

Unclassified

ENV/EPOC/PPC(97)17/REV2



Organisation de Coopération et de Développement Economiques
Organisation for Economic Co-operation and Development

OLIS : 19-May-1998

Dist. : 21-May-1998

PARIS

Or. Eng.

ENVIRONMENT DIRECTORATE
ENVIRONMENT POLICY COMMITTEE

Cancels & replaces the same document:
distributed 13-May-1998

Group on Pollution Prevention and Control

**CONSIDERATIONS FOR EVALUATING WASTE MINIMISATION IN
OECD MEMBER COUNTRIES**

65666

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FOREWORD

This report presents the outcome of Project 2 under the OECD's Waste Minimisation Work Programme for 1996-97, which addressed definitions, terms, concepts, target-setting, and the evaluation of waste minimisation in OECD Member countries. It thus elaborated the outcome of Project 1 [see *Waste Minimisation in OECD Member Countries*, ENV/EPOC/PPC(97)15/REV2, and *Waste Minimisation Profiles of OECD Member Countries*, ENV/EPOC/PPC(97)16/REV2]. The results of these two projects constitute an extensive input to Project 3, which began in October 1997.

The major outcome of the OECD Workshop on "Building the Basis for a Common Understanding on Waste Minimisation," held in Berlin in October 1996, has been incorporated in this report.

Funding for this project was provided by the Federal Government of Austria. The report was originally drafted by Gerhard Vogel, Institute of Technology and Commodity Science, Vienna University of Economics, in collaboration with Suzanne Gruber, Suzanne Krenn, Michael Pieber and Herbert Loicht. The final draft was produced within the OECD Secretariat by Alain Rajotte. The report has been prepared for publication with the assistance of a consultant, John Smith.

Delegates to the Pollution Prevention and Control Group have had the opportunity to review this document and have agreed that it should be declassified. It is published under the authority of the secretary-general of the OECD.

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EXECUTIVE SUMMARY

Objectives of Project 2

This report presents the outcome of Project 2 of the OECD Waste Minimisation Work Programme for 1996-1997, which addressed definitions, terms, concepts, and the evaluation of waste minimisation in OECD countries. It reviews the results, and further elaborates on the outcome, of Project 1. The objective of Project 2 was to achieve better comparability of waste accounting methodologies that could be used by Member countries.

Project 2 examined current experiences in Member countries in order to identify means to better evaluate waste minimisation. Particular attention was given to the role of incineration with energy recovery within waste minimisation. These issues were discussed with regard to various combinations of measures and instruments that might be applied in order to attain waste minimisation objectives. Accordingly, evaluation and accounting methods have been assessed for the purpose of weighing the contribution of different approaches to overall waste minimisation. Several case studies have been used to illustrate the contribution of various elements within the waste hierarchy to waste minimisation, as well as the proposed evaluation methodology.

Waste minimisation terminology

Section 2 of this report discusses definitions, terms and concepts within waste minimisation. Considerations bearing on waste minimisation terminology, in particular the role of incineration within waste minimisation, are also discussed. Although national definitions of waste minimisation may not necessarily be identical in all OECD countries, the outcome of the OECD Waste Minimisation Workshop in Berlin in 1996 confirmed that there is general agreement among Member countries on the OECD working definition within the framework of OECD work on waste minimisation. Accordingly, waste minimisation encompasses the following three elements, in this order of priority:

- **preventing and/or reducing the generation of waste at source;**
- **improving the quality of waste generated, such as reducing the hazard; and**
- **encouraging re-use, recycling and recovery.**

The results of Project 1 indicate that OECD countries apply a similar hierarchy of actions in implementing waste minimisation policies. Likewise, notwithstanding the fact that incineration with energy recovery is considered to contribute to waste minimisation in some countries, energy recovery is generally ranked towards the lower end of the hierarchy. Priority is therefore given to waste avoidance and reduction at source, as well as to re-use and recycling.

Policy approaches and ranking systems by which priorities are set, and the most appropriate measures are selected, will not be identical in Member countries either. Reviewing current practices indicates that local considerations have an influence on both the ranking and selection of waste minimisation tools. Therefore, the use of LCA/LCM methodology is advisable to guarantee successful outcomes from waste minimisation projects.

Current experiences in Member countries suggest that implementation of effective waste minimisation policies requires a careful and pragmatic evaluation of different options. This evaluation should take into account the environmental performance and cost-effectiveness of different scenarios, the availability of environmentally sound technologies, and public acceptance. While the relative hierarchy of preferences provides a good basis for selecting the best waste minimisation options, each situation may not call for a sequential or rigid application of the entire hierarchy. In some cases, for example, recycling may be preferable to prevention and/or reduction at source; in others, incineration with energy recovery may be the most practical and environmentally sound solution.

Lack of knowledge with regard to the evaluation of waste streams and the potential of preventive measures needs to be addressed if more comprehensive assessment of different scenarios is to be developed. Effective evaluation and cost-accounting methodologies also have the potential to help better identify the most appropriate combinations of strategies and instruments.

Measurement and evaluation of waste minimisation

In Section 3, issues and problems related to the evaluation and measurement of waste generation are examined. Experiences in Member countries and the outcome of discussions at the OECD Workshops in Washington, D.C. and Berlin are reviewed. Current means of evaluating the effects of different waste minimisation tools, and areas in need of further development, are identified. Case studies illustrate some promising measurement and accounting methodologies.

The implementation of effective waste minimisation policies requires that waste generation be properly analysed. Waste generation is a multi-faceted issue. It involves different considerations which have a bearing on the measurement of the contribution of various waste minimisation tools. Regarding the various performance evaluation and accounting methods used in OECD countries, the lack of reliable and comparable waste minimisation data impedes the identification of any significant statistical trends in the implementation of measures. As a result, the conventional wisdom is often that preferences with regard to the order in which actions will be taken are based on national (local) conditions.

The development of harmonized methodologies concerning accounting systems for measuring waste minimisation will require intensive testing and comparison of current approaches. Nevertheless, several case studies suggest that waste minimisation can be effectively described and evaluated, provided that adequate means of data collection and analysis exist.

Current experience with municipal waste management programmes and private initiatives aimed at reduction and recycling of waste provide many examples of successful monitoring and measurement systems. Several case studies have identified useful approaches for the development of mathematical formulas to measure waste minimisation and the relative contribution of the different elements of the waste hierarchy.

The evaluation methods described in Section 3 are examined further in Section 4. Case studies illustrate the contributions of different elements (i.e. prevention, reduction at source, re-use and recycling) to waste minimisation, and how each can be measured. In addition, the contribution of incineration with energy recovery to municipal waste management systems has been evaluated. These results clearly show that there are promising approaches in measurement and accounting methodologies, which will be useful inputs to Project 3.

1. INTRODUCTION

Despite ongoing initiatives aimed at achieving environmentally sound waste policies, the amount of waste generated in OECD Member countries continues to increase. Thus waste minimisation has been identified politically, economically and socially as a key policy goal in these countries.

Waste generation and disposal is a part of practically every human activity. Yet, despite wastes' damaging environmental and economic effects, relevant policy approaches are often vague. Problems associated with the poorly understood impacts of wastes on natural processes are exacerbated by the complex and wrongly structured production and consumption patterns that generate them. All these factors together create social controversy and uncertainty concerning the means that should be adopted to respond to the waste crisis.

Agreement on a definition of waste is still pending, a fact that may slow down the attainment of social consensus on measures to reduce waste generation (and promote re-use, recycling and recovery). In turn, these disagreements slow down the implementation of international and national strategies aimed at shifting wasteful production and consumption patterns towards preventive approaches and the closing of material cycles.

The OECD Waste Minimisation Work Programme has directed most of its efforts towards the identification and evaluation of waste minimisation measures in OECD countries. In 1994-95, the need for a clear and harmonized working definition of waste minimisation as a prerequisite for successful work in this area was identified. Member countries have since agreed (see 2.1 below) on a working definition of waste minimisation, according to which it encompasses the following three elements in this order of priority: preventing and/or reducing the generation of waste at source; improving the quality of the waste generated, such as reducing the hazard; and encouraging re-use, recycling and recovery.

This broad definition comprises not only practices which aim at preventing waste at source, but also those for dealing with unavoidable waste, as the ultimate goal is to divert as much waste as possible from being stored in landfills.

In addition to the compilation and assessment of Member countries' policies, work has been carried out to further examine and discuss experiences with minimising specific waste streams, and to identify policy issues associated with the implementation of waste minimisation measures. Participants in the OECD Workshop held in Washington, D.C. in 1995 unanimously recognised that the development of a common language, and understanding of waste minimisation terms and concepts, were essential in order to effectively measure programmes and concrete actions. In particular, the need to address the following issues was recognised with respect to the future implementation of waste minimisation approaches in OECD countries:

- The definition of a common set of terms and concepts is required in order to be able to implement and properly evaluate waste minimisation measures.

- Although waste prevention should be given primary emphasis, there was consensus on neither the definition of waste minimisation measures nor a relative hierarchy of actions, in particular with regard to the status of incineration with or without energy recovery.
- Measurement and evaluation of waste streams should be a starting point for the whole discussion of waste minimisation.

Participants acknowledged that the OECD would be the most appropriate forum in which to reach common ground on the above issues and to harmonize follow-up actions in this field.¹

In 1996, the German consulting firm of Lahmeyer International carried out a comprehensive survey of current national waste minimisation definitions, concepts, strategies, instruments and experiences (including target-setting) in OECD countries.² The outcome of this survey was used as background material for a workshop on “Building the Basis for a Common Understanding on Waste Minimisation”, hosted by the German government in Berlin in October 1996. The Berlin Workshop consisted of four sessions dealing with the following questions:

- How do Member countries define waste minimisation? Is it possible to agree on some common definition for subsequent work?
- What criteria do countries use to set targets? Are the targets met? How is waste minimisation measured?
- Are prevention and source reduction policies more effective than recycling/recovery policies? What are the optimal policy options, and under which circumstances? Can waste incineration be considered as an element of waste minimisation?
- What is the effectiveness of various waste minimisation policies and instruments? Can guidance be recommended to policy-makers regarding performance measurement and accounting methodologies?

The Berlin Workshop provided OECD countries with a useful forum for the exchange of concrete information and experiences concerning waste minimisation. Participants had an opportunity to discuss and examine benefits and shortcomings associated with the implementation of different waste minimisation definitions, terms and concepts, and various accounting methodologies, as well as the status of incineration within waste minimisation.

In this context, Project 2 of the OECD Waste Minimisation Work Programme was undertaken in order to review the results of Project 1, identify commonalities and converging practices in OECD countries, explore possibilities for a common understanding on waste minimisation, and evaluate accounting methodologies.

