1.0 ECONOMIC ANALYSIS OF OPTIONS FOR MANAGING BIODEGRADABLE MUNICIPAL WASTE[1]

1.1 Background

The main objective of the study was:

To conduct an economic evaluation, that considers both private and social welfare costs and benefits, of existing options for managing the biodegradable fraction of municipal solid waste.

Although all management options (anaerobic digestion, composting, landfilling, incineration, etc.) receive some consideration in the study, the main emphasis has been on the separate collection and composting / anaerobic digestion of the biodegradable fraction of municipal solid waste. The study focuses on the Member States of the European Union and on the first wave of Accession countries, i.e. the Czech Republic, Poland, Hungary, Estonia, Slovenia and Cyprus.

1.2 Private and External Costs and Benefits of Switching Between Treatments

1.2.1 Key Messages

1. The switch from landfill or incineration is favourable to both composting and anaerobic digestion on environmental grounds;
2. The environmental benefits of switching to anaerobic digestion are greater than for composting;
3. However, the private costs are higher. Therefore, compost is more favourable from a cost-benefit perspective;
4. However, the net benefit of the switch to compost is not very large. However, the benefits from composting are probably underestimated.

1.2.2 Results

1. The external benefits of switching from landfill to composting are generally quite small (of the order €1 - €4 per tonne);
2. They are larger for the switch from incineration to composting (of the order €12 - €25 per tonne);
3. When anaerobic digestion is used to treat separately collected waste instead of composting, the external benefits of switching away from either landfill or incineration are higher;

[1] ECOTEC Research and Consulting Limited (ECOTEC), in association with Eunomia Research & Consulting, HDRA Consultants Ltd (UK), Zentrum für rationelle Energieanwendung und Umwelt GmbH (ZREU), Scuola Agraria del Parco di Monza and LDK Consultants

4. However, the difference is not very large (€2 - €5 per tonne when switching from landfill to anaerobic digestion, and €13 - €29 per tonne when switching from incineration to anaerobic digestion);
5. The additional benefit improvement is less than the increase in costs which a resort to anaerobic digestion appears to imply;
6. The external benefits of the switches away from landfill vary significantly (across countries) as a proportion of the costs of the change. This is due to the fact that the charges for landfilling vary significantly across countries (as well as within them). It is expected that there will be some harmonisation in gate fees as the implementation of the Landfill Directive progresses over time. This will increase the costs of landfilling and reduce the costs of the switch in those countries where the costs of switching are not already negative;
7. The external benefits of the switches away from incineration are generally more significant. The private costs of incineration also vary significantly across countries, though they are nowhere as low as landfill gate fees are in some countries.

1.2.3 Assumptions

1. Discount rates of 1%, 3% and 5% are assumed, with 3% as the central rate;
2. The private costs used in the analysis are 'current' gate fees;
3. The disamenity estimates derived within the study for incineration and landfill are not used due to the facts that:
    - there is no basis available for estimating disamenity from composting and anaerobic digestion plants (so the analysis would be skewed by virtue of the inclusion of incinerator and landfill disamenity); and
    - in any case, estimates of landfill and incinerator disamenity are subject to considerable conjecture;
4. The typical assumption used in life-cycle studies – that carbon dioxide emissions from the treatment of biogenic wastes can be ignored – is rejected in this study. The aim is a comparative analysis of the treatments, and the time profile for the release of greenhouse gases from biogenic fractions, whilst unimportant from the point of view of a life-cycle emissions inventory, is important from an economic perspective;
5. Contrary to some other studies, no assumptions are made about transport externalities linked to specific treatment routes. This is because it is impossible to know what the changes in transport externalities will be when separate collection is introduced. Collection frequencies, vehicles, distances and even modes may change in the local situation.
6. In support of the previous assumption, analysis was carried out to assess the significance of transport externalities relative to levies paid on fuel in different Member States. This suggests that there is a high level of internalisation of transport externalities in the private costs of transport across the countries of the EU. Hence, an assessment of the

external costs of transport related to waste management would, arguably, imply a degree of double counting in the overall analysis; and
7. Benefits were attributed to those technologies generating energy on the basis of an assumption that the source of energy avoided was a combined cycle gas turbine generating station.

