Environment Agency

using science to create a better place

Update on the international use of substitute liquid fuels used for burning in cement kilns

SC030168/SR1

ea/br/e/sci/v1

SCHO0106BJZL-E-P

The Environment Agency is the leading public body protecting and improving the environment in England and Wales.

It's our job to make sure that air, land and water are looked after by everyone in today's society, so that tomorrow's generations inherit a cleaner, healthier world.

Our work includes tackling flooding and pollution incidents, reducing industry's impacts on the environment, cleaning up rivers, coastal waters and contaminated land, and improving wildlife habitats.

This report is the result of research commissioned and funded by the Environment Agency's Science Programme.

Published by:
Environment Agency, Rio House, Waterside Drive, Aztec West, Almondsbury, Bristol, BS32 4UD
Tel: 01454 624400 Fax: 01454 624409
www.environment-agency.gov.uk

ISBN: 1844325261

This report is printed on Cyclus Print, a 100% recycled stock, which is 100% post consumer waste and is totally chlorine free. Water used is treated and in most cases returned to source in better condition than removed.

Further copies of this report are available from:
The Environment Agency's National Customer Contact Centre by emailing enquiries@environment-agency.gov.uk or by telephoning 08708 506506.

Author(s):
Baird, D. Prosser, G

Dissemination Status:
Publicly available

Keywords:
Cement|Substitute Fuels|Co-incineration

Research Contractor:
Atkins Process
Woodcote Grove
Ashley Road
Epsom
Surrey KT18 5BW

Environment Agency's Project Manager:
Martin Whitworth
Environment Agency
Block 1, Government buildings
Burghill Rd
Westbury on Trym
BS10 6BF

Science Project reference:
SC030168/SR1

Product Code:
SCHO0106BJZL-E-P

Science at the Environment Agency

Science underpins the work of the Environment Agency. It provides an up-to-date understanding of the world about us and helps us to develop monitoring tools and techniques to manage our environment as efficiently and effectively as possible.

The work of the Environment Agency's Science Group is a key ingredient in the partnership between research, policy and operations that enables the Environment Agency to protect and restore our environment.

The science programme focuses on five main areas of activity:

- **Setting the agenda,** by identifying where strategic science can inform our evidence-based policies, advisory and regulatory roles;
- **Funding science,** by supporting programmes, projects and people in response to long-term strategic needs, medium-term policy priorities and shorter-term operational requirements;
- **Managing science,** by ensuring that our programmes and projects are fit for purpose and executed according to international scientific standards**;**
- **Carrying out science**, by undertaking research – either by contracting it out to research organisations and consultancies or by doing it ourselves;
- **Delivering information, advice, tools and techniques,** by making appropriate products available to our policy and operations staff.

Steve Killeen

Head of Science

CONTENTS

ABBREVIATIONS

The following list contains the same abbreviation as were found in the 1998 Survey plus additional abbreviations added to suit the updated report.

APCD	Air pollution control device
AITEC	Italian Cement Agency
ATILH	Association Technique de l'Industrie des Liants Hydrauliques
BACT	Best available control technology (US)
BAT	Best available techniques
BCA	British Cement Association
BIF	Boiler and Industrial Furnace Regulations (US)
CAA	Clean Air Act (US)
CEMSUISSE	Switzerland Cement Association
CEVA	Slovak Republic Cement Agency
CFR	Code of Federal Regulations (US)
CIF	Cement Industry Federation (Australia)
CKD	Cement kiln dust
CV	Calorific value
DOT	Department of Transport (US)
DRE	Destruction and removal efficiency (US)
EA	Environment Agency (UK)
EPA	US Environmental Protection Agency (US), also Irish Republic Environment Agency
EU	European Union
EULA	European Union Lime Association
FEBELCEM	Belgium Cement Agency
FLS	F.L. Smidth, cement equipment manufacturer
HWF	Hazardous waste fuel (American classification of SLF)
KHD	KHD Humboldt Wedag A.G., cement equipment manufacturer
LCUK	Lafarge Cement United Kingdom
LCV	Lower calorific value
MACT	Maximum achievable control technology (US)
MBM	Meat and bone meal
MEI	Maximum exposure individual (US)
MSC	Multi-staged combustion for NO_x reduction
NESHAP	National Emission Standards for Hazardous Air Pollutants

	(US)
NSPS	New Source Performance Standards (US)
OFICEMEN	Spanish Cement Agency
PCB	Polychlorinated biphenyls
PCDD	Polychlorinated dibenzo-*p*-dioxins
PCDF	Polychlorinated dibenzofurans
PCP	Pentachlorophenol
PCT	Polychlorinated triphenyls
PIC	Products of incomplete combustion (US)
POHC	Principal organic hazardous constituents (US)
PSP	Processed sewage pellets, also
	A cement equipment manufacturer
RCRA	Resource Conservation and Recovery Act (US)
RfDs	Reference doses (US)
RLF	Recycled liquid fuel (term for SLF)
SFIC	French Cement Agency
SFP	Substitute Fuels Protocol
SLF	Substitute liquid fuel
SNCR	Selective non-catalytic reduction – NO_x reduction technique
TOC	Total organic carbon
USA	United States of America
VDZ	Verein Deutscher Zementwerke, German Cement Organisation
VOC	Volatile organic compound
VOZ	Austrian Cement Agency
WID	Waste Incineration Directive (EU)

EXECUTIVE SUMMARY

A study into the use of substitute liquid fuels (SLF) was carried out by Atkins during 1998-1999 and was reported in early 1999. This survey included the major European countries plus the USA and used data available for 1995-1997. In May 2004, the European Union (EU) expanded with 10 new member states, which were not surveyed in the earlier Atkins report.

The purpose of this new report is to update the information on the use of SLF in Europe and the USA, taking into account the new EU member states. It is not intended to repeat information available in the earlier report, such as the specifications of the SLF used or the cement making process sections. These data are still relevant to the current SLF studies and updates are included here.

There have been some significant changes in the cement industry since the earlier report. These changes include:

- Greater globalisation of cement manufacture, with expansion and/or acquisitions by the major cement producers, such as Lafarge, Holcim, Heidelberg, Italcementi, Cement Roadstone Holdings (CRH), etc.
- These major players have well-developed programmes to minimise costs by maximising the use of alternative fuels. They have also invested heavily in modernising their new plants and/or processes to improve process efficiency, maximise alternative fuel usage and minimise plant emissions. With greater emphasis upon minimising CO_2 emissions, the greater use of biofuels becomes increasingly more important.
- The alternative fuel market has become more sophisticated and most of the major companies prepare wastes via specialist subsidiary companies.

The definition of SLF has been widened in this report to incorporate a wider range of liquid fuels, including fuels with a minimum calorific value (CV) below the previous limit of 21 MJ/kg. The main conclusions of this report are listed below.

The use of SLF in Europe and USA – Tonnages and Thermal Substitution Rates

- SLF continue to form an important part of the national alternative fuel usage. The major European countries are reported (by Cembureau in their September 2004 report) to use around 841,000 tonnes per annum (tpa) SLF, which represents a thermal substitution rate of 3.04%.
- The total alternative fuel usage was around 12.23%, and so SLF represent 24.9% of the total alternative fuel usage.
- The key users of SLF in Europe continue to be France, Belgium, Austria, Switzerland and Germany.
- Atkins have updated the estimates of SLF usage and found that the above estimate may be an underestimate, as it does not include all of the EU states.

- Unfortunately, it has been very difficult to obtain factual usage data from most of the cement companies, national cement and/or environment agencies, and fuel blenders contacted during the survey. However, literature and web surveys imply that the overall use of SLF in the expanded EU was slightly in excess of one million tpa in 2003.
- The problem with defining SLF tonnages alone is the increased use of solid medium, such as sawdust, in conjunction with liquid wastes. As an example, the Danish cement alternative fuel figures included 5000 tonnes of waste oil (bitumen), which is normally counted in with the solid waste fuel tonnage.
- It was felt important to demonstrate the trends in the use of SLF in different countries, where data were available. This allowed us to consider SLF usage in the wider context of alternative fuel usage. The following trends were noted.
- In the USA the use of SLF in 2003 was very similar to their use in 1996. The SLF volume increased 39.3% on its 1996 volume before returning to a similar level of consumption. While the total use of alternative fuels has increased, this growth results from the greater use of solid waste fuels, not of SLF.
- Austria is a good example of an EU member state with a well-developed alternative fuel use in its cement industry. A similar pattern emerges in which the use of SLF between 2000 and 2003 has only increased from 9.6% to 10% thermal substitution. In the same period, all alternative fuels increased from 33.5% to 48.1% through the significant increase in solid waste fuels.
- Similar trends were observed in Switzerland, where the additional 71,345 tpa of alternative fuels used between 2000 and 2003 included only 12,400 tpa of SLF.
- In Spain the increase in solid alternative fuel tonnage was 3.4 times higher than the corresponding SLF tonnage increase.
- The use of SLF and other alternative fuels in the UK cement industry is not as advanced as that in several European countries. The UK average use of around 6% thermal substitution is low compared with that in The Netherlands (83%), Austria (48.1%), Germany (38.2%), France (34.1%), Belgium (30%), Norway (35%) and The Czech Republic (25%).
- The overall conclusion regarding the usage of SLF is that the tonnage used appears to reach a certain level and then stabilises. This may be the result of several factors, such as:
  - changes in fuel preparation;
  - diversion of some liquids to solid waste fuel production;
  - supply quantity, quality and/or cost considerations;
  - availability of more cost-attractive fuels with a better gate fee;
  - local pressure to dispose of other waste materials (e.g., meat and bone meal), etc.

  It was not possible to come to any firm information and/or market reasons for the observed patterns of SLF use. Hence the above possible explanations must remain conjectural until wider research is carried out.

The use of SLF in Europe and the USA – Environmental Legislation

Since the earlier report legislation concerning the burning of hazardous waste in cement kilns has changed significantly, in both the USA and the EU.

In the USA, the Boilers and Industrial Furnaces (BIFs) rule has been superseded by maximum achievable control technology (MACT) rules. This new piece of legislation is a technology-based approach rather than the mainly risk-based standard of the previous rules.

In the EU the Waste Incineration Directive (WID) 2000/76/EC has replaced the Prevention of Air Pollution from Waste Incinerators directives, 89/369/EEC and 89/429/EEC and the Hazardous Waste Incineration Directive (HWID) 94/67/EC. The WID extends the scope of the previous directives to cover the incineration of toxic wastes not previously covered by 94/67/EC. Special provisions for cement kilns are laid out in the directive. Where a specific pollutant is not covered a formula is used to calculate an emission limit.

General Considerations

- Economics of using SLF – no data on gate fees was received from the limited number of replies to the Atkins enquiry letters. This area remains a sensitive issue because of commercial considerations. Some general observations on the economic factors and process implications of using SLF are included in the report. An assessment of the viability of using SLF can only be made on a site-specific evaluation of all the process and/or environmental factors involved.
- The technology of cement making processes has developed significantly since 1998 and some background notes are included. These are relevant as there has been a substantial modernisation of kiln plants in Europe and the USA. The examples quoted for new cement kiln installations plus plant retrofits and modernisations show that to maximise alternative fuel use is a major design consideration.
- During the data gathering exercise, additional data were obtained on the use of SLF within Australia and Japan. These data are included as they show the differences between the use of SLF and other alternative fuels in a well-developed SLF user (Japan) and that in a developing SLF user (Australia). There are parallels with the European situation, where the accession states are usually not as advanced in their use of SLF and/or alternative fuels as are France, Belgium, Austria, Switzerland and Germany.
- A brief review of the published data for three major cement producers is also included to show the level of thermal substitution achieved by the major companies who aim to maximise the use of such fuels for commercial and environmental considerations.

1 Introduction

In January 2005, the Environment Agency commissioned Atkins to provide an update of their earlier report (1998) on the use of substitute liquid fuels (SLF) in the cement and lime industries of Europe and the USA, plus a review of the legislation, which covers the use of SLF. This report represents an update of the earlier report, which is still considered to be relevant to the subject of SLF usage. For these reason the earlier report should also be studied as it provides more supporting information on the quality of the SLF used in different countries. The following objectives and scope of study were identified: -

1.1 Work objectives

- To update information on the amount, substitution rate and composition of SLF being burned in both cement and lime kilns in Europe and the USA;
- To update information on the legal framework for permitting SLF burning in cement kilns in Europe and the USA.

1.2 Scope of study

- Only liquid fuels or combinations of liquid and solid fuels are to be considered.
- Countries to be evaluated are those specified in the original report P282, prepared during 1998-1999 and published in early 1999. This report is referred to here as the 1998 Survey. It mainly considered the data that were available from the period 1995 to 1996.
- Since the latter report was published, the European Union (EU) has expanded with the new members (accession states). From 1 May 2004, the 10 new EU members are Czech Republic, Slovak Republic, Hungary, Slovenia, Latvia, Lithuania, Estonia, Cyprus and Malta.
- References to best available techniques (BAT) should be included as appropriate.
- The format and structure of the original report should be maintained as far as practicable.
- Where limits are quoted in units other than 10% oxygen, dry, 273K, 101.3 kPa, both the original units and a conversion to these conditions are to be included.
- Information on the locations, types and capacities of kilns is to be included.
- Performance data are to be included where available.

1.3 Methodology used

The methodology used can be summarised as follows:

- An initial meeting between the Environment Agency and Atkins was held by videoconference on 23 December 2004. This meeting served to clarify the objectives of this study.

- Draft enquiry letters were drawn up in January 2005. These took three basic formats to suit (a) cement companies and international groups, (b) national cement agencies and national environment agencies or (c) fuel blenders and/or suppliers of SLF.
- The definition of SLF was widened to include those alternative fuels that use SLF in combination with a solid medium, such as SLF-impregnated sawdust.
- For this study, SLF with a minimum calorific value (CV) value below 21 MJ/kg were also to be considered. This allows for the use of waste water, water-contaminated diesel, etc., provided such fuels meet the European Court of Justice (ECJ) criteria.
- The Environment Agency provided Atkins with a letter of Introduction that requested support for the study. This was duly attached with the enquiry letters, which were issued in late January or early February. Over 100 enquiry letters were issued together with over 20 e-mail requests for data. Two samples of the enquiry letters are given in Appendices 1 and 2.
- It was appreciated that many cement companies and organisations could consider the information requested to be confidential and commercially sensitive. While seeking the information directly from the various cement and/or lime organisations, Atkins also undertook a literature search plus an Internet search for data.

1.4 Tasks

The key tasks identified were very similar to those carried out in the 1998 Survey:

- Identify the countries and cement plants at which SLF are burned in cement and/or lime kilns. Update to include new EU countries not covered in 1998 Survey.
- Provide information on the volumes of SLF used and estimate the thermal substitution rate achieved.
- Update any new data on SLF composition.
- Update the information regulatory regime and emission limits used to control the releases from plants at which SLF are fired.
- Identify any special abatement systems used to clean up the releases from plants at which SLF are fired.
- Estimate the economics of SLF usage on each plant, including any subsidies and their sources.

1.5 General comments concerning tasks

The above key tasks have been followed as far as possible. However, during the course of this study it was apparent that several major companies and organisations were unwilling to provide information that they regarded as confidential or commercially sensitive. Hence, it was not possible to obtain any reliable information concerning the economics of burning SLF. However, some general observations based upon the practical aspects and/or economic considerations regarding burning SLF are included within this report. Similarly, some organisations were not prepared to indicate where they were burning SLF or the tonnages involved. In this situation, an estimate of the use of SLF has been made using the data available in the literature and on the web. By piecing together these sources of information, a very rough estimate of the fuels used can be made. However, it must be appreciated that the accuracy of such estimates may not be very high, especially as the sources of fuels used for SLF may vary within countries and locations. In several cases, literature and web data were found to contain contradictory data, which had to be checked by further searches before any estimates could be made. Another factor is the timescale. It is clear that the growth in alternative fuel use in Europe and the USA means that data are soon out of date. Several organisations have indicated that their environmental reports, etc., for 2004 will not be released until after the end of March 2005. Hence these data cannot be included here.

In the course of the data-gathering exercise, Atkins found some additional information concerning the use of SLF in countries other than the USA and those in Europe. To capture this information some additional notes have been included for Australia and Japan. Major cement organisations, such as Holcim and Italcementi, also publish details of their global use of alternative fuels. Where relevant, some of these data are also included.

1.6 Definition of SLF

The definition used for SLF is given in Appendices 1 and 2 and the wider range of waste liquid fuels examined is also noted in Section 1.3 above. This is to reflect the changes proposed to the Substitute Fuels Protocol (SFP), which included:

The main proposals are: removal of the minimum calorific value (21 MJ/kg) criteria for waste materials provided that: the main purpose is the generation of heat; the amount of heat generated, recovered and effectively used is greater than the amount of heat consumed in its use; and the principal use of the waste is as fuel. This gives the potential to increase the number of waste types that could be used as fuel.

During the course of this study it became clear that SLF are only one component in the overall picture of using alternative fuels in the cement industry. To examine the pattern of SLF usage it has to be seen in the context of the other fuels used. A further complication when assessing SLF usage is the practise of mixing SLF with solid media, such as sawdust. When tonnages of impregnated sawdust are reported they may not indicate the component tonnages of waste liquids used. Hence there is more risk of underestimating SLF use rather than overestimating it.

The preparation of SLF is now well developed, with the major cement groups operating fuel-blending facilities such as:

- Scoribel is a subsidiary of Holcim Belgium and of Scori;
- CemMiljo is a subsidiary of Aalborg Portland, which is part of the Italian Cementir Group;
- Lafarge North America, Inc., has a wholly owned subsidiary, Systech Environmental Corp.

In addition, the sources of materials used to produce fuels derived from solid waste and SLF may not be of national origin. For example, some 18,000 tonnes of waste was imported from Norway for processing by CemMiljo in Denmark during 2003. The following ruling is also relevant to the current global situation concerning SLF – to quote the Environment Agency's own web site:

Recent European Court of Justice (ECJ) judgments on transfrontier shipment of waste clarified the criteria for distinguishing between recovery and disposal of wastes. Revision of the Substitute Fuels Protocol is also consistent with new EU legislation (the Waste Incineration Directive) and European Court of Justice judgments.

The composition of some solid wastes may include components that fit the description of SLF given in Appendices 1 and 2. The definition is complicated because semi-liquid or solid 'sludges' are used to produce solid waste fuels, and so the strict definition of liquid or solid is confusing.

In the course of this survey, it was found that the use of SLF is reported alongside that of the other solid alternative fuels. It was felt that the SLF tonnage data should be reported alongside the reported solid waste fuel data; to show the trends in the use of these fuels in different countries. The Conclusions section reviews these trends.

2. The cement making process – update

The 1998 Survey included descriptions of the wet- and dry-process cement kilns. The basis information contained therein is still valid and these notes are intended only as an update.

The survey has confirmed the continued decline in wet process kilns, and details of the relative production by wet or dry process kilns are included as an example in the US section of this report. The major developments in kiln technology therefore centre on dry process kilns using precalciner technology. Since 1998 there have been further developments of the precalciner processes, the salient features of which are summarised:

- Modern precalciner kiln systems often feature enlarged precalciner vessels to allow greater gas/raw meal and fuel residence times. This is especially important when burning unconventional or alternative fuels, which may have more difficult combustion characteristics than coal or petcoke firing. As an example, a typical precalciner vessel of 1985-1990 would have a typical gas residence time of approximately 2-3 seconds. Typical gas residence times for a precalciner vessel designed to 2005 standards are between 4 and 7 seconds.

- Many of the new plants are built with multi-staged combustion (MSC) provisions. This may take several different forms depending upon the plant designer. For example, in the F.L. Smidth (FLS) MSC design with an in-line calciner (ILC), the fuel is introduced in the lower section of the precalciner vessel, where it burns in a reduced oxygen atmosphere. The carbon monoxide (CO) produced helps to reduce oxides of nitrogen (NO_x). The combustion process continues in the main body of the precalciner, where combustion is completed. The typical gas residence time is around 0.2 seconds in the reduction zone followed by a further 4 seconds in the main vessel. Several different designs are available from suppliers such as Polysius, KHD Humboldt Wedag A.G. (KHD), Technip, FLS, etc.

- The precalciner process is adapted to suit a wider range of raw materials and fuels. Hence, a plant with raw materials of around 28% moisture that traditionally would have used wet process technology would now use, for example, a two-stage preheater (designation SP2), enlarged precalciner vessel plus a crusher dryer for raw material preparation. Examples of recent SP2 precalciner kiln processes are seen in the modernised Rugby Cement plant at Rugby, UK, and at the Greencastle modernisation in the USA. Both these plant modernisations were replacements for wet process plants.

- Preheater cyclone designs have improved using more compact designs, which make it more practical to use up to six cyclone stages (SP6) for plants with raw materials of low moisture content.

There has been wider development of the precalciner design, which uses a separate combustion chamber with tertiary air prior to the main precalciner vessel. This design was seen with the reinforced suspension preheater (RSP) type of precalciner design of the 1980s, but it has been developed further since then. The type is referred to either as a ‘Hot spot’ or ‘CC’ (combustion chamber) design in this update. The advantage of these designs is that they allow precalciner fuel to be burned in an oxygen-rich atmosphere. This is especially advantageous when burning difficult fuels, which often include alternative fuels. The operating temperature in the combustion chamber can be controlled by raw meal addition, etc., but it is generally higher than is normal for the main precalciner vessel (860-890°C). For example, a typical combustion chamber operating temperature may be in the region of 1000-1200°C, which reduces to 860-890°C in the remainder of the precalciner vessel.

- Reference is drawn to the use of new kiln burner designs (e.g., Pillard and C. Greco), which are designed to suit a wide range of alternative fuels while minimising NO_x emissions. Several examples are quoted in this study.

- To permit the use of a wider range of raw materials and process fuels, kiln by-pass systems are commonly applied to new kilns. The study has indicated several kilns in which by-pass systems have been retrofitted to allow the use of a wider range of alternative fuels. The literature survey yielded several kiln plant modernisations in which kiln by-passes were added to remove 5-10% of the kiln gases to control chloride input. Chloride inputs from the fuel is a design consideration, which becomes more relevant when burning fuels, such as SLF and plastics. For example, the range of SLF used in UK lime and cement Industries has a typical chloride content of between 1.5% and 6%. Blending of the different (oil, solvent, paint, varnish, etc.) inputs that form SLF has to take into account clinker chemistry and/or process limitations associated with this chloride content. Use of a kiln by-pass system can raise the acceptable level of chloride input to the kiln process. However, it is not simply a case of using a kiln by-pass to permit a fuel of higher chloride content. The economics of this situation have to be assessed since kiln by-pass systems have a financial penalty in terms of higher raw material processing costs, possible by-pass dust treatment and disposal costs, higher fuel and power costs for handling exhaust gases, and disposal and environmental problems and/or costs associated with by-pass dust.

- It should be appreciated that the basic precalciner kiln design features outlined above were generally available at the time of the earlier survey. However, the application of these technologies has now become more widespread and features in the many examples of plant modernisations quoted in this report.

3. United States of America

3.1 Comparison of SLF usage between 1995 and 2003

The 1998 Atkins survey used data for the use of SLF during 1995 and 1996. The total quantity used at the 20 listed sites was:

- 960,700 tonnes of hazardous waste in 1995. This included 9500 tonnes of solid waste at Chanute. Hence the total liquid waste used was 951,200 tonnes.
- 975,000 tonnes of hazardous waste in 1996 with no correction required for any solid waste.

The source of this earlier data was the EI Digest report *Hazardous Waste 1997 No. 7*. To compare the usage of SLF in US plants, reference is now made to the data published in the *US Geological Survey Minerals Yearbooks* for the period 1995-2003 (Tables 6 and 7 therein). Atkins contacted this organisation and they kindly provided assistance with evaluation of the data in thermal substitution terms. The data presented, together with a literature and web survey, show the fuel usage in different kiln processes and indicate the changes, described below, that have taken place since 1995.

3.1.1 Plants no longer burning SLF

- The Alpena plant of Lafarge ceased using SLF after the last shipments of liquid waste in August 2000. The *Kansas Environmental News* (2004) reported that Heartland Cement in Independence had ceased burning hazardous waste in 1999. These two plants burned a total of 58,000 tpa of hazardous waste in 1996.

3.1.2 Wet Process Plants in the USA

- The number of wet process kilns has reduced from 35 in 1995 to 26 in 2003. This is an important factor as the previous survey showed that there were 17 plants using SLF in 1998 of which 13 were wet process plants. The following wet process plants, featured in the Atkins 1998 survey, have since been modernised to dry process single kiln lines.

- The four wet process kilns (0.678 million tpa clinker capacity) at Giant Cement's Harleyville plant were burning 104,000 tonnes of SLF in 1996. The plant uses both solid and liquid wastes, including solvents, waxes, paint residues and oils. The wet process kilns were to be shut down in two stages in 2004/2005 to allow some SLF firing to continue on two kilns while the new 3000 short tons per day (stpd) precalciner kiln plant is commissioned. In April 2004 it was reported that permits for the new kiln to burn waste had been applied for. It was reported that the new plant was designed such that substitute fuels could replace 70% of the kiln and calciner fuel. The kiln is designed with a by-pass system that allows for greater operational flexibility when selecting suitable substitute fuels.

- The two wet process kilns at Holcim's Holly Hill plant were burning 48,000 tonnes SLF in 1996. These were shut down in May 2003 and replaced by a new precalciner kiln of 6000 stpd clinker capacity. The kiln burner is designed to fire liquid hazardous wastes comprising waste solvents, paints, dry cleaning fluids and oils. The new kiln is equipped with a kiln by-pass for chlorine removal, which allows for 15% of the kiln gases to be by-passed when burning SLF.

- Ash Grove Chanute plant replaced its two wet process kilns by a single 4200 stpd clinker kiln in July 2001. The modern kiln retains the use of SLF from Cadence.

