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Solid Recovered Fuels

ICS 13.030.40; 75.160.10

British Standards

National foreword

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The UK participation in its preparation was entrusted to Technical Committee PTI/17, Solid biofuels, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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Solid Recovered Fuels

This Technical Report was approved by CEN on 18 july 2003. It has been drawn up by the Technical Committee CEN/TC 2.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36   B-1050 Brussels

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Foreword

This document CEN/TR 14745:2003 has been prepared by Technical Committee CEN/SS NO**2 "*Solid fuels***", the secretariat of which is held by ***CMC***

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2004, and conflicting national standards shall be withdrawn at the latest by April 2004.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom

This technical report considers the production of solid recovered fuels from selected, non-hazardous, mono- and mixed-wastes and has been prepared by members of the CEN Task Force 118 "*Solid Recovered Fuels*".

Solid recovered fuels can be derived from a wide range of waste streams and are processed into different physical forms for the (partial) substitution of primary fuels in various combustion technologies.

The estimated quantity of solid recovered fuels produced in the European Union in 2000 was 1.4 million tonnes (0.7 Mtoe). That figure is expected to rise to 13 million tonnes (6.5 Mtoe) in 2005 and to continue to grow as combustible waste that is not suitable for material recovery is diverted from landfill in accordance with the Council Directive on the landfill of waste.

This report aims to present sufficient information about the production, use and environmental considerations of solid recovered fuels to justify the establishment of a Technical Committee for solid recovered fuels by the CEN Technical Board, with the approval of the relevant services of the European Commission (EC).

The preparation of the report was supported financially by Contract NNE5-1999-00533 "*Waste to Recovered Fuel*" awarded through the ENERGIE Programme of the European Commission's Fifth Framework Programme for research.

Annex H of the report was prepared by the European Commission's Joint Research Centre at Ispra, which has participated in the CEN Task Force on behalf of DG Environment Unit A.2 and provides an additional survey of solid recovered fuels in CEN Member Countries, including data on fuel properties and composition, sampling techniques and analytical methods.

Introduction

CEN Task Force 118 "*Solid Recovered Fuels*" was created by BT Resolution C64/2000 in April 2000. Its aims are to initiate the drafting of a CEN Report to describe solid recovered fuels and their use, and also to develop a Work Programme for drafting relevant Standards. The Work Programme will provide the basis for a CEN Technical Committee to work on Standards for solid recovered fuels.

CEN/TF118 was established as a consequence of previous CEN activity in the field of solid biofuels. During the pre-normative work undertaken by CEN Working Group 108 "*Solid Biofuels*" in 1999/2000 it was decided that the scope of a future Technical Committee should not include fuels comprising waste materials that would be subject to the forthcoming Council Directive for the incineration of waste. In due course, that limitation was applied to the scope of CEN/TC335 "*Solid Biofuels*" which was established in April 2000, and CEN/TF118 took on the responsibility for investigations into solid recovered fuels. CEN/TF118 maintains a close working relationship with CEN/TC335, to avoid any duplication of effort.

This report is concerned with the current and potential market for solid recovered fuels made from non-hazardous, mono- and mixed-wastes, excluding those fuels which are included in the scope of CEN/TC335. The point at which Standards can be applied to solid recovered fuels in the transformation from waste to useful thermal and electrical energy is illustrated in Figure 1 below. It is intended that Standards should be used to promote trade in solid recovered fuels and to improve environmental protection.

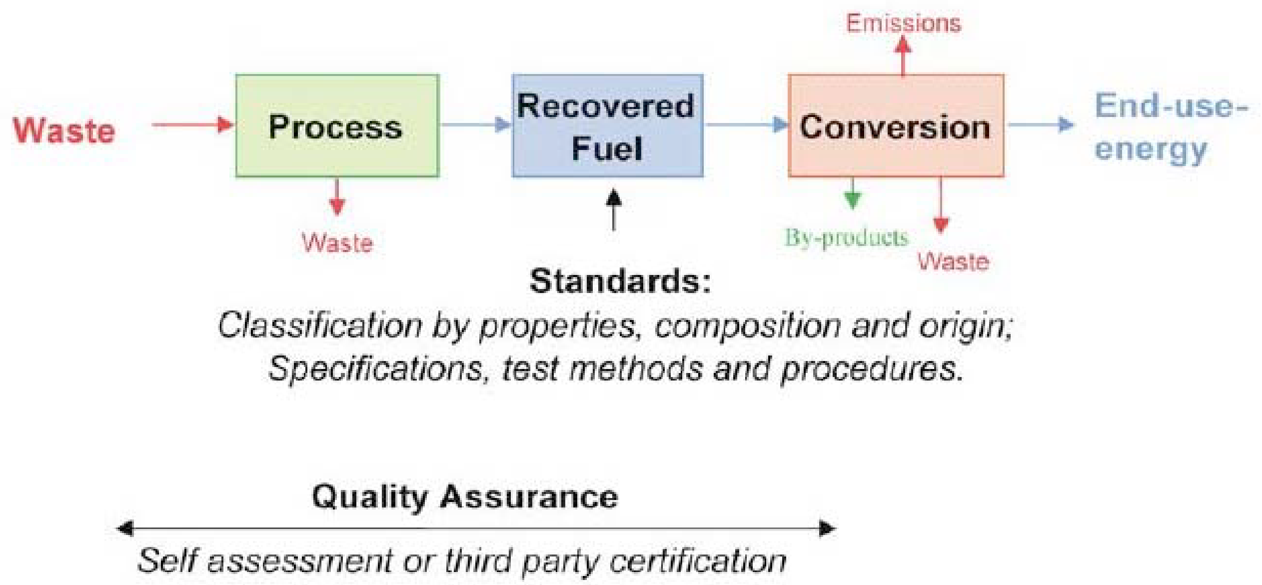

Figure 1 — The application of standards to solid recovered fuels

1 Scope

This technical report considers the production of solid recovered fuels from selected, non-hazardous, mono- and mixed-wastes.

2 Terminology

The terminology used in this report is explained in detail in Annex A. It takes account of terms and definitions derived from European legislation (such as Council Directives), the ongoing work of CEN Technical Committees (such as CEN/TC292 "*Characterisation of waste*") and published technical reports. In cases where definitions conflict, those set out in legislation must take precedence.

It is not the aim of this report to introduce standardised terminology and definitions; that will be the task of an expert Working Group within a CEN Technical Committee. The terminology and definitions presented are simply a means to assist the discussion of the topic of solid recovered fuels and to reduce ambiguity by providing a common point of reference for all participants in the debate.

At present, there is no clear definition of Solid Recovered Fuel that can claim general acceptance. However, as a first step, the following definition (based on the term defined in the report "*Fuel and Energy Recovery*" produced under Contract DIS-1375-97-FI of the European Commission's THERMIE Programme) is offered:

Solid Recovered Fuel is a solid fuel of uniform quality which meets public user-oriented specifications. It is prepared from selected pre- and post-use, non-hazardous combustible waste in a dedicated process applying a quality assurance system.

NOTE Note: Combustible wastes fall within the scope of European Directive 2000/76/EC on the incineration of waste (WID). Plants incinerating only the following wastes are excluded from the scope of the WID. These wastes are included in the scope of work of CEN/TC335 Solid Biofuels:

i) vegetable waste from agriculture and forestry,

ii) vegetable waste from the food processing industry, if the heat generated is recovered,

iii) fibrous vegetable waste from virgin pulp production and from production of paper from pulp, if it is co-incinerated at the place of production and the heat generated is recovered,

iv) wood waste with the exception of wood waste which may contain halogenated organic compounds or heavy metals as a result of treatment with wood-preservatives or coating, and includes in particular such wood waste originating from construction and demolition waste,

v) cork waste.

It will be a clear priority for a future CEN Technical Committee to establish an acceptable definition as a sound basis for the rest of its work.

3 Abbreviations

Abbreviations used in this report are listed below:

CFB	Circulating-fluidised-bed (combustor)
IPPC	Integrated Pollution Prevention and Control
IRWM	Integrated Resource and Waste Management
kt	kilotonne (1,000 tonnes)
MSW	Municipal Solid Waste
Mt	Megatonne (1,000,000 tonnes)
Mtoe	Million tonnes of oil equivalent
PPWD	Packaging and Packaging Waste Directive
toe	tonne of oil equivalent
WD	Waste Directive
WID	Waste Incineration Directive

4 Summary of conclusions and recommendations

The following conclusions can be drawn from the information presented in the report:

1) Solid recovered fuels can be derived from household waste, commercial waste, industrial waste and other non-hazardous, combustible waste streams.

2) European Standards for solid recovered fuels are important for:

   — the facilitation of trans-boundary shipments (in accordance with the European Regulation 259/93 and the OECD Green List or Appendix B of the Basel Treaty)

   — access to permits for the use of recovered fuels

   — cost savings for co-incineration plants as a result of reduced measurements (e.g. for heavy metals)

   — the rationalisation of design criteria for combustion units, and the cost savings for equipment manufacturers that go with it

   — guaranteeing the quality of fuel for energy producers.

3) The estimated quantity of solid recovered fuel produced in 2000 was 1,000 kt/a, corresponding to 500 ktoe/a. That figure is expected to rise to 10,000 kt/a in 2005, corresponding to 5,000 ktoe/a. The main market drivers are economic, resulting from the implementation of instruments within the framework of European policy on environmental protection.

4) Solid recovered fuels are already used to substitute fossil fuels in cement kilns, power stations and industrial boilers. Their use in co-incineration and incineration plants is expected to increase.

5) The cost-benefit analysis presented in Annex E shows that, for the three model regions considered, energy recovery scenarios lead to a significant reduction of greenhouse gas emissions (carbon dioxide and methane) compared to the baseline scenario of landfilling. The reduction is proportionate to the diversion of combustible waste from landfill and the yield of recovered fuel (that substitutes fossil fuel).

6) Fuel recovery is suited to sparsely populated regions where relatively small, de-centralised fuel-production plants can deliver recovered fuel to existing power stations or plants for the production of material products. However, this is subject to the granting of appropriate permits in accordance with the applicable legislation.

7) For larger cities or regions, the production of recovered fuel on the one hand and direct incineration with energy recovery on the other hand may be an appropriate solution.

8) A survey of solid recovered fuel producers in 2001 has concluded that:

   — there is a large variation in the standards applied for the sampling, digestion and analysis of solid recovered fuels and harmonisation is required urgently

   — the wide ranges in the analytical results reported justify the need for a fuel standard with limit values

   — more detailed information is required about the waste input to the production process

   — there is sufficient information available to justify the drafting of a Standardisation Mandate to be issued to CEN by the European Commission for developing European standards for solid recovered fuels (RDF, etc.)

It is strongly recommended that a CEN Technical Committee should be established as soon as possible, with a view to producing relevant European Standards by the end of 2003.

5 Status of the waste market

It must be said that it is very difficult to obtain accurate, up-to date information about waste generation and recovery/disposal routes in the European Union. One of the greatest obstacles is the lack of consistency among the Member States in the definition of waste categories such as Domestic Waste and Municipal Solid Waste. The data for Member States in the two tables below are based on the report from the Commission to the Council and the European Parliament on the implementation of Community waste legislation for the period 1995 to 1997 (COM (1999) 752 final of 10th January 2000), unless stated differently in the notes following the table.

Table 1 — Solid waste generation in Europe

State	Domestic Waste/MSW (kt/a)	Other Waste (kt/a)	Other Waste that is incinerated (kt/a)
Austria	2 775	42 950	1 940
Belgium	(1997) 4 633	42 253	2 261
Denmark	(1996) 2 767	(1996) 9 876	867
Finland	(1997) 980	(1997) 65 787	4 779
France	(1998) 27 000	(1998) 600 000	3 600
Germany	(1997) 39 068	N/r	N/r
Greece	(1992) 3 197	N/r	N/r
Ireland	(1995) 1 503	(1995) 4 888	36
Italy	(1995) 25 400	N/r	N/r
Luxembourg	(1997) 208	(1997) 2 520	0
Netherlands	(1997) 7 945	(1997) 44 740	2 925
Norway	2 794	4 698	N/r
Portugal	(1994) 3 480	N/r	N/r
Spain	(1994) 14 296	N/r	N/r
Sweden	(1994/95) 3 200	N/r	N/r
Switzerland	(1999) 2 600		
UK	(1995/96) 26 500	(1994/95) 221 915	N/r
Total	168 346		

NOTE kt/a = 1,000 tonnes per year

(1995) = source-year for data

N/r = not reported

Domestic Waste = Household Waste

Data for France come from ADEME (French Agency for Environment and Energy Management). The figure for Other Waste that is incinerated does not include the biomass waste that is incinerated.

Data for Norway come from the Norwegian Council for Building Standardisation

Data for Switzerland come from the Swiss Agency for the Environment, Forests and Landscape

The figures in this table are only indicative as they do not correspond to the same harmonized definition throughout the European Union.

The term "*Other Waste*" in Table 1 (as it is applied to the figures for EU Member States with the exception of France) covers a multitude of waste materials such as sludge, industrial waste, waste from energy and water supply, mining waste, agricultural waste and construction waste. A proportion of Other Waste is combustible, as can be seen from the last column of Table 1. The total quantity of combustible waste other than Domestic/MSW could be estimated at 30 to 50% of the Domestic/MSW total i.e. 50 to 80 Mt/a.

Table 2 —Domestic Waste/MSW management options applied in Europe

State	Recycling (kt/a)	Incineration (kt/a)		Landfill (kt/a)	Other (kt/a)
		With energy recovery	Without energy recovery		
Austria	1 263	431	0	1 261	0
Belgium (1997)	1 828	1 089	235	1 481	0
Denmark (1996)	777	1 545	N/r	428	16
Finland (1997)	170	32	0	560	218
France (1998)	2 204	7 900	1 800	13 700	1 400
Germany (1997)	11 562	8 992	0	17 904	N/r
Greece (1992)	226	1		2 970	N/r
Ireland (1995)	118	N/r	N/r	1 383	N/r
Italy	N/r	1400		24 000	N/r
Luxembourg (1997)	15	116	N/r	77	N/r
Netherlands (1997)	3 520	3 220	130	1 205	N/r
Norway	480	391	84	1 676	168
Portugal (1994)	N/r	N/r	N/r	3 060	420
Spain (1994)	N/r	625		11 901	1 770
Sweden (1994)	500	1 300	N/r	1 200	200
Switzerland (1999)	2 000	486	0	114	
UK (1995/96)	1 868	1 217	1 099	22 080	236
Total	26 531			105 000	

NOTE kt/a = 1,000 tonnes per year

(1995) = source-year for data

N/r = not reported

Domestic waste = Household Waste

Data for France come from ADEME (French Agency for Environment and Energy Management).

Data for Norway come from the Norwegian Council for Building Standardisation

Data for Switzerland come from the Swiss Agency for the Environment, Forests and Landscape

In the Netherlands, the GEVUDO plant still has two incinerators without energy recovery

The figures in this table are only indicative as they do not correspond to the same harmonised definition throughout the European Union.

The total installed capacity for waste incineration in the EU Member States in 2000 has been estimated at 45 Mt/a (according to a European Incineration Profile compiled by the Juniper Consultancy in October 2000).

6 Status of the market for solid recovered fuels

6.1 Market drivers and barriers

6.1.1 Community energy policy

The EU's main energy policy targets include:

— Meeting Kyoto objectives (through 8% reduction in CO_2 emissions between 2008 and 2012 compared to 1990)

— Doubling the share of renewable energy sources (from 6% to 12% of gross inland energy consumption)

— Improving energy efficiency (increase it by 18% until 2010 compared to 1995)

— Maintaining security of supply.

The tools for the EU's strategy for renewable energy are:

— White Paper on Energy (1995)

— White Paper on Renewable Energy Sources (RES) (1997), including the Action Plan and Campaign for Take-Off

— Draft Directive on RES (2000)

The use of biomass and waste accounted for 44.8 Mtoe in 1995. Its projected contribution in 2010 is135 Mtoe, of which about a third will come from waste.

6.1.2 Community environmental policy

The European Commission has proposed a new action programme for the environment (the 6th EU Environment Action Programme). The Programme focuses on areas where more action is needed. It sets out objectives for the next ten years and beyond. It suggests that the key to our long-term welfare is *sustainable development*; finding ways of improving our quality of life without causing harm to the environment.

One of the main areas where new effort and impetus is needed is ”Preserve natural resources and manage waste”. The Commission proposes to the European Parliament and the Council to agree the following aims:

The Programme aims at stabilising the atmospheric concentration of greenhouse gases at a level that will not cause unnatural variations of the earth's climate. (3)

The Programme aims at protecting and restoring the functioning of natural systems and halting the loss of bio-diversity. (4)

The Programme aims at an environment where levels of man-made contaminants do not give rise to significant impacts on, or unacceptable risks to, human health. (5)

The Programme aims at better resource efficiency and resource and waste management (6)

The Programme shall stimulate the development of a global partnership for environment and contribute to a sustainable development (9)

The Programme shall ensure that the Community's environmental policy-making is undertaken in an integrated way (10)

6.1.3 Community legislation

The Waste Directive, WD (75/442/EEC and its amendments)

- gives a wide definition of waste. The definition does not distinguish between well-controlled industrial residues (pre-use waste, by-products) and mixed Municipal Solid Waste, MSW
- does not give a practical definition of recovery process but refers to a list of operations as they occur in practice
- does not take a position on when and how a waste that has entered a recovery operation becomes a non-waste product that freely can enter the eco-cycle (= market).

The Waste Strategy (Council Resolution of 24th February 1997)

The first waste strategy dates from 18th September 1989. The Commission produced a revision after some years. On 1st August 1996 the revision was presented to the Council, who accepted it on 24th February 1997 (397Y0311(01)).

In the draft resolution (paragraph 20) the Commission confirms the principal hierarchy (established in the document from 1989), which gives preference first to waste prevention, then to waste recovery (which includes reuse, recycling and energy recovery, with preference being given to material recovery), and lastly to waste disposal (which includes incineration without energy recovery and landfilling). The hierarchy must be applied in a flexible way. The realisation of the hierarchy must be guided by the best solution for the environment with regard to economic and social costs.

In the resolution the Council

(21) INSISTS on the need for promoting waste recovery with a view to reducing the quantity of waste for disposal and saving natural resources, in particular by reuse, recycling, composting and recovering energy from waste,

(22) RECOGNIZES, as regards recovery operations, that the choice of option in any particular case must have regard to environmental and economic effects, but considers that at present, and until scientific and technological progress is made and life-cycle analyses are further developed, reuse and material recovery should be considered preferable where and insofar as they are the best environmental options, and

(27) IDENTIFIES the importance of Community criteria concerning the use of waste, in particular as a fuel or other source of energy.

The Directive on Packaging and Packaging Waste, PPWD (94/62/EC)

- defines energy recovery as "direct incineration of waste …. With recovery of the heat"
- sets limits on the contents of four heavy metals in packaging allowed on the internal market.

The Landfill Directive (1999/31/EC)

- sets binding targets for the diversion of biodegradable waste from landfill.

NOTE 1 Some Member States do not, or will not, allow combustible waste in landfill; others do the same for untreated waste.

NOTE 2 Combustible waste is often of biogenic origin but will not pass the test on biodegradability as developed by CEN under Mandate M 200 rev.3 for the PPWD.

NOTE 3 Some Member States have introduced a Landfill Tax to encourage diversion of wastes from landfill.

The Waste Incineration Directive, WID (2000/76/EC)

— sets emission limit values for incineration and co-incineration of all wastes

— excludes plants that incinerate only certain types of waste from its scope

— requires continuous measurements of several emission components, and dioxin and heavy metal measurements twice a year.

