Cohesion Fund.

Site Assessment	€ 320,000.00	10	€ 45,560.80	€ 0.26
Acquisition	€ 1,600,000.00	10	€ 227,804.00	€ 1.30
Capex and Development	€ 14,088,729.60	10	€ 2,005,918.14	€ 11.46
Restoration	€ 960,000.00	10	€ 136,682.40	€ 0.78
Aftercare	€ 4,924,582.40	10	€ 701,149.74	€ 4.01
Total	€ 21,893,312.00		€ 3,117,115.09	**€ 17.81**
Operating costs				
Operation			€ 1,920,000.00	**€ 10.97**
Total Costs		€ 5,037,115.09		**€ 28.78**

The above breakdown excludes considerations for energy recovery. At the site in question, this is effectively taken on by a third-party, which pays a royalty to the operator (equivalent to approximately €1 per tonne). As regards the activity of energy recovery, the electricity derived from combustion of landfill gas has, in the past, attracted subsidies under a scheme to develop non-fossil fuel sources of energy.

Under a given regime, the unit costs are affected by fill rates and the total capacity. The two together effectively determine the period over which waste is accepted, and thereby, the depreciation period for capital. Total capacity determines the quantity of material which can be used as the basis for effectively generating a fund to support aftercare expenditure. Increasingly (and this becomes compulsory under the Landfill Directive), landfills collect gas for energy recovery as far as possible, and for flaring where energy recovery is not possible. Some revenues may be generated from the sale of energy from landfill gas depending upon the regime governing energy sales. In some cases, operators may contract out the management of landfill gas for energy recovery, and where energy prices are favourable, they may take a royalty fee in lieu of the contract.

Within a given country, as well as across countries, acquisition costs are difficult to specify in any formulaic manner. In some cases, the site may be acquired outright for a fee, in others, a royalty may be paid, or the site may be leased. It is difficult to generalise about the costs of acquisition and much depends upon the landowner in determining these costs.

Capital expenditure and development costs are affected by Member State regimes in terms of the requirement for liners, as well as the geology of the site, and the site's proximity to sensitive aquifers etc. The detailed approach to regulation in this respect will determine whether the approach allows reduced expenditure (on liners, etc.) where a low risk is illustrated.

Operating costs for landfills can be quite small, whilst restoration costs are determined more on an area basis than on quantity of material accepted.

The regime regarding aftercare potentially becomes extremely important in the wake of the Landfill Directive. This requires adequate financial provisions to be made by the operator to cover the costs of aftercare. It seems quite likely that different Member States will require (implicitly) funds of differing magnitude to cover these costs. Presumably, those who take a more precautionary approach will require greater provisions (to cover eventualities) than others. On the other hand, some Member States may take the view that their precautionary measures occur in the pre-operation phase through environmental impact assessments and risk assessment procedures. This means that the costs of the fund which operators have to generate over the operational life of the site will vary, with consequences for unit costs.

Given these points, differences in unit costs are affected by the following factors:

- Land acquisition;
- Requirements for engineering (potentially affected by geology / proximity to sensitive aquifers);
- Scale of the landfill (total void space);
- The rate at which the landfill is filled;
- Costs for daily cover / restoration;
- Requirements for gas collection, and where this occurs, the offsetting revenues from sales of energy (which may be sold at premium prices in some Member States);
- Financial provisions / aftercare; and
- Landfill taxes (which are becoming more and more prevalent, and higher).

The costs which have been collected are shown in Table 17 below (see Annex 18 for further details). These are not 'costs' in all cases. In some cases, only gate fees have been obtained and we have indicated where this is the case. There is enormous variation in the cost net of taxes. There appears to be less, however, where underlying costs are concerned, especially if one takes into account the existence of scale economies.

For those countries for which data was available, the operating costs appear lower in France, Greece and the UK. Only some of this is likely to be explained through scale economies. Total costs are highest for Luxembourg, but these are small landfills so the diseconomies of small scale clearly have their effect.

The picture is likely to be quite dynamic in ensuing years, especially for those countries where costs have been, historically, at low levels. This is known to have been the case in Greece, Ireland, Italy, Portugal, Spain and the UK. Ireland and

Italy have already experienced some significant cost increases owing to changes in approach. In the UK, economies of scale have, to some extent, reduced the extent of cost increases.