¹ *Washington Waste Minimisation Workshop*. Volume I: *Five Waste Streams to Reduce*; Volume II: *Which Policies, Which Tools?* OECD, Paris, 1996. (Also published in a French translation.) The Washington Workshop was co-hosted by the United States, Canada and Mexico. It was attended by approximately 180 representatives of government, industry, environmental NGOs and intergovernmental organisations.

² *Waste Minimisation in OECD Member Countries*, ENV/EPOC/PPC(97)15/REV 1, and *Waste Minimisation Profiles of OECD Member Countries*, ENV/EPOC/PPC(97)16/REV 1. OECD, Paris, 1998.

The purpose of Project 2 was, in combination with the outcome of Project 1, to provide input material for Project 3, so as to further evaluate the role of incineration within waste minimisation and delineate appropriate and implementable methodologies for measurement and evaluation of waste minimisation.

2. THE DEFINITION OF WASTE MINIMISATION

The 1995 Washington Workshop recognised the need for a common understanding of the most critical terms and concepts underlying waste minimisation approaches in OECD countries. This is necessary in order to properly assess the effectiveness of policies and to facilitate comparisons between countries. Workshop participants identified four critical issues and/or questions that need to be resolved if there is to be real progress towards this end:

- What relevant factors are most likely to reflect waste minimisation? For example, how can such items as waste-to-energy activities, source reduction, re-use/resource recovery/recycling (on-site and off-site), etc. be incorporated into a set of indicators enabling the comparison of waste minimisation data between Member countries?
- While there is wide agreement that waste prevention and source reduction should be given top priority, there is no clear consensus on the whole set of policy measures which make up waste minimisation measures, nor on the hierarchy of actions.
- There is a need to understand different procedures and operating parameters used by Member countries to identify and implement waste minimisation objectives.
- There is a need for a mutual understanding of, and agreement on, relevant terms, definitions and concepts associated with waste minimisation in order to harmonize actions and assess the effectiveness of waste minimisation policies in OECD countries.

Two activities were carried out in 1996, under Project 1, with the goal of developing an acceptable definition of waste minimisation among OECD countries. These activities (already briefly described in Section 1) were the survey of waste minimisation policies in Member countries and the Berlin Workshop on “Building the Basis for a Common Understanding on Waste Minimisation”.

2.1 Key elements of waste minimisation policies

The survey was carried out using a detailed questionnaire addressed to national authorities that deal with waste minimisation policies in Member countries. It was structured in such a way as to identify the relative priorities given to waste minimisation instruments domestically.

While the implementation and order of priority of waste minimisation measures differ among Member countries, the results of the survey and discussions at the Berlin Workshop demonstrated that there is wide agreement among participating countries on the OECD working definition of waste minimisation in the context of ongoing OECD work.

The Berlin Workshop achieved general consensus on the following previously proposed working definition of waste minimisation, according to which it encompasses these three elements in this order of priority:

- **preventing and/or reducing the generation of waste at source;**
- **improving the quality of the waste generated, such as reducing the hazard; and**
- **encouraging re-use, recycling and recovery.**

The OECD working definition is broad. It comprises not only practices which aim at preventing waste at source, but also those for dealing with unavoidable waste, the ultimate goal being to divert as much waste as possible from being stored in landfills.

Seventeen countries out of the 21 surveyed reported that their domestic definitions of waste minimisation corresponded with the working definition. Only the definitions used in Spain and the United Kingdom did not correspond to the working definition. Spain provided the following definition: “preventing and/or reducing waste, improving the quality of waste generated, including reduction of hazard. As well, reuse, recycling and recovery on-site with a favourable environmental balance.” Although the UK agreed to use the OECD working definition for the purpose of the survey (and its participation in related OECD work), so that its situation could be meaningfully compared with that of other countries, waste minimisation was defined in that country as the reduction in quantity and hazard of waste at source. Re-use, recycling and recovery were not included in this definition. In all the countries surveyed, waste minimisation included reduction of the amount of waste at source, as well as the reduction of hazard.

On the basis of the information from the survey summarised in Table 1, the following conclusions can be drawn concerning countries’ relative waste minimisation priorities:

- In all the countries surveyed, prevention of waste generation (including prevention of hazard) had priority over any recycling or recovery operation.
- In ten countries, on-site recycling had priority over off-site recycling (i.e. use in other processes). Seven countries considered on-site and off-site recycling to have equal priority.
- Countries did not agree on whether reducing the hazard of the waste generated should have priority over reducing the waste amount. Eleven countries gave the same priority to reduction of hazard and reduction of waste amount.
- Material recycling had a clear priority over energy recovery. Material recycling and energy recovery had the same priority in only six countries. In one of these countries, the UK, decisions concerning which to use were based on Best Practicable Environmental Option (BPEO).
- All the countries surveyed gave priority to recycling and recovery over landfilling.

All but one of the countries reported that they applied a hierarchy with regard to objectives and measures for waste prevention, recovery and disposal (Table 1). These hierarchies were generally set out in legal documents. Italy did not have a legally defined hierarchy of this type, but applied a hierarchical structure according to the understanding of waste minimisation in that country.

Table 1 Relative waste minimisation priorities

	Hierarchy exists		Waste prevention over recycling			On-site over off-site recycling			Reduction of hazard over reduction of amount			Material recycling over energy recovery			Recycling/recovery over landfilling		
	Yes	No	Yes	No	=	Yes	No	=	Yes	No	=	Yes	No	=	Yes	No	=
Australia	X		X			X			X			X			X		
Austria	X		X			X			X			X			X		
Canada	X		X			n.a.				X		X			X		
Czech Republic	X		X					X			X	X			X		
Denmark	X		X			X					X	X			X		
Finland	X		X					X			X	X			X		
France	X		X					X	n.a.					X	X		
Germany	X		X					X			X			X	X		
Hungary	X		X					X	X			X			X		
Italy		X ¹⁾	X			X				X		X			X		
Japan	X		X			X					X	X			X		
Korea	X		X			X			X					X	X		
Netherlands	X		X			X					X	X			X		
New Zealand	X		X					X			X	X			X		
Norway	X		X					X		X				X	X		
Poland	X		X			X			X			X			X		
Spain	X		X			X			X			X			X		
Switzerland	X		X					X			X			X	X		
Turkey	X		X					X			X	X			X		
United Kingdom	X		X					X			X			X ²⁾	X		
United States	X		X			X					X	X			X		
Total	20	1	21	0	0	10	3	7	6	3	11	15	0	6	21	0	0

n.a.: no answer; =: same priority

¹⁾ A hierarchical structure is applied according to the understanding of waste minimisation in that country.

²⁾ Case-by-case evaluation is based on Best Practicable Environmental Option (BPEO).

Table 2 gives an overview of how waste minimisation plans and programmes were being used in the countries surveyed.

Although different conditions and ranking systems exist in different countries, similar waste streams are increasingly being addressed by either mandatory measures or voluntary programmes. The types of waste most often addressed are:

- industrial waste;
- municipal waste; and
- key waste streams and products.

In accordance with the generally agreed hierarchy of actions, cleaner production and recycling are the preferred waste minimisation measures. That is, top priority is being given to this type of waste prevention measures.

Economic, technical and social constraints need to be considered, as they are likely to influence both the prioritisation and the implementation of waste minimisation targets and measures. This may suggest that a fixed hierarchy of actions could be counterproductive. For instance, cleaner production could eliminate the need for recycling, or recycling could lead to negative environmental effects such as environmental impacts associated with the transport of recyclable goods. Incineration could provide an escape route by which producers managed to avoid making changes to production and products.

Waste minimisation strategies therefore require examination of the economic, social, organisational and technical consequences of regulatory initiatives. Effective approaches will seek to promote continuous improvement of environmental performance. To achieve this, a well defined hierarchy of waste minimisation priorities is a prerequisite.

Table 2 Waste Minimisation Plans and Programmes

	Area of application			Area of support		
	1	2	3	4	5	6
Australia	v	v	v	v	v	v
Austria	v	v	v	v	m	v
Canada	m/v	m/v	m/v	v		m/v
Czech Republic	m	m	v	v	v	m
Denmark	m/v	v	v	v	v	m
Finland	m/v	m/v	m/v	v		m/v
France	m	m	n.a.	n.a.	n.a.	n.a.
Germany	m/v	m/v	m/v	v	m\ v	m
Hungary	n.a.	v	m	n.a.	n.a.	n.a.
Italy	m	v	m/v	v	v	
Japan	m/v	m/v	m			m/v
Korea	v	m	m	v	v	m
Netherlands	v	v	m/v	v		m/v
New Zealand	v	v	v			
Norway	v	v	v	v	v	v
Poland	v	v	v	v	v	v
Spain	v	v	v			
Switzerland	m/v	m/v	m/v		m/v	m/v
Turkey	m	m	m	m	m	m
United Kingdom	m	v	m/v	v	v	m
United States	v	v	v	v	v	v
Total (m/v)	11/15	9/ 17	11/16	1/14	4/11	11/10
1 Municipal waste 2 Key industrial sectors 3 Key products and waste streams 4 Research and development 5 Provision of consultancy services 6 Approval and control for specific plants m: mandatory v: voluntary n.a.: no answer						

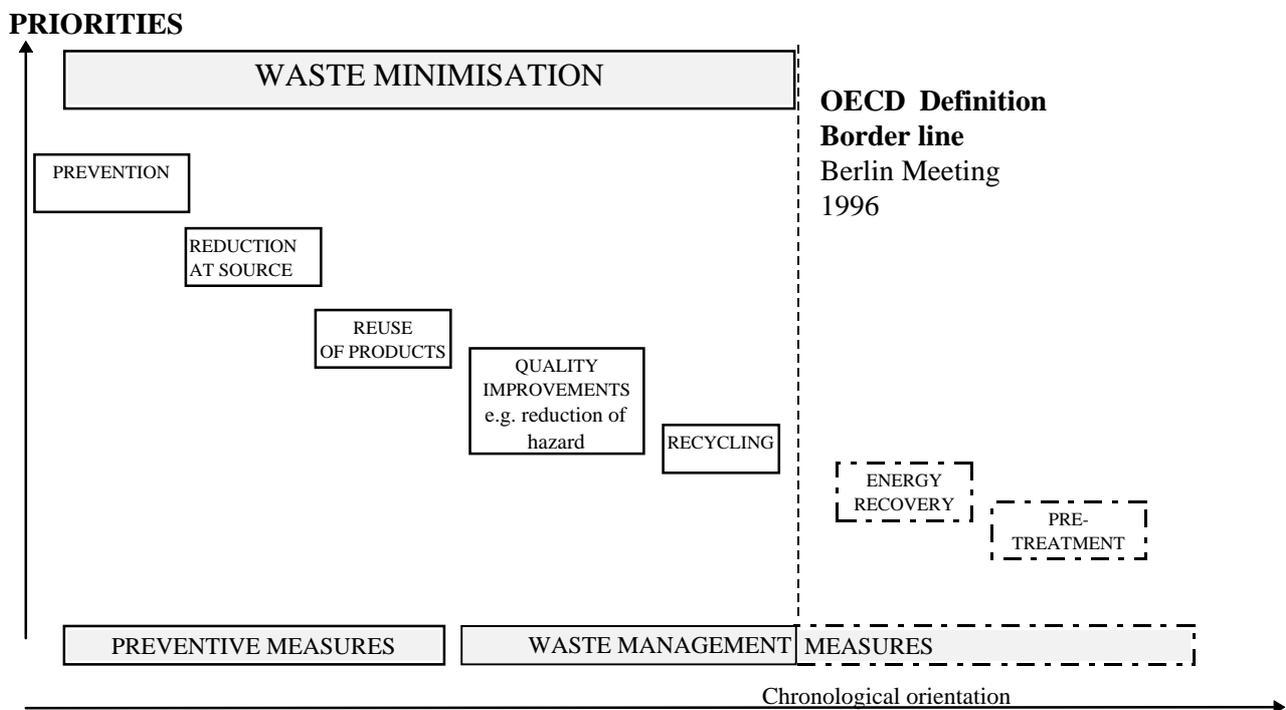
2.2 Attempting to define terms and concepts within waste minimisation

Based on the information provided by the countries surveyed, the most important elements of waste minimisation are described in this subsection. Some problems are also examined, in particular concerning the status of incineration within waste minimisation.

