Energy Use in the Cement Industry in North America: Emissions, Waste Generation and Pollution Control, 1990-2001

Prepared by

Marisa Jacott, Fronteras Comunes

Cyrus Reed, Texas Center for Policy Studies

Amy Taylor and Mark Winfield, The Pembina Institute for Sustainable Development

For:

Commission for Environmental Cooperation

2nd North American Symposium on Assessing the Environmental Effects of Trade

May 30, 2003

Table of Contents

ACKNOWLEDGEMENTS.

The authors would like to thank several individuals who assisted in the production of this report. Scott McClain of Austin, Texas provided the initial research on the U.S. cement industry for the report, including production data, investment information and environmental regulations, while TCPS intern Greta MacDonald helped with graphics and calculations. Special thanks also to Hendrik G. van Oss, cement commodity specialist at the United States Geological Survey for providing insight and access to government data on the cement industry, particularly in regards to energy use, efficiency and carbon dioxide emissions. In addition, in Mexico, CANACEM, the National Cement Chamber, was particularly helpful in providing information about the use of alternative fuels and data on energy efficiency in the cement industry there. In addition, the authors would like to recognize the hard work of the staff at the North American Comission on Environmental Cooperation, both for their financial assistance as well as their comments and insights. Finally, several independent reviewers provided insights that proved helpful to the final version of this study.

EXECUTIVE SUMMARY

This paper examines issues related to the use of energy inputs in the manufacture of cement clinker and cement in Mexico, Canada and the U.S since 1990 and particularly since implementation of the North American Free Trade Agreement (NAFTA) in 1994. Cement manufacturing is a key – and growing -- industry in all three countries, and a major user of energy. In recent years, trade and investment between the three NAFTA countries has increased in this important sector of the economy. As part of this increased production, trade and investment, cement producers make decisions about the type of energy used to fuel the kilns where the cement clinker is produced.

Cement manufacturing requires very large amounts of energy and cement manufacturers have used a variety of energy inputs. Among the most common types of fuels are fuel oils, coal, petroleum coke and natural gas. In addition, in all three countries, certain hazardous – such as used lubricants and contaminated soils -- and non-hazardous wastes – such as scrap tires -- can be burned as fuel in the rotary kilns. These decisions in turn have environmental consequences in terms of the emissions of toxics and other atmospheric contaminants, global greenhouse gases and the generation of large quantities of cement kiln dust (CKD) waste. *It is important to note that this report focuses narrowly on the production of clinker in cement kiln and upon fuel use and does not address the mining of the inputs used in the cement manufacturing process, nor the transportation and use of cement products*.

Key research questions for this paper include the following:

- How has energy use –including fuel type -- in the cement manufacturing industry changed over the last ten years, and what have been the the environmental impacts of that change?
- How has the regulatory structure governing the sector changed, specifically with respect to energy efficiency and the prevention and control of pollutant releases and transfers?
- What has been the impact of trade liberalization on these trends? Specifically:
    - Are companies investing in cement manufacturing in any country to take advantage of less stringent environmental regulations and enforcement; or
    - Has foreign investment led to improvements in energy efficiency and pollution prevention, including through the use of new technologies and pollution control equipment.

The report finds that the cement industry is a continental industry in North America, although the trends in the sector tend to be driven by US demand. Over the past decade, US demand has exceeded domestic supply by a wide margin. In this context, Canada has emerged as a major source of supply to the US, with major increases in production and particularly exports since the early 1990s. Mexico exports to the U.S. have also outpaced a nearly stagnant growth in production for its domestic market, although anti-dumping tariffs stemming from 1989 have prevented Mexican-based

companies from gaining a major market share of the U.S. market. Within the last few years, two Mexican cement companies have been building plants in US to gain access to the market and have become major producers of cement in the US. These investment decisions have not been driven by less stringent environmental regulations, but simply by the economics of tariffs and transportation costs versus investment as a way to enter the U.S. market. Still, the lack of environmental regulations for the cement industry has until now allowed cement manufacturers significant freedom in their choice of fuels and pollution control equipment.

Table A. Production and Exports of Cement in NAFTA countries, 1990 – 2001 in Thousand Metric Tons

Year	U.S. Production	U.S. Exports to NAFTA Countries	Mexican Production	Mexican Exports to NAFTA Countries	Canadian Production	Canadian Exports to NAFTA Countries
1990	69,954	450	23,824	363	11,083	2,916
1991	67,193	504	25,093	47	9,446	2,669
1992	69,585	555	26,886	824	8,612	2,353
1993	73,807	523	27,506	783	9,284	3,096
1994	77,948	572	30,029	640	10,457	3,803
1995	76,906	599	23,971	850	10,600	3,831
1996	79,266	641	25,365	1,272	11,003	4,339
1997	85,582	650	27,548	995	11,790	4,413
1998	83,931	619	27,744	1,280	12,168	4,693
1999	85,952	577	29,413	1,286	12,643	4,037
2000	87,846	632	31,677	1,409	12,753	4,583
2001	88,900	657	29,966	1,645	12,793	4,748
1993-2001 % Change	**20.45%**	**25.62%**	**8.94%**	**110.09%**	**37.80%**	**53.36%**

Energy use – and in particular fuel use – is a major price factor in the production of cement. Because of this, companies in all three countries have invested in energy efficiency measures, such as converting wet kilns to dry kilns, or to adding precalciners and predryers to their cement production process, a more efficient process in terms of fuel use. Despite these investments, electric and total energy consumption per unit of output appears to have risen slightly in the US over the past decade. In contrast, the Canadian and Mexican cement industries appear to be more efficient and in general energy efficiency has increased (i.e. energy use per unit of output decreased) over the last decade. In Canada, a number of newer plants have come on-line since the early 1990s in part in response to the increased US demand. The Mexican plants tend to be newer, “dry” process facilities and most have preheaters and/or precalcinators as well. Still, efficiency gains in the early 1990s have not continued at the same pace, and in fact, in recent years there has been a slight decline in energy efficiency, in part because of the shift toward petroleum coke.

Table B. Total Energy Intensity in Cement Manufacturing Process, NAFTA Countries, 1990 –2001

Year	U.S. Energy Consumption (TJs) (1)	Estimated Energy Efficiency (TJs per Thousnd Metric Tonne)	Mexican Energy Consumption (TJs) (2)	Mexican Estimated Energy Efficiency (TJs per Thousand Metric Tonne)	Canadian Energy Consumption (TJs)	Canadian Estimated Energy Efficiency (TJs per Thousand Metric Tonne)
1990	303,647	5.06	100,532	4.22	58,909	5.32
1991	326,564	5.65	104,872	4.18	50,985	5.40
1992	310,868	5.10	112,643	4.19	51,485	5.99
1993	353,715	5.26	110,856	4.03	53,215	5.73
1994	362,259	5.30	107,554	3.58	53,311	5.29
1995	388,889	5.69	91,593	3.82	61,005	5.76
1996	387,138	5.39	98,452	3.88	58,997	5.27
1997	391,115	5.24	96,609	3.51	57,746	4.90
1998	408,526	5.34	105,235	3.79	63,752	5.24
1999	436,768	5.63	96,890	3.29	67,013	5.30
2000	440,348	5.54	118,284	3.73	64,043	5.02
2001	426,301	5.36	116,164	3.88	NA	NA
1990-2001 % Change (3)	**40.39%**	**5.93%**	**15.55%**	**-8.06%**	**8.72%**	**-5.64%**
1993-2001 % Change (3)	**20.52%**	**1.90%**	**4.79%**	**-3.72**	**20.35%**	**-12.39%**

Notes:

1) U.S. 1990-1992 totals do not include alternative fuels and are therefore likely slightly undercounted.

2) Similarly, to account for use of alternative fuels in total for Mexico, between one and two percent were added to Mexican totals between 1994 and 2001, based upon data provided by the Mexican Cement Association. While some alternative fuels were in use in Mexico since 1991, the amounts were less than one percent of total energy consumption.

3) Canadian data only through the year 2000.

In all three countries, the use of fuels has changed significantly over the last five to ten years. In the U.S., there has been a general shift toward coal, petroleum coke and alternative wastes such as liquid and solid hazardous wastes, and a lessening dependence upon natural gas to fuel the cement making process. As in the U.S., kilns in Mexico have been shifting their use of fuels, in this case from an almost universal reliance on fuel oils to fuel oils, petroleum coke and alternative fuels. Interestingly, this new reliance on hazardous wastes has continued at the same time as Mexico has become a signatory to the Stockholm Convention, calling for the control and phase-out of the production of dioxins and furans. In Canada, there has been less of shift in terms of the type of fuel used, although there has been a decrease in the use of natural gas and an increase in the use of coal. This shift may reflect the changing price of natural gas rather than a major change in fuel use.

The volume of ‘alternative’ fuels (tires, solid hazardous waste and liquid hazardous and non-hazardous wastes) used by the cement sector is increasing in all three countries, although it still makes up a relatively small percentage of total waste. In the US and Mexico the industry has emerged as a major manager of hazardous wastes. This has not, however, been the case in Canada where emphasis has been on the use of tires and non-hazardous wastes, including wood waste, as alternative fuels. Cement facilities burning hazardous wastes as fuels in Canada continue to be approved and regulated as hazardous waste disposal facilities despite opposition from the industry.

Table C. Percentage of Total Fuel Use by Type in NAFTA Countries and total Energy Consumption in Terajoules, 1994 - 2000

Fuel Type	1994 U.S.	2000 U.S.	1994 Mexico	2000 Mexico	1994 Canada	2000 Canada
Coal	84.88%	67.24%	0.00%	0.00%	46.94%	53.21%
Coke from Coal	Not Reported	2.86%	0.00%	0.00%	0.55%	1.61%
Petroleum Coke	Not Reported	10.78%	0.00%	22.33%	14.64%	14.56%
Fuel Oils	0.55%	1.15%	87.27%	67.55%	3.50%	3.91%
Natural Gas	6.91%	2.96%	11.19%	7.63%	25.34%	21.00%
Tires	1.07%	2.74%	0.27%	0.72%	Not Reported	Not Reported
Other Solid Waste	0.39%	4.38%	0.06%	0.20%	Not Reported	Not Reported
Liquid Waste	6.20%	7.90%	1.20%	1.56%	Not Reported	Not Reported
Total Alternative Fuels	7.66%	15.02%	1.54%	2.48%	9.02%	5.70%
Total TJs	362,258	440,348	93,991	104,380	49,010	56,737

Note: Does not include electricity.

Air emissions are determined both by the type of fuel burned as well as the types of pollution control equipment used by cement manufacturers. In all three countries, data on emissions is somewhat limited and is often based upon emission factors rather than direct measurement. Cement manufacturing – by its very nature – leads to carbon dioxide (greenhouse gas) emissions, both because carbon dioxide is released in the process of turning limestone into clinker, as well as in the combustion of fuels. In the U.S., continued reliance on coal, as well as the sustained use of petroleum coke, as well as of tires, has probably resulted in increased emissions of greenhouse gas emissions, both as a total and on a per tonne basis. Toxic pollution, including dioxins and furans and heavy metals – mainly as a result of the increased use of hazardous wastes as fuels – appears to have also increased since 1993.

Canadian data suggests that there has been a slight decrease in per tonne emissions of carbon dioxide, although preliminary toxic data suggests an increase in toxics. Unfortunately, data on emissions in Mexico is either not available or inaccessible. Nonetheless, emission factors widely used would suggest that the shift from fuel oils to petroleum coke has probably increased greenhouse gas emissions in the sector over the period. Very limited data from Mexico suggests that the small use of hazardous wastes as fuels in the sector has not led to major releases of dioxins and furans or other toxics, but it is important to note that only very limited company testing has been done thus far to measure such emissions.

Table D. Carbon Dioxide Emissions due to Fuel Consumption, U.S. and Canadian Cement Industry

Year	Thousand Metric Tons of Carbon Dioxide Emissions due to Fuel Combustion, U.S.	Tons per ton of cement, U.S.	Thousand Metric Tons of Carbon Dioxide Emissions due to Fuel Use, Canada	Tons per ton of cement, Canada
1990	26,599	0.38	3,721	0.34
1991	28,054	0.42	3,191	0.34
1992	26,109	0.38	3,294	0.38
1993	30,007	0.41	3,453	0.37
1994	30,906	0.40	3,604	0.34
1995	32,814	0.43	3,981	0.38
1996	33,717	0.43	3,822	0.35
1997	33,560	0.39	3,720	0.32
1998	34,662	0.41	4,131	0.34
1999	38,263	0.45	4,429	0.35
2000	39,133	0.45	4,195	0.33
2001	37,348	0.42	NA	NA
1993-2000% Change	**30.4%**	**2.4%**	**21.5%**	**(10.8%)**

Notes: This table only shows carbon dioxide emissions resulting from fuel combustion. Both the U.S. and Canada use a factor of approximately 0.51 tons of carbon dioxide emissions per ton of cement produced to account for carbon dioxide “process” emissions.

The multipliers used to determine greenhouse gas emissions from fuel combustion vary slightly in Canada and the U.S.

The US and Mexico have recently adopted new, more comprehensive emission standards for cement kilns after years of relatively lax regulation and enforcement. The US applies more comprehensive standards to kilns burning hazardous wastes, while the Mexican standards apply to all kilns regardless of fuel type. Nonetheless, these rules are still being implemented and have yet to be enforced. Still, these regulations are leading to more investment in pollution control equipment, including baghouses, scrubbers and electrostatic precipitators. It is important to note that the standards are significantly less stringent than similar standards for incinerators of hazardous waste. There is also concern that the limited amount of monitoring required, particularly in Mexico, will not gaurantee compliance with the new standards.

In contrast, Canada has no enforceable national emission standards for the sector. National emission guidelines, adopted by the federal government in 1991 only deal with NOx emissions and are not legally enforceable. The CCME adopted guidelines for cement kilns using wastes as fuels in 1996, but again these standards are not legally enforceable. More recent CCME standards for emissions of dioxins and furans and mercury from incinerators have not been applied to cement facilities.

In all three countries, there are currently no standards for greenhouse gas emissions, although ratification of the Kyoto Agreement in Canada and Mexico could eventually lead to some standards or goals for the cement industry. In the U.S., action is more likely through voluntary measures taken by cement companies, led by international companies like Lafarge and CEMEX. The lack of a requirement to report greenhouse gas emissions is also problematic, although again major cement companies have pledged to institute a common framework for reporting such emissions.

The report also found that Cement Kiln Dust is the major waste stream produced by the cement manufacturing process. Nevertheless, a lack of data makes it difficult to determine what the trend is in terms of generation and management of this waste stream. Limited data from the U.S. suggests that hazardous waste burning increases the amount and toxicity of this waste, although overall the amount of CKD waste generated has declined as cement kilns put CKD back into the production process. In all three countries, regulations regarding cement kiln dust have gaps. While the U.S. began the process of regulating management of CKD, it appears it will delay final implementation until further study of current management practices, despite major, well-documented environmental problems. Standards in Mexico and Canada are similarly ill-defined or non-existent.

It does not appear that companies are investing in cement manufacturing in any country to take advantage of less stringent environmental regulations and enforcement but rather to gain access to the market. Whether or not new pollution control rules in the U.S. will cause a shift in investment strategy among the three countries is unclear, although the major factors in decisions about fuel use will probably continue to be price and availability, not energy efficiency or environmental cleanliness. It is also unclear whether the burning of hazardous wastes could lead to major shipments of hazardous wastes across international lines for cement kiln incineration, as some have proposed.

This report was not able to determine with precision whether the recent investment by Mexican companies in the U.S. or the consolidation of the industry has led to important technology transfer gains in terms of energy efficiency or pollution control, although initial evidence suggests that plants purchased by the Mexican companies have been upgraded in terms of pollution control and energy efficiency. Further study – including direct surveys and examination of company documents -- could help determine with precision whether the consolidation of the cement industry in North America and particularly within the U.S. has led to any such improvements.

The report recommends, however, that given the international nature of the cement industry, that some common guidelines and/or regulations be adopted in all three countries. Recommendations include:

- Cement kilns burning hazardous wastes should be regulated as hazardous waste disposal facilities

- Canada needs to adopt updated enforceable emission standards for kilns burning both conventional fuels and hazardous wastes, as have the US and Mexico.

- Energy efficiency standards and greenhouse emission standards for the cement sector should be adopted in all three countries;

- A continued dialogue about the burning **of alternative wastes in cement** kilns with a specific focus on dioxin and furan monitoring and emissions and the control of CKD, with the CEC having an important role in that process.

- The CEC should continue to strengthen its Sound Management of Chemicals program to emphasize a North American Management Strategy of hazardous wastes and reduction of dioxin and furan emissions.

1.0 Introduction

This paper examines issues related to the use of energy inputs in the manufacture of cement clinker and cement in Mexico, Canada and the U.S since 1990 and since implementation of the North American Free Trade Agreement (NAFTA) in 1994. Cement manufacturing is a key – and growing -- industry in all three countries, and a major user of energy. In recent years, trade and investment between the three NAFTA countries has increased in this important sector of the economy. As part of this increased production, trade and investment in cement manufacturing, decisions have been made about the type of energy used to fuel the kilns where the cement clinker is produced.

