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The IPTS REPORT

EDITED BY THE INSTITUTE FOR PROSPECTIVE TECHNOLOGICAL STUDIES (IPTS)
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SPECIAL ISSUE: WASTE

EUROPEAN COMMISSION
Joint Research Centre

ENGLISH VERSION

ABOUT THE IPTS REPORT

The IPTS Report was launched in December 1995, on the request and under the auspices of Commissioner Cresson. What seemed like a daunting challenge in late 1995, now appears in retrospect as a crucial galvaniser of the IPTS' energies and skills.

The Report has published articles in numerous areas, maintaining a rough balance between them, and exploiting interdisciplinarity as far as possible. Articles are deemed prospectively relevant if they attempt to explore issues not yet on the policymaker's agenda (but projected to be there sooner or later), or underappreciated aspects of issues already on the policymaker's agenda. The long drafting and redrafting process, based on a series of interactive consultations with outside experts, guarantees quality control.

The first, and possibly most significant indicator of success is that the Report is being read. Issue 00 (December 1995) had a print run of 2000 copies, in what seemed an optimistic projection at the time. Since then, circulation has been boosted to 7000 copies. Requests for subscriptions have come not only from various parts of Europe but also from the US, Japan, Australia, Latin America, N. Africa, etc.

The laurels the publication is reaping are rendering it attractive for authors from outside the Commission. We have already published contributions by authors from such renowned institutions as the Dutch TNO, the German VDI, the Italian ENEA and the US Council of Strategic and International Studies.

Moreover, the IPTS formally collaborates on the production of the IPTS Report with a group of prestigious European institutions, with whom the IPTS has formed the European Science and Technology Observatory (ESTO), an important part of the remit of the IPTS. The IPTS Report is the most visible manifestation of this collaboration.

The Report is produced simultaneously in four languages (English, French, German and Spanish) by the IPTS; to these one could add the Italian translation volunteered by ENEA: yet another sign of the Report's increasing visibility. The fact that it is not only available in several languages, but also largely prepared and produced on the Internet World Wide Web, makes it quite an uncommon undertaking.

We shall continue to endeavour to find the best way of fulfilling the expectations of our quite diverse readership, avoiding oversimplification, as well as encyclopaedic reviews and the inaccessibility of academic journals. The key is to remind ourselves, as well as the readers, that we cannot be all things to all people, that it is important to carve out our niche and continue optimally exploring and exploiting it, hoping to illuminate topics under a new, revealing light for the benefit of the readers, in order to prepare them for managing the challenges ahead.

Preface

This month's issue of The IPTS Report deals with the important issue of waste management in Europe from the standpoint of sustainable development.

To give an idea of the scale of the challenge, European output of waste has been estimated at 2.2 billion tonnes, of which 720 million tonnes are from industry and 26 million tonnes are hazardous.

Taking a preventive approach and reducing this output is a priority for European policy, as is reducing its level of toxicity. From this viewpoint I would like to mention one of the key actions in the Fifth Framework Programme for Research and Development which focuses on the development of technologies intended to make it possible to reduce resource utilization and promote the re-use and recycling of wastes. This action is also looking at clean processes and products based on the 'Life Cycle Analysis' concept.

Its overall aim is to facilitate the development of innovative high-quality products and services which respond to the needs of citizens and the market, together with new methods of production which economise on resources and respect the environment.

This orientation is compatible with the goal of integrated pollution prevention and control launched in 1996 by the directive. The JRC has already played a significant role in this, in particular thanks to the European Integrated Pollution Prevention and Control Bureau set up within the IPTS in Seville. Indeed, this bureau is in charge of drafting reference documents on Best Available Techniques for all the industrial sectors specified in the directive.

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EDITORIAL

L. Bontoux and F. Leone

The first generation of European waste legislation (1975 -1995) is generally recognized to have had positive environmental consequences. However, care must be taken to ensure that the continual tightening of the legislation does not end up bringing such achievements into question. Since 1975, waste recovery techniques and technologies have improved significantly, and past policy actions and waste management strategies must evolve to recognize this. A long term perspective is now needed, where environmental, technological and economic considerations are all satisfied.

The European strategy for waste management places waste prevention as its top priority, thereby following the broad European policy aim to move towards sustainable development. However, so far, in practice, most waste management efforts seem to be concentrated on material recycling and energy recovery on the one hand and waste treatment and disposal on the other. In effect, over the last ten years, national and European waste management regulations have made considerable progress towards more stringent environmental quality requirements.

In this issue of *The IPTS Report*, the first article provides some elements to explain why waste prevention has so far not been as successful as it could have been. It seems that socio-cultural and organizational barriers are still high. Additionally, while regulatory requirements for waste handling and disposal are numerous and pressing, waste prevention cannot be easily legislated into action. It requires a wide range of changes, from industrial processes to living habits, from product design to new visions of the world.

Re-use is also often talked about, and in some industrial sectors it seems already to be common practice (e.g. tertiary packaging), but little is known about the true significance of this practice in terms of waste prevention. The European packaging directive (94/62/EEC) mentions it explicitly in article 5 but does not propose any specific measures to promote it. The second article of this special issue of *The IPTS Report* deals with this point. It discusses current examples of re-use of primary packaging, often the most conspicuous form of municipal waste, and describes a number of issues that limit the scope of packaging re-use operations.

In the area of waste disposal, the debate about the choice between landfilling and incineration has been given new force by the recent proposal for a landfill directive. This proposal aims at drastically reducing the amount of organic waste going to landfill. Many experts think that this will result in more waste going to incinerators. Our third article sheds light on this debate by proposing a prospective view of the various ways to treat and dispose of organic waste in an environmentally-friendly way. This article also defends the view that the use of organic waste to produce energy will have growing importance, especially in the medium to long term.

Another area of concern in waste management, beyond the mere reduction of the volume of waste produced, is reducing the hazard it represents. Currently, the main practical consequences of the European waste legislation on hazardous waste is to limit its movement. The restrictive conditions and requirements of the Basel Convention and of Council Regulation 259/93/EEC raised a number of environmental, economic and social issues linked to waste management, in particular for recovery and recycling. In Europe, these issues range from limitations on transport to debates on incineration, and from potential disruption of markets to hampered industrial competitiveness.

The large amounts of waste from industrial countries dumped without any control in developing countries during the past decade and poor waste disposal practices in Europe have prompted policy action to ban the export of hazardous waste and severely restrict the movement of waste in general. This has increased the need to precisely know what is waste and has sparked off heated debates on this subject, both within the European union and world-wide.

Our fourth article deals with the issue of 'hazardousness' and how it is legally defined. So far, European regulations have sought to identify, name, quantify and classify wastes in terms of the potential danger they represent for man and the environment. However, the article raises the question of the applicability of these regulations.

Another important issue for the decision maker in waste management is to be able to choose the best option, given the local economic and environmental constraints. This question is becoming every day more important in the quest for sustainability. There is therefore now a need to develop better ways to evaluate the environmental performance of waste management options and to communicate the results of this evaluation. Methodologies such as LCA, risk assessment, multi-decision criteria analysis or cost/benefit analysis all have a contribution to make in this area. Our last article deals with the issue of indicators, important for comparing various technology options. It places the discussion in the context of the IPPC directive.

The issue of waste management is complex and far reaching. It touches everyone of us and involves all industrial sectors. In this special issue, we only deal with a few of its aspects. It would seem that the quest for sustainable development requires us to broaden 'waste management thinking' to the management of material streams, the economy and all industrial activities, abandoning a vision strictly limited to waste. This idea has been taken up in the new Integrated Pollution Prevention and Control (IPPC) concept now part of European environmental and industrial policies. This opens the door to the broader adoption of concepts such as 'Integrated Waste Management', which is an attempt to find the most appropriate economic and environmental means to deal with unavoidable waste. The final success for European society will be measured on the ground, once we can see whether the practice has remained faithful to the spirit of the policy.

Stimulating Greater Uptake of Waste Minimization

Celia Greaves, *CEST*

Issue: Waste minimization demonstration projects across Europe have highlighted the benefits which can be achieved through a rigorous approach to waste management. However, despite the success of these types of projects, many organizations remain reluctant to embark on similar initiatives. An improved understanding of the obstacles to greater uptake will help to highlight the opportunities for policy to stimulate progress.

Relevance: Waste minimization lies at the heart of efforts to achieve sustainable waste management in the future. More widespread adoption requires an insight into the factors which influence organizations' waste management activities. Through a better appreciation of the motivations and barriers it is possible to identify how policy and other initiatives can encourage progress in this area.

Introduction

Over recent years, pressure on resources across Europe has lead to an increased focus on the effective management and, where possible, avoidance of waste. Furthermore, research suggests that the costs of waste can be as high as 10% of a company's turnover (ETBPP, 1996). Both governments and other organizations have recognized the benefits that waste minimization can bring. As well as making good economic sense, leading to efficient use of resources and considerable cost savings, it helps to reduce pressure on waste disposal facilities. The financial benefits have been highlighted in a series of demonstration projects. For example, in the UK, a group of eleven companies saved almost 5 million ECU per year and substantially improved their environmental performance through waste minimization (CEST, 1994). Nevertheless, despite these clear and proven benefits, many companies have failed to take up waste minimization. Efforts to understand why this should be the case have highlighted a number of factors which influence motivation and behaviour, and have revealed scope for policy intervention to improve uptake.

Despite the clear and proven benefits of waste minimization for companies, relatively few have taken it up

Encouraging uptake of waste minimization typically focuses on supporting demonstration projects whose success is then hoped to encourage others

Factors influencing uptake of waste minimization

A typical approach to encouraging uptake of waste minimization is based around the provision of support for discrete demonstration projects, involving a limited number of representative organizations, usually in a particular location. Those taking part receive consultancy advice and assistance in identifying opportunities for minimization, as well as the regular interaction with other participants, allowing exchange of views and experience. As the benefits (both financial and otherwise) emerge, it is hoped that other groups will be stimulated to action.