2.2.1 Outcome of the Berlin Workshop

A general consensus was reached at the Berlin Workshop (see Section 2.1) on an OECD working definition of waste minimisation. **Figure 1** interprets the OECD working definition graphically.

Figure 1 OECD Working Definition Agreed at the Berlin Workshop



As stressed earlier, although Member countries *generally* agree on the hierarchy of actions included in the OECD definition, the definition of waste minimisation (and the means used to achieve practical implementation) are not necessarily the same in all Member countries. In addition, the policy approaches and ranking systems by which priorities are set and the most appropriate measures are selected may vary substantially between countries. Waste incineration, with or without energy recovery, appears to be the most controversial issue with regard to its contribution to waste minimisation.

The controversy surrounding the inclusion of incineration within waste minimisation should be considered in the wider context of waste management. The sometimes complex role of incineration in waste minimisation strategies, along with public resistance to the siting of both new and existing incineration plants, suggest that a number of factors (e.g. landfill space, public pressure, environmental trade-offs) influence its hierarchical ranking.

The consensus among Member countries on the definition of waste minimisation can be illustrated using the following examples:

PREVENTION

- Strictly avoiding waste generation, both qualitatively (through virtual elimination of hazardous substances) and quantitatively (through reducing material or energy intensity in the production, consumption and distribution of commodities)

Examples:

Qualitatively:

- ⇒ Avoiding and/or substituting materials that are hazardous to humans or to the environment (e.g. through bans on PCBs and ozone-depleting substances, or virtual elimination of toxic organochlorines released in bleached pulp mill effluents)

Quantitatively:

- ⇒ Avoiding unnecessary use of materials or stages of production/consumption (e.g. through eliminating interim packaging for toothpaste, or substitution of continuous casting for ingot casting at steelworks)

REDUCTION AT SOURCE

- Minimising use of toxic or harmful substances; minimising material or energy consumption

Examples:

Qualitatively:

- ⇒ Reducing the use of harmful substances in products, in production and sales systems, and in consumption and disposal systems
- ⇒ Reducing the use of substances that hinder re-use or recycling (e.g. “stickies” on paper, chlorinated solvents as cleansing agents)

Quantitatively:

- ⇒ Using smaller amounts of resources to provide the same product or service (e.g. reducing foil thickness, introducing re-use or refill systems, miniaturisation, resource-orientated purchasing and consumption)
- ⇒ Using less resource-dependent construction principles and materials

RE-USE OF PRODUCTS

- Multiple use of a product in its original form, for its originally intended purpose or an alternative purpose, with or without reconditioning

Examples:

Re-use after reconditioning:

- ⇒ Refilling glass or plastic bottles after washing
- ⇒ Using empty barrels with residues of adhesives as oil barrels after reconditioning

Re-use without reconditioning:

- ⇒ Using shopping bags more than once
- ⇒ Using shopping bags as waste bags

RECYCLING

- Using waste materials in manufacturing other products of an identical or similar nature

Examples:

- ⇒ Industrial melting of one-way glass bottles for use in new bottles
- ⇒ Recycling of collected newspapers for production of sanitary paper products
- ⇒ Aerobic or anaerobic treatment of separately collected organic household waste (bio-waste) or special non-toxic or non-harmful sludge for soil improvement

OECD countries agree that only waste that cannot be avoided, re-used, or recycled/recovered cost-effectively should be disposed of (and then only in an environmentally sound manner). However, there are differences among countries related, for example, to definitions of waste, to capacities, and to technological know-how. The definition of waste minimisation therefore has considerable bearing on priority-setting and targets. The following should be considered in the further development of the waste minimisation concept:

ENERGY RECOVERY

- Utilising the energy content of waste materials with or without pre-processing

Examples:

- With pre-processing:
 - ⇒ Obtaining refuse-derived fuel (RDF) from waste after mechanical sorting and pelletising
 - ⇒ Hazardous waste incineration after decantation
 - ⇒ Transformation of bio-gas from anaerobic processes to electricity
- Without pre-processing:
 - ⇒ Household waste incineration, with energy used for district heating

PRE-TREATMENT

- Reducing volume, mass or toxicity before landfilling or final storage by mechanical, physical, chemical or biochemical processes

Example:

⇒ Sorting of waste streams in order to reduce volume and leachate

National considerations that influence the definition and setting of waste priorities are another important factor in waste minimisation. Each country addresses different circumstances, including production patterns and waste streams. Different ranking systems are used to prioritise chemicals, wastes, or pollutant releases from processes/products. These ranking systems provide guidance for pollution prevention, waste minimisation, waste management, and related activities. There does not appear to be a consensus on a “best”, or universal, prioritising system nor does it appear that identifying such a system would be necessary *per se*.³

Without more harmonized information and monitoring, little can be said about the relative successes and failures of current policies, nor about optimal combinations of waste minimisation measures. Measuring the contributions of individual waste hierarchy options to overall waste minimisation is therefore of basic importance for evaluating the performance of each option and identifying optimal combinations. This issue will be further examined in Section 3.

2.2.2 *The role of incineration within waste minimisation*

In this subsection, the status of incineration with energy recovery within waste minimisation is further examined. Incineration remains the most important single element of debate among OECD countries with regard to the definition of waste minimisation. Information provided by countries and discussions at the Berlin Workshop, as well as other relevant information, are used here to examine the potential contribution of energy recovery to waste minimisation.

A strict distinction needs to be made between normal incineration, which is merely a waste disposal method, and energy recovery through combustion. The former is used primarily to minimise the hazardous content and/or quantity of waste. In some countries, incineration is considered to be energy recovery if it meets certain levels of performance, specified by technical criteria and/or standards addressing minimum calorific value of waste and/or combustion efficiency requirements. Other countries do not apply specific criteria for separating incineration from energy recovery.

There are significant differences among OECD countries with regard to whether incineration contributes to waste minimisation. In some countries, incineration is considered a waste minimisation

³ Ralston, M., “Chemical and Waste Prioritization Systems Used in OECD Countries: Overview, Issues and Research Needs: Technical Report,” *Washington Waste Minimisation Workshop*, Vol. II, p. 13.

measure only if the process includes energy recovery. **Table 3** shows the positions of the countries surveyed on this issue:

- In 13 countries, incineration or any other type of thermal treatment **with** energy recovery was considered to contribute to waste minimisation. In six countries, it was not.
- In only four countries was incineration or any other type of thermal treatment **without** energy recovery considered to contribute to waste minimisation. In 15 countries, it was not.
- Criteria to distinguish energy recovery from incineration had been defined in four countries. These criteria were often based on the minimum calorific value of the waste concerned (e.g. Canada: 12,700 kJ/kg; Germany: 11,000 kJ/kg). In Norway, such criteria were in preparation. Some countries required maximum energy recovery or a certain waste quality (Austria, Germany). Spain considered incineration to be a recovery operation “when the economic and environmental balances are positive.”
- In Japan, waste incineration with energy recovery for electric power generation was defined as thermal recycling.
- In 13 countries, such criteria were not applied. However, some of these countries did distinguish between incineration with or without energy recovery.

Incineration not only reduces waste volume and weight, but also minimises the need for landfilling. In the United States, nearly 70 per cent of waste is still sent to landfills and approximately 15 per cent is incinerated. The situation in Europe is similar. In Japan, two-thirds of waste is incinerated with the remainder being landfilled. Waste incineration in Japan is widely practised as an important way to reduce toxicity, as the amount of hazardous waste is increasing and waste composition is becoming increasingly complex. Other factors reported to influence the status of incineration in national waste management schemes are: use of the favourable environmental balance approach in prioritising options, financial and technical considerations, and social issues related to new or existing sitings.

Trends in the use of incineration are sometimes thought to be influenced by political and environmental considerations rather than solely by economics.⁴ Most countries consider incineration to be a valid component of a comprehensive waste management system. As mentioned above, many countries appear to support the use of incineration, at least as a complementary measure to other waste minimisation approaches. According to the waste management industry, incineration decreases the volume of waste by up to 70 per cent and destroys up to 80 per cent of contaminants such as dioxins. It also has the potential to save natural resources. For example, one tonne of municipal waste in a modern incinerator replaces 350 kg of coal and generates 300-700 kWh of electricity or 15 tonnes of hot water for district heating.

The costs of incineration compared with those of landfilling are another reason for its increasing use. Although landfilling has benefited from considerably lower costs than those of incineration, this situation is likely to change as landfill taxes in many countries increase gate fees. The upcoming EU Landfill Directive could have a significant impact on future use of incineration, particularly if the requirement for pre-treatment of waste prior to disposal is adopted.

⁴ However, once an incinerator is built, the need for a constant supply of wastes to keep the facility economically viable shifts the driven factors towards economic considerations.