- The Texas Industries (TXI) plant at Midlothian was modernised with a new dry process 5500 stpd clinker line in January 2001.

- The Greencastle plant of Buzzi Unicem burned 40,600 tpa SLF in 1996 in a single 2600 stpd clinker wet process kiln. The plant was modernised by FLS in 2000 by conversion to a semi-dry process with precalciner, crusher dryer and single stage preheater (described in FLS Review 137). This kiln process conversion route was selected because of raw material considerations (i.e., the relatively higher pyritic sulphur and carbon content). This conversion allowed the kiln to be uprated to 4000 stpd plus clinker, while allowing SLF burning to continue. The kiln has a by-pass for chlorine removal since the waste solvents contain 2-3% chlorine.

- Hence, in some of the above examples, the new kiln plant design has taken into account the need for a kiln by-pass for chlorine removal and the intention has been to continue with the use of SLF. While SLF firing tends to be restricted to the kiln main burner, the use of modern precalciner kiln designs will allow future greater flexibility with the use of substitute fuels, especially solid fuels. The annual usage of SLF is expected to vary according to factors such as the timescale for plant modernisations as well as the permit procedures for these fuels.

3.1.3 Dry Process Plants in USA

- There has been a steady increase in the total number of dry process kilns from 72 in 1995 to 79 in 2003.

- The remainder of the plants are mixed wet–dry process kilns. The number of these was three in 1995 and four in 2003. Hence the total number of plants has hardly changed, from 110 to109 units.

- In terms of clinker production, the proportion of clinker produced by wet kiln plants has reduced from 26.4% in 1995 to 15.9% in 2003, with a corresponding rise in dry process plant clinker production.

- The usage of waste liquid fuels has varied with a significant increase being reported in 1998, when the total used increased to 1.268 million litres.

3.1.4 All Kiln Processes

- The average annual usage of waste liquid fuels during the period 1995-2003 was 937,000 litres per annum. Hence, apart from the unusually high usage during 1998, there has been no real growth in the usage of waste liquid fuels in the US cement industry. The most recent data show a similar usage of waste liquid fuel in 1996 as in 2003 (i.e., around 0.91 million litres in both years). *Table 3.1*, compiled from the US Geological Survey Minerals Yearbooks for the period 1995 to 2003, shows this trend. The usage of SLF is reported in 1000 litres rather than by weight, and the actual weight depends upon the source(s) of liquid fuels used. This makes estimation of the thermal substitution rate more complicated. In the 1998 survey, the tonnage of SLF is given as 975,600 tonnes, while the data in *Table 3.1* show 910 million litres. The density assumed was therefore 1.0719 t/m^3. This value is within the range quoted for solvents–waste oil mixes in the UK and so it is used for the recent data (2003).

Table 3.1. Usage of waste liquid fuel in 1996-2003.

Year	*Wet kiln SLF used (1000 litres)*	*Total all kilns SLF used (1000 litres)*	*SLF burned in wet kilns (%)*
1995	626,436	884,586	70.8
1996	649,978	910,153	71.4
1997	671,385	835,180	80.4
1998	1,172,357	1,268,166	92.4
1999	819,209	905,528	90.5
2000	801,288	929,087	86.2
2001	653,000	829,000	78.8
2002	725,400	961,600	75.4
2003	686,000	910,000	75.4
Average 1995-2003	*756,117*	*937,033*	*80.7*

- Note that the maximum usage of SLF occurred during 1998, when the consumption was 39.3% higher than in 1996.

- Despite the falling numbers of wet process kilns now available to burn liquid waste fuels, the consumption of this fuel has increased slightly from 0.65 million litres in 1996 to 0.686 million litres in 2003, with the peak consumption recorded in 1998 at 1.172 million litres.

- In the same period, the quantity of waste liquid fuels burned in dry and mixed dry–wet process plants has decreased from 0.260 million litres in 1996 to 0.224 million litres in 2003. Hence the quantity of waste liquid fuels burned in the dry process kilns is still low in comparison with wet process kilns, as shown in *Table 3.2*. To simplify *Table 3.2*, the dry and mixed dry–wet plant data have been grouped together.

Table 3.2. Usage of waste liquid fuel in 1996-2003 (%).

Process	*1996*	*2003*	*Change 1996-2003*
Clinker produced in wet process kilns	25.8	15.9	– 9.9
Waste liquid fuel used in wet process kilns	71.4	75.4	+4.0
Clinker produced in dry and mixed dry–wet plants	74.2	84.1	+9.9
Waste liquid fuel used in dry and mixed dry–wet process kilns	28.6	24.6	–4.0

Source: data from Annual Tables 6+7 data in the US Geological Survey Minerals Yearbooks 1995-2003.

3.1.5 Solid versus Liquid Waste Fuel Usage

- During the same period, the total quantity of tyres burned increased from 191,000 to 388,000 tonnes. Solid waste fuel usage has increased from 72,000 tonnes in 1996 to 317,000 tonnes in 2003. Hence tyres and other solid waste fuels are becoming increasingly more important to the cement industry, while liquid waste fuels remain static. The composition of the SLF used in 2003 is not provided, but an annual amount of around 975000 tonnes appears to have been burned.

3.1.6 Overall USA Alternative Fuel Substitution Rates

- The reported total alternative fuel (tyres, solid waste and liquid waste fuels) thermal substitution rate was around 9.25% on average between 2001 and 2002. In the same period, SLF comprised 5.5% of the total alternative fuel usage. The latest data for 2003 (see below) show SLF at 4.82% thermal substitution, while solid waste fuels amount to 5.01%, to give an overall alternative fuel substitution rate of 9.83%. Hence SLF are still a significant contributor to the total alternative fuel usage in the US cement industry. However, the overall substitution rates from alternative fuels are significantly lower than those achieved in Europe, where The Netherlands, Belgium, Austria, Switzerland, France and Germany lead the field with substitution rates typically between 30% and 83%.

- The thermal substitution rate for all alternative fuels in the USA during 2003 was estimated as follows. The data were kindly supplied by the US Geological Survey and show that SLF represented 4.82% thermal substitution, while the overall alternative fuel substitution rate was 9.83% (*Table 3.3*). Using the density of 1.0719 t/m^3 (see above), the tonnage of SLF in 2003 works out as 975,436 tonnes. Hence there was negligible change in the tonnage of SLF used in 2003 and the tonnage found in the earlier survey for 1996 data. As a comparison, the usage of alternative fuels in 1996 was recalculated as 5.41% thermal substitution by SLF and a total alternative fuels rate of 7.66%. Hence the growth in alternative fuel usage has not been as high as in several European countries.

Table 3.3. Usage of waste liquid fuel in 1996-2003 (%).

Alternative fuel 2003	*Amount*	*Thermal substitution (%)*
Tyres	387,000 tonnes	3.25
Solid waste fuel	317,000 tonnes	1.76
Liquid waste fuel (SLF)	910,000 litres	4.82
Total tonnage alternative fuels	*1,679,436 tonnes*	*9.83*

3.2 Plants reported as using SLF

The plants that use SLF are listed in a number of sources, such as the Environmental Protection Agency (EPA) emissions data, the sample report from EI Digest for 2002, the HRWT (US Army Corps of Engineers) and from various opposition groups, etc. Taking into account the above-mentioned plants that have ceased to use SLF, it is believed that the plants listed below still use SLF. The new Giant Harleyville kiln status concerning SLF usage is mentioned above. It is recognised that this list may not be up-to-date because of the lack of feedback from the major cement producers.

- Artesia
- Bath
- Cape Girardeau
- Chanute
- Clarksville
- Foreman
- Fredonia
- Greencastle
- Hannibal
- Holly Hill – dry replaced wet, permit believed to continue
- Logansport
- Midlothian – dry replaced wet, permit status not clear
- Paulding.

3.3 Emission Data for USA Cement Kilns burning SLF

There is a comprehensive data bank for USA kilns that burn SLF. This is available from the US EPA web site and consists of data for each kiln in Excel spreadsheet or PDF formats. Some of the data are now out of date as it includes, for example, Giant's four wet process kilns at Harleyville, which were replaced by a single precalciner kiln described above. The data are a useful data source for any study into the emission levels from plants that burn SLF. However, it must be appreciated that it includes data for older wet process kilns, which were not designed to the more stringent environmental standards that now apply in the US cement industry.

Cement Kiln Recycling Coalition (CKRC) were contacted for information on the use of SLF in the USA and they referred Atkins to data available on the following web sites:

- National Environment Agency data for sites – www.epa.gov/hwcmact/
- Environmental Legislation – www.epa.gov/combustion/preamble.htm
- CKHC members, use of SLF, fuel blenders, general info – www.ckrc.org/membership.html
- www.envirobiz.com (information is for members only but a sample report is available without tonnage data)
- www.ckrc.org/wte.html
- The US Geological Survey Minerals Yearbooks for the period 1995-2003 (reference Tables 6 and 7) are very useful and are available from http://minerals.usgs.gov/minerals/pubs/commodity/cement
- Environmental study into emissions from plants that burn waste in Kansas can be found on http://www2.kumc.edu/ceoh/skhs/finalreport.htm
- Data sheets for plants that use SLF, in Excel and PDF formats – http://www.epa.gov/epaower/hazwaste/combust/newmact/hazmact.htm

3.4 Conclusions – Use of SLF in US Kilns

The above data imply that the use of waste liquid fuels (SLF) has not grown significantly during the period 1996-2003 despite a growth in clinker production of 16.2%. The total tonnage of SLF used in 2003 was very similar to that used in 1996. The total use of alternative fuels has only increased slightly in the period 2001 (9.5%) to 9.83% in 2003, for which thermal substitution values are available from US Geological Survey minerals reports.

The rate of growth of alternative fuel use since 1996 in the USA is lower than has been reported in European countries such as Switzerland, Austria, France, Germany and Belgium. The use of SLF in wet process kilns will decline as the older wet process plants are gradually replaced. The growth in waste fuels has been mainly from increased solid waste fuels, and further growth may be expected as plants are modernised and their designs are better suited to burning higher quantities of alternative fuels.

3.5 Environmental Legislation, USA

3.5.1 History of Hazardous Waste Burning Cement Kiln Regulations

The early introduction of the Federal Water Pollution Control Act and the Clean Air Act had excluded the option to dispose of large quantities of hazardous waste to water or air. Since no standards existed to preside over landfill quality the next most financially efficient method was to dispose of hazardous wastes at landfill. There were no incentives to burn hazardous wastes at the time, as landfill was still the least expensive option.

The Resource Conservation and Recovery Act (RCRA) was enacted in 1976. The Act established a 'cradle to grave' management approach to control hazardous wastes.

Liquid wastes, curiously, fall under the RCRAs definition of *solid* waste:

The term 'solid waste' means any garbage, refuse, sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities, but does not include solid or dissolved material in domestic sewage, or solid or dissolved materials in irrigation return flows or industrial discharges which are point sources subject to permits under section 1342 of title 33, or source, special nuclear, or byproduct material as defined by the Atomic Energy Act of 1954, as amended (68 Stat. 923) [42 U.S.C. 2011 et seq.][1]

The four main components of the RCRA are:[2]

- **Identification of Hazardous Wastes** – A waste considered to be hazardous is subject to federal regulations. Although the rules are complex, wastes generally fall under two categories – (1) characteristic wastes are those with ignitability, corrosivity, reactivity or toxicity attributes that imply substantive risk, and (2) listed wastes pre-identified by the EPA as meeting certain toxic or carcinogenic constituents.
- **National Manifest System for Tracking Wastes** – The National Manifest System tracks the transfer of hazardous wastes offsite for treatment, storage or disposal. The manifest document remains with the shipment from its generation to final disposal.
- **The Permit System** – A permitting system controls the management of the waste at Treatment, Storage and Disposal Facilities (TSDFs). Every TSDF must obtain a permit to operate.
- **Standards –** General regulatory standards apply to all TSDFs, which control generic functions such as emergency plans. Technical regulatory standards provide outline procedures and equipment for specific types of waste facilities.

The RCRA, however, did not suggest preferred methods for dealing with the waste, which meant that large quantities were still being disposed of at landfill. When the Hazardous and Solid Waste Amendments of 1984 were passed the emphasis changed from land disposal to waste reduction. The Act also gave authority for the introduction of the Land Disposal Restrictions (LDR). The LDR barred land disposal (except under very restrictive conditions) of untreated hazardous waste that poses a potential threat of groundwater contamination.[3]

The new laws the disposal of hazardous waste to landfill became very costly, which made other disposal options increasingly attractive. The disposal of waste through

[1] http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=browse_usc&docid=Cite:+42USC6903
[2] Callan, S J. and Thomas, J M; *Environmental Economics and Management: Theory, Policy, and Applications*; Second Edition (2000); The Dryden Press.
[3] http://www.epa.gov/epaoswer/hazwaste/ldr/snapshot.htm

burning became the most economic and, in some cases, the only option for a large class of hazardous wastes.

A number of exemptions were included in the RCRA, including the burning of hazardous waste for energy or material recovery, as in cement kilns that used SLF. Other activities that relate to the storage and transportation of waste fuels and residues were, however, regulated.[4]

In 1991 Subtitle C of the RCRA was expanded to include new regulations to regulate the burning of hazardous waste in Boilers and Industrial Furnaces, commonly known as the 'BIF rule'.

The EPA defines an industrial furnace as '*one of those designated devices that are an integral component of a manufacturing process that uses thermal treatment to recover materials or energy*'. Cement kilns fall under this definition.

RCRA regulations applicable to BIFs are 40 CFR Part 266, Subpart H. RCRA permit requirements for these units are covered by 40 CFR Part 270. These units are also subject to the general TSDF facility standards under RCRA.

The BIF rule controlled emissions of:

- toxic organic compounds
- hydrogen chloride and chlorine gas
- toxic metals
- particulate matter

for hazardous waste combustors (HWCs).[5]

---

4 Gossman Consulting, Inc., http://gcisolutions.com/jwawma01.htm
5 An excellent guide to the BIF rule can be obtained by downloading a small executable file from: http://www.epa.gov/seahome/bif.html

3.5.2 Current US Regulations

Background

Prior to 1990 emission limits for BIFs were largely based on a risk-based health approach. These standards were termed the National Emission Standards for Hazardous Air Pollutants (NESHAP). The chemical-by-chemical approach for setting the standards proved difficult and resulted in NESHAPs for only seven toxic air pollutants.[6]

The Clean Air Act Amendments (CAAA) of 1990 required the EPA to identify industrial or 'source' categories that emit one or more of the listed 188 toxic air pollutants. Major sources are those that emit 10 tons per year or more of a single air toxic or 25 tons per year or more of a combination of air toxics. For major sources within each source category, the Clean Air Act required the EPA to develop national standards that restrict emissions to levels consistent with the lowest emitting (also called 'best-performing') plants. These air toxics control standards are based on what is referred to as 'maximum achievable control technology' (MACT). The Clean Air Act required EPA to issue air toxic control standards over a 10-year schedule.

In 1999 the authority for the primary regulation of BIFs was updated under the joint authority of the CAAA of 1990 and the RCRA (Title 40 Code of Federal Regulations (CFR) Part 63 Subpart EEE).[7]

NESHAP was to be updated by the EPA in two phases (Phase 1 has already been published):

- Phase 1 covers hazardous waste burning incinerators, cement kilns and lightweight aggregate kilns;
- Phase 2 will address hazardous waste burning industrial boilers, process heaters and hydrochloric acid production furnaces.

Maximum Achievable Control Technology

On 30 September 1999, the EPA issued a complex set of rules entitled *National Emission Standards for Hazardous Air Pollutants: Final Standards for Hazardous Air Pollutants for Hazardous Waste Combustors* (64 FR 52828-53077). The rules are codified primarily in 40 CFR Part 63 (§§63.1200-63.1213). In these rules the EPA established emission standards for three types of HWCs:

1. incinerators
2. cement kilns
3. lightweight aggregate kilns.

---

[6] EPA: http://www.epa.gov/epaoswer/hazwaste/combust/toolkit/index.htm
[7] RMT Inc. Bulletin, Volume 5, No. 1.; http://www.rmtinc.com/public/docs/151.pdf

The EPA generally refers to these standards as the MACT standards. The standards were based on what was already being achieved by the best-controlled and lower emitting sources within each industry group.

HWC MACT rules were published in two stages. The first part established a rule that facilities not intending to comply with HWC MACT within a 3 year timescale had to stop burning hazardous waste within 2 years. Those plants that were intending to comply had 3 years to achieve HWC MACT compliance. This rule was successfully challenged in court, based on the argument that waste normally sent to HWCs that had ceased to operate after 2 years would be sent to other HWCs, which would not have to comply with HWC MACT for another year. It was successfully argued that this would not lead to an overall reduction in emissions. In actuality, most of the facilities had already filed their 'Intent to Comply' with HWC MACT rules, as per the original regulations, before the court decision had been made.[8]

The second stage of the MACT related to a reduction in allowable emissions. This second stage was also challenged in court. A decision to vacate the HWC MACT standards was issued by the US Appeals Court for the District of Columbia Circuit on 24 July 2001. It was ruled that the standards set by the EPA violated the Clean Air Act 'because they failed to reflect the emissions achieved in practice by the best performing sources'.[9]

As a result of the decision, industry groups and environmental groups filed a joint motion to request a stay of the mandate and the EPA agreed to issue Interim Standards by 13 February 2002 and Permanent Replacement Standards by June 2005.

In May 2002 the EPA issued a *Guide to Phase 1 HWC MACT Compliance*. The document neatly summarises the original emission standards under HWC MACT against the newer (current) standards (*Table 3.4*).

[8] Stoll, R G.; *D.C. Circuit's Pivotal Role in HWC MACT Standards*; Foley & Lardner LLP; date not given.
[9] McHale, H S and Gehring M E, RMT, Inc.; *HWC MACT from NIC to NOC – An Industry Survey* (2003); IT3 '03 Conference, May 12-16, 2003, Orlando Florida.

Table 3.4. 1999 and Interim Standards for Existing and New Cement Kilns – Interim Standards are currently in effect.

Hazardous air pollutants or hazardous air pollutant surrogate	*Emissions standard*[1]			
	Existing sources		*New sources*	
	1999 standards[2]	*Interim standards*[3]	*1999 standards*[2]	*Interim standards*[3]
Dioxin and furan	0.20 ng TEQ/dscm; or 0.40 ng TEQ/dscm and control of flue gas temperature not to exceed 400°F at the inlet to the particulate matter control device	Unchanged from 1999 standard	0.20 ng TEQ/dscm; or 0.40 ng TEQ/dscm and control of flue gas temperature not to exceed 400°F at the inlet to the particulate matter control device	Unchanged from 1999 standard
Mercury	120 μg/dscm	Unchanged from 1999 standard	56 μg/dscm	120 μg/dscm
Particulate matter[4]	0.15 kg/Mg dry feed and 20% opacity	Unchanged from 1999 standard	0.15 kg/Mg dry feed and 20% opacity	Unchanged from 1999 standard
Semi-volatile metals	240 μg/dscm	330 μg/dscm	180 μg/dscm	Unchanged from 1999 standard
Low-volatile metals	56 μg/dscm	Unchanged from 1999 standard	54 μg/dscm	Unchanged from 1999 standard
Hydrochloric acid/chlorine gas	130 ppmv	Unchanged from 1999 standard	86 ppmv	Unchanged from 1999 standard
Hydrocarbons: kilns without by-pass[5,6]	20 ppmv (or 100 ppmv carbon monoxide)[3]	Unchanged from 1999 standard	Greenfield kilns: 20 ppmv (or 100 ppmv carbon monoxide and 50 ppmv[7] hydrocarbons) All others: 20 ppmv (or 100 ppmv carbon monoxide)[5]	Unchanged from 1999 standard
Hydrocarbons: kilns with by-pass; main stack[6,8]	No main stack standard	Unchanged from 1999 standard	50 ppmv[7]	Unchanged from 1999 standard
Hydrocarbons: kilns with by-pass; by-pass duck and stack[5,6,8]	10 ppmv (or 100 ppmv carbon monoxide)	Unchanged from 1999 standard	10 ppmv (or 100 ppmv carbon monoxide)	Unchanged from 1999 standard
Destruction and removal efficiency	For existing and new sources, 99.99% for each principal organic hazardous constituent (POHC) designated. For sources burning hazardous wastes F020, F021, F022, F023, F026, or F027, 99.9999% for each POHC designated. Unchanged from interim standard			

dscm, dry standard cubic metre; ppmv, parts per million by volume; TEQ, total equivalent quotient.
[1] All emission levels are corrected to 7% O_2, dry basis.
[2] 1999 standards refers to the original (now vacated) final standards promulgated on 30 September 1999 (64 FR 52828).

[3] Interim standards refers to the current enforceable final standards promulgated on 13 February 2002 (67 FR 6792). 'Unchanged from 1999 standards' indicates that the 1999 standard was re-promulgated as the interim standard.
[4] If there is an alkali by-pass stack associated with the kiln or in-line kiln raw mill, the combined particulate matter emissions from the kiln or in-line kiln raw mill and the alkali by-pass must be less than the particulate matter emissions standard.
[5] Cement kilns that elect to comply with the carbon monoxide standard must demonstrate compliance with the hydrocarbon standard during the comprehensive performance test.
[6] Hourly rolling average. Hydrocarbons are reported as propane.
[7] Applicable only to newly constructed cement kilns at greenfield sites (see discussion in Part Four, Section VII.D.9). 50 ppmv standard is a 30-day block average limit. Hydrocarbons reported as propane.
[8] Measurement made in the by-pass sampling system of any kiln (e.g., alkali by-pass of a preheater and/or precalciner kiln; mid-kiln sampling system of a long kiln).

In April 2004 the EPA entered the NESHAP: Proposed Standards for Hazardous Air Pollutants for Hazardous Waste Combustors (Phase I Final Replacement Standards and Phase II) Proposed Rule into the Federal Register. A period of time is allowed for public comment before the rule is finalised. The proposed rules are summarised in *Table 3.5*.

Table 3.5 Proposed rules

Hazardous pollutant or surrogate	*Emission standard*[1]	
	Existing sources	*New sources*
Dioxin and furan	0.20 ng TEQ/dscm; or 0.40 ng TEQ/dscm and control of flue gas temperature not to exceed 400°F at the inlet to the particulate matter control device	
Mercury[2]	64 µg/dscm	35 µg/dscm
Particulate matter	65 mg/dscm (0.028 gr/dscf)	13 mg/dscm (0.0058 gr/dscf)
Semivolatile metals[3]	4.0×10^{-4} lb/MMBtu	6.2×10^{-5} lb/MMBtu
Low volatile metals[3]	1.4×10^{-5} lb/MMBtu	1.4×10^{-5} lb/MMBtu
Hydrogen chloride and chlorine gas[4]	110 ppmv or the alternative emission limits under § 63.1215[5]	78 ppmv or the alternative emission limits under § 63.1215[5]
Hydrocarbons: kilns without by-pass[6,7]	20 ppmv (or 100 ppmv carbon monoxide)[6]	Greenfield kilns: 20 ppmv (or 100 ppmv carbon monoxide and 50 ppmv[8] hydrocarbons) All others: 20 ppmv (or 100 ppmv carbon monoxide)[6]
Hydrocarbons: kilns with by-pass; main stack[7]	No main stack standard	50 ppmv
Hydrocarbons: kiln with by-pass; by-pass duct and stack[5,7]	10 ppmv (or 100 ppmv carbon monoxide)	10 ppmv (or 100 ppmv carbon monoxide)
Destruction and removal efficiency	For existing and new sources, 99.99% for each principal organic hazardous constituent (POHC). For sources burning hazardous wastes F020, F021, F022, F023, F026, or F027, however, 99.9999% for each POHC	

dscm, dry standard cubic metre; gr/dcsf, grains per dry standard cubic metre; MMBtu, one million British thermal units; ppmv, parts per million by volume; TEQ, total equivalent quotient.
[1] All emission standards are corrected to 7% oxygen, dry basis. If there is a separate alkali by-pass stack, both the alkali by-pass and main stack emissions must be less than the emission standard.
[2] Mercury standard is an annual limit.
[3] Standards are expressed as mass of pollutant stack emissions attributable to the hazardous waste per million British thermal units heat input of the hazardous waste.
[4] Combined standard, reported as a chloride (Cl^-) equivalent.
[5] 'The proposed rule includes a compliance alternative provided for in the Clean Air Act [section 112(d)(4)] for hydrogen chloride and chlorine gas whereby sources can comply with risk-based emission levels rather than levels determined by performance of technology. Risk-based emission levels must show that the emissions of these pollutants are protective of human health with an ample margin of safety'.[10] The regulations can be viewed at http://www.epa.gov/oar/caa/caa112.txt
[6] Sources that elect to comply with the carbon monoxide standard must demonstrate compliance with the hydrocarbon standard during the comprehensive performance test.
[7] Hourly rolling average. Hydrocarbons reported as propane.

A complex set of technical support documents for the HWC MACT proposed rules are available for viewing on the EPA's web site at:
http://www.epa.gov/epaoswer/hazwaste/combust/newmact/tchsprtdoc2.htm

An installation must comply with the replacement rules within 3 years of the publishing of the final rule, although an existing unit can apply for an extension of up

[10] http://www.epa.gov/combustion/newmact/webpgdoc/mactfctsht.pdf

to 1 year. As with the interim MACT standards, a comprehensive performance test has to be conducted to demonstrate compliance.