Costs can be expected to exhibit considerable evolution over the next decade as old landfills are phased out and new sites begin to dominate the disposal side of waste management. One would expect also that there will be a good deal of ‘exit’ from smaller players as they will struggle to comply with incoming legislation. This is likely to lead to smaller numbers of larger landfills in those countries where landfill is still important (and this may have the effect of reducing any cost increases). Arguably, in Denmark, Netherlands, Flanders, and to some extent, Austria and Germany, this route is becoming less important as a treatment route owing to the bans in place. However, equivalence laws in Germany and Austria suggest a role for landfill as a disposal route following pre-treatment through mechanical biological treatment. France and Finland are among nations who are also considering bans of one or other type in future.

Table 17 Comparative Costs of Landfill in Different Member States (€/tonne)

Country	Operational Expenditure (€/t)	Costs (excl tax) (€/t)	Gate Fees (excl. tax) (€/t)	Tax (€/t)	Total Costs (incl. tax) (€/t)[1]	Tendency (costs excl. tax)
AU		67		43	110	Rising due to tax and improvements at old sites. Also, standards for pre-treatment imply diminishing importance
BE (Fl)	No data		47.5	52-55	100	Becoming less relevant for MSW due to bans
BE (Wa)	No data	45	-[3]		45	
DK	No data		44	50	94	Becoming less relevant for MSW due to bans
FI	4		37-46	15	52-61	Likely to become less relevant due to incoming bans
FR	3-5 (for 100 ktpa) 6-8 (for 20ktpa)	31-85 (high for low rates of input)		9	40-94	Ban for 'ultimate waste' due to come into force
GE	7.3 (for 300ktpa)	20 (for 300ktpa) 51 (for 50 ktpa)	35-220		30-51	Gate fees in turbulent state – costs likely to remain broadly constant. Standards for pre-treatment imply diminishing importance
GR	1.5-15 (larger for lower rates of fill)				9-30	Costs likely to increase significantly in coming years due to Landfill Directive
IR	13 (approx 100ktpa at 2 million cubic metre site)		35-78	19	60-95[2]	Costs have increased significantly in recent years
IT	13 (125ktpa at 1.25 million cubic metre site)	52 (at 1.25 million cubic metre site)		Varies[3]	70-75	Underlying costs increasing due to Landfill Directive
LUX	35-43 (40ktpa and 32 ktpa respectively)	123 (40ktpa in 400,000 cubic metres) 147 (32ktpa in 400,000 cubic meres)			123-147[4]	Underlying costs unlikely to change much
NL	No data		43-100 (avge 75)	64	107-164	Becoming less relevant due to bans on landfilling MSW
PO	No data		6-15 (est)		6-15	Costs likely to increase significantly in coming years due to Landfill Directive
SP	No data	25-35 (est, depending upon revenue from energy recovery)	6-40		25-35	Costs likely to increase significantly in coming years due to Landfill Directive
SW	No data		20-60	30.6	50.6-90.6[2]	Combustible waste cannot be landfilled from 2002, organic waste cannot be landfilled from 2005
UK	6.5-8 (up to 250ktpa) 3-4 (500ktpa)	28 (175ktpa at 1.75 million cubic metre site)	8-35	19.2	40-48[5]	Costs likely to increase slightly in coming years due to Landfill Directive (also, older, lower costs sites filling up)

[1] Where only gate fees are available, this is based on estimated average gate fees
[2] Estimate based upon assumption of complete pass-through of landfill tax
[3] Varies by region (and sometimes, degree of source-separation in municipality or level of pre-treatment)
[4] The costs quoted are for landfilling inclusive of mechanical biological pe-treatment
[5] The costs are estimated for new landfills of different size and fill rates. Older landfills (still operating) have lower costs associated with aftercare and other items.

The Landfill Directive is already affecting gate fees in some countries so where it is gate fees which are being quoted, this should be borne in mind. In some countries where gate fees have been historically high, such as Germany, gate fees are falling as a consequence of the implementation of the TASi. In other Member States, where gate fees have been low in the past, these may well rise in the medium-term as a consequence of the Directive.