Cement manufacturing requires large amounts of energy and cement manufacturers have used a variety of energy inputs. Among the most common types of fuels are fuel oils, coal, petroleum coke and natural gas. In addition, in all three countries, certain hazardous – such as used lubricants and contaminated soils -- and non-hazardous wastes – such as scrap tires -- can be burned as fuel in the rotary. These decisions in turn have environmental consequences in terms of the emissions of toxics and other atmospheric contaminants, global greenhouse gases and the generation of large quantities of cement kiln dust (CKD) waste.

Following a discussion of the direct and indirect impacts of NAFTA on the cement industry, the report will focus on the cement manufacturing industry in each of the three countries, including production, imports, exports, energy (and fuel) use, electricity, emissions, generation of waste, and regulatory and technological issues. Conclusions and policy recommendations follow.

But first a few caveats. *This report does not examine the economics or environmental consequences of the initial mining of limestone, gypsum and other cement inputs, nor does it examine the economic or environmental consequences of other related products like concrete and cement batching plants nor the transport of these products throughout North America*. Instead, it focuses narrowly on what happens within the confines of the cement manufacturing process itself, and even more narrowly, within the rotary kilns which turn the raw materials into cement clinker. It is here, however, where key decisions are made about fuel choices, pollution control equipment and waste management – choices which by their very nature have local and potentially worldwide environmental consequences.

Key research questions for this paper include the following:

- How has energy use –including fuel type -- in the cement manufacturing industry changed over the last ten years, and what have been the the environmental impacts of that change?

- How has the regulatory structure governing the sector changed, specifically with respect to energy efficiency and the prevention and control of pollutant releases and transfers?
- What has been the impact of trade liberalization on these trends? Specifically:
    - Are companies investing in cement manufacturing in any country to take advantage of less stringent environmental regulations and enforcement; or
    - Has foreign investment led to improvements in energy efficiency and pollution prevention, including through the use of new technologies and pollution control equipment.

How is Cement Produced

Cement is produced through a five-step process:

A) It begins with the extraction of its prime materials, principally limestone (70%), but also other materials like clay, aluminum oxide, iron, shale and silica. B) The materials are ground and stored separately. C) The material is measured to achieve a specific combination, depending upon the type of cement desired, and ground to produce a very fine powder. D) The powder is pumped to silos, where the blend is standardized before being placed in long, rotating kilns, where the material is calcinated at high temperatures (approximately 1,500 degrees centigrade), causing chemical and physical reactions. A new material is formed, which is called pre-cement or more commonly clinker, which are composed of small balls about the size of a nut. E) Finally, the clinker is ground up, combined with calcium sulfate – usually gypsum -- and other materials and packaged. When this product -- cement -- is mixed with sand, stone, other materials and water, concrete is produced.

The calcination process, turning the limestone into clinker in the kiln, is the fundamental step described above. This process requires a substantial amount of energy, provided by the burning of fuels, which are injected at the opposite end of the kiln, and it represents the major economic cost in cement production.

2.0 NAFTA and Cement: A Connection?

2.1 Introduction

This section briefly reviews the connection between NAFTA and the North American cement industry. The North American Free Trade Agreement is a treaty designed to open trade and investment – though not completely -- between Mexico, the United States and Canada. Although it called for the immediate elimination of tariffs on some products, NAFTA has served as a system to gradually reduce tariffs over time – usually 10 to 15 years – while providing investment protection and mechanisms to resolve trade and investment disputes. In terms of cement and clinker production, NAFTA has eliminated tariffs nearly completely on most cement and clinker, while also providing increased protection to foreign investors.

Nevertheless, because of an ongoing dispute between the U.S. and Mexico over prices of cement produced in Mexico, since 1989 the U.S. Commerce Department has continued to assess “anti-dumping” tariffs on Mexican portland cement and clinker through an annual assessment – first through pre-NAFTA mechanisms and currently through Chapter 19 of NAFTA. Moreover, as cement producers have increasingly turned to hazardous waste as a fuel source, certain provisions of NAFTA potentially impact this practice. Finally, the creation of the North American Commission on Environmental Cooperation has served to focus international attention upon certain chemicals which can be produced by the cement industry, including emissions of dioxins and furans.

2.2 Disappearing Tariffs

Provisions within NAFTA have served to gradually reduce tariffs over time and to carefully regulate trade between the three countries. In many cases, the elimination of tariffs takes up to 15 years to complete.

Five years after NAFTA, 76.2% of Mexico's exports to the United States and 66.2% of Mexico's imports from the United States crossed the border without tariffs. Most of this trade involved the import of inputs for the maquiladora export sector and the export of its maquiladora-made products to the United States.

Cement products, on the other hand, were largely exempt from tariffs when NAFTA went into effect on January 1, 1994. Thus, under Annex 302.2, “Tariff Elimination”, with the exception of white cement, both the U.S and Canada had placed most cement products in the Duty-Free Category D (NAFTA, Annex 302.2) 1(e). White cement had a relatively small tariff of 22 cents per ton in the U.S. and 54.25 cents in Canada. Mexico did have a 10 percent duty on most cement products and placed cement in category B, such that all goods were made duty-free on January 1, 1998. Thus, at the signing of

NAFTA, most cement products already could be traded freely among the three countries with minimal tariffs, and even those were scheduled to be phased out by 1998 (NAFTA, Annex 302.2, Schedule of Canada, Schedule of Mexico, Schedule of U.S). Currently, for example, in theory, all countries – including Mexico and Canada -- enjoying “Normal Trade Relations” with the U.S. can export clinkers and finished cement duty-free and even exports from countries with non-NTR status can export cement clinker with only a duty of $1.32 per ton.[1]

Nonetheless, the reality is that since 1989 Mexico has not been able to enjoy these low or nonexistent duties because the U.S. has been applying anti-dumping tariffs against Mexican grey portland cement and clinker under the Tariff Act of 1930.

In 1989, motivated by growing imports from CEMEX, a group of southern U.S. producers –many of them actually owned by foreign companies – petitioned the U.S. government under the Tariff Act of 1930 to impose anti-dumping[2] tariffs against Mexican grey portland cement and clinker. In that year, the number of cement plants in the U.S. had been decreasing, as had sales and income.[3] For example, in 1989, the U.S. imported nearly 15 million metric tons of clinker and cement, and Mexico accounted for about a third of total imports, and about half of the total going to the Southern States -- $124 million in all -- came from CEMEX. While imports remained steady or declined in the late 1980s, Mexican exports increased by 22 percent between 1986 and 1989. Data used in the petition showed that Mexican cement was selling for significantly less than domestically-produced cement even though in most cases they had to transport the cement several hundred miles. Transportation of cement and clinker is extremely expensive, averaging at that time $9.86 per ton within 100 miles, but almost three times that amount for cement shipped more than 500 miles. Despite these high transportation costs, a review of prices over 24 months in the case revealed that Mexican cement undersold the domestic product in all 24 months between 7.2 to 18 percent. In 1990, the Department of Commerce found that the Mexican cement was being sold at dumping margins ranging from 3.69 to 57.96 percent and U.S. Customs began imposing an anti-dumping deposit of 43 percent. In 1990, the Department of Commerce found that the Mexican cement was being sold at dumping margins ranging from 3.69 to 57.96 percent and U.S. Customs began imposing an anti-dumping deposit of 43 percent.

In response, Mexico brought the issue to the GATT Committee on Antidumping Practices and 1992 the Committee determined that the duties were inconsistent with GATT Articles 1 -- guaranteeing most favored nation status -- and 5:1 -- because the U.S. had not established prior to the initiation that the petition was on behalf of all or most of the producers in the region. Rather than going through a lengthy process to revoke the standard, the U.S and Mexico agreed to try and resolve the dispute (see

---

[1] U.S. International Trade Commission, 2003 Tariff Database, HTS Number 25231000.

[2] “Dumping” occurs when:
A company exports its goods at a price below the sales price in its own country;
A company exports its goods at a price lower than the cost of production.

[3] Much of the information for this section is from Robert Cook “Cement Exports from Mexico,” TED (Trade and Environment) Case Studies: An Online Journal, American University, (Vol. 3, No. 2, June 1994), available at www.american.edu/TED/CEMEX.HTM.

next section). In the meantime, under U.S. law, each year an administrative review of the antidumping duty order must be conducted. During the third such review, the Department of Commerce found that CEMEX was continuing to dump into the U.S. and increased the antidumping duty deposit from 43 to 62 percent. The latest – the tenth administrative review – resulted in an anti-dumping duty of 48.53% (GCC, Annual Report 2001).

2.3 Investor Protections and Disputes

Although NAFTA serves principally to facilitate commercial exchange between the three countries, it also promotes foreign direct investment in the region. According to four of the Agreement's objectives, NAFTA seeks to:

- *Promote conditions of fair competition in the free trade area;*
- *Increase substantially investment opportunities in the territories of the Parties;*
- *Provide adequate and effective protection and enforcement of intellectual property rights in each Party's territory: and*
- *Create effective procedures for the implementation and application of this Agreement, for joint administration and for the resolution of disputes.*

These provisions offer much more explicit protection of foreign investment, including Chapter 11 of NAFTA, a dispute resolution mechanism which has been controversial. The provision allows foreign companies to seek compensation if a government either expropriates its investments or takes actions that could be tantamount to expropriation. Thus far, no cases have directly involved either cement manufacturing, mining or disposition of cement kiln wastes.

NAFTA's Chapter 19 specifically deals with disputes over anti-dumping tariffs or export subsidies (so called Antidumping and Countervailing Duty (AD/CVD) disputes). The litigants are typically both the importer or exporter concerned with anti-dumping duties as well as their governmental authorities. The provision allows for a binational panel of experts to review any domestic law or provision leading to such duties, and the panel must make a decision within 315 days. Once a decision is reached, Chapter 19 allows a party to initiate an "extraordinary challenge" alleging gross misconduct by the panel.

Mexico began seeking settlement through NAFTA on the anti-dumping duties on cement as far back as 1994. The case took several years to make its way through the NAFTA Chapter 19 process as rules were still being implemented at the federal level. Finally, on June 18,1999, a binational panel ruled against certain aspects of the antidumping determination by the U.S. Department of Commerce. In response, the U.S. requested an Extraordinary Challenge Committee (ECC) in 2000, a move also supported by the Southern Tier Cement Committee (STCC), an ad-hoc groups of 27 cement producers, after continued inaction.[4] However, the case is currently stalled. Thus, while NAFTA has served to provide a mechanism to review the tariffs, due to inaction from both parties, and continued legal challenges, the dispute is still ongoing and has not been resolved to the satisfaction of either party. In the meantime, the U.S. continues to require duty deposits on Mexican cement and clinker, both from CEMEX and other companies. These duties effectively limit the imports of Mexican cement into the U.S., while at the same time NAFTA has encouraged capital investment flows into the U.S..

2.4 Hazardous Waste, Cement and NAFTA

Because cement manufacturers in all three countries have begun using alternative fuels – including solid and liquid hazardous wastes and tires – to provide fuel to their kilns, provisions in NAFTA regarding waste could potentially influence cement manufacturer decisions about fuel use. A key question for this section is whether a country could prohibit the export or import of wastes designed to be used for fuel in cement kilns.

First of all, NAFTA assumes the free flow of goods, including wastes. Chapter 3 of the NAFTA sets out requirements for the “national treatment” of goods. Article 309 specifically provides:

> “1.Except as otherwise provided in this agreement, no party may adopt or maintain any prohibition or restriction on the importation of any good of another Party -- except in accordance with Art. XI of the GATT.”

Article 415 of the NAFTA defines good to include “waste and scrap derived from (I) production in the territory of one or more of the Parties.” Therefore hazardous wastes and tires are likely to be considered a good for the purposes of the Agreement, and the right of Parties to prohibit or restrict their import -- or for that matter their export -- may therefore be limited.

Article XI of the GATT does, however, permit countries to impose restrictions or bans on imports of goods, via article XX, where such measures are “necessary to protect human, animal or plant life or health.” The term “necessary” has been interpreted to mean that the country maintaining the ban must show: (1) there is no reasonable available alternative measure consistent with the GATT to achieve the desired end and (2) the measure taken is the least trade restrictive measure available. Thus, by incorporating Article XI, NAFTA allows countries to ban or restrict exports and imports of hazardous wastes only to the extent that they can show there is no alternative and that it is the least restrictive trade measure.

---

[4] Cement America, ‘U.S. Cement Producers allege Government Inaction Violates Constitutional Rights,” Mar 1, 2002.

NAFTA declares that major multilateral conventions on hazardous waste disposal, as well as bilateral agreement on hazardous waste shipments and disposal take precedence over NAFTA itself. Specifically, Article 104 provides that:

> In the event of any inconsistency between this agreement (NAFTA) and the specific trade obligations set out in:
>
> (c) the Basel Convention on the Transboundary Movement of Hazardous Wastes, on its entry into force for Canada, Mexico and the US, such obligations shall prevail to the extent of the inconsistency, provided that where a party has a choice among equally effective and reasonably available means of complying with such obligations, the Party choose the alternative that is least inconsistent with the other provisions of (NAFTA).
>
> (d) the agreements set out in Annex 104.1 (these are the 1986 *U.S. Canada Agreement on Transboundary Movement of Hazardous Waste* and the 1983 *U.S.-Mexico Agreement on Cooperation for the Protection and Improvement of the Environment in the Border Area* (the La Paz Agreement)

Article 4 of the Basel convention permits countries to ban or restrict imports of hazardous waste if they have reason to believe that the wastes will not be managed in an “environmentally sound manner.” While both Canada and Mexico have ratified the Basel convention, the U.S. has not, making the two binational agreements currently more relevant to NAFTA. Both of these agreements establish the mechanisms for imports and exports between the countries. Of particular importance is Annex III of the La Paz agreement, which states that as long as applicable hazardous waste regulations are met, either country must accept the return of hazardous waste generated by production from raw materials that were imported under a temporary import regime. In practice, this requirement, along with Mexican regulations adopted under federal law, has meant that most maquiladoras are required to send their hazardous wastes back to the U.S.

Mexico does import a significant amount of waste from the U.S. Under Mexican law, however, Mexico only allows the import of hazardous wastes from the United States *for “recycling”, which thus far has conisted mainly of recycling lead batteries and extracting metals from electric arc furnace dust.* Between 1995 and 1999, hazardous waste imports from U.S. companies grew from 160,000 to 255,000 tons[5].

Where have these imports been going? Apparently to recycling facilities. Since 1994, there has been a tremendous growth in hazardous waste facilities authorized in Mexico, particularly in terms of recycling facilities, which includes metal recycling, solvent recycling and “energy” recycling such as that practiced in cement kilns. According to the most recent data available, Mexican officials have not authorized imports for fuel blending or energy recovery. Nonetheless, because the use of wastes in cement kilns is sometimes defined as disposal and sometimes as “energy recycling” it is unclear whether wastes in the future could be imported for burning in cement kilns in Mexico. Some waste sent from Mexico to the U.S. does go to fuel blenders and ends up in cement kilns in the U.S.

---

[5] Ibid.

2.5 Environmental Side Agreement, the CEC and Cement

The North American Agreement for Environmental Cooperation (NAAEC), sometimes referred to as the Environmental Side-Agreement to the NAFTA, came into effect at the same time as NAFTA. Articles 5,6,7, 10(4), 12 (2) collectively impose obligations on parties to effectively enforce laws; to pursue avenues of cooperation to this end; to effect specified private enforcement rights and opportunities; and to provide an annual public report on the enforcement of environmental laws. The Agreement also provided for the creation of the North American Commission for Environmental Cooperation (CEC).

Articles 14 and 15 of the NAAEC establish a mechanism through which any resident of a NAFTA country may file a submission that assert that a NAFTA country "is failing to effectively enforce its environmental law." To date, no cases involving cement manufacturing or burning of waste in cement kilns have been brought by citizens through this process.

In 1995, the CEC initiated a program through its Pollutants and Health Program known as the Sound Management of Chemicals (SMOC) Project. Through this project, the three governments have committed to assessing and then taking steps to reduce the production of and exposure to organic pollutants such as dioxins and furans, PCBs and mercury. This is accomplished through North American Regional Action Plans, or NARAPs.. In 1999, the Council authorized development of a NARAP for dioxins and furans. In the decision document leading up to the decision, part of the rationale for choosing both dioxins and furans are both their persistence in the environment, and how easily they can be transported thousands of miles, and thus a regional approach is needed. The decision document made the recommendation to identify technological changes that can be made in industrial sectors to reduce dioxins and furans, as well as to identify control strategies and develop measures -- potentially including regulations as well as voluntary measures -- that could lead to reductions (North American Working Group for Sound Management of Chemicals 1999: 8). Because cement kilns can be major emission sources of such chemicals, in theory the CEC focus on these substances could eventually lead to new regulations or voluntary measures for the cement industry. Nevertheless, thus far a NARAP for dioxins and furans has not been developed.

In addition to a NARAP for dioxins and furans, in 1999 the CEC Council passed a resolution to develop a NARAP on Environmental Monitoring and Assessment, which was completed in June of 2002. If successfully implemented, the NARAP on Environmental Monitoring and Assessment will lead to improved identification of risks from chemicals like dioxins and furans and the development of a more extensive monitoring network for environmental contaminants (CEC 2002).

3.0 The U.S. Cement Industry

3.1. Introduction

This section provides an overview of trends in production, exports, energy sources and usage and pollutant releases by the cement industry located in the U.S., the use of waste fuels and management of cement kiln dust as well as providing an overview of the regulatory regime in U.S. regarding emissions and waste management.

