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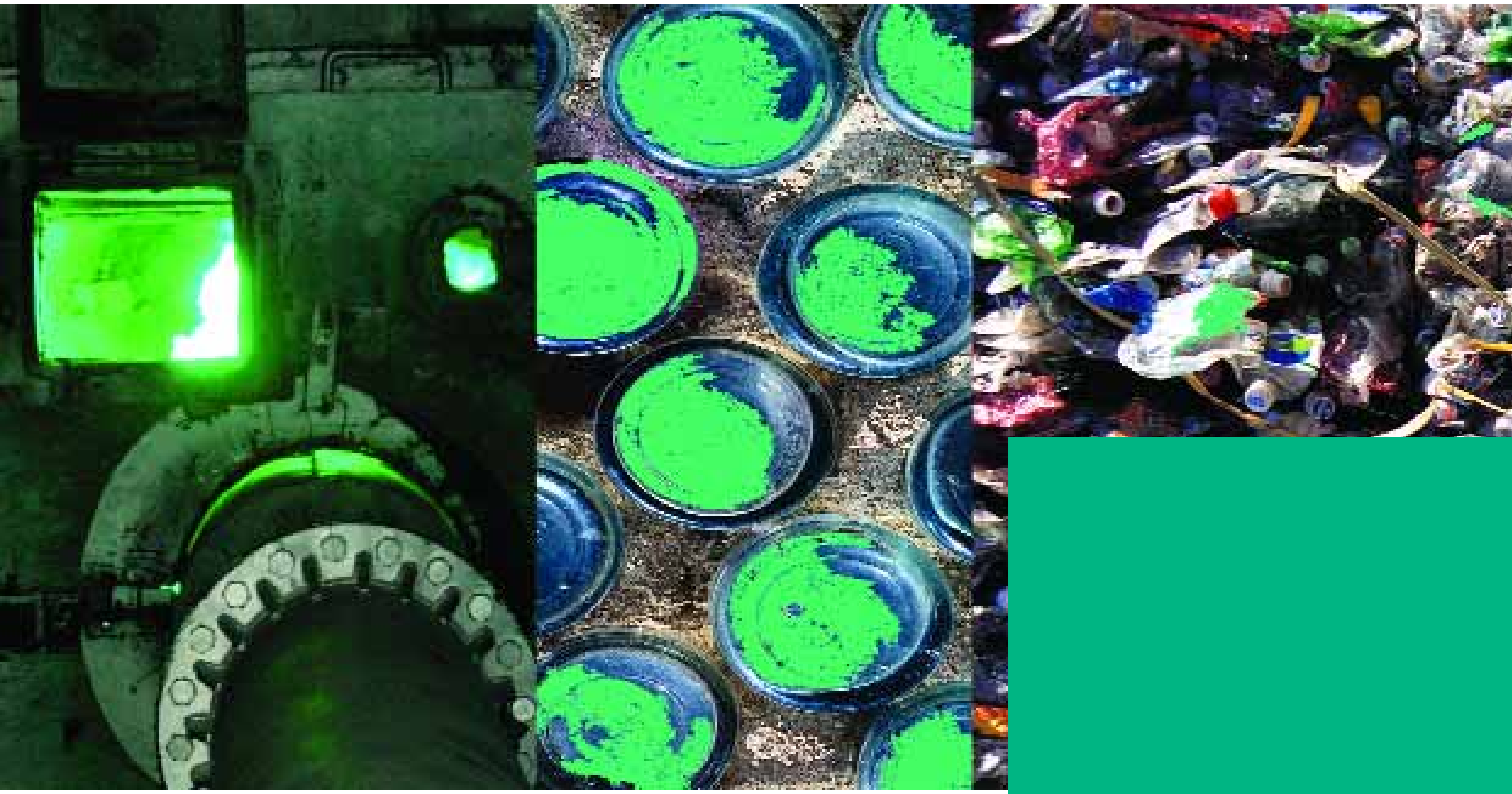
Cement Sustainability Initiative (CSI)



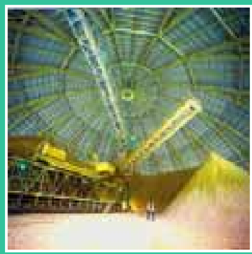
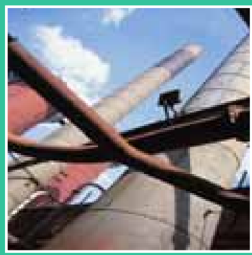
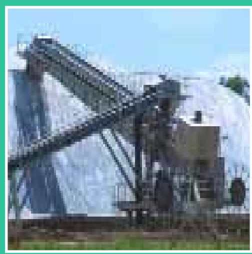
Fuels and raw materials

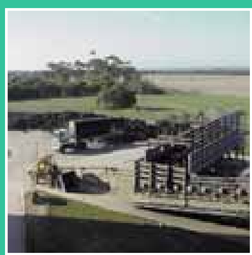
Guidelines for the Selection and Use of Fuels and Raw Materials in the Cement Manufacturing Process

December 2005

Version 1.0

World Business Council for Sustainable Development

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Executive summary

To meet the demands of a growing world population, all industries must become smarter about how they use, reuse, and recycle raw materials, energy, and wastes. The cement industry is no exception. Producing cement takes both large amounts of raw materials and fuel, and produces substantial carbon dioxide emissions. The cement industry is actively engaged in industrial ecology, in which by-products from one industry become inputs for another. We can recover and use many industrial byproducts and other materials in cement manufacturing. Some are incorporated into the final product; others provide the fuel needed to convert limestone into cement.

Using by-products as fuel reduces the amount of virgin fossil fuels needed, and thus reduces the associated environmental impacts of finding, producing, transporting, and burning these fuels. Using by-products and/or wastes as fuel also decreases the demands on local landfills and incinerators and reduces their environmental impacts, including potential groundwater pollution, methane generation and hazardous ash residues. Cement kilns can be used to recover energy from many non-hazardous wastes such as tires and biomass, as well as from some hazardous wastes. In some countries (Norway, Switzerland, and Japan are examples) cement kilns also play an important role in waste management and hazardous waste disposal.

While the industry has been safely using these materials for many years, the processes, practices and techniques to do so are generally part of individual company procedures, and thus not well known to a broader public. Stakeholders have told us they are concerned about the kinds of fuels and materials we use, and the kinds of emissions produced. They want to know that they are properly managed, and that serious thought and effort goes into understanding, controlling and minimizing impacts to our employees and the communities in which we operate.

Consequently, the Cement Sustainability Initiative (CSI) has produced these guidelines which offer both basic explanations about our operations, the role of fuels and materials in our products, and some very practical guidance for cement companies to use in managing their materials and fuels. During the preparation of this material we sought and received feedback from many of our stakeholders, including very specific comments on this document from more than 100 people in more than 20 countries. The guidelines are built upon the principles of sustainable development, eco-efficiency and industrial ecology. These guidelines include information on the occupational health and safety concerns of handling different materials. Our hope is that the guidelines are equally helpful to all cement companies and public bodies; that they are widely distributed and used, particularly in countries and regions where specific requirements have not yet been identified. However, these guidelines are not meant to, and can neither replace nor supersede local, national, or international requirements, which must be followed.

This document is divided into three sections that cover, respectively:

1 Principles for fuel and material selection
2 The role of various fuels and materials in cement manufacture, and
3 Practical considerations for cement plant owners and operators

Introduction

Cement manufacturing is an energy- and resource-intensive process. Every year the cement industry produces over 1.8 billion tonnes of cement at plants in almost every country in the world. The way the industry selects and uses fuels and raw materials is an important factor in determining its environmental, social, and economic impacts.

These guidelines provide a practical reference for cement companies and their stakeholders to help them to understand and identify responsible and sustainable approaches to the selection and use of fuels and raw materials.

They have been developed by 17 major cement companies, in consultation with a range of stakeholders representing NGOs, government, academia, and community groups across the world, as part of the Cement Sustainability Initiative (CSI), described in more detail below. Headquartered in 15 different countries, from Switzerland to India, our operations extend to almost every continent. Together, we represent more than half of the world's cement manufacturing capacity outside China. We are also leaders in making our industry a force for sustainable development.

Objectives of the Guidelines

In this document we attempt to define a consistent approach to the selection and use of fuels and raw materials in the cement industry, built upon the principles of sustainable development. We will promote this approach and associated good practices throughout the industry. The document has three parts:

1 The first section sets out the thinking and principles that underpin the CSI's approach to sustainable development in the selection and use of fuels and raw materials.
2 The second explains how fuels and raw materials are used in cement manufacturing. It describes some of the different kinds of fuels and materials being used today and the drivers behind changes in industry practices.
3 The third section gives practical advice for companies and site managers, covering a variety of topics including selection, operating practices, process control, and working with local communities.

The Cement Sustainability Initiative

The CSI is a program of the World Business Council for Sustainable Development (WBCSD). Its members, all cement companies, created it in 2000 to develop and promote practical ways for the industry to improve its environmental and social performance. The Initiative provides a forum for companies and stakeholders to come together to find solutions to some of the challenges facing the industry. The member companies agreed to consider a 20-year timeframe and examine issues stretching from the limestone quarry to delivery of the cement products to customers. As these guidelines go to press, the 17 member companies (and their headquarter countries) are:

- Ash Grove Cement (USA)
- Cementos Molins (Spain)
- Cemex (Mexico)
- Cimpor (Portugal)
- CRH (Ireland)
- Gujarat Ambuja (India)
- HeidelbergCement (Germany)
- Holcim (Switzerland)
- Italcementi (Italy)
- Lafarge (France)
- Secil (Portugal)
- Shree Cement (India)
- Siam Cement (Thailand)
- Taiheiyo (Japan)
- Titan (Greece)
- Uniland (Spain)
- Votorantim (Brazil)

The cement industry can play a role in helping society move toward sustainable forms of progress. Our stakeholders around the world increasingly look to us to take a lead in social and environmental issues. As individual companies, we hope to benefit from the new business opportunities created by sustainable approaches to managing waste and carbon dioxide emissions, and by new sustainable business concepts such as industrial ecology and eco-efficiency.