1.2.4 Sensitivities

1. The assumption concerning the basis for assigning avoided burdens to those treatments which generate energy is potentially crucial. All analyses which have been carried out on this subject agree on this point, but there is no clear agreement as to what the 'correct' assumption should be. Evidently, the assumption's significance is increased in proportion to the energy used / generated by the specific treatment option;
2. Because it is not assumed that carbon dioxide emissions from biogenic sources were unimportant, the time profile of greenhouse gas emissions becomes important. Implicitly, this makes the discount rate more important. This is reflected both through changes in the time profile of greenhouse gas emissions and the unit damage costs applied in the analysis for greenhouse gases. The lower the discount rate, the higher the global warming externalities become for all scenarios;
3. The private costs used are estimates of gate fees. These are subject to considerable variation both within and across countries. Ranges reflect both underlying costs, affected by scale, choice of technology, and the levying of taxes, as well as local market conditions. Gate fees are unlikely to remain stable for landfill in the future owing to the imposition of the Landfill Directive. They are likely to go up in many countries. For some technologies, such as anaerobic digestion, costs seem more likely to fall as process control improves;
4. Uniform performance standards were used both for incineration and landfill. For the former, the actual performance achieved, in terms of air emissions in particular, varies across Member States and Accession Countries. Some perform better than the latest Incineration Directive demands, others perform worse. The same variation can be observed in landfill performance regarding efficiency of gas collection and of energy recovery from the gas collected, and leachate control. Sensitivity was applied through adjusting expected costs of treatments rather than attempting to define country-specific performance standards for landfill and incineration. This reflects the fact that in future, it is the costs which are expected to change whilst performance standards are harmonised. Costs are unlikely to remain at their current low levels in Accession States and (for landfill) in Greece, Portugal and Spain;
5. Regarding separate collection, it is assumed that the costs can be treated using an incremental cost above the standard 'refuse collection' costs. In best practice schemes, either concentrating on kitchen waste only or on both kitchen and garden waste, this incremental cost is low.

1.2.5 Omissions and Uncertainties

1. The emissions data for the different treatment options, especially for anaerobic digestion, is not well-established;
2. The quantification of external costs and benefits is incomplete. For all treatments, the full range of external costs is not captured. This is not so much a case of 'under-estimation' as a recognition that as far as many environmental effects are concerned, either a) the economic approaches are underdeveloped, or b) the underlying science required to estimate external costs is uncertain. Overall, it seems that regarding negative externalities, these are incomplete for all treatments. On the positive side, the benefits of energy recovery techniques are captured quite well. The benefits of compost use, on the other hand, are far from fully captured. As such, the benefits side for anaerobic digestion and compost is less well represented in the figures derived than are the benefits from energy recovery treatments;
3. Of great significance for this study, and reflecting the previous comment, the benefits of using compost, though well understood by practitioners, are still poorly understood in terms of mechanisms and scientific processes. They are, therefore, very difficult to quantify. The study attempts to capture some of these but the benefits related to, for example, avoided pesticide use, whilst based on 'reasonable' assumptions, are highly uncertain;
4. Disamenity estimates are also poorly established. Most work in this area has concentrated on landfill rather than other treatments.
5. The significance of mechanical biological treatment as a means of dealing with biodegradable municipal waste is on the rise. However, the role of mechanical biological treatment has not been assessed in this study.

1.3 Private and External Benefits of Mandating Separate Collection Relative to the Projected Implementation of the Landfill Directive

In seeking to understand the implications of a policy of source separation across the EU and Accession States, it was necessary to make a number of assumptions concerning the way in which Member States might seek to implement the Landfill Directive in the absence of any mandatory requirement for separate collection. For some countries, the effect of mandating source separation is minimal since separate collection is effectively already mandated by some Member States' policies. This is broadly true of Austria, the Flemish region of Belgium, Germany, Luxembourg, and the Netherlands, as well as Denmark where garden waste is concerned. It is likely to be true in future for some other countries too (for example, Finland).