3.2 An Overview of Trends in Production, Exports, Energy Sources and Pollutant Releases.

3.2.1 Cement and Clinker Production and Consumption, 1990 - 2001

Tables 1 and 2 provide information on cement production, imports, exports and consumption over the last decade. Currently, the U.S. produces more cement than any country except for China and India. Production of cement and its main intermediate product – cement clinker – has risen steadily over the last decade through two minor recessions, indicating that the sector is less cyclical in nature than other manufacturing sectors. Consumption increased even more than production (40% vs. 27%), as the U.S. imported more cement to meet growing internal demand. Imports seem to have steadied in recent years, making up approximately 20 percent of apparent consumption. A significant amount of clinker and finished cement comes from Mexico and Canada. For example, between 1993 and 2001, the quantity of imports from Mexico increased more than 110 percent, while imports from Canada increased by some 40 percent. While the percentage increase was higher from Mexico, the actual amount of cement imported was significantly greater from Canada. In fact, currently the U.S. imports more cement and clinker from Canada than from any other country, although countries like Thailand and Korea are close behind. As the previous section noted, if not for anti-dumping tariffs placed on cement products from Mexico, it could be argued that Mexican cement would have replaced some of the Asian producers, particularly in Southern California. For example, in 1989, when significant import anti-dumping tariffs were imposed, there were more than 4 million metric tons of cement and cement clinker imported from Mexico. As Table 1 shows by the following year, imports had been reduced to a trickle. Despite the high transport cost, the U.S. also imported significant amounts of cement from other non-NAFTA countries, mainly from Asia, including cement from countries like Thailand, Korea and China.

Not surprisingly, the cement imported from Canada flows to the Seattle, Detroit, Buffalo and Cleveland areas, a fact that was true in both 1993 and 2001, while cement from Mexico is imported through Nogales, Arizona, El Paso and Laredo, Texas. Interestingly, in the early 1990s, Los Angeles was a key importing area, while today there are virtually no imports of Mexican cement to California, which is dominated by imports from Asia. The rise in imports particularly in El Paso and Arizona is probably due to the emergence of a network of Mexican-owned cement importers, concrete batch plants and cement manufacturers in the U.S. Southwest (see following sections).

Table 1. Cement and Clinker Production, Imports, and Exports in the U.S., 1990-2001 (thousand metric tons)

Category	Production, Portland and Masonry Cement	Production, Clinker	Imports of Cement, Total	Imports of Clinker, Total	Imports of Cement and Clinker from Mexico	Imports of Cement and Clinker from Canada	Exports of Cement and Clinker	Exports of Cement and Clinker to Mexico	Exports of Cement and Clinker to Canada
1990	69,954	64,356	12,041	NA	363	648	503	28	422
1991	67,193	62,918	7,893	NA	47	668	633	22	482
1992	69,585	64,294	4,582	1,532	824	2,998	746	19	536
1993	73,807	66,597	5,532	1,507	783	3,629	625	21	502
1994	77,948	68,525	9,074	2,206	640	4,268	633	62	510
1995	76,906	69,983	10,969	2,789	850	4,886	759	17	582
1996	79,266	70,361	11,565	2,401	1,272	5,351	803	30	611
1997	85,582	72,686	14,523	2,867	995	5,350	791	45	605
1998	83,931	74,523	19,878	3,905	1,280	5,957	743	54	565
1999	85,952	76,003	24,578	4,164	1,286	5,511	694	44	533
2000	87,846	78,138	24,561	3,673	1,409	4,948	738	51	581
2001	88,900	78,451	23,700	2,100	1,645	5,110	746	43	614
1990-2001% Change	27.08%	21.90%	96.83%	NA	353.17%	688.58%	48.31%	53.57%	45.50%
1993-2001 % Change	20.45%	**17.80%**	**328.42%**	**39.35%**	**110.09%**	**40.81%**	**19.36%**	**104.37%**	**22.31%**

Source: U.S. Bureau of Mines Mineral Yearbook, 1990; United States Geological Survey, Minerals Yearbook, Annual, 1991 – 2001, Tables 1, 18 and 21

Table 2. Total Consumption in Thousand Metric Tons and Net Import Reliance of Cement, U.S., 1990 –2001

YEAR	Cement Consumption (Production + Imports - Exports)	Net import reliance (% of apparent consumption)
1990	81,305	14.81%
1993	79,198	6.99%
1994	86,476	10.49%
1995	85,931	12.76%
1996	90,426	12.79%
1997	96,018	15.13%
1998	103,457	19.21%
1999	108,862	22.58%
2000	110,472	22.23%
2001	114,000	20.79%
1990-2001% Change	40.21%	40.38%
1993-2001 % Change	**43.94%**	**197.63%**

Source: U.S. Bureau of Mines Mineral Yearbook, 1990; United States Geological Survey, Minerals Yearbook, Annual, 1991 – 2001, Tables 1, 18 and 21.

3.2.2 Cement Location, Ownership Structure and Investment

Cement production in the U.S. is concentrated in Texas, California, Pennsylvania, Michigan and Missouri near large limestone deposits. While there are currently 115 different plants in the U.S. making portland cement, many of them small in size, about 75 percent of production and production capacity are owned by only 10 large companies: Lafarge North America, Inc., Holcim (U.S.) Inc; CEMEX, SA de CV, Lehigh Cement Co, Ash Grove Cement Co., Essroc Cement Corp., Lone Star Industries Inc, RC Cement Co, Texas Industries Inc (TXI) and California Portland Cement Company. Over the last decade, the cement industry has undergone significant consolidation. All but two – TXI and Ash Grove – are foreign-owned and one – Cemex USA – is a subsidiary of the Mexican company, CEMEX, S.A, currently the world's third largest cement company. Cemex has made a number of purchases in recent years, including purchasing U.S.–owned Southdown in 2000, and is today among the top three U.S. producers.[6] Another Mexican company, Grupo Cementos de Chihuahua, SA de CV has also entered the U.S. market, purchasing a number of new plants, including Rio Grande Portland Cement in Tijeras, NM and GCC Dacotah in South Dakota and is also finalizing plans for a plant in Colorado (see Table 3). In fact, given high tariff levels imposed under both the 1930 U.S. Tariff Act and the as-yet unresolved tariff dispute in Chapter 19 of NAFTA, Mexican companies began to invest in the U.S. market directly in the 1990s, rather than export substantial amounts of their product for U.S. consumption as they had previous to the enactment of high tariff duties. Still, in 2001, Grupo Cementos de Chihuahua did export about 500,000 metric tons of cement from their Samalayuca plant in Chihuahua to supplement their new production within the U.S. (Grupo Cementos de Chihuahua 2001).

Both CEMEX and GCC have made substantial improvements and investments in these plants. While additional research would be needed to determine the scope of these

---

[6] See CEMEX, Annual Report 2000, page 28.

improvements, examples include improvements in energy efficiency in the South Dakota and New Mexico plants. In Texas, after ending the practice of burning tires at its New Braunfels plant, CEMEX has invested millions of dollars to better control cement kiln dust and particulate matter. In 2002, they succesfully applied with the environmental state agency for a new permit, which depending upon test results, will allow the plant to burn between 50 and 100 percent petroleum coke.[7] The move reflects CEMEX's desire both in the U.S. and Mexico to move toward petroleum coke has their main fuel input. Nonetheless, in the process, some air emissions – such as sulfur dioxide – as well as greenhouse gases – are likely to increase.

Table 3. Mexican Cement Companies Investments in U.S.

Company	Number of Cement Plants	Production Capacity (million metric tons per year)	Locations
CEMEX	12 (1)	13.2	Texas (2), California, Colorado, Michigan, Alabama, Florida, Georgia, Tennessee, Kentucky, Ohio, Pennsylvania
Grupo Cementos de Chihuahua	2 (2)	1.4	South Dakota, New Mexico
Total	15	15.6	

(1) CEMEX also has minority participation in 4 other cement plants.
(2) GCC has been seeking to build a new coal-fired dry-kiln cement plant in Pueblo Colorado with a production capacity of approximately 1 million metric tons since 1998. The on-site mining reclamation permit is currently being challenged, however, by local citizen groups and residents concerned in part about the increase in smog-forming pollutants from the increased burning of coal.

Sources: CEMEX, 2001 Annual Report; GCC, 2001 Annual Report and The Pueblo Chieftan, "Building May Start This Year on Cement Plant," February 17, 2003.

3.2.3. Cement Industry Clinker Process and Electricity Use

Electricity is used throughout the cement making process. For example, electricity is consumed to crush and grind the raw materials in the finishing mills, to operate fans and blowers in preheating or precalcinating facilities and to cool the clinker. A small amount of electricity can also be used to rotate the kiln itself. In addition to electricity, however, the core function of turning raw materials into clinker is accomplished through consumption of large amounts of fuel(see next section).

There are two main types of technology used to turn raw materials into clinker in rotary kilns in the U.S.: wet and dry kilns. Wet kilns are an older technology and use larger and longer kilns. Wet kilns involve blending the raw materials with an aqueous slurry, and then dry, dehydrate, calcinate and sinter the raw material. Dry kilns, on the other hand, are generally smaller, and are fed their raw materials as dried powder. In addition, the

---

[7] Information for this section is both from CEMEX USA, 2001 Annual Report, and files at the Texas Commission on Environmental Quality from Air Permit PSD-TX-74M1 and 6048.

most modern dry kilns are significantly smaller, having added both preheaters and precalcinaters and essentially only "sinter" the materials, in which the calcinated limestone reacts with other materials to form clinker materials. Dry and Wet kilns have different heating and cooling temperatures and thus different electric and fuel needs. In simple terms, wet kilns take less electricity to run since all the drying functions occur within the kiln itself, but do require significantly more fuel to burn.

In the U.S., there has been a gradual move from wet kilns to dry kilns. As recently as 1980, there were 85 wet kilns and 60 dry kilns. By 2000, there were 32 wet kilns and 77 dry kilns and 2 kilns operating both dry and wet kilns as old plants were either converted or replaced (see Table 4). Over the last 10 years, electricity use has remained fairly steady in these plants, increasing almost exactly as production has, or about 30 percent overall. In essence, gains in energy efficiency have been offset by the higher electrical needs of dry kilns and increased demands and production levels. Overall, electricity use per ton of clinker produced has remained steady (Table 5).

Table 4. Number of Active Plants by Clinker-Process Type in U.S. Cement Industry, 1990-2001

	1990	1993	1994	1995	1996	1997	1998	1999	2000	2001	Change,90-2001	Change, 93-2001
Total number of Active Plants	104	113	110	110	111	110	110	111	111	111	6.73%	-1.77%
Total Number of Plants, Dry Kiln	67	72	71	72	74	73	74	75	77	77	14.93%	6.94%
Total Number of Plants, Wet Kiln	43	37	36	35	35	35	34	34	28	32	-25.58%	-13.51%
Total Number of Plants, both	4	4	3	3	3	2	2	2	6	2	-50.00%	-50.00%

Source: U.S. Bureau of Mines Minerals Yearbook, 1990; United States Geological Survey, Minerals Yearbook, Annual, 1991 – 2001, Table 7.

Table 5. Average Consumption of Electricity at Cement Kilns, U.S. (kilowatt hours per ton of cement produced)

	1990	1993	1994	1995	1996	1997	1998	1999	2000	2001	90-001	93-2001
Average Consumption of Electricity at Wet Kiln Cement Plants	135	126	139	137	137	132	133	131	131	136	0.74%	7.94%
Average Consumption of Electricity at Dry Kiln Cement Plants	153	148	153	149	150	149	148	147	148	148	(3.27)%	0.00%
Average Consumption of Electricity at Average Cement Plant	147	142	150	145	146	145	144	143	144	146	(0.68)%	2.82%

Source: U.S. Bureau of Mines Mineral Yearbook, 1990; United States Geological Survey, Minerals Yearbook, Annual, 1991 – 2001, Table 8.

3.2.4 Fuel Use and Total Energy Consumption in the Cement Industry

While total electrical consumption per unit of production has remained steady over the last decade in all types of kilns, total energy consumption – including fuels in the clinker process – has varied considerably. The change has resulted both from the switch from wet kilns to dry kilns in many cases – requiring less heat input and fuel use – greater production – requiring greater fuel use -- and a change in fuel use itself, with coal, petroleum coke and “alternative” fuels favored over natural gas and fuel oils. Thus, back in 1970, cement plants burned over 1,594 million liters of fuel oils and 5,998 million cubic meters of natural gas, while today only 124 million liters of fuel oils and a little more than a thousand million cubic meters of natural gas is burned, mainly to start kilns up. Instead, cement plants in the U.S. rely principally upon coal, and petroleum coke to turn limestone and other raw materials into clinker. In addition, since the 1980s, cement kilns have been burning a variety of alternative fuels, including tires, solid hazardous wastes and liquid hazardous and non-hazardous wastes such as used oils and solvents to run their kilns. In particular, the use of tires and solid wastes appear to have increased significantly in recent years (Table 6). In order to compare these fuels, these volumes must be converted to a common heat input index, such as MBTUs or TJs. Using common “gross heat” conversion factors, Table 7 shows energy consumption in the cement industry over the decade. The table shows that by 2000, alternative fuels had become the second leading fuel category behind coal for the cement industry.

Table 6. Energy Use in the Cement Industry, 1990-2001

	1990	1993	1994	1995	1996	1997	1998	1999	2000	2001
Coal (Thousand Metric Tons)	9,098	10,034	10,484	8,241	8,764	9,035	9,066	9,206	10,095	10,240
Coke (from Coal) (Thousand Metric Tons)	Not Reported	Not Reported	Not Reported	455	458	351	432	343	442	420
Petroleum Coke (Thousand Metric Tons)	379	Not Reported	Not Reported	1,475	1,295	1,288	1,197	1,622	1,351	1,370
Fuel Oils (million liters)	299	46	49	42	64	86	73	82	124	93
Natural Gas (million cubic meters)	294	668	650	1,069	710	672	720	653	338	397
Tires (thousand metric tons)	Not Reported	70	120	158	191	277	269	685	374	300
Other Solid Waste (thousand metric tons)	Not Reported	90	74	68	72	68	74	816	1,016	320
Liquid Waste (million liters)	Not Reported	744	600	885	910	835	1,268	906	929	829

Source: U.S. Bureau of Mines Mineral Yearbook, 1990; United States Geological Survey, Minerals Yearbook, Annual, 1991 – 2001, Table 7.

Table 7. Energy Consumption in the Cement Industry in TJs, 1990-2001 (1)

	1990 (1)	1993	1994	1995	1996	1997	1998	1999	2000	2001	% 1990-001	%1993-2001
Coal	266,835	294,287	307,485	241,700	257,039	264,988	265,897	270,003	296,076	300,329	12.55%	2.05%
Coke from Coal	No Data	No Data	No Data	12,961	13,046	9,998	12,306	9,770	12,590	11,964	NA	NA
Petroleum Coke	13,315	No Data	No Data	51,819	45,495	45,249	42,052	56,983	47,463	48,130	261.47%	NA
Fuel Oils	12,176	1,873	1,995	1,710	2,606	3,502	2,973	3,339	5,050	3,787	(68.90%)	102.17%
Natural Gas	11,321	25,723	25,030	41,165	27,340	25,877	27,725	25,145	13,016	15,287	35.04%	(40.57%)
Tires	No Data	2,258	3,871	5,097	6,162	8,937	8,678	22,099	12,066	9,679	NA	328.63%
Other Solid Waste	No Data	1,709	1,405	1,291	1,367	1,291	1,405	15,496	19,294	6,077	NA	255.58%
Liquid Waste	No Data	27,865	22,472	33,145	34,082	31,273	47,490	33,932	34,793	31,048	NA	11.42%
TOTALS	**303,647**	**353,715**	**362,259**	**388,889**	**387,138**	**391,115**	**408,526**	**436,768**	**440,348**	**426,301**	**40.39%**	**20.52%**

(1) Standard gross (high) heat values for fuels were used to convert volumes to MBTUs and then to TJs. For Liquid wastes, a conversion of 32.5 MBTUs per thousand liters was used; for solid wastes, 18.0 MBTUs per metric ton was used; and for tires 30.58 MBTUs per metric ton was used. Sources include EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1996; and IPCC, Volume 3.

(2) Alternative fuels such as tires, solid wastes and liquid wastes were in use, but not reported prior to 1993. Therefore, for these years, the numbers represent an undercount of total energy consumption in the cement industry.

Source: U.S. Bureau of Mines Mineral Yearbook, 1990; United States Geological Survey, Minerals Yearbook, Annual, 1991 – 2001, Table 7.

Based upon a recent scholarly article, Table 8 shows total energy demand per output for clinker and cement manufacturing over the last decade.[8] For clinker, the energy requirements include only the heat content of the fuels, while cement production includes both the fuels consumed and the heat content of the electricity consumed in the other non-clinker processes involved in making cement. These energy needs are expressed in one TJ per thousand tons of clinker or cement produced. Two case scenarios are shown. Case A is based on published gross (high) heat contents of fuels, while Case B utilizes the actual heat content reported by U.S. plants in 2000. It is important to note that because no data on waste fuels was collected before 1993, the energy demands of plants using these fuels before 1993 are probably an underestimate. Overall, the table suggests that there was no major changes in energy efficiency in fuel use in cement kilns over the 1990s, despite more modern kilns. (Energy consumption did decline substantially over previous decades, when major investments in kiln technology were made). Table 8 shows that whichever case basis is used, total energy consumption increased approximately six to 12 percent over the decade per unit of output. One potential reason could be the increase in petroleum coke and alternative fuels, which burn hotter and might negate gains made in terms of energy efficiency. Still, since 1995 it appears that some energy efficiency measures have been taken as the total energy demand per unit of output has been stabilized.