4 European Union environmental legislation

4.1 Current legislation

Directives that currently govern the EU's waste incineration system for existing plants are:

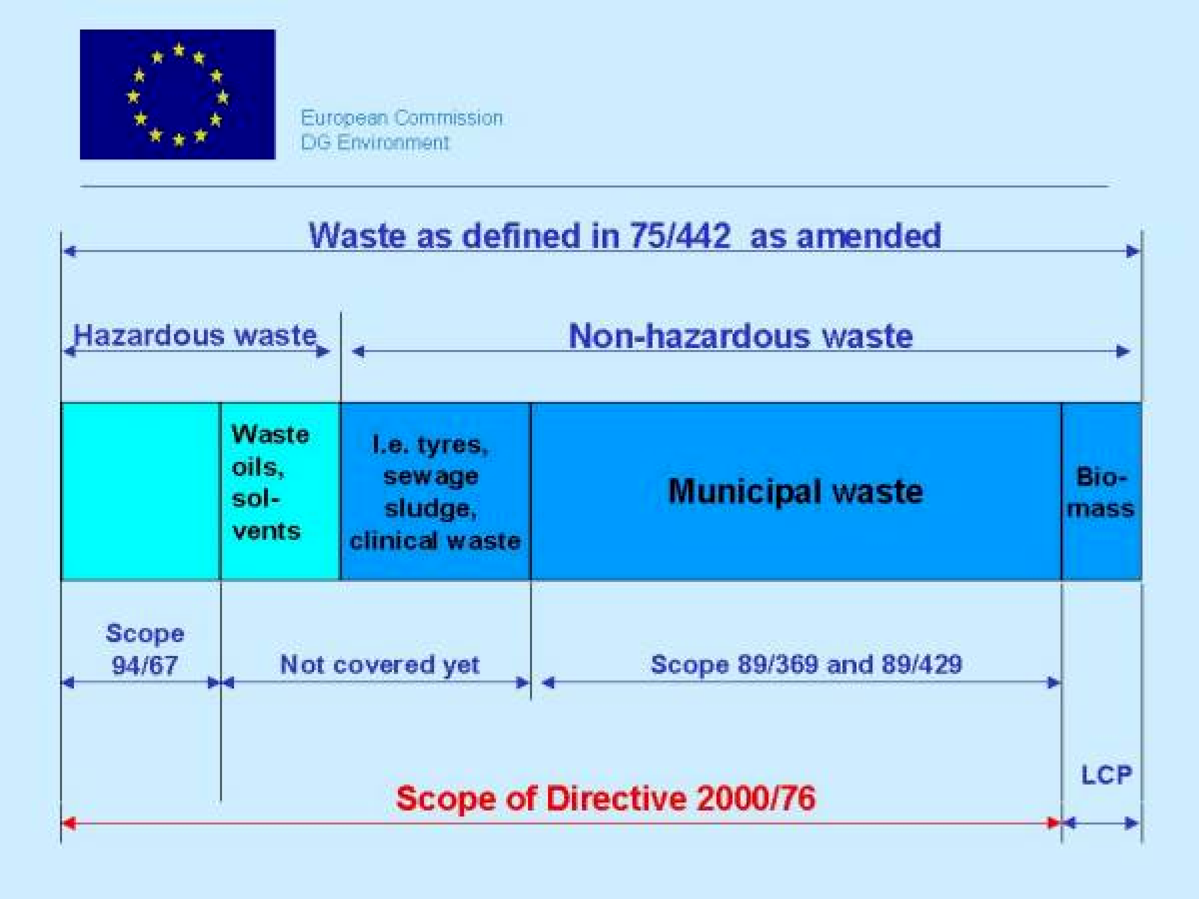
- Directives 89/369/EEC and 89/429/EEC Prevention of air pollution from waste incinerators (new and existing municipal waste-incineration plants);
- Directive 94/67/EC Hazardous waste incineration.

Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste (commonly known as the Waste Incineration Directive, or WID) has applied to all new plants from 28 December 2002 and will apply to existing plants from 28 December 2005.

Directives 89/369/EEC, 89/429/EEC and 94/67/EC will be repealed on 28 December 2005.

Figure 4.1 summarises the scope of the various directives.

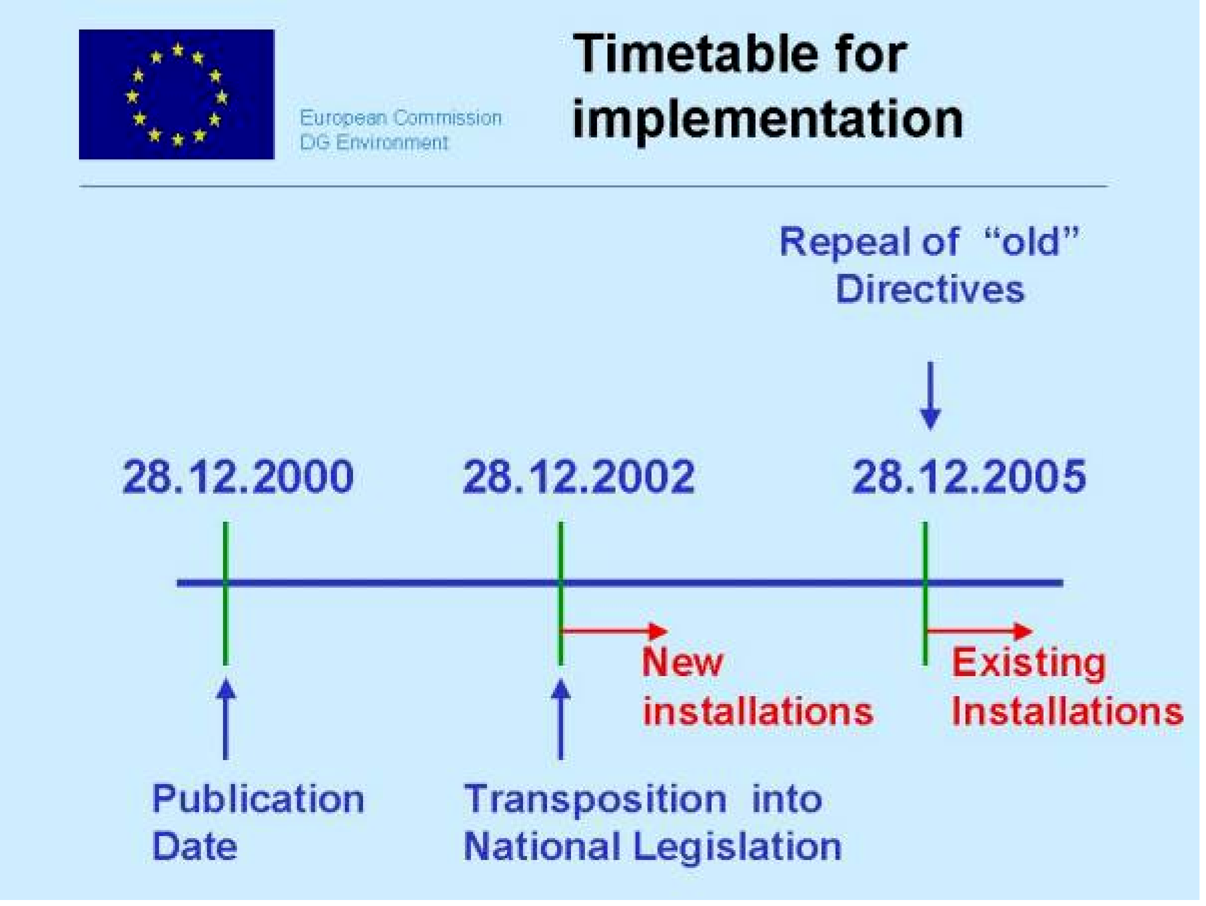
Figure 4.1: Scope of Directives covering 'waste', as defined by 75/442/EEC.



Source: http://europa.eu.int/comm/environment/wasteinc/scope.htm

Figure 4.2 summarises the implementation of WID.

Figure 4.2: Timetable for implementation.



Source: http://europa.eu.int/comm/environment/wasteinc/scope.htm

4.2 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste

WID extends the scope of the previous directives to cover the incineration of non-toxic non-municipal waste and toxic wastes not covered by Directive 94/67/EC.

It is also intended that the WID will ensure EU compliance with protocols signed under the United Nations Economic Commission Convention on long-distance cross-border atmospheric pollution.

4.3 Definitions

For the purposes of the Directive ‘waste’ means any solid or liquid waste as defined in Directive 75/442/EEC and ‘hazardous waste’ means any solid or liquid waste as defined in Directive 91/689/EEC of 12 December 1991 on hazardous waste. However, the WID does not apply to two types of combustible liquid wastes:

(a) *combustible liquid wastes including waste oils as defined in Article 1 of Council Directive 75/439/EEC of 16 June 1975 on the disposal of waste oils (2) provided that they meet the following criteria:*

(i) *the mass content of polychlorinated aromatic hydrocarbons, e.g. polychlorinated biphenyls (PCB) or pentachlorinated phenol (PCP) amounts to concentrations not higher than those set out in the relevant Community legislation;*

(ii) *these wastes are not rendered hazardous by virtue of containing other constituents listed in Annex II to Directive 91/689/EEC[11] in quantities or in concentrations which are inconsistent with the achievement of the objectives set out in Article 4 of Directive 75/442/EEC[12]; and*

(iii) *the net calorific value amounts to at least 30 MJ per kilogram,*

(b) *any combustible liquid wastes which cannot cause, in the flue gas directly resulting from their combustion, emissions other than those from gasoil as defined in Article 1(1) of Directive 93/12/EEC (3) or a higher concentration of emissions than those resulting from the combustion of gasoil as so defined.*

Cement kilns that burn SLF fall under the definition of ‘co-incineration plants’ for the purposes of the Directive as their ‘*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*’. The definition covers the entire plant and the entire site.

4.4 Operating conditions

To guarantee complete combustion, co-incineration plants are required to retain gases that result from the co-incineration of a waste at a temperature of at least 850°C for a minimum of 2 seconds. If the hazardous wastes have a content of more than 1% of the halogenated organic substances, expressed as chlorine, the temperature must be raised to 1100°C for the same time period.

It is a requirement that the heat generated is to be put to as good use as possible.

An automatic feed system is to be put in place to prevent the feeding of waste into the system if the minimum temperature for combustion is not met and ‘*whenever the continuous measurements … show that any emission limit value is exceeded due to disturbances or failures or purification devices*’.

[11] http://europa.eu.int/smartapi/cgi/sga_doc?smartapi!celexplus!prod!CELEXnumdoc&lg=en&numdoc=31991L0689

[12] http://europa.eu.int/smartapi/cgi/sga_doc?smartapi!celexplus!prod!DocNumber&lg=en&type_doc=Directive&an_doc=1975&nu_doc=442

4.5 Emission limits to air

Special provisions for cement kilns are laid out in Annex II of the Directive and give allowable emissions. The ‘mixing rule’ must be applied where a total emission limit value, ‘C’, has not been specified. There is no limit on thermal substitution when burning non-hazardous waste, but there is a limit of 40% thermal substitution for hazardous waste, above which the provisions laid out in Annex V of the Directive will apply.

The two main tables that contain emission limits are reproduced here as *Tables 4.1* and *4.2*.Annex II.II.1, *Special provisions for cement kilns co-incinerating waste*, is reproduced in *Table 4.1*.

Table 4.1. Special provisions for cement kilns co-incinerating waste.

Pollutant	*C*[1]
Total dust	30
HCl	10
HF	1
NO_x for existing plants	800
NO_x for new plants	500 [2]
Cd + Ti	0.05
Hg	0.05
Sb + As +Pb +Cr + Co + Cu + Mn + Ni + V	0.5
Dioxins and furans	0.1

[1] All ‘C’ values in mg/m^3 (dioxins and furans ng/m^3).
[2] For the implementation of the NO_x emission limit values, cement kilns which are in operation and have a permit in accordance with existing Community legislation and which start co-incinerating waste after the date mentioned in Article 20(3) [28 December 2004] are not to be regarded as new plants. Until 1 January 2008, exemptions for NO_x may be authorised by the competent authorities for existing wet process cement kilns or cement kilns which burn less than three tonnes of waste per hour, provided that the permit foresees a total emission limit value for NO_x of not more than 1200 mg/m^3. Until 1 January 2008, exemptions for dust may be authorised by the competent authority for cement kilns, which burn less than 3 tonnes of waste per hour, provided that the permit foresees a total emission limit value of not more than 50 mg/m^3.

Section II.1.2, *C – total emission limit values for SO_2 and TOC*, is reproduced in *Table 4.2.*

Table 4.2. Total emission limit values for SO_2 and TOC.

Pollutant	*C*[1]
SO_2	50
TOC	10

[1] All ‘C’ values in mg/m^3.

Exemptions may be authorised by the competent authority in cases where TOC and SO_2 do not result from the incineration of waste.

Emission limit values for CO can be set by the competent authority (II.1.3. Emission limit value for CO).

No limit has been set by the Directive for emission limits for polycyclic aromatic hydrocarbons. This has been left to the Member States provided that it does not conflict with other EU legislation.

4.6 Water discharges from the cleaning of exhaust gases

All discharges of effluents caused by exhaust-gas clean up must be authorised. ‘As far as practicable’, the emission limits set out in Annex IV of the Directive are not to be exceeded.

If a treatment plant is used solely for the waste water from the cleaning of exhaust gases, the emission limit values can be applied at the point where the waters leave the treatment plant.

Dilution of the waters may not be used to meet the emission limit values. Similarly, if the waste waters are treated in a treatment plant not solely used for the treatment of waste water from incineration, mass balance calculations must be used to determine compliance with Annex IV.

Rain or fire fighting water must be collected and analysed before being discharged.

4.7 Residues

Incineration residues must be reduced to a minimum quantity and recycled as far as is possible

Dry residues must be transported in such a manner that prevents release to the environment (e.g., in enclosed containers).

The physical, chemical and polluting potential of the residue must be determined by analytical analysis to determine the appropriate disposal route.

4.8 Measurement

Measurement equipment must be installed and used in accordance with the permit issued by the competent authority. Annex III and Article II of the Directive state how emissions to the atmosphere and water are to be measured, calculated and how frequently they should be measured.

5 France

The French cement industry is a major user of alternative fuels, including SLF. The Atkins 1998 survey reported that 22 plants used SLF, with an annual consumption of 262,093 tonnes in 1996. The Syndicat Francais de L'Industrie Cimentiere (SFIC) publishes annual reports on the consumption of fuels via their web site (see www.infociments.fr).

The overall picture concerning alternative fuel usage is shown in *Table 5.1*.

Table 5.1. Fuel usage in French cement kilns.

Year	*2000*	*2001*	*2002*	*2003*
Clinker (mtpa)	16.323	16.503	16.479	16.313
Heat (%) from alternative fuels (see text)	26.0	33.5	34.0	32.0
Heat (%) from various others	16.5	15.0	14.5	14.0
Alternative fuels and others (TJ)	25,747	29,506	29,790	27,960
Coal used (tpa)	212,000	167,000	199,000	226,000
Petcoke used (tpa)	849,000	783,000	790,000	784,000
Heavy fuel oil (tpa)	59,000	53,000	50,000	43,000
Natural gas (TJ)	385	429	369	384

The total usage of alternative fuels in 1996 was around 15%. Hence the total usage of these fuels has more than doubled since the previous Atkins survey. The reporting method shows the alternative fuels as *combustibles de substitution*, at 32% in 2003. The *brais et divers* (pitches and various others) is shown as a further 14%. The Cembureau data reported in 2004 (see Section 37.3 of the report) shows 34.1% alternative fuel use.

Unfortunately, the SFIC data do not distinguish between solid and liquid alternative fuels. We contacted SFIC, Association Technique de l'Industrie des Liants Hydrauliques (ATILH, www.infociments.fr), as well as the French Environment Agency to clarify the use of SLF. The only reply received was from the French Environment Agency that stated that they did not have the statistics available at the national level to answer the Atkins questions.

The 1998 survey identified the plants using SLF and this is updated below.

5.1 French cement plants that burn SLF

Ciments Calcia is part of the Italcementi Group. Since the 1998 survey, the use of SLF appears to be more widespread within the group's French factories. The Italcementi Group reported a 33.2% usage of alternative fuels for the Calcia plants in 2003. There are seven plants quoted as using SLF compared with five plants in 1996. The plants that currently use SLF are listed in their web site www.ciments-calcia.fr) as follows:

- Airvault (1.2 mtpa cement) – solvents, paints, varnish plus used oils;
- Beaucaire (0.75 mtpa cement) — used oils and sawdust;
- Beffes (0.5 mtpa cement) – aqueous industrial waste and contaminated sawdust since 1999;
- Bussac (0.74 mtpa cement) – the site alternative fuels brochure quotes the use of impregnated sawdust, G2000 SLF, and the plant description also mentions '*Since 1999, a prefectural authorization has allowed the recycling and the burning of industrial waste (tankage, residues from water treatment plants, old tyres, commonplace industrial waste, etc.)*';
- Couvrot (1.0 mtpa cement) – the plant description quotes that used oil, contaminated sawdust and tankage are used as alternative source of energy;
- Gargenville (milling approx. 1.0 mtpa cement) – the plant description quotes the use of Lipofit or vegetable fat from the food and feed industry;
- Ranville (0.5 mtpa cement) uses contaminated sawdust, water treatment plant waste and tankage;
- total usage of SLF in 1996 was 67,490 tonnes;
- the Italcementi environmental report quotes that a thermal substitution rate of 33.2% was achieved within the Ciments Calcia plants in 2003.

Pillard supply burners to the French Cement Industry and supplied reference lists for this survey. The Pillard web site gives good case studies of plants that use alternative fuels, including Ciments Calcia. *Table 5.2* summarises the fuel usage and burner details.

Table 5.2. Fuel usage and burner details

Plant	*Capacity (tpd clinker)*	*Kiln burner (MW)*	*Main fuels used*	*Kiln burner other fuels*	*Other alternative fuels*	*Thermal substitution alternative fuels (%)*
Airvault	2 kilns, each 1450	47	Petcoke High viscosity oil	Animal meal	Used oil Solvents Waste water	13.5
Beffes	1750	46	Petcoke Tyres in precalciner	Animal meal Impregnated sawdust	Solvents Waste water	23.5
Bussac	2300	47	Petcoke	Animal meal Impregnated sawdust	Solvents Waste water Animal fat	26.6
Guarain	4500	86	Petcoke Heavy oil	Animal meal	Animal fat	7.1
Ranville	1200	37	Petcoke Heavy oil	Animal meal	Animal fat	12.4

Source: Italcementi – experiences with Rotaflam ASR firing and NO_x reduction in Calcia.

The French cement industry is a significant user of waste oils. The 'Used Lubricant Disposal' web article quotes from Lafarge '*With a cap in excess of 130,000 metric tons, cement plants recover roughly 53% of the used oil collected in France, reducing fossil fuel consumption by 8%. Lafarge now burns waste oil to produce energy in several industrial countries as well*'.

The Lafarge cement plants that burned SLF in 1996 were listed as Contes, Le Tiel, Frangey, Havre Saint Viger, La Malle, Port La Nouvelle, St Pierre La Cour and Val d'Azergues, and were reported as using 105,420 tonnes of SLF.

The Lafarge web site mentions that La Couronne also burns waste impregnated sawdust made from a mixture of sawdust with semi-solid wastes (paint residues, varnish, ink and adhesives). Some 4800 tonnes were burned in 2001 and 10,000 tonnes in 2003. This illustrates one problem when defining SLF (i.e., how to quantify those component tonnes of impregnated sawdust that started off as liquids and those that started off as solids).

Overall, the use of SLF is very difficult to estimate without firm data from the major producers and cement agencies. The SLF consumption in 2000 is thought to be around 300,000 tonnes but there is no official confirmation of this figure.

6 Belgium

The Belgium cement industry has used alternative fuels for several years. The growth in the use of these fuels is described in documentation produced by the National Cement Agency FEBELCEM (www.febelcem.be/) concerning the plan of action signed with the Belgium government on 6 July 2001. In a paper entitled 'Plan D'Action Sectorial De L'Industrie Cementiere Wallone', Annexe 5 shows that the substitution rate was 6.3% in 1990 and had increased to 29% in 2001.

Examples of the use of SLF in Belgium cement plants are given below.

Heidelberg operates four plants in Belgium (Lixhe, Antiong, Ghent and Harmignies) with a combined capacity of 2.6 mtpa cement. The 2003 Environmental Report mentions the following statistics:

- coal, petcoke and gas represented 47% of the total fuels used in its three clinker kilns;
- alternative fuels therefore represent 53% of the total fuels used and some 22% of this quantity is biomass fuel.
- the Antiong plant is quoted as using only 28% fossil fuel, or 72% alternative fuels.

The Lixhe plant was uprated in 2001. This plant is a good example of how an existing kiln plant can be modified to make it more suitable for burning substitute fuels. The kiln capacity was increased from 3400 to a designed 4200 tpd (maximum 4600 tpd) by various additions, which included a Minox RSP precalciner vessel, new preheater and a kiln by-pass system. The precalciner RSP design combines a 'Hot spot' combustion chamber and a reduction zone for NO_x reduction and has a gas residence time of around 5 seconds. The 5% kiln by-pass was designed to cope with higher chloride inputs from substitute fuels. The substitute fuels count for 50-60% of the total fuel input and include animal meal, tyres and resofuel, a solid waste fuel. SLF are burned in the kiln main burner at a rate of 2 tph. Other fuels include coal (6 tph) and MBM (8 tph), used in the kiln main burner. Tyres (2 tph) enter the kiln inlet, while the precalciner fuel uses coal (1.2 tph) and 'Resofuel' (8 tph).

Heidelberg would not provide details of their use of SLF generally, but an estimate can be made from published articles, such as Verein Deutscher Zementwerke (VDZ, German cement industry association) and *International Cement Review* (ICR) reviews in September 2002 and April 2003, respectively. The estimated use of SLF alone is around 16,800 tonnes. There is also the use of Resofuel, which is taken to be sawdust impregnated with solvents, etc. If the solvent content of this fuel were assumed to be 30%, this would bring the total estimated SLF usage to very roughly 35,000 tpa. This figure cannot be confirmed.

The CBR Heidelberg Environmental Report for 2003 shows a total alternative fuel use of 53% in three kilns for 2003. Of this, the biomass fuel substitution rate was 22%. There are several references to Heidelberg worldwide operations in this report and further information is available on www.heidelbergcement.com

Holcim operates the Obuorg cement plant with an annual capacity of 1.388 mtpa clinker (1.949 mtpa cement) in 2003.The overall substitution rate achieved with alternative fuels has been high at this plant (i.e., 68.1% in 2002 and 66.3% in 2003). Scoribel, a Holcim subsidiary company, prepares the SLF fired in the two wet process kilns. The Holcim web site includes an environmental report for the plant in 2003. This mentions that a new storage and handling facility for impregnated sawdust was to be made operational in 2004. There was also investment in handling viscous liquid fuels to enable greater use of alternative fuels.

The European Commission Research Directorate reported in August 2002 that the replacement by fuel derived from liquid waste alone (i.e., not counting other waste fuels) was equivalent to 41% thermal substitution, or the equivalent of 128,000 tpa coal. If the CV of SLF were assumed to be approximately 15 MJ/kg, this would imply an SLF consumption of over 230,000 tpa.

While firm figures on SLF were not available from cement companies in Belgium, the above estimates based upon the interpretation of published data imply a total SLF usage of at least 265,000 tpa.

7 Germany

The German cement industry is a well established user of alternative fuels. The 1998 survey identified the use of 170,000 tonnes of waste oil in 1996 together with 250,000 tonnes of used tyres. The British Cement Association (BCA) identified 32 out of 35 plants as using alternative fuels, which represents a thermal substitution rate of 30%.

The German cement industry association (VDZ) publishes statistics for fuel usage and Table 7.1 summarises the data for 2001 to 2003.The web site contains useful data and is available on http://www.vdz-online.de/home.htm. This site shows the overall split between conventional fossil fuels and alternative fuels.

Table 7.1. Statistics for German fuel usage.

Year	*2001*	*2002*	*2003*
Clinker production (mtpa)	24.523	20.120	21.513
Thermal input from fossil fuels (m GJ per annum)	62.6	55.9	56.4
Thermal input from alternative fuels (million GJ per annum)	27.2	29.9	34.9
Total thermal input from all fuels (million GJ per annum)	89.8	85.8	91.3
% of total heat from alternative fuels	30.29	34.85	38.23

Hence there has been a steady increase in the use of alternative fuels in recent years and the consumption was approximately 38% in 2003. The breakdown of the alternative fuels used is as follows:

- used oils – 116,000 tonnes
- solvents – 48,000 tonnes
- total waste oil and solvent – 164,000 tonnes
- in energy terms, the total heat input from these two SLF types was 12.92% of the total alternative fuel input
- The total thermal substitution by SLF was 4.94% of the total process fuel
- The major alternative fuel inputs are from tyres (247,000 tonnes – 6.78% thermal substitution), MBM (452,000 tonnes – 8.59% thermal substitution) and plastics, paper, textiles and sorted industrial wastes (626,000 tonnes – 13.86% thermal substitution).

To show the development of alternative fuels in Germany, *Table 7.2* compares the 2003 data with similar data from 1997 (i.e., the year just after the previous Atkins survey data were reported). This demonstrates that the growth in alternative fuels is not in SLF. Use of SLF has actually declined (i.e., the total SLF used in 2003 was 164,000 tonnes compared with 205,000 tonnes in 1997).

Table 7.2. Growth in use of alternative fuels in Germany.

Year	*1997*	*2003*
Clinker production (mtpa)	26.493	21.513
Total tonnes alternative fuel used	923,000	1,733,000
% thermal input – tyres	4.37	6.78
% thermal input – MBM	0.0	8.59
% thermal input plastics, paper, textile and carpet waste	4.84	13.86
% thermal input solvent SLF	0.46	1.27
% thermal input waste oil SLF	4.51	3.67
% total SLF	4.97	4.94
Total alternative fuel thermal input (%)	15.81	38.23

Hence the main increase in alternative fuels has been in the solid waste fuel sector, with greater use being made of tyres, MBM and mixed or sorted plastics, paper and textiles. There is now a much wider range of fuel types used in the German cement industry than in 1997. The data for 2004 will be published in mid-2005 and it will be interesting to see how the trends in waste fuel usage develop.