Table 3 The role of incineration within waste minimisation

	Incineration <u>with</u> energy recovery is considered a waste minimisation measure		Incineration <u>without</u> energy recovery is considered a waste minimisation measure		Criteria exist to distinguish energy recovery from incineration	
	Yes	No	Yes	No	Yes	No
Australia	X		n.a.			X
Austria	X			X	X	
Canada		X		X	X	
Czech Republic	X		X			X
Denmark	X			X		X
Finland	X			X		X
France	X		X		n.a.	n.a.
Germany	X			X	X	
Hungary	n.a.		n.a.			X
Italy	X			X		X
Japan	X		X			X
Korea	X			X		X
Netherlands		X		X		X
New Zealand	not used			X		X
Norway	X			X		X
Poland	X		X		X	
Spain		X		X	X	
Switzerland		X		X		X
Turkey		X		X		X
United Kingdom	X			X		X
United States		X		X	X	
Total	13	6	4	15	6	14
n.a.: no answer						

Incineration may involve perverse trade-offs with regard to waste minimisation strategies. Although optimal operations should lead to the expected breakdown of harmful substances (with by-products captured using pollution control techniques), the performance of furnaces (i.e. level of heat required to effectively destroy hazardous compounds) may be affected by different conditions. For instance, the waste stream content has been shown to influence the oxygen potential in the furnace, impacting on the nature of the organic compounds formed in the process (e.g. dioxins).⁵

Opponents of incineration argue that it basically transfers pollution across media. They point out that solid and liquid wastes are transformed into gases and ash. They also claim that energy recovery achieved through incineration results in a negative ratio if the energy used to manufacture the products that are burned is taken into account. Consequently, incineration is depicted as “business as usual”: the destruction of waste encourages neither prevention and/or reduction at source nor recycling of valuable materials. Most countries take into account the above criticisms.

The EU’s approach may be indicative of most countries’ position on the use of incineration within waste management policies. The 1996 Review of the Community Waste Strategy ranks recycling above energy recovery unless there is a clear environmental case to do otherwise. This was already stated in the 1994 Packaging Directive. The 1996 Review clearly indicates that, without energy recovery, incineration is considered to be a pre-treatment process. However, its contribution to waste minimisation remains ambiguous.

Public resistance to both incinerator and landfill siting also influences waste policies. It continues to be an inevitable aspect of the implementation of integrated waste management strategies. Australia states that incineration cannot be classified as a waste minimisation method, due to community resistance to waste incineration plants. In most OECD countries an emphasis on avoidance, re-use and recycling measures is becoming a precondition for public acceptance of municipal waste incineration.

In conclusion, the status of incineration within waste minimisation was not agreed definitively at the Berlin Workshop. Although its effective role within integrated waste management was clearly recognised, its status remains ambiguous with regard to its influence on concrete, long-term waste minimisation strategies. Depending on the circumstances, the incineration of waste might be considered a means of recovery or of final disposal.

Some elements to be considered in this regard might include:

- best environmental option;
- overall economic costs;
- waste characteristics (e.g. mixed versus homogeneous waste, calorific value);
- use as a fuel substitute;
- energy efficiency of the process; and
- the option of incinerating only non-avoidable, non-recyclable-waste.

⁵ “Effect of Scrap Preparation on Emissions and Steel Composition,” *Jernkontorets Forskning*, Sweden, 1994.

Waste incineration, whether or not it includes energy recovery, appears to be the most controversial practice with respect to its contribution to waste minimisation. Therefore, the outcome of the Berlin Workshop strongly recommended that the OECD further consider the role of incineration within waste minimisation under Project 3.

3. MEASUREMENT AND EVALUATION OF WASTE MINIMISATION

3.1 Context of evaluation and measurement methodologies

Shifting the orientation of waste management policies from pollution control towards waste prevention and reduction at source will require approaches that define priority actions and waste streams and encourage the closing of material cycles (e.g. environmentally benign production and consumption patterns). Moreover, implementing effective waste minimisation policies and programmes will require improved data in order to measure the effectiveness of different options and to identify priority problems and/or potential opportunities for improvement.

Current problems associated with prioritising and measuring waste streams may be related to the predominant waste management approaches in Member countries. In the past, waste management issues were mainly addressed in accordance with the prevailing pollution control paradigm. The main concern of regulatory authorities was that public health and the environment should not be damaged through improper waste disposal. Preventing waste generation was not a priority. The aim was to control wastes at the post-consumption stage, not to understand why and how they were generated throughout products' life cycles.

Scope, levels of detail, and classification systems differ among countries. In Europe, data on waste generation are generally more readily available for municipal and household waste than for industrial waste. Conversely, databases in the United States are much more oriented towards industrial waste. Industrial waste data in the United States are collected through two major databases: the Biennial Reporting System (BRS) and the Toxics Release Inventory (TRI). Both are concerned with only fractions of the total amount of industrial wastes generated nationally. Neither system is likely to provide comprehensive information for waste minimisation programmes, since waste streams include substances that are not reported.

As environmental, economic and social pressures mount in reaction to the waste "crisis", lack of harmonization among countries is becoming a major issue. It was singled out as the most important factor in an extensive study by the European Commission on the status of Community Statistics on Waste.⁶ This study provided a detailed review of underlying problems related to the lack of harmonization among countries. These problems, which may be extended to include all OECD countries, are:

- different scopes and definitions of waste (categories and types);
- different methods of quantifying waste;
- different data collection methods;

⁶ Campbell, D., "Measurement and Evaluation of Waste Streams," *Washington Waste Minimisation Workshop*, Vol. II, p. 87.

- omission of unreported wastes from statistics;
- varying methods of data presentation and levels of detail in standard documents;
- different dates and baseline years for compilation of statistics; and
- legislative constraints restricting collection and presentation of data.

In response to a US Environmental Protection Agency survey on Chemical and Waste Prioritisation Systems, which was presented at the OECD Washington Workshop,⁷ many Member countries agreed on the critical importance of better waste characterisation data for proper identification of priorities, and for implementing and evaluating waste minimisation measures and costs. Participants also agreed that one important task for the OECD would be to work on harmonization of waste definitions, classification, collection methods, and presentation of data. These aspects could be defined by developing or adapting a “framework for setting priorities, the elements of which would be selected and weighted individually by countries.”⁸ The prioritisation of waste streams is considered a step in the right direction. By assessing the results of the implementation of targets for priority waste streams, the harmonization of waste minimisation measurement and evaluation might be developed along three mutually supporting lines:

- the development of a standardised monitoring system;
- the exploration of approaches for indexing waste to units of production, in order to cover more broadly the components of waste streams for waste minimisation; and
- the wide dissemination of monitoring results from waste minimisation programmes.

The development of indicators, such as waste per households or per capita, may be worth exploring. Indexing waste generation to production may be another fruitful approach. Also, the development of monitoring systems in support of programmes on priority waste streams has the potential to provide the necessary input for the development of standardised protocols for waste generators. This is also true for the measurement of waste requiring final treatment and disposal. The full participation of waste generators in monitoring programmes is considered essential, although national authorities must remain the appropriate body to ensure standardisation and consistency of reporting.

The development and harmonization of measurement and evaluation methodologies for waste minimisation is likely to require extensive research and dedication by all OECD countries and the various stakeholders. Considering the difficulties involved, and the financial burden associated with the establishment of such databases, Member countries might choose to work jointly on international programmes that identify specific waste streams and/or priority pollutants. Indeed, the sharing of experiences and information on national approaches and programmes is likely to provide useful insights.

In the following subsections, some experiences and results of public policies and industry initiatives are used to highlight the relative contribution of the three main components of waste minimisation: prevention and reduction at source, re-use and recycling. The difficulty involved in assessing the contribution of waste prevention to waste minimisation is addressed. Re-use is used to propose a conceptual framework for measuring the contribution of the different means of waste

⁷ Ralston, M., “Chemical and Waste Prioritization Systems Used in OECD Countries: Overview, Issues and Research Needs: Technical Report,” *Washington Waste Minimisation Workshop*, Vol. II, p. 13.

⁸ Nowina, R., “Prioritising Waste Streams,” *Washington Waste Minimisation Workshop*, Vol. II, p. 77.

minimisation. Finally, case studies and experiences illustrate the contribution of different waste hierarchy elements to waste minimisation.

3.2 Evaluation of waste minimisation

3.2.1 Evaluation of waste prevention and reduction at source

The evaluation of waste minimisation is particularly difficult, due to the lack of comprehensive and comparable data. The ability to measure and identify opportunities for waste minimisation is seriously hindered by the fact that current measuring programmes cover only a fraction of the components of waste streams. Statistical systems seldom permit a thorough understanding of the dynamics of waste generation in relation to economic growth. Issues such as the rate of use of a given product are not taken into account in economy-oriented statistics, challenging authorities to devise policies and/or programmes that have the potential to produce this kind of information.

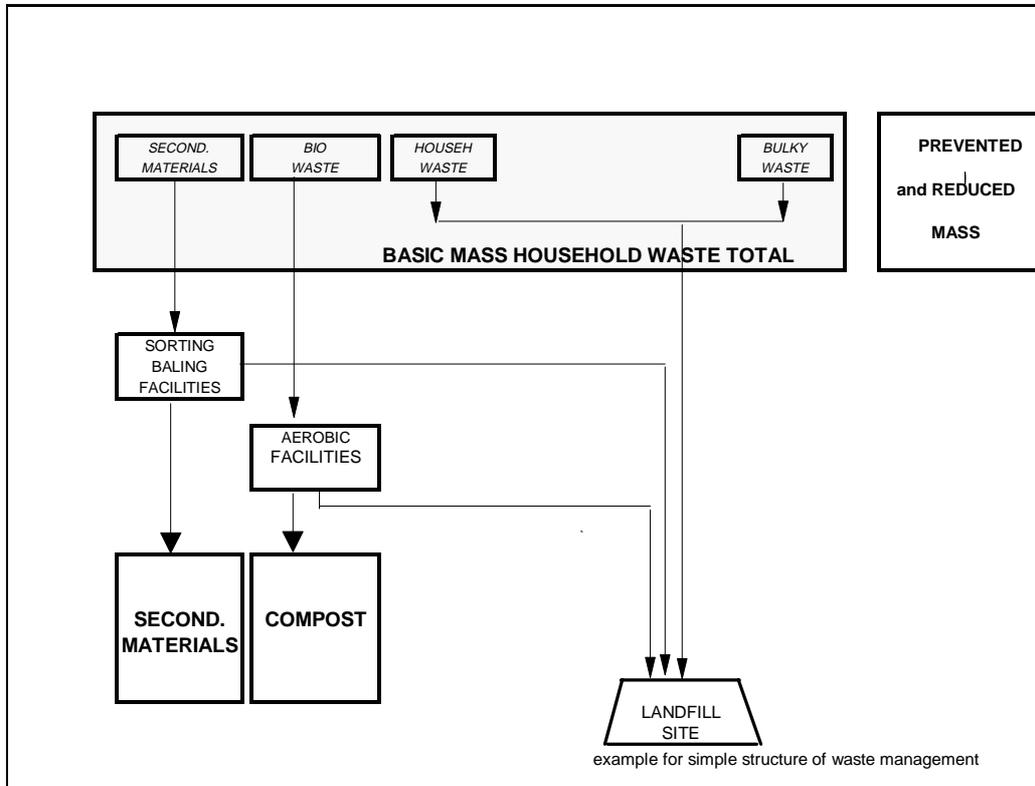
In order to ensure the success and cost-effectiveness of waste minimisation policies, it is imperative to assess the relative contribution of different waste minimisation tools. Effective evaluation and measurement programmes must therefore be based on an appropriate set of indicators that would provide the data necessary for assessing the implementation of waste minimisation measures, or for selecting the most effective and appropriate options.