---

[8] Table 6 and this discussion are from Hendrik G. van Oss and Amy Padovani, "Cement Manufacture and the Environment: Part 1, Chemistry and Technology," Journal of Industrial Ecology (Volume 6, No. 1): 89 – 105.

Table 8. Energy Consumption in Clinker and Cement Production, U.S., 1990-2000
TJs per metric ton of clinker or cement.

Energy Consumption	1990 (1)	1991 (1)	1992 (1)	1993	1994	1995	1996	1997	1998	1999	2000	2001	%, 1990-2001	%, 1993-2001
Case A - clinker basis (2)	4.72	5.18	4.83	5.14	5.19	5.30	5.23	5.13	5.17	5.51	5.36	5.19	9.96%	1.02%
Case A - cement basis (3)	5.06	5.65	5.10	5.26	5.30	5.69	5.39	5.24	5.34	5.63	5.54	5.36	5.93%	1.82%
Case B - clinker basis (4)	4.24	4.68	4.38	4.67	4.75	4.88	4.81	4.71	4.76	5.11	4.97	4.76	12.26 %	1.85%
Case B - cement basis (5)	4.61	5.19	4.66	4.83	4.88	5.28	4.99	4.85	4.96	5.26	5.18	4.96	7.59%	2.65%

(1)Data are undervalued because of lack of waste fuel data between 1990 and 1992. In 1991, data was used from the Portland Cement Association, and then factored to account for other cement. Waste fuels have been consumed since 1980s but were not reported until 1993
(2) Values are based on standard gross heat values of fuels and exclude electricity.
Values exceed those for standard net heats by 0.03 to 0.09 units.
(3) Assigned all to portland cement. Values are based on standard gross heats of fuels and include electricity.
(4) Values for all years use the actual heat values (gross heat basis)
reported by plants in 2000 and exclude electricity.
(5) Assigned all to portland cement. Values for all years use the actual heat values (gross heat basis)
reported by plants in 2000 and include electricity.

Source: Hendrik G. van Oss and Amy Padovani, "Cement Manufacture and the Environment: Part 1, Chemistry and Technology," Journal of Industrial Ecology (Volume 6, No. 1): 98.

It is important to note that the Portland Cement Association publishes its own survey of member's energy use. For example, in 2000, their data suggested slightly lower average energy uses of 4.73 TJs per thousand metric tons of clinker and 4.91 TJs per thousand metric tons of portland cement. Their data shows that average energy needs are much lower for modern dry plants, particularly for those with preheaters or preheaters and precalciners. Thus, the most modern dry plants had energy consumption rates of only 2.65 TJs per metric ton of clinker, while some older, wet kilns had requirements of 7.4 TJs per metric ton of clinker. Still their data suggests that average energy consumption has remained level over the last decade.

3.2.5 Cement Industry Pollutant Releases: CO2, NOX and Toxics

Cement manufacturing leads to large-scale emissions of greenhouse gases like carbon dioxide, criteria air emissions of nitrogen oxides, particulate matter, carbon monoxide and volatile organic compounds important in the formation of ground-level ozone and toxic chemicals, including those considered persistent and bioaccumulative. In the U.S., there has been no regulatory effort to limit greenhouse gas emissions such as carbon dioxide from cement manufacturing. The U.S. Environmental Protection Agency estimates that all industrial production emitted the equivalent of nearly 288 million metric tons of carbon dioxide of greenhouse gases in 2001, or about 4.1 percent of all greenhouse gas emissions (U.S. EPA, 2003, page 77). Cement manufacturing produces a significant amount of these industrial emissions, and is second only to iron and steel production in carbon dioxide emissions. Still, overall, cement manufacturing only contributed to an estimated 0.6% of total greenhouse gas emissions in 2001 (Ibid, 17), dwarfed by emissions from power plants and transportation sources.

Greenhouse gas emissions from the cement manufacturing industry are the result of both the process of turning limestone and other inputs into clinker – which releases carbon dioxide – and the burning of fuels in the rotary kilns, which also releases carbon dioxide. Overall, emissions of "process" greenhouse gases from cement manufacturing – including clinker production, masonry cement and emissions from cement kiln dust – generated over 9 million metric tons of carbon equivalent or 33 million metric tons of carbon dioxide emissions in 1990, a total which rose an estimated 25 percent by 2000. These estimates are based upon the production of cement and an emissions factor of 0.507 tons of CO2 per ton of clinker produced, plus some added CO2 attributed to Cement Kiln Dust "production" and to masonry cement. As such, these estimates to not reflect changes in the lime content of the cement itself – some cement manufacturers are replacing limestone with other products such as pozzolanic slag -- nor to changing fuel use within the industry.

Because the industry currently is not required to measure or even estimate their release of carbon dioxide, estimates of carbon dioxide emissions from the burning of fuels are based upon multipliers of the total amount and type of fuel used. Table 9 shows the estimated release of carbon dioxide from fuel consumption between 1990 and 2001 based upon some common multipliers. Such emissions increased by some 40 percent over the period based upon these multipliers.

Table 9. Estimated Carbon Dioxide Releases in the Cement Industry in Thousand Metric Tons, 1990-2000

	1990 (2)	**1991 (2)**	**1992 (2)**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Coal	23,864	20,357	23,626	26,319	27,500	21,616	22,988	23,699	23,780	24,148	26,479	26,860
Coke	No Data	No Data	No Data	No Data	No Data	1,193	1,201	921	1,133	900	1,159	1,102
Petroleum Coke	1,288	4,551	No Data	No Data	No Data	5,013	4,402	4,378	4,069	5,513	4,592	4,657
Fuel Oils	878	1,776	449	135	144	123	188	252	214	241	364	273
Natural Gas	569	1,370	2,034	1,293	1,258	2,069	1,374	1,301	1,394	1,264	654	768
Tires	No Data	No Data	No Data	196	336	443	535	776	754	1,919	1,048	840
Other Solid Waste	No Data	No Data	No Data	225	185	170	180	170	185	2,040	2,540	800
Liquid Waste	No Data	No Data	No Data	1,839	1,483	2,187	2,249	2,064	3,134	2,239	2,296	2,049
Total	**26,599**	**28,054**	**26,109**	**30,007**	**30,906**	**32,814**	**33,117**	**33,560**	**34,662**	**38,263**	**39,133**	**37,348**

(1) Standard gross (high) heat values and carbon equivalents of fuels were used to convert volumes of fuels used to the amount of carbon dioxide emissions per unit of fuel. For Liquid wastes, a conversion of 2.4 metric tons of carbon dioxide per thousand liters was used; for solid wastes, 2.5 tons of metric tons of carbon dioxide per metric ton was used; and for tires 2.8 tons of metric tons carbon dioxide per metric ton was used. Sources include EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1996; and IPCC, Volume 3.

(2) Alternative fuels such as tires, solid wastes and liquid wastes were in use, but not reported prior to 1993. Therefore, for these years, the numbers represent an undercount of total carbon dioxide emissions in the cement industry.

Source: U.S. Bureau of Mines Mineral Yearbook, 1990; United States Geological Survey, Minerals Yearbook, Annual, 1991 – 2001, Table 7.

A recent study of the cement industry estimates CO2 per unit of output based upon fuel use. This estimate shows a slight increase between seven and 17 percent over the decade in tons of carbon dioxide per ton of clinker or cement produced (Van Oss: 98). However, considering that use of alternative waste fuels were underreported in the early 1990s, the increase was probably slightly lower. The most likely explanation for this increase is the decrease in the use of natural gas – which has a low per unit greenhouse gas emission rate – and the increase in petroleum coke and tires, which have higher greenhouse gas emission rates.

Table 10. U.S. Carbon Dioxide Emissions from Cement Manufacturing, Thousand Metric Tons and Tons Per Ton of Clinker and Cement, 1990-2001

	1990 (1)	**1991 (1)**	**1992 (1)**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**000**	**2001**	**%, 1990-2001**	**%, 1993-2001**
Process Carbon Dioxide Emissions	33,330	32,450	32,780	34,687	36,814	36,924	37,147	38,390	39,307	40,077	41,287	41,690	25.08 %	20.19 %
Fuel Carbon Dioxide Emissions	26,599	28,054	26,109	30,007	30,906	32,814	33,117	33,560	34,662	38,263	39,133	37,348	40.41 %	24.46 %
Total Carbon Dioxide Emissions	59,929	60,504	58,889	64,694	67,720	69,738	70,264	71,950	73,969	78,340	80,420	79,038	31.89 %	22.17 %
Case A – Fuel CO2 per Ton of Clinker(2)	0.41	0.45	0.41	0.45	0.46	0.46	0.46	0.45	0.46	0.49	0.48	0.46	12.20 %	2.22 %
Case A – Total CO2 per Ton of Cement (3)	0.92	0.96	0.92	0.96	0.97	0.97	0.97	0.96	0.97	1	0.99	0.97	5.43%	1.04 %
Case B – Fuel CO2 per Ton of Clinker (4)	0.37	0.40	0.37	0.40	0.41	0.41	0.41	0.40	0.41	0.44	0.43	0.42	13.51 %	5.00 %
Case B – Total CO2 per Ton of Cement (3,4)	0.88	0.91	0.88	0.91	0.92	0.92	0.92	0.91	0.92	0.95	0.94	0.93	5.68%	2.20 %

(1)Data are probably undervalued because of lack of waste fuel data from 1990-1992. Waste fuels have been consumed since 1980s but were not reported until 1993

(2)Calculated based on standard gross heat values for fuels.
Values exceed those calculated using net (low) heat values by 0.00 to 0.01 units.

(3) Includes calcination emissions of 0.51 ton per ton of clinker.

(4) Calculated based on actual heat value for fuels reported by plants to the USGS in 2000.

Sources: Energy Information Administration, Emissions of Greenhouse Gases in the United States, 2000 (Washington, DC, October 2001); and Hendrik G. van Oss and Amy Padovani, "Cement Manufacture and the Environment: Part 1, Chemistry and Technology," Journal of Industrial Ecology (Volume 6, No. 1): 98.

In addition to greenhouse gases – with their anticipated worldwide impacts – cement manufacturing in the U.S. are also major emitters of criteria air pollution. Recent EPA data –itself based on state-level emissions inventories-- reports that the industry spewed out over 550,000 tons of carbon monoxide, nitrogen oxides, particulate matter (PM10), sulfur dioxide and volatile organic compounds in 1999. In fact, overall, the cement manufacturing industry accounted for 1.6 percent of total point emissions, and actually increased its total emissions and percentage of the national point source total between 1996 and 1999. Again, the data suggests that increased production to meet growing demand, and a fuel mix which emphasizes dirtier coal, petroleum coke and some "alternative" products high in emission potential have conspired to make the cement manufacturing industry a high emission polluter in the U.S. It is important to note that some alternative fuels – such as tires -- are actually low in ozone-producing chemicals like nitrogen oxides.

Table 11. Tons of Emissions of Criteria Air Pollutants from U.S. Cement Manufacturing Industry, and Percentage of National Total, 1996-1999

Category	Tons, 1996	Percent of Total Emissions, 96	Tons, 1999	Percent of Total Emissions, 99
Carbon Monoxide	67,351	1.34	69,312	1.31
Nitrogen Oxides	203,701	2.17	218,486	2.42
Particulate Matter-10 Microns	39,249	3.42	41,520	3.73
Particulate Matter – 2.5 Microns	20,911	3.05	22,196	3.3
Sulfur Dioxide	196,022	1.2	209,648	1.29
Volatile Organic Compounds	12,922	0.61	13,204	0.64
Total Criteria Air Emissions	519,245	1.5	552,170	1.6

Source: U.S. EPA, AIRSDATA, National Emissions Trend Database, 1996 and 1999.
Query run on February 11, 2003.

Cement manufacturing is also responsible for the release of millions of kilograms of toxics, both to on-site landfills, often quarries located behind the plant itself, and into the air, either through the kiln "stack" or from fugitive emissions released from leaks from equipment. Virtually all cement plants in the U.S. are required to report their toxics to the U.S. EPA through the Toxics Release Inventory. Table 12 shows total toxics between 1991 and 2000 for those "common" chemicals required to be reported in all years. Table 13 shows total toxic releases for the 1995 to 2000 period since new chemicals were added in 1995. The data suggests that in recent years, total toxics being emitted from cement plants have increased from cement plants, both in "other landfills" and in air emissions. The increase to "other landfills" may actually reflect widespread use of baghouse devices to catch cement kiln dust which may have improved "catching" the dust before it enters the air. Still, the data suggests that increased burning of coal, petroleum coke and alternative fuels have increased toxic emissions, even as more efficient kilns have come on line. Much of the increase occurred during the middle 1990s, when use of alternative fuels increased substantially. In fact, as the tables show, reported toxic production has risen even when adjusted for the added production over the period.

Table 12. Toxic Releases (in Kilograms) from Cement Manufacturing Plants, 1990-2000

	Toxic Air Emissions (Stack and Fugitive)	Other On-Site Toxics Releases, Including Landfills/ Quarries	Total Toxic On-Site Releases	Tons of Thousand Metric Tons of Cement Produced	Kg of on-site toxic releases/ thousand metric tons of cement	Kg. of air toxics/ thousand metric tons of cement
1990	498,654	224,273	722,927	69,954	7.13	10.33
1991	398,517	373,344	771,861	67,193	5.93	11.49
1992	638,078	96,800	734,877	69,585	9.17	10.56
1993	1,287,401	283,166	1,570,567	73,807	17.44	21.28
1994	1,464,492	330,201	1,794,692	77,948	18.79	23.02
1995	2,917,191	363,952	3,281,143	76,906	37.93	42.66
1996	3,509,121	425,268	3,934,389	79,266	44.27	49.64
1997	3,085,749	927,027	4,012,776	85,582	36.06	46.89
1998	3,414,033	1,220,098	4,634,131	83,931	40.68	55.21
1999	2,988,351	1,270,913	4,259,264	85,952	34.77	49.55
2000	3,748,067	1,764,672	5,512,739	87,846	42.67	62.75
% Change	651.64%	651.64% 686.84%	662.56%	25.58%	498.55%	507.24%

Source: Query run on U.S. EPA's Customized Query for Toxic Release Inventory using SIC Code 3241, April 25, 2003 and including all chemicals required to be reported in 1987 and 1991. (www.epa.gov/enviro/tri/)

Table 13. Toxic Releases (in kilograms) from Cement Manufacturing Plants, 1995-2000

	Total Kgs of Toxic Air Emissions (Stack and Fugitive)	Other On-Site Releases, Including Landfills/ Quarries	Total On-Site Releases	Tons of Thousand Metric Tons of Cement Produced	Kg of on-site toxic/ thousand metric tons of cement	Kg. of air toxics/ thousand metric tons of cement
1995	3,477,671	363,952	3,841,623	76,906	49.95	45.22
1996	4,061,112	425,268	4,486,380	79,266	56.60	51.23
1997	3,646,170	927,027	4,573,197	85,582	53.44	42.60
1998	3,908,384	1,220,099	5,128,482	83,931	61.10	46.57
1999	3,438,301	1,270,913	4,709,214	85,952	54.79	40.00
2000	4,186,512	1,764,672	5,951,184	87,846	67.75	47.66
% 95-2000	20.38%	384.86%	54.91%	14.23%	35.64%	5.40%

Source: Query run on U.S. EPA's Customized Query for Toxic Release Inventory using SIC Code 3241, April 25, 2003 and including all chemicals required to be reported since 1995. (www.epa.gov/enviro/tri/)

In 2000, the EPA also added a number of new chemicals to the TRI list which facilities had to report and lowered the reporting threshold for certain "Persistent, Bioaccumulative Toxics (PBTs)," including Dioxins and Dioxin-like Compounds. Tables 14 and 15 show total on-site releases of PBTs, and the grams of toxic equivalent dioxin released by the cement industry in 2000 respectively. While the cement industry only releases a small percentage of total PBTs, the cement industry is one of the leading air emitters of dioxin in the U.S. among point sources, emitting almost nine percent of all dioxin and dioxin-like compounds among industries reporting to the TRI in 2000. Understandably, there is considerable concern that the move toward incineration of "alternative" products has or could increase the amount of dioxins released from cement manufacturing plants. In fact, data from EPA's own assessments of dioxin releases from different industries found that burning hazardous wastes increased releases of dioxin and dioxin-like compounds.[9] In 1997, the EPA estimated that cement facilities released 57 grams I-TEQ of dioxin, 13 grams of which came from the mere 18 facilities burning hazardous wastes.[10]

Table 14. On-site Reported Releases of Bioaccumulative, Persistent Toxics (in pounds) from Cement Manufacturing Industry (SIC 3241), 2000

	On-site Air Releases	**Surface Water Releases**	**Underground Injection**	**Releases to Land**	**Total On-site Releases**
Cement Industry	10,069.40	2.14	0.00	1,663.72	11,735.26
All Facilities	2,157,110.00	21,319.00	21,778.00	5,319,246.00	7,519,454.00
% of Total	0.467%	0.010%	0.000%	0.031%	0.156%

Source: Query run on U.S. EPA's Toxic Release Inventory, February 12, 2002. (www.epa.gov/triexplorer)

Table 13. On-site Reported Releases of Dioxin and Dioxin-like Compounds (in grams) from Cement Manufacturing Industry (SIC 3241), 2000

	On-site Air Releases	**Surface Water Releases**	**Underground Injection**	**Releases to Land**	**Total On-site Releases**
Cement Industry	449.59	0.73	0.00	45.02	495.34
All Facilities	5217.77	2075.63	405.19	38217.02	45915.62
% of Total	8.62%	0.04%	0.00%	0.12%	1.08%

Source: Query run on U.S. EPA's Toxic Release Inventory, February 12, 2002. (www.epa.gov/triexplorer)

3.2.6 Cement Industry Waste Management

Because many cement kilns in the U.S. do combust hazardous wastes, they are required to report this activity to the U.S. Environmental Protection Agency through the Biennial Reporting System. Data from these reports between 1991 and 1999

---

[9] See EPA, September 2000, page 5-5. According to the EPA's analysis, which was based on burning from 16 cement kilns burning hazardous waste and 15 kilns not burning hazardous wastes, the average emission factors were about 90 times greater for kilns burning hazardous wastes. Nonetheless, because this data was based on a sample of cement kilns, the results may not be representative. In addition, other factors – the type of kiln used, the temperature of the flue gas – may have an even greater effect on dioxin levels. Still, it appears that burning hazardous wastes increases emissions of dioxin.