7.1 German cement plants that burn SLF

Specific examples of German cement plants using SLF were identified in the literature surveys from 2003 to 2004, and some typical cases are given below.

Wossingen – according to BCA data, this plant burns MBM, waste solvents, tyres and processed sewage pellets (PSP). In addition, the Lafarge web site quotes this plant as a case study for NO_x reduction. The waste liquids of the photo processing industry are recycled as reagents to decrease NO_x emissions from the cement plant.

Rohrbach Zement GmbH, Dotternhausen – Pillard reference list shows an order in November 2003 for a Rotaflam kiln 50.4 MW burner for coal, petcoke, heavy fuel oil (HFO), solid waste and liquid waste.

Duena Zement GmbH – a Pillard 115 MW Rotaflam kiln burner was supplied in August 2003 to burn lignite, solid waste fuel, liquid waste and solvents. The solvent capacity was given as 5000 kg/h.

Gresek-Dycherhoff A.G. – C. Greco supplied a new 52.4 Gcal/h kiln burner for the 1400 tpd kiln line. The burner was designed for multifuel combustion using pulverised lignite fuel oil, solid wastes and liquid wastes.

Neubeckum-Dyckerhoff – a C. Greco new burner for the 3500 tpd kiln line (2002) is reported as being designed to fire coal, petcoke and HFO, as well as solid and liquid waste fuels. A design was also being prepared for the 2800 tpd kiln line.

Pheonix Zement, Beckum – Pillard supplied a 61.4 MW burner for coal, HFO, solid waste and liquid waste firing.

Heidelberg – in their environmental report for their German operations Heidelberg shows the following fuel breakdown for their cement plants, which include Lengfurt, Schelkingen, Leimen, Burglengenfeld and Mainz-Weisenau:

- conventional primary fuels (coal and/or petcoke) = 60%
- plastics = 20.7%
- tyres = 8.3%
- MBM = 5%
- waste oil = 4.4%
- solvents = 1.4%
- wood = 0.1%
- others = 0.3%
- the total is slightly over 100% because of individual rounding of results.

Hence, the total SLF used within these plants was 5.8% compared with a national average of 4.94% for the whole German Cement Industry in 2003.

7.2 German environmental legislation

The Environmental report also lists the legislation applied to cement plants and to plants with co incineration. The BImSch 17 regulations (2003) are applied to these plants and the limits are given as follows, based upon same gas basis (dry gas, Nm^3 at 10% oxygen):

Particulates – 20 mg/m^3
Hg – 0.03 (0.05)* mg/m^3
Tl, Cd – 0.05 mg/m^3
Ni, Co, Se, Te, Pb, Sb, Cr, Cu, Mn, V, Sn – 0.5 mg/m^3
NO_x as NO_2 – 500** mg/m^3
SO_2 – 50* mg/m^3
HCl – 10 mg/m^3
HF –10 mg/m^3
TOC – 10* mg/m^3
CO – 50* mg/m^3
PCDD/F – 0.1 ng/m^3

The limits marked * are subject to raw material constraints (e.g., pyritic sulphur or organic materials in raw materials). The limit on NO_x (**) is valid for a secondary fuel rate up to 60%.

8 Austria

8.1 Fuels used in the Austrian cement industry

The Austrian cement industry includes nine integrated works with a total clinker capacity of around 4.26 mtpa. Clinker production in 2003 was 3.12 mtpa. Information on the use of alternative fuels is obtainable from the Vereinigung der Osterreichischen Zementindustrie (VOZ, Austrian National Cement Association) web site (http://www.zement.at/) in the emissions data files. Data are currently available up to 2003 and a summary of the key data between 2000 and 2003 is given in *Table 8.1*.

Table 8.1. Summary of the key data on the use of alternative fuels in Austria between 2000 and 2003.

Year	*2000*	*2001*	*2002*	*2003*
Used oil (tonnes)	27,794	26,437	30,017	30,057
Solvents (tonnes)	8,702	13,963	17,242	12,459
Total SLF (tonnes)	36,496	40,400	47,259	42,516
Used oil (MJ/kg)	36.65	36.27	36.23	36.70
Solvents (MJ/kg)	26.93	24.99	24,41	25.12
Thermal substitution by used oil (%)	9.58	8.81	9.84	10.00
Thermal substitution by solvents (%)	2.20	3.21	3.81	2.84
Total thermal substitution by SLF (%)	11.79	12.01	13.65	12.84
Total thermal substitution by all alternative fuels (%)	33.47	41.76	44.94	48.09

Note that rounding the percentages for the thermal substitution figures to two decimal points results in some subtotals not matching to 0.1%. The conclusions that can be drawn from these data are:

- the Austrian cement industry has steadily increased the amount of alternative fuels used from 33.5% in 2000 to 48.1% in 2003;
- the increase in alternative fuels used has resulted mainly from the increase in solid waste fuels such as tyres, plastics, MBM and others;
- there has been only a small increase in the use of SLF, with a range from11.79% minimum to 13.65% maximum;
- in 2003, thermal substitution by used oils was 10% compared with 2.84% thermal substitution by solvents;
- the total tonnage of SLF used ranged from a minimum of 36,496 tonnes to a maximum of 47,259 tonnes in the 4-year period considered;
- the CV of the used oil was typically between 36.23 and 36.70 MJ/kg and the CV figures are reasonably consistent;

- the CV of the solvents used was between 24.41 and 26.93 MJ/kg, which is less consistent than the used oil;
- the overall fuel consumption using conventional and alternative fuels was between 3.481 and 3.536 GJ/tonne clinker (831-849 net kcal/kg clinker);
- to compare the above data with the 1998 Atkins survey, the data for 1996 were processed to allow comparison on the same basis – in 1996, petcoke was treated as an alternative fuel, but if this is removed from the alternative fuel category the total alternative fuel use was 20.85%, with SLF use at 28,392 tonnes (represented 9.30% thermal substitution), and hence the growth in SLF use since 1996 is from 9.30% to a recent maximum of 13.65% in 2002.

8.2 Austrian cement plants that use SLF

The plants that use SLF were identified by the earlier Atkins survey as well as in the VOZ report for 2002. These plants are:

- Peggau (0.418 mtpa clinker) and Gmunden (0.512 mtpa clinker) used oil and non-halogenated solvents, which totalled 25,792 tonnes for both plants in 1997. These fuels are still reported as being used in VOZ 2002.
- Mannersdorf (0.89 mtpa clinker) used waste oil in 2002.
- Retznei (0.439 mtpa clinker) used waste oil in 2002.
- Kirchdorf (0.462 mtpa clinker) used oil-impregnated sawdust in 2002. In 2003 it was reported that Unitherm received an order for a new kiln burner to fire coal, animal meal and wood, plus a liquid waste oil burner gun for polluted deposit water. The latter is aimed at reducing NO_x emissions.
- Wopfing, Peggau, Gmunden and Gartenau plants are listed as using animal fats and greases.
- Wietersdorf plant has a Lepol kiln of 800 tpd capacity. This plant is included in the Unitherm reference list as having a new kiln burner supplied in 2001. The burner was designed to fire coal, gas, solvent, animal meal, plastic chips and HFO. This kiln is also reported as being equipped with a kiln by-pass system by Polysius to allow greater flexibility when burning substitute fuels (*World Cement*, July 2003).

8.3 Environmental aspects – Austrian cement industry

The environmental and fuel data presented in the VOZ Environmental Reports is of a high standard and there is a comprehensive breakdown of the plant emissions. With the very wide range of fuels used in Austrian cement kilns, it would be a very complicated task to try and establish what the effects of using SLF alone might be. The following information therefore refers to the overall picture for these fuels.

- CO_2 generation was 2.712 mtpa in 2003. Of this 0.147 mtpa was via biofuels and 0.267 mtpa came from alternative fuels. Conventional fuels, such as coal, petcoke and HFO contributed 0.563 mtpa CO_2 with the remaining 1.736 mtpa coming from raw meal decarbonation.
- For emission levels, any changes in plant emissions do not necessarily stem solely from changes in alternative fuels or raw materials. As the cement industry modernises some changes arise through changing technology, such

as the application of NO_x reduction techniques (selective non-catalytic reduction (SNCR), MSC), SO_x reduction (flue gas desulphurisation by wet scrubbing, raw mix changes to, say, reduce pyritic sulphur input, alternative raw material sources, etc.). The extent of these changes is outside the scope of this report and cannot be determined from the limited data available. However, the overall changes to plant emissions between 1998 and 2003 are worth noting and given in *Table 8.2*.

Table 8.2. Overall changes to plant emissions between 1998 and 2003 in Austria.

Year	*1998*	*2003*	*Change 2003-1998*
Clinker production (tonnes)	2,869,035	3,119,808	+250,773
Total net energy (GJ/tonne clinker)	3.586	3.536	–0.050
Net Fuel consumption (kcal/kg clinker)	857	845	–12
Total thermal substitution by alternative fuels (%)	25.99	48.09	+22.10
SLF thermal substitution (%)	12.41	12.84	+0.43
Gas volume at 10% oxygen basis (1000 Nm^3 dry gas)	6,231,152	6,563,848	+332,696
Exhaust gas on dry gas basis at 10% O_2 (Nm^3/kg clinker)	2.172	2.104	–0.068
CO_2 (kg/kg clinker)	0.867	0.879	+0.012
NO_x as NO_2 (g/tonne clinker)	1359.75	1347.46	–12.29
SO_2 (g/tonne clinker)	143.36	159.40	+16.04
Cd, Tl, Be (g/t clinker)	0.025753	0.025667	–0.000086
As, Co, Ni, Pb (g/t clinker)	0.073718	0.036650	–0.037068
Hg, Cr, Se, Mn, V, Zn (g/t clinker)	0.183036	0.088404	–0.094632
HCL (g/tonne clinker)	5.161	2.731	–2.430
HF (g/tonne clinker)	0.388	0.246	–0.142
TOC (g/tonne clinker)	64.072	69.204	+5.132
CO (g/tonne clinker)	2629.5	2672.2	+42.7

These data must be considered alongside all other changes that have taken place within the Austrian cement industry. In the period considered there was little change in the total quantity of SLF used in terms of thermal substitution rates. The total amount of alternative fuel increased by 85%, mainly through higher solid waste usage. There was a small improvement in net fuel consumption (12 net kcal/kg clinker), but this can be misleading. Often the specific fuel consumption and waste gas volume increase with alternative fuels if the latter are of lower quality with a lower net/gross CV ratio than that of coal and petcoke (0.96-0.98, typically). That the specific fuel consumption has not increased tends to suggest that any increase has been more than compensated for by efficiency improvements and/or process modernisation, etc. The heavy metal emission levels were all lower in 2003 than in 1998. The increase in the SO_2 emissions (approximately 11%) are less easy to account for, as this is more likely to be related to raw materials than to fuel sulphur content. However, there are some wider variations in the annual SO_2 results. Between 1998 and 2003 the range of annual average SO_2 was a maximum of 168.72 g/tonne in 2002 to a minimum of 60.81 g/tonne clinker in 1999. The very wide range of alternative fuels used in Austrian cement plants thus makes it very difficult to attribute changes in emission levels to any individual fuel type, such as SLF.

9 Spain

Oficemen, the national cement association, reports the use of alternative fuels in the Spanish cement industry – see the web site www.oficemen.com

The annual usage of alternative liquid fuels has increased from 5400 tonnes in 1996 to 42,477 tonnes in 2003. The SLF used in 2003 consisted of the following components:

- used oil, 15,329 tonnes;
- animal grease, 2227 tonnes;
- varnish and paint waste, 19,185 tonnes;
- alternative liquid waste, 4992 tonnes;
- residual oil from the petroleum industry, 744 tonnes
- total SLF, 42,477 tonnes.

The *Table 9.1* demonstrates the growth in both liquid and solid alternative fuels from 2000 to 2003.

Table 9.1. Summary of the key data on the use of alternative fuels in Austria between 2000 and 2003.

Year	*2000*	*2001*	*2002*	*2003*	*Increase 2000 to 2003*
Coal and Petcoke (tonnes)	3,081,064	3,201,018	3,311,018	3,449,089	
Solid alternative fuels (tonnes)	20,099	32,123	56,114	99,307	79,208
SLF (tonnes)	19,240	14,002	13,583	42,477	23,237
Heavy fuel oil (tonnes)	64,120	67,137	52,568	44,286	
Natural gas (m Nm^3)	5.239	6.174	6.344	5.156	
Gas oil (million litres)	5.792	6.002	5.675	6.044	

The increase in SLF is 121% over the 4-year period, while the increase in solid alternative fuels is 394% for the same period. The installed cement capacity in Spain was reported as 51 mtpa, with a consumption of approximately 46 mtpa in 2003.

Thermal substitution rates for 2003 are not given with the Oficemen data. However, using typical fuel analysis data the estimated thermal substitution rate for 2003 would be approximately 2% solid waste fuel and only 0.8% for SLF, a total of 2.8%. Published data for the year 2002, listed below, show the fuel input breakdown and that alternative fuel usage has grown:

- petroleum coke, 90.4%
- coal, 6.1%
- fuel oil, 2.0%
- alternative fuels (solid and SLF), 1.3%
- natural gas, 0.2%
- total tonnage of alternative fuels was 69,697 tonnes in 2002 compared with 141,784 tonnes in 2003.

During 2002 to 2003, the use of alternative fuels is very low in comparison with that of the main fuels, petcoke and coal, which account for approximately 95-96% of the total thermal input. Petcoke is still the major fuel source. Notwithstanding this, the use of alternative fuels has increased in recent years. The current low substitution rate means that there is plenty of scope to develop the use of SLF in line with the trends seen in other European countries, such as Germany, France, Belgium and The Netherlands.

9.1 Spanish cement plants that use SLF

Some examples and references to plants that use SLF were found from the literature survey.

The Holcim Espana group operates six cement plants with a total capacity of 5.5 mtpa cement. Holcim Espana also owns Energis, who supply both liquid and solid waste fuels to their plants in Spain. The liquid and solid alternative fuels are prepared at their Albox plant. The Holcim Espana 2004 sustainability report mentions that the Holcim plants achieved 11% thermal substitution rate using alternative fuels in 2003.

References to the plants that use SLF or plan to use SLF can be found in the orders for new kiln burners, etc. Some of the following references were obtained from literature surveys 2003-2004.

Cementos Lemona upgraded their the kiln plant by the addition of an RSP ‘Minox’ precalciner plus modification of the preheater. This increased the kiln output from 1900 to 2250 tpd clinker. The precalciner modifications were made to allow higher kiln outputs plus an increase in the amount of alternative fuels burned. Pillard also received an order for a 43 MW kiln burner for heavy fuel oil, residual oils, petcoke, animal dust and plastics (*World Cement*, July 2004).

The Cemex group operates nine integrated cement plants in Spain. These use solid waste, such as powdered meat, at the Brunol, Alicante and Castillejo plants, together with tyres at Castillejo. In May 2004 it was reported that Cemex had awarded C. Greco the contract for a new kiln burner at Castillejo for coal and petcoke fuel oil and residual liquid fuel.

10 Norway

Norcem A.S. is part of the Heidelberg Group and operates two cement plants in Norway at Brevik (capacity 1.3 mtpa cement) and Kjøpsvik (capacity 0.6 mtpa cement). Norcem also acquired Renor A.S. in March 2003, a company that prepares alternative fuels, including SLF, from waste oil, paint, tar, solvents, glue, oil sludges and contaminated soil (*World Cement*, August 2004). In 2003, Norcem burnt approximately 100,000 tonnes of alternative fuels comprising SLF, solid hazardous waste, wood chips, MBM and refuse-derived fuel (RDF). Other process fuels include coal and petcoke.

The Brevik plant used approximately 30% alternative fuels in 2003. The 3500 tpd Brevik Kiln VI was uprated in 2004 by KHD. The main aim of the conversion was to allow an increase in the substitution rate of alternative fuels from approximately 30% to 60% while maintaining plant emission standards. The upgrade included the addition of a combustion chamber designed to maximise the use of both solid and liquid hazardous waste fuels. The KHD article in ICR (January 2004) describes the kiln conversion and a claim that 60% of the total fuel input is alternative fuels. The fuel composition quoted by KHD is:

- Calciner Combustion Chamber:
    - 5% coal–petcoke mix
    - 15% solid hazardous waste
    - 40% fluff
    - total calciner fuel, 60%;

- Kiln main burner
    - 35% coal–petcoke mix
    - 5% liquid hazardous waste
    - total kiln fuel, 40%.

This implies a low usage of SLF (5%) in the calciner. However, the *World Cement* August 2004 article claims that the waste, which can be reduced and blended to a liquid fuel, is injected into the kiln burner. The rest of the liquid waste is mixed with sawdust and is burned in the calciner. There was a 50:50 distribution between solid and liquid fuels derived from hazardous waste. This complicates the assessment of the total usage of SLF as some SLF is mixed with solid wastes.

The Heidelberg Technical Centre was not prepared to provide any data on SLF usage within their group. Hence the estimate of SLF usage at Brevik can only be estimated from the above information plus the 1998 Atkins report. The latter report noted that the plant used 7510 tonnes of SLF in 1997 (equivalent to 3.8% thermal substitution) and was authorised to use up to 20,000 tonnes. Assuming a clinker capacity of 1.056 mtpa clinker at a 756 net kcal/kg clinker fuel consumption with SLF of 4000 net kcal/kg, the annual consumption of SLF in the kiln would be just under 10,000 tonnes. This is based upon the KHD claim of 5% of the kiln fuel comprised SLF. If the liquid waste fuels were 50% of the total, this would imply the use of 20,000 tonnes per annum of SLF, which is the same as the authorised value quoted in 1998. For this survey an average SLF use of 15,000 tpd has been assumed in the absence of any firm data from the producer.

Sicon have supplied conveying equipment to the Brevik plant, which is described in *World Cement* (April 2002). This article quotes the use of three fuel sources:

- FAB (Norwegian acronym for processed alternative fuel) at 25,000 tpa, which was expected to increase in future – FAB consists of household waste mixed with industrial waste;
- Bone meal (20,000 tpa);
- 'Hotmix' (17,000 tpa), which is a mix of wood chips, solvent, lacquer, printing ink and dye residues.

The Kjøpsvik plant has a 1600 tpd FLS ILC kiln. This kiln was modified in 2002 by the addition of an FLS 'Hotdisc' combustion chamber, which enables burning tyres and other types of solid waste fuels, such as wood and chemical waste – the thermal substitution rate is typically 25% with a maximum 35% quoted by FLS (VDZ Conference September 2002 and *World Cement* August 2004 reports). In the 1998 Atkins report it was noted that this plant was also authorised to use waste oil.

In the environmental declaration ISO/CD 14025 Type 111 for the Norcem A.S. Kjøpsvik ordinary Portland cement, there is an energy balance for cement production, which shows that approximately 10% of the fuel used is from waste incineration. In view of the above plant changes it is clear that both plants can achieve much higher alternative fuel addition rates. The declaration also states, '*Norcem has permission to burn waste oil, solid wastes (such as plastics, FAB and tyres) and hazardous waste in their clinker kiln. The share of waste energy used is increasing*'.

In conclusion, although SLF are not the major alternative fuel used in Norway, it is an important fuel either in liquid form for injection into the Brevik Kiln VI or mixed with solid fuel for the calciner firing. The recent modifications to Brevik should allow the total alternative fuel usage to be doubled, with corresponding increases in SLF usage.

11 Sweden

The Swedish Mining Association reports the use of alternative fuels in Sweden in global terms. The cement production in 2001 was around 2.6 mtpa and the thermal substitution by alternative fuels was 25%. In 2003 the figures were 2.5 mtpa cement and 29% alternative fuel substitution.

References to Swedish cement plants using SLF can be found from literature surveys for 2003 to 2004. An example is Cementa A.B.'s operation of the 6000 tpd kiln line 8 at Slite. In 2002 C. Greco supplied a new kiln burner. The burner was designed to fire coal, petcoke and fuel oil as well as solid and liquid alternative fuels.

12 Finland

CRH own Finnsementti Oy, which includes the Lappeenranta cement factory. The plant has an annual clinker capacity of 650,000 tonnes using two dry process kilns. These consist of a long dry kiln plus a single-stage preheater kiln.

The plant uses approximately 4000 tonnes of waste oils per annum. The thermal substitution rate is approximately 8%. The recent Integrated Pollution Prevention and Control (IPPC) licence restricts the use of SLF to the single-stage preheater kiln. With the implementation of BAT due in 2007, these older dry process kiln systems will have difficulty complying with the more stringent NO_x emission limits required. CRH are therefore currently studying the feasibility of replacing the two kilns by a single modern process, which could be optimised to use more alternative fuels. The potential kiln fuels and the licences required are currently under study and CRH expect the WID conditions to apply. *World Cement* (April 2002) reported that the main process fuels used were Russian coal and Petcoke. Both kilns were equipped with new Duoflex kiln burners, which allow for the injection of SLF (a single kiln is used currently, as outlined above) as well as water for flame cooling and NO_x reduction.

Other alternative fuels used in Finland include tyres, which are burned at Finnsementti's Parainen plant in the 2000 tpd four-stage preheater kiln plant. *World Cement* (April 2002) reported that tyres are fed to the riser duct at a rate of 1 tph. The kiln was equipped with a new Duoflex kiln burner in February 2002. The new burner design was equipped with provisions to burn alternative fuels, including MBM.

13 Portugal

The Portuguese cement industry does not appear to make use of alternative fuels to the same extent as other EU countries. The Cembureau data shows either zero or 1% use of alternative fuels.

The Cimpor Group operates several cement plants within Portugal. The fuels reported in early 2003 were petcoke and coal at the Alhandra (2.7 mtpa cement), Loule (0.7 mtpa) and Soulselas (2.8 mtpa) cement factories. Kiln line 3 of the Soulselas plant was uprated in 2001-2002. The precalciner design is an FLS SLC-D type with a combustion chamber that operates with tertiary air. Such a design should permit greater usage of petcoke or, if permitted, alternative fuels (*World Cement*, February 2003). ICR noted in November 2003 that plants such as Alhandra were not permitted to use alternative fuels such as chemical wastes and tyres. This situation was claimed to be common in the Iberian Peninsula, despite the cement industry making submissions to use substitute fuels. The Cimpor group sustainability report for 2003 mentions the use of alternative raw materials and a reduction in fuel consumption to around 2.95 MJ/t clinker through process improvement. While the use of alternative fuels is mentioned as a target there seems to be little quantification of any tonnages actually used.

Hence, there was no clear evidence of the use of SLF within the Portuguese cement industry and their use of alternative fuels appears to be very low. Atkins contacted the national cement agency Associação Técnica da Indústria de Cimento (ATIC) to clarify the situation, but received no replies.

14 Italy

The Italian cement industry was not reported as using SLF in the Atkins 1998 survey. Atkins contacted the national cement agency Associazione Italiana Tecnico Economica del Cemento (AITEC, http://www.aitec.com./) to ascertain the current situation. No information was provided by this organisation and so the information below came from literature surveys plus web searches.

According to the AITEC web page, the use of alternative fuels increased from just less than 1% thermal substitution in 1998 to around 5% in 2003. This is higher than the 2.1% quoted by Cembureau in the 2004 article.

The plants that use alternative fuels, which include SLF references, were identified. :

Pillard supplied details of their burner supply reference list for Rotaflam kiln burners. This list includes the following plants:

- Holcim Merone – 63.9 MW burner that fires coal, solid waste and waste oil (May 2002);
- Italcementi Calusco – 61.6 MW burner that fires petcoke, fuel oil and solvents (December 2000).
- Merone, Ternate – 70 MW burner that fires petcoke, fuel oil, solid waste and liquid waste (October 2000).

Unfortunately, there was no clear indication of the quantities of SLF consumed.

Italcementi operates 18 cement plants plus eight grinding plants in Italy. The 2003 Environmental protection paper mentions that alternative fuels supply a 3.8% thermal substitution rate. Italcementi has operations worldwide and some notes on their global use of SLF are included later in this report. There is an article on the use of animal meal in Italcementi's Italian cement plants. This mentions that animal meal can be used for 10-15% fuel substitution. Italian Law No 49 of 9/3/01 '*makes it obligatory that animal meal is incinerated or co-incinerated at suitable facilities from a technological viewpoint'.*

In conclusion, while the use of alternative fuels may be increasing in Italy, any SLF use appears to be of secondary importance.

15 The Netherlands

The cement industry in The Netherlands consists of Heidelberg's ENCI plant and the grinding plants at IJmuiden and Rotterdam (see the web site http://www.enci.cl/ for further details). Hence clinker production is restricted to the single kiln line 8 at Maastricht. Since Heidelberg were not willing to provide any firm data on their use of SLF, the only way this can be estimated is from published data such as their article in *World Cement*, November 2003.

The total thermal substitution rate claimed for alternative fuels is quoted as 83%, which appears to be the case for 2001 and 2002. The kiln burned the following fuel mixture in 2002:

- animal meal (10%)
- paper (1%)
- sewage sludge (15%) – in 2003 it was reported that 40,000 tpa were burned and this was expected to increase to 80,000 tpa in 2004
- coke (38%)
- coal shale (7%)
- lignite (9%)
- natural gas (5%)
- rubber chips (10%)
- glycol bottoms (5%).