Hence, the effects of mandating source separation, relative to the situation where the Landfill Directive is applied in its absence, are concentrated on certain nations. Thus, the effect at the EU level will reflect the effects of the policy on those countries which:

- produce most municipal waste; and
- seem unlikely to embark on major moves towards separate collection in future.

1.3.1 Key Messages

1. Under specific circumstances, private costs are likely to be negative whilst external benefits are always positive. In scenarios where private costs are high, costs exceed the quantifiable benefits;
2. The total value of the benefits is relatively small for the whole of the EU and Accession States as depicted in these scenarios partly because it is assumed that many countries will be proceeding along this path to a greater or lesser degree anyway;
3. External benefits increase (and potentially, net benefits also) as the rate of growth in municipal waste increases. However, it must generally be hoped that growth is lower. To this end, it is worth speculating on the role which source separation may play in sensitising citizens concerning waste issues, and enabling a more positive application of 'pay-as-you-throw' systems for waste collection (though this is legally forbidden in some countries at present);

1.3.2 Assumptions

The key assumptions are as follows:

1. Low and high costs of separate collection and composting of €35 / tonne and €75 / tonne;

2. Low and high costs of separate collection and anaerobically digesting of €80 / tonne and €125 / tonne;

3. Costs for landfill and incineration at €55 / tonne and €90 / tonne respectively. The landfill figure represents the estimated cost of landfill at a site meeting Landfill Directive requirements,[2] and the estimated costs for incineration represent costs for a plant meeting Incineration Directive requirements;[3] and

[2] The externalities of both landfill and incineration were both calculated assuming performance which equates with compliance with the Landfill and Incineration Directives, respectively.

[3] Incinerators will also be regulated under the IPPC Directive so that a BREF (Best Available Technology Reference) document will be produced detailing standards which these are required to meet. There is no reason why the BREF document should not establish standards which exceed those laid down in the Incineration Directive.

4. The switch from landfill and incineration is in the proportion 95% to composting and 5% to anaerobic digestion (which may be considered, in this analysis, to be the low cost, but lower external benefit, scenario).

5. Countries follow one of three specific paths in order to comply with the requirements of the Landfill Directive.

1.3.3 Sensitivities

Key sensitivities are as follows:

- The analysis of net costs and benefits is highly sensitive to the private costs of the different waste treatments. Broad ranges have been used for the costs of composting and anaerobic digestion (including a component for separate collection). A single price across Europe for landfill and incineration has been used.
- Regarding compost, as experience increases, the tendency appears to be that costs are falling. The same applies to anaerobic digestion since control over microbiological processes appears to be improving also.
- For landfill, it is expected that some harmonisation in costs will occur. Landfill taxes already make the treatment cost greater than indicated here for many countries.
- A key variable in the context of strategies for diversion of waste from landfill is likely to be the cost of incineration. In fact, this varies considerably across Europe at present. For a given plant scale, this reflects the differences in Member State policies and regulations in respect of energy recovery, recovery of packaging, air emission limit values, treatment of fly ash and air pollution control residues, and taxes on incineration.

1.3.4 Uncertainties

Key uncertainties are identified below:

- Given the sensitivity to costs, it seems important to state that the level of private costs in ten years' time is not known. Indeed, though it is frequently stated that external costs are subject to uncertainty, private costs are not so well-known either. Furthermore, they are subject to considerable variation with choice of process technology and scale.
- The path which Member States will follow in implementing the Landfill Directive is not well-known (and this constitutes the baseline for this analysis). Variation in this would imply changes in quantities diverted from different treatments, so would affect the magnitude of the net benefit as calculated here; and
- The assumptions and uncertainties outlined above in respect of the external cost analysis clearly influence these results also. To the extent that these are only partially known, the analysis of net external and private costs and benefits tends, by implication, to be influenced more

by private costs than one might expect. This is especially true given the fact that the study has made what can only be described as 'first steps' in what is likely to be a lengthy process of quantification of the external benefits, and costs, of the application of compost to soil.