7.4 Other Treatments

A range of other treatments for municipal waste exist, but few are used widely for municipal waste (exclusively).

7.4.1 Anaerobic Digestion

Anaerobic digestion (AD) is utilised in Germany, Netherlands and Denmark, there are developments in Spain and Portugal, and it is used to a limited extent in other countries such as Sweden, UK, and France. In some countries, there is little if any utilisation of AD exclusively for municipal waste. In many cases, municipal waste is co-digested alongside other wastes. Important developments are currently being reported for example in Northern Italian Alpine Regions, where local regulations promote farm-scale AD facilities to treat manure and source separated food waste.

The costs for AD are likely to vary in accordance with the following factors:

- Costs for acquisition of land;
- The choice of process (there are many variants);
- The input materials used (which, amongst other things, affect biogas generation);
- Efficiency of energy recovery (and whether recovery is of electricity, heat, or both);
- Price support for energy production (and effect on revenues);
- Regulations concerning the conditions for utilisation of digestate and liquor (and the implications for their treatment, e.g. can digestate be applied direct to land, or is it required to be stabilised through aerobic composting?); and
- Revenues for digestate (composted or otherwise).

Few detailed breakdowns of costs have been obtained (see Annex 14). The Table below summarises the basic results of the investigations. It appears that costs for this treatment are coming down, and discussions with some process technologists suggests this relates to improved understanding and control of the digestion process (allowing, amongst other things, control of partitioning between digestate and biogas).

Table 18: Costs for Anaerobic Digestion

Country	Aus	Be	Dk	Fi	Fr	Ger	NL	Sw	UK
Cost (€/t)	80	82	67[a]	35[b]	57	109 79 [c]	50-84	60-70[a]	80-96[d]

[a] *In these cases, there may be no need for aerobic treatment of digestate*
[b] *Only basic storage of digestate for aerobic phase*
[c] *Figure for co-digestion on farm*
[d] *UK figures are estimates*

7.4.2 Mechanical Biological Treatment

Mechanical biological treatment (MBT) is playing an increasingly important role, and has the potential to play a strategic role in the future, in the treatment of residual wastes.

The possible permutations for treatment plants in which MBT plays a role are very great indeed. Broadly, however, one could distinguish between:

- ‘separation’ facilities (which seek to split residual waste into ‘biodegradable’ and ‘high calorific’ fractions; and

- ‘dry stabilisation’ processes, which are less concerned with the splitting into fractions, and aim to use the heat from ‘composting’ processes to dry the residual waste and increase its calorific value to make it suitable for use as refuse derived fuel.

The former type can be found in Netherlands, are likely to become important in Italy, and constitute a basic template for some ‘integrated facilities’ planned in the UK (although the ultimate fate being imagined for the stabilised biowaste may be different in these cases). The latter is more common in Germany and Austria, where MBT is most commonly found.

Some information on costs is presented in Annex 15, but perhaps more so with MBT than other treatment, there is little sense in reporting costs without knowing a) what the plant seeks to achieve, b) the fate of the materials and the terms upon which they are accepted (is a gate fee paid to combustion facilities to have RFDF treated, or is revenue received for the delivery of the calorific value?), and b) the destination of any residuals (and as seen from earlier in this section, the residual waste treatments themselves vary in cost across countries).

7.4.3 Thermal Treatment

There are a small number of pyrolysis and gasification plants which have been operating successfully for an extended period of time treating municipal waste. The more successful examples appear to operate on sub-fractions of residual municipal waste.

Limited information has been obtained for these treatments. This can be found in Annex 17.