If the total net fuel consumption in 2002 was 3.5 GJ/tonne clinker, the SLF input via glycol bottoms would be 0.175 GJ/tonne. The estimated annual tonnage of SLF is therefore very approximately 6100 tpa. In the 1998 Atkins survey the total SLF used was reported as 10,000 tpa of glycol bottoms during 1997. This represented 8% of the total thermal energy required to produce 697,000 tpa clinker from kiln 8 with a net fuel consumption of 3.4 GJ/tonne clinker. Using these data a similar value of 6100 tpa SLF can be estimated for the 2002 usage if a similar clinker production level is assumed. The total quantity of alternative fuels consumed in 1997 was around 67% (estimated from a graph), compared with the 83% reported for 2003. ENCI use a wide range of alternative fuels and were planning to use more sewage sludge in 2004. Hence one would expect that SLF would contribute a lower overall percentage of the total alternative fuels used in the future. Details of the glycol bottoms fuel are given in the 1998 survey (page 37, Table 15.1).

16 Switzerland

The Swiss cement industry is an established user of alternative fuels and there has been a steady increase in the use of substitute fuels in recent years. The national cement agency, Cemsuisse, publishes annual reports that detail the production of Swiss cement and the fuel usage (see the web site http://www.cemsuisse.ch/).

In 2003 it was reported that some 238,898 tonnes of alternative fuels were burned in Swiss kilns. Of this amount, the following SLF tonnages are estimated:

- waste oils, 45,900 tonnes (19.2% of total solid fuels)
- chemical solvents, 31,300 tonnes (13.1% of total solid fuels)
- total SLF, 77,200 tonnes (% of total SF)
- the remaining 84,498 tonnes of substitute fuels were listed as bone meal, animal fat, sewage sludge, plastic waste and tyres
- typical cement production, 3.7 mtpa.

The cement production is an impressive total. The use of substitute fuels in Switzerland is shown by the data in *Table 16.1* from Cemsuisse. The tonnages for waste oil and solvents are calculated from the rounded percentage values shown in the Cemsuisse reports for 2001 and 2003. These percentages are percentages of the total alternative fuel tonnage burned.

Table 16.1. Use of substitute fuels in Switzerland.

Year	*Waste oil (%)*	*Solvent (%)*	*SLF (Tonnes, ounded)*	*Total alternative fuels (tonnes)*
2000	27.9	10.8	64,800	167,553
2001	20.0	10.6	63,100	206,066
2002	21.6	13.6	79,300	225,170
2003	19.2	13.1	77,200	238,898
Increase from 2000 to 2003			12,400	71,345

Hence the general increase in the use of substitute fuels is attributable to increases in both liquid and solid fuels. The pattern of usage changes, but there has been a marked increase in MBM use since 2001.

The proportion of alternative fuels burned in Swiss cement kilns has been increasing steadily from 33.9% in 1997 to 50.1% in 2003. The increased use of substitute fuels generally has allowed the CO_2 emissions from fossil fuels to be reduced to 54% of the base value of 100% in 1990. The average fuel consumption of all the cement plants was 3.53 GJ/tonne clinker in 2003. This value has increased steadily since 2000, when it was 3.40 GJ/tonne. This is more likely to reflect the higher waste gas losses from the kiln process associated with burning lower quality fuels rather than any deterioration in kiln and/or cooler efficiency. Hence, in overall fuel usage terms, the performance of Swiss cement plants in 2003 can be summarised as:

- overall alternative fuel usage, 50.1% thermal substitution;
- thermal substitution achieved by SLF alone, 19.1%;
- total tonnage of SLF, 77,200 tonnes (rounded to nearest whole 100).

There are eight integrated cement plants plus one clinker grinding plant in Switzerland. Some examples of the use of SLF in Swiss cement plants are given below.

Holcim operates four integrated cement plants plus one grinding plant with a combined capacity of 3.8 mtpa cement. The plants at Untervaz and Eclepens are reported to burn 100% alternative fuels (Pillard report, February 2004). A new Pillard design burner replaced the kiln burner for Eclepens in May 2002, designed to handle the fuels:

- MBM and dried sewage sludge (4 tph)
- oil-impregnated sawdust (4 tph)
- animal grease (4 tph)
- solvent (1.5 tph)
- contaminated water (0.5 tph).

Hence the burner can handle up to 2 tph of SLF.

The Wildegg plant of CRH has a capacity of 0.7 mtpa cement. The main alternative fuels used are tyres (25% of fuel) plus 15% other fuels including MBM. The only liquid fuel reported in September 2004 was the use of photographic waste, which is mainly used for NO_x reduction because of its ammonia content. CRH advised that the use of SLF at Wildegg is small (i.e., under 2% of the total fuel consumption).

CRH also own the Cornaux plant of Jura cement. Cornaux is a Lepol process kiln with an annual capacity of 240,000 tpa clinker. In recent years, the following SLF have been used:

- waste oils, 34% thermal substitution (5000 tpa)
- solvents, 21% thermal substitution (4200 tpa).

The SLF are prepared by a supplier who blends the fuel to the required specification. The use of SLF is strictly controlled to the standards of the waste regulations of the Swiss Federal Authorities. The Federal Regulations can be obtained on the Internet address http://www.umwelt-schweiz.ch/buwal/shop/files/pdf/phpFk14Pa.pdf. The local Neuchatel Komune limits the use of SLF to 5000 tpa. Typical specifications for the SLF (waste oils and solvents) are included in Appendix 3.

17 Greece

The Hellenic Cement Industry Association (HCIA) was contacted, which confirmed no current use of SLF in Greek cement plants. Titan Cement Company SA operates four cement plants in Greece (Elefsina, Thessaloniki, Patras and Kamari) with a combined capacity of 6 mtpa cement. Titan also confirmed their Greek cement plants do not currently use SLF.

The HCIA web site (www.hcia.gr) states that the Greek cement industry '*Positively contributes to the national effort for waste management by exploiting residues or by-products of other processes for alternative raw materials (flying ash, slags) and alternative fuels (rubber, RDF etc.), while simultaneously reducing the use of non-renewable natural resources*'. Hence it is to be expected that the use of alternative fuels in the Greek cement industry will increase, as it has in other European countries.

18 Denmark

Aalborg Portland A.S. is a part of the Italian Cementir Group and operates the sole integrated cement plant in Denmark. The company also has a 70% share in CemMiljo, the waste recovery company set up in 1998. CemMiljo supplies alternative fuels to the cement plant. Waste is collected within Denmark and may be imported from other countries. Some 18,000 tonnes of waste was imported from Norway for processing by CemMiljo in 2003.

Atkins contacted Aalborg and CemMiljo via the web site http://www.aalborg-portland.dk/

Aalborg confirmed that their use of SLF was limited to 5000 tonnes during 2004. In their environmental report the SLF, which is waste oil (bitumen), is grouped in with alternative fuels that are primarily solid waste fuels. Since the data were obtained on solid wastes they are reported here for future reference.

The cement plant produces 2 mtpa grey cement and 0.85 mtpa of white cement. The plant uses a variety of alternative fuels, which are described in the 2003 Aalborg Portland A.S. environmental report. The use of alternative fuels has increased from around 18,000 tpa in 1999 to 60,000 tpa in 2003 (see graph on page 26 of the environmental report). Initially, the alternative fuel was CemMiljo fuel, at approximately 18,000 tpa. CemMiljo fuel is a mix of mainly solid waste, such as non-PVC plastics, rubber tyre chips, textiles, reject waste from paper and plastics recycling, etc. The usage of this fuel has doubled since 1999 to just over 36,000 tonnes in 2003. Dried sewage sludge has been used since 2000 and MBM use was approved in October 2001. Aalborg Portland A.S. has set a target of 40% thermal substitution by alternative fuels. During 2003 they achieved a substitution rate of 17% against a target of 25% for the grey kiln and 6% for the white kilns. The main alternative fuels used in 2003 were:

- CemMiljo Fuel – some 36,758 tonnes were burned in 2003, which saved 629,884 GJ of fossil fuels;
- MBM – some 19,336 tonnes were burned in 2003, which saved 315,630 GJ of fossil fuels;
- dried sewage sludge – the tonnage of this is not quoted in the report, but its weight appears to be approximately 3900 tonnes;
- total alternative fuels used is 60,000 tpa – this figure is assumed to be on a dry basis as the report also shows an alternative fuel consumption of 71,331 wet tonnes for 2003.
- in percentage terms, the thermal substitution is 17%, which implies that the thermal substitution by CemMiljo fuel alone is around 10.6% and compares with 5.3% for MBM and 1.1% for dried sewage sludge.

The thermal substitution by alternative fuels has grown significantly since 1999. The longer-term target of 40% substitution was recognised as requiring some process modifications to the kiln plant. In June 2003 a kiln by-pass was installed on kiln 87, the grey cement kiln. The kiln by-pass was installed to allow for chlorine removal, which enables fuels with a higher chlorine input to be fired in the process. The by-pass system used at Aalborg allows for low chloride dust return to the process, while the fine (high chloride) dust is disposed via landfill.

There are some relevant references to the future use of SLF and other alternative fuels:

- The CemMiljo Environmental report of 2003 and their web site (www.cemmiljo.com) indicated that CemMiljo anticipated increasing its production from 37,000 tpa in 2003 to 85,000 tpa in 2004. As Aalborg cement wished to increase its use of CemMiljo fuel in 2005, the capacity was expected to increase to 100,000 tpa from 2005.

- The Danish Environmental Assessment Institute carried out a study into the potential use of alternative fuels at Aalborg. The study was published in February 2004 and concluded that Aalborg had the potential to use 250,000 tpa waste for cement production. A scale-up of 2003 production figures implies that Aalborg's targeted 40% fuel substitution would amount to around 170,000-180,000 tpa as received waste fuel. The report considered three alternatives for waste and concluded that '*the use of waste as fuel in the production of cement at Aalborg Portland A/S is a better technique for disposal, as compared to incineration at the most efficient municipal incinerator in Denmark*'.

19 Irish Republic

The cement industry of Ireland comprises factories in the Irish Republic (Irish Cement – CRH, Lagan Cement and Quinn Cement) that are represented by IBEC, the Cement Manufacturers Association of Ireland. IBEC advised us that the cement industry in Ireland does not use SLF, but is keeping the matter under review.

The Environment Protection Agency (EPA) also confirmed this situation and noted that they had received some queries regarding the use of SLF from the cement manufacturers. The EPA advised that this would require a licence review and it had not received any such request for licence review by 11 February 2005.

20 Poland

During the period 1997-2003, the use of alternative fuels in Poland was not as well developed as it was in other European countries. Some data are available on the web site http://www.polskicement.com.pl/

There has only been a slow growth in the use of alternative fuels. For example, in 1997 some 1.34% of the fuel burned was alternative fuels. The most recent published data from the Polish Cement and Lime Association showed an increase to 3.5% in 2002 and 6.5% in 2003. This rate is still comparatively low when compared with the rates achieved in Germany, Austria, Belgium, The Netherlands, France and Switzerland.

However, this situation is expected to change as the Polish cement industry modernises its factories and shuts down older wet process kilns. The modernisation process has seen the capacity of wet process kilns reduce from 33% in 2000 to only 2% in 2003. Between 1996 and 2002, the average fuel consumption reduced from approximately 5.02 to 3.68 MJ/tonne clinker. Modernisations of older plants include that of the Lafarge Kujawy works where the three wet process kilns were replaced by a single 4500 tpd precalciner kiln. Similarly, Heidelberg modernised its Górażdże plant, which allowed the older wet process kilns at Strzelce Opolskie to be shut down. The major cement groups, such as Lafarge, Dyckerhoff, CRH, Heidelberg and Holcim, all have investments in the Polish cement industry. As this modernisation process takes place it is expected that the amount of alternatives fuels, such as SLF, used will increase.

The types of alternative fuel currently used are mainly solid fuels (e.g., tyres, shredded rubber, paper, plastics, cardboard, foil, sawdust, textiles, tobacco dust, chemical coke and MBM). The only liquid fuel reported in 2003 was heavy fractions from distilling processes.

Modernisation of the Górażdże plant is described in ICR (January 2004), and this plant has features that will allow it to maximise the use of alternative fuels. The modernised kiln line 1 (6000 tpd design) has a 5-7% kiln by-pass for chlorine and/or alkali and the precalciner vessels feature a relatively high residence time of >6 seconds. The calciner design is a twin 'Hot spot' type in which combustion is in tertiary air. All these features favour the use of alternative fuels. Górażdże has two kiln lines and can use tyres up to 10% thermal substitution (*World Cement*, January 2005).

Lafarge Polska was reported to be using tyres at the Malogoszcz plant and was planning to also use tyres at Kujawy. The Malogoszcz plant was also reported to be using shredded plastic wastes plus some liquid alternative fuels. The total alternative fuel rate achieved at Malogoszcz was claimed to be around 25% (*World Cement*, January 2005).

CRH operates the Ozarow cement plant, which is part of Grupa Ozarow. CRH confirmed that the use SLF is limited to small quantities (<2% thermal energy), largely for trial purposes.

Neither the major suppliers nor the Polish Cement Association provided any firm information on the use of SLF in Poland. However, the total use of alternative fuels was reported as over 65,000 tpa in 2002, when the average thermal substitution rate was 4%. On this basis the total alternative fuels would have been over 94,000 tonnes in 2003, subject to fuel composition.

21 United Kingdom

The UK cement industry uses both liquid and solid alternative fuels. However, the quantities used are relatively low when compared with the main European users, such as Belgium, Switzerland, France, Germany, Austria, Sweden and The Netherlands. The average usage of alternative fuels in Europe is around 12% according to Cembureau, which compares with a value of around 6% advised by Cembureau and the BCA. The difference is even more apparent when comparing the UK use of alternative fuels with that of the above-mentioned European countries. Section 39 summarises data obtained from the BCA, Cembureau and Atkins estimates for the global use of alternative fuels including SLF.

The use of SLF and other alternative fuels is summarised in *Table 21.1* (data from BCA).

Table 21.1. Use of SLF and other alternative fuels in the UK.

Year	*2001*	*2001*	*2002*	*2002*	*2003*	*2004 to 2007*
Condition	Permitted capacity	Actual	Actual	Actual	Actual	Estimate
Source	BCA submission to EFRA committee[1]	Hansard[2]	Hansard[3]	BCA data[4]	BCA data	BCA submission to EFRA committee[1]
Waste-derived liquid fuels	110,000	83,502	98,345	118,474	115,665	200,000
Waste oils		0	0			90,000-345,000
Solid alternative fuels	40,000	30,674	45,370	50,814	76,026	970,000
Total alternative fuels	150,000	114,176	143,715	169,288	191,691	1,260,000-1,515,000

[1] BCA submission to the Environment, Food and Rural Affairs (EFRA) Select Committee.

[2] House of Commons EFRA Committee, *The Future of Waste Management*, Eighth Report of Session 2002-2003, HC 385-2, page Ev 208.

[3] Elliott Morley, Hansard, 18th June 2003, Col 288W; Alun Michael, Hansard, 3 June 2003, col 18W.

[4] The higher usage within the BCA data is possibly a combination of the omission of PSP at Cauldon and the non-inclusion of Dunbar works (which falls within the control of the Scottish Environmental Protection Agency (SEPA) rather than the Environment Agency).

The BCA web site is http://www.cementindustry.co.uk/

The data show that the proportion of liquid fuels exceeds that of solid fuels up to and including 2003. Reference is drawn to the data for the USA, Australia, Germany and Austria, for which the proportion of SLF burned has tended to reduce because of the corresponding increase in solid alternative fuels. It remains to be seen whether SLF use continues to grow in the UK cement industry or decreases in overall percentage terms through wider use of solid alternative fuels.

The plants that use SLF are listed in the recent application by Lafarge Cement UK (LCUK) to carry out a trial with SLF at their Westbury works in Wiltshire – see the Pollution Prevention and Control (PPC) permit reference BL 7752. LCUK are currently licensed to use SLF at their Dunbar and Cookstown works.

The quantities of SLF used by LCUK in 2004 and expected to be used in 2005 are:

- 27,000 tonnes at Dunbar, equivalent to 22% thermal substitution for a fuel consumption of 750 net kcal/kg clinker;
- 1000 tonnes at Cookstown for trials (1.6% substitution for a kiln fuel consumption of 830 net kcal/kg clinker);
- it is expected that the use of SLF in 2005 will be 36,000 tonnes at Dunbar (28% substitution) and 9000 tonnes at Cookstown (13% substitution).

Other users of SLF in the UK are shown in *Table A4.1* in Appendix 3. The works using SLF also include:

- Rugby Cement (Cemex) Barrington and South Ferriby works – the Environmental Data Services (ENDS) report for June 2003 listed the use of 17,000 tonnes of SLF at Barrington plus 10,000 tonnes of SLF at South Ferriby during 2003;
- Castle Cement (Heidelberg), Ribblesdale and Ketton works – the ENDS report for June 2003 listed the use of 37,500 tonnes of SLF at Ribblesdale plus 37,500 tonnes of SLF at Ketton during 2003.

Cement production in Northern Ireland comprises Lafarge (Cookstown) and Quinn (Derrylin) plants. No references were found to any use of SLF at the Quinn Derrylin plant.

21.1 The effects of using SLF upon plant emissions – UK experience

Data on plant emissions with alternative fuels in the Austrian cement industry are shown in the relevant section of the report. However, the wide range of alternative fuels used in Austria means that it is extremely difficult to judge the environmental effects of using SLF alone. Data from the UK are more relevant, as the following case demonstrates, because the assessment is made with conventional fuels (coal and/or petcoke for baseline testing) with and without SLF.

In the PPC permit reference BL 7752 for the Westbury Works; some supporting data are included to show the results of using RLF (SLF) at the former Blue Circle Masons works, which carried out trials with RLF in 1997. This plant is now closed, but was authorised to use RLF on a permanent basis. Data from the trials using 20% RLF are summarised as:

- reduction in NO_x from the process of 29%;

- reduction in SO_2 from the process of 26% through reduced sulphur input;
- no significant change in the dioxin and/or furan emissions with all results below the limit of 0.1 ng/Nm^3;
- small reduction in volatile organic compounds (VOCs), with some increase in HCl and HF;
- no significant change to the emission levels of the heavy metal groups;
- the overall environmental quotients (EQs) were in the same order of magnitude in each case, but the RLF resulted in a value for the EQ 28% lower than the coal–petcoke fuelling option;
- summarised data from the trial are shown in *Table 21.2*.

Table 21.2. Data from trials using 20% RLF

	Baseline coal and petcoke	*With 20% (RLF) SLF*	*Units*
NO_x as NO_2	1691	1194	mg(NO_2)/Nm^3
Particulates	48	48	mg/Nm^3
SO_2	42	31	mg/Nm^3
CO	123	116	mg/Nm^3
HCl	5.0	6.7	mg/Nm^3
HF	0.19	0.22	mg/Nm^3
VOC	14.5	14	mg C/Nm^3
Hg	0.0011	0.0027	mg/Nm^3
Cd and Tl	0.0037	0.0056	mg/Nm^3
Group III metals	0.1429	0.3657	mg/Nm^3
Dioxins and furans	Less than 0.1	Less than 0.1	ng/Nm^3 International Toxic Equivalent

Note that the figures in *Table 21.2* (1997 basis) were expressed as wet gas with no correction for oxygen, except for the dioxins and furans, which are corrected to 11% oxygen, dry gas basis.

The results of the RLF (SLF) trials at Dunbar are also given in the PPC permit application and showed a reduction in NO_x emissions from an average of 825 to 525 mg/Nm^3 dry gas at 11% oxygen standard. SLF have been authorised at Dunbar since 1994.

The current emission limits are applied under WID, as described in Section 21.2.

21.2 Environmental legislation – UK Notes

The recent PPC application to use SLF (RLF) at the Westbury works states a limit of 40% thermal substitution, which is not reached at the Dunbar or Cookstown works. It is worth noting the conditions applicable to using SLF under WID. Additional comments (in square brackets) are included in the reproduction of these notes.

Extracted from 4.3.3 Air Emission Limit Values for Co-incinerators

Determination of air emission limit values for the co-incineration of waste.
For this, Annex II of the WID generally applies a mixing rule based on the principle that, in a mixed fuel/waste firing situation, the flue gases generated by the waste meet the ELVs given in Annex V of the WID. ***However, in some particular cases, e.g. cement plants, no mixing rule is applied (see later).*** *Annex II is reproduced below from the WID but some points need to be noted.*
Burning of waste in cement plants is not subject to a mixing rule. Limits have been set which must be complied with if the plant burns waste. There is no limit on thermal substitution when burning non hazardous waste ***but there is a limit of 40% thermal substitution for hazardous waste.***
Annex V limits for heavy metals and dioxins also apply in full to all co-incineration plants without pro rata.
If the resulting heat release from the incineration of hazardous waste amounts to less than 10% of the total heat released in the plant, waste must be calculated from a (notional) quantity of waste that, being incinerated, would equal 10% heat release, the total heat release being fixed.
Setting ELVs for cement kilns co-incinerating waste.
The ELVs as given in Annex II.1 for cement kilns are summarised in the table below. There are no half-hourly limits but half hourly value will be needed to calculate daily average value. With the possible exception of TOC and SO_2, there is no need to apply the Annex II mixing formula when burning nonhazardous waste or hazardous waste below 40% thermal substitution. ***If the heat input from hazardous waste is greater than 40%, the ELVs given in Section 4.3.1 (incinerators) apply.***

	Emission Limit mg/m^3	*Averaging Period*
Particulates	30 *	Daily
VOCs (as TOCs)	10 **	Daily
HCl	10	Daily
HF	1	Daily
SO_2	50 **	Daily
NO_x as NO_2-Existing plant	800 ***	Daily
NO_x as NO_2-New plant	500 ***	Daily
CO	Set by Regulator ****	Daily
Cd and Tl	Total 0.05	All average values over the sample period (30 minutes to 8 hours) to be less than these limits
Hg	0.05	As above for Cd and Tl conditions
Sb, As, Pb, Cr, Co, Mn, Ni and V	Total 0.5	As above for Cd and Tl conditions
Dioxins	0.1 ng/m3 TEQ	CEN method, sample period 6 to 8 hours

Reference conditions: 273 K, 101.3 kPa, 10% O_2, dry gas

Notes:

: Until 1 January 2008, a dust limit of 50 mg/m^3 may be authorised by the regulator for cement kilns which burn* ***less than three tonnes of waste per hour**.*
***: Exemptions can be granted in cases where TOC and SO_2 do not result from the incineration of waste. It will be up to the operator to prove that these pollutants exclusively arise from raw materials. In other cases, the regulators are likely to use the mixing rule for pro rata calculations of these.* [Comment – allows for SO_2 emissions from pyritic sulphur in raw materials.]
****:* ***Until 1 January 2008, derogation for NO_x for existing wet process cement kilns or cement kilns which burn less than three tonnes of waste per hour, may be granted provided that the emission limit does not exceed 1200mg/m^3. A limit of 800 mg/m^3 will apply from 1/1/08.***
*****. Daily average ELV to be set based on a site-specific assessment.* [Note the CO value will also depend upon process and allowance is made if kiln process uses, for example, the production of some CO by MSC technique to reduce NO_x. Another consideration is the presence of organic carbon in raw materials, etc., that may burn off in the preheater.] *Note the different standard oxygen content specified in the standard reference conditions, 10% O_2 rather than 11% O_2 specified for incineration plant. This means that the limits for heavy metals and dioxins are tighter than incinerators.* [Note this may affect emission limits by 9% because of gas correction factors.]

22 Lime manufacture

The 1998 Atkins survey contained some data on the use of SLF within the lime industries of Europe and the USA. The overall conclusion was that the use of SLF was not as widespread as its use within the cement industry.

22.1 Lime Production within the USA

From discussions with a US waste fuel organisation, which monitors the use of SLF, Atkins understand that SLF are not used as a fuel for US lime production.

22.2 Lime Production within the EU

Atkins contacted the European Union Lime Association (EULA) for information on current European practise with respect to the use of SLF. The only responses obtained from non-UK companies were:

- Portugal – Calcidrata S.A. advised that they used some alternative fuels for lime production, but as they were cork dust and wood dust (10,000 tpa) they do not count as SLF.
- Germany – the national lime agency (Bundesverband der Deutschen Kalkindustrie, BVK) stated that only a few of their members had experience in using SLF. As these producers were in direct competition, the BVK were not able to supply the required information. It was also stated that the BVK did not monitor the information requested.

Examples of the fuels used in European lime manufacture are quoted in an article concerning Maerz Ofenbau AG lime plant projects (*World Cement*, April 2002):

- Spain Calcinor S.A. for the Dolomitas del Nortes' plant – fuels used include natural gas and petcoke;
- Italy – Fornaci Calce Grigolin S.p.A. ordered an alternative fuel system in 2001 for its existing 300 tpd lime kiln, a system that uses sawdust produced in the local furniture manufacturing industry (the kiln can be fired using 100% sawdust);
- Austria – Voest Alpine Stahl Linz GmbH's lime plant in Steyrling ordered the turnkey installation of a 250 tpd gas-fired lime shaft kiln;
- Germany – the 550 tpd Maerz kiln at the Fels Werke's Rüdersdorf plant used natural gas;
- Spain –Tudela Veguín S.A. doubled its lime production capacity by ordering two new Maerz shaft kilns with capacities of 300 tpd each (the kilns are natural gas fired);
- Romania – the Lafarge Romcim Medgidia plant ordered basic engineering from Maerz to convert its existing three shaft kilns into natural gas firing.

22.3 Lime Production in the UK

Steetley Dolomite produces lime at their Whitwell and Thrislington plants. Both plants use SLF. Steetley Dolomite provided the following information concerning their use of SLF.

Table 22.1. Steetley Dolomite's use of SLF.

Plant	*Whitwell*	*Thrislington*
SLF used (tonnes)	17,300	18,400
Thermal substitution (%)	17	32
Total fuel consumption (million GJ)	2.4367	1.3352
SLF supplier	SRM – Morecambe	SRM – Sunderland
Environmental legislation applied	PPC, HWID, WID	PPC, HWID, WID

The environmental impacts of using SLF were reported as reductions in SO_2 and NO_x in the range 20-40% at both locations. Details of the SLF specifications used are provided in Appendix 3.