In July 2002, we published An Agenda for Action for the member companies of the CSI[1] that recognized that the principles of sustainable development are vital to ensuring our industry's future success. The Agenda identified the industry's key impact areas and set out a five-year program of work on them. It contained two kinds of actions: joint projects on which a group of companies work together to tackle a specific issue; and individual actions, to be implemented by each company in its own operations. Since 2002 we have been working in five task forces focused on joint projects addressing:

1. Climate change and CO_2 management (*www.wbcsdcement.org/climate.asp*)
2. Responsible use of fuels and materials (*www.wbcsdcement.org/fuels.asp*)
3. Employee health and safety (*www.wbcsdcement.org/health.asp*)
4. Emissions monitoring and reporting (*www.wbcsdcement.org/emissions.asp*)
5. Local impacts on land and communities (*www.wbcsdcement.org/impacts.asp*)

The guidelines in this document are the main output of the task force dealing with the use of fuels and materials.

In June this year we reported on our progress in implementing the joint and individual actions promised in the Agenda for Action. We will publish a five-year progress report in 2007. You can also find out more about our activities on the CSI website at *www.wbcsdcement.org*. Individual members produce reports on their environmental and social performance, which may be found on their individual company websites (See *www.wbcsdcement.org/participants.asp* for links to company websites.)

Principles

Moving toward sustainable use of fuels and raw materials in the cement industry

Sustainable development can be defined as forms of development that meet the needs of people living today without compromising the ability of future generations to meet their own needs.

Cement helps people today meet their needs for housing, buildings, and for much of the infrastructure of civilization; it will do so into the future until a better material is developed. However, its production is both energy- and material-intensive, using non-renewable resources today that will not be available for future generations. Emissions from production processes may affect the quality of air, water, and soil today, and also in, future generations. The cement industry can contribute to sustainable development by using energy and resources as efficiently and cleanly as possible. It can also help manage the wastes and by-products of other sectors.

A focus on sustainable development has directed us in developing these guidelines and in arriving at the conditions below, which define the cement industry's contribution to a more sustainable society.

The four basic elements for the cement industry's contribution to sustainable development are:[2]

> **Managing resources**: increasing the efficiency with which we use energy and material resources ('eco-efficiency'), and recovering and finding new ways to use wastes and by-products from other industries ('industrial ecology');

> **Protecting ecosystems:** actively intervening to reduce our "footprint" in our operations and prevent quarrying or related activities from degrading natural systems past the point where they can successfully recover;

> **Reducing pollution:** minimizing concentrations of polluting substances in the air, ground, or water which might result from our manufacturing activities;

> **Promoting quality of life:** producing high-quality cement products for all types of construction projects, while protecting the health and safety of our workforce; providing high-quality employment opportunities, and working with our local communities to contribute to their changing social and economic needs.

Of course, individual company strategies and actions need to be designed to balance the complex demands of society, economic development, and the environment, while maintaining the financial viability of the company and its ability to respond to a changing world.

Our vision

To assist cement companies in designing their own strategies, we have developed the following vision for CSI member companies, including how they will select and use fuels and raw materials in the future:

> We will maintain an economically vibrant industry, delivering profit to shareholders, rewarding employees, and contributing to local communities through employment, taxes and community activities.

- We will continue to deliver high-quality, competitively-priced goods and services that meet our customers' needs and the strictest product standards. We will develop new cement products in response to society's changing social, environmental and economic needs.

- The health and safety of those involved in and affected by the production of cement will be paramount in decision making. Installation, transport, handling, and operating procedures will be designed to protect the health and safety of employees, contractors, and local communities.

- We will be recognized as attractive employers and we will work to build relationships of trust with the communities in which we operate.

- We will evaluate our choices within the broader context of sustainable resource management. We will seek to use the waste and by-products of other industrial, agricultural, or municipal processes in our operations to replace natural fuels and raw materials where possible and appropriate.

- We will be involved in the waste management infrastructure of the countries in which we operate. We will be prepared to respond quickly to changes in the supply of waste and by-product resource streams, in particular where more sustainable options for their use emerge.

- We will seek to use fuels and raw materials as efficiently as possible by designing our installations using the best available techniques, and by continuously improving our process management systems.

- We will use common principles for monitoring, managing, and reporting impacts in key areas, in particular health and safety, carbon dioxide and other airborne emissions, and material substitution rates.

- We will continuously monitor and improve our safety, health, environment, and quality management practices, and train employees in the policies and procedures relevant to their roles. We will pay particular attention to maintaining strong management practices in countries where few safety, health, environment, or quality regulations currently exist.

- We will comply with laws, regulations and standards relating to safety, health, environment and quality where they currently exist.

- We will engage in constructive dialogue with stakeholders, and make decisions regarding the use of fuels and raw materials in an open and accountable way.

- We will collect data to continuously improve our understanding of the impacts of our operations and report regularly on our performance.

Our companies have already begun to deliver in many of these areas. A primary aim of the CSI is to raise awareness of good practices so that they can be more widely applied in our industry. We also want to enable our stakeholders to understand the role we can play in society, and to facilitate their collaboration with us.

Sustainable resource use and eco-efficiency in the cement industry

Using resources more efficiently is an essential step toward creating a more sustainable society. Eco-efficiency means producing more with less: less waste and pollution, and fewer resources. It not only helps to break the link between economic growth and environmental degradation, but can help companies improve financial performance as they pay less for inputs and pay less for waste and pollution management.[3]

Cement companies can achieve eco-efficiency gains in several ways:

- Optimized processes - reducing fuel and material use and minimizing pollution by continuously increasing the efficiency of manufacturing equipment and processes.

> Waste co-processing and energy / material recovery - using the waste and by-products of other industries as fuels and raw materials for cement manufacture, creating ‘closed loops’ of resource use.

> Eco-innovation - using new knowledge and technology to make cement products increasingly resource-efficient to produce and use.

The industry has and continues to make progress in improving the efficiency of cement manufacturing equipment and processes. Current estimates suggest that the industry can increase its energy efficiency by 0.5% to 2% per year, although regions that are already highly efficient (for example, Japan) may improve more slowly than countries like the United States, which are less efficient.[4] Replacing old or outdated equipment is the most effective way to increase efficiency: as new, dry-process plants replace older, wet-process units, significant energy efficiency gains are possible. Such improvement must also be financially viable so that new investments are paid for with the energy savings and/or other improvements in product quality and manufacturing cost.

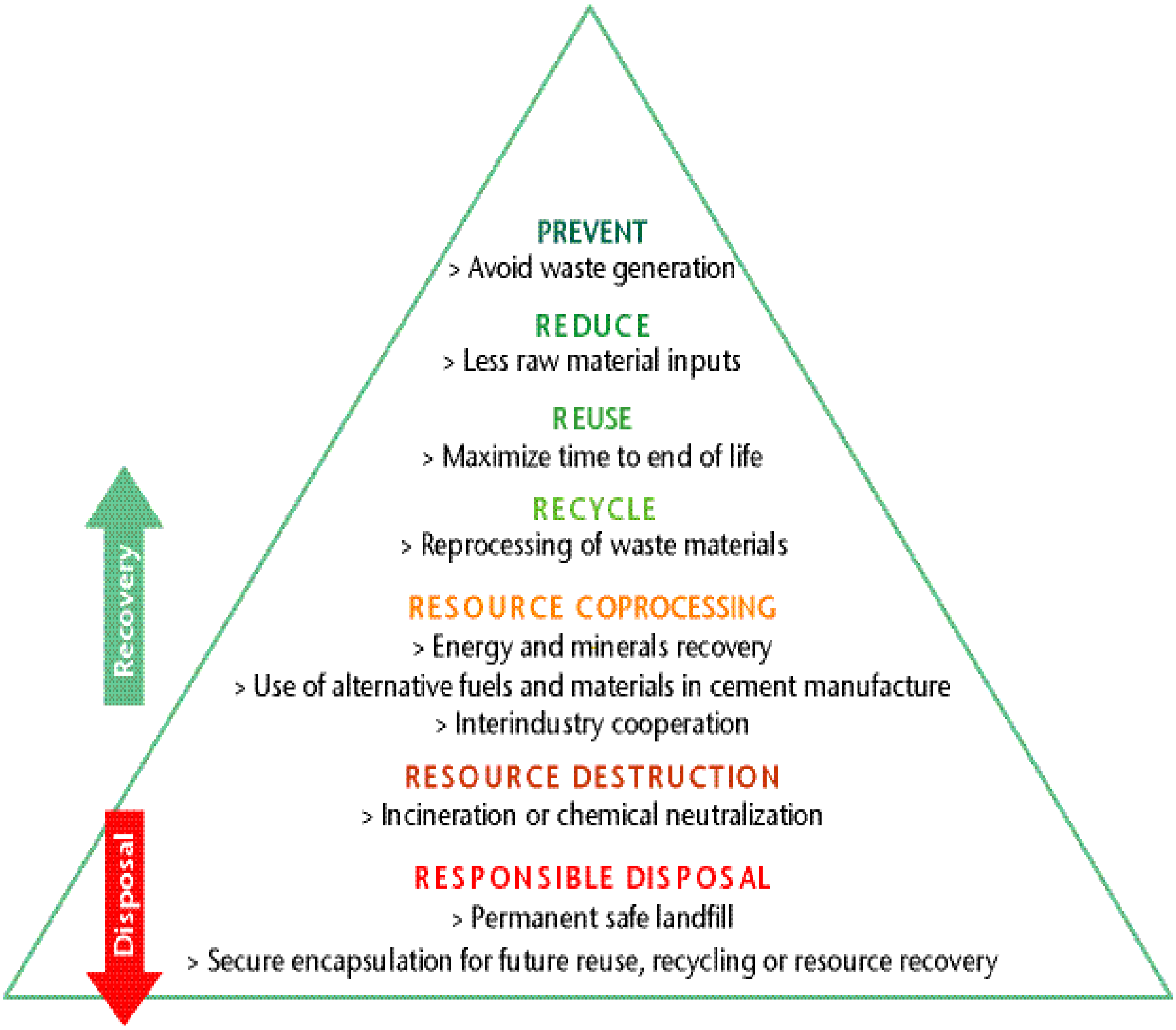
For some time, the industry has focused on mineral and energy recovery from the waste and by-products of other processes, a process known as ‘co-processing’. Cement kilns can be used for energy recovery from non-hazardous wastes such as tires and biomass, as well as some hazardous wastes. This allows us to reduce the volume of virgin fuels and raw materials used to produce a tonne of cement, thus increasing resource efficiency and frequently reducing costs.