NOTE 1 Plants treating only the following wastes are excluded from the scope of the WID:

i) vegetable waste from agriculture and forestry,

ii) vegetable waste from the food processing industry, if the heat generated is recovered,

iii) fibrous vegetable waste from virgin pulp production and from production of paper from pulp, if it is co-incinerated at the place of production and the heat generated is recovered,

iv) wood waste with the exception of wood waste which may contain halogenated organic compounds or heavy metals as a result of treatment with wood-preservatives or coating, and includes in particular such wood waste originating from construction and demolition waste,

v) cork waste,

vi) radioactive waste,

vii) animal carcasses as regulated by Directive 90/667/EEC without prejudice to its future amendments,

viii) waste resulting from the exploration for, and the exploitation of, oil and gas resources from off-shore installations and incinerated on board the installation.

NOTE 2 The emission measurement costs can be substantial enough, in some cases, to make an economic barrier for some combustion plants.

NOTE 3 The introduction of the Directive states that “(21) Criteria for certain combustible fraction of non-hazardous waste not suitable for recycling, should be developed in order to allow the authorisation of the reduction of the frequency of periodical measurements”. Periodic measurements of HCl, HF and SO_2 instead of continuous measuring may be authorised if the operator can prove that the emissions of those pollutants can under no circumstances be higher than the prescribed emission limit values. The reduction of the frequency of the periodic measurements for heavy metals, dioxins and furans may be authorised provided that the emissions are below 50% of the relevant emission limit values and provided that criteria for the requirements to be met (to be developed in a Technical Adaptation Committee) are available. Until 1 January 2005, the reduction of the frequency may be authorised even if no such criteria are available provided that:

— the waste consists only of certain sorted combustible fractions of non-hazardous waste not suitable for recycling and presenting certain characteristics

— national quality criteria, which have been reported to the Commission, are available for these wastes

— co-incineration and incineration of these wastes is in line with the relevant waste management plans

— the operator can prove that the emissions are under all circumstances significantly below the relevant emission limit values

— the quality criteria and the new period for the periodic measurements are specified in the permit

- all decisions on the frequency of measurements and information on the amount and quality of the waste concerned shall be communicated to the Commission.

The Draft Directive on Large Combustion Plants **(88/609 Directive on the limitation of emissions of certain pollutants into the air from large combustion plants, Common Position 52/2000 of 28th December 2000, and text approved by the Conciliation Committee on 2nd August 2001)**

- Defines fuel as any solid, liquid or gaseous combustible material used to fire the combustion plant with the exception of waste covered by Council Directive 89/369/EEC of 8 June 1989 on the prevention of air pollution from new municipal waste incineration plants, Council Directive 89/429/EEC of 21 June 1989 on the reduction of air pollution from existing municipal waste incineration plants and Council Directive 94/67/EC of 16 December 1994 concerning the incineration of hazardous waste, or any subsequent Community act repealing and replacing one or more of these Directives.

The Directive on Integrated Pollution Prevention and Control (IPPC) (96/61)

- IPPC sets the requirement for installations to use best available technologies (BAT). "*Integrated*" means that the permits must take into account the whole environmental performance of the plant i.e. emissions to air, water and land, generation of waste, use of raw materials, energy efficiency, noise, prevention of accidents, risk management, etc.

The Directive on the promotion of electricity produced from renewable energy sources in the internal electricity market (RES-E) (2001/77/EC)

- The Directive and its position will affect the market for solid recovered fuels. It states that "Where they use waste as an energy source, Member States must comply with current Community legislation on waste management. The application of this Directive is without prejudice to the definitions set out in Annex 2a and 2b to Council Directive 75/442/EEC of 15 July 1975 on waste. Support for renewable energy sources should be consistent with other Community objectives, in particular respect for the waste treatment hierarchy. Therefore, the incineration of non-separated municipal waste should not be promoted under a future support system for renewable energy sources, if such promotion were to undermine the hierarchy."

NOTE 1 Some Member States classify the biodegradable share or the whole amount of energy from MSW as renewable energy. A brief review of the legal definitions of waste as a source of energy is presented in 6.1.4.

NOTE 2 The Rapporteur to the European Parliament has proposed to ask the Commission to draft a separate Directive on the promotion of energy from waste.

Working Document on the biological treatment of biowaste (2nd draft, 12 February 2001)

The Working Document and its position will affect the market for solid recovered fuels.

6.1.4 The Kyoto Protocol

The Kyoto Protocol sets binding targets for different countries for six different greenhouse gas emissions. Member States have different practices for calculating the reductions of greenhouse gas emissions from energy generation through the incineration of waste and combustion of waste-derived fuels. A summary of those practices is given below.

The Austrian strategy for climate protection acknowledges the high potential of an optimisation of the waste management sector for the reduction of greenhouse gases by the application of thermal treatment instead of landfilling (according to a climate strategy paper by the Federal Ministry of the Environment, 2000).

In Belgium, the AMPERE Commission has estimated that 65% of MSW is biogenic.

NOTE Commissie AMPERE, October 2000. Rapport van de Commissie voor de Analyse van de Productiemiddelen van Elektriciteit en de Reorientatie van de Energievectoren.

In the Danish air emission inventory, the emission of CO_2 from plastic in municipal waste is included in the total CO_2 emission. The Danish Environmental agency has estimated the content of plastic in municipality waste to be 6.4 w/w%.

In Finland, the IPPC methodology is applied in calculating the emissions of MSW (CO_2/MJ). At present (2000) the reporting is based on analysis made of MSW at the incinerator in Turku. In a detailed analysis, 80% of the MSW energy content was considered to be of biomass origin, which percentage is used as CO_2 neutral in official reporting for the Kyoto Protocol. The percentage used in reporting can be changed when the MSW composition changes.

The French position is to count biogas and the biodegradable fraction of municipal waste as sources of renewable energy.

In the German renewable energy law (EEG), MSW is not counted as a renewable energy source.

In Italy, waste and waste fuels (both municipal and industrial waste) are considered as a renewable energy source. Their use is strictly regulated by the law, and the energy produced from these wastes can be admitted under the law to incentives such as "*green certificates*"**.**

In the Netherlands it has been estimated that the amount of biogenic waste contributes 71% to the total mass of municipal solid waste; however, it is responsible for 62% of the energy production from the incineration of MSW (see Notes 1 and 2). 60% of bulky household waste is regarded as being biogenic, as is 65% of household waste and 58% of commercial waste. The Dutch government recognises 50% of MSW to be biogenic and thus contributing to the production of renewable energy; this assumption appears somewhat conservative when compared to the information above. The assumptions made by the Dutch government are staed in the "*Protocol Monitoring Duurzame Energie*" (see Note 3).

NOTE 1 GAVE, December 1999. Beschikbaarheid van afval en biomassa voor energieopwekking in Nederland. Project number 356198/3020.

NOTE 2 In the Netherlands, MSW is understood to include household waste and similar commercial and industrial waste.

NOTE 3 Novem, September 1999. Protocol Monitoring Duurzame Energie.

Swedish reporting for the incineration of MSW is based on emission factors (CO_2/MJ). These factors are based on an estimate of fossil fuel content in MSW and will be revised according to new estimates. The percentage of biogenic origin can be roughly calculated by comparing emission factors for MSW with factors for wood and residual fuel oil. The result of such a calculation is that the biogenic share is 60 to 70%

In the United Kingdom, electricity from renewable sources is defined in the Utilities Act 2000, Part 4, Section 62. "*Renewable sources*" means "*sources of energy other than fossil fuel or nuclear fuel, but includes waste of which not more than a specified proportion is waste which is, or is derived from, fossil fuel*". The primary legislation does not proceed to specify the acceptable proportion of waste which is, or is derived from, fossil fuel. That will be set out later in secondary legislation (an Order rather than an Act) in which an obligation (the Renewables Obligation) will be placed on all suppliers of electricity to purchase a percentage of their electricity from renewable energy sources. The Order for the Renewables Obligation is expected to be laid before Parliament in February 2002.

6.1.5 Economic and environmental considerations

Some economic and environmental considerations related to solid recovered fuels are set out below:

- the most important greenhouse gases are methane and carbon dioxide
- methane leaks from the excavation of fossil energy sources and from disposal of biogenic waste in landfill

- carbon dioxide is the combustion product of the carbon content in organic materials. The higher the hydrogen to carbon ratio of a hydrocarbon is, the lower is the emission of carbon dioxide per released energy unit (see Annex B)

- a high energy conversion efficiency is the best means to reduce emissions for a given energy production and to improve sustainability

- overall effects should be considered in a concept of Integrated Resource and Waste Management (IRWM)

- dedicated MSW incineration requires an investment cost of Euro 500-700 per tonne of annual capacity and is consequently a centralised option for larger cities and densely populated regions. Plants are designed for a defined amount and composition of waste. Significant changes in the amount and the calorific value of the waste could affect the operation of the plant. The investment has to be depreciated over the full lifetime of the equipment. Changes in the amount or calorific value of available waste will significantly influence the economy of the investment

- the separation of non-hazardous combustible waste for processing to produce recovered fuel can operate on a smaller scale and can therefore be a decentralised option. The recovered fuel can be stored and transported for the substitution of primary fuel (usually fossil).

- dedicated MSW incineration plants give a very high protection level for the environment. Negative effects on the environment, in particular pollution by emission into air, soil, surface water and groundwater, and the resulting risk to human health, will have been prevented or limited as far as practicable when the new Directive is transformed into national law

NOTE A Cost-Benefit Analysis (CBA) on Waste to Recovered Fuel has been completed under contract NNE5-1999-00533 of the 5th Framework Programme of the European Commission. The main results are given in Annex E.

6.2 Solid recovered fuel producers

A list of companies (sorted geographically) currently engaged in the production of solid recovered fuels within CEN Member countries is given Annex C.1. Annex C.2 gives some additional information about the production of solid recovered fuels in some Member States, and Annex C.3 includes some examples of analytical data.

In some Member States, producers have joined together to form associations of various types to promote the use of solid recovered fuels (both at national and European level) and to encourage good practice within the industry. A list of those associations is given in Annex D.

In 2001, a group of companies producing solid recovered fuels in Europe formed the European Recovered Fuel Organisation (ERFO). ERFO has about 14 members and aims to promote the use of solid recovered fuels as a means to solve problems in waste management. ERFO maintains that solid recovered fuels can replace imported fuels, reduce carbon dioxide emissions and improve the efficiency of thermal conversion plants, all within the context of sustainable development. It presented its objectives at a workshop entitled "*Waste to Recovered Fuels*" held in Brussels on 26th September 2000, and held a follow-up workshop under the same title in Brussels on 29th May 2001. Contact details for ERFO are given in Annex D.

6.3 Solid recovered fuel users

Potential users of solid recovered fuels are:

- heating and power plants

- cement kilns

- lime kilns

- iron and steel production

— non-ferrous metal production

— brick production.

For the user of solid recovered fuel, it is most important that the fuel properties are guaranteed and that the quality can be controlled. The decision on purchasing recovered fuel is based on the same properties of fuel as in the case of any other fuel and is made based on technological and economic arguments.

6.4 Methods of processing

The processing chain consists of one or more of the following steps:

— separation at source,

— sorting or mechanical separation,

— size reduction (shredding, chipping and milling by different means),

— separation and screening (including magnetic and non-magnetic separation),

— blending (according to specified formulas),

— drying and pelletising,

— packaging, and

— storage.

6.5 Current market size and potential for growth

The current best estimate of the quantity of solid recovered fuels produced and consumed in Europe is about 1.4 Mt/a, as set out in Table 3 below.

Table 3 — Summary of European Solid Recovered Fuels market in 2000

State	Production		Consumption		Export / Import +		Note % CK
	kt/a	toe/a	kt/a	toe/a	kt/a	toe/a	
Austria	100	50000	100	50000			7
Belgium	<100	<50000	<100	<50000	0	0	
Denmark	0	0	0	0	0	0	
Finland	170	58000	170	58000	0	0	0
France	0	0	0	0	0	0	
Germany	500	250000	500	250000	0	0	50
Greece	0	0	0	0	0	0	
Iceland	0	0	0	0	0	0	
Ireland	0	0	0	0	0	0	
Italy	<200	<100000	<200	<100000	0	0	
Luxembourg	0	0	0	0	0	0	
Netherlands	250	100000	15	6000	-145	60000	20
Norway	1)		1)				
Portugal	0	0	0	0	0	0	
Spain	0	0	0	0	0	0	
Sweden	1)		1)		+500 2)		
Switzerland							
United Kingdom	60	30000	60	30000	0	0	0
Total	1380						

NOTE kt/a = 1000 tonnes per year;

toe/a = tonnes oil equivalent per year (It is assumed that solid recovered fuel has a calorific value of 21 MJ/kg, although it is lower in Finland and the Netherlands, and oil has a calorific value of 42 MJ/kg)

% CK = % of consumption that occurs in cement kilns

The figures in this table are only indicative as they do not correspond to the same harmonised definition throughout the European Union

1) There is no overall statistic for Sweden or Norway because this fuel is used in ordinary heat/power plants and in waste incinerators.

2) No exact figures exist, but approximate figures give 500 kt of waste which was imported in 1999. 90% consisted of wood, paper, plastic and rubber.

According to Table 2, the total Household Waste/MSW sent to landfill is about 100 Mt/a. Assuming a potential recovered fuel production rate of 15 to 20% for Household Waste/MSW yields totals for that source of between 15 and 20 Mt/a. Assuming a recovered fuel production rate of 60% for other combustible waste (which is estimated to be 30 to 50% of the Household Waste/MSW) yields totals for that source of between 18 and 30 Mt/a. Combining the lowest and highest yields for the two sources indicates a total potential production of solid recovered fuel of between 33 and 50 Mt/a. That range is lower than the 80 Mt/a estimated in "*Fuel and Energy Recovery*" (Krajenbrink et al., 1999) but that study assumed a recovered fuel production rate of 40% for Household Waste/MSW and also assumed that the mass of industrial waste to be used for fuel recovery is of the same order as the fuel recovered from MSW.

Industry's best estimate of solid recovered fuel production in 2005 is about 13 Mt/a (see Table 4).

Table 4 — Forecast/potential for European Solid Recovered Fuels market in 2005

Member	Production		Consumption		- Export/Import +		∆ 2000
State	kt/a	toe/a	kt/a	toe/a	kt/a	toe/a	%
Austria	500	250000	500	250000	0	0	400
Belgium	300	150000	300	150000	0	0	200
Denmark	0		0		0	0	
Finland	350	120000	350	120000	0	0	100
France	1000	500000	0	0	-1000	-500000	
Germany	4000	2000000	5000	2500000	+1000	+500000	700
Greece	500	250000	500	250000	0	0	
Iceland	0		0		0	0	
Ireland	500	250000	500	250000	0	0	
Italy	2000	1000000	2000	1000000	0	0	900
Luxembourg	50	25000	50	25000	0	0	
Netherlands	1500	600000	1000	400000	-500	-200000	500
Norway	150	75000	150	75000	0	0	
Portugal	500	250000	500	250000	0	0	
Spain	1000	500000	1000	500000	0	0	
Sweden	500	250000	1000	4500000	+500	+200000	
Switzerland	0	0	0	0	0	0	
United Kingdom	200	100000	200	100000	0	0	200
Total	13050						

NOTE kt/a = 1000 tonnes per year;

toe/a = tonnes oil equivalent per year (It is assumed that solid recovered fuel has a calorific value of 21 MJ/kg, although it is lower in Finland and the Netherlands, and oil has a calorific value of 42 MJ/kg)

∆ 2000 = Difference from year 2000

It is assumed that no Solid Recovered Fuel is exported outside the European Union

The figures in this table are only indicative as they do not correspond to the same harmonised definition throughout the European Union

It is interesting to note that the consumption of hard coal and lignite for power production in the EU was 145 Mtoe/a in 1999 (European Commission 1999 Annual Energy Review). The total production of solid recovered fuel forecast in Table 4 for 2005 (6 to 7 Mtoe/a) represents a substitution rate of 4 to 5%.

6.6 Integrated resource and waste management and Cost-Benefit Analysis

Sustainable development and growth can be achieved within a concept of Integrated Resource and Waste Management (IRWM) implemented in a spirit of shared responsibility. The efficiency of primary production processes and the resulting products shall be continuously improved. Waste shall be used as a resource as far as economically sensible and environmentally wise. This is also underlined as priorities in the European Waste Strategy – prevention, recovery and safe final disposal.

Organic natural resources are used for energy and material products alike. Despite improvements of efficiency in all sectors, the dependency on fossil fuels, especially on coal, is expected to prevail in most European countries. Waste management is developing in the direction of segregation and separate treatment of waste fractions, e.g. bio-waste and combustible waste.

Inorganic waste materials like glass and metals can be recovered as material by re-melting processes. Organic materials made from both renewable (e.g. wood, paper and board), and other resources (e.g. plastics and rubber) may be recovered as material or energy. The latter replaces primary fossil fuels in production processes.

A study presented in Annex E evaluates the overall effects of different recovery options for non-hazardous combustible waste on national welfare. The study compares (a) direct incineration with energy recovery and (b) fuel recovery for substituting fossil fuel in a co-combustion process to (c) direct landfill, as illustrated in Figure 2. Costs such as those for combustion residue disposal and air pollution control are included in the CBA. A summary of the CBA is presented in Annex E. It is also acknowledged that the Commission has contracted a separate study on re-use and material recovery of packaging waste in the EU.

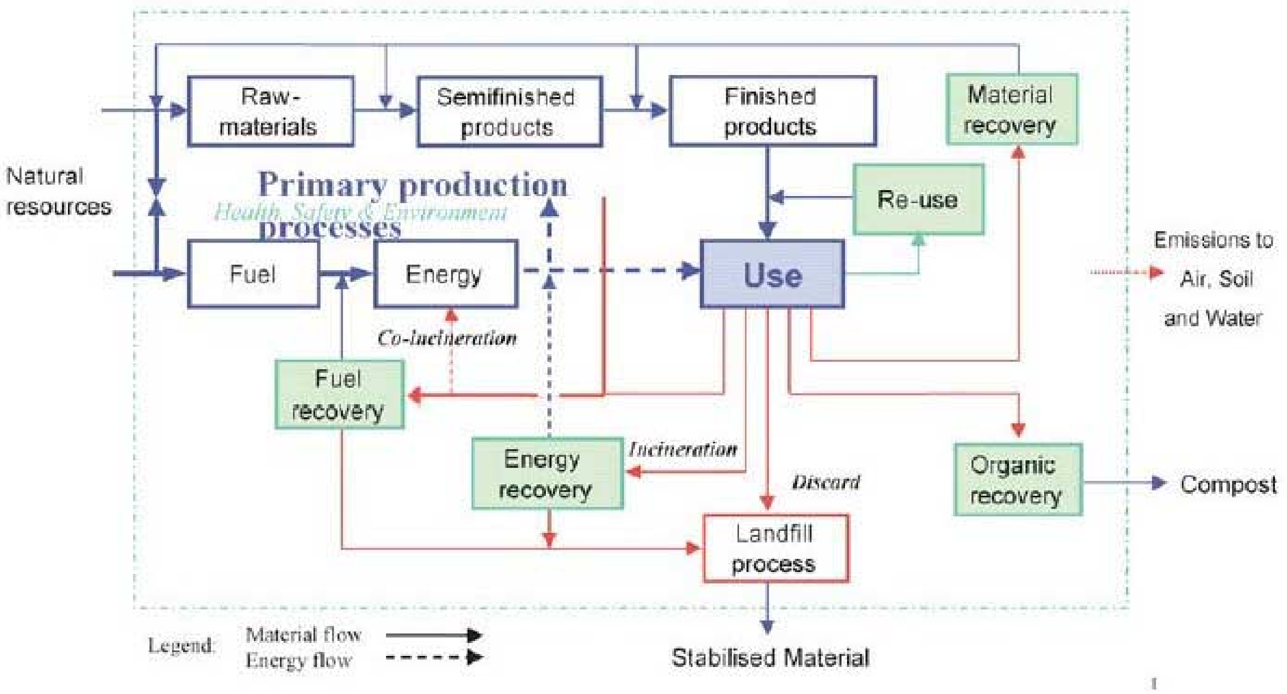

Figure 2 — System boundaries for Integrated Resource and Waste Management

7 Review of current standards and related CEN activities

The overall objective of CEN/TF118 is to prepare the ground for the future development of European Standards (ENs) for solid recovered fuels (subject to the approval of the relevant services in the European Commission). An essential part of that preparation is to review the current status of national and international Standards. The following sections describe the availability of relevant Standards on a geographical basis. A full list of references is given in Annex F.