1.4 Conclusions

On the balance of evidence that has been presented, it seems that a policy of source separation will be justified where the collection system for source-separated biowastes is carried out in such a way as to optimise costs. Furthermore, where the costs of composting itself are kept to a reasonable level, it becomes likely that the net private cost increase will be minimal, or negative (as is already the case in several countries). This will be especially true if costs for other treatments increase. It is worth noting that the costs of landfilling and incineration have shown a tendency to rise (owing to controls on pollutants etc.,) whereas those for enclosed composting and anaerobic digestion have, if anything, shown a tendency to fall. The costs for composting are likely to be lower under mandatory separate collection to the extent that this increases typical plant scale.

If the private costs of the change to source separation were negative, this is a change which would be likely to occur anyway. It may well be the case that a 'policy' which seeks to reduce the level of the subsidies to incineration, and which seeks to ensure that the spirit and letter of the Landfill Directive is correctly applied (including, for example, issues related to the destiny of incinerator ash residues, and what should be seen to constitute pre-treatment) has a similar effect in terms of encouraging source separation as a mandatory requirement to implement this service. The separate collection of biowastes would flow naturally as an outcome of the relative costs of different waste management options.

The more difficult it becomes to ensure the relative costs of treatment options favour the source separation approach (for example, due to Member State initiatives to support the development of energy from waste as a renewable energy source), the stronger the argument becomes for implementing a *requirement* for source separation. This would constitute recognition of the fact that, however positively one may view the objective of supporting energy from waste in the context of a target for electricity generation from renewable energy, such policies have the potential to distort waste management decisions. This perspective is especially important given the 'so-far-limited' exploration of the potential external benefits of applying compost to the soil. In either context, the establishment of Europe-wide standards might enable compost products to be marketed more freely across Europe.

Hence, a policy requiring source separation might not be necessary in a world where the Landfill Directive is fully implemented and where subsidies distorting the net costs of residual waste treatments were less prevalent than they are. However small the external benefits of such a proposed policy might appear (owing partly to the level of source separation already being achieved, but also, to the relatively low external benefits of such a switch), these are

benefits that can be captured at low or negative cost relative to the costs of alternative treatments. Where the net costs are not negative, they may be in the future.

It is quite possible, even likely, that the external benefits of applying compost to land will appear greater as understanding improves concerning the complex interactions between compost and soil. It should be borne in mind that the externality assessment leaves certain negative consequences of waste treatments under-explored, whilst the benefits side is relatively well-established for energy recovery facilities (being linked to the well-researched area of energy-related externalities). For compost, estimating the benefits has something more of an art about it. As such, over time, society may come to understand that the benefits of applying quality composts to the soil, and hence, of a policy mandating source separation, are much greater than have been anticipated thus far.

One of the key conclusions of this type of study must be that the numerous assumptions, sensitivities and omissions / uncertainties make it very difficult to use the out-turn figures as a basis for establishing policy. Equally, precisely because such an analysis can highlight these sensitivities, it can help shed some light upon what the total picture might look like if it were possible to carry out the 'ideal' analysis.

Notwithstanding the limitations of this type of analysis, there is little to suggest that a policy mandating source separation of biodegradable municipal waste would be damaging if imposed in the EU. On the contrary, some countries which might be considered to be relatively far advanced in terms of waste management have already made this an integral part of their strategies. Furthermore, for the Accession Countries, such a path to compliance wih the Landfill Directive is likely to be far less demanding in terms of capital expenditure than one more heavily reliant upon, for example, incineration.

Other factors which may weigh in favour of this type of policy are:

- The fact that separate collection increases the possibility for implementing variable charging schemes, which can influence waste generation, and act to sensitise citizens to waste as an environmental issue;

- The relative unpopularity of larger treatments such as landfills and incinerators; and

- The potential linkages with agri-environmental / rural development policies, in which compost utilisation (and production) could be encouraged.