This practice also provides society with a useful waste management option that can be an economically viable and environmentally sound alternative to land disposal, treatment, or incineration. In Norway, national policy makes cement kilns the preferred method for hazardous material management, including destruction of polychlorinated biphenyls (PCBs), an approach that has been used safely and successfully for more than 10 years. In recent years, animal bone meal has been successfully destroyed in a number of kilns following its implication in “mad cow” disease.
As well as increasing resource efficiency, co-processing reduces the volume of waste ultimately going to landfill, and can help reduce society’s overall carbon dioxide emissions.[5] It may also reduce the need for quarrying and extraction of virgin fuels and raw materials. This approach comes under the heading of industrial ecology or by-product synergy, in which by-products unusable by the producing industry may become feed-stocks in the processes of another industry.

The strict quality controls for cement products and the nature of the manufacturing process mean that only carefully selected waste and by-products are suitable for use. Some examples of these are given on pages 9 - 10. Changes in technology and consumer behavior mean that co-processing may not always be the most economic or environmentally sustainable way of using a waste and by-product resource stream. Such decisions need to be re-evaluated over time. For example, in some countries, used tires are sometimes used as an alternative fuel. Now some are being used as an additive in road beds and playgrounds. Nevertheless, nearly 50 million tires are still discarded each year world-wide, and many are currently abandoned, and untreated - an unacceptable approach.

Figure 1 - The waste hierarchy

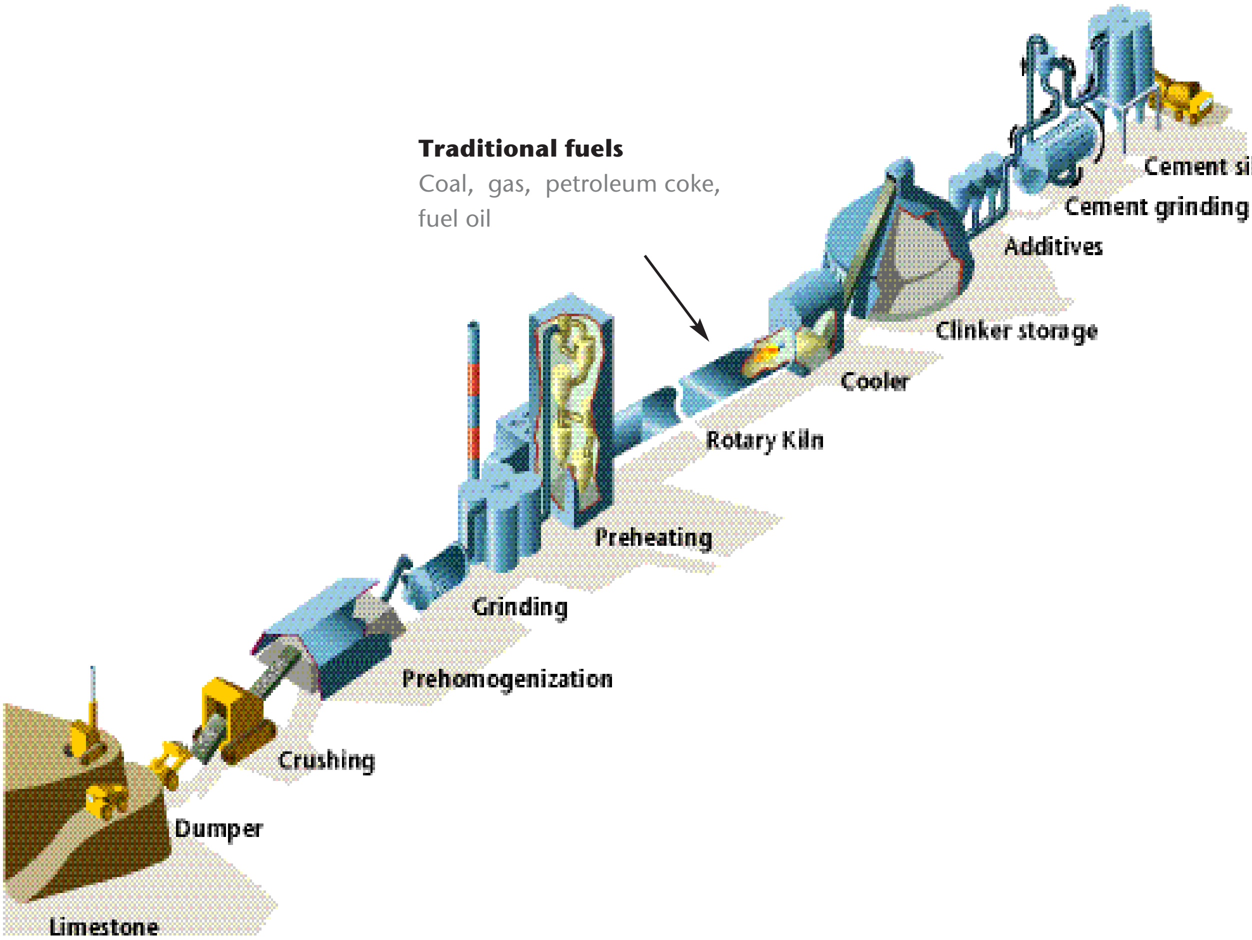
Society can manage wastes in a number of ways, depending on their physical and chemical nature, and on the economic, social, and environmental context in which they are produced. Some of these are listed below. Specific decisions will always be influenced by local circumstances such as the availability of waste treatment facilities, alternative markets for materials, and the infrastructure available to safely collect, manage and transport waste materials.



Principles

Use of fuels and raw materials in cement manufacture

Figure 2: Process of cement manufacture



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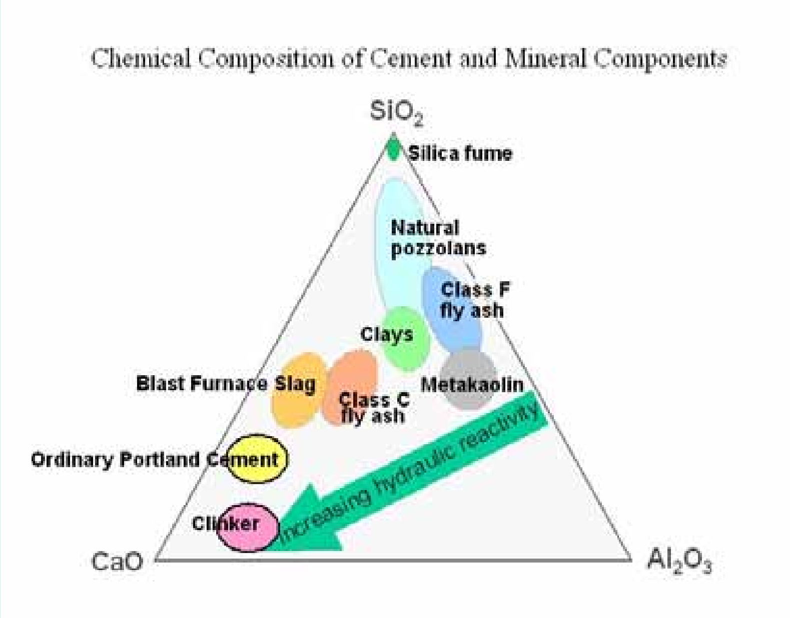
What is Cement?

Cement is made from an intermediate product called clinker. Clinker itself is a complex mixture formed during high temperature reactions of limestone, clay, sand and iron. It contains calcium oxide (CaO), aluminum oxide (Al_2O_3), silica dioxide (SiO_2) and small amounts of iron oxide (Fe_2O_3). When the primary ingredients (SiO_2, CaO and Al_2O_3) are mapped on a phase diagram, (see figure below), it is easy to see how cement (OPC), clinker and other materials are related to these basic mineral elements. Changing the final composition can impact the properties of the cement produced - its reactivity, strength, and setting time.

Figure 3



How cement is made

Cement is made by heating limestone with small quantities of other materials (such as clay) to 1450°C in a kiln, a process which requires large amounts of fuel. The resulting hard intermediate product, called clinker, is ground with a small amount of gypsum into a powder to make Ordinary Portland Cement (OPC). Blending additional constituents, such as coal fly ash, limestone, pozzolana (a naturally occurring volcanic ash), and blast furnace slag with the clinker creates blended cements with different properties depending on the materials added. Ordinary Portland Cement and blended cements are the most commonly used types of cement.

Cement must conform to the strict building standards set for it. Consequently, the manufacturing process itself must be closely monitored and controlled to obtain clinker and cement that meet these standards. The chapter “Practical guidance for cement manufacturers” of this report discusses good operating and management practices in more detail.

Conventional fuels and materials

Fuels

A cement plant consumes 3,000 to 6,500 MJ of fuel per tonne of clinker produced[6], depending on the raw materials and the process used.[7] Most cement kilns today use coal and petroleum coke as primary fuels, and to a lesser extent natural gas [8] and fuel oil. As well as providing energy, some of these fuels burn to leave fuel ash containing silica and alumina compounds (and other trace elements).

These combine with the raw materials in the kiln contributing to the structure of the clinker and form part of the final product. Energy use typically accounts for 30-40% of the production costs.

Raw materials

As noted above, the main components of cement are oxides of calcium, silica, aluminum, and iron. These are formed by the transformation of minerals and materials in the kiln. Calcium is provided mainly by raw materials such as limestone, marl, or chalk. Silica, aluminum, and iron components, as well as other elements, are provided by clay, shale, and other materials. The different kinds of raw materials needed to achieve the required cement composition are ground and mixed to produce a homogeneous blend processed in the kiln. The composition of the raw materials is tested on a regular basis.