An analysis of the perceived incentives for participation in externally sponsored waste minimization projects (CEST, 1995) revealed that:

- opportunities for cost reduction provided the greatest motivation;
- the availability of external funding, resulting in reduced financial risk, was also important (although 35% of those surveyed stated that they would have got involved without such funding); and
- where there was an existing and already recognized environmental issue, this helped to encourage involvement.

Recent projects have shown that cost savings can be achieved just as easily through numerous, small actions, which can be easily introduced, as through a limited number of major actions, which might encounter internal obstacles to their implementation (W S Atkins, 1997). However, in all cases there is a need to recognize that it takes time for the financial benefits to accrue, and the lack of immediately apparent results can act as a brake to progress amongst companies introducing waste minimization.

Although environmental pressures are increasing, the environmental benefits of waste minimization have been found to have a relatively small role in motivation, particularly by comparison with potential financial savings. Where environmental benefits can be determined, these are frequently viewed in terms of improving public relations.

Balanced against financial and environmental incentives there can often be obstacles to be overcome. First, until actively involved, many companies have only a limited understanding of waste minimization, or do not believe that there is scope for improvement in their businesses. For the individuals involved, there can be concerns about revealing weaknesses and faults in their areas of responsibility. These can be overcome by ensuring that explicit senior management support is in place.

Participants in demonstration projects almost always consider their involvement to have been worthwhile. External consultants and assessors help to give their efforts focus, drive, an external perspective and a systematic approach. However, there is often reluctance to work with such organizations without the financial and managerial support offered by the projects.

The long term success of waste minimization initiatives is helped by ensuring the involvement of staff across the organization from the outset. This might typically take the form of a series of project teams focusing on specific operational areas, with a co-ordinating team having responsibility for overall cohesion.

Demonstration projects are often based on a 'Club' approach, which allows participants to come together on a regular basis and share information. A survey of those involved in recent projects found that 70% found this approach useful. Major perceived benefits are summarized in Figure 1. Others included the inspiration from other members' progress, reassurance on issues of concern, peer group pressure to demonstrate progress and a sense of community. Potential problems, such as conflict between competing companies who might be unwilling to share information, the resources needed for attendance at meetings and other club activities, and inequality between club members in terms of expertise and value derived, have also been highlighted.

Policy issues

Notwithstanding the positive response to participation in demonstration projects, the key challenge for policy makers is to develop strategies

A large number of small actions can be just as effective as a single large action, which may prove more difficult to implement

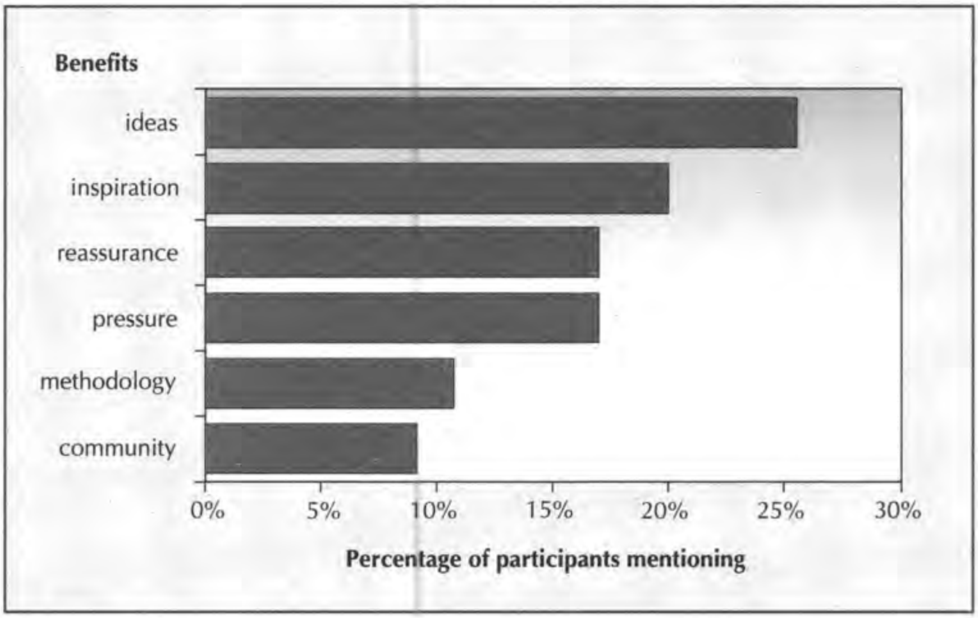
Explicit senior management support may be necessary in order to overcome internal obstacles within companies

The sharing of information between participants in demonstration projects is generally positive, but may encounter problems when competitors are suspicious of each other or members are unequal

Dissemination of the results of demonstration projects needs to concentrate on cost benefits and clarifying the underlying concept

The long payback period for waste minimization initiatives is a deterrent to companies

Figure 1. Benefits of a 'club' approach



(Source: CEST, 1995)

for promoting wider uptake of waste minimization across the business community and more widely. The policy issues cover two main areas:

- dissemination; and
- encouraging stand-alone initiatives.

Dissemination of the results of waste minimization demonstration projects is essential if more widespread uptake of successful approaches is to be achieved. To have greatest impact, dissemination activities need to focus on the cost benefits to those involved. At a more fundamental level, they also need to address the fact that many organizations do not have a clear understanding of the concept of waste minimization or, perhaps more worryingly, believe that they are already minimizing their waste when, in fact, they have little idea of either the quantities or sources of waste arising, let alone the opportunities for reduction. Those who could take a positive role in dissemination range from the European Commission, through national and local government, to trade associations and local business groups. As well as published material, organizations considering waste minimization could benefit from direct exposure to those who have had success with their own initiatives. This could take the form of discussion groups or site visits.

For companies considering establishing a waste minimization initiative, a major deterrent is often the investment required. The key challenge here is to highlight the link between a short-term investment and long term payback. Analysis suggests that a waste minimization club, using a shared consultant, could operate independently. The key challenge here is to ensure that companies are sufficiently convinced of the long term benefit to invest in waste minimization the short term.

Small and medium sized enterprises (SMEs) remain a particular challenge for those seeking to encourage waste minimization. For these types of companies, readily accessible information on what can realistically be achieved with minimal investment (both of time and money) can be useful. Success stories can be particularly helpful in this context. SMEs can benefit particularly from the interaction provided by a Club, providing they can be persuaded of the benefits to be derived from the time commitment necessary.

Research in the UK suggests that there is a relationship between company size and the amount of savings which can be achieved. In one study, data extrapolated from a sample of 11 companies indicated that the mean ratio of annual first year savings to turnover was just over 0.3% (CEST, 1995). These types of results could be consolidated with those from other projects across Europe to develop a more detailed picture of the results which might be expected at the company level. The data could then be used by individual organizations embarking on a waste minimization project to benchmark progress.

The extent to which technical solutions are required to progress waste minimization varies according to the type of activity undertaken. For those seeking guidance on solutions, there could be value in the establishment of a database of technological options. Such a database could be developed to be accessible over the Internet, to allow as broad a coverage as possible.

Organizations developing waste minimization solutions need to be aware of the principles of Integrated Pollution Prevention and Control (IPPC). The 1996 IPPC Directive seeks to ensure that efforts to minimize pollution take account of potential impacts on the full range of environmental media, and employ Best Available Technology (BAT). Waste minimization initiatives, including new technologies, should not operate in such a way that pollution reduction across one area of an organization's activities is replaced by increased pollution in another. A good example of where this might apply is sewage treatment works.

With respect to stand alone initiatives, a mechanism is needed to allow companies to obtain the benefits which consultants can bring, in terms of focus and structure, without the need to invest in external resources. This could be, in part, achieved by ensuring the involvement of an enthusiastic project champion with senior management support, and financial and operational resource. The establishment of local 'clubs', which allow organizations to share experience, can also be beneficial. Local environmental or trade groupings could have an important role in facilitating the setting up of such clubs. To maximize the interaction amongst club members, it is, generally, advisable to avoid including organizations who are in direct competition with one another in a single club. On the other hand, there can be benefits in bringing together companies operating in the same broad industry sector. By making the club focus as local as possible, concerns regarding time commitments to attend meetings etc. can be minimised.

As the role of cost savings as an incentive to greater uptake of waste minimization are highlighted, it is important that the environmental benefits are not overlooked. There has been a tendency in some recent demonstrator projects to no longer measure changes in environmental performance. The development of a policy framework which is optimized to encourage greater uptake of waste minimization needs to recognize the full range of improvements that can be achieved, and the mechanisms which need to be established for them to be realised.

Stimulation of greater uptake of waste minimization is best achieved through the involvement of the full range of stakeholders. Box 1 illustrates possible roles for key players.

Information on available technical solutions needs to be made as widely available as possible

A mechanism is needed to allow companies to obtain the benefits which consultants can bring, in terms of focus and structure, without the need to invest in external resources

Research in the UK suggests that there is a relationship between company size and the amount of savings which can be achieved

Box 1. Stakeholder roles in advancing waste minimization

Industry:

- Collaboration between experienced companies and their suppliers to spread good practice and reduce costs along the supply chain.
- Promotion of improved environmental performance and the contribution of waste minimization.

Trade Associations:

- Provision of a forum for exchange of experience in specific sectors, including technical aspects.

Research community:

- Research into technological solutions which are in accordance with IPPC.
- Development of LCA and other tools for evaluation of waste minimization options.

Local Government/local interest groups (e.g. Chambers of Commerce):

- Provision of local focus for sharing of experience and collective action.

Policy makers:

- Promotion of benefits of waste minimization.
- Development of policies which support waste minimization (e.g. financial incentives such as waste based taxes).
- Dissemination of good practice.