8.0 CONCLUDING REMARKS AND RECOMMENDATIONS

This report summarises the accompanying Annexes which contain a significant amount of information concerning the costs of municipal waste management across Member States. Some general remarks can be made concerning the information gathered for this project:

- The information tells us a great deal, but it does not tell the whole story. There are gaps which exist regarding the information obtained;

- Previous studies have focused on the costs of collection per tonne of material collected. Because of the way in which collection systems function, the cost per tonne of any type of which is waste collected is likely to increase where less waste of that type is 'intercepted' by that collection system (other things being equal). Consequently, a dual focus on cost per household and cost per tonne is necessary;

- Collection costs for residual waste per household are not very different across the Member States. Costs per tonne are, and this probably reflects the fact that some Member States are more successful than others in terms of rates of source separation;

- Collection methods for source-separated fractions exhibit considerable variation. Not all countries have widespread kerbside / door-to-door collections in place, and those that do seem to adopt different approaches to collection, leading to different requirements for post-collection materials sorting;

- The prospects for obtaining 'one figure' for the unit cost of any of the treatments being considered in any given country are rather remote. Scale alone influences the costs of different treatments, often significantly. To the extent that there may be convergence in the costs of any specific treatment, this has to be considered in the context of the variations which are related to scale;

- The degree to which convergence, accounting for scale, actually occurs varies across treatments. There is some convergence in costs for composting at medium-to-large-scale facilities. In the case of compost, it is not obvious that legislation plays a major role in influencing costs. For other treatments, it would appear that Member State-specific approaches to regulation, and implementation of EU Directives has a more significant impact on costs; and

- As expected, detailed information is still somewhat sparse for treatments such as anaerobic digestion, pyrolysis and gasification.

On the basis of these observations, and on the basis also of the work itself, one can make certain suggestions for further work in this area:

1. It is quite clear that the extent of the involvement of public and private sectors in waste management varies across the EU Member States. The significance of this deserves some exploration in terms of the effects on contract structures, costs, and the reasons why the different sectors play their different roles;

2. The costs for the collection of specific waste fractions are often not borne directly by the municipality (or only partially so) as a result of producer responsibility initiatives. The range of materials to which such mechanisms are applied varies across countries. Other things being equal, one would expect countries with strong producer responsibility legislation aimed at covering the costs to municipalities of collection to be able to charge households less for the waste collection function. Although work has been undertaken concerning packaging waste management systems in Europe, the extent of the effect on fees for municipal waste collection has not been explored;

3. In order to understand better the significance of the different collection and treatment approaches, one needs to have not only information concerning the amount of material sent to each different treatment route, but also, a detailed 'road map' of material flows within collection and sorting systems. This is required so as to understand the significance of the different collection approaches in different countries;

4. Such an exercise should be carried out with a view to investigating (at the European level) the potential for cost-optimisation in collection systems for different materials across Europe. There are many variables to be considered regarding choice of collection approach. Learning about cost-optimisation in collection should bring significant benefits to most Member States. Another question which should be asked in this context is whether Member State implementation of the Packaging Directive assists in such a process of cost-optimisation, or whether it might imply an unhelpful degree of fragmentation of the collection system;

5. The above considerations acquire particular significance in the context of Accession. Collection systems can be very labour intensive. Given the low labour costs in many Accession States, it seems entirely possible that well-optimised systems will be easily competitive with other treatments being considered in the context of

strategies to comply with the Landfill Directive. These are typically much more capital intensive. Indeed, it may well be that rather than capital being used to support such facilities, a more intelligent strategy would be to assist in the development of reprocessing industries (which can be capital intensive);

6. The study carried out here has just scratched the surface in terms of investigating the reasons for variations in the costs of specific treatments. It would be useful to see more detailed, treatment-specific cost comparisons. These could examine the economic instruments in place (for energy and waste), the regulatory framework, and the degree to which Member State interpretation and implementation of EU Directives allows the persistence of cost differentials across the EU; and

7. It would be useful to understand the degree to which costs and 'gate fees' deviate across countries, and within countries, across regions. However, such a detail requires considerable local expertise and knowledge, and effectively requires that the work in the previous recommendation has already been undertaken.

The pieces of work being suggested here are substantial pieces in their own right. They would need to be properly resourced. As long as studies of this nature are offered only limited resources, it cannot be expected that they will be able to do more than scratch the surface of what is, in reality, a quite complex area of investigation. That having been said, there is a clear need to understand the costs of waste management and the market for waste management services which is beginning to consolidate across national borders. This is especially true if policy is to be guided, or influenced by cost-benefit assessments. Frequently, neither private nor external costs and benefits are especially well characterised in this area.