Natural limestone contains calcium carbonate and a complex mixture of minerals that varies from place to place. The typical contents of some heavy metals (in parts per million by weight) in natural materials and industrial by-products often used in cement production are shown in Table 1 on pages 12 - 13:[9]

Table 1: Heavy metal content of various materials[9]

Elements ppm (by weight) parts per million - typical ranges shown	Limestone	Lime marl	Clay and argillaceous rock	Granulated blast furnace slag	Fly ash from bituminous coal
Lead	0.27-21	1.3-8.5	9.7-40	1.0-10	58-800
Cadmium	0.02-0.50	0.04-0.35	0.05-0.21	0.01-0.5	0.2-4.0
Chromium	0.70-12.3	4.6-35	20-90	1.0-75	71-330
Nickel	1.4-12.9	5.9-21	11-70	1.0-10	92-250
Mercury	0.005-0.10	0.009-0.13	0.02-0.15	<0.01-0.2	0.04-2.4
Thallium	0.06-1.8	0.07-0.68	0.60-0.90	<0.2-0.5	0.7-5.1
Zinc	1.0-57	24-55	55-110	1.0-20	67-910

Gypsum	Oil shale	Pozzolans	Continental crust	Soil (average worldwide values)
0.3-20	10-50	10-70	15	
<0.2-3	0.5-3.0	0.1-1.0	0.10	0.30
2.8-33	20-40	2.0-90	88	40
unknown	unknown	1-5	45	20
<0.01-1.3	0.05-0.3	<0.01-0.1	0.02	70
<0.2-0.6	1.0-3.0	<0.1-1.0	0.49	
1.0-61	160-250	60-190	65	90

Other cement constituents

A variety of other constituents can be used with clinker to create different kinds of cement with different uses. These other raw materials may have cementitious properties in their own right. In Ordinary Portland Cement, the proportion of gypsum (required to control the setting time of cement) to clinker is around 5%. For blended cements, a variety of materials can be added in varying proportions, in addition to clinker and gypsum. These include pozzolana and limestone. The properties and proportions of clinker, gypsum, and other constituents must be managed carefully to provide a product that meets the desired performance criteria or set of standards.

None of the natural materials (fuels, marls, and limestone) used in cement production are pure substances as extracted from the ground; all are complex mixtures and all contain trace mineral elements, including heavy metals.

Figure 3 on page 9 shows how the chemical compositions of typical materials compare to the clinker and to Portland Cement.

Alternative fuels and raw materials

The cement industry has many opportunities to replace a portion of the virgin natural resources it uses with waste and by-products from other processes. These may be used as fuels, raw materials, or as constituents of cement, depending on their properties.

Alternative fuels and raw materials must meet quality specifications in the same way as conventional fuels and raw materials. Their use should follow the good practices discussed in chapter: "Practical guidance for cement manufacturers" of this document.

Alternative fuels

Selected waste and by-products with recoverable calorific value can be used as fuels in a cement kiln, replacing a portion of conventional fossil fuels, like coal, if they meet strict specifications. Sometimes they can only be used after pre-processing to provide 'tailor-made' fuels for the cement process.

Waste or Fuel?

When the Prestige, a large tanker carrying heavy oil, broke up off the coast of Spain in 2004, much of its oil cargo reached the shoreline, contaminating local beaches. As there is no effective cleaning method to restore the sand, it ultimately had to be removed. At the request of local governments, it was burned in a cement kiln, where the oil residue contributed thermal energy, and the sand provided the silica dioxide necessary to make cement.

When mad-cow disease was linked to contaminated animal feed in 2000, several governments requested and received special assistance to burn the remaining feed in cement kilns where it was completely destroyed.

At other times they can be just used as they are delivered without further processing. In nearly all cases, fuel components are blended prior to use to ensure a homogenous mixture with near constant thermal properties.

Alternative raw materials

Selected waste and by-products containing useful minerals such as calcium, silica, alumina, and iron can be used as raw materials in the kiln, replacing raw materials such as clay, shale, and limestone.

Because some materials have both useful mineral content and recoverable calorific value, the distinction between alternative fuels and raw materials is not always clear. For example, sewage sludge has a low but significant calorific value, and burns to give ash containing minerals useful in the clinker matrix.

Mineral and energy recovery from waste materials in the kiln

Cement kilns have several features that make them particularly appropriate and efficient for the recovery of minerals and energy from waste fuels and raw materials.

> Kilns have high temperatures, which the process requires: 2,000°C in the flame of the main burner, 1,450°C in the material to make clinker, and 1,000 to 1,200°C in the precalciner.
> The typical residence time of combustion gases in the kiln is more than five seconds at a temperature higher than 1,000°C. By constrast, gas residence time in a typical incinerator is only two seconds. Residence time for solid materials varies from tens of minutes to an hour depending on the cement process.
> The process takes place under oxidizing conditions.
> The stable nature of these conditions in a well-operated kiln guarantees the complete destruction of the organic components of the waste, provided that the waste is introduced in the hot part of the process.
> Waste materials in the kiln are in contact with a large flow of alkaline (basic) materials that remove potential acid off-gases from combustion.
> Any inorganic mineral residues from combustion – including most heavy metals* – are trapped in the complex matrix of the clinker and cement.
> Complete combustion and the trapping of mineral residues mean that in most cases there is no ash residue from the process **.

Given the differences in temperature between different parts of the process, it is important that waste materials are introduced at the correct point in the process to ensure complete combustion or incorporation and to avoid unwanted emissions. For example, raw materials with volatile organic components may be introduced in the cement kiln at the main burner, in mid-kiln, in the riser duct, or at the precalciner. They should not be introduced with other raw materials except where tests demonstrate that this will have no effect on the off-gases. (See Section "Manufacturing operations", p. 27)

*Some volatile heavy metals are not completely immobilized in this way; so their content in raw and/or waste materials must be assessed and controlled.
**Excess in chlorine or alkali which may be in some virgin materials may produce cement kiln dust or bypass dust which must be removed, recycled or disposed of responsibly.

Alternative cement constituents

These materials can be used with clinker to produce different types of cement. They may help to control the setting time of the cement (synthetic gypsum); they may have cementitious properties in their own right (blast furnace slag), or they may be completely inert.

The use of these alternative constituents is extremely important in reducing the environmental impact of cement production. They can reduce the amount of energy-intensive clinker required for each tonne of cement, further reducing CO_2 emissions per tonne.

Controlling impacts on air, soil, and water

Many people are concerned about emissions from cement kilns, particularly in cases where the kilns use waste fuels and alternative raw materials. The cement industry recognizes these concerns and is establishing processes to monitor, measure, and report emissions from its operations[10]

A recent report by SINTEF[11] reviewed the available research into the effects of fuels and raw materials on dioxin/furans emissions from cement kilns. The report concluded that there is no relationship between the fuels and raw materials used in cement production and the emission of persistent organic pollutants (POPs), in a well designed, well operated, well maintained kiln. Government regulators in the US and the UK have reached similar conclusions.

Controlling emissions to the atmosphere from cement manufacture requires precise control of the process, whether using conventional or alternative fuels and raw materials. Particular attention is paid to the specification of the fuel, (specifically its homogeneity, particle size, and flammability) and to the use of best combustion practices, including proper metering, feeding, and burner technology to maintain smooth kiln operating conditions.[12]

The third section of this document, “Practical guidance for cement manufacturers” sets out recommendations for the design of installations, their management and operation, particularly with regard to controlling and minimizing the impacts of the fuels and raw materials use on air, soil and water.

Use of cement kilns for waste disposal

In some countries, the cement industry provides a public or industrial service by disposing of wastes even those with little or no useful energy or mineral content. This may be done at the request of national governments or in response to local demand. It can be done because a cement kiln provides high temperatures, long residence time, and a carefully controlled facility capable of high destruction efficiency. However, this activity is not part of the fuel or raw material substitution process.

Cement kilns have been used in this way for many years in countries such as Japan, Norway, and Switzerland, where there is little space for landfill sites. In Norway, PCBs have been disposed of in this way for more than ten years. More recently, modern kilns have been used for waste disposal in some developing countries where the lack of existing waste disposal and incineration infrastructure means that kilns are the most economical option. Even where good waste disposal infrastructure exists, it may be useful to increase local capacity through use of cement kilns.

The use of cement kilns for waste disposal may be less desirable than other approaches, such as recycling or reprocessing, but is a useful alternative to landfill or dumping. The industry will avoid disposing of wastes that could be more effectively handled by other means.

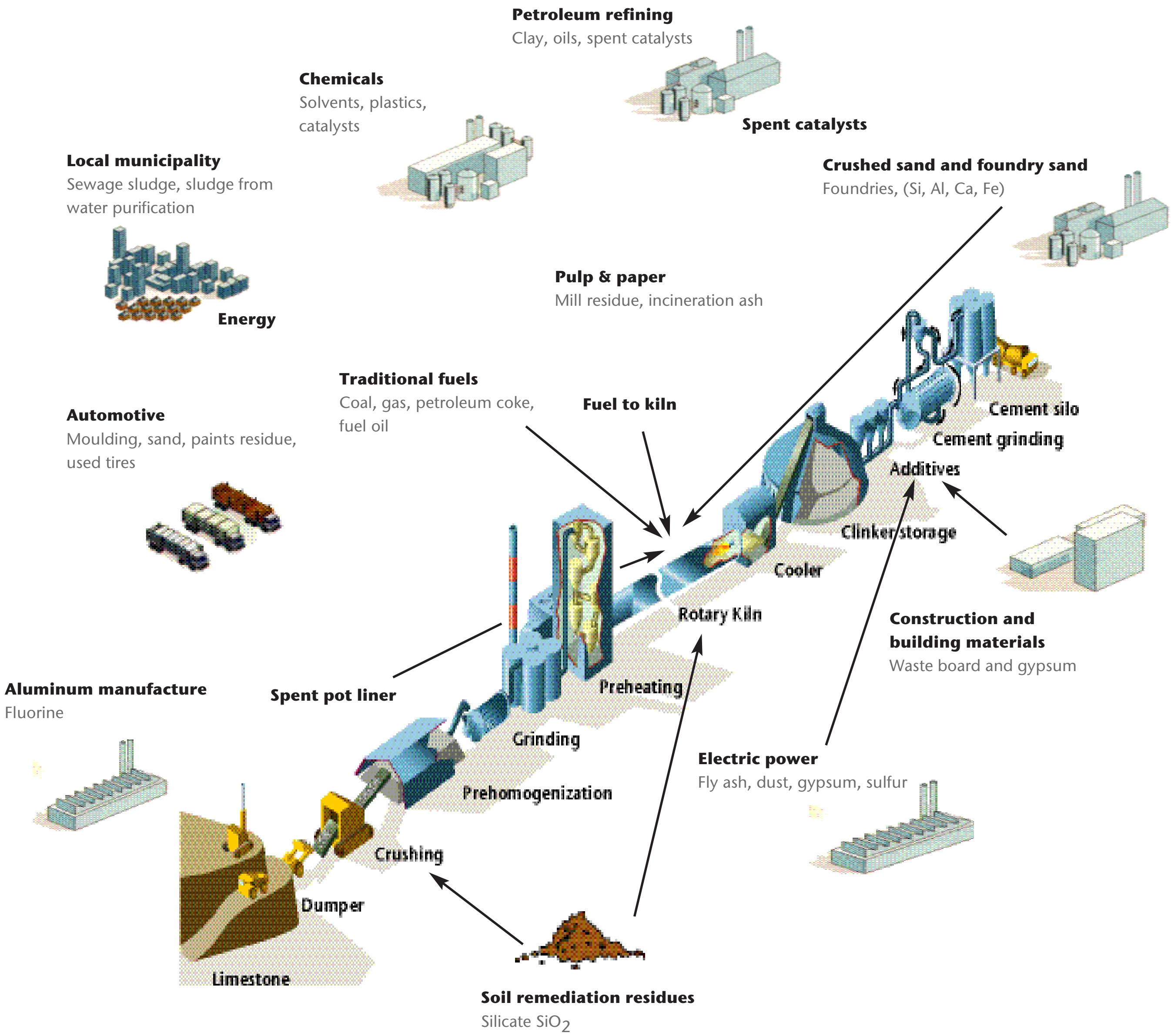
The CSI aims to apply the same principles to the selection and use of wastes as it does for alternative fuels and raw materials. Their treatment must meet strict environmental, health, and safety standards, and must not impair the quality of the final product. The process must be precisely controlled when destroying such wastes, and emissions regularly measured.