7.1 Austria

A relevant Austrian Standard is in preparation within WG 157.13.

7.2 Finland

A new Finnish Standard, SFS 5875 "*Solid Recovered Fuel. Quality control system*", was released in March 2000. It defines the procedures and requirements by which the quality of solid recovered fuel, produced for the purpose of energy production from source-separated waste, can be controlled and reported unambiguously. The Standard covers the whole chain of supply from the source-separation of wastes to the delivery of solid recovered fuel. For analytical methods, it relies totally on ISO Standards for solid mineral fuels (which are listed in Annex F).

7.3 France

There is no existing national Standard in France. Some specifications exist, but they are used locally for specific co-incineration purposes, such as the manufacture of cement. There are some Standards (NF) for test methods for solid mineral fuels that may be applicable to solid recovered fuels and they are listed in Annex F.

7.4 Germany

The Bundesgütegemeinschaft Sekundärbrennstoffe (BGS, the German association for Quality Assurance of Solid Recovered Fuels) produced "*Quality and test instructions for solid recovered fuels*" in 2000 (translated into English in 2001). BGS is an association of quality assurance, which is accredited by the RAL Institute. The scope of the quality scheme is described in more detail in clause 8.2.

7.5 Italy

The Italian Standard for RDF, UNI 9903 "*Non mineral refuse derived fuels (RDF)*", was first published in 1992. It specifies the classification, requirements and methods of analysis applied to RDF for civil and industrial uses, and briefly covers storage, transportation and documentation. The Standard is divided into 14 parts (which are listed in Annex F).

7.6 Sweden

Sweden has a suite of Standards (SS) for biofuels and peat (see Annex F) some of which may be applied to solid recovered fuels

7.7 ISO

The following ISO Standards for analytical methods for solid mineral fuels are referred to in the Finnish Standard SFS 5875: ISO 333, 351, 352, 540, 562, 567, 589, 601, 609, 625, 1013, 1171, 1928, 1994, ISO/DIS 8983, 15237, 15238.

ISO 1928 gives a test method for the determination of gross calorific value but the method is most relevant for homogeneous materials (e.g. well-identified sources of waste with one, or very few, components. The sample for the ISO standard needs to be homogeneous and the quantity of material used is no more than a few mg. The sample has to be representative of the material to be tested. The representative samples have to be ground finely and that can be a problem when the wastes are heterogeneous. Moreover, some materials cannot be evaluated with this test method (e.g. packaging with aluminium).

7.8 Related CEN activities

A CEN Technical Committee "*Solid Biofuels*" (CEN/TC335), was established in April 2000 and began to draft European Pre-Standards (ENVs) for solid biofuels in September 2000, in accordance with a mandate to be issued by the EC. A substantial amount of common ground between CEN/TF118 and CEN/TC335 has been identified, so close co-operation and communication between the two is required, to avoid duplication of work. For example, many of the Standards identified by CEN/TC335 for physical/mechanical and chemical tests are considered equally applicable to solid recovered fuels and do not need to be drafted in duplicate by a CEN/TC for solid recovered fuels. The secretariat is provided by SIS (Mr Sjoberg, lars.sjoberg@sis.se).

CEN/TC292 "*Characterisation of Waste*" is also drafting documents that are of interest to CEN/TF118, and the same principles of co-operation and communication apply in that area. Some of the Standards for sampling and analysis that are under development by CEN/TC292 may be applicable to solid recovered fuels. The secretariat is provided by NEN (Mrs Kramps-Luitwieler, Inge.Kramps@nen.nl).

CEN/TC308 "*Characterisation of sludges*" has a Work Programme which covers terminology; sampling; physical, chemical and biological testing; guidelines for good practice in the production, utilisation and disposal of sludges; recommendations to improve and to extend sludge utilisation and disposal routes. The secretariat is provided by AFNOR (Mrs Feuille, anne-marie.feuille@email.afnor.fr).

8 Proposed approach to standardisation

8.1 Preliminary ideas on classification

An ad hoc group of participants in EC Contract NNE5-1999-00533 "*Waste to Recovered Fuel*" was convened in November 2000 to put together some preliminary ideas on the classification of solid recovered fuels. The result was a Working Document (CEN/TF118 Document N19), which was considered by CEN/TF118 at its second meeting on 30th January 2001. CEN/TF118 accepted the document as a start for future discussions, but recognised that a Standard for classification will have to be developed in due course in a CEN/BT Technical Committee. Some preliminary ideas on classification and identification systems are presented in Annex G.

8.2 Systems for quality assurance

Finnish Standard SFS 5875 does not contain a separate section on quality assurance, but in SFS 5875 clause 4.3 on "*Production and delivery of solid recovered fuel*" does set out some responsibilities for producers and suppliers. These include keeping records of the origin and material composition of the energy fraction, delivery modes, production quantities, reject quantities, deliveries, problems encountered during production and remedial measures taken and necessary licences. Quality control and sampling are left to be agreed between the supplier, producer and user, within the instructions set out in normative annexes for sampling and analysis.

The German Bundesgütegemeinschaft Sekundärbrennstoffe's (BGS) quality and test instructions for solid recovered fuels aim to assure the quality of solid recovered fuels and establish a quality label (through the RAL Institute). They specify in some detail the allowable heavy metal contents for the fuels and the sampling and testing methods to be used. The types of wastes (all non-hazardous) that can be used for solid recovered fuel production are also listed, using the notation of the European Waste Catalogue.

9 Conclusions and recommendations

The following conclusions can be drawn from the information presented in this report:

1) Solid recovered fuels can be derived from household waste, commercial waste, industrial waste and other non-hazardous, combustible waste streams.

2) European Standards for solid recovered fuels are important for:

   — the facilitation of trans-boundary shipments (in accordance with the European Regulation 259/93 and the OECD Green List or Appendix B of the Basel Treaty)

   — access to permits for the use of recovered fuels

   — cost savings for co-incineration plants as a result of reduced measurements (e.g. for heavy metals)

   — the rationalisation of design criteria for combustion units, and the cost savings for equipment manufacturers that go with it

   — guaranteeing the quality of fuel for energy producers.

3) The estimated quantity of solid recovered fuel produced in 2000 was 1,000 kt/a, corresponding to 500 ktoe/a. That figure is expected to rise to 10,000 kt/a in 2005, corresponding to 5,000 ktoe/a. The main market drivers are economic, resulting from the implementation of instruments within the framework of European policy on environmental protection.

4) Solid recovered fuels are already used to substitute fossil fuels in cement kilns, power stations and industrial boilers. Their use in co-incineration and incineration plants is expected to increase.

5) The cost-benefit analysis presented in Annex E shows that, for the three model regions considered, energy recovery scenarios lead to a significant reduction of greenhouse gas emissions (carbon dioxide and methane) compared to the baseline scenario of landfilling. The reduction is proportionate to the diversion of combustible waste from landfill and the yield of recovered fuel.

6) Fuel recovery is suited to sparsely populated regions where relatively small, de-centralised fuel-production plants can deliver recovered fuel to existing power stations or plants for the production of material products. However, this is subject to the granting of appropriate permits in accordance with the applicable legislation.

7) For larger cities or regions, the production of recovered fuel on the one hand and direct incineration with energy recovery on the other hand may be an appropriate solution.

It is strongly recommended that a CEN Technical Committee should be established as soon as possible, with a view to producing relevant European Standards by the end of 2003.

Annex A
(informative)

Terminology

A.1 Definitions from European Directives

Co-incineration Plant means any stationary or mobile plant whose main purpose is the generation of energy or production of material products and:

- which uses wastes as a regular or additional fuel; or

- in which waste is thermally treated for the purpose of disposal.

(Directive 2000/76/EC of the European Parliament and of the Council).

Collection shall mean the gathering, sorting and/or mixing of waste for the purpose of transport (Council Directive 75/442/EEC as amended by 91/156/EEC).

Disposal shall mean any of the operations provided for in Annex IIA of Directive 75/442/EEC as amended by 91/156/EEC and 96/350/EC.

NOTE Annex IIA lists:

— D1 Deposit into or onto land (e.g. landfill, etc.)

— D10 Incineration on land.

Energy recovery shall mean the use of combustible (packaging) waste as a means to generate energy through direct incineration with or without other waste but with recovery of the heat (Council Directive 94/62/EC).

Fuel shall mean any solid, liquid or gaseous combustible material used to fire the combustion unit with the exception of waste within the meaning of Directives 75/442/EEC, as amended by 91/156/EEC, and 91/689/EEC as well as Council Decisions 94/3/EC and 94/904/EC.

Recovery shall mean any of the operations provided for in Annex IIB of Directive 75/442/EEC as amended by 91/156/EEC and 96/350/EC.

NOTE Annex IIB lists:

— R1 Use principally as a fuel or other means to generate energy.

— R3 Recycle/reclamation of organic substances which are not used as solvent (including composting and other biological transformation processes).

Recycling shall mean the reprocessing in a production process of the waste materials for the original purpose or for other purposes including organic recycling but excluding energy recovery (Council Directive 94/62/EC).

Waste shall mean any solid or liquid waste or sludge as defined in Article 1(a) of Council Directive 75/442/EEC as amended.

Waste management shall mean the collection, transport, recovery and disposal of waste including the supervision of such operations and after-care of disposal sites (Council Directive 75/442/EEC as amended by 91/156/EEC).

A.2 Terms and definitions derived from the work of CEN/TC292

Working Group 4 of CEN/TC292 "*Characterisation of waste*" is drafting a Standard (prEN 13965) for terminology in two parts. Part 1 deals with material-related terms and definitions. Part 2 deals with terms and definitions related to waste management and provisions for waste management. Selected items from Parts 1 and 2 (May 2000 version) are listed below.

Part 1 – Material-related terms and definitions

502 bottom ash
combustion residue arising at the bottom of combustion furnaces

208 bulky waste
waste that due to its bulky character needs special consideration for its management

501 combustion residue
solid material that remains after combustion

502 construction waste
waste arising from construction of buildings or from civil engineering works

209 degradable waste
waste that predominantly consists of easily biologically, chemically or physically degradable organic matter

503 demolition waste
waste arising from demolition of buildings or from civil engineering works

506 flue-gas cleaning residue
waste arising from cleaning of flue gases

213 fly ash
solid material that is entrained in flue gases

507 garden and park waste
waste arising from garden and park management

202 household waste
waste arising in households

210 kitchen waste
waste arising from household food preparation or from similar activity

217 landfilled waste
waste placed in landfill

513 recovery process waste
waste remaining after a recovery process

514 shredder residues
waste arising from shredding after removal of components for recovery

Part 2 – Terms and definitions related to waste management and provisions for waste management

49 bio-gas production
activity to collect combustible gas generated by anaerobic biodegradation of waste.

12 bring collection
collection of waste that the holder has brought to a point for centralised collection.

NOTE This concept is the activity in *bring system*, which is the more frequently used term.

23 co-incineration
activity to use waste as regular or additional fuel in a plant whose main purpose is the generation of energy or production of material products

30 composting
treatment by aerobic biodegradation under controlled conditions and using micro-organisms.

NOTE Composting is usually used with the aim to produce soil improvers.

39 energy recovery
activity to use combustible waste as a means to generate energy through direct incineration with recovery of the heat

NOTE 1 Collection of landfill gas or production of fuel pellets is not energy recovery.

NOTE 2 Note 2: Cf. Packaging Directive 94/62/EEC

36 gasification
activity where combustible gas, through biological, chemical or thermal transformation is produced from nongaseous waste.

NOTE Methanisation due to biological processing is a special case of gasification.

22 incineration
treatment by combustion

13 kerbside collection
collection of waste that the producer has brought to the kerbside

29 pyrolysis
thermal treatment with limited supply of oxygen

A.3 Terms and definitions derived from THERMIE Report "*Fuel and Energy Recovery*".

The report "*Fuel and Energy Recovery*", produced under Contract DIS-1375-97-FI of the European Commission's THERMIE Programme, proposed terminology for the following areas: Waste, Fuel, Efficiencies and Emissions. Those terms and definitions are reproduced below. It must be stressed that the proposed terms and definitions carry no legal validity, nor are they endorsed by CEN. They are provided here simply as suggested elements of a common working language that can assist discussions about solid recovered fuels in the pre-normative phase. Some of the terms originally included in "*Fuel and Energy Recovery*" have subsequently been defined in legislation or by CEN/TC292; such terms have been deleted from the lists below.

Part 1 – Waste.

Mixed municipal solid waste (MSW) includes waste generated in households (HHW) and similar waste generated in commercial and small industrial operations which is collected in the same system.

Dry residual waste (DRW). When biowaste, hazardous waste and fractions used as material are separated at source and collected separately, the residue of MSW is called DRW. (Note: This term has been added at the request of Finland.)

Other waste includes specific wastes from e.g. industry, construction or demolition.

Pre-use production residues (clean wastes) are well defined side-streams from industrial operations.

Post-use wastes are substances or objects which have performed in their intended purpose.

Separate collection is any collection scheme gathering segregated waste streams.

Waste treatment is any mechanical, chemical, thermal or biological *recovery* or *disposal operation*.

Pre-treatment is any operation to make waste more suitable for recovery or disposal.

Material recovery facility (MRF) is any installation separating recoverable materials from waste.

Fuel recovery process is any operation where waste is intentionally converted to a useful solid, liquid or gaseous fuel.

Part 2 – Fuel.

Recovered fuel (RF) is a fuel of uniform quality which meets public user-oriented specifications. It is prepared from selected pre- and post-use, non-hazardous combustible waste in a dedicated process applying a quality assurance system.

Refuse derived fuel (RDF) is a fuel mechanically separated from mixed MSW. (It is a type of solid recovered fuel – Ed.) (Note: RDF is also made from construction and demolition waste which is mechanically separated by sorting and screening.)

Fuel input is the energy input to a combustion unit. It is calculated on lower heating value (LHV) which is the same as net calorific value (Q_{net}).

Combustion is a process of complete oxidation.

(e.g. burning fuel for the purpose of energy (electrical and thermal) generation or production of material products).

Co-combustion is the combustion of a mixture of fuels.

Combustion technology is any process used to convert the chemical energy of a fuel in a combustion installation (CI) or other industrial process (IP) into useful process heat, steam or hot water, e.g. pulverised fuel combustion (PF); grate firing (GF); rotary kiln firing (RK); bubbling fluidised bed (BFB) or circulating fluidised bed (CFB) combustion and pressurised fluidised bed firing (PFB).

Energy (electrical and thermal) generation is converting natural resources to useful end-use energy.

End-use energy is the output product of a combustion installation, i.e. process heat, steam, hot water and/or electricity.

Energy conversion technology is any process used to convert the energy content of a fuel into useful energy, (process) heat or electricity. This includes the power plant as a whole, e.g. condensing steam cycle; combined heat and power production (CHP) and integrated gasification combined cycle (IGCC) applying both gas and steam turbine.

Net Calorific Gain (NCG) or energy output is the sum of net electricity and heat outputs as well as utilised process heat. Gross Calorific Gain (GCG) includes also the energy consumed in the process.

Part 3 – Efficiencies.

Efficiency is the relation between input and output of a process. Improving efficiency of any industrial operation is a key issue for Sustainable Growth and Development.

Combustion efficiency is a measure of the completeness of oxidation of organic carbon in fuel.

Boiler efficiency is the ratio between heat transferred to the steam cycle and fuel input.

Overall plant efficiency is the ratio between net calorific gain and fuel input.

Power-to-heat ratio is the ratio between electricity output and heat output.

Availability is the ratio between actual and planned annual operation time.

Part 4 – Emissions.

Emission is the release of substances or heat from the combustion installation to the air, water or land. Minimising emissions in relation to overall plant efficiency is a key issue for environmental performance.

Emission Limit Value (ELV) is the mass, expressed in terms of certain specific parameters, concentration and/or level of an emission, which may not be exceeded during one or more periods of time. Emissions to air are measured in mass/volume flue gas and are for power plants usually expressed as mass/MJ fuel input.

Overall emissions is an expression for total environmental impact which may be assessed as influence on e.g. Climate Change, Acidification, Eutrophication or as "*externality costs*

Annex B
(informative)

CO_2 emissions from selected fuels

Table B.1 — CO_2-emission from selected fuels

Material	Composition of dry substance, %					Moisture	Higher Heating Value[4], MJ/kg	Calculated CO_2 emission based on HHV		Lower Heating Value[4], MJ/kg	Calculated CO_2 emission based on LHV	
	C	H	N	O	Ash	%		g/MJ_{HHV}	Relative to coal		g/MJ_{LHV}	Relative to coal
99 % CH_4 [1]	74	25	-	-	-	0	54	50	**0.55**	49	55	**0.58**
Polyethylene[2]	86	14	-	0.2	0	0.1	46	68	**0.75**	43	73	**0.78**
Polish coal[1]	73	4.7	1.0	9.1	11	9	27	90	**1.00**	26	94	**1.00**
Wood[1]	50.4	6.2	0.5	42.5	0.4	55	9.2	90[3]	**1.00**	7.25	115[3]	**1.22**
Wood[1]						0	20.2	90[3]	**1.00**	19.1	97[3]	**1.03**

1) Source: Electrowatt-Ekono.

2) Source: REport 95-3; Laboratory scale characterisation of plastics-derived fuels, Åbo Akademi University, Finland

3) Wood and other biomasses are considered renewable energy sources and the climate change effects of their CO_2 emissions are calculated as zero.