Finance bodies:

- Provision of favourable investment conditions.

Recommendations

Actions which could help to stimulate greater uptake of waste minimization, based on experience to date, can be summarized as follows:

- Dissemination - a coherent approach across Europe could help to ensure that there is consistency and reinforcement in the messages reaching target groups. The full range of communications media should be utilised, with a focus on clearly demonstrable benefits and practical experience in real organizations. An example of a national dissemination programme where waste minimization has received considerable support is the UK Environmental Technology Best Practice Programme (ETBPP). One of the ETBPP's key aims is to promote the use of better environmental practices which reduce business costs for UK industry and commerce. As well as regular events to encourage waste minimization, the Programme produces a series of free publications, including case studies, good practice guides, information on new technologies and techniques (new practice).

- Frameworks - Future developments in areas such as Environmental Management Systems, IPPC and other initiatives aimed at improving environmental performance across industry should take account of the benefits and practical challenges of waste minimization, and seek to provide an appropriate framework for stimulating greater uptake.
- Local action - Where possible, consideration should be given to mechanisms which will encourage stand alone initiatives, possibly based around a club approach, which needs to be established at the local level. This could include consideration of the role of local support networks, such as business clubs and trade associations. By way of illustration, considerable success has been achieved with demonstration projects based in river catchment areas in the UK. The Dee (W. S. Atkins, 1997) and Aire and Calder (CEST, 1994) Waste Minimization Projects achieved annual cost savings of over 3 million ECU and around 6.75 million ECU shared amongst 14 and 11 companies respectively.

There would also be benefit in a pan-European assessment of success factors, based on demonstration projects and other activities, which draws on individual countries' experiences to refine understanding and ensure that future policy is appropriately focused for maximum impact.

Keywords
waste, motivation, minimization, management, greater uptake

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Packaging Re-use: Building on the Opportunities to Improve Environmental Performance and Reduce Costs

Celia Greaves, *CEST*

Issue: Packaging waste forms an important component of the non-hazardous waste stream, typically accounting for up to 10% of total arisings. This waste is produced throughout the supply chain, from raw material manufacture through to the consumer. European legislation aimed at harmonizing national packaging waste management measures and minimizing the environmental impacts of packaging waste seeks to achieve this through increasing levels of recovery, recycling and re-use.

Relevance: The European Parliament and Council Directive 94/62/EC on Packaging and Packaging Waste sets specific targets for the recovery and recycling of packaging waste, including re-use. An efficient response requires an understanding of the issues around, and scope for re-use amongst those who produce and handle packaging, as well as a suitable framework of support. Stakeholders include both policymakers and industry.

Introduction

Over recent years, pressure on resources across Europe has lead to an increased focus on the effective management of waste. In the case of packaging, this has been manifest in European legislation setting specific recovery and recycling targets which will come into effect in 2001. One way in which the response to the obligations arising from this legislation can be optimized is through increased packaging re-use, whether this be in the context of industrial transit packaging or primary consumer packaging.

Packaging re-use offers benefits in terms of cost savings on account of reduced material use, as well as being a response to European legislation

Packaging re-use offers a number of clear benefits (UK Department of the Environment, 1997):

- a sustainable approach to packaging waste - in line with the aspirations of the waste hierarchy;
- an effective response to the European legislation; and
- cost savings - through reduced use of raw materials and reduced quantities of waste requiring disposal.

In addition, re-use can, in many cases, be introduced more easily than recycling, which often requires more complex and costly infrastructure and procedures. For a variety of activities, it may be possible for organizations to introduce packaging re-use with very few changes to existing ways of working. Furthermore, simple, closed loop re-use schemes can help to avoid some of the problems associated with over-supply in the recycled material sector, as have already been experienced in some countries. By decreasing the amounts of material to be recycled, whilst at the same time reducing the amount of waste to be disposed of, future over-supply in recyclate markets should be minimized.

The realization of these benefits can be facilitated by policies which encourage packaging re-use. There is also a need for those involved to understand the scope for and limitations to packaging re-use.

Types of packaging

Packaging can be considered as falling into three main groups:

- primary - that which forms part of the sales unit to the consumer (e.g. a drink can);
- secondary - that which is used to group individual sales units, either for the consumer, or to ease handling by the retailer (e.g. a cardboard sleeve for holding several drink cans); and
- tertiary - that which allows sales units to be transported in bulk (e.g. transit packaging for securing and handling a large number of drink cans).

In principal, re-use is feasible for all of these types of packaging. However, in each case there are specific issues which need to be addressed. For example, primary packaging is typically distributed across a large number of consumers, and collection and consolidation after use in such circumstances can be challenging.

The materials used in packaging will vary according to the type of packaging (i.e. primary, secondary, tertiary) and the circumstances of its use. Attributes typically required are summarized in Box 1.

Re-use is often technically easier than recycling and can avoid over-supply in recyclate markets

Box 1. Packaging attributes

- Protection of contents against damage (e.g. during handling or through contamination)
- Containment (e.g. to prevent spillage)
- Ease of handling (i.e. size, weight and shape)
- Ease of storage (e.g. to allow a number of packages to be safely stacked)
- Identification (both for product management purposes and branding)
- Customer preference (particularly in the case of primary packaging)

Packaging falls into three different groups according to its role and re-use considerations are different for each

Designing for re-use

Packaging has traditionally been designed to provide the optimum mix of attributes (see Box 1) for the lowest cost. In many cases there are trade-offs to be made between particular attributes. For example, a more expensive type of packaging could provide better protection, but the additional cost may not justify the benefits. More recently, there has been a growing recognition of the environmental implications of packaging decisions, and this has begun to emerge as a further design consideration.

For any organization moving from single trip to reusable packaging, a major concern will be to ensure that the packaging is sufficiently durable to be used a number of times. Here there will be a balance to be achieved between the costs of packaging, the number of times it can be re-used, and the scope for and cost of refurbishment. There are also issues around sustainability, with the additional material typically required for more robust (re-usable) packaging being at odds with moves towards waste minimization. However, if packaging is re-used sufficient times, the average amount per product is reduced over time.

Packaging design seeks to provide an optimum mix of attributes. Recently, environmental considerations have begun to emerge as a further consideration

Packaging designed for re-use needs to be more durable; packaging components which may be repaired or replaced may therefore become cost-effective

Re-use of primary packaging (i.e. the packaging in which the final customer receives the goods) requires changes in consumer attitudes and may clash with brand image factors

In general, it is likely to be easier for organizations to introduce re-use of tertiary packaging (i.e. that used to transport units in bulk) than primary packaging

There are a growing number of suppliers who can provide packaging which is specifically designed for re-use, including the ability to replace particular parts if they become broken. For example, Perstorp Plastic Systems (Perstorp Plastic Systems, undated) has developed a range of plastic containers with hinged sides which can be removed and replaced as appropriate.

Whilst much progress can be made in packaging re-use without the need for major technological intervention, technology can make a valuable contribution. For example, electronic tags (using bar-codes or magnetic memory chips) attached to containers could help organizations to manage the flow of reusable packaging through the supply chain. Advancements in materials technology could be significant in the development of new packaging materials which are particularly appropriate for re-use, and in the redeployment of existing materials. An example of the latter is the use of inflatable cushion packaging for fragile products (Heesemans, 1995).

Issues relating to packaging design are particularly important in the context of primary packaging, where attributes such as branding and customer requirements have a high priority. Consumer support for re-usable packaging, notwithstanding issues such as container return after use (see below), is a major challenge in a 'throw-away' culture. The Body Shop (Wheeler, 1994) has offered an in-store refill service since 1976 but, despite discounts of more than 20% on certain products, only around 2% of their UK purchases involve a refill. Although levels are slightly higher in Sweden and Germany, at 7% and 5% respectively, there is still considerable scope for improvement.

Branding can form a significant constraint to re-use of primary packaging, with companies often reluctant to move towards the standardization of design which would make the process more streamlined and cost-effective.

Areas offering greatest scope for progress in consumer packaging re-use include those with a mass market characterized by standard containers, such as certain types of drink bottle and, on a smaller scale, egg cartons. For bottles, re-use can be stimulated by the establishment of 'bring' deposit systems, which have had some success in countries such as Norway and the Netherlands.

Supply chain issues

In general, it is likely to be easier for organizations to introduce re-use of tertiary packaging than primary packaging. Whilst tertiary packaging may be passed between several organizations, primary packaging is often distributed between large numbers of consumers. In such situations it can be difficult to ensure that the packaging is returned to the supplier. 'Bring' systems, such as those described above, offer the greatest potential here.

Perhaps the simplest way in which re-use of tertiary and, to some degree, secondary packaging can be introduced is through closed loop schemes where suppliers and their industrial customers work together to achieve re-use of a particular type of packaging. For such schemes to be successful, there needs to be understanding of objectives and full support from all parties involved. There may be particular benefit in the various users of the packaging having a role in its design. In this way, problems associated with handling, storage and integration into production processes can be minimised.

In planning packaging re-use, organizations need to be sure that they have sufficient stocks to accommodate patterns of flow between suppliers and customers. For example, a scheme is unlikely to be successful if all empty containers are with the customer when they are needed for filling by the supplier. Arrangements for the transfer of such containers back to suppliers requires particular consideration. Costs and environmental impacts associated with such transfer can be avoided by returning empty containers as part of the return journey of the goods delivery vehicle, where appropriate. This may not always be possible but, where it is, would help to ensure efficient use of the transport infrastructure.

Policy implications and recommendations

In seeking to encourage greater packaging re-use, there may well be lessons to be learned from previous experience, particularly in terms of primary packaging. Over the past 50 years, the number of refillable/re-usable containers has declined sharply, and there has been a corresponding decrease in levels of re-use. Reasons for this are likely to include:

- public attitudes - as manifest in consumerism and the throw-away culture and
- the 'value' attached to packaging and its re-use - as defined by economic signals, such as the value of returns and the costs of disposal, etc.