23 European Union accession states – cement industry

The expansion of the EU on 1 May 2004 resulted in 10 new members. These countries were not included in the 1998 Atkins Survey and so there were no comparative data available on SLF usage for the period 1995-1997. Some historical data on fuel usage are included where available, so that any trends can be commented upon.

24 Cyprus

There are two integrated cement plants in Cyprus. Cyprus cement has an annual capacity of 0.4 Mt with two kilns. This plant burns a mix of coal and petcoke with no use of alternative fuels reported in 2004.

Vassiliko cement operates a single white cement kiln plus two grey cement kilns. All three kilns are Lepol grate kilns. The total cement capacity is 1.2 Mt, which includes 0.2 Mt of white cement. The kilns use a fuel mix of coal and petcoke. However, the range of fuels has been increased to include sewage sludge, animal bone meal, plastics, paper, RDF and some confiscated tobacco waste. No SLF use was reported in May 2004.

25 Czech Republic

The use of alternative fuels in the Czech Republic is described in the web site of The Cement and Lime Producers Association. The data available were for the period 1990 to 2001, which demonstrates the changes in fuel type used (*Table 25.1*).

Table 25.1. Use of fuels in the Czech Republic (percentage of total thermal input).

Year	*1990*	*2000*	*2001*
Natural gas (%)	69.6	0.2	1.0
Coal (%)	16.4	61.7	54.0
Heavy fuel oil (%)	12.0	23.1	20.0
Used tyres (%)	2.0	3.0	2.0
Other solid fuels (%)	0.0	2.7	7.0
Other liquid fuels (%)	**0.0**	**9.3**	**16.0**

The total alternative fuel usage in 2001 was 25% according to the published data. However, the major international cement companies, such as Holcim, Heidelberg and Lafarge, have major investments in the Czech cement industry. It is therefore e expected that these companies will aim to maximise the use of alternative fuels while they also continue to modernise their plants in capacity, efficiency and environmental performance terms.

The Heidelberg Environmental Report, Central Europe East, for 2002 gives some details of fuels used in the Czech Republic plants at Českormoravský Cement (www.heidelbergcement.com/cee). The range of fuels was extended to include solid waste made from paper, plastics, textiles, rubber and wood wastes, but no mention of SLF usage.

The actual tonnages of SLF used were not found in the cement agency data available, but a very approximate estimate, using assumed fuel CVs, would be roughly 67,000 tonnes of SLF in 2001. Atkins have sought data on SLF from the national cement agency, but this has not been provided.

The above data clearly show that the use of SLF has increased. The growth in SLF was more than the corresponding increase in other solid fuels during the period 1990-2001. It will be interesting to see how the fuel distribution changes once the data for 2002 to 2003 become available. Some examples of plants that burn SLF are given below, using data from journals and web sites.

Mokrá cement plant, part of the Heidelberg group, has been progressively modernised to increase output and allow greater use of alternative fuels. Kiln 1 was uprated to 1950 tpd, while Kiln 2 produces 1750 tpd and is used to supplement capacity during high demand periods. Kiln 1 was also reported (*World Cement*, January 2003) as scheduled to be equipped with a kiln by-pass system, which will allow greater use of alternative fuels. The typical fuel split in the 2002 was:

- heavy fuel oil, 2.5%
- gas, 0.13%
- SLF, 53.12%
- tyres, 14.39%
- coal with kormul (solid sludge), 26.05%
- solid alternative fuel, 3.81%

The proportion of SLF used at Mokrá was increased from 3.43% in 1999 to 53.12% in 2002. Heidelberg also operates the Radotin plant, where the fuels used are coal and kormul. The Heidelberg sustainability report also mentions use of animal meal at Mokrá (2450 tonnes between August 2003 and early 2004), and the same fuel was used 4 months later at Radotin.

Cizkovice, operated by –Lafarge, was modernised with a five-stage preheater process. The BCA lists this plant as using used oils, MBM, tyres, waste hydrocarbons and biomass fuels.

Prachovice, operated by Holcim, has a 3200 tpd kiln. In July 2003 it was reported that Unitherm-Cemcon would provide a new 135 MW kiln burner to fire a mix of fuels including coal, petcoke, HFOs, natural gas and waste oil. Solid waste fuel firing is also possible with the new burner.

26 Estonia

The cement industry of Estonia consists of Kunda Nordic Cement, which is 75% owned by Heidelberg and 25% by Holcim according to an ICR report in April 2003. The plant produced 0.64 mtpa cement in 2002.

Apart from a reference to the company looking at building an oil shale mine (http://www.ce-review.org/00/5/estonianews5.html), no references to SLF were found in the web and literature searches. However, since Heidelberg is an international company and has both cement and fuel-blending plants, one would expect alternative fuels to be used or alternative fuel programmes to be developed.

27 Hungary

The use of alternative fuels in the Hungarian cement industry was reported as 10% in the Cembureau paper entitled 'The Sustainable Use of Alternative Resources in the European Cement Industry' (ref. T1702/NG/MHT 22 September 2004).

Heidelberg own Duna-Drava Cement, with two factories at Vác and Beremend. *World Cement* (January 2004) reported that the Beremend plant had two 1500 tpd kilns of which only one was in operation. The plant produces around 1 mtpa cement and has carried out extensive tests with alternative fuels. These fuels include waste oil, acid sludge and plastics. Environmental improvements have been carried out or were planned to comply with the European IPPC requirements. These include investments in filter plants, NO_x reduction and storage improvements. The Vác plant was also reported to have had new filters and other environmental improvements to storage facilities, etc. The Heidelberg environmental reports for Central and Eastern Europe include the following notes on SLF:

- 2001 Report – mentions that around 110,000 tonnes of acid sludge were available for processing to alternative fuels. The Vác plant was permitted to use this fuel, which was processed by CEVA Hungary Kft.
- The acid sludge and waste oil are mixed together in an approximately 50:50 ratio to produce the SLF. The Vác plant received permission to burn this fuel from November 2001.
- The permit allows 1 tph waste to be burned, or about 8000 tpa. This is equivalent to a 20% thermal substitution.
- Environmental benefits claimed were NO_x reduction, as well as disposing of a hazardous waste material.

A review of the available waste materials, which could be used in cement kilns, is reported by CEEBIC (The Central and Eastern Europe Business Information Center) web site http://www.mac.doc.gov/ceebic/countryr/Hungary/research/plengwaste.htm. The conclusions from this study (dated February 2004) indicated that the annual waste available from tyres (40,000 tpa, most recoverable), oils (80,000 tpa, 50% considered recoverable) unusable stored forage (16,000 tpa), sewage sludge (700,000 tpa, 33% considered recoverable) could be partially used by Hungarian cement plants. Under the Hungarian National Waste Management Plan of 2002, '*preference should be given in cement factories to co-firing*'. The report considered that half of the used oil could be used in cement kilns, equal to 40,000 tpa.

All four cement factories in the country are claimed to have already carried out trials with refuse incineration. The report also states '*Test runs for replacing coal with PVC-free plastic fuel have been promising at Swiss-owned Holcim Hungaria's cement plant in Hejőcsaba, northern Hungary. The factory, which uses 70,000 tons of coal annually, seeks to implement a widely accepted technology of burning traditional fuels mixed with one ton of plastic waste per hour. Holcim's cement plants in Beremend, SW Hungary, and Vác, central Hungary, have been using alternative fuels for several years. The four Hungarian cement plants have a total annual production capacity of 4.2 million tons of which 74% was utilised last year.*'

It is to be expected that the use of alternative fuels, including SLF will grow in Hungary in a similar manner to the growth in other EU countries. Environmental legislation will follow established EU practices, with cement factories having to meet more stringent emission limits. As of 2003, used tyres cannot be sent to landfill and so alternative solutions, such as burning in cement kilns, will become more attractive.

28 Latvia

Broceni cement plant is the sole integrated cement plant in Latvia with a capacity of 590,000 tpa clinker. There is also a clinker grinding plant at Riga. The plant is part of the Cemex group, after the acquisition of RMC. The plant is licensed to burn whole tyres using mid kiln technology. The RMC group recently reported (ICR January 2005) their efforts to reduce pollution contained within a lake near Riga. The lake contained 40,000 tonnes of asphalt, oils and sulphuric acid tar left over from the oil cracking process. Recovery of this material started in 2001. These wastes are burned in the kiln; some 15,000 tonnes of tyres and 10,000 tonnes of waste liquids from the lake were burned in accordance with European standards.

The Unitherm kiln burner reference list quotes Broceni as having a 912 tpd kiln with a new 65 MW burner for gas–HFO and solid wastes.

29 Lithuania

Lithuania became a member of the EU in May 2004. As such, its environmental legislation will have to comply with the current EU regulations.

Lithuania has a single integrated cement plant, Akmenes Cementas AB. The plant comprises five wet process kilns. There are two operational kilns (7 and 8), which have an output of up to 1900 tpd each. The kilns were oil fired, but conversion to coal firing started in 2002 and will be completed in 2005.

In July 2003 it was reported that the new 135 MW Unitherm-Cemcon kiln burner had been commissioned on kiln line 11, of 2300 tpd capacity. The burner was designed for coal–HFO firing, with provisions to fire shredded tyres in the future.

There is no current use of SLF at Akmenes though the use of tyres is being considered. Akmenes Cementas AB are currently examining the options for process modernisation. One of the aims of the study is to review the further use of alternative fuels, and SLF usage may therefore be considered.

30 Malta

The minerals reports for Malta from Euromines (source U.S. Geological Survey Minerals Information) list Malta as importing 260.812 tonnes of cement in 2001. A planned cement plant project was apparently abandoned.

31 Romania

CIRCOM, the national cement agency for Romania, advised us of the current situation with respect to the use of SLF in Romania.

- The main cement producers are Lafarge-Romcim (two plants, total 9000 tpd clinker), Holcim (three plants, total 5400 tpd grey clinker, plus one plant of 400 tpd white clinker) and Carpatcement (Heidelberg, three plants, total 9000 tpd clinker).
- Only minor quantities of SLF had been used by February 2005. CIRCOM quoted that less than 0.2% thermal substitution by SLF had been co-processed.
- The low usage of SLF was attributed to the lack of companies that specialised in the collection, transportation and pre-treatment of waste, and to the fact that Romanian industry was at the beginning of the implementation phase of European legislation.
- The three main cement groups are part of multi-national organisations that have a proven track record in implementing programmes to use alternative fuels, such as SLF. To quote CIRCOM '*As active members (at the groups level) within the "Cement Sustainability Initiative" taskforce of the WBCSD – World Business Council for Sustainable Development, and initiators of the "Towards a Sustainable Cement Industry 2000" project, they are actively taking actions also in Romania in order to put into practice one of its basic principles: preservation of the natural resources by the substitutions of the traditional fuels and/or raw materials with alternative ones, resulted from wastes of the other industries and from sorted household wastes*".
- Environmental legislation status – CIRCOM noted that Romania, as part of joining the EU, has made sustained efforts to transpose the European Directives into national legislation, including waste-related directives. Directive 76/2000, regarding waste incineration, was transposed in March 2002 by Government Decision No. 128, followed by the Technical Normative 1215/2003.

Liquid Alternative Fuel – The following reference was found on the CEVA site (http://www.cevaonline.com/projects.htm):

> *S.C. CIMUS S.A. ('CIMUS') is a cement manufacturer owned by Holderbank Financiere Glaris, Ltd. located in Campulung Muscel, approximately 120 kilometers from Bucharest and is one of nine cement manufacturers in Romania. The plant has five large cement kilns. CEVA and CIMUS have entered into a joint venture for the procurement of alternative fuels and the on-site processing and management of the supplemental fuels technology. The fuel processed by CEVA at the CIMUS plant will replace the more expensive heavy oil that CIMUS currently uses to fire its kilns. The entire residual processing facility was designed and built in the US and shipped in 1997 to Romania and operated by US personnel with Romanian support. The plant is designed to handle the refinery residuals and tars stored and generated in the region.*

ICR (Feb 2004) noted that the fuels used in Romania included heavy fuel oil at the Alesd plant, while the Campulung plant used 40% heavy fuel oil and 60% gas. The Romanian cement industry would therefore be expected to reduce gradually the high fuel costs associated with oil–gas firing by making greater use of alternatives fuels, which could include SLF.

Heidelberg operations in Romania – The Heidelberg 2004 sustainability report Central East Europe mentions the use of alternative fuels in Romania and key points were:

- the governmental authorities granted the cement plants in Moldocim Bicaz and Casial Deva permits to collect and transport waste oils, old tyres and waste wood;
- both plants also received the environmental permits to recover these wastes for use as alternative fuels;
- the first plant tests were carried out in November 2003;
- The initial aim was to achieve 10% substitution with alternative fuels, but one problem with recovering waste oil was the tendency for people to burn this for domestic purposes;
- by late 2003, over 4400 tonnes of tyres had been collected and a new fuel line was scheduled for April 2004 in Casial Deva and August 2004 in Moldocim;
- a literature review (ICR July 2004 and *World Cement* January 2005) confirmed the use of 60 tonnes per day of used tyres at the Deva plant from June 2004. It was also stated that Carpatcement intended to use tyres, used oils, and wooden and petroleum wastes at all its three cement plants

.

32 Slovakia

References to Slovakian cement plants using SLF can be found from literature surveys for 2003-2004. Limited data are available on http://www.zvcv.sk/

Horne Srnie – it was reported that Cemmac A.S. put into test operation a facility for waste fuels in January 2004. The kiln burner design of Unitherm allowed the use of gas, coal, liquid and solid wastes plus mixtures of plastics, fabrics, paper and wood. The installation of a solid alternative fuel complex was scheduled for operation in January 2005.

Ladce Works – Pillard reference list quotes the supply of the following burners to Považská Cementáreň vis PSP Engineering A.S. (December 2004):

- one 22 MW calcination burner for petcoke, natural gas and liquid secondary fuel;
- one 22 MW calcination burner for petcoke and liquid secondary fuel;
- one 11 MW calcination burner for petcoke;
- one burner valve train for natural gas and accessories.

Holcim Slovensko, Rohoznik Works – Pillard supply list includes a 45.6 MW Rotaflam burner. The fuels fired include petcoke, natural gas, waste oil and solid waste (April 2003).

33 Slovenia

The Slovenian cement industry comprises cement plants that belong to Salonit Anhovo at Skale plus the Lafarge's Cementarna Trbovlje plant. Both plants are listed in the IPPC register of plants. The traditional fuel used in Slovenia was oil, which was gradually being replaced by systems that fire solid fuel.

Salonit Anhovo recently a reported a cement production of 694,000 tonnes. Loesche reference lists report that Salonit Anhovo ordered an LM 17.2 D mill in 2003 for coal and petcoke grinding. In addition, *World Cement* (July 2004) reported that Beumer has supplied a fully automatic whole-tyre transport installation for car and truck tyres with a conveying capacity of 2.5 tph.

The Trbovlje plant produces around 530,000 tonnes of cement per annum. Lafarge publish a newsletter on the plant on the web. The newsletters refer to the use of alternative fuels (plastics?), but no clear references to the use of SLF were found at either of the above-mentioned plants.

34 Non European union countries – Japan and Australia

The information in Sections 35 and 36 was found during web and literature surveys. The data are relevant as they show it's the developing use of SLF and other alternative fuels in Australia. The case of Japan illustrates the use of SLF and/or alternative fuels in a highly developed cement industry that has used these fuels for many years.

35 Japan

Although the scope of the 1998 survey did not include Japan, some data from the Japanese Cement Industry may be of interest for comparison with the European and US use of SLF. In 2002, Japanese cement industry production was around 75 mtpa cement. The Taiheiyo cement group reported the following use of alternative fuels in the whole of the Japanese cement industry during 2002:

- recycled oil, 252,000 tonnes
- waste oil, 100,000 tonnes
- total SLF, 352,000 tonnes.

Other types of alternative fuels used are mainly solid fuels, such as tyres (253,000 tonnes) and paper wastes (211,000 tonnes). Some used clay is also used for raw materials and fuel (97,000 tonnes). The thermal substitution rate by SLF is not stated. The Taiheiyo group has developed a kiln by-pass design to handle the chlorine input associated with the use of plastics and waste-wood alternative fuels.

36 Australia

Although Australia is not strictly within the scope of this survey, brief mention of the Australian cement industry is made in the 1998 Atkins report. As more recent data have been found during the literature and web searches into SLF use, it was decided to include this information here. The Australian cement industry comprises three main operating Groups – Blue Circle Southern Cement (BCSC), Adelaide Brighton (ABL) and Cement Australia (CAPL). In 2003, clinker production from the 10 plants was around 6.5 mtpa.

The Australian national cement organisation, the Cement Industry Federation (CIF) issues an annual environmental report, which mentions the use of SLF.

The CIF environmental web site mentions the policy adopted with regard to using waste oil (www.cement.org.au/environment.htm), to quote '*Use of Waste Oil in Cement Kilns – The Commonwealth's Product Stewardship (Oil) Act 2000 sets out a scheme for the economic refining and reuse of waste oil. When such refining and reuse are not economically viable, the use of waste oil as a cement kiln fuel offers the most efficient use of this energy source. The high temperature and long residence time in the cement kiln mean there are no net adverse environmental effects from the use of waste oil as a kiln fuel*.'

The graph of alternative fuel usage shows that in 2001-2002 this totalled just under 6% of the total thermal input. Of this, SLF accounted for approximately 2.5-3.5% (average 3%) of the total thermal input. The CIF report does not state the actual tonnage of SLF used, but a very approximate estimate is around 28,000 tonnes per annum in 2003, based upon the overall clinker production and the fuel consumption distribution taken from the CIF graphs.

The graphic data from CIF does not show any major increase in alternative fuel usage during 2003. The fuel trends have shown a gradual reduction in natural gas through its replacement by coal or petcoke and alternative fuels. The fuel consumption for the plants gradually reduces as modern precalciner process kilns have replaced older wet process kilns.

The users of SLF have been identified from published data on the web. The CIF environment report of 2002 mentions that the CAPL's Fishermans Landing plant had been using solvent-based fuel (SBF) for more than 2 years. The SBF accounted for approximately 7% of the thermal energy requirements at the plant.

BCSC operates the Waurn Ponds cement plant. The CIF presentation *Managing our Resources-Use of Alternative Fuels at Blue Circle Southern Cement* mentions that the Waurn Ponds plant uses waste oil derived from engine oils, lubricants and ship oils. The Environment Protection Authority regulates the use of waste oil as fuel through a licensing system, which imposes restrictions upon the composition of the fuel and its combustion products. The quantity of waste oil used at Waurn Ponds has been as high as 15 million litres per annum, equivalent to as much as 30% of the natural gas fuel replacement. Other fuels used at Waurn Ponds include tyres (25%

thermal substitution), tallow residue and waste carbon dust. The total replacement by alternative fuels is quoted as 50% in the CIF environmental report of 2002.

Hence, while the Australian cement industry's use of alternative fuels is not as well established as in the leading European countries, their use has been steadily increasing from around 1% in 1992 to approximately 6% in 2001-2002. SLF are an important contribution to the alternative fuels used. Between 1991 and 1994, only liquid waste fuel usage is reported. Solid waste usage is reported from 1995 and has grown in importance. Hence, the use of SLF may well follow the patterns established in several of the countries studied (e.g., the USA and Austria). Here the use of SLF appears to reach a certain level and the growth in alternative fuels is mainly from to greater use of solid wastes, with a wider range of solid fuels being permitted and used.

37 Economics of using SLF

The 1998 survey includes several references to the cost of SLF in terms of the disposal fees paid to cement companies to burn SLF. The cement producers, agencies and fuel blenders were not prepared to provide any information on gate fees for SLF. In this section of the report, some general observations are made on the economics aspects of using SLF.

The economics of using SLF will vary from country to country and several factors affect its use, including:

- Countries such as Germany are reported to have surplus cement capacity. Hence the potential loss of kiln output associated with using some alternative fuels, such as SLF, is not such a serious issue.
- SLF have various water contents, typically from zero to 20% free water for UK-supplied SLF. This range may be higher (e.g., up to 35%) according to the source of supply and its composition.
- This water contributes no CV and simply serves to increase waste gas volumes and hence waste gas heat losses. It has been noted that NO_x reduction was found with the use of SLF at a wet process works. The NO_x reduction technique may derive partially from the lowering of flame temperature because of the moisture content and other characteristics of the SLF. While this helps lower NO_x levels it is not consistent with achieving the highest potential kiln output.
- The use of SLF in the process plant has generally benefited NO_x reduction, which may help to offset the cost of other NO_x reduction techniques.
- Other effects could be the effect upon the kiln process sulphur input. A typical UK SLF contains 0.3-1.5% sulphur, which is lower than petcoke, which can be up to 6% sulphur depending upon the type. Since the fuel sulphur tends to be retained in the clinker, the replacement of petcoke by SLF would be expected to benefit the energy costs of cement grinding, as they would lower the cement grindability. If the flame temperature is lowered too much by the SLF water content, a poorer heat exchange could result in a higher clinker-free lime, which promotes a higher clinker C2S content. This then makes the clinker harder to grind and of lower quality. These effects have to be judged on a site-specific basis to take into account other factors that affect the cement quality and/or grindability.
- This report mentions several cases in which kiln burner designs have been modernised to enable the burning of more difficult fuels without compromising plant output or NO_x emissions. Modern kiln burner designs are very sophisticated, to achieve the aims of maximising alternative fuel use and minimising emissions.
- SLF with a higher moisture content can have a very detrimental effect on the kiln capacity, especially in a process limited by waste gas volume and burning zone loading. For example, one kiln suffered an output loss of 4.5% when the moisture content of the SLF supply increased, while its CV reduced. The net savings in fuel consumption were offset by the loss in the value of the clinker capacity, which cost at least 47% of the fuel saving benefit.

- In a fully sold market situation this makes the economics of using SLF less attractive unless an economically acceptable supply of clinker is available.
- Other costs of using SLF in the UK were identified by the BCA. These include the following costs for trials and permitting. To quote from the BCA's letter of 13 September 2002 (Energy Policy Review) to the Department of Trade and Industry (DTI):

  High, up-front costs are essentially risk capital, and extended authorization periods of 15-30 months have a significant effect on the payback period. Delays between the end of trials and the granting of permits are problematic in terms of continuity of supplies (of alternative fuel to required quality standards) and operational conditions The up-front costs of plant required to trial are £1M to £2M, with trial costs adding a further £600,000 to £800,000. All of these costs are essentially risk capital, which is forfeit if permanent permission is not forthcoming.

- On the basis that cement organisations have a high incentive to reduce operating cost, the widespread use of SLF implies that gate fees are attractive when compared with fossil fuels. However, the pattern of SLF use in Europe and the USA tends to suggest that future growth in alternative fuels is more likely to be with solid-derived fuels, which may or may not incorporate some liquid wastes. This situation is no longer country specific, as the ECJ rulings permit transborder movement of wastes for processing into fuels such as SLF.
- The major cement companies have invested in fuel-blending facilities and the capital and/or operating costs of these units will be reflected in the gate fees applied to the tailor-made SLF product. The SLF in this situation is a controlled and blended product, and not simply a depository for unwanted liquid wastes.
- The conclusions are that the economics of using SLF are very much site specific. Key factors are the location and suitability of waste collection and/or blending facilities, transportation costs, basic plant process and environmental design standards, market situation (i.e., if fully sold out in event of any loss of output), etc. Any assessment should consider the factors outlined above. The fluctuations observed in recent international coal and petcoke prices also impact the gate fees applied to SLF and other alternative fuels.

38 Special abatement systems

The 1998 Atkins survey concluded that the users of SLF in the USA and Europe confirmed that no additional pollution control measures, other than those commonly used in the industry to treat the exhaust gases, were installed.

During this survey the only changes reported are:

- Additional continuous monitors were in installed in the UK to monitoring VOC and HCl emissions.
- The cement journals make frequent mention of plant upgrades using new dust-control measures, NO_x reduction measures (e.g., the programme of NO_x reduction at the Wildegg plant in Switzerland, which was reported in *World Cement*, September 2004). These improvements should be seen as part of the ongoing environmental improvement programmes to meet current EU regulations, etc. They may not be specifically related to the fuels used.
- New plant design – this report includes several references to plants, which have been modified to make better use of SLF. Please refer to the examples in Section 7 (Germany) and other sections of new kiln burners supplied by companies such as Pillard and C. Greco. These aim to allow the SLF and other alternative fuels to be burnt while achieving lower NO_x emissions. Other plant modifications to allow greater alternative fuel and/or SLF usage includes the retrofitting of kiln by-pass systems. These may be incorporated at the design stage to cope with chloride input from both the raw materials and alternative fuels. Examples referred to in this report include Greencastle modernisation (USA) and Mokra modernisation (Czech Republic).

39 Major cement companies – use of SLF

Examples of the global use of major international cement organisations were found on the web, and are given in Sections 40-42. The data do not show the specific use of SLF in different countries, but help to paint a wider picture of their use.

40 Holcim – worldwide use of SLF

Holcim is the second largest cement manufacturer in the world and operates in Europe, Asia, the USA, South America, Africa and Asia. The breakdown of alternative fuel use is quoted as follows in the Holcim corporate sustainable development report 2003 available from the web (www.holcim.com).

The thermal substitution rate achieved at Holcim plants worldwide in 2003 was 13.1%. The percentage alternative fuel usage was quoted as 32% in Western Europe, 17% in the USA and 14% in Latin America. Of these alternative fuels, some 26% were counted as biomass fuel. For the whole of the European operations, a Holcim presentation (*Waste co-processing in Latin America*, E. Guerra, November 2004) showed a substitution rate of approximately 42%. In 2003.the total alternative fuel use was quoted as 2.1 million tonnes, equivalent to 934,000 tpa fuel oil. The percentage input from SLF was:

- waste oil, 11% of total
- solvents, 13% of total
- total SLF, 24%
- total cement production in 2003, 111.3 mtpa
- if the average alternative fuel used is 13.1% of the total fuel, the SLF proportion would be 13.1 × 0.24 = 3.14% thermal substitution by SLF.