4) Higher heating Value (HHV) is a measure of chemically bonded energy and takes into account that water is in liquid phase. In the Lower Heating Value (LHV) the energy for evaporating water has been deducted. This energy can be recovered with modern combustion technique. HHV has been calculated with the following formula

$$HHV = LHV + 2.44 \cdot (Moisture/100) + [2.44 \cdot (H/100) \cdot 18.02/2.02] \cdot \{1 - (Moisture/100)\}$$

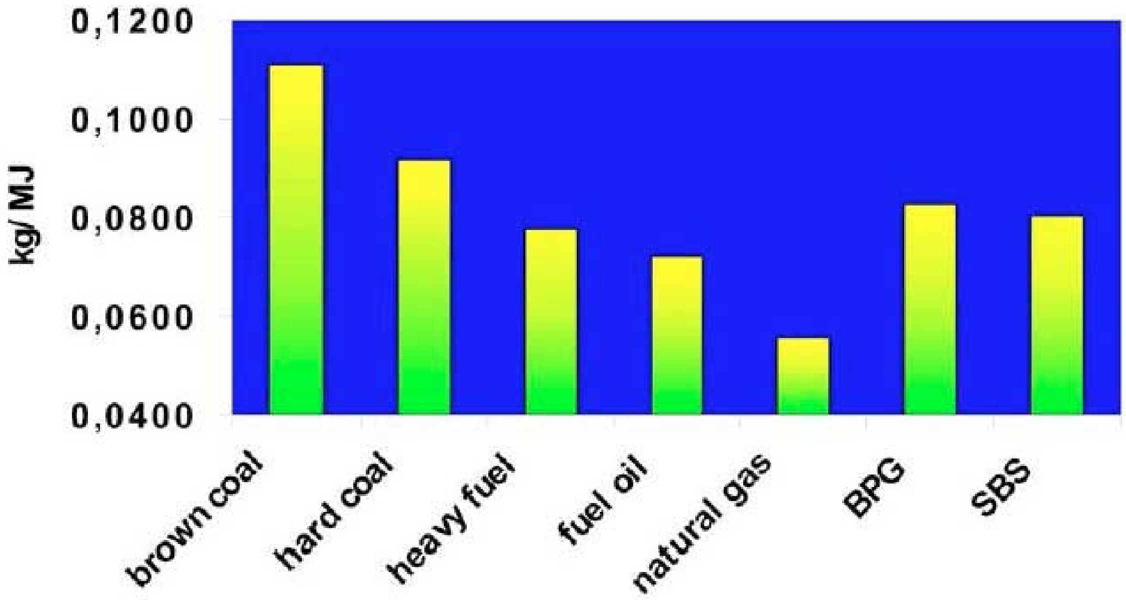

Figure B.1 — CO_2-emissions of several fuels

Source: Presentation by T. Glorius at the Workshop "Waste to Recovered Fuel", 29 May 2001, Brussels

BPG = Secondary fuel made from production-specific commercial waste

SBS = Substitute fuel made from household waste

Annex C
(informative)

Solid recovered fuel producers in CEN Member countries

C.1 Directory of companies

Austria

ASA Abfall Service AG Auer-Weisbachgasse, 25, 8055 Graz-Puntigam	Tel: 0316 292791 Fax: 0316 29279120
ABRG Asamer-Becker Recycling GmbH Industriestrasse, 17 9601 Arnoldstein	Tel: 04255 3990 88 Fax: 04255 3990 10
ADL Abfalldisposition und Logistik GmbH Feldkirchner Strasse, 111 8055 Seiersberg	
AEVG GmbH Sturzgasse, 8 8020 Graz	Tel: 0316 295898 0
ARGEV Lindengasse, 43/12 1070 Wien	Tel: 01 52149 Fax: 01 5238540
AVE Entsorgung GmbH Flughafenstrasse, 8 4063 Linz-Hörsching	Tel: 07221 601 0 Fax: 07221 6011 40
Gratz Gebrüder 21, 4650 Edt/Lambach	Tel: 07245 28815 0
Häusie Hubert GmbH & Co KG PF 26, Königswiesen 6890 Lustenau	Tel: 05572 392 0 Fax: 05572 392 20
Komptech-Heissenberger Pretzler GmbH Kühau, 37 8130 Frohnielten	Tel: 03126 505 0 Fax: 03126 505 505
Fritz Kuttin GesmbH Flossländ, 16 8720 Knittelfeld	Tel: 03512 82202 Fax: 03512 72115
Linde-KCA-Dresden GmbH Lunzerstrasse, 64 4031 Linz	Tel: 0732 6585 2431 Fax: 0732 6980 6174
Loacker Recycling GmbH Lustenauerstrasse, 33 6840 Götzls	Tel: 05523 502 Fax: 05523 502 33
Lobbe MTU GmbH Stöcklfeld, 45 6365 Kirchberg	Tel: 05357 2562 0 Fax: 05357 3947 19
Metall Recycling GmbH Industriestrasse, 12 3300 Amstetten	Tel: 07472 64181 Fax: 07472 64181 38

M-U-T GesmbH Schiessstattgasse, 49 2000 Stockerau	Tel: 02266 603 146 Fax: 02266 603 202
NO Umweltschutzenstalt Südstadtzentrum, 4 2344 Maria Enzersdorf	Tel: 02236 44541 Fax: 02236 44541 220
OKK Osterr. Kunststoff Kreislauf AG Handelskal 388, Top 841 1020 Wien	Tel: 01 7107001 Fax: 01 7207001 40
Ing. Rudolf Rottner GesmbH Kleinneusiedlerstrasse,25 2401 Fischamend	Tel: 02232 76277 0 Fax: 02232 76277 7
SAB Salzburger Abfallbeseltigun GmbH PF 78, Aupoint 15 5101 Bergheim	Tel: 0652 46949 0 Fax: 0662 46949 15
Thön Industriebetrie GmbH Obermrktstrasse, 48 6410 Telfs/Tirol	Tel: 05262 6903 0 Fax: 05262 6903 8201
Tiroler Shredder und Ragg GesmbH Obere Land, 45 6060 Hall I. Tirol	Tel: 05223 52192 0 Fax: 05223 52164
Trelbacher Industrie AG Auer von Weisbachstrasse 9330 Althofen	Tel: 04262 505 0 Fax: 04262 2005
UEG Umwelt und Entsorgungstechnik AG Feldkirchnerstrasse, 111 8055 Neu Selersberg	Tel: 0316 297176 Fax: 0316 22716 20
Johann Zellinger Gmbh Ralffeisenplatz, 10 4111 Walding	Tel: 07234 82303 Fax: 07234 823039
Saubermacher dienstieistungs AG Hötzendorfstrasse, 162 8010 Graz	Tel: 0316 461515 0 Fax: 0316 461515 3
Umweltdienst Burgenland GmbH Rottwiese 7350 Oberpullendorf	Tel: 02612 42120 Fax: 02612 42120

Belgium

Containers Vanheede NV
Dullaardstraat, 11
B-8940 Geluwe

Continental Green
Noorderlaan, 98/40
B-2030 Antwerpen

Demets Containers NV/WATCO
Chaussée de Vilvorde, 218
B-1120 Bruxelles

Garwig NV
Poelkapellestraat, 18
B-8650 Houthulst

Indaver
Poldervliegweg, 22
B-2030 Antwerpen

Page Conteneurs SA
Rue Baudouin Ier, 70
B-6180 Courcelles

Van Gansewinkel NV
Berkenbossenlaan, 7-9
B-2400 Mol

Denmark

Renovationsselskabet 4 SI/S Kåstrupvej 22, Kåstrup DK 7860 Spøttrup	Tel: +45 9758 1288

Finland

Erkki Salminen Oy Myllyharjuntie, 18 FIN-42300 JÄMSÄNKOSKI	Tel: +358 14 7194218
ET Energiatuote Oy Hallintie, 11 FIN-LAIHIA	Tel: +358 40 7229495
Ewapower AB Oy Spituholmsvägen 90 FIN-68600 Jakobstad	Tel: +358 6 7237711 Fax: +358 6 7237713
Huurinainen Oy Sepänkatu, 1 FIN-87150 KAJAANI	Tel: +358 8 6131100
Kymenlaakson Jäte Oy Matarojantie, 79B FIN-46860 Anjalankoski	Tel: +358 5 7443430
Lahden Lämpövoima Oy Box 24 FIN-15101 Lahti	Tel: +358 3 8233221
Loimi-Hämeen Jätehuolto Oy Kiimassuontie 127 FIN-30420 Forssa	Tel: +358 3 4242600
Pirkanmaan Jätehuolto Oy Hammareninkatu 5B FIN-33100 Tampere	Tel: +358 3 240522
SITA Finland Sahaajankatu, 49 FIN-00880 Helsinki	Tel: +358 9 755961
Säkkiväline Oy Sepelitie 6 FIN-40320 JYVÄSKYLÄ	Tel: +358 14 334 9830

France

CGEA ONYX Parc des Fontaines 169, avenue Georges Clémenceau 92735 Nanterre Cedex	Tel: +33 1 46 69 31 61 Fax: +33 1 46 69 34 91
SITA 132, rue des Trois Fontanot BP 693 92758 Nanterre Cedex	Tel: +33 1 42 91 63 63 Fax: +33 1 42 91 68 50

Germany

Abfallwirtschaftsgesellschaft Bassum Klövenhausen 20 27211 Bassum	Tel: +49 42 41 801150 Fax: +49 42 41 801100
Baufeld Energie GmbH Riesenfeldstrasse 80809 München	Tel: +49 89 35488550 Fax: +49 89 35488999 http://www.baufeld.de
Willy Böhme GmbH & Co. KG Postfach 11 45 95101 Rehau	Tel: +49 92 83 85634 Fax: +49 92 83 4287
Borchers Containerdienst Hansestrasse 44 46325 Borken	Tel: +49 28 61 93410 Fax: +49 28 61 64773
Edelhoff Unweltservice Deininghauser Weg 95 44577 Castrop-Rauxel	Tel: +49 23 05 9820 Fax: +49 23 05 982360
ERFA Entsorgung und Recycling Fotochemischer Abfälle GmbH Ginsterweg 21 42781 Haan	Tel: +49 21 29 604547 Fax: +49 21 29 34083
Fischer Recycling In Rammelswiesen 8 78056 VS-Schwenningen	Tel: +49 77 20 97170 Fax: +49 77 20 971799
Herhof Umwelttechnik Riemannstrasse 1 35606 Solms-Niederbiel	Tel: + 49 64 42 207212 Fax: + 49 64 42 207222
MBM Industrieanlagen GmbH & Co Gerichtsstrasse 22 59227 Ahlen	Tel: +49 23 82 5327 Fax: +49 23 82 5315
RAG UmweltRohstaffe GmbH Gleiwitzer Platz 3 46236 Bochum	Tel: +49 20 41 1660 Fax: +49 20 41 166390 http://www.rag-umwelt.de
Recotex Körner Strasse 40 58095 Hagen	Tel: +49 23 31 12322710 Fax: +49 23 31 12322121
Rectec Entsorgung GmbH Haagweg 3-7 65462 Ginsheim-Gustavsburg	Tel: +49 61 34 755060 Fax: +49 61 34 755059
Rethmann Entsorgungswirtschaft GmbH & Co.KG Dieselstrasse 3 44805 Bochum	Tel: +49 2 34 8921131 Fax: +49 2 34 8921111
Rethmann Entsorgungswirtschaft GmbH & Co KG Region Nord Ernst-Böhme-Srasse 22 38112 Braunschweig	Tel: +49 531 210460 Fax: +49 531 2104650
SITA Deutschland GmbH Gustav-Heinemann-Ufer 54 50968 Köln	Tel: +49 2 21 3773322 Fax: +49 2 21 3773390
Trienekens AG Greefsallee 1-5 41747 Viersen	Tel: +49 21 62 376662 Fax: +49 21 62 376777
TUE Entsorgungs GmbH Schwerborner Strasse 33 99086 Erfurt	Tel: +49 3 61 7397200 Fax: +49 3 61 7397202

Zweckverband Abfallwirtschaft Kaiserslautern Kapiteltal 67657 Kaiserslautern	Tel: +49 6 31 341170 Fax: +49 6 31 43036

The Netherlands

Afvalverwerking Groningen BV Postbus 66 9350 AB LEEK	Tel: +31 594 587260 Fax: +31 594 587265
Afvalverwerking Regio Nijimegen BV Postbus 7006 6503 GM NIJMEGEN	Tel: +31 24 3781766 Fax: +31 24 3779769
AVR Postbus 1120 3180 AC ROZENBURG	Tel: + 31 181 275766 Fax: + 31 181 275502
Bowie Bouwstoffen BV Postbus 32 5450 AA MILL	Tel: +31485 478651 Fax: +31 485 478474
BRW vof Postbus 5 9418 ZG WIJSTER	Tel: +31 593 563939 Fax: +31 593 563993
BTC Emmeloord Montageweg 2 8304 BG Emmeloord	Tel: +31 527 63 11 00 Fax: +31 527 63 11 01
BTC Zoetermeer Aluminiumstraat 50 2718 RA Zoetermeer	Tel: +31 79 36 111 55 Fax: +31 79 36 108 58
De Jonge Sebra PO Box 8053 4330 EB Middelburg	Fax: +31 118 618 955 Tel: +31 118 618 961
Dorrestein BV Fornheselaan 180 3734 GE DEN DOLDER	Tel: +31 30 2250544 Fax: +31 30 2251144
Energie Productie Moerdijk BV (EPM) Moldiepweg 7 3313 Dordrecht	Tel: +31 78 630 6700 Fax: +31 78 630 6701
ESSENT PO Box 5 9418 ZG WIJSTER	Tel: +31 593 563939 Fax: +31 593 563993
H.van Bennekom Postbus 1142 3900 BC VEENENDAAL	Tel: +31 318 585000 Fax: +31 318 585005
Keunen Recycling BV Postbus 3078 5902 RB VENLO	Tel: +31 77 3246666 Fax: +31 77 3246688
Langezaal Haaksbergen BV Postbus 198 7480 AD HAAKSBERGEN	Tel: +31 53 5721980 Fax: +31 53 5727655
Putman Recycling BV Postbus 27 6930 AA WESTERVOORT	Tel: +31 26 3112151 Fax: +31 26 3111134
Recycling Dongen BV Industriestraat 9 5107 NC DONGEN	Tel: +31 162 374700 Fax: +31 162 316680

RCS (Recycling Centrum Soest) Postbus 458 3760 AL SOEST	Tel: +31 35 6099080 Fax: +31 35 6099093
Rouwmaat Groenlo BV Postbus 74 7140 AB GROENLO	Tel: +31 544 474040 Fax: +31 544 474049
SIB (Sorteer Inrichting Brabant) Veerweg 9 5145 NS WAALWIJK	Tel: +31 416 564844 Fax: +31 416 564224
Waste Management (Icova B.V.) Kajuitweg 1 1041 AP AMSTERDAM	Tel: +31 20 6114011 Fax: +31 20 6139034
Watco Rotterdam (Terlouw Recycling) PO Box 59025 3008 PA Rotterdam	Tel: +31 10 428 7733 Fax: +31 10 428 7777
Van Vliet Contrans Postbus 201 2290 AE WATERINGEN	Tel: +31 174 297888 Fax: +31 174 297773
VAR (Veluwse Afval Recycling BV) PO Box 184 7390 AD TWELLO	Tel: +31 55 3018300 Fax: +31 55 3018310

Norway

Bøler Gjenvinning AS P.O.Box 39 N-2020 Skedsmokorset	Tel: +47 63874433 Fax: +47 63874024
Ragna-Sells AS P.O.Box 101 N-1471 Skårer	Tel: +47 67976690 Fax: +47 67976695
Miljøtransport AS P.O.Box 33 Økern N- 0508 Oslo	Tel: +47 22889900 Fax: +47 22889919
Norsk Gjenvinning ASA P.O.Box 153 Økern N-0509 Oslo	Tel: +47 22649300 Fax: +47 22649301
Grønmo Avfallsanlegg Klemetsrud N-1278 Oslo	Tel: +47 23169300 Fax: +47 22610451
Hedmark Renovasjon & Resirkulering AS Gålås N-2320 Furnes	Tel: +47 62542800 Fax: +47 62542805
Renovasjonsselskap Glør P.O.Box 170 N-2601 Lillehammer	Tel: +47 61270560 Fax: +47 61269126
Renovasjonsselskapet for Kristiandsandsregionen P.O.Box 393 N-4664 Kristiandsand S	Tel: +47 38177070 Fax: +47 38177071
Norsk Gjenvinning As Vest P.O.Box 34 Blomsterdalen N-5868 Bergen	
Franzefoss Gjenvinning AS, Florø N-6901 Florø	

Norsk Gjenvinning AS Sunnmøre
P.O.Box 7580 Spjelkavik
6022 Ålesund

Romsdal Gjenvinning AS
Årødalen
N-6400 Molde

Franzefoss Gjenvinning AS
Haakon VII gate 13c
N-7041 Trondheim

Heggstadmoen Avfallsbehandling
Hegstadmoen 57
N-7080 Heimdal

Hålogaland Ressursselssskap DA
Djupvikveien 21
N-8517 Narvik

Lofoten Avfallskap AS
P.O.Box 99
N-8370 Leknes

Perpetum AS
P.O.Box 82
N-9059 Storsteinnes

Finmark Miljøtjeneste AS
P.O.Box 322
N-9711 Lakselv

Øst-Finnmark Avfallsselkap
Tanatorget
N-9845 Tana

Sweden

Note: The following list does not include companies who supply only their own combustors with fuel

Ragn-Sells AB PO Box 952 SE-191 29 Sollentuna	Tel: +46 8 625 47 00 Fax: +46 8 625 47 25
SITA Sverige PO Box 1294 SE-171 25 Solna	Tel: +46 8 519 330 00 Fax: +46 8 519 330 47
Orbit Miljölogistik AB Umestans Företagspark 366 SE-903 47 Umeå	Tel: +46 90 71 86 00 Fax: +46 90 71 85 99
Industrial Quality Recycling (IQR) AB Stallbackagatan 20 SE-461 38 Trollhättan	Tel: +46 520 382 20 Fax: +46 520 48 01 18
Carl F Agnelundsvägen 16 SE-212 15 Malmö	Tel: +46 40 18 03 00 Fax: +46 40 18 71 58
SÖRAB PO Box 63 SE-186 21 Vallentuna	Tel: +46 8 511 806 00 Fax: +46 8 511 799 41
Sydkraft/SAKAB AB SE-692 85 Kumla	Tel: +46 19 30 51 00 Fax: +46 19 57 70 27

United Kingdom

Cleanaway Limited
Bridges Road
Ellesmere Port
Cheshire CH65 4EQ
Tel: +44 151 348 5000
Fax: +44 151 348 5201

Fibre Fuel Limited
c/o Slough Heat & Power Limited
342 Edinburgh Avenue
Slough
Berkshire SL1 4TU
Tel: +44 1753 213200
Fax: +44 1753 790038

Island Waste Services Limited
Forest Park, Forest Road
Newport
Isle of Wight PO30 5YS
Tel: +44 1983 821234
Fax: +44 1983 825664

Reprotec Limited
West End Lane
Essendon
Hertfordshire AL9 6AT
Tel: +44 1707 271112
Fax: +44 1707 273003

C.2 National commentaries

Denmark

In Denmark, only one company is manufacturing pellets from RDF. Several waste management companies and waste disposal companies have tried to make RDF pellets, but have given up because it is too expensive when compared to bales or other forms of storage. RDF pellets can only be used as fuel at waste incineration plants and such plants have an abundance of fuel, so there is no market for trading RDF pellets.

Finland

In Finland, the source-separated, quality-controlled waste can be used in existing boilers by co-incineration with the main fuel (mostly biofuel). At source separation, material recycling is the first priority and energy recovery is the second priority.

In Finland, approximately 40% of combustion capacity of solid recovered fuels is found in the forest-based industry. A great deal of solid recovered fuel is burned in the paper industry's fluidised bed boilers, but always in the form of controlled single waste materials such as paper and board, converted paper with plastic or other fibre-based waste products. In combustion contracts, and in any relevant Standard, it is essential to assess unambiguously the material categories of solid recovered fuels and their material purity demands. Quality assurance concerning the combustible waste material is also applied in the contract between the user and the supplier of the waste; it is based on the standardised grades of organised paper collection systems and/or other certified quality systems.

France

The current situation in France is that the initiative for the production of solid recovered fuels lies with the waste management companies who have responsibility for the disposal of waste in accordance with national regulations and in a cost-effective way.

Italy

The national law (D. M. 5/2/98) identifies a *refuse derived fuel* from municipal waste that can be used for energy recovery both in dedicated plants and in industrial plants under a simplified procedure that is a notification to the provincial authority before starting the activity instead of a full authorisation. This activity corresponds to the recovery operation R1 as stated in the directive 91/156/EEC as: *use of waste as fuel to produce energy*. This RDF is produced by mechanically sorting municipal waste in order to remove glass, metals, etc. Under the law it can be produced not only from municipal waste but also from industrial waste up to the 50 % (w) of the total amount. Industrial wastes that can be used are plastics, textiles, paper and cartons, and tyres under specific conditions. The RDF should respect specific prescriptions defined by the Italian regulation as in Table C.1.