A major success factor is the extent to which frameworks can be established which reflect the true cost of production, use and disposal of packaging. This helps to highlight the benefits of packaging re-use and stimulate industry and consumers to take a more proactive role.

Countries such as Denmark, Belgium and Luxembourg have provided support for packaging re-use through a variety of economic instruments. The challenge for the future is to determine whether and how such mechanisms could be applied across Europe, whilst ensuring a consistent, pragmatic and coherent approach to waste management in the widest sense.

As well as economic/fiscal measures, there are a number of other actions which could help to stimulate greater uptake of packaging re-use. Options include:

- Public awareness - There would be benefit in promotion of the value of packaging re-use amongst consumers. This could be linked to the broader issue of sustainable development and could be aimed at overcoming the stigma attached to 'second hand' packaging.
- Industrial promotion - Greater uptake of packaging re-use across industry can be encouraged by highlighting the real benefits that can be accrued. Where companies can see practical experience at other similar organizations, they are much more likely to recognize the relevance to themselves and, more importantly, to take action, than on the basis of unqualified guidance. A particular advantage of encouraging organizations to take responsibility for re-use of their own packaging is that it could help to avoid some of the trans-border and subsidiarity related issues that might arise. The extent to which this is possible will depend upon the relationship between suppliers and customers throughout the supply chain.
- Standardization - The standardization of certain types of consumer packaging could facilitate the cost-effective operation of 'bring' deposit systems. This would require co-operation between companies, in the context of both packaging design and the management of its re-use. Standardization of tertiary packaging, particularly where it is used by a limited number of organizations, can be achieved more easily.
- Incentive schemes - Traditional approaches, such as 'deposits' on bottles, demonstrate the

Re-use of tertiary and secondary packaging requires full involvement and support of all parties and planning to ensure sufficient stocks

As a result of changing attitudes and economic signals, packaging re-use has in fact declined sharply over the last 50 years

Awareness raising, standardization and economic incentives are among the actions which could help to stimulate greater uptake of packaging re-use value of well planned, consistent incentive schemes. However, consideration does need to be given to issues such as subsidiarity and free trade.

- Economic Instruments - Proposals for the new European Waste Strategy have included suggestions for the introduction of charges for non-reusable products. Consideration could be given to how similar economic instruments might help to stimulate greater packaging re-use. New forms of waste taxation (for example, the landfill tax in the UK) could form important incentives for packaging re-use.
- Trans-European aspects - The introduction of large scale re-use schemes could have implications for trade across EU member states. These would need to be fully evaluated prior to the introduction of any major policy initiatives, to ensure that market distortions do not arise.

As with other aspects of the European policy, any measures to encourage greater re-use of packaging need to take account of the subsidiarity and related issues. Whilst many companies might welcome a standard approach, the benefits of any economies of scale which could be achieved will need to be weighed against the priority given to local determination and interpretation. The need to ensure free trade conditions is also relevant.

Support for packaging re-use is likely to be best targeted towards producers/industry lead schemes where those who are likely to re-use the packaging take a key role. Any other approach is likely to be less able to achieve a comparable impact (in terms of levels of re-use) for equivalent input.

In conclusion, as measures to encourage increased packaging re-use are examined and developed, it is important to recognize that this approach is not always appropriate, either in economic or environmental terms. Life cycle analyses could play an important role in determining the balance between the benefits highlighted earlier, and the costs and impacts of additional material handling, storage and transport, and the need to invest in different types of packaging. This is particularly pertinent in more complex cases, for example where containers need to be cleaned, or incorporate disposable liners.

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Keywords
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Environmentally Compatible Treatment and Use of Organic Waste

Ludwig Leible, *ITAS*

Issue: Environmentally compatible treatment and use of waste is a great challenge that will have to be met if our production and consumption conditions are to be brought closer to sustainability. Nevertheless, it is becoming more and more difficult and expensive to use wastes in an environmentally-friendly way. In this context the use of organic waste as a source of energy will be an interesting alternative with growing importance, especially in the medium and longer term.

Relevance: Organic wastes make up a large part of total wastes from both production and consumption. Although landfilling is economically attractive today, landfill capacity is clearly finite and its environmental impact is causing concern. Regulatory restrictions are therefore being introduced, placing increased emphasis on alternatives.

Introduction

Non-fossil organic residues and wastes (for further definitions, see Table 1) make up a large part of the volume of waste from production and consumption of products. For example, in Germany the current annual volume of organic wastes generated is about 65 - 75 million tonnes of dry organic matter. This corresponds approximately to one third of above-ground biomass production. Today the cheapest option for most of this waste is to landfill it, but in the longer term this will no longer be permitted for organic wastes on account of their environmental impact and the limited landfill capacity. The forthcoming European Landfill Directive aims in this direction. Consequently, the search for other treatment methods and uses of organic waste will have to be reinforced. Their use for energy will be at the centre of the attention and both economic and environmental considerations are likely to give it even greater priority than the cultivation of specific renewable crops for the generation of energy.

The Volume and Importance of Organic Waste

Vegetable raw materials are the starting point for almost all organic waste. This material is consumed either directly or following processing into food, animal fodder and industrial raw materials (renewable resources). Both in the harvesting of vegetable raw materials (plant production) and in their processing (animal husbandry, food industry, processing of renewable resources) and following their consumption, organic wastes of varying volume and composition are left over.

The forthcoming European Landfill Directive will put limits on the amount of waste which can be dumped in the ground

Organic waste is mostly derived from vegetable matter and may be a result of agriculture, forestry, industry or consumption in homes

Although difficult to calculate exactly, in Germany an average of 0.8 tonnes of organic waste are produced per person each year

Technical alternatives for treatment depend crucially on the composition and pollutant content

Depending on the area where this is accumulated and its actual composition, the resulting pressure for disposal varies a great deal in both the medium and long term. For example, straw from agricultural crops generally presents no serious disposal problems, in stark contrast to municipal waste. The report by the European Environmental Agency on the monitoring of the EU Fifth Environmental Action Programme states that because of past developments at the European level, greater attention should be paid, among other things, to the waste sector and climate change (Wieringa, 1997). On the one hand, the volume of waste in the EU countries continues to increase; on the other, improvements in recycling are being restricted by the related costs and the lack of a market for secondary raw materials. The per capita volume of municipal waste in the EU is currently (1995) roughly 430 kg per year with a tendency for further increase (OECD, 1997). In 1980 this volume was 340kg per inhabitant of the EU.

Estimations of the total volume of organic residues and waste are only possible with considerable uncertainty due partly to the very sparse statistical data and lack of detail. This applies equally with regard to their composition and contribution to pollution. For instance, rough estimates for Germany result in a volume of around 65 to 75 million tonnes of dry organic matter (DOM). To give an impression, this corresponds to an annual volume of 0.8 tonnes per inhabitant or, in terms of heating value, to 400 litres of fuel oil. About one third of the volume originates from manufacturing or municipal waste. With regard to volume, the most important types of organic waste are industrial waste and used wood, paper and cardboard waste which is not recycled, sewage sludge and kitchen and garden scrap. Two thirds of the total volume are from agriculture and forestry.

The Composition of Organic Waste

It is of central importance for the assessment of the various technological alternatives for treatment and use of organic waste to know the dry matter (DM) content, its physical state (liquid, solid, unit type) and its chemical composition (DOM, N-content etc. macro nutrients). In particular, it is decisive to know which pollutants (e.g. heavy metals, organic pollutants) it contains and its salt and chlorine content. For a preliminary distribution of organic waste to the individual technological treatment processes, the most important factor is the content of dry organic matter. According to the type of waste and its conditioning stage, this can amount to roughly 5 to 95% (in % of fresh mass, FM). With respect to dry matter content, the various processes for the treatment and use of organic wastes have the following requirements regarding the substrate:

- Wet fermentation: ≤ 15% DM (%FM)
- Dry fermentation: 20 to 45% DM (%FM)
- Composting: 40 to 60% DM (%FM)
- Incineration: ≥ 60% DM (%FM)

For fermentation (biogas production), the most important factor beside the proportion of dry organic matter (DOM) is the ease with which this 'organic matter' is biologically degradable. Sugar, starches and fats are particularly suitable fractions for this in contrast to those contents which are difficult to degrade biologically, such as cellulose, hemi-cellulose or lignin.

The nutritional content of organic wastes, e.g. nitrogen, phosphate, potassium or calcium content, is of less importance for the quality of the processes for biological methods of treatment. It may play a part in the use of organic wastes in agriculture ('fertilizer value').

Thermal treatment methods tend to produce higher emissions of NO_x when there are larger amounts of nitrogen in the waste unless a denitrification process is envisaged for flue gas purification. Another disadvantage of thermal treatment methods is that large amounts of potassium can lead to a reduction of the ash softening temperature during combustion, thus creating problems during ash extracting (baking ash). Since large volumes of potassium in biomass are frequently linked with increased levels of chlorine, this could amplify the risk of corrosion or production of dioxins.

The amounts of pollutants contained in organic wastes are of central importance for the assessment of environmental compatibility. However, analyses of organic pollutants (e.g. dioxins, furan, PCBs) have partly been performed only sporadically for individual types of waste. This could be due to the fact that organic pollutants have only recently become the subject of analyses, partly on account of the elaborate analysis procedures needed, in comparison with heavy metals, which have been the subject of analyses for a longer period of time. In this connection, it should be pointed out that a higher relative basic level of pollution of organic waste can be assumed for cadmium, zinc and copper. Although further reductions of pollutants could be achieved by sorting waste, these should not be overestimated. More polluting organic waste should be subjected to treatment methods destroying the pollutants or transforming them so as to render them inert.