[10] Ibid. Page 5-10

demonstrate that both fuel blending – needed to prepare some wastes for burning – as well as “energy recovery” – burning of hazardous wastes either at cement plants as well as other industries has become a significant part of the off-site hazardous waste management strategy in the U.S. Between 800,000 and one million tons of hazardous waste a year have been burned for energy recovery over the last ten years, most of which occurred at cement kilns. These cement kilns generate a small amount of hazardous wastes themselves, as do some facilities which do not burn hazardous wastes. Often, cement plants burning hazardous wastes receive the waste from fuel-blending plants, burn it, generate some residue wastes which are sent back to the same fuel blending plants to eventually be burned again.

Table 16. Tons of RCRA Hazardous Waste Managed Off-Site by Year and Management Method, 1991-1999

Off-Site	**1991**		**1993**		**1995**		**1997**		**1999**	
	Tons Managed	**%**	**Tons Managed**	**%**	**Tons Managed**	**%**	**Tons Managed**	**%**	**Tons Managed**	**%**
Management Method										
Metals Recovery (For Reuse)	692,778	9	440,894	5.3	397,861	4.6	819,868	22.6	532,324	8.9
Solvents Recovery	463,447	6	430,519	5.2	291,180	3.3	530,703	19	349,678	5.8
Other Recovery	199,200	2.6	118,600	1.4	68,499	0.8	102,446	9.7	47,952	0.8
Incineration	452,235	5.9	487,576	5.9	645,471	7.4	531,693	26.5	757,844	12.7
Energy Recovery (Reuse as fuel)	533,868	6.9	920,579	11.1	1,005,767	11.5	901,439	15.8	879,003	14.7
Fuel Blending	1,033,329	13.4	956,303	11.5	2,254,669	27	1,324,814	29	927,769	15.5
Aqueous Inorganic Treatment	475,239	6.2	577,667	7	587,800	6.7	No data	No data	No data	No data
Aqueous Organic Treatment	298,511	3.9	178,809	2.2	207,757	2.4	No data	No data	No data	No data
Aqueous Org & Inorg Treatment	293,922	3.8	44,527	0.5	107,334	1.2	No data	No data	No data	No data
Sludge Treatment	6,550	0.1	4,606	0.1	2,808	0	20,025	3.5	328	0
Stabilization	758,611	9.9	707,883	8.5	804,011	9.2	1,119,623	15.2	1,039,047	17.4
Other Treatment	783,440	10.2	903,393	10.9	798,111	9.2	No data	No data	No data	No data
Land Treatment/Farming	642	0	57,546	0.7	353	0	0	0.6	13	0
Landfill	1,228,710	16	1,732,070	20.8	812,237	9.3	946,673	13.9	792,923	13.3
Surface Impoundment	8,477	0.1	No data	No data	No data	No data	No data	No data	No data	No data
Deepwell/Underground Injection	425,720	5.5	701,719	8.4	622,887	7.1	488,340	5.5	637,644	10.7
Other Disposal	35,837	0.5	44,605	0.5	15,641	0.2	25,295	8.1	15,586	0.3
Unknown System Due to Invalid Code	1	0	1,869	0	No data	No data	No data	No data	No data	No data
Total	7,690,516	100	8,309,165	100	8,722,387	100	6,810,921	100	5,980,112	100
Totals Common to All Four Years	5,830,927		6,604,769		7,021,385		6,810,921		5,980,112	

Source; U.S. EPA, The National Biennial RCRA Hazardous Waste Report (Based on 1991, 1993, 1995, 1997 and 1999 Data), August 93, 95,97, 99, 2001.

There has not been a significant change in the amount of hazardous wastes burned at cement kilns over the 1990s, even as some facilities ended the practice due to compliance problems or citizen opposition (see Table 17) In 1999, a number of cement plants were among the largest off-site managers of hazardous waste (see Table 18). Thus, cement plants in the U.S. have become major managers of hazardous waste, even though the cement making process itself does not generate large amounts of EPA-defined hazardous wastes.

Table 17. Hazardous Waste Generation and Management in the U.S. Cement Industry, 1991-1999

YEAR	No. of Facilities Generating RCRA Hazardous Waste	Tons Generated	No. of Facilities Managing RCRA Hazardous Waste	Tons Managed
1991	23	1,190	12	609,967
1993	29	7,997	15	673,281
1995	25	18,872	15	654,373
1997	21	8,719	16	695,535
1999	Data Unavailable			

Source:, Query run on Envirofacts, February 10, 2003, (www.epa.gov/enviro/).

Table 18. Ten Largest Cement Plants RCRA Hazardous Waste Receivers, 1999

Name	City	Tons Received
Giant Cement Company	Harleyville, SC	113,248
Lafarge Corporation	Paulding, OH	98,278
Continental Cement Co.	Hannibal, MO	81,096
Lone Star Alternate Fuels	Greencastle, IN	78,391
Essroc Cement Inc.	Logansport, IN	76,381
Ash Gove Cement	Foreman, AK	73,159
TXI	Midlothian, Texas	72,995
Ash Grove Cement	Chanute, KS	58,723
Keystone Cement Co.	Bath, PA	53,524
Lone Star Industries	Cape Girardeau, Mo	42,558
Total		748,523

Source: EPA, 1999 National Biennial Report, Exhibit 3.14.

In addition to small amounts of hazardous wastes, cement kilns do generate large amounts of cement kiln dust, or CKD, which has potential and documented health and environmental impacts. Made up of small particles of clinker, raw materials which did not burn properly, left-over fuel deposits and even bits and pieces of the inside of the kiln, CKD can contain metals, organics and even small traces of furans and dioxins. Thus, in explaining a 1999 decision to consider new rules to more properly manage CKD waste, the EPA said CKD waste does have many hazardous properties. Thus, while not corrosive itself, when mixed with water it can have corrosive qualities; it contains certain metals listed in RCRA which could leach out; and CKD does contain levels – albeit low – of dioxin and dioxin-like compounds.[11]

---

[11] Environmental Protection Agency, 40 CFR Parts 259,261,266 and 270, Standards for the Management of Cement Kiln Dust; Proposed Rule, Federal Register, August 20, 1999, p. 45636.

Moreover, the EPA found during its initial rule-making procedure, that there had been five cases of groundwater contamination, 10 cases of surface water contamination and 21 cases of damage to air quality from CKD waste management units.[12] In fact, in the past, two CKD disposal units have been placed on thee Superfund National Priorities List (NPL) due to groundwater contamination from metals contained in the waste.[13]

Just how much CKD is generated? Most CKD waste is captured by fabric (baghouse) filters, electrostatic precipitators or both. While most of the collected dust is sent back into the kiln, a significant amount is sent off-site for "benefitial" uses or disposed of on or off-site. In 1990, the cement industry generated an estimated 12.7 million tons of CKD, 4 million metric tons of which were disposed of in piles, quarries and landfills.[14] In 1995, a Portland Cement Association (PCA) survey found that generation had declined slightly, and that about 8.2 million metric tons of CKD was recycled back into kilns, about 780,000 metric tons of CKD – about 5.4% of the gross CKD -- was used beneficially, including for sludge, waste and soil –stabilization, land reclamation, waste remediation, acid neutralization, agricultural applications and construction applications -- and about 3.3 million metric tons were sent mainly to on-site disposal facilities. Data also suggests that wet kilns that burn hazardous wastes generated significantly more CKD waste than wet kilns that didn't, though there was little differences between wet and dry kilns (Table 19).

Table 19. Average Net CKD Generation Ratios by Kiln Type

Kiln Type	**Average Net CKD to Clinker Production Ratio (metric ton of CKD per metric ton of clinker)**
Non-Hazardous Fuel Kiln	
Dry Process	0.060
Dry Preheater/Precalciner Process	0.024
Wet Process	0.107
Hazardous Fuel Kiln	
Dry Process	0.061
Dry Preheater/Precalciner Process	0.038
Wet Process	0.166

Source: American Portland Cement Association, 1997. APCA 1995 CKD Survey, as reported in DPRA Incorporated, Technical Background Document: Compliance Cost Estimates for the Proposed Land Management Regulations of Cement Kiln Dust (St. Paul, Minnesotta, 1998), p. 6.

And where does this waste go? A technical document prepared to determine the costs of complying with new EPA proposed standards reports that 20 plants sent their wastes to nearby quarries for disposal, 21 sent them to some kind of above-ground landfill or pile, and 11 sent CKD waste to a combination above ground/below ground disposal facility. Another 13 did not report, but probably sent them to quarries, while 37 reported that they either did not generate CKD waste for disposal – sending it off for beneficial

---

[12] Environmental Protection Agency, 40 CFR Parts 259,261,266 and 270, Standards for the Management of Cement Kiln Dust; Proposed Rule, Federal Register, August 20, 1999, p. 45635.

[13] Ibid.

[14] EPA, Environmental Fact Sheet: Management Standards Proposed for Cement Kiln Dust Waste (Office of Solid Waste: EPA530-F-99-023), August 1999.

use – or sent it off-site.[15] In citing the need for regulation, the EPA specifically noted that in 1991, only 17 percent of the CKD facilities had ground-water monitoriing systems.[16]

More recent data submitted by the industry suggests that the "net" amount of CKD has been reduced as industries have begun to reuse more dust in the kiln. Thus, in a filing with the EPA arguing against new standards for CKD management, the Portland Cement Association reported that CKD disposal has decreased by 22 percent since 1990.[17]

3.3 Regulatory Structure for Waste and Emissions Management

Over the last decade there has been considerable effort by the Environmental Protection Agency and state regulatory agencies to improve regulations on several areas where cement manufacturing contributes to environmental degradation, including CKD management, toxic emissions and criteria air pollutants. There has not been a regulatory effort to curb greenhouse gas emissions.

Still, the implementation of new regulations have been slow, in part because of considerable effort by the cement industry itself to delay and weaken new regulations. It should also be stated that in general new regulations came about when citizen groups and others forced the EPA to take action through political pressure and lawsuits, rather than through EPA-led initiative.

3.3.1 Emission Controls

The EPA has been pursuing so-called Maximum Achievable Control Technologies to control air emissions both for cement kilns that burn hazardous wastes and those that do not separately, although the final rules are very similar. First of all, in April of 1996, the EPA issued proposed standards for hazardous waste combustion facilities, including aggregate kilns, incinerators and cement kilns through the Clean Air Act. In September of 1999, the EPA issued the final standards to control emissions of hazardous air pollutants from these facilities, including dioxin and furans, toxic organic compounds, hydrocarbons and mercury. Under the standards, facilities would have until September of 2002 to comply. However, both industry and environmental groups sought judicial review of the rules – albeit for different reasons -- and on July 24, 2001, the United States Court of Appeals for the District of Columbia Circuit granted the Sierra Club's petition for review and vacated some portions of the rules. EPA asked for authority to develop interim standards which the Court granted. Finally, on February 14, 2002, the EPA issued "interim" emission standards for hazardous waste combustion facilities. In

---

[15] DPRA Incorporated, Technical Background Document: Compliance Cost Estimates for the Proposed Land Management Regulations of Cement Kiln Dust (St. Paul, Minnesotta, 1998), p. 8.

[16] Environmental Protection Agency, 40 CFR Parts 259,261,266 and 270, Standards for the Management of Cement Kiln Dust; Proposed Rule, Federal Register, August 20, 1999, p. 45635.

[17] U.S. Environmental Protection Agency, "Additional Data Available on Wastes Studies in Report to Congresson Cement Kiln Dust," *Federal Register*, July 25, 2002.

the process, the EPA pushed back the compliance deadline until September 30 of 2003.[18]

The estimated cost to the 18 facilities presently burning hazardous wastes to meet the final standards is between $0.53 and $0.72 million, and the annual post-consolidation compliance costs are estimated to range from $17 to $24 million. Potentially, the new standards could increase the price of cement about $13 per ton.[19] According to the EPA, the new controls are expected to cause one or two cement kilns to decide not to burn hazardous wastes because of the added cost, but they are not expected to lead to a decline in the total volume of hazardous waste combusted.

At the same as MACT standards were being developed for hazardous waste combustion, the EPA also published MACT standards for all cement kilns on June 14, 1999, also challenged legally. On December 6, 2002, the EPA settled the lawsuit by making relatively small changes to the MACT standard. The MACT standards apply new emission limited on hazardous and non-hazardous burning cement kilns alike for dioxin/furans, particulate matter, and hydrocarbons. However, the MACT standard for non-hazardous burning cement kilns does not establish standards for some hazardous pollutants like mercury. As such the standards for hazardous waste burning cement kilns are somewhat stricter. Still, taken together, the new MACT standards are expected to reduce emissions of dioxins from all cement plants by nearly 40 percent.

Hazardous waste-burning cement kilns are not required to meet the same emission standards as incinerators under the new MACT standards, giving cement operators a regulatory advantage over incinerators in the burning of hazardous waste.

3.3.2 Cement Kiln Dust Management

Since the Resource Conservation and Recovery Act (RCRA) was passed by Congress in 1980, cement kiln dust and certain other “mining” wastes have been exempt from otherwise applicable hazardous waste regulations under Subtitle C of the federal law. Nonetheless, EPA was given the task of studying the issue of CKD waste and reporting back to Congress. Only after considerable delay and various lawsuits, did the EPA issue a report in 1993 which found widespread problems with the management of CKD waste. At Congress’ urging, EPA determined that additional controls were needed in 1995. Finally in August of 1999, EPA came up with a compromise solution between those who wanted to consider CKD waste as hazardous waste and those who felt no additional controls – beyond a voluntary agreement between EPA and the cement industry – were needed. The 1999 proposed standards accepted that CKD waste would be considered non-hazardous so long as basic management standards were met.

---

[18] United States Environmental Protection Agency, Environmental Fact Sheet: Interim Emission Standards for 1999 Hazardous Waste Combustor Rule, EPA530-F-02-008, February 2002.

[19] U.S. EPA, Office of Solid Waste, Information from website (http://www.epa.gov/epaoswer/hazwaste/combust/faqs.htm#ck).

Options outlined in the proposal included both performance based standards and technology-based standards. Only if these performance and/or technology standards are not complied with can waste be considered hazardous. Thus, under the standards, CKD waste which can not be used beneficially as a lime agent because of high levels of contamination would have to be managed in landfills designed to prevent groundwater contamination. Liners, groundwater monitoring, corrective action, closure and post-closure are among the technical requirements.

In addition, to prevent continued releases of cement kiln to the air, EPA proposed requiring additional control measures to prevent releases from landfills, storage areas, or conveyance areas. The EPA invited public testimony on the proposed standards. According to a study done to determine the compliance costs, the new regulations for the land management of cement kiln dust would increase costs of CKD management from about $55 million per year to nearly $100 million. However, the increased costs would only impact about 68 plants, and the annual increase in management costs would only average about $650,000.[20] Still, the cement industry responded with a litany of complaints about the proposed standards.

In July of 2002, the EPA announced that it was accepting comments on a slightly new proposal: finalizing the proposed management options in rulemaking under RCRA Subtitle D (non-hazardous waste), and withdrawing any consideration of mismanaged CKD waste as hazardous under Subtitle C. Instead, the agency would "assess" CKD practices and regulatory programs over the next three to five years to determine if consideration of the waste as hazardous is warranted. In doing so, the proposal significantly curtails EPA's enforcement abilities and the liability of the cement industry for mismanaged wastes. Instead, in order to seek enforcement, citizens would have to instead rely upon states and citizen suits to enforce CKD management regulations against the industry.

In proposing to delay considering mismanaged CKD waste as hazardous, the EPA accepted arguments from the cement industry that it had made significant improvements in management practices.[21] According to the Portland Cement Association, a survey of 18 CKD disposal facilities where 95 percent of the CKD is landfilled, found that 57 percent of the facilities already monitor groundwater, 97 percent practice landfill dust control techniques, 86% employ compaction techniques, 77% have water runoff controls and 91 % practice road-dust control.[22] The EPA is still studying its options, however, and has not made a final determination.