National approaches provide some indication of the magnitude and relative importance of different waste minimisation tools. In the Netherlands, comparison of Gross Domestic Product (GDP) and generation of household waste between 1986 and 1995 provides a good example of the decoupling of economic growth and environmental impact. Further analysis indicates that the relative contribution of waste prevention to overall waste minimisation might be somewhere between 5 and 10 per cent. By comparison, recycling has contributed around 70 per cent.

These results suggest that while prevention might be the most desirable goal of waste minimisation policies, recycling appears to have much more immediate potential. This conclusion underlines the importance of adopting a pragmatic approach when designing waste minimisation programmes and targets. As mentioned earlier, the order of preference should not necessarily lead to a sequential application, but should be understood as a governing principle for the assessment and selection of the most appropriate options. Thus, from both an environmental and economic perspective, recycling may be preferred to prevention and/or reduction at source in some cases.

Notwithstanding the relative contributions of the different means of waste minimisation, a conceptual structure and basic method for the evaluation of prevention and reduction rates may be developed based on order of preference, as shown in **Figure 2**. The purpose of the model is to provide a conceptual framework for evaluating the relative contribution of various tools and methods to overall minimisation of wastes.

Figure 2 Basic structure for evaluating prevention and reduction rates



By using the given data for each component in Figure 2, the contribution of prevention and reduction at source could be evaluated using the following formula:

$$\text{Waste Minimisation Rate \% by Prevention and Reduction} = \frac{\text{PREVENTED AND REDUCED MASS}}{\text{BASIC MASS HH WASTE TOTAL} + \text{PREVENTED AND REDUCED MASS}} \times 100$$

Table 4 provides an example of how collected data may allow an evaluation of the effects of preventive measures on different waste streams. According to the example, the amount of separately collected fractions (to be recycled) increased by 5000 tonnes, while the amount of residual household waste decreased by 7000 tonnes. Thus, household waste was reduced at source by 2000 tonnes through either direct preventive measures or re-use. The prevented and reduced mass is only a theoretical figure. However, as an approximate value the mass difference from two (successive) years could be inserted.

Table 4 Results of Waste Minimisation in “Sunshine City”

Sunshine City	1990 in t	1991 in t	PREVENTION REDUCTION in t	WASTE MINIMISATION RATE by PREV / RED in %
Separately collected materials	22,000	27,000	-5,000	
Residual HH waste	110,000	103,000	7,000	=2.000:132.000
Total HH waste	132,000	130,000	2,000	1.5

Comprehensive waste monitoring systems are needed in order to fully assess the potential of waste minimisation. Issues such as the effects of lifestyles on consumption patterns, the lack of effective environmental cost accounting systems, and the knowledge of prevention options in industry must be addressed in designing and implementing environmentally sound, cost-effective policies. Consequently, a potential approach to examining the overall contribution of various waste minimisation tools could be illustrated by single cases of specific waste streams, products and/or processes. This approach will be used in the following subsections. Examples of preventive measures are also given in Section 4.

3.2.2 Evaluation of re-use

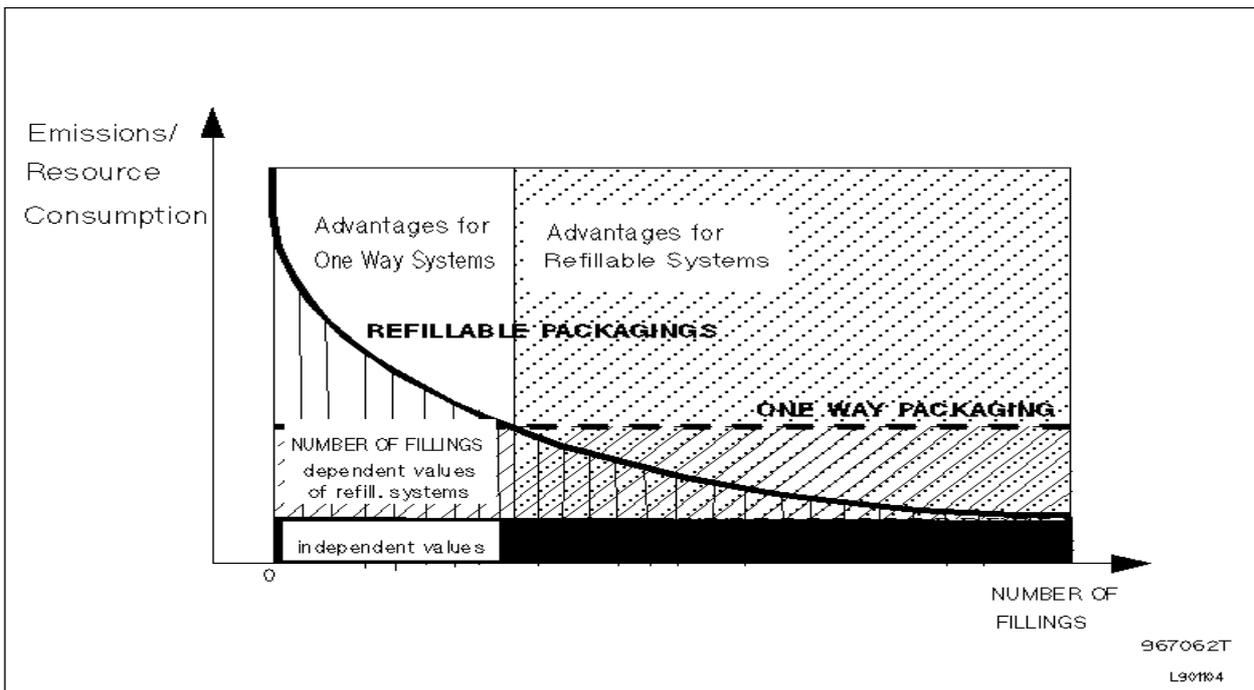
The number of uses per unit of packaging is usually referred to as the “circulation rate”. One-way packaging passes through only one cycle before being discarded. Multiple-use packaging will normally be used several times. Between the different stages of utilisation of re-usable packaging, expenditures for output maintenance (substantial maintenance), such as washing and repair, are necessary. However, if multiple use of packaging no longer satisfies either quality specifications or marketing strategies, it may be discarded. In turn, re-usable packaging can be divided into circulation-dependent and circulation-independent resource consumption and environmental strain:

- circulation-independent resource consumption is similar to any other single cycle, i.e. it is constant in relation to the specific unit of the packaged commodity (energy consumption for returning used packaging for refill, washing, etc.); and
- circulation-dependent resource consumption occurs only once during the life cycle of re-usable packaging and once at the time of disposal. With regard to the specific unit of the packaged material, it is dependent upon the number of uses.

For output maintenance (i.e. substantial maintenance), such as taking back used packaging, storage, washing, control, etc., additional resources (energy, water, chemicals, electronics) must be used. This again results in waste and other environmental impacts. The indirect resource consumption and

environmental impacts caused by the production of raw and supplementary material as inputs for the processing of packaging items also have to be considered. In assessing these different considerations, the ultimate objective is to define the optimal environmental balance, i.e. a packaging system which consumes as few resources as possible and generates as little environmental strain as possible in the total balance per specific filling output. **Figure 3** illustrates the relationship between the life cycles of different packaging systems and their contributions to waste minimisation.

Figure 3 Outcome of packaging requirements on environmental strains



To illustrate the relative contributions of re-use (and recycling) to waste minimisation, the following example is provided:

- **In Case A** (re-use of a one litre, 400 gram glass bottle returned 40 times) there is a material loss of 10 g/litre per refill. In most cases, 50 per cent or 5 g/l is recycled in-house.
- **In Case B** (a one litre, 300 gram one-way bottle) there is a recycling rate of 60 per cent, leading to a material loss of 120 g/l.
- **In Case C** (a one litre, 300 gram one-way bottle) the material loss from landfilling is 300 g/l.

Material loss or waste product amounts to 2.5 per cent in case A (or only 1.25 per cent if glass is collected and recycled in-house). By comparison, in case B the loss is 40 per cent and in case C it is 100 per cent.

The following therefore applies:

WASTE REDUCTION BY RE-USE OR RECYCLING VS. DISPOSAL			
Case C/Case B	⇒	300 to 120 g/l	⇒ 60.0 per cent (recycling/disposal)
Case C/Case A	⇒	300 to 5 g/l	⇒ 98.3 per cent (re-use/disposal)

3.2.3 *Evaluation of recycling*

As already indicated, recycling appears to provide the most important contribution to minimisation of waste that would otherwise be landfilled or incinerated. Data provided by the Netherlands at the Berlin Workshop suggest that the contribution of recycling to overall waste minimisation could be nearly 70 per cent (see 3.2.1). This assumption seems confirmed by the results of several other studies, as described below.

A study on the costs and benefits of municipal waste management systems was mandated by the European Commission and conducted by Coopers & Lybrand and the Centre for Social and Economic Research on the Global Environment. Among the results of this study, recycling would have “the most significant net benefits in all (EU) Member States.”⁹ However, the study acknowledged that the benefits would vary among countries due to differences in transport costs, energy savings, and different waste streams. As a general conclusion, the authors suggested that on average the total net costs of recycling are significantly smaller than those of either landfill or incineration.

Again, information on packaging and packaging waste gives an insight into the relative contributions and ongoing development of recycling measures. Recent results of packaging programmes indicate the important contribution of recycling to waste minimisation. Indeed, in most European

⁹ “Study on Costs and Benefits of MSW-Management Systems,” *Resources Report*, Belgium, No. 5, 1997.

countries companies responsible for collecting and recovering packaging waste had significant success in 1996:¹⁰

- In France, 1.1 million tonnes of household packaging waste was recovered, compared with 700,000 tonnes in 1995. More than half this amount was recycled. Eco-Emballages intended to recover as much as 1.8 million tonnes by the end of 1997, of which 65 per cent would be recycled.
- In Austria, Altstoff Recycling Austria collected 607,000 tonnes of packaging waste from households, business and industry, of which 558,000 (92 per cent) was taken to recycling plants for mechanical recycling.
- In Belgium, 4.2 million persons had been incorporated into the collection system, with nearly 45 kg of used packaging per person being collected annually. Approximately 288.9 kilotonnes of used packaging was sent for recycling.
- In Germany, recycling figures indicated a clear upward trend and stable costs for the collection, sorting and recycling of commercial packaging. It was estimated that 5.32 million tonnes of recyclable materials could be separated from the total amount collected, which would amount to 84 per cent of total commercial packaging consumed by households and small businesses. All sorted materials were sent for recycling in accordance with the mandatory requirements of the Packaging Ordinance.