Processes for the Treatment and Use of Organic Waste

The existing alternatives for the treatment and use of organic waste are mainly biological and thermal processes. For the biological processes we may make a general distinction between processes for the production of biogas and composting. Biowaste separated from municipal wastes includes animal and vegetable waste unlike plant waste containing only vegetable wastes like garden waste, leaves or grass cuttings. The main thermal processes are the use of organic waste and residues in waste incineration plants and biofuel facilities (for less polluted wastes). The direct landfill of organic waste is currently being practised a great deal for economic reasons, but its relative importance will decline in the medium to long term. The reasons for this are the limited availability of space for landfills, but more especially the restrictions increasingly imposed at the national level, some strictly prohibiting landfills of organic waste in the medium term. Table 1 provides an overview of the processes which are technologically suitable for the treatment and use of various types of organic waste and residues.

The current situation for the treatment and use of organic wastes in the EU thus by no means corresponds to these reported technological options or preferences. The bulk of organic residues and waste in agriculture and forestry is currently not used at all or in negligible amounts in the ways mentioned. For municipal waste, roughly two thirds of the total volume in the EU are currently (1995 figures) being directly landfilled (without pre-processing) (OECD, 1997). This is still currently the cheapest disposal alternative compared to other forms of treatment, although in the medium term it will no longer be permissible in this form. In 1997 the European Commission adopted a new Proposal for a Council Directive on the Landfill of Waste with binding targets for the reduction of the landfilling of biodegradable municipal waste. According to this draft, Member States would be required to reduce landfilled biodegradable municipal waste to 75% in 2002, 50% in 2005 and 25% in 2010 (with respect to the total amount by weight of biodegradable municipal waste produced in 1993) (Commission of the EC, 1997). These

Thermal treatment of organic waste faces the problem of potentially polluting combustion products

Organic waste with a higher level of pollution should be subjected to treatment methods destroying the pollutants or transforming them so as to render them inert

In addition to incineration biological treatment, including biogas production and composting, are further options for organic waste targets are being challenged, but it seems certain that a sharp decrease in organic waste landfilling will be maintained. In 1995 about 18% of the total volume of municipal waste in the EU was incinerated, 6% composted, and 10% recycled (OECD, 1997).

The methods of recycling and composting, which are currently in the spotlight of public debate in several European countries, at present only account for part of the technologically feasible potential - partly with tendencies which are still increasing. The costs and narrowing bottlenecks for marketing the resulting volumes of compost and secondary raw materials already indicate that the potential for the realization of these processes is limited not so much by the volume of input and recycling techniques, as by the market potential of secondary raw materials.

The forthcoming proposed European landfill directive envisages a drastic decrease in the amount of organic waste permitted in landfill

Table 1. Suitability of technologies for the treatment and use of organic waste

TREATMENT/ UTILISATION	Type of organic waste										
	Untreated wood, straw	Bark	Kitchen scrap	Garden/cultivation waste with low wood content	Garden/cultivation waste with high wood content	Foliage and leaves	Biowaste	Waste from beverage/food industry	Liquid manure	Sewage sludge	Used and waste wood, wastepapaer, cardboard
Composting:											
Plant waste composting		+		+	+	+					
Biowaste composting		(+)	+	+	+	+	+	(+)		(+)	
Biogas production:											
Liquid manure fermentation with cofermentation			+	(+)			+	+	+		
Biowaste fermentation (wet/dry fermentation)			+	(+)		(+)	+	+			
Thermal treatment:											
Combustion in incineration plants	+	+	+	+	+	+	+	+		+	+
Combustion in biofuel plants	+	+		(+)	(+)	(+)					
Other:											
Utilisation as forage			(+)	(+)				(+)			
+ suitable; (+) conditionally suitable											

Source: Wintzer et al. 1996

Evaluation of the Processes

The basis for the evaluation of the processes for the treatment and use of organic wastes is provided by the technological, economic and environmentally relevant characteristics, which are in part quantifiable, but partly can only be implemented qualitatively. Keywords for quantifiable technological characteristics are, for instance, 'decrease of DOM' or 'energetic substitution value'. Comparisons reveal that the suitability of the processes for DOM reduction varies a great deal. For instance, while biogas production or composting merely reduce the DOM by 40 to 60%, thermal processes (waste incineration plants, biofuel facilities) achieve a reduction of close to 100%.

Similar distinctions exist for the resulting products, which can be put to further use and lead to income. For composting, this is compost which can be used to improve the fertility of soils. For biogas production and processes for thermal treatment, these are electric current and heat, which can be used and thus make a contribution to our supply of primary energy.

For the purposes of the description and evaluation of processes it is possible to use the quantitative economic measures of 'specific investments', 'processing costs' (including collection and transport), 'receipts' and 'deficits' (see Table 2). In terms of the remaining costs (deficits) per tonne of DOM input to the process (DOM_{In}) - following the subtraction of receipts -

Table 2. Characteristic economic data on selected processes for the treatment and use of organic waste

	Capacity (1000 t FM/year)	Specific investments (ECU/t FM per year)	Processing costs (ECU/t FM)	Receipts (ECU/t FM)	Deficits (ECU/t DOM)
Composting:					
Plant waste composting	2 - 10	180 - 370	45 - 90	0 - 8	90 - 240
Biowaste composting	6 - 50	290 - 730	160 - 300	-8 to +8	560-1110
Biogas production:					
Liquid manure fermentation with cofermentation	10 - 40	50 - 70	12 - 16	15	10 to -30
Biowaste fermentation	10 - 30	470 - 790	170 - 300	9 - 17	570 - 1080
Thermal treatment:					
Combustion in incineration plants	100 - 200	Biowaste 730 - 940 materials with high wood content	200 - 340	-30 15	780 - 1250 310 - 540
Combustion in biofuel plants	10 - 50	340 - 500	105 - 175	60	80 - 210
Other:					
Direct landfilling		not available	50 - 260	-	190 - 935

Source: Wintzer et al. 1996 Exchange rate 1996 (1 ECU = 1.91 DM)

Table 3. Energetic substitution values and greenhouse gas balances of selected processes for the treatment of organic waste

	Energetic substitution value ($Mwh_{fossil}/t\ DOM_{In}$)	Greenhouse gas balance net (tCO_2-eq./t DOM_{In})
Composting:		
Plant waste composting	- 0.04	+0.0026 to +1.07
Biowaste composting	- 0.29	+0.34 to +1.29
Biogas production:		
Liquid manure fermentation with cofermentation	1.98	-1.21 to -1.55
Biowaste fermentation	1.59	-0.54 to -0.61
Thermal treatment:		
Combustion in incineration plants	0.61	-0.65
Combustion in biofuel plants	3.83	-0.9 to -1.3
Other:		
Direct landfilling	0	+0 to +10

Source: Wintzer et al. 1996

The composition and low polluting character of organic waste make it suitable for co-fermentation with liquid manure, combustion in biofuel facilities or plant waste composting

it becomes apparent that the combustion of biowaste in waste incineration plants is most expensive at roughly 800 to 1300 ECU, following processes for composting biowaste and biowaste fermentation. To the extent that organic waste, due to its composition and low degree of pollution, is suitable for economic reasons for cofermentation with liquid manure, combustion in biofuel facilities or vegetable matter waste composting.

Biogas production and thermal processes for waste treatment can make a significant contribution toward a favourable shift in the greenhouse gas balance

From the environmental point of view, the emission of air pollutants (e.g. NO_x, SO_2, CO) and more specifically the emission of greenhouse relevant trace gases (CO_2 equivalents) is of great importance in assessing processes. According to the extent to which fossil fuels can be saved in the processing and use of organic waste (energetic substitution value) or existing emissions of greenhouse relevant gases (e.g. methane, nitrous oxide) are increased or decreased, the results are overall amplification or reduction effects in the greenhouse gas balance. Biogas production and thermal processes for waste treatment can make a significant contribution toward a reduction in this balance, which can be of the order of -0.5 to -1.6 tonnes of CO_2 equivalents, per tonne of DOM input for the process (cf. Table 3).

Economic aspects and, on account of their long-term impact on the environment, the climate-altering greenhouse gases, heavy metals and organic pollutants, are of particular importance for the final assessment. Emissions of odours are primarily of importance for the local acceptance of treatment processes.

The following conclusions may be drawn from the comparative evaluation of the advantages and disadvantages of treatment processes and methods for the use of organic waste:

In the thermal treatment of organic wastes, durable organic pollutants (e.g. dioxins, furans, PCBs) are destroyed and the bulk of heavy metals are concentrated in the ash or held back by filters and thus amenable to special treatment and landfilling. The potential for concentration and virtual 'inertialization' are important advantages. The biological processes are, however, not suitable for the reduction of organic pollutant content, or for the conversion of heavy metals into less problematic states, which can be more or less serious, depending on the type of waste. The application of compost or fermentation residues to agricultural land or gardens usually leads to a gradual increase in the concentration of inorganic and durable organic pollutants in the soil, which is very difficult to reverse.

Assessments for the net account for climate-altering trace gases indicate that anaerobic processes have advantages over composting. These advantages are particularly large if the effect is not only the substitution of fossil fuels, but also a reduction or even avoidance of methane emissions (e.g. during landfill or liquid manure storage). Unfortunately, our state of knowledge on the amounts of methane or nitrous oxide released during biological processes - in particular composting - is unsatisfactory. Accounts on climate-altering trace gases in biological treatment processes can thus only be very rough estimates. In the case of thermal processes, the bulk of the reduction is attributable to the substitution of fossil fuels.

The environmental advantages of modern biological processes - biogas production and composting - compared to thermal processes, are to be found in the improvement of the structure of the soil and its nutrient balance thanks to the spreading of the resulting compost or fermentation products on agricultural land. This also depends on location. These advantages are appreciated more in landscaping than in agriculture, where the difficulty in estimating the availability of nutrients from composts or fermentation products is a grave disadvantage along with the risk posed by other pollutants (e.g. heavy metals).