---

[20] DPRA Incorporated, Technical Background Document: Compliance Cost Estimates for the Proposed Land Management Regulations of Cement Kiln Dust (St. Paul, Minnesotta, 1998), p. 21.

[21] U.S. Environmental Protection Agency, "Additional Data Available on Wastes Studies in Report to Congresson Cement Kiln Dust," *Federal Register*, July 25, 2002.

[22] U.S. Environmental Protection Agency, "Additional Data Available on Wastes Studies in Report to Congresson Cement Kiln Dust," *Federal Register*, July 25, 2002.

3.3.3. Controling Ozone Precursors

New Source Review Standards controling “criteria” air pollutants like particulate matter were developed back in 1986 for new cement plants or existing plants which were undergoing major changes. Since that time, states with cities violating national ambient air standards for ozone, particulate matter and other criteria pollutants have been developing new emission standards for cement kilns. A recent example occurred in Texas, where the Texas Natural Resource Conservation Commission imposed significant new reductions on nitrogen oxide emissions for cement kilns in central and eastern counties of Texas to meet standards in the Dallas/Ft. Worth Area. Specifically, the cement industries in these areas were told to reduce nitrogen oxide emissions by an average of 30 percent, with the actual rate dependent upon the type of kiln process. However, following a lawsuit, the TNRCC agreed to allow increased burning of tires at cement facilities as a way to reduce nitrogen oxides, as opposed to requiring new pollution control equipment. In fact, as part of the settlement, the Texas legislature set aside $9.5 million to help deal with surplus tires. Of that, $7.5 million will be spent eliminating two of the largest stockpiles—in Atlanta in Northeast Texas and Stamford in North Texas. The remaining funds may be used to retrofit several cement kilns to burn tires as fuel. Permits are currently being rewritten to allow increase tire burning at these cement kilns, including at TXI’s Midlothian Plant, one of the largest burners of alternative fuels and the subject of contentious permit and legal battles.

Thus, one way the cement industry has met its Clean Air obligations to reduce nitrogen oxides is to increase the burning of tires. While use of tire-derived fuel is on the upswing in both Texas and the U.S., the practice is not without critics. Many environmental organizations argue that facilities have inadequate air pollution controls for tire-derived fuels and that while some pollutants may be reduced – such as nitrogen oxide – others – like heavy metals –can be increased. Supporters maintain that tires burn cleaner than coal and the process uses 100 percent of the tire, including the metal. It also is preferable to open air burning of tires, as often happens at illegal dump sites. In Texas, the TNRCC requires all companies burning tires to do trial burns and to meet the emissions requirements of their air permits. Permits limit that total amount of tires that can be burned.

3.3.4. Greenhouse Gas Controls

Unlike the efforts to control hazardous emissions from cement kilns, or the attempt to better manage cement kiln dust, there has not been regulatory efforts in the U.S. to control carbon dioxide emissions. In part this stems from the present administration’s decision to withdraw from the Kyoto Treaty, which would have required substantial reduction commitments from the cement industry as a leading greenhouse gas emitter. Still, one of the industry’s main concerns is that eventually carbon dioxide emission reductions will be required. Members of the Portland Cement Association have agreed to a voluntary goal of reducing their average CO2 emission by 10 percent below 1990 levels by 2020 on a per-ton cement product basis.[23] Such reductions would imply

---

[23] Hendrik G. van Oss, “Cement,” Annual Minerals Yearbook, Cement: 2001, 16.2.

substantial pollution control expenditures, a change in the type of fuel used, or changing the main input of cement from limestone to alternative materials, including fly ash, slag and other "pozzolanic" materials. These alternative inputs have the potential to reduce process carbon dioxide emissions (see especially Humphreys and Mahasenan 2002). Recently, ten major world cement makers –including companies like CEMEX, Holcim and Lafarge operating in the U.S.-- came up with a set of "sustainable" strategies, including reduction of CO2, and other measures to make their plants "greener." Produced in association with the World Business Council on Sustainable Development, the "Agenda for Action on Sustainable Development" includes a pledge to develop and publish individual performance data and targets for carbon dioxide emissions by 2006 and stakeholder dialogues to develop guidelines on fuel use.[24]

3.4. Conclusions

Over the last ten years, production of cement and clinker has increased at U.S. plants. So has consumption, in fact at a faster rate than production, and therefore imports have made up a growing portion of total consumption. Imports from Canada and Mexico have grown substantially over the period.

At the same time, however, anti-dumping tariffs on certain types of cement products from Mexico have limited imports from that country since NAFTA. Instead, several Mexican-owned cement companies have begun investing heavily in the U.S. Ownership in the cement industry has become more consolidated in the U.S. even thought the total number of plants has remained steady. There is some evidence of some gains in technology transfer because of this ownership, though further, more detailed study would need to be conducted to determine if this represents a truly "cleaner" more efficient technology transfer.

There has been a continued change from wet kilns to dry kilns in recent years. While this has reduced fuel use on a per ton basis, total electricity and energy use in the U.S. has increased, both in total volume and on a per-ton basis. A major reason for this continued increase in total energy consumption is the continued use of coal and petroluem coke in U.S. cement kilns, as well as the increasing use of "alternative" fuels, including hazardous wastes and tires. In fact, the cement industry in the U.S. has become one of the major "managers" of hazardous waste sent off-site, a trend that appears to be continuing based on EPA data.

Because of these choices on fuel, carbon dioxide, criteria air pollutants and toxic emissions have increased, both on a total and per-ton of cement produced basis. The volume of cement kiln dust appears to be declining, and according to industry data, is

---

[24] CEMEX, "10 Cement Companies Pledge Specific Actions on 6 High Priority Issues for Sustainable Development," July 3, 2003 Press Release. Available at www.cemex.com/qr/mc_pr_070302.asp.

being better managed, in part in response to proposed EPA standards. However, significant problems with CKD management appear to continue, and the threat of considering CKD as a hazardous waste – requring more stringent regulations – has been put on hold. New toxic air emission standards known as "MACT" standards will gradually force the cement industry to reduce toxic and other emissions, however. Still, new regulations will not likely influence fuel choices to a great degree, even as it forces the industry to burn fuel more cleanly by installing more modern pollution control equipment.

Requirements to reduce nitrogen oxide and other criteria air pollutants has led some cement kilns to turn toward greater use of alternative fuels like tires. While nitrogen oxide emissions are decreased, other emissions may be increased by this energy input decision.

New regulations on global greenhouse emissions are unlikely in the U.S., although pressure for voluntary cuts, as well as steps being taken by international cement companies to better account for their emissions could eventually lead to significant cuts in this area and potentially influence fuel choice as well as the choice of alternatives to limestone to decrease process carbon dioxide emissions.

4.0. The Mexican Cement Industry

4.1 Introduction

This section reviews the present situation of the Mexican cement industry, with a particular focus on energy consumed and on the increasing use of hazardous and other wastes as an alternative to traditional fuels. Commercial and environmental factors are discussed, as well as the present regulatory approach to control emissions and waste products from the cement manufacturing process. A central concern of this section is the lack of information in Mexico about the use of hazardous wastes as a fuel and their impacts, which throughout the world are being promoted as an input to those industries – like cement manufacturing – which consume vast quantities of energy.

4.2 An Overview of Trends in Production, Exports, Ownership, Investments, Energy Use and Pollutant Releases.

4.2.1 Number of Plants, Production and Exports

Production of cement in Mexico rose more than 25 percent between 1990 and 2001. Nonetheless, production rose most rapidly between 1990 and 1994, when more than 30,000 tons were produced. Devaluation of the peso and a subsequent loss of demand both in the residential and public sectors caused a contraction in the Mexican cement market in 1995. Since then, however, demand has been increasing and total production once again topped 30,000 tons in 2000 and 2001. In fact, the cement industry has been less impacted by the recession in 2001 than other industries, in part because its manufacture is principally geared toward the domestic market and not the export market.

Following anti-dumping tariffs imposed by the U.S. in 1989, exports from Mexico to the U.S. have also steadily risen, although they are still less than pre-1990 levels.

The number of plants has remained fairly steady. More than 90 percent of plants in Mexico use the more efficient, less polluting dry process to produce cement as it is a relatively young industry compared to Canada and the U.S.

Table 20. No. of Plants, Kilns, Production Capacity, Annual Production and Exports to the U.S. in Thousand Metric Tons in the Mexican Cement Industry, 1990 – 2001

Year	No. of Plants	Annual Production	Exports to U.S.
1990	29	23,824	363
1991	29	25,093	47
1992	29	26,886	824
1993	35	27,506	783
1994	35	30,029	640
1995	35	23,971	850
1996	35	25,365	1,272
1997		27,548	995
1998		27,744	1,280
1999		29,413	1,286
2000		31,677	1,409
2001	30	29,966	1,645
% Change 1990-2001	3.4%	25.78%	353.17%
% Change, 1993-2001	13.4%	8.94%	110.09%

Source: INEGI, Estadísticas Históricas de México; INEGI: Principales Actividades Humanas Vinculadas con el Medio Ambiente; and USGS, U.S. Bureau of Mines, USGS, “Cement” Chapter in Minerals Yearbook, Annual, 1991 – 2001, Tables 1, 18 and 21.

4.2.2 Ownership and Investments of the Mexican Cement Industry

Currently there are 30 cement manufacturing plants in Mexico owned by six different companies. The leaders are CEMEX, with 15 cement manufacturing plants, and APASCO. CEMEX is a wholly-owned Mexican private company and has today become the third largest cement manufacturing company in the world, with plants in Mexico, the United States, Spain, Egypt, the Phillipines, Indonesia, Thailand and various countries in Central and South America. The second largest, Holderbank, a Swiss Company is the parent company of Cementos Apasco. Another of the world’s largest cement companies – Lafarge – recently acquired one cement manufacturing plant in Mexico. The three other companies are more regional in nature. Cementos Cruz Azul is a cooperative with three plants, Grupos Cemento Chihuahua – itself partially owned by CEMEX -- has three plants in Chihuahua (and two in the U.S. with a third planned), while Cementos Moctezuma has two plants near the capital city. In general these plants are designed to serve the local Mexican demand for cement, although both CEMEX and GCC have exported significant amounts of cement to the U.S. in recent years.

Table 21. Mexican Cement Plants and Capacities, 2001

Company	Number of Plants	Total Capacity, Thousand Metric Tons, 2000
CEMEX	15	27,200
Cementos Apasco	6	8,912
Cementos Cruz Azul	3	1,000
Grupo Cementos Chihuahua	3	1,925
Cementos Moctezuma	2	2,950
Lafarge Cementos	1	NA
Total	30	41,987

Source: CANACEM,

4.2.3 Mexican Cement Industry Investment in the U.S. Market

In recent years, some Mexican companies have begun to invest in the United States. According to CANACEM, the Cement Association in Mexico, part of the rationale has been the high anti-dumping tariffs imposed by the U.S. on Mexican cement products, making exports costly. Instead, both CEMEX and Grupo Cementos Chihuahua have become major participants in the U.S. market.

Currently, CEMEX owns 12 plants in the U.S., largely due to the purchase of Southdown in 2000, as well as having minority ownership in 4 other U.S. plants. In fact, the U.S. ranks a close second to Mexico in terms of total investment, sales and infrastructure. Similarly, Grupo Cementos Chihuahua has also purchased several cement plants in recent years, and is planning the building of a dry kiln coal-burning plant outside of Pueblo, Colorado. In fact, if the plant is built, the company will have a larger production capacity in the U.S. than in Mexico.

Table 22. Comparison of CEMEX investments in U.S. and Mexico, 2001

	Annual Production Capacity (million metric tons)	Wholly-Owned Cement Plants	Minority-Owned Cement Plants	Concrete Batch Plants	Distribution Centers	Maritime Terminals
Mexico	27.2	15	3	211	62	8
U.S.	13.2	12	4	87	48	4
Total World	79.5	51	17	456	175	54

Source: CEMEX, Annual Report 2001.

Table 23: Grupo Cementos Chihuahua Investments in the U.S.

Cement Plants	**Production Capacity (metric tons)**
Tijeras, Nuevo México	450,000
Rapid City, Dakota del Sur	950,000
Pueblo, Colorado (2003)	1,000,000
Total in 2003	2,400,000

Source: Grupo Cementos Chihuahua, 2001 Annual Report

Not surprisingly, because of the purchases of plants in the U.S., both companies have increased their sales significantly in recent years. For example, Grupo Cementos Chihuahua more than doubled sales in the U.S between 1997 and 2001 according to its annual report. Most of this was due to U.S. production, although about 500,000 metric tons was also exported in 2001. Similarly, in the case of Cemex, the rate of increase in sales in the United States outstripped the rate of increase in sales in Mexico. Again, most of this is due to the purchase of Southdown facilities at the end of 2000, more than doubling CEMEX's U.S. production capacity.

Table 24. GCC and CEMEX Cement Sales in U.S. and Mexico, 1997 - 2001

Grupos Cementos Chihuahua/ Thousands of Metric Tons	**% Change, 97-2001**	**2001**	**2000**	**1999**	**1998**	**1997**
Total Sales U.S.	100.22%	1,820	978	937	1,034	909
Sales in Mexico	**36.39%**	**877**	**848**	**743**	**773**	**643**
CEMEX / millions of dollars	**% Change, 97-2001**	**2001**	**2000**	**1999**	**1998**	**1997**
Sales in Mexico	23.99%	**2,682**	**2,702**	**2,332**	**1,952**	**2,163**
Sales in U.S	70.35%	**1,872**	**769**	**597**	**541**	**555**

Source: CEMEX, Annual Report 2001 and Annual Report 1999; Grupos Cementos Chihuahua, Annual Report 2001.

4.2.4. Energy and Fuel Use in the Mexican Cement Industry

As total production has increased during the 1990s, so has electricity and fuel use in the Mexican cement industry. According to INEGI, the cement industry,

- Became the 4th largest industrial consumer of electricity in 1997, as total purchases of electricity rose from 452 million pesos to 920 million pesos between 1995 and 1997.
- Became the 2nd largest consumer of fuels and lubricants, as fuel purchases rose from more than 869 million to 1,908 million pesos between 1995 and 1997.
- Became the No. 1 consumer of fuel oils among Mexican industries.

Table 25. Purchases of Electricity and Fuels in the Mexican Cement Industry, Thousands of Pesos

Industry	**1995**			**1997**		
	No. of Facilities	**Electricity**	**Fuels and Oils**	**No. of Facilities**	**Electricity**	**Fuels and Oils**
Hydraulic Cement Production	35	452 514	869 730	35	920 671	1 908 379
All Manufacturing Industries	**6 783**	**6 844 545**	**7 104 619**	**6 439**	**13 303 359**	**13 818 582**

Source: INEGI, **Encuesta Industrial Anual 1995** y **1997**, México, 1999.

While the total amount of energy and fuel used has increased along with production, there has been a gradual decline measured in input per ton of clinker produced as the industry has become more efficient in total energy use. There has also been a corresponding switch in fuel use. In the 1980s, most cement kilns in Mexico burned fuel oils to turn their raw material into cement clinker. In the last several years, a number of plants have suddenly switched from fuel oils to petroleum coke, and these and plants have begun using a greater percentage of alternative fuels. Despite the presence of one large plants – Samalayuca – which relies almost exclusively on natural gas, total use of natural gas has actually declined over the last five years. In fact, the Samalayuca plant has recently been outfitted to be able to burn coal, petroleum coke and natural gas, and has also been exploring the use of tires (GCC Annual Report 2001). All of these other sources of fuel are likely to increase global gas emissions and toxic releases.

Table 26. Fuel Use by Type in the Mexican Cement Industry, 1990 – 2001 (in TJs)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001p	1993-2001
TOTAL INDUSTRY	1,216,839	1,243,677	1,233,960	1,259,681	1,203,924	1,255,447	1,282,543	1,288,467	1,320,649	1,242,095	1,273,933	1,166,285	(7.41%)
	0	0	0	0									
CEMENT	100,532	104,872	112,643	110,856	106,412	90,463	95,997	95,088	103,720	95,177	115,694	113,257	2.17%
Solid Fuels	0	0	0	0	0	0	0	0	0	0	23,312	34,188	
Pet Coke	0	0	0	0	0	0	0	0	0	0	23,312	34,188	
Liquid Fuels	79,599	83,261	85,872	85,466	82,027	69,753	73,914	73,214	78,420	69,800	70,510	59,153	(30.79%)
Liquid Gas	0	0	0	0			0	0	0	0	0	2	
Diesel[a]	1,000	0	0	0			0	0	0	0	0	309	
Fuel Oils	78,598	83,261	85,872	85,466	82,027	69,753	73,914	73,214	78,420	69,800	70,355	58.842	(31.15%)
Natural Gas	11,567	9,927	14,819	13,070	10,521	9,977	10,268	10,171	11,370	10,973	7,968	6,383	(51.16)%
Electricity[b]	9,366	11,685	11,952	12,321	13,864	10,733	11,815	11,703	13,930	14,404	13,904	13,533	9.84%

Notes: p Preliminary Figures

[a] Includes Industrial Diesels

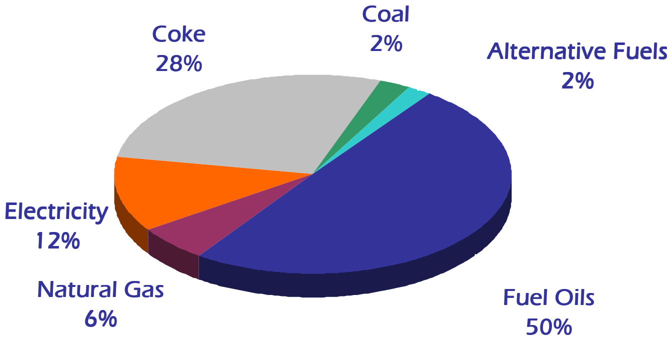
[b] Excludes cogeneration

Also excludes alternative fuels such as tires and hazardous wastes, which have been estimated at 1 percent in 1994 and 2 percent in 2000 of total fuel burned.