Examples of alternative fuels and raw materials used by the cement industry and their sources

There are many sources of waste materials and by-products that can be used as alternative fuels, raw materials, and cement constituents. The diagram below lists some of those used by the industry, and their sources.

Recycling wastes from one process as raw materials and fuels for another creates a web of relationships between industries that moves society closer to a zero-waste economy.

Fig. 4 Examples of alternative fuels and raw materials



Feed point will vary depending on composition. (See page 27 of this document)

This diagram (fig. 4) and many of the comments about material use in kilns apply to modern, well-operated, well-maintained, rotary cement kilns. Other types of kilns are in use, and not all are equally suitable for using alternative fuels and materials. In particular, most vertical shaft kilns, still common in many smaller Chinese cement factories for example, would not be suitable, due to poor emissions control.

Reasons for using alternatives to conventional fuels and raw materials

The selection of alternative fuels and materials is driven by a number of interrelated considerations, including:

- Impact on CO_2 emissions and on fuel consumption,
- Impact on fuel cost,
- Impact on other emissions,
- Impact on mining and quarry activity.

These are discussed briefly below.

Managing CO_2 emissions and reducing fuel consumption

The cement industry is committed to managing and reducing its CO2 emissions. The industry produces 5% of global man-made CO2 emissions worldwide. Half of this is a result of the chemical process involved in the transformation of limestone into clinker; 40% is a result of burning the fuel. The remaining 10% is split between electricity use and transport.[13]

There are three main techniques available to the industry in reducing net total and per tonne CO_2 emissions:

- Maximize the efficiency of the manufacturing process and associated equipment to use fuels and materials as efficiently as possible;

- Reduce the amount of fossil fuel used in the process by replacing it with biomass and wastes that would otherwise have been burned without energy recovery, and other materials having lower carbon content;

- Replace a proportion of the clinker in cement with alternative materials (which do not require thermal processing), reducing the CO_2 emissions per tonne of cement produced.

Use of alternative fuels and raw materials can significantly reduce the CO_2 emissions from an individual plant, and of society as a whole.

Reducing fuel and raw material costs

The costs of fuel are a significant part of the costs of manufacturing cement. Waste fuels may be less expensive than primary fossil fuels although costs will vary with the type of waste and local conditions. Against these lower fuel costs alternative fuels and materials must frequently be pre-treated and made sufficiently homogeneous to be used in a cement kiln. Some additional environmental equipment may also be installed to control emissions. Special control and process measures may be needed to maintain safety, quality, and environmental standards.

Providing resource management services to society

Many of the alternatives to conventional fuels, raw materials, and additives are wastes and by-products from industrial, agricultural and other processes that are generally managed through landdisposal, treatment or incineration. Organic waste disposed in landfills may release methane (a more potent greenhouse gas than CO_2), or contaminate groundwater. An incinerator produces CO_2 and residual ash (typically high in heavy metals which requires careful disposal). Most incinerators do not recover energy. A cement kiln incorporates inorganic ash into the clinker complex so there is no residual waste to be land-filled. Also, the energy produced in the kiln is used to create the high temperatures needed to make cement. Using waste and by-products in cement production not only reduces the industry’s demand for virgin fossil fuels and raw natural materials, it also enables society to use resources more efficiently and move toward more sustainable production and consumption patterns.

Reducing the need for mining and quarrying of raw materials and fuels

Most of the fuels, raw materials, and additives traditionally used to make cement are mined or quarried. The majority of the fuels used are non-renewable fossil fuels. Extraction, processing and transport of these materials can have a significant and lasting impact on the environment, particularly on the landscape. Using wastes as a fuel or raw material reduces the exploitation of natural resources and the environmental footprint of such activities.

Recent Trends in the Use of Alternative fuels and Materials

Local and national governments are recognizing that the cement industry can play an important role in efficient waste management. We in the industry are waking up to our opportunity to reduce our overall carbon dioxide emissions and to operate more sustainably in a carbon-constrained world.

The substitution of fossil fuels and virgin raw materials with alternatives is a well-developed practice in a small number of countries. Some countries have been using it for almost 30 years, and some national governments actively promote this approach. In a number of countries this practice is well understood and highly developed. (See tables below.)

Table 2: Recent patterns in the use of alternative fuels

Country or region	% Substitution[14]
Netherlands	83
Switzerland	47.8
Austria	46
Norway	35
France	34.1
Belgium	30
Germany	42
Sweden	29
Luxembourg	25
Czech Republic	24
EU (prior to expansion in 2004)	12
Japan[15]	10
United States[16]	8
Australia[17]	6
United Kingdom	6
Denmark	4
Hungary	3
Finland	3
Italy	2.1
Spain	1.3
Poland	1
Ireland	0
Portugal	0
Greece	<1%

Table 3: Types of alternative fuels (2001)

Type of fuel	Quantity in kT
Solid fuels (80%)	**3,532**
Meat and bone meal & animal fat	890
Other wastes	788
Tires	554
Plastics	210
Paper/cardboard/wood	180
Impregnated saw dust	167
Coal slurries/distillation residues	112
Sludge (paper fiber, sewage)	107
Fine/anodes/chemical cokes	89
Refuse derived fuels	41
Shale/oil shales	14
Packaging waste	12
Agricultural and organic waste	11
Liquid fuels (20%)	**841**
Waste oil + oiled water	402
Solvents and others	266
Other hazardous liquid fuels	173

Table 4: Types of alternative materials (2002)

Material
Blast furnace slag
Fly ash (coal ash)
By-product gypsum
Others *
Total tonnage used in 2002 in Europe and Japan: 45,723

Note: "Others" include steel manufacturing slag, nonferrous slag, coal tailings, dirt, sludge, etc.

Practical guidance for cement manufacturers

The guidelines below are in no way meant to replace local, national, or international laws, regulations, and conventions. We believe these guidelines represent a minimum set of good practices to be used in managing fuels and materials. They can be augmented with successful company operating experience, where acceptable performance can be documented.

Successful substitution of fuels and materials in cement manufacturing is hard work. Guidelines alone cannot ensure adequate performance. Execution of these guidelines requires well-trained staff, knowledge of current environmental regulations, and well-maintained and well-operated facilities. Appropriate monitoring and reporting systems must be in place to provide good plant control, measure performance, minimize impacts, and make adjustments where needed.

Considerations when selecting and using fuels and raw materials

Many cement plants operate nearby quarries that supply raw materials such as limestone, marl, and clay. High transport costs mean that cement production is usually a localized activity. Where choices of raw materials and fuels are greater, the selection of these can be a complex process. Selection is a result of subjective as well as objective valuation of alternatives, and we must often manage trade-offs among a variety of factors: availability, transport costs, calorific value, mineral content, CO_2 emissions, equipment requirements, etc. Each facility's circumstances are unique, and the selection of fuels and raw materials can rarely be made from a simple list.

This guidance does not set limits for specific chemical content or other characteristics, because these will be determined by the company in the light of the required characteristics of the final product, the parameters of the process, and the limits set for emissions. Decisions must be made by each plant on a case-by-case basis, within the broad framework of sustainable development considerations as discussed in the previous sections.

Guidance for the selection of fuels and raw materials

The operator should develop a fuels and raw materials evaluation and acceptance procedure that includes the following features:

> Each material supplier should be required to prepare a sample of fuel or material, which will be used to evaluate the fuel or material before delivering it to the plant. This should include a datasheet detailing the chemical and physical properties of the fuel or material being supplied, information on relevant health, safety, and environmental considerations during transport, handling, and use, and a typical sample of the material. It should also specify the source of the particular shipments being made.

> The sample's physical and chemical characteristics should be tested and checked against specifications.

Based on this information, the operator should then:

> Assess the potential impact of transporting, unloading, storing, and using the material on the health and safety of employees, contractors, and the community. Ensure that existing and new equipment or management practices required to address these impacts are in place.

> Assess what personal protective equipment will be required for employees to safely handle the fuel or material on site.

> Assess the effect the fuel or material may have on plant emissions and whether new equipment or procedures are needed to ensure that there is no negative impact on the environment.

> Assess the potential impact on process stability and quality of the final product. Assess the compatibility of the new fuels and raw materials with those currently in use. Reactive or non-compatible fuels and materials should not be mixed.