The economic comparison of thermal process and modern biological treatment facilities is unfavourable to thermal treatment, although its greater cost is offset by its environmental advantages, notably with respect to the retention and destruction of pollutants. The extent of the advantages and disadvantages in individual cases and recommendations for treatment resulting from these depend heavily on the type and degree of the contamination of the organic waste requiring treatment.

Conclusions and Perspective

The use of organic waste as compost, fodder or in the production of chip-boarding, provides only limited market opportunities, in particular due to the risks of contamination and market disadvantages when competing with products not using waste as a raw material. When the various methods for the treatment and use of organic wastes are compared, it is to be assumed that energy production will gain significance in the medium term. This will be supported by the forthcoming Council Directive on the Landfill of Waste. By the year 2030, for example, organic waste from manufacturing, households, agriculture and forestry could meet roughly 5% to 7% of the German demand for primary energy. In 1995 about 2.4% of demand for

In the thermal treatment of organic wastes, durable organic pollutants (e.g. dioxins, furans, PCBs) are destroyed and the bulk of heavy metals are concentrated in the ash or held back by filters and thus amenable to special treatment and landfilling

Biogas production and composting offer advantages in terms of soil improvement in certain locations. Thermal processes offer better retention and destruction of pollutants primary energy in the IEA countries was provided by biomass, including organic wastes, 0.4% of it by waste (IEA 1997). In order to take full advantage of the potential, additional efforts are required. An important step could be utilities paying higher prices for electricity from biomass, including organic waste, if this is fed into the public supply grid. This potential could be fully developed by means of additional financial incentives for the environmental benefits achieved, e.g. reduction or even avoidance of previous emissions of methane or other greenhouse-relevant gases. Political initiatives in this direction are of central importance.

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Ludwig Leible holds a diploma in agricultural engineering and a PhD in agricultural science. He has been a researcher at the Institute for Technology Assessment and Systems Analysis at the Karlsruhe Research Center, Germany, since 1988. His main areas of research are technology assessments and systems analysis in the field of renewable energies and raw materials, organic wastes and sustainability.

Keywords
organic waste, thermal treatment of waste, energetic use, biogas production, CO_2 balance, costs

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Waste Hazards and Impact: From Regulatory Classification to Environmental Compatibility

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Issue: Over the last ten years national and European regulations governing the management of waste have made considerable progress towards more stringent environmental quality requirements. In the same vein, European regulations have sought to identify, name, quantify and classify wastes in terms of the potential hazard they represent for man and the environment. However, there is still a long way to go before these regulations are fully applicable.

Relevance: All developments in society, and particularly those relating to industry, need clear and lasting rules. If these rules are undergoing constant evolution, as is the case in the environmental domain, it is not only essential to keep up with their current state, but, above all, it is necessary to know the main trends and understand the way in which they are developing. Indeed, it is foreseeable that the regulations covering wastes may change in terms both of their intrinsic hazards and in the development of their behaviour in given situations in which they have been recovered, reused or eliminated.

Definition/classification of Wastes

In the industrialized world wastes have always been referred to empirically along five main complementary approaches:

- Presumed hazardous or harmless nature.
- Source (by sector, industrial activity, single producing operations, etc.)
- Characteristics (combustible, fermentable, etc.), often associated with one or more potential sub-types.
- The nature or content (plastic wastes, arsenic-contaminated wastes, etc.)
- In the case of consumer wastes, the function of the product after the end of its useful life (batteries, solvents, packaging, etc.)

Single, clear and unambiguous lists having so far not been created, the absence of a common language has seriously handicapped progress in the management of waste in industry in a way that respects the law and the environment. No serious incentivation or control policy can genuinely be put in place without a common definition and classification tool.

A certain number of Member States have nomenclatures or catalogues that have arisen as a result of this desire to achieve a pragmatic common language, among these the most important being the German catalogue and the French nomenclature.

At community level, framework directive 75/442/EEC was based on an unsatisfactory

No serious incentivation or control policy can genuinely be put in place without a common definition and classification tool

The community framework directive was based on an unsatisfactory definition of wastes. The update identified the need for a uniform, exhaustive, list in tune with the reality of the industry

definition of wastes. The 16 categories included in Annex I have titles that are vague, indicating the reasons that have led to the material under consideration being abandoned (products falling outside the standards or expired, accidentally spilled matter, substances unfit for consumption, etc.) but nothing usable for the pragmatic and effective management of wastes.

The update (91/156/EEC) links the definition of wastes to their belonging to a list published three years later. A group of 8 consultants was mandated by the Commission to draw up this list of waste. The main principles of the specifications were the following:

1. The need for a single, linear list.
2. Exhaustiveness. An elusive goal, as it depends upon the degree of accuracy of the definitions and is unable to take emerging technologies into account.
3. The pragmatic aspect of the descriptive text used, linked to the generating operation.
4. The absence of references to substances contained or the concentration of any particular element.
5. Concern for consistency with Community documents mentioning wastes.
6. Taking into account the reality of industry through the work of consultants for the preparation of a series of projects built by the manufacturing sector.

In addition to the translation and information work undertaken by the consultants on the various different existing national approaches and texts, this also resulted in the delivery to the Commission of a European Catalogue of Wastes. Following 'retouching' work without the group of consultants, the European Catalogue of Wastes was published on 7 January 1994. A number of errors in this version have to be noted. For example, the confusion between slag produced by the first and second smelting of lead (10 04 01) which have nothing in common except the fact that their descriptive texts are near synonyms. As a result of the highly polluting nature of the latter their assimilation into the first category puts in hazard operations aimed at recovering the low-polluting slag resulting from first smelting.

The deletion of category 19 01 (waste produced by the incineration of hazardous industrial waste) has resulted in an essential part of waste treatment, including important wastes such as bottom ash and above all, air pollution control residues, to be excluded from the catalogue. The reason given was the impossibility of referring to wastes for which the list had not yet been published on account of the difficulties met in drawing it up.

The work by the Committee for Adaptation to Scientific and Technical Progress (CASTP) on updating the Catalogue should solve this problem.

Definition/Classification of Hazardous Wastes

The group of consultants, whose second task was to lay down the foundations of the list of hazardous wastes, has very quickly made apparent the difficulty of legislating systematically once and for all on the hazardous nature of the majority of wastes. In fact, a variation from one country to the next, one company to the next and indeed from one day to the next, could change both the nature of the substance contained or its environmental availability (solubility, volatility, etc.). Consequently the potential impact on man and the environment may be radically altered.

On the suggestion of certain Member States (mainly France and Germany), a minimal list was established (decision 94/904/EEC) whose updating and progressive expansion depend on criteria for classifying a waste as hazardous and above all their effective applicability.

These 14 criteria, listed in Annex III of directive 91/689/EEC, are of four types: H1 to H3 'physical hazard', H4 to H12 'hazard for human health', H13 'hazard following elimination of waste' and H14 'environmental hazard.'

Criterion H14 is crucial given the risks presented by pollutants in uncontrolled contact with the environment in the absence of adequate regulations. Moreover, the classification a priori of catalogued wastes as hazardous has shown that around 80% of the wastes judged hazardous would be so on account of H14 alone. In 1994 DGXI entrusted POLDEN with the task of undertaking a study of a criterion H14 attribution methodology.

These criteria are not really operational in the Member States on account of the delay in their incorporating the list itself. A certain number of countries, including the United Kingdom, Austria and France, have nevertheless begun to incorporate the lists at national level, integrating the 14 criteria for the extension and/or delisting of wastes.

Since the start of 1997 France has worked actively for the establishment of practical modalities for the application of hazard criteria (H1 to H14). To do so, the Waste Cooperative Research Network, RECORD (Réseau Coopératif de Recherche sur les Déchets) and the French Ministry for the Environment have jointly launched experimental programmes relating to the application of hazard criteria for a wide range of wastes. The Act implementing the decree of 15 May 1997 (applying decision 94/904/CEE), published in January 1998, contains the minimum method and the thresholds for the H14 criterion. The current project is similar to that carried out by POLDEN for the Commission in 1994.

The main question that remains relates to the conditions in which these criteria are to be put in practice. On this point there are several interpretations:

- Application with a view to the evolution of the European list (extension or delisting, in the framework of the official work of the CAPST, on the request of the Member States). This is what the Commission is hoping for.
- Extension at national level (the way France is willing to go).
- Delisting of a particular batch of wastes based on data from the producer (certainly the desire of industry).

The Notion of Final Waste

The French waste law of 13 July 1992 concerning all wastes (hazardous, municipal, inert, etc.) states that by 2002 only 'final' wastes may be admitted for landfill. According to this law, a final waste is 'a material which can no longer be treated under current technical and economic conditions, particularly by extraction of the recoverable or reusable fraction or reduction of its hazardous or polluting character'.

This notion can of course evolve. Moreover, as it is not based on quantitative criteria it is often the object of many debates concerning its application, particularly for household wastes.

The question arises: 'to what extent must wastes be treated?'

The perspective for the application of new regulations concerning the landfilling of final

A minimal list of hazardous wastes, intended for future expansion, has been created, classifying wastes according to 14 criteria

The 'environmental hazard' criterion (H14 in the classification) is extremely broad, 80% of the wastes judged hazardous would be so on account of H14 alone

Some countries have already begun to incorporate the list at national level and others are applying it in experimental programmes

Requirements for stabilization of wastes prior to landfilling are likely to drastically increase costs, leading to a rethink of processes generating them

The difference between national and European lists will mean some wastes will need to be looked at on a case-by-case basis

For a waste to be re-used it must offer technical characteristics identical to the material it is due to replace after recovery

wastes from industry has raised the prospect of a drastic increase in the costs involved in managing these wastes (landfilling and prior stabilization in some cases). This has led industries to rethink the processes generating wastes (reduction at source, pretreatment) making it possible to reduce the amount to be treated or the polluting qualities. In some extreme cases this has led to the process itself being brought into question and the elimination of the hazardous waste under consideration.