A small amount of coal has been burned at cement plants in recent years and is also excluded from the table.

Source: INEGI, El Sector Energético. Mexico. 1995, 2000 and 2002 (available at http://www.inegi.gob.mx/difusion/espanol/bvinegi/secener/secener02.pdf)

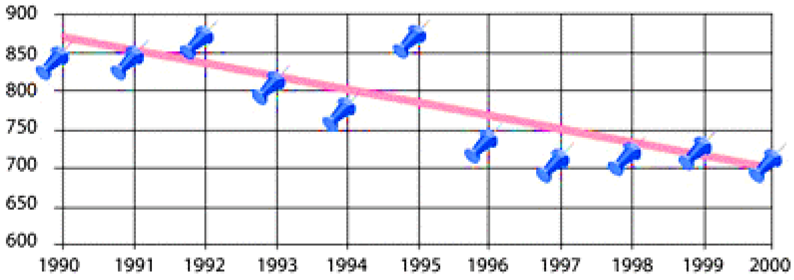
Figure 2. Energy Use by Fuel Type in Mexican Cement Industry, 2001



Source: CANACEM, Contribución de Industria de Cemento a la Gestión de Residuos, 2002.

Given the high and growing amounts of electricity and fuels purchased by the Mexican cement industry, it is not surprising that the industry has placed significant investments in becoming more energy efficient while also exploring a diversity of different fuels to meet their energy needs. Energy costs in the Mexican cement industry generally make up between 30 to 40 percent of production costs. It is for this very reason that over the last decade the industry has explored the use of both petroleum coke and alternative fuels to make clinker. As the following graphs shows, the average amount of energy used to produce cement has declined nearly 20 percent over the last decade, according to the Mexican Cement Association.

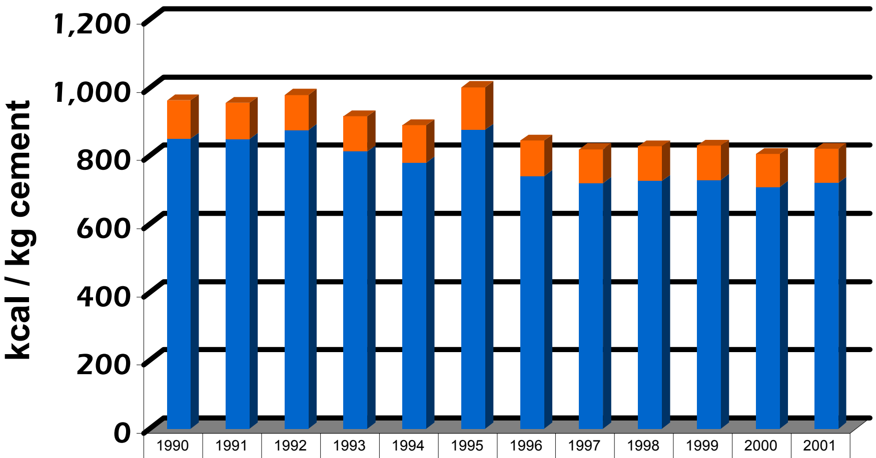
Figure 3. Thousand Calories Consumed in Fuel Use per Kilogram of Cement, 1990-2000



Source: CANACEM, found at http://www.canacem.org.mx/desarrollo_desarrollo.htm

Figure 4.

Total Energy Used in Mexican Cement Industry in Kcal per Kg of Cement Produced, 1990-2001



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
🟧 ELECTRICIDAD	112	106	104	102	110	124	104	100	101	101	97	99
🟦 E. TERMICA	851	849	875	813	780	877	741	720	727	729	709	721

Electrical energy is used principally to crush and grind the raw materials in the finishing mills, as well as to mix the clinker with other materials into cement. Thus, these pre-kiln and post-kiln processes make up aproximately 75 percent of the electricity consumed in the industry. Still, while there has been important gains in electricity efficiencies in the Mexican Cement Industry, the most important gains have been efficiencies in the kiln process itself with the amount of fuels and heat input to turn the raw materials into clinker.

Still, the gains made throughout the early and mid-1990s have slowed, and in recent years, there appears to be a slight decrease in energy efficiency. This is in part due to the increased use of petroleum coke, which burns hotter than most fuel oils.

Year	**Mexican Energy Consumption (TJs) (1))**	**Mexican Estimated Energy Efficiency (TJs per Thousand Metric Tonne)**
1990	100,532	4.22
1991	104,872	4.18
1992	112,643	4.19
1993	110,856	4.03
1994	107,554	3.58
1995	91,593	3.82
1996	98,452	3.88
1997	96,609	3.51
1998	105,235	3.79
1999	96,890	3.29
2000	118,284	3.73
2001	116,164	3.88
1993-2000 % Change	**6.70%**	**-7.44%**

(1) To account for use of alternative fuels in total for Mexico, between one and two percent were added to Mexican totals between 1994 and 2001, based upon data provided by the Mexican Cement Association. While some alternative fuels were in use in Mexico since 1991, the amounts were less than one percent of total energy consumption.

The cement industry has taken a number of steps to increase access to electricity and to diversify its fuel base:

- ***Cemento Apasco*** for example has gradually reduced its use of fuel oils and switched to petroleum coke, increasing its use of petroleum coke from 27 percent to 33 percent between 1999 and 2000. In addition, it has engineered a number of contracts to receive electricity, including with Mexicana de Hidroelectricidad Mexhidro, S.A. de C.V.[25]; Enron Energía Industrial de México[26]; and Iberdrola Energía Monterrey, S.A. de C.V.
- ***CEMEX*** has slowly converted 11 of its 15 plants from fuel oil to petroleum coke, because of its more stable price and less volatile make-up. In fact, in just two years, the giant cement maker has switched from almost 70 percent fuel oils to 71 percent coke. In addition, it has signed contracts to generate its own electricity with Termoeléctrica del Golfo, S.A. de C.V[27]; Iberdrola Energía

---

[25] http://www.cre.gob.mx/diario_oficial/avisos99/012_030399.pdf

[26] Enron Energía Industrial de México. Proyecto de cogeneración de 284 MW para el suministro de vapor y energía eléctrica a la empresa Vitro, tanto para su planta en Monterrey, Nuevo León, como a otras centros industriales de Vitro y de otras empresas ubicados en diferentes puntos del país. Enron es la empresa desarrolladora. La planta consumirá gas natural y se tiene prevista su operación comercial para octubre de 2002. El 2 de junio de 2000 le fue otorgado el permiso de cogeneración por la CRE. Enron solicitó asistencia financiera al Banco Interamericano de Desarrollo (BID). Enron traspasó sus contratos a la empresa franco-belga Tractebel

[27] http://www.cre.gob.mx/boletines/1996/bol14.pdf

Monterrey, S.A.[28];, and signed a natural gas contract with Gas Natural de Mérida, S.A. DE C.V[29]

- ***GRUPO CEMENTOS CHIHUAHUA*** has reached agreement for electricity generation with Iberdrola Energía Monterrey, S.A.[30]. In addition, they made significant investments in both the Chihuahua Plant and Samalayuca Plant so that it could have the flexibility of burning coal, fuel oils or natural gas. In essence, despite the fact that the Samalayuca Plant has been burning nearly 100% natural gas, GCC recognizes that it needs flexibility to burn other fuels in the event of a price hike (GCC, Annual Report 2001).
- ***CEMENTOS PORTLAND MOCTEZUMA*** has a contract with Mexicana de Hidroelectricidad Mexhidro, S.A. de C.V. to provide electricity to its plant[31]
- ***COOPERATIVA CRUZ AZUL*** also has a contract with both Mexicana de Hidroelectricidad Mexhidro, S.A. de C.V. and Fuerza Eólica Del Istmo, S.A. De C.V.[32]

Table 28. Fuel Use in CEMEX Plants, 1999-2002

	1999	2000	2001
Fuel Oils	67%	44%	16%
Petroleum Coke	27%	47%	71%
Coal	2%	5%	5%
Natural Gas	3%	2%	6%
Alternative Fuels	1%	2%	2%

Source: CEMEX, Annual Report 2001, p. 31.

4.2.6 Use of Alternative Fuels in the Mexican Cement Industry

Beginning in the early 1990s, some cement manufacturers began to use “alternative fuels” in their kilns. Thus, both Cementos Apasco and CEMEX worked with hazardous waste management companies – with significant U.S. investment -- to create fuel blending facilities where hazardous and other wastes could be blended for their eventual use in cement kilns. In 1996, the Mexican Cement Association – CANACEM – the Cooperative Cruz Azul and Mexico’s federal environmental authorities – SEMARNAT – signed an agreement allowing the cement industries to “recycle” alternative fuels and industrial wastes.[33]: Under the agreement, these companies and others began pilot testing the use of such alternative fuels, conducting test burns and then receiving annual authorizations to burn the waste. Both CEMEX and APASCO even created their own fuel blending facilities. Currently, five of the six companies in Mexico are burning or have authorizations to burn hazardous wastes in approximately 30 plants and 60 kilns. All the kilns used for burning hazardous wastes are dry kilns, most of which are equiped with a precalcinator.

---

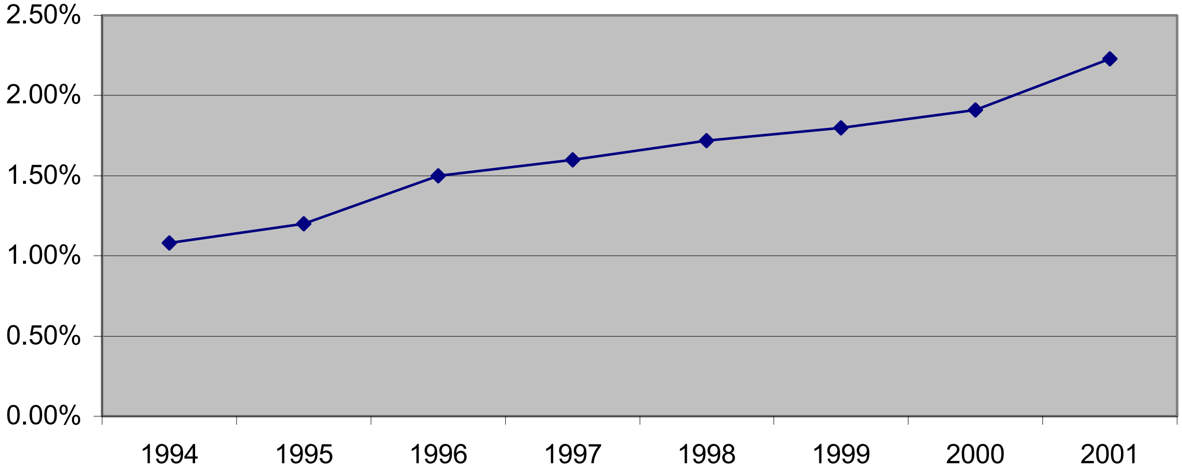
[28] http://www.cre.gob.mx/registro/resoluciones/2002/res-001.pdf
[29] http://www.cre.gob.mx/registro/resoluciones/2000/res227-2000.pdf
[30] http://www.cre.gob.mx/registro/resoluciones/2002/res-001.pdf
[31] http://www.cre.gob.mx/diario_oficial/avisos99/012_030399.pdf
[32] http://www.cre.gob.mx/boletines/1998/01_090198.pdf
[33] Documento de Canacem

Table 29. Cement Plants with Authorizations to Burn Alternative Wastes

Company	No. of Plants	Annual Production Metric tons/yr	Authorizations to Burn Alternative Wastes			
			State	Municipality	% Authorized	Authorized Kilns
Cementos Apasco	6	1,811,000	Estado de México	Apasco y Tlanepantla	10-30%	2
		1,179,000	Coahuila	Ramos Arizpe	10-30%	2
		1,866,000	Veracruz	Ixtaczoquitlán	10-30%	1
		582,000	Guerrero	Acapulco	10-30%	1
		2,426,000	Colima	Tecomán	10-30%	1
		1,048,000	Tabasco	Macuspana	5%	1
		TOTAL: 8.912,000				
CEMEX México	15		San Luis Potosí	Tamuín y Valles	5%	2
			Coahuila	Torreón	10-25%	1
			Hidalgo	Huichapan y Atotonilco	10-30%	2
			Estado de México	Barrientos	5%	1
			Nuevo Léon	Monterrey	5%	1
			Jalisco	Guadalajara y Zapotitic	5%	2
			Puebla	Tepeaca	5%	1
			Sonora	La Colorada y Hermosillo	5%	2
			Baja California	Ensenada	5%	1
			Yucatán	Mérida	5%	1
		TOTAL: 27,2000,000				
Grupo Cementos de Chihuahua	Me-xico 3	**900,000**	Chihuahua	Samalayuca	5%	1
		885,000	Chihuahua	Chihuahua		1
		140,000	Chihuahua	Ciudad Juárez		1
		TOTAL: **1,925,000**				
Cementos Portland Moctezuma	2	450,000	Morelos	Jiutepec	25%	1
		2,500,000	Morelos	Tepetzingo		
		TOTAL: **2,950,000**				
Cooperativa La Cruz Azul	3		Hidalgo	Cruz Azul, **Municipio de** Tula de Allende	10-30% 5%	2
			Oaxaca	Lagunas	10-30%	1
			Aguascalientes	Tepezalá		1
		TOTAL: **1,000,000**				

Fuente: Dirección General de Residuos, Materiales y Actividades Riesgosas. Dirección de Residuos Peligrosos. Instituto Nacional de Ecología. SEMARNAP, 2001/ Página Web de CANACEM / Documento de CANACEM

Figure 5. Use of Alternative Fuels in the Mexican Cement Industry, as % of Total



Source: CANACEM, Information provided to authors, February 2003.

Although authorizations to burn hazardous and other industrial wastes in cement kilns range from five to 30 percent of the total fuel burned, according to the Mexican Cement Association the actual substitution has ranged between one and three percent over the last five years. [34]. Some plants with authorizations have not yet burned hazardous or other wastes. Still, it is clearly a growing trend to burn alternative fuels in cement kilns in Mexico, and given increased generation of these wastes, it is likely to continue. Currently, for example, about 91,000 metric tons of alternative waste are burned in Mexico's cement industry, making it an important manager of off-site hazardous waste.

Table 30. Types of Fuels burned in Mexican Cement Kilns, 1994 – 2001

	1994	1998	2000	2001	2001, %	% Change, 94-2001
Liquid Alternative Wastes	30,000	38,250	43,581	48,532	30%	61.77%
Tires	8,000	13,500	23,160	21,254	13%	165.68%
Solid Alternative Wastes	3,200	10,000	11,090	21,262	8%	564.44%
TOTAL:	41,200	61,750	77,831	91,048	51%	120.99%

Source: CANACEM, Information provided to authors, February 2003.

According to the cement industry, over the last five years, over 322,000 tons of tires, liquid and solid industrial wastes have been recycled in cement kilns. In the process, nearly 193,000 tons of fuel oils have been "saved." In a single year, the use of alternative fuels has saved over 1.5 percent of the total heat input of the cement making

---

[34] CANACEM 2001. Información reportada a la Secretaría de Energía para la emisión anual del Balance Nacional de Energía. Referido en Documento de CANACEM.

process, equivalent to gasoline use of 125,000 cars over an entire year. In essence the use of alternative fuels has allowed the cement industry to save money and fuel

Table 31. Wastes Utilized in Mexican Cement Kilns

Liquids	Solids	
Used Oils and Solvents	Resins	Contaminated Solids
Fondos de columnas de destilación	Textiles	Tires
Paints, Thiners, Varnishes	Leather	Contaminated Soils
Contaminated Hydrocarbons	Rubber	Used Catalytic Converters
Greases and Waxes	Plastics	
Organic and Refining Sludge	Woods	
Recortes de perforación	Papers	
Source:Instituto Nacional de Ecología		

In the process, the cement industry has become one of the leading “recyclers” of hazardous waste in Mexico. It is estimated that the cement kilns authorized to burn industrial wastes represent about 50 percent of all capacity to “recycle” hazardous wastes and about 20 percent of the total capacity to manage hazardous waste in Mexico (see table).

Table 32. Installed Capacity to Recycle Hazardous Waste in Mexico, 2000

Type of Facility	**Installed Capacity (metric tons/year).**
Used Oil Recycling	116,181
Used Solvents	197,369
Liquid Photography Recycling	5
Textile Recycling	300
Metal Recycling	504,913
Used Drum Recycling	44,863
Paints	17,655
Others	3,668
Energy Recycling (*)	**1'249,841**
TOTAL	2'134,795
(*) Fuel Blending	**806,756**

Source: Instituto Nactional de Ecología, July 2000.