Germany has also been experiencing an increase in the rate of reutilisation of building and demolition waste. Of the nearly 85 million tonnes of construction debris from building work, roadwork and construction sites, some 31 million tonnes is currently being recycled. In addition, the industrial and commercial sectors concerned have embarked on a voluntary initiative. At least 23 million tonnes out of the 54 million tonnes currently being disposed of will be recycled, in addition to the current amount.¹¹

These results suggest that recycling's important contribution to waste minimisation will probably continue and even grow. As experience with waste minimisation increases, the implementation of effective programmes (including the development of level playing fields for recovered products) is likely to have a positive influence both on the development of markets for recycled goods and on innovations in environmentally sound recycling technologies. This area will require much attention in the upcoming years.

¹⁰ "Green Dot – Successful in Europe," *Resources Report*, Belgium, No. 5, 1997.

¹¹ "Germany: Increase in the Reutilisation of Building Waste," *Resources Report*, Belgium, No. 5, 1997.

Following the conceptual framework presented above under 3.2.1, the contribution of recycling to waste minimisation could be evaluated as follows:

Waste Minimisation Rate % by Recycling	$= \frac{\text{MASS OF SEPARATELY COLLECTED MATERIALS MINUS LANDFILLED COMPOST RESIDUES}}{\text{BASIC MASS OF TOTAL HOUSEHOLD WASTE}} \times 100$
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Using the example from Table 4, the waste minimisation rate through recycling could be calculated as 27,000 tonnes : 130,000 = 20.8 per cent. Assuming further that 1000 tonnes of compost plant residues was landfilled, the final contribution of recycling to waste minimisation would be 20 per cent. Further examples of the contribution of recycling to overall waste minimisation will be found in Section 4.

In conclusion, the framework described above could provide a basis for evaluating the contributions of different elements in the waste hierarchy to waste minimisation, so long as the required amount of data is available. These data are not available in all OECD countries. Therefore, a workable system for evaluating progress in waste minimisation is needed and should be linked to established targets. Under Project 3, a monitoring system should be developed that includes methods for:

- measurement of waste requiring final treatment/disposal;
- priority waste streams; and
- the contribution of different elements in the waste hierarchy.

Possibilities for a standardized monitoring system that can be progressively refined should be identified.

4. CASE STUDIES ON WASTE MINIMISATION

This section reviews waste minimisation approaches and evaluation techniques used for different production phases and product life cycles. Case studies provide positive examples of, and insights into, the establishment of procedures for evaluating the performance of waste minimisation measures. Most of the case studies are taken from Austria, but they may also be applicable to other OECD countries.

The need to consider environmental impacts is still too often considered a business obstacle rather than an opportunity. Case studies are an excellent means of presenting the desirability and effectiveness of waste minimisation measures.

The following subsections address the roles and contributions of the different elements in the waste hierarchy to overall waste minimisation.

4.1 Product design

Waste minimisation strategies need to start with the very beginning of a product's life cycle: i.e. with product design. Not only should industry minimise expenditures on processes that eventually result in excessive releases of pollutants and wastes, but it should also take advantage of every opportunity to improve the environmental performance of its products and use material and energy inputs more efficiently. Product design should consider all environmental aspects, in order to ensure that the products will conform to standards adopted for environmental protection purposes.

Countries are increasingly adopting policies and instruments (e.g. waste minimisation targets, mandatory and voluntary recycling, eco-labelling) whose purpose is to encourage the marketing of environmentally conscious products. Many industries have implemented strategies to comply with stringent environmental standards and respond to environmentally oriented market signals. Discarded products and by-products are increasingly being recycled and hazardous substances are being replaced by environmentally benign ones.

These strategies have direct implications for product design. Product specifications may now include:

- reversible environmental effects (or sustainable use of resources and energy);
- waste-free and non-toxic;
- durable; and
- easily re-usable or recyclable.

Table 5 shows how minimisation of material inputs and increased material yield were achieved through product redesign. A current model video camera, together with compatible video recorder, offer more functions with a 93 per cent reduced weight, compared with 1970s models.

Table 5 Reduction of material consumption through product design in household electronics

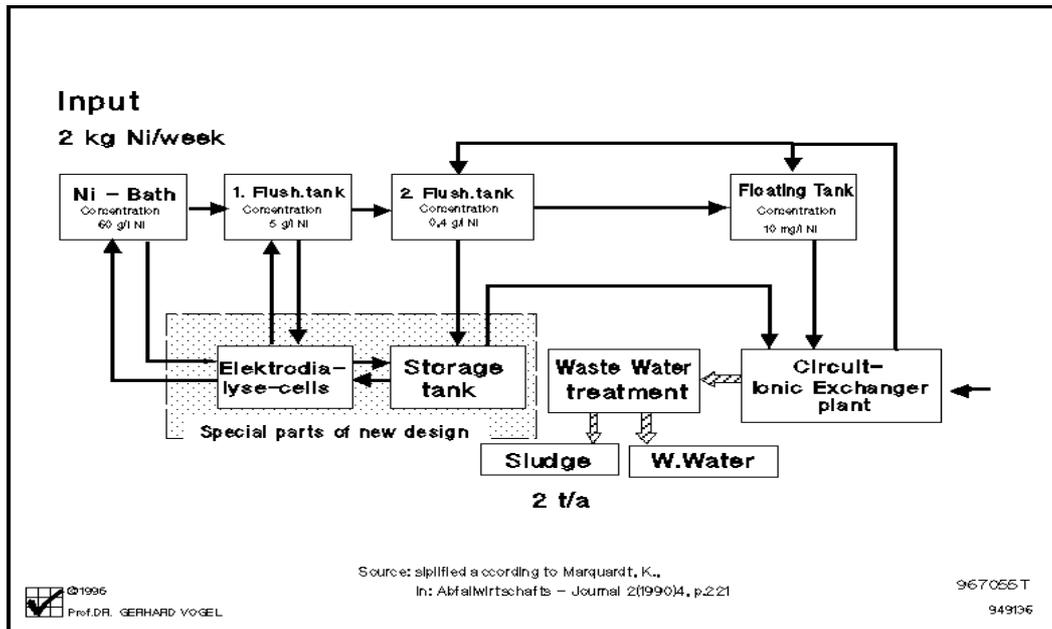
PRODUCT	Dimensions in mm	Weight in kg	REDUCTION		WASTE MINIMISATION RATE by REDUCTION in %	<i>Material intensity factor</i>
			Model / Model in kg	Fist model / Model in kg		
VIDEORECORDER HITACHI VT 65006 plus CAMERA PANASONIC A1 Total	263x108x257 113x160x236	9,90 1,10 11,00				1
CAMCORDER SONY PRO 8	98x196x366	2,60	8,40	8,40	= 8,4:11*100 -76,4	= 11:2,6 4
CAMCORDER SONY CCD Video 8	109x106x183	0,79	1,81	10,21	-92,8	14
DIGITAL VIDEO CAMERA REC SONY DCR-PC7E	59x129x118	0,50	0,29	10,50	-95,5	22

4.2 Production processes

Reducing or preventing waste at source in industrial processes should be given top priority, as this will influence waste generation throughout the product's life cycle. In the following example from the metal industry, both material inputs and releases were reduced through better management and recycling of waste streams.

In galvanisation, an important problem is the permanent dilution of the baths in the process and the resulting pollutant stream. This entails high consumption of metals and/or chemicals and strong pollution of sewage water, as well as generation of sludge from sewage water treatment. A cleaner technology that uses electro dialysis has recently been introduced (**Figure 4**), allowing the reconcentration of baths. Acid consumption and nickel losses are therefore reduced, and sludge generation is also considerably reduced (**Tables 6 and 7**). Moreover, this environmentally oriented improvement has contributed to a reduction in the cost of operations, as shown in Table 7.

Figure 4 Scheme of a low-waste galvanisation process



Source: simplified from K. Marquardt, Membranverfahren zur Erfüllung neuer Abwassergrenzwerte, in *Abfallwirtschafts Journal*, 2 (1990) 4, p. 220.

Table 6 Waste minimisation using this low-waste technology

Galvanisation	process	process		WASTE MINIMISATION RATE by REDUCTION in %	Material intensity factor	Emission reduction factor
		old	new			
Ni Input	kg/week	78	2	-97,4	39	
Sludge disposal	t/y	50	2	-96,0		25

Source: K. Marquardt, Membranverfahren zur Erfüllung neuer Abwassergrenzwerte, in *Abfallwirtschafts Journal*, 2 (1990) 4, p. 221

Table 7 Cost reductions using this low-waste technology

Galvanisation Costs	process		Costs Reduction	
	old	new	DM/a	in %
Ni Input DM/a	115.000	2.900	-112.100	-97
Acid Input DM/a	5.000	1.000	-4.000	-80
Sludge disposal DM/a	45.000	1.800	-43.200	-96
Recovery Costs*		63.000	63.000	-
Total Costs DM/a	165.000	68.700	-96.300	-58

* 0,2 Mio DM Investment, 8 % interest, incl. Costs for Energy, Chemicals, Maintenance and Labour

Redemption period: 200.000 : 96.300 2,08

This case study demonstrates that actively promoting waste prevention not only leads to positive environmental effects, but can also result in economic gains. Given an investment of 0.2 million DM and treatment cost savings amounting to 96,300 DM per year, any investment in the introduction of electro dialysis technologies is a clever move since these figures correspond to a pay-back period of 2.08 years.

4.3 Packaging /distribution

4.3.1 Redesign of toothpaste packaging

The redesign of toothpaste packaging is a highly publicised example of a waste prevention initiative. A standing tube with a screw cap larger than those on conventional tubes has been introduced. Marketing of tubes without cardboard packaging was an innovation which took into account environmental impacts. This successful example of waste prevention in Austria responded to market trends and introduced an innovative new packaging concept for distributing the product. **Table 8** indicates the waste prevention and reduction achieved.