> Determine what certifications or materials analysis data the supplier will be required to provide with each delivery, and whether each load should be tested prior to off-loading at the site.

> If it is a waste fuel or material, the operator should ask the supplier to confirm that shipments crossing international boundaries and classified as hazardous waste under the Basel Convention meet with the requirements of the Convention.

Exclusions

CSI member companies will not use any of the following in our kilns as fuel or raw material, as a constituent of cement, or in our waste recovery and disposal operations:

> nuclear waste,
> infectious medical waste,
> chemical or biological weapons destined for destruction,
> entire batteries,
> unknown or non-specified waste.

Individual companies may exclude additional materials depending on local circumstances.

Variables to consider in the selection of fuels and raw materials

Kiln operation:

- Chlorine, sulfur, and alkali content (fuel or raw material): these may build up in the kiln system, leading to accumulation, clogging, and unstable operation; excess in chlorine or alkali may produce cement kiln dust or bypass dust (and may require installation of a bypass) which must be removed, recycled or disposed of responsibly.
- Water content (fuels or raw materials): high water content may reduce the productivity and efficiency of the kiln system.
- Heat value (fuel): the heat value is the key parameter for the energy provided to the process.
- Ash content (fuel): the ash content affects the chemical composition of the cement and may require an adjustment of the composition of the raw materials mix.

Clinker and cement quality:

- Phosphate content: this influences setting time.
- Chlorine, sulfur, and alkali content: these affect overall product quality.
- Chromium: this may cause allergic reactions in sensitive users.

Emissions:

- Sulfides in raw materials: these may result in the release of SO_2.
- Organic carbon in raw materials: this may result in carbon monoxide, CO_2 and volatile organic compound (VOC) emissions.

As well as the above considerations, the volatile heavy metal content of a fuel or raw material must be assessed and controlled.

- Heavy metals in fuel or raw material: volatile heavy metals, which are not completely captured in the clinker, must be monitored and controlled

The choice of fuels and substitute materials can also affect greenhouse gas emissions. For example, substituting alternative materials for limestone reduces CO_2 emissions and may decrease fuel use, as discussed elsewhere in this report.

Guidelines for good practice in site operations

This section offers operators general guidance in the responsible use and handling of conventional and alternative raw materials and fuels. It describes good practice in the different areas of site operations.

In some countries, sites will have obtained an operating permit from local authorities, which will specify conditions of operation in certain areas. Where such a permit is in place, the site should fully comply with it.

We cannot provide specific numerical limits and values in many instances because:

> manufacturing equipment and process can vary significantly;

> the composition of trace components in fuels and raw materials can vary significantly;

> there are complex interactions between the different components used to make cement. Therefore changes in composition in one feedstock may affect the suitability of other materials;

> different types of cement are manufactured in different ways, having different product specifications and chemical properties;

> local permit and regulatory requirements can vary significantly and will take precedence over these guidelines.

Basic management systems

Compliance with regulations or company policy

> Relevant laws, regulations, standards, and company policies relating to safety, health, environment, and quality control should be identified, and compliance continually reviewed.

> Employees should be made aware of the relevant laws, regulations, and standards and should be made aware of their responsibilities under them.

> Where company policy is more stringent than national regulations, or where there are no relevant national regulations in place, the site should comply with company policy.

> Companies operating in regions without safety, health, and environmental quality (SHEQ) regulations may work together with national, regional, and local authorities and other cement companies to develop such regulations.

Basic management systems should cover:

Personnel management

> Sufficient resources and training should be provided to operate and manage SHEQ systems efficiently.

Operational Management

> Sites should develop procedures for operation and maintenance that cover safety of workers and installations.
> Operation and maintenance procedures should be systematically reviewed following modifications to or new installations of equipment, fuels, and raw materials.

Emergency procedures

> Sites should develop robust emergency procedures. Such procedures may be developed in cooperation with relevant authorities and experts.

Stakeholder communications

> A stakeholder engagement plan should be established for working with the local community and authorities. Such a plan should include procedures for responding to community interests, comments, or complaints, and feedback should be given promptly.

The following sections apply to key areas of operations and provide more specific guidelines

Installation design

General design considerations

- Assess operations for health and safety risks or concerns to ensure that equipment is safe and to minimize risks of endangering people or installations, or damaging the environment.
- Use appropriate procedures to assess risks or hazards for each stage of the design process. Only competent and qualified personnel should undertake or oversee such hazard and operability studies.
- Carefully consider plant layout to ensure access for day-to-day operations, emergency escape routes, and maintainability of the plant and equipment.
- Apply recognized standards to the design of installations and equipment. Any modification to installations and equipment should meet requirements set in the standards. Thoroughly evaluate existing equipment refitted for a different service from a safety and performance standpoint before resuming commercial production.
- Document modifications to installations and equipment.

Reception and storage of materials

- Establish suitable and safe transfer systems from transportation to the storage area to avoid SHEQ risks from spillage such as fugitive emissions or vapor displacement. Suitable vapor filtration and capture equipment should be in place to minimize impact to the reception point and surrounding areas from unloading activities.
- Assure that storage facilities fit their purpose. Appropriate storage for liquids should meet relevant safety and design codes for storage pressures and temperatures.
- Solid materials handling systems should have adequate dust control systems.
- Storage design should be appropriate to maintain the quality of the materials: for solids, prevent build-up of old materials; for liquids, mix or agitate to prevent settlement, etc.
- Design transfer and storage areas to manage and contain accidental spills into rainwater or firewater, which may be contaminated by the materials. This requires appropriate design for isolation, containment, and treatment.
- Appropriate storage for liquids should have adequate secondary containment.

Material handling and feed systems

- Handling systems and feed systems should be appropriate to the fuel and raw material used. The feed systems should allow stable and controlled input of materials to the kiln.
- The operator should assess risks from fugitive emissions; equipment failure modes and appropriate safeguards should be incorporated into the design to prevent environmental pollution, health, and safety problems.

Delivery and on-site transport

- Use appropriate vehicles and equipment to transport fuels and raw materials.
- Personnel involved in transportation should be adequately trained and qualified.
- The transport provider (including in-house transport) should document maintenance and operator training.

Selection and reception of materials

- Select fuels and raw materials only after the supplier, and the chemical and physical properties and specifications of the materials have been clearly identified.
- Stop vehicles carrying fuels and raw materials upon arrival at site and make the necessary identifications. Such vehicles should be weighed in and out of the site. Deliveries should be recorded.

- Check documents relating to vehicles carrying waste and determine their compliance with site acceptance specifications and regulations. Document checks may cover waste certificates, transport certificates, etc. A vehicle found not to comply should not be allowed to enter the site.

- Instructions for unloading, including safety and emergency instructions, should be provided in due time to vehicle drivers.

- Sample and analyze vehicle loads once on site according to the frequency and protocol defined in the site control plan; check agreement with site specifications according to the plan of control.

- Fuels and materials can be accepted once their properties are confirmed to agree with specifications.

Management of quality control

Develop a plan of control that covers fuels, raw materials, and any material entering, processed at, or produced at the site. The plan should provide detailed instructions for sampling, personnel assignment, frequency of sampling and analysis, laboratory protocols and standards, calibration procedures and maintenance, and recording and reporting protocol. The plan should include specifications for each material.

- The detailed control plan will depend on the nature and origin of the fuels and raw materials.
- Adequate laboratory design, infrastructure, sampling and test equipment should be provided and maintained.
- Inter-laboratory tests may be carried out periodically in order to check and improve the performances of the laboratory.
- Personnel should be trained according to their specific needs and to the nature of the fuels and raw materials used.

Management for non-compliant deliveries of waste fuels and raw materials

Make written instructions available that describe measures to be implemented in case of non-compliance with specifications set for waste fuels and raw materials.

The producer of waste fuels and raw materials should be informed about non-compliant deliveries.

If non-compliance cannot be cleared with producer, the shipment must be rejected; if required in the permit, authorities must be notified.

Deliveries should be evaluated for each producer on a statistical basis in order to assess the performance and reliability of the waste fuels and raw materials producers; periodically review contract accordingly.

On-site handling and storage

- There should be written procedures and instructions in place for the unloading, handling, and storage of the solid and liquid fuels and raw materials used on site.

- Relevant employees should be trained in the company's operating procedures, and compliance with such procedures should be audited regularly.

- Storage facilities should be operated in such a way as to control emissions to air, water, and soil.

- Designated routes for vehicles carrying specified fuels and raw materials should be clearly identified within the site.

- Appropriate signs indicating the nature of materials should be in place at storage, stockpiling, and tank locations.

Risks and safety tips for handling and storage of fuels

Solid fuels: coal and pet-coke
Risks are fire with auto-ignition for coal and explosion for given concentrations of oxygen and dust with an ignition source.

Fine coal and pet-coke silos should be fitted with carbon monoxide and temperature monitoring systems, an explosion safety device, and an atmosphere control device such as CO_2 inertization.

Liquid fuels: heavy oil and used oils
Risks are leaks and spills from storage and handling areas, with contamination of soils, surface, and water tables.

Oil storage and handling areas should be tight; storage areas should be fitted with secondary containments.

Scrap tires: whole and shredded
Risks are fire, and for whole tires, a proliferation of mosquitoes and rodents.

Storage halls should be fitted with water sprinkler systems.

Waste solvents
Risks are fire and explosion, leaks and spills from storage and handling areas, with contamination of soils, surface, and waters tables.

Solvent tanks and handling areas should be tight; tanks should include secondary containment. Tanks should be fitted with an explosion safety device. Additional devices may be considered such as atmosphere control (e.g. N_2 inertization) and temperature control (e.g. shell cooling), etc.

Impregnated saw dust
Risks are fire with auto-ignition after temperature rises spontaneously, and explosion of vapors from the solvent fraction of the product.

Silos should be fitted with carbon monoxide and temperature monitoring systems, an explosion safety device, and an atmosphere control device (e.g. CO_2 inertization).

Storage halls should be vented to control accumulation of solvent vapors (which could be sent to the kiln), and fitted with water sprinkler systems.

Fuels derived from refuse
Risks are fire.

Storage halls should be fitted with water sprinkler systems.

Meat and bone meal
Risks are fire with auto-ignition after temperature rises spontaneously, and explosion for given concentrations of oxygen and dust, with an ignition source.