As regards the management of 'unavoidable' hazardous ultimate wastes from industry, two areas of reflection have been opened up:

1. The delisting of the waste (authorizing its disposal under the 'non-hazardous' category, even potentially as 'inert').
2. The recovery of waste as it stands or after stabilization without landfilling, indeed to obtain income from it).

In both cases it is necessary to undertake a genuine study of the environmental behaviour of the waste in real disposal or use scenarios, and to consider this as a complement to the verification of the officially 'hazardous' status of the waste.

Delisting of Hazardous Industrial Wastes

Today, it is clear that certain stabilization techniques should be considered for delisting, such as processes involving extraction. This position can be justified on the one hand because the composition, and thus the polluting potential, of the waste, is greatly modified by the extraction of the most soluble fraction and part of the leachable metals, and on the other hand because part of the saline fraction can sometimes be recovered for subsequent re-use.

This is also the case for vitrification, whose cost alone is generally higher than that of landfilling after stabilization by mineral binders. A comprehensive evaluation procedure for the vitrification process is currently being validated. Its application could allow delisting, or even widespread use of vitrified materials under certain conditions and respecting certain thresholds that have yet to be defined.

It must be noted here that since stabilized wastes are not considered hazardous in the European list, the French regulations which stipulate their landfilling as hazardous wastes (according to the typology of the draft Landfill Directive) could be reviewed on a case by case basis by considering the technical and scientific aspects, in particular for wastes having undergone an extraction or a reduction of the polluting potential.

Recovery and Re-use of Industrial Wastes

The RECORD network has funded a study of the general approach concerning the widespread use of materials derived from waste, leading to the definition of technical (use criteria) and environmental specifications (present and future) to be taken into account. Some conclusions can be drawn from this study:

- To have a chance of being recovered, a waste must be able to substitute for a material already being used (sand, granulate, filler) and must respect technical specifications such as granulometry, mechanical strength and reactivity towards the other components. For example, the problem of compatibility between hydraulic binders and vitreous matrices led various vitrifiers to adopt slow cooling, which enhances crystallization.
- Furthermore, its cost must be lower than that of the material it substitutes and that its

quantitative and geographical availability be at least equivalent.

- Environmental specifications are sadly lacking at national level in France. The development of standard ENV 12-920 should fill this gap in the long term (see below).
- The recovery which consists of simply diluting the waste in a construction without participating by its properties in the specifications of the construction is excluded.
- The simple fact that a waste stabilization for landfilling is expensive does not confer any value to it as regards re-use in civil engineering.

The future for the utilization of wastes (including bottom ash from the incineration of household wastes) needs to take into account their long term behaviour in a well defined scenario leading to environmental specifications.

Long-term behaviour

The draft European Landfill Directive mentions three levels of evaluation of wastes:

- Level 1: basic characterization, long-term leaching behaviour
- Level 2: compliance tests, verification of long-term behaviour parameters
- Level 3: rapid tests - on-site control.

Level 2 corresponds to compliance tests existing in most European countries for landfill acceptance. Working Group 2 of CEN/TC 292 is in charge of the standardization of these tests at European level.

Working Group 6 is in charge of level 1, which is of strategic importance as it supposedly conditions the other levels. This work led to the ENV 19 920 'Methodology for the leaching behaviour of waste under specified conditions'.

Parameter specific tests and simulation tests are both used, and behaviour modelling has been proposed. On this basis a prediction of release may be established over a given time-scale. In this framework the three tests which are the object of priority European standardization are:

1. A parametric test to measure the influence of the chemical context (in particular pH) on the solubilization of the pollutants from a waste.
2. A simulation test of the percolation behaviour of a volume of granular waste.
3. A simulation test of surface transfer of pollutants for monolithic wastes.

The domain of application of this work greatly exceeds the framework of hazardous waste landfilling. It also concerns other types of landfilling (project under preparation for a French regulatory framework for the landfilling of different types of inert wastes integrates this idea), the recovery or reuse of wastes in public works (in road building, for example) and in general all evaluation of the spreading of pollutants from a determined source in the environment under specified conditions (mechanical, geo-technical, climatic, biological, site usage, risk factors, etc.) over a given time-scale.

The progressive application of these ambitious steps in the environmental field will considerably improve the evaluation of flows of pollutants emitted from various sources of waste in the environment and their evolution over time. The question thus arises of the real impact of these flows of pollutants on man and the environment. The integration of these two notions 'source term' and 'effect on receptor environments' is at the base of the new concept of environmental compatibility.

The draft European Landfill Directive envisages evaluation of wastes in terms of a basic characterization, compliance tests and rapid on site testing

Parametric tests and simulation tests of percolation and surface transfer are priority objectives for standardization at European level

The environmental compatibility of wastes may be defined as a situation in which the flows of pollutants from wastes are acceptable for this receptor environment

Complementarity between the stages of evaluation concerning emission control, transport of pollutants and pollutant impact on the environment needs to be sought

Environmental compatibility: a fundamental concept

The conditions for disposal or utilization of wastes are today still defined on the technical and regulatory basis of the best available technology. Working with the logic of impact would consist of founding regulations on reliable measurement and tools for the evaluation of the real impact of waste on man and the environment.

The environmental compatibility of a waste may be defined as a situation in which the flows of pollutants from wastes placed in a certain physical, hydrological and bio-physico-chemical context are compatible with the acceptable flow of pollutants for this receptor environment. The evaluation of environmental compatibility requires three main terms to be taken into account.

- The emission of flows of pollutants by the depositing of wastes, or 'source term'. This term is itself a function of the intrinsic polluting potential of the wastes ('term A') and the mode of deposition of the waste in the environment ('term B' or 'envelope term').
- The transport of polluting flows exiting the envelope to the receiving medium, or 'term T'.
- The level of acceptance of the polluting flows by the receiving medium or 'term C'.

This ambitious objective is currently being pursued by the multi-annual research programme financed by the French environmental and energy agency, ADEME (Agence française de l'Environnement et de la Maîtrise de l'Énergie), coordinated by the POLDEN division of INSA Lyon Développement. This involves the intervention of specialists in the many disciplines involved: physico-chemistry, microbiology, geo-technology, hydrology, eco-toxicology, ecology, etc. and should allow the definition of the optimal conditions for disposal and utilization of wastes.

In time environmental compatibility could turn out to be a very useful communication tool when opening new landfills or recovery operations.

In April 1999 INSA (Lyon) will be organizing an international conference on 'Stabilization of Wastes and the Environment' whose aim will be to highlight the need for complementarity between the three consecutive stages of the evaluation:

- Emission control of pollutants from stabilized wastes in function of their intrinsic properties and those of the scenario conditions.
- Transport and evolution of pollutants arising from these wastes in the natural environment.
- The impact of these pollutants on health and the environment.

The final objective pursued is to bring information to the regulatory organizations and the waste management industry.

Conclusion

Directive 91/689 has led to the drawing up minimal list of hazardous wastes together wit 14 hazard criteria. These criteria may, *a priori*, be used both to extend the list and to delist certain wastes at both national and European level.

There is an increasing tendency to complete, indeed substitute, these intrinsic criteria for behavioural criteria in the real situations in which the wastes are disposed of or recovered. This is particularly so for re-use in civil engineering or landfilling of final waste, such as residues from thermal processes (slag, fly ash and air pollution control residues).

The development of new evaluative approaches such as ENV 12-920 by CEN/TC292 Working Group 6 and in the longer term, the investigation of the environmental compatibility of wastes, must be supported. The long-term objective is, of course, to feed information back to the regulatory and industrial bodies in charge of the management of stabilized waste.

Keywords
hazardous wastes, European waste legislation, Environmental compatibility, criteria, testing

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The Assessment of Measures for the Processing of Waste from Plants Subject to Licensing Procedures

Dietrich Brune, *ITAS*

Issue: Waste minimization by recycling is currently a highly accepted strategy. Several laws and ordinances at the EU level and in different Member States require corresponding measures by all who hold and produce waste. Competent authorities licence and supervise individual recycling measures - at least in the case of plants subject to licensing procedures. Meaningful indicators for the quality of recycling options as well as for other waste minimization measures can facilitate the necessary bargaining process between companies and supervising authorities.

Relevance: Competent authorities in charge of licensing and supervising industrial sites have to assess proposed recycling measures and compare the environmental impacts from these measures with other options for waste prevention or waste treatment. This assessment process must be carried out within a reasonable period of time. Consequently an instrument is needed to help identify the best recycling and waste treatment options. This instrument should be easily manageable both by the authorities and the companies concerned as well helping the necessary negotiations.

The IPPC directive (96/61/EU) calls for an examination of whether waste can be avoided, or, failing this, be re-used. If re-use or recycling is not technically or economically feasible, waste must be treated and the environmental impact must be minimized

Introduction

Article 3 of the IPPC directive (96/61/EU) calls for an examination of whether waste can be avoided, or, failing this, be re-used. If re-use or recycling is not technically or economically feasible, waste must be treated and any impact arising for the environment must be minimized. Furthermore the use of energy should be as efficient as possible. In addition, national legislation sometimes requires that the operators of recycling processes make sure that the proposed measure is technologically feasible, environmentally and economically sustainable, that processing is of a high quality and that there is a market for the resulting products.

A wide variety of different recycling processes exist, differing not only in the type of technolog used but also in the necessary input of energy an of other raw materials, in the resulting produc and in the remaining unavoidable emissions a secondary waste. As a consequence, supervisi and licensing authorities are faced with t. question of how to assess different recycling processes and compare them with other waste minimization measures.