Table C.1

moisture	25 % max
heating value	15,000 kJ/kg
Ashes	20 % (w)
Chlorine	0.9 % (w)
Sulphur	0.6 % (w)
Pb	200 mg/kg
Cu (soluble)	300 mg/kg
Mn	400 mg/kg
Cr	100 mg/kg
Zn	500 mg/kg
Ni	40 mg/kg
As	9 mg/kg
Cd+Hg	7 mg/kg

RDF is still a waste and can be burned both in dedicated and industrial plants under the following conditions:

- The minimum thermal power of a dedicated plant for energy recovery should be not less than 10 MW
- The minimum thermal power for industrial plants should be not less than 20 MW
- The energy recovery activity should guarantee a net transformation of a minimum rate of the calorific value in thermal energy corresponding to 75% per year or, in the case of electrical energy production, a net transformation of the calorific value as follows:

$$\frac{16 + \text{electric power (MW)}}{5}$$

Other industrial waste can be used as a fuel under the law following the same simplified operational procedures such as:

- Green waste (from agricultural and forestry activity)
- Waste from the wood industry
- Waste from textile fibres
- Pulper rejects
- Dried sewage sludge (both civil and industrial)
- Fossil coal rejects

All of these kinds of waste should have a minimum calorific value (from 6,000 kJ/kg for sludges to 16,000 kJ/kg for fossil coal) and limits on chlorine and metal content.

The emission limit values when burning these waste fuels are as in Table C.2.

Table C.2

Pollutants		D.M. 5/2/98 RDF combustion
CO	mg/m3	50
Dust	,,	10
TOC	,,	10
HCl	,,	10
HF	,,	1
SO2	,,	50
NOx	,,	200
NH3	,,	250
PAH	,,	0,01
Cd + Tl	,,	0,05
Hg	,,	0,05
heavy metals	,,	0,5
PCDD -PCDF	ng/m3	0,1(*)

The Netherlands

A summary of the production of solid recovered fuels in The Netherlands is set out in the table C.3.

Table C.3 — Solid recovered fuel producers in The Netherlands in 2001

Company	Location	Input	Output
Shanks (Icova)	Amsterdam	Commercial waste	Pellets
Essent	Wijster	MSW, paper-plastic	Fluff
Essent	Wijster*	Commercial waste, paper-plastic	Fluff
Essent	Groningen (VAGRON)	MSW, paper-plastic RDF	Fluff Fluff
Essent	Born	Commercial waste	Pellets
BTC	Zoetermeer	Commercial waste	Pellets
BTC	Emmeloord	Commercial waste	Pellets
VAR	Wilp	Commercial waste, construction & demolition waste	Fluff
WATCO*	Rotterdam, Helmond, Maastricht	Commercial waste, construction and demolition waste	Fluff, pellets
Kappa	Roermond	Reject paper	Pellets (Rofire)

Source: Essent Milieu (personal communication)

The current size of the market in The Netherlands is about 25 kt/a of pellets used for cement production by ENCI. However, there is potential for growth represented by the following power generation initiatives:

- E.ON (EZH) – (a) CFB with an input of 420 kt/a RDF and 100 kt/a sludge and (b) co-combustion of, amongst others, paper/plastic 45 kt/a (pellets) and 100 kt/a biomass (compost, de-inking residue, yard trimmings).
- Essent (EPZ) – (a) gasifier with an input of 150 kt/a wood and (b) co-combustion of, amongst others, paper/plastic, sludge and RDF, total 1800 kt/a (dry matter).
- Electrabel (EPON) – (a) gasifier for dried sludge, RDF, wood, waste oil, etc; 100 MW_{th} and (b) co-combustion of demolition wood 60 kt/a.

There is also a proposed project (REDOP) in the steel sector, to develop a substitute fuel for blast furnaces (project partners include the plastics industry, AVR, VAGRON and APME).

Some coal-fired power plants in the Netherlands have stated their intention to substitute recovered fuel for 20% of their energy input as part of a covenant with the government concerning the reduction of CO_2 emissions. 20% can be regarded as the maximum for substitution from a technical point of view, taking account of the potential for corrosion by chlorides.

Sweden

In Sweden, during the 12 months beginning December 1999, companies operating incinerators and municipal heating plants notified the Swedish Environmental Protection Agency about the import of 339,232 tonnes of fuel derived from municipal solid waste and waste wood separated at source. Eight companies handled imports from five countries including members of the EU and Norway.

C.3 Composition of solid recovered fuel

Solid recovered fuels can be produced from MSW and other non-hazardous, combustible wastes. The tables on the following pages are intended to give an indication of the composition of recovered fuels that have been produced and used successfully, from the following waste streams:

- Construction and demolition waste, and commercial waste (an example from a German company)
- MSW (an example from the Netherlands)
- Source-separated fractions from MSW and other combustible waste (an example from Finland)
- Monostreams of commercial and industrial waste (an example from a German company)

It is intended to present more information about the composition of a range of solid recovered fuels in Annex H of this CEN Report, following a survey that will be carried out by the European Commission's Joint Research Centre at Ispra in the second half of 2001.

NOTE As there is so far no standard method of taking samples of material such as solid waste or the fuel produced from it, which can be quite inhomogeneous, and as there are no clear rules about taking continuous samples over a period of time or taking grab samples, comparability between data-pools from different countries can be low. Another problem is how results which fall below the detection limit are taken into account. Counting them at the detection limit, at half the detection limit, at zero, or not counting them at all are options which can change certain results significantly. The German data-pool includes several results from test runs with new materials. Therefore, some of the higher results for a few parameters do not necessarily represent the quality of the finally-produced fuel.

Table C.4 — Recovered fuel produced from the high calorific fraction of demolition waste (Germany)

Parameter	Median	80 Percentile	Number of samples
Net Calorific Value (MJ/kg)	20,6	25,1	179
Moisture content (%)	13,4	18,8	346
Ash content (% dm)	13,8	20,6	151
Chlorine total (%)	0,7	1,1	171
Fluorine total (mg/kg dm)	100,0	400,0	55
Sulphur total (%)	0,1	0,4	110
Cadmium (mg/kg dm)	2,2	4,9	266
Mercury (mg/kg dm)	0,2	0,3	249
Thallium (mg/kg dm)	0,4	0,5	241
Arsenic (mg/kg dm)	1,0	2,0	257
Cobalt (mg/kg dm)	2,9	4,7	245
Nickel (mg/kg dm)	13,1	26,3	243
Selenium (mg/kg dm)	0,4	1,7	235
Tellurium (mg/kg dm)	0,4	1,0	222
Antimony (mg/kg dm)	10,8	42,4	284
Beryllium (mg/kg dm)	0,2	0,3	230
Lead (mg/kg dm)	89,0	160,0	265
Chromium (mg/kg dm)	48,0	82,9	259
Copper (mg/kg dm)	97,5	560,0	286
Manganese (mg/kg dm)	61,0	94,0	229
Vanadium (mg/kg dm)	3,6	5,3	241
Tin (mg/kg dm)	4,0	12,2	192
PCB (Sum DIN 51527)	0,2	0,5	21

NOTEs Notes: dm = dry matter

All percentages are by mass

The MSW used at this time did not include the high calorific fraction of household waste. It contained the high calorific fraction from construction and demolition waste and from commercial waste, which explains the stated value of Net Calorific Value.

Table C.5 — Recovered fuel produced from MSW (Netherlands)

Parameter	Median	80 Percentile	Number of samples
Dry matter (%)	75,3	78,0	42
Gross Calorific Value dm (MJ/kg)	20,7	22,0	42
Net Calorific Value a/r (MJ/kg)	13,3	16,1	42
Ash content in dry matter (%)	16,0	17,7	41
Carbon (%)	47,1	50,7	42
Chlorine (%)	0,6	0,8	42
Fluorine (%)	0,01	0,02	42
Hydrogen (%)	6,6	7,0	40
Nitrogen (%)	0,5	0,8	42
Oxygen (%)	30,4	34,4	39
Sulphur (%)	0,2	0,3	40
Antimony (mg/kg dm)	10,1	20,3	35
Arsenic (mg/kg dm)	3,0	4,9	33
Beryllium (mg/kg dm)	0,2	0,3	33
Cadmium (mg/kg dm)	0,6	1.6	39
Chromium (mg/kg dm)	70,0	103	42
Cobalt (mg/kg dm)	3,7	5,8	38
Copper (mg/kg dm)	59,5	88	40
Lead (mg/kg dm)	121	189	37
Nickel (mg/kg dm)	21,5	33,3	42
Mercury (mg/kg dm)	0,4	0,5	34
Manganese (mg/kg dm)	73,5	78	34
Selenium (mg/kg dm)	<2	<2	40
Tellurium (mg/kg dm)	<1	<1	41
Thallium (mg/kg dm)	<0,8	<0,8	41
Tin (mg/kg dm)	10,5	27,6	27
Vanadium (mg/kg dm)	6,6	10,2	41
Zinc (mg/kg dm)	225	307	42
Determined in the ash:			
Aluminium (%)	6,9	9,2	42
Calcium (%)	17,6	21,8	42
Iron (%)	1,6	2,2	42
Potassium (%)	1,9	2,2	42
Magnesium (%)	1,4	1,7	42

Sodium (%)	1,9	2,7	42
Silicon (%)	17,9	20,8	42
Titanium (%)	1,0	1,6	42
EOX (mg/kg dm)	31	42	25

NOTE a/r = as received

dm = dry matter

All percentages are by mass

Table C.6 — Recovered fuel produced from source-separated fractions from MSW and other combustible waste (Finland)

Parameter	Source-separated raw materials from apartments, offices, etc. Mean derived from 742samples	Source-separated raw materials from industries and companies. Mean derived from 490samples
Moisture (%)	33,6	16,6
Gross Calorific Value dm (MJ/kg)	23,1	21,2
Net Calorific Value dm (MJ/kg)	22,3	20,1
Net Calorific Value a/r (MJ/kg)	14,0	16,8
Energy content (MWh/tonne)	3,9	4,7
Ash content (%)	10,2	6,7
Volatile matter (%)	74,8	78,3
Chlorine (%)	0,4	0,3
Aluminium (%)	0,6	0,2
Metallic aluminium (%)	-----	0,03
Sulphur (%)	0,2	0,1
Nitrogen (%)	1,5	1,4
Sodium (%)	0,4	0,1
Sodium soluble (%)	0,3	0,1
Potassium (%)	0,3	0,1
Potassium soluble (%)	0,2	0,1
Mercury (mg/kg dm)	0,3	0,1
Cadmium (mg/kg dm)	1,2	-----
Chromium (mg/kg dm)	140	-----
Copper (mg/kg dm)	80	-----
Nickel (mg/kg dm)	20	-----
Zinc (mg/kg dm)	340	-----
Manganese (mg/kg dm)	210	-----
Arsenic (mg/kg dm)	8,8	-----
Lead (mg/kg dm)	52,4	-----

NOTE a/r = as received
dm = dry matter
All percentages are by mass

Table C.7 — Recovered fuel produced from monostreamsof commercial and industrial waste (data from one German company)

Parameter	Median	80 Percentile	Number of samples
Net Calorific Value (MJ/kg)	22,9	25,3	1402
Moisture content (%)	11,5	17,2	1849
Ash content (% dm)	9,6	11,6	1308
Chlorine total (%)	0,4	0,7	1475
Fluorine total (mg/kg dm)	100	400	200
Sulphur total (%)	0,1	0,1	307
Cadmium (mg/kg dm)	0,8	3,2	443
Mercury (mg/kg dm)	0,2	0,4	402
Thallium (mg/kg dm)	0,5	1,5	410
Arsenic (mg/kg dm)	1,5	1,7	394
Cobalt (mg/kg dm)	2,0	3,8	383
Nickel (mg/kg dm)	6,2	16,0	384
Selenium (mg/kg dm)	1,0	2,5	318
Tellurium (mg/kg dm)	1,0	5,0	322
Antimony (mg/kg dm)	9,4	33,9	547
Beryllium (mg/kg dm)	0,2	0,3	343
Lead (mg/kg dm)	25,0	64,4	406
Chromium (mg/kg dm)	20,0	43,9	417
Copper (mg/kg dm)	48,0	118	504
Manganese (mg/kg dm)	28,0	47,0	369
Vanadium (mg/kg dm)	3,3	10,0	347
Tin (mg/kg dm)	7,0	12,4	114
PCB (Sum DIN 51527)	0,2	0,5	134

NOTE dm = dry matter
All percentages are by mass

Annex D
(informative)

Associations of solid recovered fuel producers in the EU

European Recovered Fuel Organisation

ERFO	
c/o Trienekens AG	Tel: +49 2162 376 653
Dr Ludwig Ramacher	Fax: +49 2162 376 741
Greefsallee 1-5	
41747 Viersen	
Germany	
E-mail: ludwig.ramacher@trienekens.de	

Denmark

DAKOFA	Tel: +45 96 32 90 22
Ovengaden Oven Vandet 48E	Fax: +45 96 32 90 19

DK-1415 Copenhagen K

Finland

Finnish Solid Waste Association	Tel: +358 9 27800770
Opastinsilta 2A	Fax: +358 9 27800771
FIN-00520 Helsinki	
Finland	

France

FNADE (Fédération Française de la Dépollution et de l’Environnement) is the French Federation of activities related to depollution and environmental activities, and represents the sector of waste management.

33, rue de Naples,	Tel: +33 1 53 04 32 90
75008 Paris	Fax: +33 1 53 04 32 99

FGEEE (Fédération Française des Entreprises de Services aux Equipement á l’Energie et à l’Environnement) is the French Federation of companies providing services for Equipment, Energy and Environment and represents the sector for power generation (fuel users).

28. rue de la Pépinière,	Tel: +33 1 44 70 63 90
75008 Paris	Fax: +33 1 44 70 63 99

Germany

BGS (Bundesgütegemeinschaft Sekundärbrennstoffe e.V.) is the German Association for the Quality Assurance of Solid Recovered Fuels. Its objectives are to:

- Elaborate quality standards for solid recovered fuels
- Develop a quality assurance system
- Grant rights to use a label
- Assist users of solid recovered fuels with matters of fuel quality and acceptance by permitting authorities.

Schönhauser Strasse 3,
D-50968 Köln,
Germany

Tel: +49 221 93470061
Fax: +49 221 93470092

The Netherlands

At this time, the Initiatiefgroep Secundaire Brandstoffen (ISB) is the only group that joins all producers of solid recovered fuel in the Netherlands. ISB aims to develop and promote opportunities for recovered fuel through standardisation and certification.

Related organisations are BRBS (Dutch association for the recycling of construction and demolition waste) and VVAV (Dutch waste processing association) which have members active in the field of solid recovered fuels, but they are not associations of solid recovered fuel producers. BRBS represents 35 Dutch sorting plants for MSW and construction and demolition waste. These plants sort wastes into a high calorific mixture which is highly suitable for further recycling into solid recovered fuels. Most of the plants simply supply the high calorific mix, but some produce solid recovered fuels themselves (see Annex C.1).

Annex E
(informative)

Summary of a Cost-Benefit Analysis on Waste to Recovered Fuel

NOTE The present study is part of the project Waste to Recovered Fuel, which is co-funded by the ENERGIE Programme of the 5th FP of the European Commission and by an industrial consortium representing all stakeholders (contract NNE5-1999-533).

Recovered Fuel is a fuel of uniform quality that meets public user-oriented specifications. It is prepared from selected pre- and post-use, non-hazardous combustible waste in a dedicated process applying a quality assurance system. (Definition given in THERMIE report Fuel and Energy Recovery, DIS-1375-97-FI)

E.1 Introduction

Integrated Resource and Waste Management (IRWM), implemented in a spirit of shared responsibility, is an important means to reach a sustainable society. The maximum benefit should be extracted from primary natural resources and wastes that cannot be prevented. Although there are on-going efforts to continuously improve efficiency within all industrial sectors, the dependency on fossil fuels, especially on coal, is expected to prevail in modern society.

Despite successful prevention, waste will always be produced as a result of human activities. Waste is subject to detailed EU regulation setting binding targets for recovery, including recycling. Inorganic waste materials like glass and metals can be recovered as material in thermal processes. Organic combustible materials like wood, paper, board, plastics and rubber can be recovered both as material and as a fuel to be used for the production of heat and electricity.

The objective of this study is to evaluate the overall effects of different recovery options for non-hazardous combustible waste on national welfare, by means of Cost-Benefit Analysis. The study compares (a) dedicated incineration of mixed MSW with Energy Recovery and (b) Fuel Recovery for substituting fossil fuel in a co-combustion process to (c) direct landfill. It is acknowledged that the Commission has contracted a separate study on re-use and material recovery of packaging waste in the Union.

E.2 Cost-Benefit Analysis

Cost-Benefit Analysis (CBA) can be used for the assessment of sustainable integrated resource and waste management. In this study it is based on a dedicated computer model developed by GUA, Austria. The *system identification* defines boundary limits for material and energy balances. It includes all relevant waste management operations, as well as all primary production processes, which may be utilised for recovery purposes. The *functional unit* used in this CBA is € per person and year.

Internal costs are defined as fixed and variable direct costs related to the processes. *External costs* are defined as costs of all direct and indirect environmental and social impacts related to the operation. Emissions are translated into monetary units by applying the principle of *averting costs.* These are defined as (known) process costs, necessary to reduce emissions to a specified level. The processes applied are those reducing the relevant emissions most cost-efficiently.

The CBA calculation gives the total system costs, internal and external, of an analysed recovery scenario, including the avoided costs of the corresponding substituted primary production processes.

The Cost-Benefit Balance (CBB), the difference in cost between the baseline scenario and an analysed scenario, is the final result of CBA. A positive figure means an overall cost benefit compared to the baseline scenario. Comparison of several CBBs advises on the most economic solution.

E.3 Basic assumptions and scenarios

In this CBA the *analysed scenario* identifies the detailed input and output parameters of a specific system. 45 separate data combinations are analysed in the study.

Fixed parameters are: number of citizens (500000), number of households (200000), fraction of multi-family houses (50 %), fraction of single family houses (50 %), amount of combustible waste from industry and trade (100 kg/person/year), size of MSW incinerator (150000 t/year), energy efficiency at co-combustion (same as for primary fuel), free access to deliver electricity to the grid and sufficient solid fuel consumption to be substituted by recovered fuel.

Variable parameters (low, medium, high) are: amount of MSW per person, share of bio-waste, share of packaging waste, efficiency of separate collection, collection system used, energy recovery efficiency at MSW incineration, cost level of labour and investments as well as demand of district or process heat. These are combined to form three Model Regions, basically representing the situation in South, Central and North Europe.

The Energy Recovery case assumes a modern MSW incineration plant equipped with different energy conversion systems where the energy produced substitutes energy from primary sources, i.e. coal (I-coal), fossil natural gas (I-gas) or a European mix of primary energy sources (I-mix). Electricity efficiency in condensing mode is 25 % based on the lower heating value of input fuel. Overall energy efficiency for production of combined heat and power (CHP) is 80 % (up to 100 % for a plant with flue gas condensation).

The Fuel Recovery case includes three basic processes for the production of recovered fuel from selected non-hazardous combustible waste, i.e. low yield in the form of fluff (FP-1), medium yield in the form of soft pellets (FP-2) or high yield in the form of hard pellets (FP-3). The storable fuel may be used in four different combustion technologies, i.e. Cement Kiln (CK), Circulating Fluidised Bed (CFB), Pulverised Coal (PC) or in gasification with consequent combustion of the gas in PC (gasPC). All operations are "state of the art" fulfilling European legislation. Energy efficiencies are assumed to be unchanged for a reasonable range of 5 – 30 % primary fuel substitution.