Silos should be fitted with temperature monitoring systems and an explosion safety device.

General
Maintain "good housekeeping" in all areas. Storage areas should be kept clear of uncontrolled combustible materials. Clear safety warnings, no smoking, fire, evacuation route, and any procedures signs should be posted.

An emergency shower and eye washing station should be clearly marked and located near the storage of liquid alternative fuels.

A fire protection system must be available at all times and should meet all standards and specifications from local authorities (e.g. local fire department).

Adequate alarms should be provided to alert all personnel about emergency situations. Communications equipment (e.g. telephone) should be maintained at the site so that the site control room and the local fire department can be contacted immediately in case of a fire.

Equipment should be grounded and appropriate anti-static devices and adequate electrical devices selected (e.g. motors, instruments, etc.).

Manufacturing operations

- There should be written procedures and operating instructions in place for the use of conventional and alternative fuels and raw materials; such operating instructions should cover start-up and shut-down of the kiln and actions to comply with set quality requirements of the product and emissions.

- Operators should be trained in the company's operating procedures, and compliance with such procedures should be audited regularly.

- The monitoring and reporting of emissions should be carried out according to national and local regulations and requirements, and as a minimum as defined in the Cement Sustainability Initiative's Emissions Monitoring and Reporting protocol.[18]

- Adequate personal protective equipment should be made available to employees and contractors, and to individuals visiting the installation.

Selection of feed point for alternative fuels and raw materials

The point at which alternative fuels and raw materials are fed into the kiln ("feed point") should be selected according to the nature (and, if relevant, hazardous characteristics) of the alternative fuels and raw materials used.

Alternative fuels should be introduced in the high-temperature combustion zone of the kiln system, i.e. the main burner, the precalciner burner, the secondary firing at the preheater, or the mid-kiln (for long dry and wet kilns).

Alternative fuels with highly stable molecules, such as highly chlorinated compounds, should be introduced at the main burner to ensure complete combustion due to the high combustion temperature and the long retention time. Other feed points are appropriate only where test have shown high destruction and removal efficiency rates.

Alternative raw materials with volatile organic components should not be introduced with other raw materials in the process, unless tests have shown that undesired emissions at the stack do not occur.

Process control for alternative fuels and raw materials

The use of alternative fuels and raw materials should not detract from smooth and continuous kiln operation, product quality, or the site's environmental performance. Therefore a constant quality and feed rate of the alternative fuels and raw materials must be ensured.

The general principle of good operational control of the kiln system using conventional fuels and raw materials should be applied. In particular, all relevant process parameters should be measured, recorded and evaluated continuously; this should cover free lime, excess oxygen, and carbon monoxide levels.

The impact of alternative fuels and raw materials on the total input of circulating volatile elements such as chlorine, sulfur, or alkalis must be assessed carefully prior to acceptance as they may cause operational troubles in the kiln system. Input limits and operational set points for these components should be set individually by the site based on the process type and on the specific site conditions.

For start-up, shut-down, or upset conditions of the kiln, written instructions should be issued, describing conditions of use of alternative fuels and raw materials. Kiln operators should know and understand these instructions.

In most cases, waste fuels should not be used during start-up and shut-down of kilns, except where kiln temperatures are achieved to produce clinker that meets quality standards.

Waste fuels should not be used during failure of the air pollution control devices (e.g. filter or precipitator at the stack of the kiln).

On-site security

> Adequate systems and procedures should be in place to minimize the risk of unauthorized access to hazardous materials and explosives used on-site.

Emergency response plan

> A emergency response plan should be in place which:
  - identifies potential spill or contamination areas;
  - defines clean-up procedures;
  - identifies areas of high risk on site or in the local community;
  - provides written instructions in the event of an emergency;
  - documents equipment required in the event of an emergency;
  - assigns responsibilities to employees and local officials;
  - details emergency response training requirements;
  - describes reporting and communication requirements both within the company and with interested external stakeholders.

> The emergency response plan may be reviewed with relevant external emergency services.

> Emergency drills may be arranged with the local community emergency response services to ensure a coordinated response under emergency conditions.

Safety requirements

For a more complete coverage of health and safety, please see the work of the Cement Sustainability Initiative's Task Force 3 on health and safety *www.wbcsdcement.org/health.asp*.

> Safety and emergency instructions, such as Safety Data Sheets, should be provided to employees and contractors in due time, and should be easily understandable. Hazards relating to new materials should be reviewed with operating staff prior to using such materials in the facility. Conducting a job safety analysis is one approach to identifying hazards and potential exposures, along with appropriate control practices and techniques.

> Adequate personal protective equipment should be made available to employees and contractors, and to individuals visiting the installation. Its use should be required. This includes but is not limited to: helmet, glasses, gloves, hearing protection, safety shoes, respiratory protection, and other protective equipment specified in the Safety Data Sheets.

> Automated handling equipment should be used wherever possible.

> Wherever a contact risk such as infection or skin irritation exists, the company should provide appropriate facilities for operators to take required hygiene precautions.

> Maintenance work should be authorized by plant management, and carried out once a supervisor has checked the area and necessary precautions have been taken.

> Special procedures, instructions, and training should be in place for such routine operations as:
  - working at height, including proper tie-off practices and use of safety harnesses;
  - confined space entry where air quality, explosive mixtures, dust, or other hazards may be present;
  - electrical lock-out, to prevent accidental reactivation of electrical equipment undergoing maintenance;
  - "hot works" (i.e. welding, cutting, etc.) in areas that may contain flammable materials.

Employee training

Safety, health, environment and quality

> The company should develop and implement appropriate documented training programs for employees to be trained in SHEQ issues relevant to their jobs. New employees should be trained during an induction process.

> Such training programs should be given to contractors and, in some instances, suppliers. Personnel reporting to work on site for the first time should be trained through a site induction program.

> Training records should be kept on file.

> The training program should include the following:
- general and job specific safety rules;
- safe operation of equipment;
- details of the site emergency plan;
- procedures for handling alternative fuels and raw materials;
- use of personal protective equipment.

Stakeholder communications and engagement

We earn our license to operate from our stakeholders, particularly those who work on our sites and live in communities around them. As well as building goodwill, working with local groups, national NGOs, and regulators can result in better-informed and more effective business planning. It can be particularly useful in addressing local environmental and social issues. Effective, open, and transparent communication with stakeholders is essential if we are to play a responsible role in society's waste and resource management systems.

In 2002, WBCSD published stakeholder engagement guidelines for site managers, and we recommend that managers at cement manufacturing sites ensure that they have a copy of these.[19] We recommended that companies and sites develop and implement a stakeholder engagement program and policy that includes specific reference to the use of fuels and raw materials. Site managers may choose to work with their local or regional headquarters to develop and implement this program. It should contain the following elements.

Stakeholder identification and analysis

The site or company should identify its main stakeholders, and understand their expectations of and their relationship with the company and the cement industry locally, nationally, and internationally.

Site community engagement program

At site level, management should provide opportunities for stakeholders to express their concerns, listen to and understand those concerns, and build trust with the community through active engagement.

Reporting performance

Building trust with stakeholders requires both transparency and accountability in company and site operations. The production of regular reports on performance in areas of interest helps to provide key stakeholders with the information they need to make a fair and balanced judgment of the company's or site's activities and performance. As members of the WBCSD, all the member companies of the CSI are committed to producing regular reports on their environmental and social performance.

Key performance indicators

Key performance indicators (KPIs) provide a measure of how companies are moving toward more eco-efficient use of fuels and raw materials. The measures below are what the companies in the CSI have agreed to measure and report publicly on an annual basis. KPIs have also been developed by other CSI Task Forces including those for Emissions Monitoring and Employee Health and Safety.

Energy KPIs

1. Specific heat consumption for clinker production, in MJ per tonne of clinker
2. Alternative fossil fuel rate: consumption of alternative fuels, as a percentage of thermal consumption[20]
3. Biomass fuel rate: consumption of biomass, as a percentage of thermal consumption[21]

Raw material KPIs

1. Alternative raw materials rate: consumption of alternative raw materials, as a percentage of total raw materials for cement production (calculated on a dry basis)
2. Clinker / cement factor: ratio between clinker consumption and cement production

Specific heat consumption, alternative fossil fuel, and biomass fuel rate, and clinker/cement factor are defined according to the WBCSD-WRI CO_2 protocol issued in September 2001.[22]

Alternative raw materials are defined as non-quarried raw materials for the purpose of clinker and cement production.

Example – Alternative raw materials rate:

Raw materials for clinker production:

	Conventional raw materials		Alternative raw materials		
	High limetone	Low limestone	Fly ash	Iron additive	Slag
Wet basis	1,136,175 t	1,305,950 t	68,674 t	11,473 t	7,053 t
Moisture	9.6 %	10.2 %	20.7 %	9.9 %	5.8 %
Dry basis	1,027,102 t	1,172,743 t	54,458 t	10,337 t	6,644 t

Total conventional raw materials: 2,199,845 t
Total alternative raw materials: 71,439 t

Raw materials for blended cement:

	Conventional raw materials		Alternative raw materials		
	High limetone	Natural gypsum	Fly ash	Slag	Synthetic gypsum
Wet basis	50,000 t	120,000 t	150,000 t	400,000 t	230,000 t
Moisture	9.6 %	7.5 %	0.2 %	5.4 %	4.5 %
Dry basis	45 200 t	111 000 t	149 700 t	378 400 t	219 650 t

Total conventional raw materials: 156,200 t
Total alternative raw materials: 747,750 t

Alternative raw materials rate:

$$\frac{71{,}439t + 747{,}750t}{2{,}199{,}845t + 71{,}439t + 156{,}200t + 747{,}750t} = 25.8\%$$

Key performance indicators

Reporting

The indicators and reporting periods are determined according to the accounting rules and consolidation criterion set in the most current version of the CO_2 Protocol and Guidelines, available on the CSI website.
www.wbcsdcement.org/climate.asp

Which installations are covered?

This protocol covers the use of AFRs of a company where the company has either:

- the majority of ownership (> 50%) or
- the management control.

In both cases the protocol requires the reporting company to include 100% of their operation performance (unlike the CSI CO2 emission protocol, which allows pro-rata reporting according to ownership share).