This is especially relevant in the context of the IPPC Directive and of the national regulations for environmentally friendly recycling and waste minimization options and processes. In Germany, the recent 'cycle economy law' underlines the priority given to waste prevention and recycling but also requires the investigation of whether a certain type of waste treatment may not be the best environmental solution. In other words, the law not only requires that planned measures are technically and economically feasible but in addition obliges the company concerned to demonstrate that the envisaged recycling measure leads to a high quality recycling process and that a high standard of environmental friendliness is achieved (Article 5 of the law).

Similar problems also arise from more general considerations. The high standard of existing recycling technologies, the existing achievements in environmental quality improvement and the efforts of companies to reduce their resource consumption imply that clear recommendations cannot always be made. In many cases the complexity of the processes to be assessed and the variety of boundary conditions to be considered make simple decision making difficult. In addition, the environmental quality goals and/or the tolerable environmental burdens may vary greatly between regions, leading to additional complexity.

A method often used to solve this kind of problem is life cycle assessment (LCA). This method, when properly used with well defined alternatives for investigation and with acceptable system boundaries, may give reasonable results which can be accepted even in controversial situations. However, in most cases, the time required for the completion of such a study and its need for comprehensive information reduce its attractiveness in the day-to-day practice of licensing. In addition, this type of analysis can only be performed by specially trained research groups which may not be found in average companies. This in turn does not put the companies in a position to anticipate authority decisions and consequently rule out recycling options which will presumably not be accepted.

Although life cycle assessment is a useful tool, the length of time required makes it unattractive for day-to-day licensing purposes. In the case of energy conversion systems the Gross Energy Requirement indicator (GER) has been developed and is now widely accepted.

The Gross Energy Requirement (GER) indicator

A widely accepted indicator may be used to overcome these difficulties. Indicators are widely used, for example, for assessing the economic situations of companies and entire political economies (one of the best known is GNP), for the performance of technical systems (e.g. efficiency factors) and for quality assessments of environmental sectors (e.g. parameters like BOD for water quality). For the comparison of different energy conversion systems the Gross Energy Requirement indicator (GER) has been developed and is now widely accepted. This indicator represents 'all expenditures assessed as primary energy inputs which arise or can be attributed to the production, use and final disposal of economic products and commodities'. One reason for defining this indicator in this way was the need to compare electricity generating systems based on different primary energy sources where the energy expenses for the construction and operation of a plant were included and compared with the net amount of electricity generated. To make product comparisons possible, the waste treatment process or final disposal method has to be included.

The methodology for the definition of this indicator has been developed over the last five years (VDI (1997), VDI (1995), Hagedorn et. al. (1992)) in close collaboration between research institutes, government offices, technical organizations and industry. Basically the calculation is divided into three steps:

Current German law requires companies to demonstrate that planned recycling measures achieve optimum levels of environmental friendliness

In many cases the complexity of the processes to be assessed and the variety of boundary conditions to be considered make decision making difficult

The Gross Energy Requirement indicator was developed as a way of comparing electricity generating systems. To make such comparisons possible waste treatment processes and final disposal had to be included

GER is calculated in three stages, taking into account the energy inputs prior to energy production, during energy production and during waste processing

The main burden of waste processing can be assumed to be energy consumption

1. Determination of all energy inputs during the production of a good; these include all uses of electricity, of different fuels and of the so-called non-energetic expenses, assessed as primary energy inputs. The latter may, for example, include buildings, transformers, half-finished products and auxiliary substances.
2. Determination of all energy inputs during the use of the product (in the electricity production case this includes the energy needed during the operation of the plant);
3. Determination of all energy inputs during the processing of waste from the product itself or from other waste sources, such as machines, buildings, and others which may be attributed to the product.

In all three steps the non-energetic expenses of energy carriers have to be included. The sum of the energy expenses thus determined represents the Gross Energy Requirement. In the case of energy conversion plants, one has to compare the value of the GER with the amount of energy produced during the whole lifetime of the plant in order to be able to determine whether the plant will produce more marketable energy than it will consume (harvest factor). A recent study compares different photoelectric modules of the photoelectric plant in Toledo/Spain (KOHAKE et al., 1997).

For waste recycling and waste treatment processes it can be assumed that in many cases the main environmental burdens result from energy use. This is obvious in the case of waste incineration (implying that waste can be represented as fuel) but can be extended to many other processes. The latter can be demonstrated by looking at the impact categories which have been identified as most important and reasonable in normalizing the LCA process. A comparison is shown in Table 1:

Table 1. Impact categories covered by GER

Impact category	Represented by GER	Parameters covered	Parameters not covered
emissions	partly	NO_X, CO_2, SO_2	heavy metals, etc.
saving of natural resources	partly	fuel	minerals
energy	yes		
accumulation of pollutants	no		
resource consumption	partly	energy for resource provision	
consumption of natural environment	no		
green house effect	partly	non regenerative	regenerative
ozone depletion	no		
acidification	partly	SO_2	Cl
eutrophication	partly	via air	water (e.g. phosphate, nitrate)
toxic damage to organisms (ecotoxicity)	partly		
toxic damage to humans (human toxicity)	partly		
summer smog	partly	NO_X	hydrocarbons
noise	no		

Column 2 of Table 1 shows whether impacts may either directly result from energy use or, for a given impact, may result from a calculated equivalent amount of energy. The table clearly shows that for several impact categories the GER does not represent environmental burdens. Therefore it must be complemented by other instruments or indicators. This is especially relevant in the case of Germany where the 'cycle economy law' requires the competent authorities to investigate the environmental friendliness of proposed recycling activities and to compare them with other options. In an ongoing research process German authorities are trying to find a solution by asking additional questions concerning these impact categories. As a first approach the following categories have been formulated:

Emissions

- Do emissions of carcinogenic or mutagenic substances occur in a recycling process - apart from emissions from energy supply and traffic? Relevant substance lists may be found in operational health regulations.
- Are there major differences in the use of renewable energy resources between different recycling options? This question is stimulated by the limited representation of the greenhouse effect by GER. Will there be significant amounts of methane or other greenhouse gases released? Such emissions arising apart from energy consumption must be identified; the equivalent CO_2 emissions contributing to the same size to the greenhouse effect can be calculated and in turn be converted to energy equivalents.
- Will there be significant emissions of nitrate, phosphate, ammonium or organic pollutants into bodies of water? The values of the sum parameters BOD and COD should be demonstrated.

Saving of natural resources

- Are there significant savings of non energetic natural resources for different recycling options?
- Here the resources to be mentioned are mainly water and mineral substances.

Consumption of natural environment

- Is there a considerably lower consumption of natural environment for one alternative recycling option?
- As a major category the use of undeveloped areas (not used for housing etc.) should be considered.

Accumulation of pollutants

- Do pollutants accumulate in a product from a recycling process which may lead to an impact on the environment when this product is used or finally disposed of?
- Possible accumulations have to be identified and assessed.

The evaluation of this GER procedure with additional questions will take place in several steps:

In the first step the calculation of the GER will lead to an initial rating of different recycling options. In the next step the questions will be answered. If all these answers are 'no', then the value of the GER will be representative for the different options.

If some questions have been answered with a 'yes' it must be decided whether the rating of the GER is supported or not. If not, additional information is needed to reach a decision. If this last step cannot be completed either because the detailed information needed is not available or because the assessment cannot be made due to

The German law for recycling assessment looks at emissions, resource savings, consumption of the natural environment and accumulation of pollutants

Extending the GER concept could give an index of environmental impact without the complexity of LCA the complexity of the problem, the limits of this simple assessment procedure have been reached.

Outlook

Several extensions to the GER concept are possible and could avoid the complexity of a full LCA with its concomitant data requirements. A first step could be the transformation of GER into a general energy index which could include the impacts on the environment of other relevant energy consuming processes like transport and electricity generation with a primary energy-mix.

Another extension could be the calculation of a specific contribution of an impact compared to an existing impact and/or compared to a more general figure like for example average emission per person and/or per day.

A more elaborate development would be the inclusion of emissions and resources consumed in different production steps of the goods needed for the recycling process. This can include for example, the emissions and resource consumption needed to manufacture all the machinery needed to dismantle complex products and to process resulting fractions as in the case of waste from electrical and electronic products. All these emissions resulting from different productions which may be attributed to the investigated product may be calculated - at least in principle - using input/output tables for the relevant economy. An example of the possibilities and the need of further development of this method is quoted in Weber's contribution (VDI, 1995).

Ongoing research projects investigating practical examples will contribute to a clarification of the necessity of these possible extensions.

Keywords

waste processing, licensing procedures, sustainable development, indicators, Gross Energy Requirement (GER)

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The **IPTS** is one of the seven institutes of the Joint Research Centre of the EU Commission. Its remit is the observation and follow-up of technological change in its broadest sense, in order to understand better its links with economic and social change. The Institute carries out and co-ordinates research to improve our understanding of the impact of new technologies, and their relationship to their socio-economic context.

The purpose of this work is to support the decision-maker in the management of change pivotally anchored on S/T developments. In this endeavour IPTS enjoys a dual advantage: being a part of the Commission IPTS shares EU goals and priorities; on the other hand it cherishes its research institute neutrality and distance from the intricacies of actual policy-making. This combination allows the IPTS to build bridges betwen EU undertakings, contributing to and co-ordinating the creation of common knowledge bases at the disposal of all stake-holders. Though the work of the IPTS is mainly addressed to the Commission, it also works with decision-makers in the European Parliament, and agencies and institutions in the Member States.

The Institute's main activities, defined in close cooperation with the decision-maker are:

1. Technology Watch. This activity aims to alert European decision-makers to the social, economic and political consequences of major technological issues and trends. This is achieved through the European Science and Technology Observatory (ESTO), a European-wide network of nationally based organisations. The IPTS is the central node of ESTO, co-ordinating technology watch 'joint ventures' with the aim of better understanding technological change.

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