The *Baseline Scenario* is the reference that does not contain the studied fuel and energy recovery processes. It is direct landfilling of all wastes not being recycled as in the analysed recovery scenarios. The landfill operation fulfils the technical requirements of the Landfill Directive and is equipped with energy recovery from landfill gas. The examination period of landfilling is 10 000 years, since also long term effects are considered in the CBA.

The averting costs used for air- and water pollutants[1] are evaluated by the Institute of Public Finance and Infrastructure Policy at the Vienna University of Technology. They are derived from the averting costs quoted in recent scientific literature. The costs applied for Hg and Pb emissions are proportionate to the averting costs of Cd according to their toxicity for humans.

1 air pollutants: $CO_{2\ bio}$, $CO_{2\ foss}$, CH_4, CO, SO_2, HCl, NO_x, NMVOC, Dust, CFC, Cd, Hg, Pb;

water pollutants: COD, NH_4, Cd, Hg, Pb.

E.4 Results

From the 45 analysed data combinations 5 principal scenarios are selected for presentation here. Data for the baseline, landfill and incineration scenarios as well as for primary processes are derived from the GUA data bank. Data for the fuel recovery scenarios, low, medium and high yield, are acquired from the operations of Essent Milieu VAM in the Netherlands, Trienekens AG in Germany and Ewapower in Finland respectively. The mass balances (Figure E.1) show the diversion of combustible waste from landfill. For the scenarios involving incineration only process ashes are landfilled. The high yield fuel preparation, combined with organic recovery of biowaste, and consequent landfilling of rejects, meets the Landfill Directive targets.

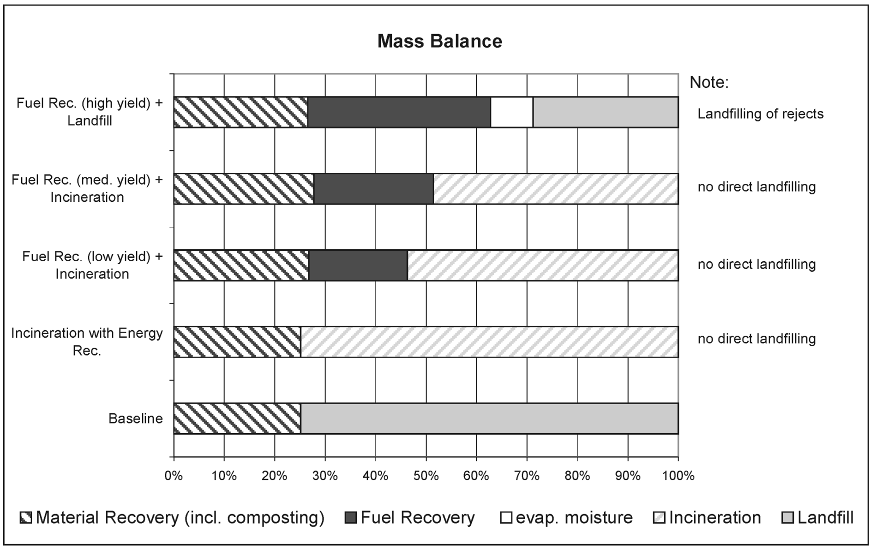

Figure E.1 — Mass balances of selected scenarios.

The energy balances give the amounts of electricity and heat produced. The amount of electricity varies significantly amongst the cases (figure E.2).

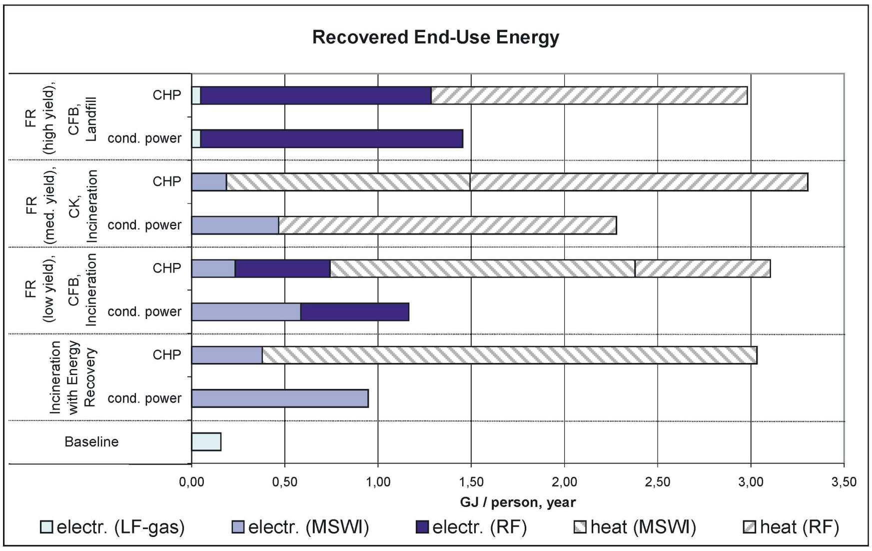

Figure E.2 — Production of end-use energy in selected scenarios

Regarding emissions of greenhouse gases (Global Warming Potential, GWP, Figure E.3) Energy Recovery and Fuel Recovery save 50 - 300 kg CO_2 equivalents per person and year. This corresponds to 20 - 50% of the total GWP of substituted primary production. In comparison with the baseline scenario, direct landfilling, as much as 250 - 500 kg CO_2 equivalents can be saved. The main reduction of greenhouse gases results from the substitution of fossil fuels (fossil CO_2 emissions) and from the diversion of biodegradable waste from landfill (CH_4 emissions).

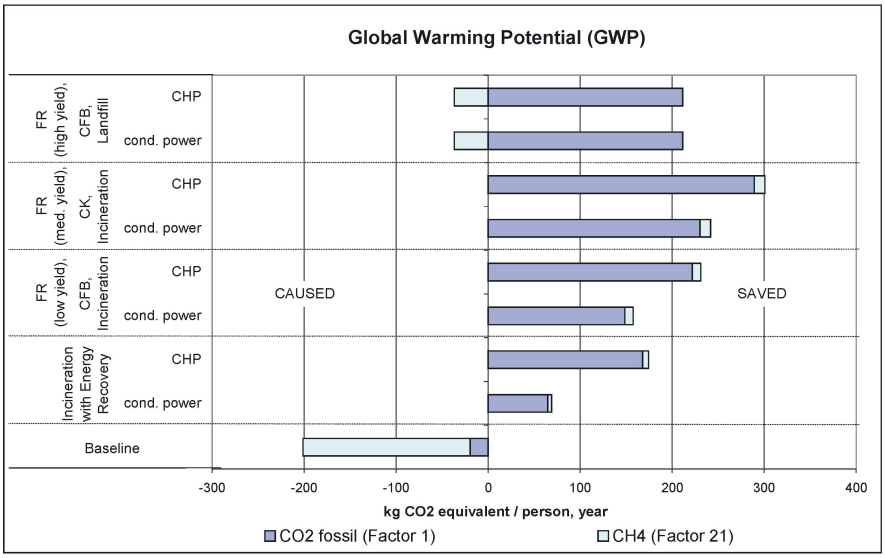

Figure E.3 — Global warming potential for selected scenarios

The final macro economic benefit (Figure E.4) is highly influenced by the total amount of energy produced. The model does not distinguish between the production of electricity and heat. Most favourable is the substitution of coal. Condensing power (electricity only) from dedicated MSW incineration, which substitutes electricity from fossil gas, does not give a macro economic benefit.

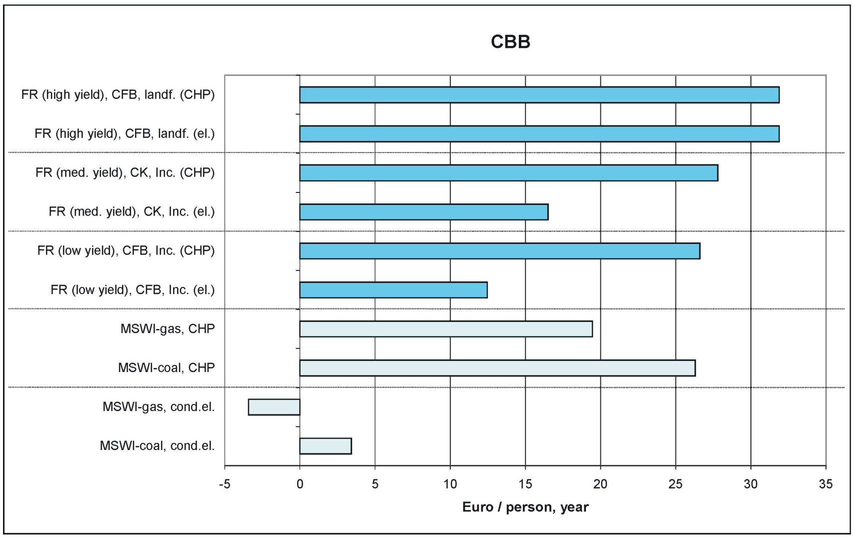

Figure E.4 — Cost-Benefit Balance of selected scenarios compared to landfill

The study shows clearly that the internal costs of direct landfilling are lower than the internal costs of any recovery operation. However, when including external costs the results change, and both Energy Recovery and Fuel Recovery show a benefit for the Society in the order of 5 – 30 € per person and year. This is mainly due to averting costs for emissions from landfill and to averting costs for fossil CO_2 emissions, saved through energy and fuel recovery. 50 % of the combustibles in MSW is considered to be of biogenic origin.

The study shows even better results for high yield fuel preparation for co-combustion in pulverised coal power plant. However, the economy of fuel pulverisation technology is not yet proven for recovered fuels in general, so these results are not as valid as those for cement kiln and fluidised bed combustion.

E.5 Conclusions

The cost-benefit analysis undertaken concentrates on the management of residual waste from households and commercial/industrial facilities after secondary materials have been separated for eco-efficient recycling.

Averaged over all scenarios and regional conditions investigated (45 data sets), the annual economic benefit that can be achieved for the national welfare is in the order of 15 - 40 Euro/person. The study shows that fuel and energy recovery can save 2 - 5 GJ/person (= 50 - 125 kg of oil equivalent). This corresponds to some 10 % of the solid fuel consumption and to 2 - 4 % of total fossil fuel consumption in Europe. It is a significant contribution to the Kyoto targets.

The main conclusions of the CBA are:

- All recovery scenarios show a significant reduction of greenhouse gas emissions, carbon dioxide and methane, compared to the baseline scenario, landfilling. The reduction is proportionate to the diversion of combustible waste from landfill and yield of recovered fuel.
- All the recovery options studied give an economic benefit to the Society, except the one where electricity generated by waste incineration substitutes electricity generated by a gas fired power plant.
- The more Recovered Fuel that can be diverted to energy production, the higher the benefit. The fuel recovery options are generally a little better than the incineration options with energy recovery.
- Fuel recovery is especially well suited in sparsely populated regions where relatively small decentralised fuel production plants can deliver recovered fuel to existing power plants or plants for production of material products.
- For larger cities or regions with an existing incineration plant, a combination of fuel recovery combined with direct incineration with energy recovery seems to be a preferred option.

E.6 Discussion

For practical reasons, the Cost-Benefit analysis is based on average available data processed by a dedicated computer model that builds on previous experience and work of GUA.

A sensitivity analysis (Figure E.5) based on “medium assumptions” (averaged over all Model Regions investigated) shows how the results of this CBB are influenced by variation of with input parameters.

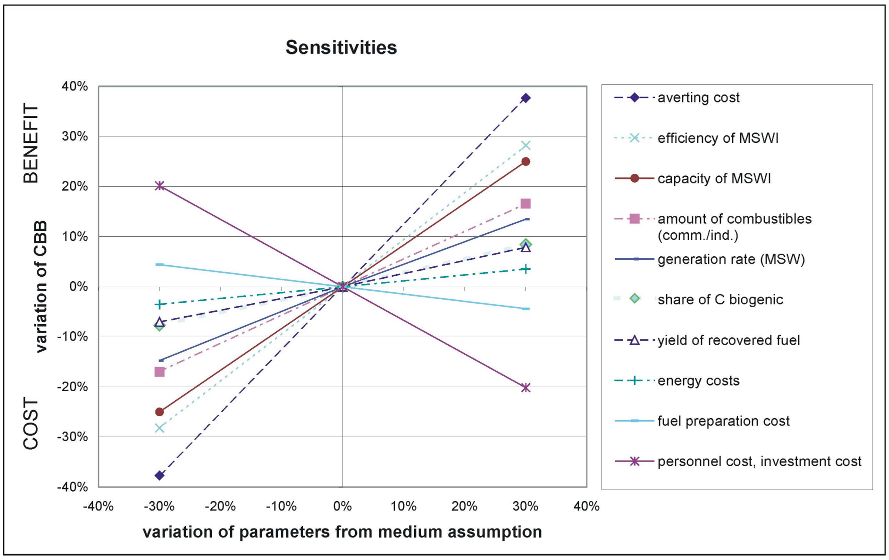

Figure E.5: — Sensitivity of CBB

The significance of input parameters to the results can be grouped in the following order:

1) The (external) averting costs have the greatest influence on the results. They affect landfilling the most, because of the long calculation period, 10 000 years, without discounting. A calculation period of 100 years for landfilling roughly reduces the results by one third, but does not change the overall conclusions or affect the internal ranking of the analysed recovery scenarios.

2) The energy efficiency and size of the MSW incinerator. The influence of (direct) labour and investment costs are also high. It is noted that Fuel Recovery in general is a decentralised option involving smaller units, more job opportunities and less investment compared to dedicated MSW mass burn facilities.

3) The amount of waste and especially the amount of non-recyclable combustible waste. This makes Fuel Recovery a favoured option in industrialised regions.

4) The share of biogenic carbon in combustible waste and the yield of recovered fuel have a less significant influence on the results.

5) The (direct) costs of primary energy sources and of recovered fuel production affect the results only to a minor degree.

Annex F
(informative)

Standards for solid recovered fuels

CEN, prEN 13965 Characterisation of waste – Terminology - Part 1: Material related terms and definitions (English).

CEN, prEN 13965 Characterisation of waste – Terminology – Part 2: Management related terms and definitions (English).

ISO 333 Coal, 1996. Determination of nitrogen – Semi-micro Kjeldahl method (English).

ISO 351 Solid mineral fuels, 1996. Determination of total sulfur – High temperature combustion method (English).

ISO 352 Solid mineral fuels, 1981. Determination of chlorine – High temperature combustion method.

ISO 540 Solid mineral fuels, 1995. Determination of fusibility of ash – High temperature tube method (English).

ISO 562 Hard coal and coke, 1998. Determination of volatile matter (English).

ISO 567 Coke, 1995. Determination of bulk density in a small container (English).

ISO 589 Hard coal, 1981. Determination of total moisture (English).

ISO 601 Solid mineral fuels, 1981. Determination of arsenic content using the standard silver diethyldithiocarbamate photometric method of ISO 2590 (English).

ISO 609 Solid mineral fuels, 1996. Determination of carbon and hydrogen – High temperature combustion method (English).

ISO 625 Solid mineral fuels, 1996. Determination of carbon and hydrogen – Liebig method (English).

ISO 1013 Coke, 1995. Determination of bulk density in a large container (English).

ISO 1171 Solid mineral fuels (1997) Determination of ash content (English).

ISO 1928 Solid mineral fuels, 1995. Determination of gross calorific value by the comb calorimetric method, and calculation of net calorific value (English).

ISO 1994 Hard coal, 1976. Determination of oxygen content (English).

ISO 5660, 1993. Part 1: Reaction to fire – Heat release measurement (cone calorimeter method).

ISO/DIS 8983 Solid mineral fuels. Determination trace elements – Flame atomic absorption method (English).

ISO/DIS 15237 Solid mineral fuels. Determination of total mercury content of coal (English).

ISO/DIS 15238 Solid mineral fuels. Determination of total cadmium content of coal (English).

NF M 03-002, 1995. Solid mineral fuels. Determination of moisture content.

NF M 03-003, 1994. Solid mineral fuels. Determination of ash content.

NF M 03-004, 1974. Solid mineral fuels. Determination of the index of volatile matter of coal.

NF M 03-005, 1990. Solid fuels. Determination of gross calorific value and calculation of net calorific value.

NF M 03-006, 1994. Solid mineral fuels. Determination of fixed carbon content.

NF M 03-032, 1969. Coal and coke. Determination of carbon and hydrogen content by high temperature combustion.

NF M 03-037, 1990. Solid mineral fuels. Determination of the moisture content of a test portion for general analysis of a natural solid fuel. Direct volumetric and gravimetric methods.

NF M 03-038, 1996. Solid mineral fuels. Determination of the total sulphur by the high temperature (ignition method).

NF M 03-048, 1984. Solid fuels. Determination of fusibility of ash

SFS 5875, 2000. Solid recovered fuel. Quality control system. (Finnish and English).

SS 18 71 06, 2000. Biofuels and peat – Terminology. (Swedish and unofficial English translation).

SS 18 71 13, 1998. Biofuels and peat – Sampling. (Swedish and unofficial English translation).

SS 18 71 14, 1992. Biofuels and peat – Sample preparation. (Swedish and unofficial English translation).

SS 18 71 20, 1998. Biofuels and peat – Fuel pellets – Classification. (Swedish and unofficial English translation).

SS 18 71 23, 1998. Biofuels and peat – Fuel briquettes – Classification. (Swedish and unofficial English translation).

SS 18 71 70, 1997. Biofuels and peat – Determination of total moisture content. (Swedish and unofficial English translation).

SS 18 71 71, 1984. Biofuels – Determination of ash content. (Swedish and unofficial English translation).

SS 18 71 73, 1986. Biofuels – Calculation of analyses to different bases. (Swedish and unofficial English translation).

SS 18 71 74, 1990. Biofuels and peat – Determination of size distribution. (Swedish and unofficial English translation).

SS 18 71 75, 1990. Peat – Determination of mechanical strength of sod peat. (Swedish and unofficial English translation).

SS 18 71 78, 1990. Biofuels and peat – Determination of raw bulk density and calculation of dry raw bulk density in a large container. (Swedish and unofficial English translation).

SS 18 71 79, 1990. Peat – Determination of raw bulk density and calculation of dry raw bulk density. (Swedish and unofficial English translation).

SS 18 71 80, 1999. Biofuels and peat –Determination of mechanical strength for pellets. (Swedish and unofficial English translation).

SS 18 71 84, 1990. Biofuels and peat – Determination of moisture content in the analysis sample. (Swedish and unofficial English translation).

UNI 9903-1, 1997. Non mineral refuse derived fuels (RDF). Classification and characteristics. (Italian only).

UNI 9903-2, 1992. Non mineral refuse derived fuels (RDF). Terms and definitions. (Italian only).

UNI 9903-3, 1992. Non mineral refuse derived fuels (RDF). Fundamental indications for systematic sampling of fuels. (Italian only).

UNI 9903-4, 1992. Non mineral refuse derived fuels (RDF). Size determination. (Italian only).

UNI 9903-5, 1992. Non mineral refuse derived fuels (RDF). Determination of fuel calorific power. (Italian only).

UNI 9903-6, 1992. Non mineral refuse derived fuels (RDF). Determination of carbon and hydrogen content in fuels. (Italian only).

UNI 9903-7, 1992. Non mineral refuse derived fuels (RDF). Total moisture measurements in fuel samples. (Italian only).

UNI 9903-8, 1992. Non mineral refuse derived fuels (RDF). Determination of volatile substances. (Italian only).

UNI 9903-9, 1992. Non mineral refuse derived fuels (RDF). Determination of ash content in fuel. (Italian only).

UNI 9903-10, 1992. Non mineral refuse derived fuels (RDF). Determination of different chlorine substances in fuel. (Italian only).