The WBCSD definition of control is used for this protocol, as follows:
"Control is defined as the ability of a company to direct the operating policies of another entity/facility. Usually, if the company owns more than 50 percent of the voting interests, this implies control. The holder of the operating license often exerts control. However, holding the operating license is not a sufficient criterion for being able to direct the operating policies of an entity/facility. In practice, the actual exercise of dominant influence itself is enough to satisfy the definition of control without requiring any formal power or ability through which it arises."

Reporting frequency and periods

The KPI values have to be reported on an annual basis by each company individually. Companies can make their own decisions about which kind of documentation will be used for the reporting (e.g. an environmental or sustainability report, web site, etc.).

Reporting can be based on financial years, rather than calendar years. This can help to reduce reporting costs and causes no problems provided that it is done consistently over time, with no gaps or overlaps. Any changes in the reporting year should be clearly indicated. National regulations should be taken into account.

Performance targets

As agreed in the CSI Agenda for Action, each CSI member company will establish, publish and report on their own individual target values for each KPI.

End notes

1 The Cement Sustainability Initiative: Our Agenda for Action' published by the CSI and WBCSD in July 2002 and available at *www.wbcsdcement.org*

2 These principles are based on careful review of stakeholder comments received during a 2-year research and consultation program and owe much to input from The Natural Step International (www.naturalstep.org). Other sources include: Stephan Schmidheiny et al. Changing Course, a Global Business Perspective on Development and the Environment (Cambridge, MA: MIT Press, 1992)
World Commission on Environment and Development. Our Common Future (Oxford, UK: Oxford University Press, 1987)

3 For more information on this see 'Eco-efficiency – creating more value with less impact' published by WBCSD in October 2002 and available at www.wbcsd.org
www.wbcsd.org/DocRoot/3jFPCAaFgl1bK2KBbvV5/eco_efficiency_creating_more_value.pdf.

4 Information taken from Substudy 8 of 'Toward a Sustainable Cement Industry', published by the Battelle Memorial Institute in 2000
www.wbcsdcement.org/publications.asp

5 For more information on this see 'The Cement CO_2 Protocol: CO_2 Emissions Monitoring and Reporting Protocol for the Cement Industry' , published by WBCSD in October 2001 and part of the WRI-WBCSD Greenhouse Gas Protocol Initiative www.ghgprotocol.org. Updated in 2005.
http://www.ghgprotocol.org/standard/Current_Tools/cement_WBCSD_guidancev1.6.doc

6 Electricity and transport together add about 10% more to the total energy used, and are not included in this figure.

7 Alternative Fuels and Raw Materials - A Technical and Environmental Review' Cembureau

8 Now used primarily in the Middle East as it is a readily available byproduct of the oil industry

9 'Concrete - Hard, Strong and Fair', VDZ

10 More details on this can be found in the report of the Emission Monitoring and Reporting Task Force of the CSI:
www.wbcsdcement.org/emissions.asp

11 The Formation and Release of POPs in the Cement Industry', a report prepared for the WBCSD and the Cement Sustainability Initiative by SINTEF, March 2004

12 The United Nations Environment Program (UNEP), acting as Secretariat for the Stockholm Convention, has recently developed BAT/BEP guidelines for cement kiln operation to minimize POPs formation. *www.unep.org*

13 Source: 'Agenda for Action' Cement Sustainability Initiative 2002 p20

14 % thermal substitution of alternative fuels for conventional fossil fuels

15 Source: Taiheiyo estimated the thermal substitution rate based on JCA data, "pet coke" is excluded.

16 Source : Portland Cement Association, USA

17 Source : Cement Industry Federation, Australia

18 More details on this can be found in the report of the Emission Monitoring and Reporting Task Force *www.wbcsdcement.org/emissions.asp*

19 Stakeholder Engagement – A Guide for Cement Site Managers' published by WBCSD. A copy can be obtained from the CSI website (www.wbcsdcement.org)

20 As an alternative, substitution ratios could be expressed in kg per tonne of clinker

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22 'The Cement CO_2 Protocol: CO_2 Emissions Monitoring and Reporting Protocol for the Cement Industry', published by WBCSD in October 2001. More information on the protocol can be found on the WRI-WBCSD Greenhouse Gas Protocol Initiative website at *www.ghgprotocol.org*

End notes

Glossary

Definitions from the Battelle report and substudies

- By-product: A secondary product of an industrial process,
- Blast furnace slag: A processed byproduct of iron production in blast furnaces that is usable as a pozzolan,
- CEMBUREAU: The European cement association, the representative organization of the cement industry in Europe, based in Brussels.
- Co-processing: Term used to refer to the practice of introducing alternative fuels and raw materials into cement production,
- Eco-efficiency: Reduction in the resource intensity of production; i.e. the input of materials, natural resources and energy compared with the output; essentially, “doing more with less”
- Fly ash: By-product with binding properties typically produced as a residue from coal fired power plants,
- Industrial ecology: Framework for improvement in the efficiency of industrial systems by imitating aspects of natural ecosystems, including the cyclical transformation of waste to input materials,
- Pozzolan: A mineral admixture that acts a supplement to standard Portland cement hydratation products to create additional binder in a concrete mix,
- Sustainable development: Ability to continually meet the needs of the present without compromising the ability of future generations to meet their own needs,
- Waste: Waste is is the material that is produced as an unwanted side effect of a production process, and which the waste generator wants to discard.

About the WBCSD

The World Business Council for Sustainable Development (WBCSD) is a coalition of 175 international companies united by a shared commitment to sustainable development via the three pillars of economic growth, ecological balance and social progress. Our members are drawn from more than 35 countries and 20 major industrial sectors. We also benefit from a global network of 50 national and regional business councils and partner organizations involving some 1,000 business leaders.

Our mission

To provide business leadership as a catalyst for change toward sustainable development, and to promote the role of eco-efficiency, innovation and corporate social responsibility.

Our aims

Our objectives and strategic directions, based on this dedication, include:

> **Business leadership:** to be the leading business advocate on issues connected with sustainable development

> **Policy development:** to participate in policy development in order to create a framework that allows business to contribute effectively to sustainable development

> **Best practice:** to demonstrate business progress in environmental and resource management and corporate social responsibility and to share leading-edge practices among our members

> **Global outreach:** to contribute to a sustainable future for developing nations and nations in transition

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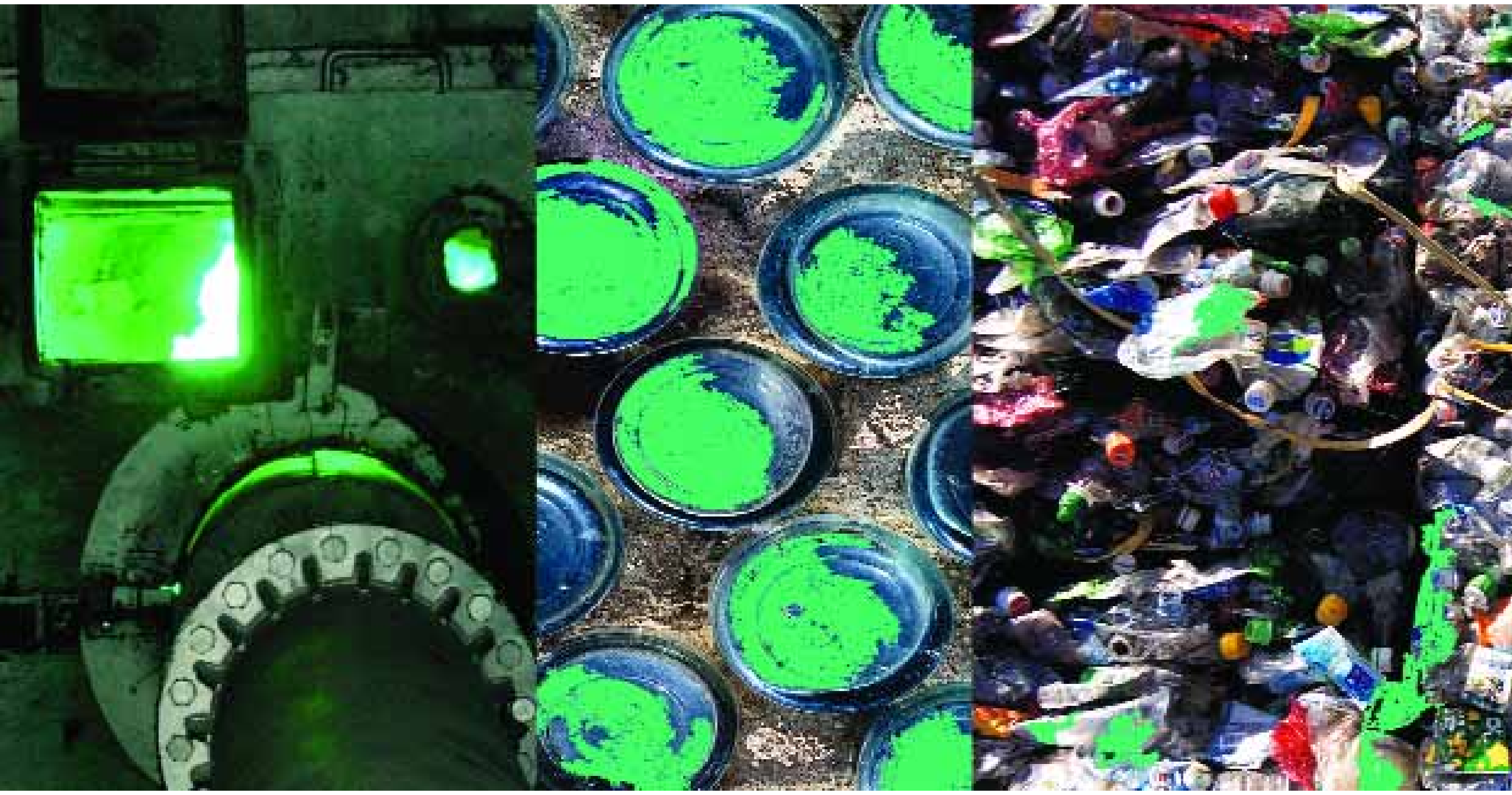
Layout: Estelle Geisinger (WBCSD)

ISBN: 2-940240-76-0



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