Table 8 Waste prevention/reduction through redesign of toothpaste packaging

Tooth paste 75 ml Tube	conventional tube	new design	PREVENTION REDUCTION	WASTE MINIMISATION RATE by PREVENTION REDUCTION in %	<i>Material intensity factor</i>
	in g	in g	in g		
Tube	7,00	7,08	0,08	1,1	
Cap	1,50	3,30	1,80	120,0	
Tube total	8,50	10,38	1,88	22,1	0,8
Cardboard box	11,50	0	-11,50	-100,0	PREV
Corrugated box	3,30	5,700	2,40	72,7	0,6
Foil	0,40	0,067	-0,33	-83,3	6,0
Distribution unit	3,70	5,767	2,07	55,9	0,6
Total	23,70	16,15	-7,55	-31,9	1,5

4.3.2 Waste reduction through a change to refillable packaging

4.3.2.1 Re-usable vegetable hampers

The Austrian Hamper Pool is a legally binding system for farmers, distributors, wholesalers and retailers. It has the following product quality, distribution and environmental objectives :

- use of re-usable hampers instead of disposable ones for fruit and vegetables;
- reduction of total material used in disposable fruit and vegetable containers;
- increasing the quality of fruit and vegetables through packaging improvements; and
- improving the flow of goods.

The height of the re-usable green plastic hamper is such that each model can be used throughout the year for different fruits and vegetables. These durable polyethylene hampers can be used nearly ten years, or sometimes up to 15-18 years.

The benefits of integrating production and post-production considerations into the design and distribution of the hampers have been significant in terms of both reduced environmental impacts and customer service. These benefits include, among others:

- preservation of optimal product quality from the producer to the retail shop ;
- suitability for cool storage, which makes better use of harvest and sorting capacities and distribution during high peaks;
- good stacking ability and stacking safety;

- standardised selling units with a uniform tare (i.e. the weight that is deducted from gross weight to obtain the net weight) and ergonomic advantages (maximum 15 kg per hamper); and
- suitability for a large number of different products (fruit, vegetables, eggs, dairy products, flowers, etc.).

Table 9 shows how re-use of these hampers reduces waste over one-year and five-year periods.

Table 9 Waste reduction through re-use of hampers

HAMPERs	one year period		REDUCTION in t	WASTE MINIMISATION RATE by REDUCTION (Re-use) in %	Material intensity factor
	One way	Re-usable			
Weight of one packaging kg	1	1,35			
Fillings per period	20.000.000	20.000.000			
Number of hampers	20.000.000	1.300.000			
Number of total fillings per hamper	1	15			
Total weight t	20.000	1.755	18.245	91,2	11

HAMPERs	five year period		REDUCTION in t	WASTE MINIMISATION RATE by REDUCTION (Re-use) in %	Material intensity factor
	One way	Re-usable			
Weight of one packaging kg	1	1,35			
Fillings per period	100.000.000	100.000.000			
Number of hampers	100.000.000	1.300.000			
Number of total fillings per hamper	1	77			
Total weight t	100.000	1.755	98.245	98,2	57

4.3.2.2 Waste reduction through changing to re-usable packaging in the ski boot industry

In the course of investigating packaging systems with regard to possible economic savings, as initiated by the Packaging Ordinance, many Austrian companies have replaced their small disposable containers with large re-usable ones. In all cases, material reduction has led not only to reduction of raw material inputs but also to a reduction of costs through avoidance of hazardous wastes. Therefore, this option is both economically and ecologically desirable. Table 10 shows the results of introducing such a change in the ski boot industry.

Table 10 Waste reduction through re-use of packaging in the ski boot industry

DISTRIBUTION OF ADHESIVES		one year perid		REDUCTION in t	WASTE MINIMISATION RATE by REDUCTION (Re-use) in %	Reduction of hazardous waste tratement costs in %	Material intensity factor
		One way barrel	Re-usable container				
Weight of one packaging	kg	15	220				
Distrubution volume	kg	79.500	79.500				
Volume per unit	kg	159	700				
Number of barrels / containers		500	4				
Number of fillings per unit		1	28				
Total weight of packagings	kg	7.500	880	6.620	88,3	88,3	9

DISTRIBUTION OF ADHESIVES		five year perid		REDUCTION in t	WASTE MINIMISATION RATE by REDUCTION (Re-use) in %	Reduction of hazardous waste tratement costs in %	Material intensity factor
		One way barrel	Re-usable container				
Weight of one packaging	kg	15	220				
Distrubution volume	kg	397.500	397.500				
Volume per unit	kg	159	700				
Number of barrels / containers		2.500	4				
Number of fillings per unit		1	142				
Total weight of packagings	kg	37.500	880	36.620	97,7	97,7	43

4.4 Waste prevention through changes in consumption patterns

In 1990-91, approximately 200 families in Vienna were requested to generate as little waste as possible by changing their consumption and shopping behaviour. Participating on a voluntary basis, these families produced *a priori* 19 per cent less waste than an average Viennese family due to high motivation and a positive attitude to environmental protection. During the one-year test period, they reduced the total amount of waste they produced by 15 per cent.

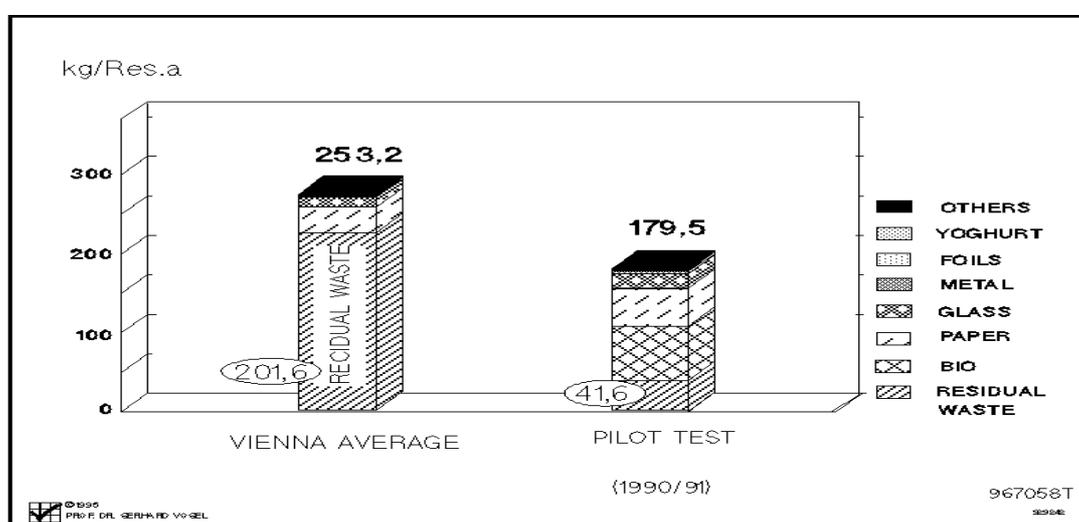
Measures that could to be taken by consumers in order to minimise waste include:

- consumption of durable, high-quality and repairable goods;
- observance of products' service obligations;
- purchase of necessary goods only, and in reasonable amounts;
- reduction in amounts of packaging though multiple re-use (of containers, shopping baskets, etc.); and
- purchase of re-used products.

Some energy consumption and waste generation is a normal part of life for most people. However, certain styles of life may lead to the generation of amounts of waste that are much greater than those of the “average consumer”. For example, the Vienna test found that a family that was fond of reading and had a dog might produce twice as much waste as the “average family”.

It is possible to reduce waste while maintaining the same living standard. The Viennese study also showed that the recoverable amount of secondary materials could be drastically increased through better separation of discarded products. While the residual waste from a household averaged about 200 kg, it could be reduced to 40 kg in highly motivated families through properly designed collection systems (collection of eight fractions), as shown in **Figure 5**.

Figure 5 Comparison of waste minimisation activities: results of the Vienna study



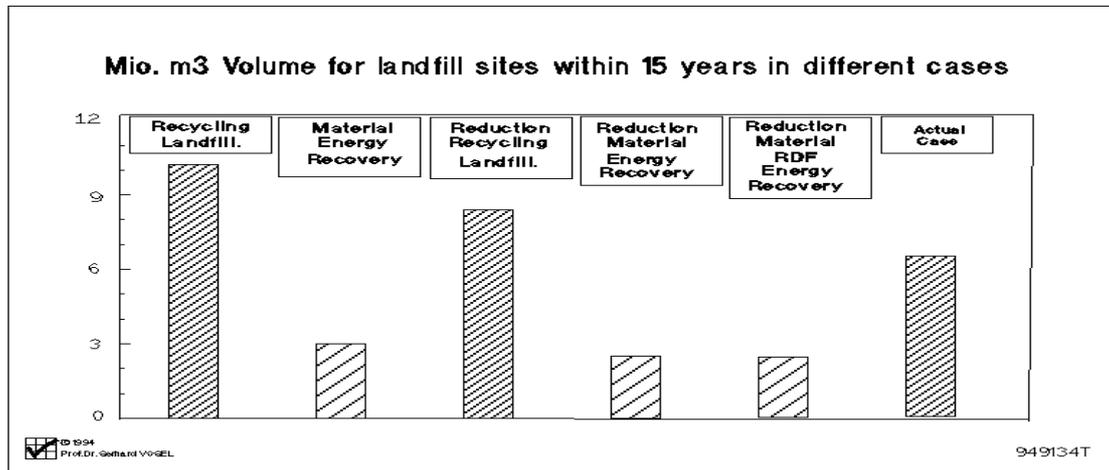
4.5 The role of waste management planning in waste minimisation

During the elaboration of the Vienna Waste Management Plan in 1988-89, attempts were made to determine the optimal combination of processes to address existing waste streams. Using computer simulation, options for extending existing landfill capacity while improving the environmental soundness of waste management were evaluated. This study had the following goals:

- to minimise landfill disposal to the extent possible;
- to recycle to the extent possible;
- to incinerate as little as possible;
- to avoid pollutant releases to the extent possible;
- to reduce environmental disturbances for residents (e.g. smells, noise);
- to stimulate future-oriented planning (i.e. ongoing implementation of measures based on new findings); and
- to be cost-effective.

The results of the study showed that the least landfill volume was required using the *best-case* option: “prevention, reduction, recycling and energy recovery”. If the landfill volume was considered the most important factor in decision-making, the best-case combination of procedures would then be given priority (**Figure 6**).