UNI 9903-11, 1992. Non mineral refuse derived fuels (RDF). Determination of total nitrogen in fuel. (Italian only).

UNI 9903-12, 1992. Non mineral refuse derived fuels (RDF). Preparation of fuel samples for metal analysis. (Italian only).

UNI 9903-13, 1999. Non mineral refuse derived fuels (RDF). Determination of metals. Method by atomic absorption spectrophotometry. (Italian only).

UNI 9903-14, 1997. Non mineral refuse derived fuels (RDF). Determination of glass content. (Italian only).

Annex G
(informative)

Preliminary ideas on classification and identification systems

NOTE This Annex is based on a document produced by an ad hoc group under Contract NNE5-1999-00533 of the European Commission's Fifth Framework Programme for research. Members of the group were M.Frankenhaeuser (Borealis Polymers Oy), K.Maniatis (EC DG TREN), L.Ramacher (Trienekens AG), J.Van Tubergen (ESSENT Milieu), J.Sarkki (Foster Wheeler Energia Oy) and A.Limbrick (Green Land Reclamation Ltd).

G.1 Background and objective

— The Mandate for CEN TC 335 Solid Biofuel requires a classification by origin and a distinction between renewable and fossil fuels.

— CEN BT created TF 118 to develop a Work Programme for, and to draft a CEN Report on, Solid Recovered Fuels.

— CEN TF 118 has adopted the scope to consider solid fuels made from non-hazardous, mono- and mixed wastes, excluding those fuels, which are included in the scope of CEN TC 335.

— CEN TF 118 has investigated an approach for fuel classification by properties, composition and origin.

— The CEN-Report on Solid Recovered Fuel, to be drafted by TF 118, will include a chapter on Classification. The adopted Work Programme and the CEN Report should be the basis for a Mandate to start drafting the needed standards.

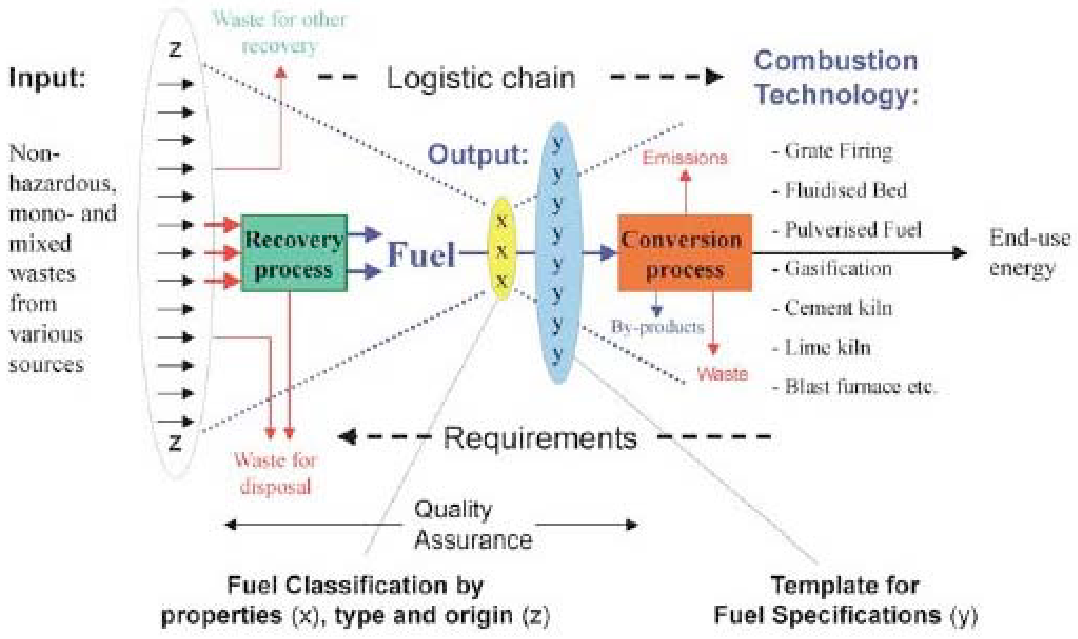

Figure G.1 — System approach for the standardisation of Recovered Fuels

G.2 Terms and definitions

The THERMIE report Fuel and Energy Recovery (DIS-1375-97-FI) proposes a terminology for the following areas: Waste, Fuel, Efficiencies and Emissions. A terminology for practical fuel classification, identification and for commercial fuel characterisation is still needed:

1. Classification System;
tool to classify recovered fuels

2. Characterisation;
description of chemical and physical fuel properties by standard test methods

3. Specification;
tool for setting typical and/or limit values of fuel properties as well as the methods of determination and their precision.

4. Certificate;
signed document of proof (- of analysis, - of composition, - of origin)

5. Data Sheet;
fuel description by typical values for relevant properties

6. Typical value;
normal production quality

7. Limit value;
maximum or minimum allowable value of a fuel property

8. Type**;**
statement of combination of input materials

9. Origin;
source of input materials

10. Source;
initial location in the economic cycle (or sustainable recycling society)

11. Blended;
intentional and controlled combination of known (single) materials

12. Mixed**;**
mixture of multi-component materials

13. Component;
substance or object that can be separated by hand or by other physical means

14. Constituent;
substance that cannot be separated by hand or other physical means

15. Major;
> 80 %

16. Dominant;
> 50 % and < 80 %

17. Significant;
> 20 % and < 50 %

18. Minor;
> 0.1 % and < 20 %

19. Trace;
< 0,1 %

G.3 Purpose and use of classification

A common classification of recovered fuel is necessary in order to increase public trust and confidence, to demonstrate the role of recovered fuels in a sustainable society, and to develop a "level playing field" in the European Union, especially for:

— the fuel, energy and equipment markets

— the permitting authorities

— certification purposes

There are already Finnish and Italian standards and/or classification systems in use and others are under development in The Netherlands and Germany.

A common Classification and Identification System (Figure G.1) for Recovered Fuels could be based on information on key **fuel properties**, as well as on **type and origin**:

1. Limit values (x in Figure G.1) for a number of essential chemical and physical **fuel properties**,

Other customer-specific typical and limit values shall be mutually agreed upon between supplier and customer and be stated in a specification (y in Figure G.1) and/or a datasheet.

2. Type (z in Figure G.1) based e.g. on dominant share of single-, blended- or mixed materials.

3. Origin (z in Figure G.1) based on:

a. the principal source in the economic cycle where the input material comes from, e.g. dominant share of (primary material), pre-use waste or post-use waste, and/or

b. the nature of input materials in the fuel, e.g. major, intermediate or minor share of biogenic material.

A detailed description may be given in a datasheet or a ***certificate of origin.***

Actual test results shall be recorded in a **certificate of analysis**.

A detailed description by material type, e.g. share of wood, paper, board, plastic, rubber or textile, may be given in a datasheet or a ***certificate of composition.***

The elements set out above may be brought together within a quality assurance system that complies with the requirements of ISO 9000 and/or ISO 14001.

G.4 Preliminary ideas on Classification and Identification Systems

All classified solid recovered fuels have to comply with limit values for Heavy Metals as stated in table G.1.

Table G. 1 — Limit values for volatile Heavy Metals

Metal	Limit Value	Method
Hg, mg/MJ_{LHV}	< ?	
Cd + Tl, mg/MJ_{LHV}	< ?	

G.5 Fuel classification by essential fuel properties

Fuel classification by essential fuel properties is as stated in tables G.2 and G.3.

Table G.2 — Main classification system

Main Class	**1**	**2**	**3**	
Parameter **1)**	Limit value	Limit value	Limit value	Method
Chlorine content, g/MJ_{LHV}	<<< ?	<< ?	< ?	
Sulphur content, g/MJ_{LHV}	<<< ?	<< ?	< ?	
Σ 10 Heavy Metals, mg/MJ_{LHV}	<<< ?	<< ?	< ?	

NOTE The highest single value for any parameter determines the Class.

Table G.2 — Sub-classification system

Sub-class Parameter	**a** Limit value	**b** Limit value	**c** Limit value	Method
Ash content, g/MJ_{LHV}	<<< ?	<< ?	< ?	

G.6 A Fuel Identification system (FID)

Fuel identification system (FID according to table G.4 shall be applied to classified solid recovered fuels.

Table G.4 — Fuel Identification System (FID)

Category Parameter	1 Property	2 Property	3 Property	
A. Type of input material: Dominant share of	Single material	Blended material	Mixed Material	
B. Source of material: Major share of	Pre-use waste	Pre- and Post- use waste	Post-use waste	
C. Share of biogenic material, %	> 80	80 - 20	< 20	
D. Code of material	In accordance with European Waste Catalogue	-----	-----	

G.7 Example

Fuel name: XXX; CEN ENV xxxx Class: 1a; FID: A3.B2.C3.D (Code, if applicable).

G.8 Templates for Data sheet and Specifications

(To be developed)

Annex H
(informative)

Survey on solid recovered fuels in CEN Member Countries

H.1 Introduction

This report estimated the production of solid recovered fuels in 2005 at 13 million tonnes. Solid recovered fuels can be produced from a wide range of waste streams and processed into different physical forms. Data about the quality of solid recovered fuel for the substitution of primary fuels, co-incinerated in various combustion technologies in the Member States of the European Union were not available.

This annex of the report tries to present sufficient information about data on recovered fuel production in Europe based on the response to documentation sheets sent to the fuel producers.

In combination with other information this report will be used by DG ENV and DG TREN to decide on a possible mandate to CEN for the establishment of a Technical Committee for solid recovered fuels by the CEN Technical Board.

As agreed in the meeting of CEN/BT/TF 118 in Brussels on 30th May 2001, the JRC Ispra proposed to send a documentation sheet (see Annex H.4) to all known recovered fuel producers in Europe (see Annex C.1). The document was sent out by the end of August 2001 to 129 recovered fuel producers in Europe (see Annex H.2).

In the meeting of the Steering Committee for EC contract NNE5-1999-00533 “Waste to Recovered Fuel” held in Brussels on 26th September 2001, it was agreed to postpone the deadline to 15th October 2001 and CEN and the JRC Ispra sent another letter to the recovered fuel producers (see Annex H.3), stressing that the data received would be used for JRC purposes only and would be treated in the strictest confidence with the aim of producing a CEN Report. Producers were advised to send the documentation sheet back to the JRC Ispra not later than 15.10.2001.

The documentation sheet was designed to collect data about the quality of the recovered fuel produced. Four experts of CEN/BT/TF 118 were involved in the design of the documentation sheet. The documentation sheet was sent to the recovered fuel producers in CEN Member countries, as listed in the CEN/BT/TF 118 N 26 document “Solid Recovered Fuels Part 1” Appendix 3 “Solid recovered fuel producers in CEN Member Countries “.

The data requested are important to the European Commission in that they may contribute to provide a basis for discussion of a possible mandate to CEN for the development of a standard on recovered fuel.

For the preparation of a CEN standard on recovered fuel, knowledge about applied national methods and standards for sampling strategy, digestion and analysis is vital.

The JRC collected and compiled these data in a supplementary CEN Report entitled “Solid Recovered Fuel Part 2”, presented here as Annex H.

In clause 2 of this report, accepted by the working group CEN/BT/TF 118 in Brussels 30th May 2001, the following working definition of the fuel is used:

***Solid Recovered Fuel is a solid fuel of uniform quality which meets public user-oriented specifications. It is prepared from selected pre- and post-use, non-hazardous combustible waste in a dedicated process applying a quality assurance system*.**

For the above fuel definition, data about the quality of the recovered fuel production in Europe must be made available by the producers. In the documentation sheet sent to the producers the following information was requested:

- Characteristics and of the recovered fuel production plant
- Capacity of the plant in Mg/y
- Composition and type of the fuel produced
- Information about sampling strategy
- Information about external controlling of the fuel production
- Information about the analytical methods and what standards are used
- Information about analytical data, heavy metals, chlorine, etc.
- Information about what analytical instrumentation is used

H.2 Evaluation of documentation sheets

H.2.1 General

From 129 documentation sheets sent out to fuel producers in 11 of the CEN Member countries two documentation sheets were received before the first deadline of October 1st 2001. After a new deadline was set at October 15th 2001, 23 documentation sheets were eventually received (All documentation sheets received before December 18th 2001 were evaluated). The response rate was 17%. About 50% of the respondents did not follow the documentation sheet. Some only by attaching another document, others by only sending a document not referring to the specific questions from the documentation sheet. The evaluation of the documentation sheets was for this reason more complicated and time consuming, however the low number of respondents compensated for this. Information extracted from the documentation sheets is summarised in Annex H.5. In Table H.1 below, the European distribution of the replies is given.

Table H.1. — European response distribution

Country	Number of replies	Number of producers	National response rate
Austria	2	26	4 %
Belgium	1	7	14 %
Denmark	0	1	0 %
Finland	2	10	20 %
France	1	3	33 %
Germany	4	19	22 %
Italy	1	25[1]	4 %
Netherlands	8	23	37 %
Norway	0	29	0 %
Sweden	3	8	26 %
United Kingdom	1	4	25 %

1) 24 producers did not receive a documentation sheet. For the response rate calculation they were left out

H.2.2 Plant data

Equipment

All plants are in one or another way sorting plants. A typical example of a flowsheet is: input (waste), mechanical transport (e.g. conveyor belt), separation (e.g. by drum-sieves, air classifiers, handpicking, magnets, dryers), size reduction (e.g. by crushing, shredding), size increasing (e.g. baling, pelletising), output (fuel).

No examples were found of process steps for physical or chemical contaminant removal.

Input material/waste

All replied to this question. A wide range of general waste types was reported. MSW, "commercial" waste, construction and demolition waste are the most common sources. In many cases, general types like "commercial waste" or "industrial waste" were not specified. The most common waste materials are paper, plastic, wood and textiles. In only one case were known contaminants (heavy metals and creosote) in the input waste reported. In one case it was reported that the input waste was not contaminated. In all the other cases no further details (apart from the general waste type indication) were given.

Fuel production capacity

Two respondents did not reply to this question without indicating the reason. The reported fuel production capacities range from 1,600 to 220,000 t/a. Due to the biased distribution over Europe and the probability that large producers replied more than small producers, calculation of a mean production capacity and extrapolation to European overall production capacity is statistically not allowed.

Fuel composition

The fuel composition depends on the waste input. It is obvious that a plant with almost 100% wood waste as input material will produce a wood fuel. Variation (20-90% for plastic) of fuel composition is observed.

Minimum Calorific Value

The reported minimum calorific values vary from 10 to 40 MJ/kg.

Fuel application

The major fuel application is in cement/lime production and power generation.

H.2.3 Sampling data

Compared to the plant data, less data/information were provided for the sampling systems.

All data are given in Annex H.4.

Conveyor belt

Approximately 50% of the respondents apply (random) single probe sampling. 15% apply continuous sampling. The rest (35%) did not reply.

Quartering

15% reported using quartering, the rest did not reply

Number of samples per tonne

40% response. Reported sample numbers ranged from 0.001 to 2 per tonne.

Size

The reported size of the sample material varies from 0.5 mm to 60 mm. It is not clear if it refers to the sample or a milled sample.

Sampling reduction

Different replies were given. Daily and or weekly samples are collected and put together once a month. Quartering is the most common reduction method.

External control

14 of the 23 respondents report to have in one or another way external (and accredited) laboratories for control.

H.2.4 Digestion

Digestion sample amounts

Reported digestion sample amounts vary from 0.5 to 15g.

Digestion procedure and equipment

Both microwave and reflux boilers were reported as digestion equipment. Reported reflux solutions are pure nitric acid, mixtures of nitric acid with hydrochloric and perchloric acid.

H.2.5 Analytical data

Instrumentation

50% did not reply. Five respondents reported using AAS, ICP-OES and Hg fluorescence. Probably they all have the same external laboratory for analysis. ICP–MS was reported four times (in combination with ICP-OES, AAS, capillary electrophoresis).

Analysis

All analytical data are given in the “analysis” tables of Annex H.5.2. The following ranges are reported. Humidity: 1.6-50%, Cal. Value: 15.4-40 MJ/kg, ash: 0.7-18 %, fluorine: 0.001-0.015%, chlorine: <0.01-1.77%, sulphur: 0.02-0.3 %, Cd: 0.16-6 ppm, Tl: < 0.1-0.5 ppm, Hg: < 0.02-0.44 ppm, As: < 0.4-160 ppm, Co: 0.4-7.4 ppm, Ni: <2.5-32 ppm, Se: 0.8-1.7 ppm, Te: 0.6- 1.58 ppm, Sb: 1-39 ppm, Cr: 2.5-226 ppm, Pb: 2.4-300 ppm, Cu: 6.8-1340 ppm, Mn: 22-590 ppm, Sn: 2-20.6 ppm, V: 2.3-5.9 ppm, Be: 0.2-0.3 ppm.

H.2.6 Applied standards in Europe

At present, only a few countries in the EU apply national standards or quality control systems for the production of solid recovered fuel.

Finland

Finnish Standards SFS 5875 “Solid Recovered Fuel, Quality control system”

Germany

Bundesgüte gemeinschaft Sekundärbrennstoffe, the German association for Quality Assurance of Solid Recovered Fuels, Quality and test instructions.

Italy

The Italian standard for RDF, UNI 9903 "Non mineral refuse derived fuels RDF" first published in 1992. It specifies the classification, requirements and methods of analysis applied to RDF for civil and industrial use, covers storage, transportation and documentation.

Sweden

Sweden has a standard for biofuels and peat, which may be applied to RDF production.

A comprehensive table of applied standards for humidity, minimum calorific value, digestion procedure, ash, fluorine, chlorine, sulphur and all heavy metals can be found in the "Standards" table in Appendix II.4.

Humidity

The following standards are applied: SS187170, SOP 125, ÖNORM M6270, DIN 51718, BS 1016 Pt 1, DIN 38414-S2, ISO 589, NEN 5747, SFS 3008, NFT X 31-210, DIN EN 12880 (S2), UNI 9903/7.

No response: 8 out of 23.

Calorific value

The following standards are applied: SS187172 (ISO 1928-1976), SS187171, SOP 113, DIN 51900, ASTM D 3268 (Leco AC-300), ISO 1928, BS1016 Pt 105, NFM 03 005, NEN-ISO 1928, UNI 9903/5.

No response: 7 out of 23.

Digestion Standards

The following standards are applied: SS028150-2, SOP 128/129, EN ISO 11885-E22, NVN 2507/ 5770, CEN/TC 292/GT5, UNI 9903, 12/13.

No response: 12 out of 23.

H.2.7 Discussion

Response rate

After an initial (deadline October 1st 2001) response rate of less than 2%, a new deadline was set at October 15th 2001. A letter by the JRC and CEN stressing that the data would be handled in strict confidentiality was sent to the original list of producers. Despite this letter and the efforts of some trade representatives, the final response did not exceed 18%. All documentation sheets received before December 18th 2001 (being two months after the second deadline) were evaluated. The response rate of 18% is rather low. A typical response rate for a targeted commercial questionnaire with an accompanying letter can be 45-55%. In such a questionnaire there is no direct interest or benefit for the respondents. Regarding the large efforts made by several trade representatives, a direct interest for the respondents was assumed and a high response rate was expected. The low response rate might be caused by the perception that the documentation sheet was inadequate. However four experts of BT/TF 118 were consulted before the documentation sheet was sent to the manufacturers. Possible fear that confidential information about applied technologies would enter the public domain is not justified, since confidentiality was guaranteed and apparently no high technology is applied in the (sorting) plants. The low response rate cannot be explained by this. A general aversion to questionnaires can neither be an explanation, since the documentation sheet differed fundamentally from an ordinary questionnaire in the sense that there is a direct interest/benefit for respondents. A lack of interest seems the most appropriate explanation for the low response rate.