Unfortunately, the actual fuel tonnages used are not given. However, assuming that these percentages refer to thermal percentage inputs by each alternative fuel (this would be the normal way to present the data), the tonnages can be roughly calculated using typical CVs for the fuels quoted. As a very rough estimate, the total SLF tonnage would be approximately 335,000 tonnes. No degree of accuracy can be assigned to this figure. This value cannot be confirmed, but it indicates the importance of SLF in Holcim's alternative fuel programme. The overall percentage of SLF used (24%) is similar to the Cembureau data shown above (24.9%).

41 Italcementi – worldwide use of SLF

Italcementi is an international cement producer that produced 46 mtpa cement in 2003. Its 2003 environmental protection and sustainability report (http://www.italcementigroup.com/) outlines the use of alternative fuels used within the group. The key figures are:

- Overall fuel consumption for the group in 2003 (excluding Cyprus, Egypt, Kazakhstan and Quebec) was 3893 MJ/tonne clinker. The European subsidiary average was 3663 MJ/tonne clinker.
- In the EU countries, alternative fuels contributed 5.9% thermal input in 2003 compared with 2% in 1990. The corresponding figures for biomass fuels were 5.6% in 2003 and 0% in 1990.
- The total thermal substitution for the group as a whole was 7.7% in 2003.
- The thermal substitution rates achieved by subsidiary companies were:

    - 33.2% for Calcia in France
    - 14.8% for CCB Belgium
    - 3.4 for Financiera y Minera in Spain
    - 8.2% for Essroc in the USA–Canada
    - 3.8% for Italcementi S.p.A. in Italy
    - 0.5% for Cimar in Morocco.

- The breakdown of waste-derived fuels used is shown in *Table 41,* which shows that some 54.02% of the total alternative fuels used is within the definition of SLF. If the total alternative fuels used is 7.7%, SLF contributes 7.7 × 0.5402 = 4.16% thermal substitution rate.
- No data are available to show the actual tonnage of SLF.
- Atkins have tried to estimate the tonnage of SLF used, but the accuracy of any estimation is low. A rough estimate for the SLF tonnage would be around 190,000 tpa subject to the assumptions made on the fuel characteristics such as CV, etc. No degree of accuracy can therefore be assigned to these figures and Italcementi did not provide any information on SLF usage.
- SLF are a significant alternative fuel source to the Italcementi Group plants. Its 54% contribution to the total alternative fuel usage may reduce in the future as greater use is made of solid fuels. This is the pattern that has been seen in the USA and Australia, as well as in European countries such as Austria and Switzerland.

Table 41.1. Breakdown of waste fuels, Italcementi 2003 sustainable development report

Waste fuel type	*Total waste fuel used (%)*
Solid waste	7.79
Tyres	10.91
Animal meal	27.27
Waste oil	16.88
Liquid waste	37.14
Total liquid waste fuels	54.02
Overall thermal substitution by alternative fuels (%)	**7.7**
SLF overall thermal substitution (%)	**4.16**

The data in Table 41.1 are from the 2003 sustainable development report, which implies the data are for 2003. However, the Ciments Francais Italcementi Group 2003 annual report uses different figures for alternative fuel use, as in *Table 41.2*,

Table 41.2. Breakdown of waste fuels, Ciments Francais Italcementi Group 2003 annual report

Year	*2002*	*2003*
Coal	49%	50%
Petcoke	36%	36%
Alternative fuels	10%	9%
High viscosity fuels	3%	3%
Other (fuel – gas)	2%	2%

While these figures are different to those quoted above, the first set of figures did not include all operations. The following notes are relevant to the use of alternative fuels generally:

- The reduction in alternative fuel usage from 10% to 9% was attributed to factors such as dependence upon the quantity of the source of supply –'*in 2003, animal meal to be eliminated was not as important as in previous years in France and Belgium … disappearance of animal fat and the spacing out of car oil changes, and therefore the disappearance of used oils, have contributed to a decrease in the share of alternative fuels*'.
- It is to be expected that the fuel mix composition of all alternative fuels, including SLF, will inevitably vary according to supply and demand. As demand for waste fuels increases, gate fees will vary accordingly and the proportions of alternative fuels used will change consequently. The success of any alternative fuel programme must also depend upon having a flexible plant process design that can cope with changes in alternative fuel type and/or composition without suffering from process and/or environmental problems.

42 Lafarge – worldwide use of alternative fuels, including SLF

Lafarge is the largest cement company in the world. Its 2004 group presentation (www.lafarge.com) lists its performance as having cement operations in 43 countries with 138 production sites. Total cement sales were around 105.7 mtpa in 2002 and the cement capacity was around 135.5 mtpa, according to ICR.

The 2003 sustainable development report gives the following breakdown of the fuel mixture used in percentage energy terms:

- coal and petcoke, 73%
- oil and pitch, 8%
- natural gas, 10%
- waste, 6%
- biomass, 3%.

This does not indicate the SLF tonnage, but gives a general distribution of fuels. It is assumed that some SLF will be included in the 8% oil and pitch as well as some of the 6% waste tonnages. The Lafarge group global use of alternative fuels is also outlined in a paper presented at the VI Feira Internacional de Meio Ambiente Industrial (FIMAI) meeting 4 November Sao Paulo 'Waste treatment in Europe and Co-Processing' (D. Lemarchand, Lafarge). This presentation is available from the Brazilian cement agency (ABCP) site (www.abcp.org.br/sala-de-imprensa/noticias/fimai/palestra1.pdf). The distribution of alternative fuels in the Lafarge group worldwide is shown as:

- USA, 1,007,000 tonnes
- Europe-Mediterranean, 520,000 tonnes
- Central Europe, 327,000 tonnes
- Association of South East Asian nations (Asean), 157,000 tonnes
- Latin America, 143,000 tonnes
- Africa, 5400 tonnes
- total alternative fuels, 2,159,400 tonnes
- total alternative fuels plus alternative raw materials, 5,214,000 tonnes.

The paper also shows the composition of a solid waste fuel, which includes 'sludges' derived from paint, oil, industrial and water treatment processes. This material produces a solid waste, which would normally be booked under solid alternative fuels. However, it could be argued that some materials are mixed liquid–solids and so they could be partially counted under the SLF category (see also the comments under Section 1.6 Definition of SLF).

43 An overview of the use of SLF

43.1 Introduction

There are a number of estimates of the use of alternative fuels in Europe and the USA. Unfortunately, some of the available data do not differentiate between liquid and solid alternative fuels. This situation is further complicated by practises such as the mixing of SLF with materials such as sawdust to produce an impregnated solid waste fuel. From the data obtained in the survey, the following is a comparison of the separate estimates. It has been noted already that there are several inconsistencies in the published data for alternative fuel and/or SLF usage. An attempt is made below to reconcile the different values quoted for alternative fuel F usage. Firstly, a summary of the 1998-1999 Atkins survey illustrates how the use of SLF has changed since the period 1995-1997.

43.2 Atkins 1998-1999 Survey – conclusions and data

The 1998-1999 survey mainly used data from 1996-1997. For comparative purposes, the summary from Section 18.1 is included here. The key conclusions drawn from this survey were:

‘*Table 18.1 (below) shows that in continental Europe only the cement industries in Belgium and France consume significant tonnages of SLF to partially fire their kilns.*

In France each of the four major cement groups used substantial tonnages of SLF to partially fire their kilns in 1996. The 262,093 tonnes of SLF burned by the major cement groups represented approximately 10.5 % of the total fuel required to produce the 16,084,000 tonnes of cement clinker produced by the French cement industry in 1996.

In Belgium only the Obourg plant uses SLF to partially fire their two wet process kilns. The 200,300 tonnes of SLF burned in 1996 represented approximately 22% of the total fuel required to produce the 4,000,000 tonnes of cement clinker produced by the Belgian cement industry in 1996.

During 1996 and 1997 the rest of the European cement industry listed in the table burned less than 50,000 tonnes of SLF, which represented less than 0.1% of the fuel required to produce the 200,000,000 of clinker capacity available to the other 15 countries in 1996. Even if the clinker capacity available to those countries who do not use SLF are removed then the usage represents less than 0.5% of the total fuel required to produce the 83 million tonnes of clinker capacity that is available in those countries who burn SLF as a partial fuel replacement.

In 1996 975,600 tonnes of SLF were burned on 20 plants in the United States, 57% of the clinker produced by the kilns on these plants used the thermally inefficient wet process. The SLF provided approximately 28% of the energy required to produce the 16,061,000 tonnes of clinker produced by the 20 plants in 1996.

The 975,600 tonnes of SLF burned represents between 3 to 5% of the total fuel required to produce the 75,000,000 tonnes of clinker capacity available in the United States in 1996.'

Table 18.1 from previous Atkins Report

		Atkins 1998-1999 Report, SLF only
Country	*Year*	*Tonnage of SLF consumed*
Australia		None used
Austria	1997	3794
Belgium	1996	200,300
Denmark		None used
Eire		None used
Finland		None used
France	1996	262,093
Germany	1997	10,000-20,000
Greece		None used
Italy		None used
Luxembourg		None used
Netherlands	1997	10,000
Norway	1997	7510
Portugal		None used
Spain	1997	3643
Sweden	1997	5891
Switzerland	1997	4600
Turkey		None used
United States	1996	975,600

The total tonnage of SLF used in the above countries can be summarised as:

- total known annual use of SLF in Europe, 512,831 tonnes;
- total known annual use of SLF in the USA, 975,600 tonnes;
- total known use of SLF in Europe and the USA = 1,488,431 tonnes.

43.3 Cembureau figures –2004 and 2005 presentations

The Cembureau estimates for alternative fuel use in European cement plants have been found in papers published on the web. The general web site is http://www.cembureau.be/

These papers are:

- 'Alternative Fuels – The Valorisation of Waste in the Cement Industry, by Willem van Loo (Warsaw, May 2004);
- 'The Sustainable Use of Alternative Resources in the European Cement Industry', ref. T1702/NG/MHT 22 September 2004.

- *Table 43.1* summarises both of these Cembureau estimates for all alternative fuels used in different European countries.

Table 43.1. Cembureau estimates for alternative fuel use in European cement plants.

Country	*Warsaw 2004 Cembureau paper (% thermal substitution alternative fuels)*	*2004 paper, ref. T172/NG/MHT (% thermal substitution alternative fuels)*
Countries Listed No.	*12*	*18 – only 12 shown for comparison*
The Netherlands	72	*83*
Switzerland	34	*47*
Belgium	30	30
Germany	30	30
Austria	29	*46*
France	27	*34.1*
UK	6	6
Denmark	4	4
Finland	3	3
Poland	1	1
Portugal	1	*0*
Irish Republic	0	0
Average, all European countries-	**12**	**12**

Data in *Table 43.1* in italics show those countries for which there is a difference between the two sets of results. This difference may result from the data belonging to different time periods, etc. The growth in alternative fuels was quoted as being from 3% in 1990 to 12% average.

The date for the data in *Table 43.1* is not clear, but some of the figures do not correspond with data found by Atkins for 2003. For example, the Austrian cement statistics published by VOZ show that the thermal substitution rate has been rising from just over 29% in 1998 to slightly over 48% in 2003 (see below).

The Cembureau presentation in Warsaw provides the breakdown in *Table 43.2* for the types of alternative fuel used in the European countries listed in *Table 43,1*. This does not include all of the new members (accession states) who joined the EU in 1 May 2004.

Table 43.2. Types of alternative fuel used in the European countries listed in *Table 43.1* (from Cembureau presentation in Warsaw).

Alternative fuel type (Warsaw presentation data)	*Amount used (mtpa)*	*% of total alternative fuels used*
Animal meal, bone meal, animal fat	0.76	19.3
Tyres	0.50	12.7
Waste oil and oiled water	0.38	9.7
Solvents and others	0.26	6.6
Plastics	0.21	5.3
Paper, cardboard, wood	0.18	4.6
Impregnated sawdust	0.17	4.3
Coal slurries, distillation residues	0.11	2.8
Paper and sewage sludge	0.10	2.5
Anodes, chemical cokes	0.09	2.3
Refuse-derived fuel	0.04	1.0
Other non-hazardous wastes	0.75	19.1
Other hazardous wastes	0.38	9.7
Total	**3.93**	**100**

Source: 'Alternative Fuels – The Valorisation of Waste in the Cement Industry', by Willem van Loo (Warsaw, May 2004).

It is not possible to establish the total quantity of SLF used in Europe from the above data alone, as SLF form part of the impregnated sawdust tonnage and may also be part of the other hazardous and non-hazardous waste tonnages. Since the total tonnage shown is less than that shown in *Table 43.3* and *Table 43.4* (see below), these data must be of earlier origin.

However, the T1702/NG/MHT report contains the breakdown given in *Tables 43.3* and *Table 43.4* for the different alternative fuels used, and they illustrate the:

- use of all types of alternative fuels used, including SLF, in both tonnage and thermal substitution rate;
- list of the 18 countries studied, which does not include all of the EU new member (accession) states.

Tables 43.3 and *Table 43.4* are believed to be more accurate and comprehensive than the data presented in the Warsaw presentation and these figures also appear to be the same as those used within the BCA.

Table 43.3. Different alternative fuels used according to the T1702/NG/MHT report.

Alternative fuels (T172/NG/MHT, Cembureau Paper)	*Volume (kT)*	*Average calorific value (MJ/kg)*	*Energy (TJ)*	*Substitution rate (%)*
Solid fuels	3532			9.19
Other non-hazardous wastes	788	19.1	15035	2.00
Animal meal, bone meal and animal fat	890	19.3	17203	2.29
Tyres	554	27.0	14980	2.00
Other hazardous wastes	357	18.3	6545	0.87
Plastics	210	23.9	5026	0.67
Paper, cardboard, wood, PAS	180	15.6	2802	0.37
Impregnated sawdust	167	11.6	1931	0.26
Coal slurries, distillation residues	112	14.8	1654	0.22
Sludges (paper fibre, sewage)	107	9.6	1032	0.14
Fine, anodes, chemical cokes	89	18.0	1603	0.21
RDF	41	13.0	531	0.07
Shales, oil shales	14	9.3	130	0.02
Packaging waste	12	22.0	264	0.04
Agricultural and organic waste	11	155	170	0.02
Liquid fuels (SLF)	**841**			**3.04**
Waste oil and oiled water	402	35.6	14331	1.91
Solvents and others	266	15.3	4081	0.54
Other hazardous liquid fuels	173	25.4	4398	0.59
Total SLF and solid alternative fuels	**4373**			**12.23**

Source: 'The Sustainable Use of Alternative Resources in the European Cement Industry, ref. T1702/NG/MHT 22 September 2004.

The corresponding thermal substitution rates for all alternative fuels used are summarised by country in *Table 43.4*. Atkins were not able to locate any separate data showing SLF use alone.

Table 43.4. Different alternative fuels used according to the T1702/NG/MHT report.

Country	*Thermal substitution level (%)*
Austria	46
Belgium	30
Czech Republic	24
Denmark	4
Finland	3
France	34.1
Germany	30
Hungary	10
Ireland	0
Italy	2.1
Netherlands	83
Norway	35
Poland	1
Portugal	0
Spain	1.3
Sweden	29
Switzerland	47.8
United Kingdom	6

Source: 'The Sustainable Use of Alternative Resources in the European Cement Industry, ref. T1702/NG/MHT 22 September 2004.

- Hence the total amount of SLF used amounts to 841,000 tonnes for the 18 European countries listed in *Table 43.4*.

In summary:

- *The Cembureau data show that the total use of SLF in the 18 countries of the EU listed amounts to 841,000 tonnes, with an average thermal substitution level of 3.04%. The total alternative fuel usage in the same period was equivalent to 12.23% thermal substitution.*
- Overall, SLF contribute 24.9% of the total alternative fuel thermal input.

43.4 BCA data for alternative fuels, including SLF

The BCA provided Atkins with information for 2005 given in *Table 33.5*, which is useful in listing the number of plants using alternative fuels in different countries.

Table 43.5. BCA Data for alternative fuels, 2005.

Country	*Substitution level (%)*	*Number of cement plants*	*Number of plants using alternative fuels*
Austria	46	9	9
Belgium	30	5	5
Czech Republic	24	6	6
Denmark	4	7	6
Finland	3	7	6
France	34.1	44	38
Germany	30	35	32
Greece	<1	8	1
Hungary	3	6	2
Ireland	0	4	0
Italy	2-21	23	23
Luxembourg	No data	1	1
Netherlands	83	1	1
Norway	35	2	2
Poland	1	6	6
Portugal	No data	No data	No data
Spain	1.3	36	16
Sweden	29	3	3
Switzerland	47.8	No data	No data
United Kingdom	6	15	9

43.5 Atkins 2005 survey

The 2005 survey mainly uses data from 2002-2003. A direct comparison with the 1998-1999 survey is complicated because the EU has expanded and the 1996-1997 data for the new accession states are not readily available. Another factor has been the greater reluctance of companies to supply information on SLF usage, which has made it necessary to estimate roughly the use of SLF by using information from several literature and web sources. It is recognised that this method contains errors, as the available information may be out of date or inaccurate.

As an example, the SLF usage in one plant was estimated from literature and web data for:

- fuel consumption for the kiln process;
- tph of SLF fired in the burner;
- stated percentage of fuel inputs by each fuel type;
- use of typical fuel CVs from earlier surveys as well as from this survey;
- equivalent fuel value in terms of oil or coal, quoted as savings, etc.

It has to be appreciated that such estimation methods will produce figures that cannot be confirmed. However, Atkins considers it better to include an estimate of SLF use rather than show no data. In addition, some additional data have been added for Australia and Japan. These data were found during the literature and web surveys. It has been included here as the use of alternative fuels in Japan is a good example of a developed alternative fuel market, while the Australian experience is a good example of the developing use of alternative fuels in the cement industry.

European Union

Austria – reported SLF use in 2003 as 42,516 tonnes
Thermal substitution by SLF, approximately 12.8%
Total alternative fuel thermal substitution, approximately 48.1%

Belgium – Estimated SLF use for two plants in 2003, 265,000 tonnes
Thermal substitution by SLF, approximately 7-40% plus in two plants
Total alternative fuel thermal substitution, approximately 50-66% in two plants

Czech Republic – Estimated SLF use in 2001, 67,000 tonnes calculated
Thermal substitution by SLF, approximately 16%
Total alternative fuel thermal substitution, approximately 25%

Finland – Reported SLF use in 2004, 4000 tonnes
Thermal substitution by SLF, approximately 8% at one plant

Germany – Reported use in 2003, 164,000 tonnes SLF
Thermal substitution by SLF, approximately 4.9%
Total alternative fuel thermal substitution, approximately 38.2%

Hungary – Possible use at Vac during 2002, 8000 tonnes SLF

Italy – Total thermal substitution by alternative fuels, 5%.
No firm references found to SLF use, but some plants with burners designed for SLF were identified

Latvia – Reported use in 2004, approximately 10,000 tonnes SLF

Luxembourg – The national cement agency mentions the use of 20% alternative fuel and there are references to tyres, paper and dried sludge, but no reference to SLF. However, a kiln burner was supplied with, as one of the fuel options, the facility to burn up to 50% of the total kiln fuel as solvent SLF.

Norway – Estimated use in 2004, approximately 10,000-20,000 tonnes SLF
Average use, 15,000 tpa.
Cembureau estimate alternative fuels are 35% of total

Spain – Reported use in 2003, 42,477 tonnes SLF
Thermal substitution by SLF, approximately 0.8%
Total alternative fuel thermal substitution, approximately 2.8%

Switzerland – Reported use in 2003, 77,164 tonnes SLF
Thermal substitution by SLF, approximately 19.2%
Total alternative fuel thermal substitution, approximately 50.1%

The Netherlands – Estimated use in 2002, 6100 tonnes SLF
Thermal substitution by SLF, approximately 5%
Total alternative fuel thermal substitution, approximately 83%

United Kingdom – Use in 2003, 115,665 tonnes SLF
Total alternative fuel thermal substitution, approximately 6 %

EU countries not using SLF, apart from in trials

Cyprus – confirmed by literature survey;
Malta – confirmed by minerals surveys – cement imported;
Greece – confirmed by National Cement Agency and Titan for their four plants;
Romania – confirmed by National Cement Agency;
Lithuania – confirmed by the sole cement plant, Akmenes;
Irish Republic – confirmed by the Environment Agency and National Cement Agency.

EU countries for which no firm data provided by producers or agencies

These figures are rough estimates using the very limited data available:

France – No data, but assumed to be 300,000 tpa based upon literature (was 262,093 tpa in 1996);
Sweden – No data, but was 5891 tpa in 1997;
Italy – No data provided, and no assumption made as use is likely to be lower than other EU countries;
Estonia – no firm references to SLF use found and no information supplied by producer.

Non-European Union

United States of America – Reported use in 2003, 975,436 tonnes SLF;
Thermal substitution by SLF, approximately 4.8%
Total alternative fuel thermal substitution, approximately 9.8%

Australia – Estimated use in 2003, 28,000 tonnes calculated
Thermal substitution by SLF, approximately 3%
Total alternative fuel thermal substitution, just under 6%

Japan – Estimated use in 2003, 352,000 tonnes listed (does not include any liquid waste fuels classed as 'others', and hence the total tonnage of SLF, as defined here, should be higher than this tonnage)

Summary Table

The reported usages of SLF and alternative fuels generally are listed in *Table 43.6*. Figures in bold are values confirmed by literature or via contacts with the organisations concerned. Figures in italics are estimates of the SLF tonnage based upon information gained from the survey or inferred by statements in environmental reports, etc. In some cases the use of SLF has been calculated from data on the percentage thermal substitution, the overall fuel consumption, assumed fuel CV values, etc. The limited information provide by various organisations means that Atkins cannot vouch for the accuracy of these figures. The data are taken from the most recent records, generally for 2003 except for:

- Denmark and Finland, 2004 data from contacts with producers;
- Czech Republic, 2001 data from cement agency reports;
- Greece, Romania and Irish Republic, data from 2004 via contacts with cement agencies.

Country	*Total alternative fuel substitution level (%)*	*Total SLF substitution level (%)*	*Estimated SLF (tpa)*
Austria	**48.1**	**12.8**	**42,516**
Belgium	*29-30*	*Varies up to 41% at one plant.*	*265,000 est.*
Czech Republic	*25*	*16*	*67,000 est.*
Cyprus	**0**	**0**	**0**
Denmark grey white	 **17% g** **6%**	**n.d.**	**5000**
Estonia	n.d.	n.d.	n.d.
Finland	**3**	**8 (one plant)**	**4000**
France	34.1		*No data, est. 300,000*
Germany	**38.2**	**4.9**	**164,000**
Greece	**0**	**0**	**0**
Hungary	10	*20 (one plant)*	*8000 minimum*
Ireland	**0**	**0**	**0**
Italy	**5**	**n.d.**	**n.d.**
Latvia			**10,000**
Lithuania	**0**	**0**	**0**
Malta	**0**	**0**	**0**
Netherlands	*83*	*5*	*6100 est.*
Norway	*35*		**<u>Average 15,000 est.</u>**
Poland	**6.5**	n.d.	n.d.
Portugal	0-1	< 1	Assumed low
Romania	**0**	**0**	**0**
Spain	**2.8**	**0.8**	**42,477**
Sweden	**29**	*n.d.*	*Likely to exceed 5800*
Switzerland	**50.1**	**19.1**	**77,200**
United Kingdom	**6**		**115,665**
USA	**9.8**	**4.8**	**975,436**
Japan	**n.d.**	**n.d.**	**352,000**
Australia	*6*	*3*	*28,000 est.*

The total estimated use of SLF is therefore:

- EU countries, 460,858 tonnes, confirmed;
- EU countries, 666,900 tonnes, estimated only;
- total estimate plus confirmed for the EU = 1,127,758 tonnes;
- USA, 975,436 tonnes;
- Japan, 352,000 tonnes;
- Australia, 28,000 tonnes estimated;
- total for countries included in survey, 2,483,194 tonnes.

44 Conclusions

44.1 Use of SLF in the USA and Europe

The following notes are a brief summary of the conclusions drawn from the 2005 Atkins survey into the use of SLF and the USA cement and lime industries.

- The overall use of SLF in the USA was 4.82% for a total alternative fuel usage of 9.83% in 2003. While, this alternative fuel use is lower than that of the main alternative fuel users in Europe, the proportion of SLF amounted to 49%, which is higher than the 24.9% average in Europe.
- This reflects the greater use of alternative fuel sources within Europe. There are indications that the growth in solid waste fuels may increase further in the USA so that SLF will eventually contribute a lower overall proportion of the total alternative fuels used.
- In Europe, SLF are still an important fuel source. The consumption as well as the patterns in the use of SLF vary from country to country, as follows: -

    - **Austria** – the use of SLF has increased slightly from 11.79% in 2000 to 12.84% in 2003. The growth in total alternative fuel use is from 33.47% to 48.09%, which shows the greater importance of solid waste fuels.
    - **Belgium** – An established user of SLF, with 30% alternative fuels reported and up to 41% SLF at one plant. The total SLF usage could only be estimated for two plants, an estimate that shows some growth over 1996 usage. Without firm data, Atkins cannot confirm the trends.
    - **Czech Republic** – increased consumption from 9.3% in 2000 to 16% in 2001. The growth in solid alternative fuels was from 2% to 9% in the same period, giving a total alternative fuel usage of 25% in 2001.
    - **Denmark** – the small quantity of SLF used in 2004 (5000 tonnes) is normally counted within the total alternative fuel tonnage and the majority of waste fuel used is waste-derived solid fuel.
    - **France** – the high alternative fuel usage of 34.1% reported is expected that SLF use has also increased since 1996. However, agencies or producers provided no firm data with which to determine trends in SLF use.
    - **Germany** – between 1997 and 2003 the SLF thermal substitution rate hardly changed (4.97% and 4.94%, respectively). However, the growth in total alternative fuel usage was significant (i.e., from 15.81% to 38.23%).
    - **Latvia** – the use of SLF is limited to waste material recovery and/or clean up of a contaminated lake. It is expected that the use of SLF and/or alternative fuels will develop further, as in other European countries.
    - **Norway** – an established SLF user and 35% alternative fuel usage. Plant (Brevik) modernisation and fuel-blending facilities could enable greater SLF use, but firm data were not provided by cement producers.
    - **Poland** – the total alternative fuel substitution rate was around 6.5% in 2003, but it is expected to grow as the major cement companies have investments in Poland. The quantity of SLF used could not be established in this survey, but references to burners designed for SLF use were found in the literature and web surveys.