Figure 6 Required landfill volume according to different planning alternatives

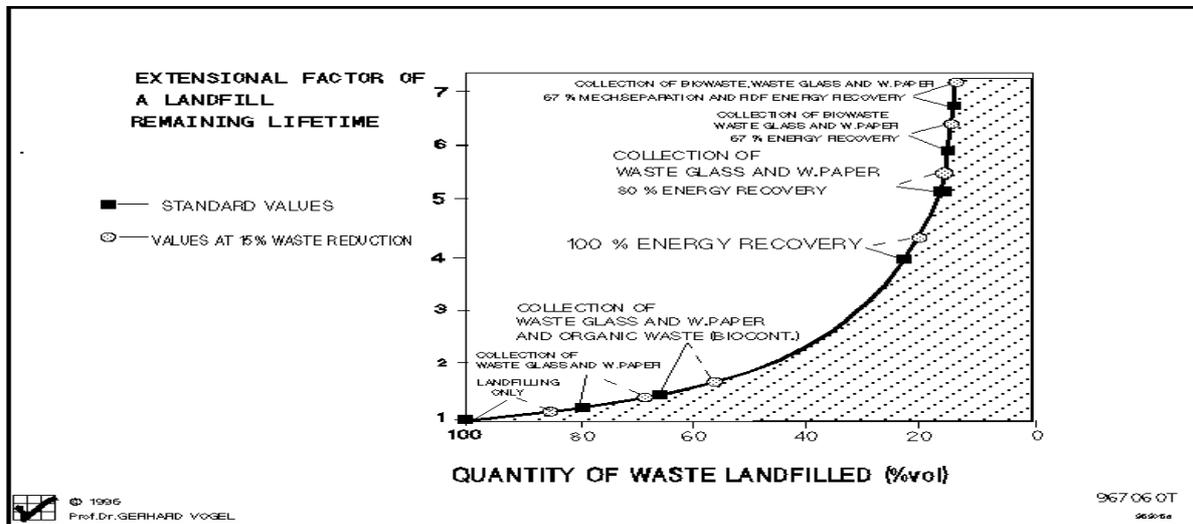


The amount of waste to be landfilled was not, however, the only criterion for evaluating combinations of procedures from the point of view of environmental impacts. A further criterion was the air pollution resulting from:

- collection and transport of waste;
- incineration with energy recovery; and
- under the landfill scenario, incineration using fossil fuels for heating and warm water in Vienna if no waste incineration is taking place.

The analysis of alternative routes using computer simulation suggested that a finely tuned combination of measures within the hierarchy of possible actions (i.e. waste avoidance and reduction, material recovery, energy recovery, environmentally sound disposal) would not only contribute to the achievement of positive results in terms of environmental considerations but would also produce economic benefits. **Figure 7** shows the contribution of various waste minimisation tools to the extension of the landfill’s remaining lifetime.

Figure 7 Effects of waste minimisation measures on the landfill's remaining lifetime



Using the city of Munich as an example, the above simulation can be projected to the real world. The contribution of different tools to waste minimisation in 1993 was as follows:

- **Separate collection of recyclables (secondary materials)**

according to weight	19.7 per cent
according to volume	25.2 per cent

- **Bio-waste collection**

according to weight	2.5 per cent
according to volume	1.3 per cent

- **Energy recovery from household waste (net)**

Only that material is considered which does not leave the incineration plant as ash or scrap (this is the amount transformed into gaseous materials). In this case, it is a question of amounts rather than an energy balance sheet.

according to weight	51.5 per cent
according to volume	65.2 per cent

- **Energy recovery from household waste (gross)**

The material included is that which leaves the incineration plant as ash or scrap.

according to weight	69.9 per cent
according to volume	67.4 per cent

- **Total household waste minimisation by recovery**

according to weight	78.2 per cent
according to volume	93.0 per cent

Figures 8 and 9 compare the estimated amounts of various types of waste going to landfill that could be reduced through waste recovery, according to weight (Figure 8) and volume (Figure 9).

Figure 8 Projected minimisation of household waste through recovery activities (according to weight)

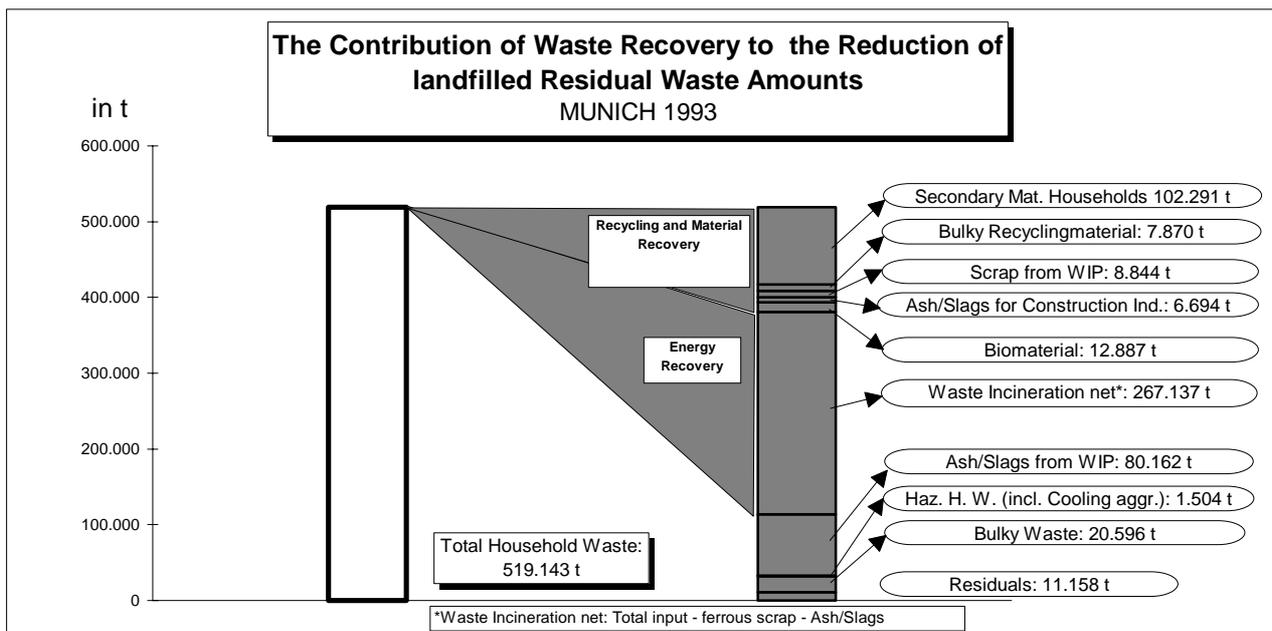
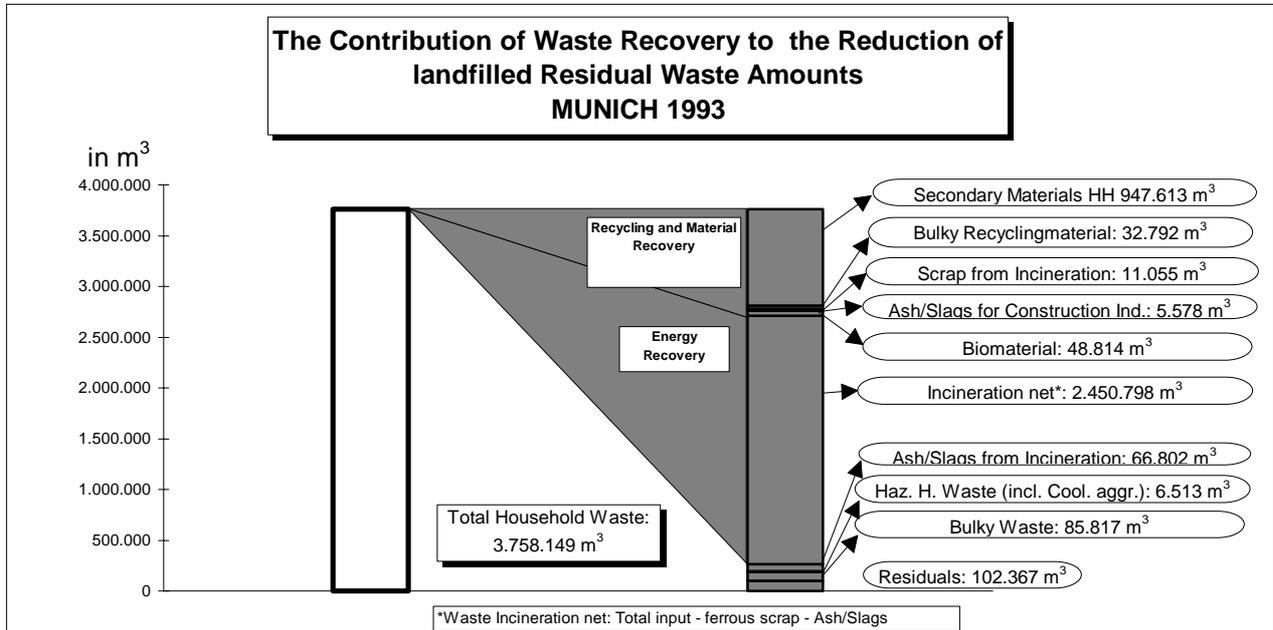


Figure 9 Projected minimisation of household waste through recovery activities (according to volume)



5. CONCLUSIONS AND RECOMMENDATIONS

The purpose of Project 2 was two-fold. First, it elaborated and further explained the outcome of Project 1 with regard to definitions, terms and concepts used in OECD countries. Second, it explored concepts and methods for measuring and evaluating waste minimisation.

General agreement was reached at the 1996 OECD Workshop in Berlin on the OECD working definition of waste minimisation. According to this definition, waste definition is:

- preventing and/or reducing the generation of waste at source;
- improving the quality of waste generated, such as reducing the hazard; and
- encouraging re-use, recycling and recovery.

The above definition also presents the relative hierarchy of waste minimisation measures.

This is a *broad definition*. It encompasses not only practices that prevent waste being generated, but also those dealing with unavoidably generated wastes. The ultimate goal is to divert as much waste as possible from landfills. This broad definition also facilitates initiatives aimed at closing material cycles.

It should be recognised that, although *general agreement was reached on this OECD working definition of waste minimisation*, national definitions of waste minimisation may not necessarily be the same in all OECD countries.

Waste incineration, whether or not it includes energy recovery, appears to be the most controversial practice with respect to its contribution to waste minimisation. Therefore, *it is strongly recommended at the Berlin Workshop that the OECD further explore the role of incineration within waste minimisation under Project 3*.

Regarding performance evaluation and accounting methods, several case studies suggest that waste minimisation can be evaluated and measured. Formulas have been proposed that appear to be effective in measuring waste minimisation successes. Effective evaluation and accounting methods are dependent upon the quality and amount of waste data. Indeed, evaluating the success of waste minimisation measures with regard to different waste streams implies that good monitoring of waste flows and management has been performed. Moreover, the harmonization of waste minimisation definitions and measurement programmes is a prerequisite to the implementation and refinement of performance and evaluation methodologies.

The availability of high-quality, comparable waste data differs among OECD countries. Therefore, a workable system for evaluating progress in waste minimisation is necessary and should be linked to established targets. A monitoring system should be developed under Project 3, including protocols for:

- measurement of waste requiring final treatment/disposal;
- priority waste streams; and
- contribution of different elements in the waste hierarchy.

Due consideration should be given to the cost of monitoring, including the need to minimise duplicative reporting. The benefits of monitoring should also be recognised (e.g. accountability, reporting, and ability to refine targets).