Regarding the response distribution over Europe it is obvious that the survey is biased. The Netherlands has both the highest absolute and relative response rate, whereas Norway has a response rate of 0. Since there are no geographical reasons for this result, the only explanation can be positive or negative lobbies (for filling out the documentation sheet). The sudden change of the response rate (second versus first deadline) confirms the presence of lobbies.

Input material/waste

Poor information was given to the question "Please give details about your input material". Only vague and general descriptions of the waste types (e.g. commercial or industrial waste) were given. Hardly any detailed information was given. A better specification of the waste types is necessary. In one case, known contaminants (heavy metals and creosote) in the input waste were reported. In another case it was reported that the input waste was not contaminated. In most of the other cases, no further detailed information (apart from the general waste type indication) was given. In this way, it is not clear if the input waste, and hence the fuel, contains severe contamination. From the replies it is not clear that, if the input waste is contaminated, the producers are aware of it. The low sampling frequency is probably not sufficient to detect this.

Standards and methods

Many different national standards or best laboratory practices/methods for sampling, digestion and analysis are applied. Large differences in sampling frequency, amounts, sizes, reduction methods and digestion sample amounts make harmonisation necessary.

Analysis

The analytical data show large ranges. Due to the biased distribution and the fact that it is not clear if the scatter in results is caused by "real" differences in the fuel or by differences in sampling, reduction, digestion and or analytical methods, calculation of mean values is statistically not allowed and meaningless. The large ranges justify the need for a standard with limit values.

H.3 Conclusions and recommendations

Conclusions

The response rate (18%) and the biased distribution over Europe, provide sufficient information to give support to the decision making process to give CEN a mandate for drafting a European standard for solid recovered fuels (RDF, etc.).

Regarding the large scatter in applied national standards or best laboratory practices for sampling, digestion and analysis, harmonisation is urgently required.

The large ranges in analytical results justify the need for a standard with limit values.

More detailed information about the input waste is necessary.

Recommendations

Considering the large scatter in analytical results, fuel classes with impurity limits are recommended. This is further justified for technical reasons like corrosion protection in boilers and constant process conditions, and constant product quality in co-incineration.

In order to give the decision making procedure and or the drafting of a European standard more support, a more representative survey based on more documentation sheet replies could be helpful. Producers not having filled out the documentation sheet have to be contacted again and possible new documentation sheets have to be evaluated. A possibility might be to contact (by letter, fax, e-mail, or telephone) all the producers informing them briefly about the results of the survey and asking them to fill out the documentation sheet. More and more detailed information about the input waste is absolutely necessary (in any way for the standard).

It is recommended to DG ENV to give a mandate to CEN for drafting a European standard for solid recovered fuels (RDF, etc.).

H.4 Documentation Sheet

Recovered fuel production in European CEN Member States

Please send the documentation sheet back to:
Heinrich Langenkamp
European Commission
JRC ISPRA
I-21027 ISPRA/VA
Tel: 0039-0332-789487
Fax: 0039-0332-789158
e-mail: heinrich.langenkamp@JRC.it

Details of the person who filled in the documentation sheet: Company name: Country: Name: Address: Phone: Fax: e-mail:	
Description of the data set	
General characteristics of the recovered fuel production plant.	*Please give a brief description of the installation and describe the incoming waste:*
Please give a flow sheet of your production plant.	
In what industry is the fuel used?	
Please give details about your input material:	
Capacity of the plant	Indicate the production of fuel in Mg/y
Type of fuel produced:	Please give the name of the product and indicate the percentages of Paper, plastic or other materials in the fuel Paper: % Plastic: % Textiles: % Wood % Other material (bio-waste, rubber, etc.)…………..% Indicate the minimum calorific value: MJ/kg

Sampling strategy *What kind of sampling is applied?*	☐ Please give a short description of the sampling system Conveyer belt sampling: Continuously: Single probe: Core sampling, single mixed, number of cores: Quarter sampling: Other sampling procedures applied please explain: Amount of samples: per Mg (internal controlling) Size of the sample material: mm to mm	
Describe your sampling reduction procedure.	Please indicate how you proceed:	
External control	Number of controls carried out by external laboratories: Number of external controls (accredited laboratories) depending on the fuel production Mg/y	

Determination of the humidity	Please specify analytical method (standard)
Determination of the calorific value	Please specify analytical method (standard)

Digestion method(s) for determination of trace elements	International standard please specify if CEN or ISO: National standard or other standards used: Please describe the digestion procedure in detail (specify the digestion solution):
	Please specify the analytical method (standard, solid : liquid ratio):
Please indicate what type of digestion equipment was used:	Microwave: Sample in g, Standard used. ISO, CEN, or national standard Microwave pressure system: Sample in g, Standard used. ISO, CEN, or national standard Other digestion methods:

Analytical results of the fuel

Please indicate the whether data sets contain: 1. raw data, 2. 80.percentile data, 3. median data

Parameter	Unit	Data	Standard applied
Humidity	Weight % raw matter		
Calorific value	MJ/kg dry material		
Ash content	Weight % dry mater.		
Fluorine content	Weight % dry mater		
Chlorine content	Weight % dry mater.		
Sulphur content	Weight % dry mater.		
Cadmium	mg/kg dry material		
Thallium			
Mercury			
Arsenic			
Cobalt			
Nickel			
Selenium			
Tellurium			
Antimony			
Chromium			
Lead			
Copper			
Manganese			
Tin			
Vanadium			
Beryllium			

Please indicate what analytical instrumentation is used.	AAS ICP-OES ICP-MS Other Please specify the used analytical methods (standards)	

Data sets	If individual data sets refer to different analytical methods, does the evaluation take into account these differences (e.g. by correction factors or functions) Yes No If ‘Yes”, please specify: Do the data sets include samples that have been considered as contaminated? Yes No If “Yes”, are these samples eliminated before data evaluation? Yes No If “Yes”, please specify how contaminated samples were identified: If “No”, please specific the composition and the number of the contaminated samples and how the contamination was identified.

Covering letter for documentation sheet

Ispra, 2001-07-31

<u>Request of data about recovered fuel production in Europe</u>

Dear Sirs,

The Soil and Waste Unit of the JRC Ispra has been asked by the Sustainable resources Unit (A2) of DG ENVIRONMENT for information regarding data on recovered fuel production in Europe.

The CEN/BT/Task Force 118 Solid Recovered Fuel Working Group adopted the CEN report ‘Solid recovered fuel Part 1” at the last meeting in Brussels. It was further agreed at this meeting that more data about recovered fuel production are needed before the European Commission can reach an informed decision about whether to give a mandate to CEN for the development of a CEN standard on recovered fuel.

The data identified as needed by CEN/BT/Task Force 118 include data on recovered fuel properties, sampling techniques, analytical data, applied standards and methods, applied in the production of recovered fuel in Europe. The JRC is collecting these data which will be compiled in a supplementary CEN Report entitled Solid Recovered Fuel Part 2.

The attached documentation sheet is being sent to all fuel producers in the CEN member countries and also to the members of CEN/BT/TF 118. We would ask you to complete the requested data, where available and send the documentation sheet back to the JRC Ispra, not later than October 1. 2001.

Yours sincerely

Heinrich Langenkamp
Soil and Waste Unit
Environment Institute

Annex: documentation sheet

Confidentiality letter

To: Recovered fuel producers

Brussels, 2001-09-27

Dear Sir, Madam,

CEN is planning to initiate standardisation activities in the field of Solid Recovered Fuels. The aim is to set the criteria for a European solid recovered fuels market.

This work is done in close co-operation with the Commission's services. The CEN/BT TF 118 "Solid recovered fuels" has done the preparatory work. In January 2002, CEN will have to decide weather or not we can go ahead with the whole project. It is our firm belief that we should go ahead, in full co-operation with the Commission's services. The next three months are crucial in the decision making process.

At the last TF 118 meeting it was decided to draft Part 2 to the CEN Report. This work is conducted by the Commission's Joint Research Centre ISPRA, who by letter of 2001-07-31, asked for basic information on the issue. Up to now, only few documentation sheets were returned.

We would like to stress that your data will be used for Commission purposes only and be handled in strict confidentiality. The collected data will be used to make a general overview of the European situation, without reference to individual companies.

We would therefore like to ask you to complete the documentation sheet before 15 October 2001 (original deadline is 1 October 2001) and send it back to Heinrich Langenkamp (e-mail: heinrich.langenkamp@jrc.it) of the Joint Research Centre in Ispra (Italy).

In case of queries, do not hesitate to directly contact Mr. Langenkamp on phone +39.0332.789487, or other Commission officials in DG TREN, ENV and DG ENTR.

Looking forward to your collaboration.

With very best regards,

Guido De Jongh — Heinrich Langenkamp

Project Manager - CEN — Soil and Waste Unit

cc: Commission's Documentation sheet

H.5 Evaluation tables

H.5.1 Sampling, reduction, digestion and analytical methods

plant	sampling system						sampling reduction	external control	
	conveyer belt	remarks	quarter	other	amount per ton	size mm		no	no/ton fuel
1	single probe							by customers	
2		SOP 150				< 0.5		accredited lab	
2b									
3									
4	single probe			SFS 5875		< 50	SFS 5875 from 600l to 25l		
5	random and regular				0,1			20	
6	none			density				none	
7	single probe				several/1000	< 60	from 10 kg to 0.5 kg	accredited labs	
8	single probe	week-4 week samples	yes			10-20		accredited lab	
9	single probe	week-4 week samples	yes					customers	
10									
11	NL standard ?								
12	continiously				0,005	<1	day-week	yes 6/week	
13	single probe				0,001	<30	day-week-3 weeks	yes 0.33/week	0,00036
14					0,04	50	truckload-month	yes 1/month	
15									
16	single probe					<1	day-week-4weeks	yes 1/4 weeks	
17									
18	single probe				2	10-20		yes	
19	"sometimes"				0.5 l	10-20	LAGA -directive PN2/78 K	all ?	
20	continiously								
21	continiously		yes		0,1	10-20			0.67-1 E-4
22	single probe					< 1	week-month	yes	
23	continiously		yes	cumulus	0,3	16-50	65kg-16kg-4kg	20% of analysis	0,002

plant	digestion sample			
	amount	procedure	equipment	analytical instrumentation
1		boiled in nitric acid		ICP-OES, ICP-MS, AFS (Hg)
2		perchloric/nitric acid		
2b		perchloric/nitric acid		
3				
4		attached list		ICP-AES, GF-AAS
5				AAS, ICP-MS
6			XRF	XRF
7		DIN 38414-S7		
8	0.5g		CEM Mars 5	AAS, ICP-OES, Hg fluorescence
9	0.5g		CEM Mars 5	AAS, ICP-OES, Hg fluorescence
10				
11				
12		HCl/HNO3 reflux		AES, ICP-AES
13				
14				ICP-MS, Capillary Electrophoresis
15				
16	0.5g		CEM Mars 5	AAS, ICP-OES, Hg fluorescence
17				
18		see description	cal. Bomb	AAS, ICP-OES, Hg fluorescence, spec. electrode for F, Ammeter for Cl
19	1-2g	HCl/HNO3 3:1	microwave	ICP-MS
20				
21				
22	0.5g	see description	microwave	AAS, ICP-OES, Hg fluorescence
23	15 g	boiled in nitric acid		AAS, ICP-OES

H.5.2 Analysis

plant		parameter									
		humidity	cal.value	ash	fluorine	chlorine	sulphur	Cd	Tl	Hg	As
		weight % a.r.	MJ/kg d.m.	weight % d.m	weight % d.m	weight % d.m	weight % d.m	ppm d.m	ppm d.m	ppm d.m	ppm d.m
1	product 1	20-45	20.2	0.7-1.5	n.a.	<0.01	0.05-0.11	<2.5	<0.1	<0.02	1.2
1	product 2	10-50	19.4-20.2	1.2-5	n.a.	<0.014-0.12	0.04-0.19	0.23-2.6	<0.42	<0.02-0.76	10-160
2		13.6	21.43	15.3	0.005	1.77	0.19	5.9	<3	0.44	1.0
3				1.8							
4	product 1	18.92	16.51 a.r.	6.46	<0.1	0.26	0.1	0.16	<15	0.05	20.3
4	product 2	31.84	14.21 a.r.	9.98	<0.1	0.51	0.19	6.06	<15	0.23	8.75
5	product 1	1.6	17.5	13.5		0.5	0.2	2		0.2	2
5	product 2	25	17.5	3		0.02	0.2	0.5		0.1	30
6		10	18	10		0.15	0.15	0.2	<0.1	<0.5	0.5
7		10.2	16		0	0.2	0.3	1	0.5	0.4	0.5
8		4.2	20.8	9.6	0.008	0.34	0.13	1.71	<0.35	0.31	5.5
9											
10											
11											
12		2.5-3	18.5	1-2	0.002	0.05-0.15	0.1-0.2			<0.15	
13		<35	>11	<20	<0.5	<1.2	<0.5	<6	<1	<1	<10
14		35.4	22.77	8.8		0.31	0.057	1.3	<0.1	0.16	5.0
15											
16											
17		22.3	20.550	11.1	0.015	0.66	0.17	1.8	<1	0.39	2.7
18		4-8	25-40	5-15	0.001-0.005	0.05-0.2	0.02-0.03	<2		<0.1	<0.4
19		9.2				0.09		<0.4		0.047	<15
20											
21											
22		23.3	15.390	13.3	0.0013	0.32	0.16	0.6	<1.1	0.1	0.7
23		12	21.6	18		0.89	0.18	1.26		0.36	0.44

plant												
	Co	Ni	Se	Te	Sb	Cr	Pb	Cu	Mn	Sn	V	Be
	ppm d.m	ppm d.m	ppm d.m	ppm d.m	ppm d.m	ppm d.m	ppm d.m	ppm d.m	ppm d.m	ppm d.m	ppm d.m	ppm d.m
1	<2.5	<2.5	<50	n.a.	<25	2.5	4.5	6.8	50	n.a.	<5	<0.25
1	0.4-2.6	11-17	n.a.	n.a.	n.a.	15-170	2.4-112	15-180	80-130	n.a.	<10	n.a.
2	7.4	20.3			8.7	226	87.2	1340	185	2.4	5.9	
3												
4	<25	7	n.a.	n.a.	<25	60	22	125	85	2.0	<15	n.a.
4	<25	17	n.a.	n.a.	<25	136	52.38	83	207	7.6	<15	
5		20				40	150	500				
5		5				50	50	60				
6	1.4	2.5			1.0	4.8	8	32	22	2.4	1.8	
7	1.0	27.0	0.8	1.0		80	170	215		15.5	5.4	0.2
8	3.5	24	1.7	1.58	39	54	92	140	68	16	3.98	<0.2
9												
10												
11												
12							300			<5		
13	<20	<100	<5	<5	<100	<250	<300	<800	<300	<50	<100	<5
14	1.6	7.6			2.5	47	54	54	78	1.6	2.3	
15												
16												
17	3.4	32.0	1.2	0.6	23.5	80	194.2	176.0	66.2	20.6	5.0	0.17
18		<10-50				<10-25	<10-20	<10-35				
19		11				42	<15	13	590			
20												
21												
22	2.8	18.9	<1.1	<1.1	5.9	72.2	84	38.3	64	6.3	5.9	0.3
23		26				95.3	228		138			

H.5.3 Standards

plant	parameter						
	humidity	cal.value	digestion	ash	fluorine	chlorine	sulphur
1	SS187170	SS187172 (ISO 1928-1976)	SS028150-2	SS187171		SS187185	SS187177
2	SOP 125	SOP113	SOP 128	SOP114	SOP 118	SOP 117	SOP 115
	ÖNORM M6270	DIN 51900	SOP 129	DIN 38414 T3		DIN 51727	DIN 51724 T1
							ÖNORM EN ISO 11885
3		SS187171		ISO 1928			
4	DIN 51718	ASTM D 3268 (Leco AC-300)					
5	SS 187170	SS-ISO 1928	SS028150	SS187171		SS187183	SS187177
6	BS1016 Pt 1	BS1016 Pt 105		BS1016 Pt 104		BS1016 Pt 8	ASTM D4239-94
7	DIN 38414-S2	DIN 51900 T1	EN ISO 11885-E22				
8	ISO 589	NEN-ISO 1928	NVN 2507/ 5770				
9			NVN 2507/ 5770				
10							
11							
12	NEN 5747	ISO 1928	NVN 5770	NEN-ISO 1171	ASTM D3761	DIN 51757	ASTM D129
13	DIN 51718	DIN 51900			DIN 51727	DIN 51727	
14	SFS 3008	DIN 51900		SFS 3008			
15							
16	ISO 589	NEN-ISO 1928	NVN 2507/ 5770				
17							
18	NFT X 31-210	NFM 03 005	CEN/TC 292/GT5	NFM 03 003	NFT 90 004		NFM 03 009/NF EN ISO 11885
19							
20	DIN EN 12880 S2	DIN 51900		DIN 51719	DEV-D4-1	DEV-D20	DEV-D20
21							
22	ISO 589	NEN-ISO 1928	NVN 2507/ 5770				
23	UNI 9903 /7	UNI 9903/5	UNI 9903, 12/13	UNI 9903		UNI 9903	UNI 9903

plant	parameter					
	Cd	Tl	Hg	As	Co	Ni
1	SS028150-2					
2	SOP 45	SOP 45	SOP 134	SOP 134	SOP 45	SOP 45
	ÖNORM EN ISO 11885	ÖNORM EN ISO 11885			ÖNORM EN ISO 11885	ÖNORM EN ISO 11885
3						
4						
5			SS028150	FCP AES+AAS		FCP AES+AAS
6	XRF					
7						
8						
9						
10						
11						
12	NVN 7322		0-NEN5779	NVN 7322		
13	EN ISO 5961	38406/26	EN 1483	EN ISO 11969		38406/11
14	SFS 3047				SFS 3047	SFS 3047
15						
16						
17						
18	NF EN ISO 11885		NF EN 1483	NF T 90 119		NF EN ISO 11885
19						
20	DIN EN ISO 11885	DIN EN ISO 11885	DIN EN 12338-5	DIN EN ISO 11885	DIN EN ISO 11885	DIN EN ISO 11885
21						
22						
23	UNI 9903		UNI 9903	UNI 9903		UNI 9903

plant	parameter					
	Se	Te	Sb	Cr	Pb	Cu
1						
2			SOP 134	SOP 45	SOP 45	SOP 45
				ÖNORM EN ISO 11885	ÖNORM EN ISO 11885	ÖNORM EN ISO 11885
3						
4						
5				FCP AES+AAS	FCP AES+AAS	FCP AES+AAS
6						
7						
8						
9						
10						
11						
12			NEN6433	NVN7322	NVN7322	NVN7322
13	38405/23	38405/23	38405/22	EN 1233	38406/6	38406/7
14					SFS 3047	SFS 3047
15						
16						
17						
18				NF EN ISO 11885	NF EN ISO 11885	NF EN ISO 11885
19						
20	DIN EN ISO 11885	DIN EN ISO 11885	DIN EN ISO 11885	DIN EN ISO 11885	DIN EN ISO 11885	DIN EN ISO 11885
21						
22						
23				UNI 9903	UNI 9903	

plant	parameter			
	Mn	Sn	V	Be
1				
2	SOP 45	SOP 134	SOP 45	
	ÖNORM EN ISO 11885		ÖNORM EN ISO 11885	
3				
4				
5				
6				
7				
8				
9				
10				
11				
12		NVN7322		
13	38406/22	38406/22	38406/22	38406/6
14				
15				
16				
17				
18				
19				
20	DIN EN ISO 11885	DIN EN ISO 11885	DIN EN ISO 11885	DIN EN ISO 11885
21				
22				
23	UNI 9903			

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