- **Portugal** – no firm data on SLF usage
- **Potential User Countries** – SLF usage is not reported for several countries, including **Greece, Romania, Lithuania, Cyprus** and the **Irish Republic**. However, interest in the use of SLF was reported by CIRCOM, the Romanian cement agency.
- **Slovakia** – no data reported for SLF use, but three kiln references were found that mention the potential firing of waste oil and other liquid waste fuels.
- **Slovenia** – no clear references to SLF were found, but the potential use of alternative fuels is referred to on web sites
- **Spain** – the tonnage of SLF increased from 19,240 tonnes in 2000 to 42,477 tonnes in 2003. The latter represents an approximately 0.8% thermal substitution rate (estimated, not confirmed), compared with solid waste fuels at 2%.
- **Switzerland** – the tonnage of SLF used has increased from 64,800 tonnes in 2000 to 77,200 tonnes in 2003. The SLF used in 2003 represented 19.1% thermal substitution of a total alternative fuel substitution of 50.1%.
- **The Netherlands** – while achieving the highest European thermal substitution rate of 83%, the use of SLF is secondary and accounts for only 5% of the total fuel input, according to one report.

Overall, the pattern of use is quite different in these countries. The most relevant cases are those countries with a more established history for using alternative fuels. If the cases of Austria, Germany and Switzerland are considered, the tendency has been for the growth in alternative fuels to be in solid waste rather than in liquid waste fuels.

However, this may be an oversimplification because of the ways in which SLF and/or alternative fuel usage are reported. The major international cement companies either have investments in fuel-blending facilities or agreements with the owners of these facilities such that they have the means to control SLF and/or alternative fuel quality. This allows them to control the fuel mix to suit the environmental limits as well as to minimise any adverse effects on the cement-making process. It is not clear how much of the solid waste fuel tonnages reported include SLF in mixtures such as impregnated sawdust or other solid waste products.

It has not been possible to confirm the total use of SLF with any great accuracy because of the limited firm data supplied by the major cement producers. However, the estimated use of SLF for the enlarged EU states is expected to be in excess of the Cembureau reported tonnage of 841,000 tpa, and may be nearer 1 million tpa. Confirmation of many of the updated figures for SLF use will be available from mid 2005, when annual reports are expected from agencies, etc. The key document will be the Cembureau update.

44.2 Environmental legislation

In the USA the HWC MACT rules apply. Emission limit values are imposed for:

- dioxin and furan
- mercury
- particulate matter
- semi-volatile metals
- low volatile metals
- hydrogen chloride and chlorine gas
- hydrocarbons
- destruction and removal efficiency.

Within the EU, the WID sets emission limits that will apply to all *new* incinerator installations from 28 December 2002 and to all *existing* installations from 28 December 2005. Previous EU directives under which burning of hazardous waste was regulated will be repealed

WID also sets requirements in terms of normal and abnormal operating conditions, water discharges from cleaning exhaust gases, ash recycling, plant control and monitoring, and public access to information. Further, WID requires all incinerators and co-incinerators to have continuous monitors for certain pollutants.

Cement kiln emission limits for are set for:

- total dust
- hydrogen chloride
- hydrogen fluoride
- NO_x
- metals
- dioxins and furans.

Different emission limits apply if more than 40% of the resulting heat release comes from hazardous waste.

44.3 Lime industry – use of SLF

There was little feedback on the use of SLF in the lime industry, except in the cases of the USA, UK and Portugal. This confirmed that SLF are not used in the USA and have been used at two UK lime plants. References to lime production and relevant comments are included in the 1998-1999 Atkins survey.

44.4 General considerations

The background conditions that currently prevail in Europe and the USA are worth considering as they impact upon the use of SLF and other alternative fuels. Some key points are:

- Globalisation of the cement industry has resulted in the major companies expanding in Europe, including the new EU states. It is expected that this will further accelerate the use of alternative fuels such as SLF.
- The major cement companies also operate subsidiary companies that provide fuel-blending facilities, which enables the cement companies to control the composition of the waste-derived fuels.
- Cement producers and agencies did not provide any data concerning the commercial aspects of using SLF. Hence it was not possible to make any estimates of the financial costs and/or benefits of using this fuel. However, some background notes on the process and/or financial aspects of using SLF are included. These conclude that the use of SLF can only be assessed on a site-specific basis because of the wide range of influencing factors, such as location and source of supply, transportation costs and the suitability of the plant's process and/or environmental design.
- Special abatement measures included additional monitoring equipment for the continuous monitoring of plant emissions. However, reference is drawn to the examples given in the report that show the plant process design and environmental protection equipment has been upgraded to suit the greater use of alternative fuels, including SLF. This has been an on going modernisation process in most countries, especially the new EU states such as Poland, where most of the old wet process kiln capacity has shut down.
- Some data on emission levels with SLF have been included. The UK data show the before-and-after effects of using SLF. In the case of Austria, several alternative fuel sources are used, which makes it more difficult to assess any benefits in NO_x reduction, etc., that result from SLF alone. In the lime industry, the results from Steetley Dolomite show improvements to NO_x and SO_2 levels when using SLF. Reference is made to the data published by the BCA concerning emissions with alternative fuels, including SLF (letter from the BCA to the DTI dated 13 September 2002 and entitled 'Energy Policy Review').
- Modernisation of the cement industries of Europe and the USA is frequently referred to in the separate country reports. A common theme is the use of modern kiln, precalciner, burner, kiln by-pass system combination designs, which are better suited to using higher quantities of waste-derived fuels. Added to this are a significant number of plant environmental improvements, referred to in the cement journals. Major investment in new plants and/or plant

modernisations, along with new environmental control equipment, is making many works more suitable to burning a wider rang of alternative fuels.

- Some additional information is included within this report to show the use of SLF:

  - the statistics for Australia are included, since this is an example of a country where SLF and alternative fuel use is developing;
  - in contrast, the high use of SLF and alternative fuels in Japan is presented as an example of a well-developed alternative fuels user;
  - the use of SLF and other alternative fuels by Italcementi, Holcim and Lafarge are reported briefly, as these data are considered relevant because they help to paint a broader picture of the global use of SLF;
  - in many cases, exact tonnage and/or thermal substitution data may not be available, but it is possible to make a very approximate estimate of SLF tonnages by using related information from literature surveys and web sites (Atkins cannot guarantee the accuracy of these estimates, as the main producers may have not provided the statistical data requested).

45 Acknowledgements

The Atkins study involved the issuing of over 100 enquiry letters to cement producers, national cement and environment agencies and fuel blenders. In addition, further information and clarification was sought by sending approximately 40 additional e-mails.

The response to these enquiries was very disappointing, which made it difficult to confirm the use of SLF with the accuracy that Atkins had hoped to achieve. The vast majority of the information was obtained from the internet and cement journals. While the figures available from the national cement agency sites are believed to be reliable, some contradictions were found in some of the web and literature references. Wherever possible, these have been clarified.

Atkins would like to express their appreciation to those organisations that assisted in this survey, which include:

Aalborg Portland
BCA
Cadence
Calcidrata S.A.
CIRCOM
CKRC
CRH
EA
EPA – Irish Republic Environment Agency
HCIA – Greece
LCUK
Pillard
TITAN
US Geological Surveys
Akmenes Cement
Cement Manufacturers Association of Ireland
Steetley Dolomite

Appendix 1

Example of the enquiry letter issued to major cement and lime companies

UK Environment Agency
Use of Substitute Liquid Fuels (SLF) in the International Cement and Lime Industries

In January 2005, the Environment Agency appointed Atkins to undertake a study of the use of Substitute Liquid Fuels (SLF) within the cement and lime industries of Europe and the USA. It is planned to complete the study before the 24 March 2005. This study is intended to be an update of a similar study carried out in 1998.

Attached is a copy of the Introductory Letter prepared by the UK Environment Agency, which requests your support with this project.

The definition used for SLF within this study is given in the attached data sheet.

The information we are now seeking is as follows:

1. The names and locations of the plants using SLF.
2. The volume of SLF used per annum at each location.
3. The percentage thermal substitution by SLF at each location. Please indicate the typical total fuel consumption for each process.
4. The capacity of each plant using SLF in terms of clinker or lime tonnes per annum.
5. A typical specification of the SLF used. We attach an example of the typical data for SLF used in the UK and we would appreciate it if you could provide similar quality data as well as any general data on the SLF feedstock(s) used.
6. The supplier of the SLF – contact name(s) and e-mail address.
7. The environmental legislation under which the fuel is burned (e.g. in England this is specified within the PPC – Pollution Prevention and Control Regulations – and WID).
8. Examples of any local environmental agreements under which the fuel can be burned would also be useful.
9. Environmental impact – any data comparing typical plant emissions with and without SLF firing would be useful.
10. Brief details of any additional abatement systems required to minimise the environmental impact of using SLF (e.g. dust arrestment plant, kiln by-pass system, additional monitoring equipment, etc.).

We appreciate any information your organisation is able to provide on the above issues. The purpose of the report is not to disclose any commercially sensitive information. If you were prepared to indicate typical cost data for SLF then such data would be useful for our study. The purpose of the report is simply to provide the UK Environment Agency with an accurate global update on the status of SLF usage within the cement and lime industries.

Atkins Process
January 2005

Typical Example of Authorised SLF Specification in the UK
Calorific Value = 21 to 42 MJ/kg (see note below)

Free Solids % = 20
Ash Content @1000 deg C (% wt/wt) = 10
pH = 4 to 10

Weight %
Water % = 20
Sulphur % = 1.5
Chlorine % = 2.5
Bromine % = 0.5
Fluorine % = 0.5
Iodine % = 0.2
Arsenic = 60 ppm
Antimony = 300 ppm
Cobalt = 100 ppm
Copper = 500 ppm
Chromium = 400 ppm
Lead = 500 ppm
Manganese = 100 ppm
Nickel = 250 ppm
Tin = 200 ppm
Vanadium = 100 ppm
Mercury = 10 ppm
Thallium and cadmium = 20 ppm total

Definition of Substitute Liquid Fuel (SLF) for this study

- SLF is a liquid alternative fuel derived from a wide range of sources. These include waste solvents, waste oils, industrial wastes – e.g. from paint, refinery, chemical industry, acid tar, sludges, oil sludges, tar by-products, etc.
- Other terminology used for SLF includes RLF – Recycled Liquid Fuel.
- SLF quality is controlled with respect to calorific value (typically 21 to 42 MJ/kg in UK), water content, heavy metal, PCBs, chlorine/sulphur content, etc.
- For this study, SLF with a minimum CV value below 21 MJ/kg can also be considered. This allows for the use of waste water, water contaminated diesel, etc., provided such fuels meet the ECJ criteria.
- Blending of feedstock is usually required in order to minimise the fuel quality variability/process stability, effect upon kiln volatile cycles plant emissions, etc.

- The data requested should also include data for any plants using SLF together with a solid absorption medium such as sawdust. If SLF is blended with other forms of solid wastes in suspensions, etc., please indicate the typical mix % weight proportions of liquid/solid used in the total fuel tonnage.

Appendix 2

Example of the enquiry letter issued to national cement/ lime agencies, environment agencies

UK Environment Agency
Use of Substitute Liquid Fuels (SLF) in the International Cement and Lime Industries

In January 2005, the Environment Agency appointed Atkins to undertake a study of the use of Substitute Liquid Fuels (SLF) within the cement and lime industries of Europe and the USA. It is planned to complete the study before the 24 March 2005. This study is intended to be an update of a similar study carried out in 1998.

Attached is a copy of the Introductory Letter prepared by the UK Environment Agency, which requests the support with this project from cement manufacturers in the USA and Europe. A copy of our basic data enquiry letter to these organisations is also attached.

The main objective of this exercise is to provide the UK Environment Agency with as factual a report on the current status of SLF. This will assist the Environment Agency with benchmarking the UK usage of SLF.

We recognise that the National Environment Agencies plus the National Cement and Lime Agencies are monitoring the overall use of Substitute Liquid Fuels in their respective countries. Hence we would appreciate it if you could provide Atkins with the following information, which is more general in nature.

National Cement/Lime Agency data request

1. The names and locations of the plants using SLF.
2. The volume of SLF used per annum at each location.
3. The sources of SLF used.
4. Does the agency have any published articles that summarise the current situation with respect to SLF usage in their membership area?
5. References to any data available on web sites or in publications available for purchase, etc.
6. Please advise us of any documentation that sets out the Agencies policy on the use of SLF.
7. Any relevant case studies showing before and after effects of using SLF from a process/environmental perspective.

National Environment Agency data request

1. Details of sites using SLF alone or in combination with other solid fuels.
2. Reference to any documentation available from the Environment Agency relating to the environmental legislation applied to end-users.
3. Examples of publicly available documents giving case study examples of the environmental effects of using SLF – for example, case study data obtained from a plant to support SLF trials under the SLF protocol.

Any assistance that your organisation can provide would be greatly appreciated.

Atkins Process
January 2005

Appendix 3

SLF specifications – typical analysis

General

The 1998 Atkins survey contains a significant amount of data on SLF specifications in the USA and Europe. Most of these data are still relevant and so the following section includes additional data acquired during the latest survey.

1) United Kingdom – SLF specifications

The range of SLF used within the UK is well documented and can be obtained from several web sites. The recent application to use RLFs (SLF) at Lafarge's Westbury contains much useful information relating to the use of SLF within the UK. Details of the typical SLF supplied to UK cement plants are shown in *Table A4.2* at the end of this report. Note that SLF are prepared by specialist fuel blenders, such as SRM and Onyx, to meet the requirements that the critical inputs, such as chloride and heavy metal contents, be controlled.

2) USA - SLF specification

The Ash Grove cement plants at Chanute and Foreman use SLF supplied by Cadence Energy Resource. Details of the SLF specification used at these works are given in the Cadence web site, as in *Table A3.1*.

Table A3.1. SLF specification

Minimum calorific value	10,000 Btu/lb
Chlorine	3.5%
Suspended particles	Maximum 5/16 inch
Water content	Maximum 20%
Antimony	450 ppm
Arsenic	1200 ppm
Barium	25,000 ppm
Beryllium	25 ppm
Cadmium	150 ppm
Chromium	2000 ppm
Lead	750 ppm
Mercury	5 ppm
Selenium	500 ppm
Thallium	250 ppm

3) Switzerland – SLF specifications

The specifications in *Table A3.2* were obtained via CRH for SLF used in Switzerland. These are for waste oils and solvents used as alternative fuels.

Table A3.2. Quality of waste oil (Altöl)

VVS Code	*1440, 1460, 1470, 1480*
Maximum particle size	≤0.5 mm
H_2O content	≤20%
Chlorine	≤1%
Sulphur	≤1%
Flashpoint	≥55°C
Upper heating value	≥7000 kcal/kg ($H_u = H_o - 670$ kcal/kg)

The characteristics of the waste fuels are listed in the document entitled ‚Waste/Air –Guidelines – Disposal of Wastes in Cement Plants'. The waste guidelines in *Table A3.3 to Table A3.6* were referred to.

Table A3.3. Waste guidelines referred to

No	*OMS W Code*	*Remarks/description*	*Supplement standard value*	*Standard value*
A1	1440 1460	Hydraulic oils Non-chlorinated insulating oils	These shall comply with the standard values in Table 1, column A, if not otherwise permitted in the supplement	Organic halogen components, 1% per weight. PCB/PCT, 50 mg/kg
A2	1470 1480 1481	Motor and gearbox oils Mineral oil mixtures Other lubricating oils	These shall comply with the standard values in Table 1, column A, if not otherwise permitted in the supplement	Pb 800, mg/kg Zn, 1000 mg/kg Organic halogen components, 1% per weight PCB/PCT, 50 mg/kg

Table A3.4. Waste guidelines: correction of calorific value back to equivalent coal value.

Elements		*Standard values (mg/kg dry material)*	
		*Indicative values for the contents of pollutants of waste not mentioned in the positive list. Indicative values (matter mg/kg dried), combustible waste materials (on the left in mg/MJ; on the right in mg/kg, brought back to a calorific value NCV of 25 MJ/kg)**	
		mg/MJ	*mg/kg (for 25MJ/kg)*
Antimony	Sb	0.2	5
Silver	Ag	0.2	5
Arsenic	As	0.6	15
Barium	Ba	8	200
Beryllium	Be	0.2	5
Cadmium	Cd	0.08	2
Chromium	Cr	4	100
Cobalt	Co	0.8	20
Copper	Cu	4	100
Tin	Sn	0.4	10
Mercury	Hg	0.02	0.5
Nickel	Ni	4	100
Lead	Pb	8	200
Selenium	Se	0.2	5
Thallium	TI	0.12	3
Vanadium	V	4	100
Zinc	Zn	16	400

*Explanation applies to the waste and/or used fuels, either in the principal burner at the exit of the clinker of the revolving kiln, or in the secondary burner at the time of the introduction of the meal into the revolving kiln. The indicative values (mg/MJ) are refer to the CV H_u of waste. For reasons of clarity, the table also gives a similar example for the indicative values (mg/kg of waste) applied to a net calorific value (NCV) of 25 MJ/kg. This value corresponds to the CV of a typical coal. If the CV of waste is higher or lower than 25 MJ/kg, the content of heavy metals allowed varies proportionally.

Table A3.5. Quality of solvent (Abfall Lösungsmittel, ALM)

VVS Code	*1211, 1221, 1222*
Maximum particle size	≤0,5 mm
Chlorine	≤1%
Sulphur	≤ 1%
Upper heating value	≥4500 kcal/kg ($H_u = H_o$ – 670 kcal/kg)

Table A3.6. Standard values for pollutant content of wastes not contained in the positive (Guideline: Disposal of Waste in Cement Plants)

Element		*Standard value (mg/kg dry matter)*			
		Column A for combustible wastes (left: in mg/MJ; right: in mg/kg, based on a lower calorific value of 25 MJ/kg)		*Column B* for wastes used as raw alternative raw materials	*Column C* for wastes used at the grinding stage in the production of Portland cement
		mg/MJ	mg/kg (at 25 MJ/kg	mg/kg	mg/kg
Arsenic	As	0.6	15	20	30
Antimony	Sb	0.2	5	1	5
Barium	Ba	8	200	600	1000
Beryllium	Be	0.2	5	3	3
Lead	Pb	8	200	50	75
Cadmium	Cd	0.08	2	0.8	1
Chromium	Cr	4	100	100	200
Cobalt	Co	0.8	20	30	100
Copper	Cu	4	100	100	200
Nickel	Ni	4	100	100	200
Mercury	Hg	0.02	0.5	0.5	0.5
Selenium	Se	0.2	5	1	5
Silver	Ag	0.2	5	–	–
Thallium	TI	0.12	3	1	2
Vanadium	V	4	100	200	300
Zinc	Zn	16	400	400	400
Tin	Sn	0.4	10	50	30
TOC, toxic organic compounds	No universal standard value. Special procedure according to OAPC, Appendix 2, subsection 719, and the precept of minimisation whenever substances such as PCB, dioxins or similar toxic compounds are suspected. For PCB in waste materials, the values specified in Section 5.2.2 or in the positive list are applicable. For organic compounds in general, Section 4.2 shall be observed.				

Notes:

Column A applies to wastes used as *fuel* introduced either in the main burner at the clinker outlet of the rotating kiln or the inlet of the rotating kiln. The standard values in column A (mg/MJ) are based on the lower CV of the waste. For reasons of clarity, the standard values (in mg/kg waste) are based on a lower CV of 25 MJ/kg. The value of 25 MJ/kg corresponds to the CV of hard coal. If the CV of the waste is less than or greater than 25 MJ/kg, the permissible heavy metal content changes proportionally.
Column B applies to wastes used ***as alternative raw materials*** in producing clinker. This waste substitutes part of the raw material normally used or serves to correct the raw meal composition, i.e. the calcium, iron, silicon or aluminium content (according to remarks on page 46 of the 'Thesenpapier').

Column C applies to wastes used at the *grinding stage* in the production of Portland cement. Portland cement consists of 90-95% ground cement clinker and 5-10% gypsum, as well as other materials added at the grinding stage (according to pages 27 and 28 in the 'Thesenpapier').
Note: The above table contains no standard values for process materials. These are therefore only permissible if they are contained in the positive list.

4) United Kingdom – SLF used for Lime Production

Steetley Dolomite Ltd kindly provided the data *in Table A4.1* for SLF supplied to the Whitwell and Thrislington lime works.

Table A4.1. SFL supplied to Whitwell and Thrislington lime works

Parameter	*Whitwell Works (PPC Permit BL3269)*	*Thrislington Works (PPC Permit BM0699)*
Calorific value (as received; gross)	21-35 MJ/kg	20.5 MJ/kg
Ash content	5%	<5% w/w
Total solids content	20%	<20.0% w/w
Particle size	3 mm	–
Specific gravity	0.7-1.3 g/ml	–
Viscosity	50 cps	–
pH	5-9	–
Chlorine	4%	5%
Other halides, in total	0.65%	5000 mg/kg
Fluorine	0.35%	5000 mg/kg
Bromine	0.4%	3000 mg/kg
Iodine	100 mg/kg	100 mg/kg
Sulphur	0.5%	5%
Mercury	20 mg/kg	28 mg/kg
Cadmium	20 mg/kg	13 mg/kg
Thallium	20 mg/kg	10 mg/kg
Group III metals, in total	600 mg/kg	1800 mg/kg
Antimony	100 mg/kg	28 mg/kg
Arsenic	100 mg/kg	10 mg/kg
Chromium	100 mg/kg	200 mg/kg
Cobalt	50 mg/kg	66 mg/kg
Copper	250 mg/kg	360 mg/kg
Lead	250 mg/kg	184 mg/kg
Manganese	200 mg/kg	50 mg/kg
Nickel	200 mg/kg	200 mg/kg
Tin	50 mg/kg	600 mg/kg
Vanadium	50 mg/kg	50 mg/kg
PCBs	10 mg/kg	10 mg/kg

Table A4.2. Typical SLF characteristics used in UK cement and lime industries

	Castle Cement			Lime		Lafarge Cement			Rugby	Rugby
	Ribble kiln 5& 6	Ribble kiln 7	Ketton	Thrislington	Whitwell	Dunbar	Westbury	Cookstown	Barrington	Ferriby
CV (MJ/kg)	23-42	23-42	21	25	21-35	**21-38**	**21-42**	**21-42**	23-27	>21
Free solids (%v/v)	20	20	20	5	20	**15**	**20**	**20**	N/A	N/A
Ash @ 1000°C %wt/wt	5	5	5	1	5	**10**	**10**	**10**	N/A	N/A
pH	5-9	5-9	5-9	5-10	5-8	**N/A**	**4-10**	**4-9**	N/A	N/A
Water (%)	20	20	No Free	No Free	N/A	**15**	**20**	**20**	N/A	N/A
Sulphur (%)	0.3	1	0.5	1.5	0.5	**1.5**	**1.5**	**0.8**	1	2
Chlorine (%)	2	2	1.5	6	4	**2**	**2.5**	**2**	2	2
Bromine (%)	0.3	0.3	0.2	0.025	0.4	**0.5**	**0.5**	**0.4**	1	0.5
Fluorine (%)	0.3	0.3	0.5	0.75	0.35	**0.5**	**0.5**	**0.5**	1	1
Iodine (%)	0.012	0.012	0.01	0.005	0.01	**0.2**	**0.2**	**0.02**	1	0.1
Total halides (%)							**3.0**	**2.5**		2.5
Arsenic (mg/kg)	50	50	50	10	100	**60**	**60**	**50**	10	100
Antimony (mg/kg)	50	200	50	28	100	**300**	**300**	**300**	300	400
Cobalt (mg/kg)	100	100	75	66	50	**100**	**100**	**100**	50	100
Copper (mg/kg)	600	600	500	70	250	**300**	**500**	**500**	100	50
Chromium (mg/kg)	200	500	500	38	100	**200**	**400**	**400**	250	1000
Lead (mg/kg)	500	500	600	184	250	**500**	**500**	**500**	300	750
Manganese (mg/kg)	100	100	70	10	200	**250**	**100**	**100**	50	800
Nickel (mg/kg)	50	100	225	265	200	**500**	**250**	**250**	1500	200
Tin (mg/kg)	50	50	70	1300	50	**200**	**200**	**200**	50	700
Vanadium (mg/kg)	50	60	30	10	50	**50**	**100**	**50**	50	50
Mercury (mg/kg)	20	20	20	28	20	**10**	**10**	**10**	10	10
Thallium plus				10	20				10	10
Cadmium (mg/kg)	40 Total	40 Total	50 Total	12	20	**30 Total**	**20 Total**	**20 Total**	20	20
Supplied By	**SRM**	**SRM**	**SRM**	**SRM**	**SRM**	**SRM**	**SRM**	**SRM**	**ONYX**	**ONYX**

We welcome views from our users, stakeholders and the public, including comments about the content and presentation of this report. If you are happy with our service, please tell us about it. It helps us to identify good practice and rewards our staff. If you are unhappy with our service, please let us know how we can improve it.