It is quite possible, in our view, that the external benefits of applying compost to land will appear greater as our understanding improves concerning the complex interactions between compost and soil. It should be borne in mind that the externality assessment leaves certain negative consequences of waste treatments under-explored, whilst the benefits side is relatively well-

established for energy recovery facilities (being linked to the well-researched area of energy-related externalities). For compost, estimating the benefits has something more of an art about it. Already, this study has, we believe, made an important contribution to understanding the potential contribution to climate change mitigation strategies which the application of compost to soil can make. Over time, we may well come to understand that the benefits of applying quality composts to the soil, and hence, of a policy mandating source separation, are much greater than we have anticipated thus far.

There are several recommendations which flow from the above considerations:

a. A systematic attempt to understand the different influences on the costs of waste management options in the EU is urgently needed. For example, whilst the external cost assessment suggests that anaerobic digestion is a superior option in environmental terms, the assumption is that the higher private costs may not justify the additional external benefits. This conclusion would alter, however, if the costs of anaerobic digestion were lower than assumed here. Such a study should focus on the different economic and regulatory instruments which currently affect the relative costs of different waste management options in the EU. Regarding the Landfill Directive, this would require some check on the adequacy of financial provisions, an assessment of the mechanism through which it was ensured that full costs were passed on to waste producers (with some agreement as to the basis for ensuring this is done), and a review of the application of the requirements for pre-treatment of landfilled waste. These would affect the costs of landfilling. In addition, the way in which the end to co-disposal affects landfilling of incinerator ash residues will have an impact on the costs of incineration. Other instruments requiring investigation are the Incineration Directive, the IPPC Directive, Member State-specific taxes on landfill and incineration, and policies in place to support energy production from waste. The presence or absence of specific measures raises questions as to the degree to which an analysis of external costs and benefits, as carried out here, actually involves double counting of costs and benefits (since these may already be internalised in private costs).

b. Although this work constitutes the first attempt to quantify, in a comprehensive manner, the external benefits associated with use of compost, these estimates are subject to great uncertainty. They do, however, provide a reference point for further work which should seek, for example, to:

    i. Investigate further the potential for compost applications to contribute to the sequestration of carbon, and also, the build up of organic matter in the soil. Note that in conventional life-cycle approaches, which effectively ignore all biogenic carbon emissions, the scope for such an analysis is not possible owing to the assumptions made;

ii. Investigate further the potential of compost applications to reduce requirements for pesticide use in agriculture and other forms of cultivation;

iii. Understand more clearly the potential of nutrient applied to offset nitrous oxide emissions associated with the use of manures and synthetic nitrogenous fertilisers;

iv. Seek to quantify the external benefits associated with the reduction in the likelihood of flooding which might be occasioned by greater use of compost, owing to its tendency to support greater infiltration and retention of water;

c. The external cost analysis does not cover all impacts. Key omissions which could be addressed are:

i. For all treatments, the disamenity associated with the plant. This analysis has to be undertaken with great care, and indeed, whilst there is uncertainty concerning health effects of different treatments, an assessment of disamenity is unlikely to be straightforward, with hedonic pricing approaches potentially generating much lower estimates than contingent valuation methods;

ii. For all treatments, the impact of the treatments on operator health;

iii. For compost, as well as the positive aspects outlined above, on the negative side, the health effects of bioaerosols in the surrounding area, the impact of heavy metal applications to the soil (relative to alternative soil improvers), and the potential for impacts from any organic pollutants in compost; and

iv. For incineration, the impacts of all air pollutants as opposed to a sub-set thereof. The issue of non-chlorinated (e.g. brominated) dioxins and related compounds needs to be addressed. In addition, the impacts of various treatment routes for ash residues (including the use of residues in construction applications) need careful consideration.

v. For landfill, the external costs associated with leachate and the full range of gaseous emissions;