The cement industry argues that both the high temperatures in the kilns (above 2000ºC); the long duration of time of the fuels within the kilns (3 seconds at more than 1200 ºC); as well as the highly turbulent nature of the process permits alternative fuels to be used in a controled, safe fashion. Nonetheless, there is currently a lack of information about the types of emissions and the impact they might have on human health and the environment. In addition, it is unclear whether the added burning of these industrial wastes could lead to higher levels of metals or organics in the clinker itself or cement kiln dust, or what the impacts of these might be. The next section discusses the possible impacts on air emissions of the burning of both conventional and alternative fuels in Mexico

4.2.7 Air Emissions in the Mexican Cement Industry

With the publication in December of 2002 of the official standard –known in Spanish as NOM-040-ECOL-2002 – Mexico established maximum emission limits for particulate matter, nitrogen oxides, sulfur dioxide, carbon monoxide, heavy meatls, dioxins and furans, total hydrocarbons, and hydrochloric acid. Despite these new emission standards – which establish standards for the clinker process, as well as the grinding of raw materials and the mixing of cement -- there has not been sufficient public analysis and assessments that allow any conclusions about the impact of using different fuels – including hazardous wastes – on atmospheric emissions.

As in the U.S. and Canada, there is little public information on the greenhouse gas emissions of the cement industry in Mexico. CANACEM – the Mexican Cement Association – argues that emissions are the same and in some cases improve with the use of hazardous wastes over conventional fuels. They point out that because the cement industry only uses dry kilns – a more efficient, cleaner process – and because they do not accept certain wastes – such as those with high levels of chlorine including PCBs and certain pesticides – dioxin and furan emissions are relatively low compared to dioxin emissions in the U.S. cement industry, whether or not they burn hazardous wastes.

In determining the amount of dioxin and furan emissions from cement kilns, CANACEM uses a different emission factor than does the U.S. Environmental Protection Agency. The EPA estimates an emissions factor of 28.58 ng TEQ/kg of clinker for kilns whose flue gas temperature at the inlet to the dust collection system (particulate matter control device) are above 450ºF (232ºC)[35]. CANACEM, on the other hand, points out that all the kilns in Mexico have much lower flue gas temperatures, averaging 130 ºC or almost 100 ºC less at the point where the flue gas enters the dust collection device[36]

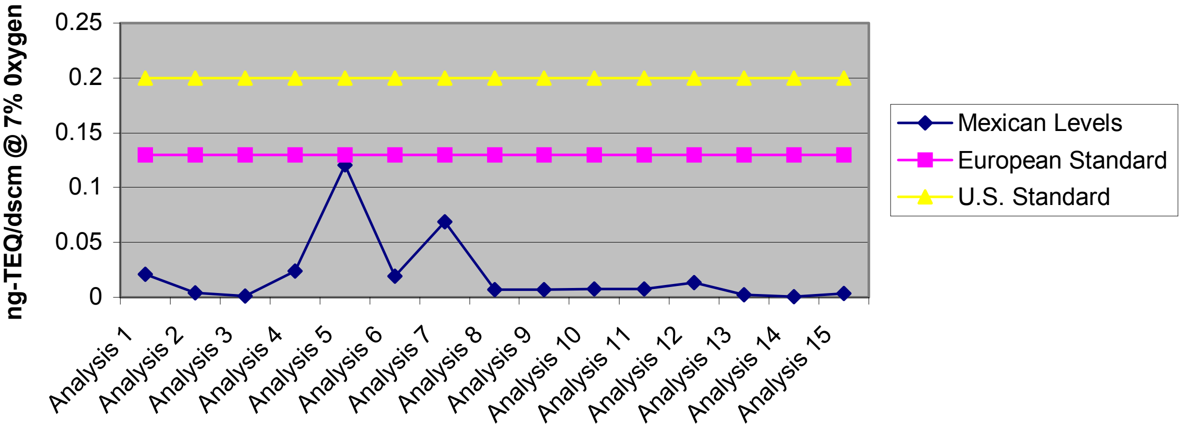
Between 1995 and 2001, CANACEM tested eight kilns for dioxin emissions and found emission factors of 0.052 ng TEQ/kg of clinker, with a maximum value of 0.2705 ng TEQ/kg clinker, less than the proposed standard of 0.29 ng TEQ/kg clinker.

---

[35] "5. Combustión Sources of CDD/CDF: Other High Temperatura Sources. 5.1. Cement Klins And Lightweight Aggregate Lightweight Agrégate Kilns". http://www.epa.gov/ncea/pdfs/dioxin/part1/volume2/chap5.pdf (no citar referencia)

[36] Documento de Canacem

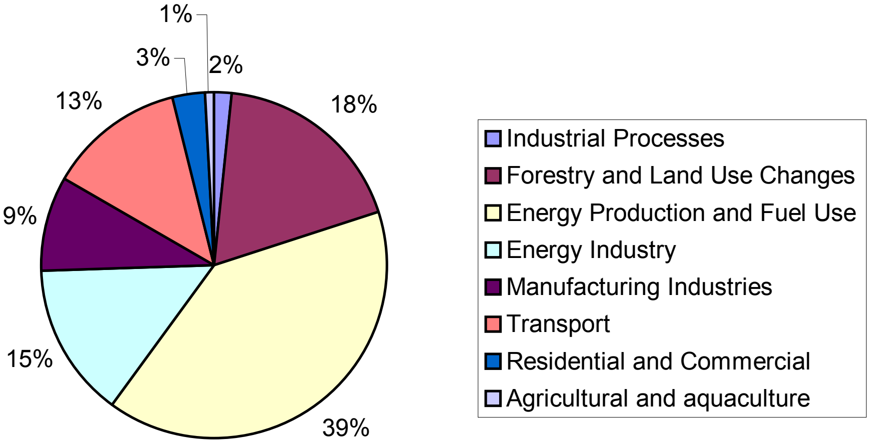
Figure 7. Reported Dioxin Emission Rates at Eight Mexican Cement Kilns, 1995-2001



Based on these eight tests, CANACEM estimated that the total air emission of dioxins would have been 1.42 grams in 2000 or only 0.3% of emissions from all sources in Mexico and a tiny percentage of the reported 450 grams of dioxin and dioxin-like substances from cement kilns in the U.S.

While detailed measurements of carbon dioxide emissions have not been made in Mexico, the manufacturing industries – including cement manufacturing – were estimated to contribute about 15 percent of all greenhouse gases in 1990, or about 65 million metric tons. Given the current switch from fuel oils to petroleum coke – which generally has the highest carbon equivalency rates of traditional fuels-- and increasing production levels, it could be expected that greenhouse gases are increasing from the cement industry. CEMEX is one of several companies which has promised to have a publicly available database of its greenhouse emisisons by 2006.

Figure 8. Mexican Carbon Dioxide Emissions by Source, 1990



Source: Semarnap, Instituto Nacional de Ecología, 1999, available at (http://www.semarnat.gob.mx/estadisticas_ambientales/estadisticas_am_98/atmosfera/atmosfera04.html)

In addition the cement industry is also a leading emitter of criteria air pollutants like particulate matter, sulfur dioxide, carbon monoxide and nitrogen oxide. However, no recent publicly available data on emissions at a disaggregated level is available to compare trends.

4.3. Environmental Regulations in the Cement Making Process in Mexico

The Mexican government has been promoting the use of alternative fuels, first through test burns in the early 1990s followed by temporary authorizations and then through the 1996 agreement with the cement industry, an agreement that was resigned in 2001. As such, since Mexican cement kilns began burning alternative fuels in the early 1990s, they have done so with individual agreements reached with federal authorities on a temporary basis. There have been no official industry-wide emission standards, other than one for particulate matter. However, after a previous proposed standard was shelved due to opposition from the cement industry, in December of 2002, the Mexican government published and approved a new standard which establishes maximum permissible emissions for the cement industry, including those that burn hazardous wastes. The standard -- NOM-040-ECOL-2002[37] -- establishes maximum emissions of particulate matter, nitrogen oxides, sulfur dioxide, carbon monoxide, dioxin and furans, total hydrocarbons and hydrochloric acid. The NOM specifically excludes certain fuels from being used by the cement industry, incuding pesticides, dibenzofurans, PCBs, dioxins, radioactive waste, compressed gases, medical waste, and organochloride compounds among others. The emissions levels are comparable to those established in the EPA's MACT standard for portland cement plants, including those that burn

---

[37] http://www.semarnat.gob.mx/dof/diciembre02.shtml

hazardous wastes, although they are not as stringent as proposed European Union standards.

By establishing the same standards for both those factories that burn hazardous wastes and those that do not, the standard states that "*the recuperation of energy from wastes does not substantially modify emissions from the cement industry compared to those using conventional fuels*." In fact, the only change in the standard is in the frequency with which the industry is required to measure its emissions. Thus, measurements of dioxins and furans are only required once every two years, unless more than a certain percentage of alternative fuel is used. Nonetheless, and despite some analysis and samples from the National Cement Industry Chamber (CANACEM), there is still no publicly available toxic or emissions database proving this statement.

One promising development is the recent passage of ammendments to the main environmental law in Mexico, the LGEEPA, or "General Law on Ecological Equilibrium and Environmental Protection." These amendments include for the first time the requirement of an obligatory Pollutant Release and Transfer Registry (PRTR or RETC in Spanish), similar to the Toxic Release Inventory in the U.S.. The change will require manufacturing facilities and hazardous waste management facilities in Mexico to report toxic releases, air emissions, hazardous waste generation and wastewater discharges to a publicly accessible database. In the past, this reporting has been voluntary and few companies have participated. While the rules and regulations governing the new law are still being implemented, having publicly available data on pollution in Mexico is a positive step since NAFTA and a direct result of both pressure by civic organizations and by the NAFTA side agreement.

The following tables show the maximum emission levels established in the new NOM.

TABLE 33.- Maximum Emissions Levels of Particulate Matter

OPERATION	MAXIMUM EMISSION LEVEL	MEASUREMENT FREQUENCY
Grinding (1)	80 mg/m^3	ANNUAL
Milling raw materials (1)	80 mg/m^3	
Milling Hydrualic Cement (1)	80 mg/m^3	
Cooling of Clinker (1)	100 mg/m^3	
Calcination of Clinker (2)	0,15 * C kg of particulate matter/ton de raw material feed	

(1) Normal conditions, dry base, based on 7% oxygen (O_2) en volume.

(2) If C is the quantity of material feed to the kiln, in tons per hour dry base, the maximum emissions level will be 0,15 * C (kg/h).

TABLE 34.- MAXIMUM EMISSION LEVELS FOR GASES (1)

Pollutant	**White Portland Cement mg/m^3**			**Grey Portland Cement mg/m^3**			**MEASUREMENT FREQUENCY**
	Mexico City Areas	Urbanized Zones	Rest of Country	Mexico City Areas	Urbanized Zones	Rest of Country	ANNUAL
Sulfur Dioxide	400	2200	2500	400	800	1200	
Nitrogen Oxides(2)	800	1400	1600	800	1000	1200	
Carbon Monoxide	3000	3500	4000	3000	3500	4000	

(1) Normal conditions, dry base, based on 7% oxygen (O_2) en volume.

(2) Measured as Nitrogen Oxide.

TABLE 35.- COMPLIANCE LEVELS, TYPE AND VOLUME OF ALTERNATIVE FUELS

Substitution of Conventional Fuels * (%)	**TIRES**	**RECOVERED FUELS**	**BLENDED FUELS**
0 a 5	Level 0	Level 0	Level 1
5 a 15	Level 1	Level 1	Level 2
15 a 30	Level 1	Level 2	Level 3
> 30	Level 2	Subject to Testing	

- Maximum substitution at any one time compared to calories of conventional fuels.

-

TABLE 36.- Maximum Air Emission Levels (1)

PARAMETER	EMISSION LIMITS mg/m^3	MEASUREMENT FREQUENCY	
		Level 2	Level 3
CO (2)	Table 31	Annual	Continuous
HCl	70	Biannual	Continuous
NOx (2)	Table 31	Annual	Continuous
SO_2 (2)	Table 31	Annual	Continuous
HCt (como CH_4)	70	Biannual	Continuous
Particulates	Table 30	Annual	Annual
Sb, As, Se, Ni, Mn	0.7 (3)	Anual	Biannual
Cd	0.07	Anual	Biannual
Hg	0.07	Anual	Biannual
Pb, Cr, Zn	0.7 (3)	Anual	Biannual
Dioxin and Furans	0.2 (ng EQT/m^3)	Every Two Years	Annual

(1)Normal conditions, dry base, based on 7% oxygen (O_2) in volume.

(2) Depending on location of facility.

(3) Sum total of heavy metals.

Source for tables: NOM-040-ECOL-2002, available at http://www.semarnat.gob.mx/dof/diciembre02.shtml

4.4 International Regulations: The Stockholm Convention

The Stockholm Convention is an international agreement promoted by the United Nations and ratified both in Canada and Mexico, but not in the U.S. The stated goal of the Convention is to reduce and ultimately eliminate the production of POPs – Persistant Organic Pollutants – worldwide. Article 1 of the Convention states “the objective of the present Convention is to protect human health and the environment” from such pollutants.[38]

Although Mexican authorities have ratified the Convention, there is not currently a federal environmental policy that actually implements what is contained in the

---

[38] http://www.pops.int/documents/convtext/convtext_sp.pdf

Convention; In fact, the environmental authorities have become promoters of incineration technologies, without mechanisms or regulations obligating adequate monitoring and control of dioxins and furans, nor mechanisms for citizen participation and pollution prevention.

STOCKHOLM CONVENTION ON PERSISTENT ORGANIC POLLUTANTS

ANNEX C PART II

Categories of Sources

The following industrial sources have the potential to form and emit relatively high levels of these chemicals to the environment:

a) Waste incinerators, including municipal, hazardous and medical incinerators;

b) Hazardous wastes burned in cement kilns;

c) Celulose and paper productions facilities which use chlorine or other chemical products that produce chlorine as part of the whitening process;

d) The following metalurgical processes:

- i) Copper Smelting Production;
- ii) Synterization Plants in the Iron or Steel Industries;
- iii) Aluminum Smelting Production ;
- iv) Zinc Smelting Production.

Source: http://www.pops.int/documents/convtext/convtext_sp.pdf

In part of the convention, it indicates that each country should evaluate emissions from a variety of potential sources of POPs, including the cement industry. Nonetheless, up to now there does not appear to be a committment to evaluate emissions, and the recently approved standard requires virtually no monitoring of dioxins and furans. In addition, the new laws and regulations actually promote incineration of toxics as an acceptable waste management option.

In addition, the Stockholm Convention states the need to promote government education, training and public outreach about efforts to minimize or eliminate POPs, promoting cleaner technologies, and enacting an action plan to permit citizen participation and increase access to environmental information.

The lack of publicly accessible information and monitoring requirements for dioxin, furans and other POPs potentially released by the Mexican cement industry continues to be a concern for citizens and public interest organizations. This concern is increased by the continued and increasing use of alternative fuels, where evidence from the U.S. experience indicates increasing toxic emissions. In addition, the cement industry, academics, CENICA – an environmental testing lab – and federal environmental authorities still have not reached agreement on establishing real and verifiable emission factors.

4.5 CONCLUSIONS

Cement production in Mexico has been fairly level throughout the 1990s, first rising, the falling with the contraction of the economy in 1995, and then rising again. While a small part of this overall rise in production is due to exports, the high tariffs on Mexican cement and the growing demand in Mexico have kept most production from Mexican plants within Mexico. At the same time, two of Mexico's companies – GCC and CEMEX – have made major investments directly in the U.S. in the last few years, significantly increasing their presence and production capacity there.

Since 1990, the cement industry in Mexico has become more efficient in its use of electricity and fuel by making major investments in its production process. All currently operating kilns in Mexico use a dry process, and most have preheaters and precalcinators, the most efficient processes. At the same time, there has been an increasing trend in diversification of fuel, from fuel oils to coal, petroleum coke and increasingly, alternative fuels including tires and solid and liquid hazardous waste. While the switch to petroleum coke has to do with both price and the less volatile nature of the quality of the fuel, the switch to hazardous wastes, albeit it small, is principally to save money or receive payment for hazardous waste management, not to become more efficient in cement production.

Whether or not this switch to petroleum coke, coal and alternative fuels has impacted total atmospheric emissions, transfers, generation of waste and disposal is unclear because environmental information is partial and aggregated. Clearly, the increased use of petroleum coke is likely leading to higher global gas emissions. The recently approved change forcing companies to report their toxic and criteria air emissions and generation of wastes could eventually help shed some light on the environmental impacts, but for the moment the information is confidential or not even reported.

The fact that the cement industry – on a production basis – has reduced the use of fuels and electricity over the last decade does not mean that it does not continue to generate emissions of dusts, dioxins, furans, heavy metals and other chemical compounds. Whether or not the incineration of hazardous wastes has increased these emissions – as it appears to have done in the U.S. – is still open for debate. The fact that Mexico finally has adopted a standard – after ten years without one even as more and more hazardous waste was burned – does not mean that the "controled" emissions of these pollutants does not harm human health or the environment. There is still no way to compare which types of fuels in Mexico generate the most emissions, or rather the use of hazardous wastes as an additive in the fuel mix increases emissions. And disturbingly, the standard only requires minimal measurements of most pollutants, meaning that there will be little information on whether the industry is actually complying with the new standard.

5.0 The Canadian Cement Industry

5.1 Introduction

This section provides an overview of trends in production, exports, energy sources and usage and pollutant releases by the Canadian cement industry, as well as providing an overview of the regulatory regime in Canada regarding the use of waste fuels in the cement industry.

5.2 An Overview of Trends in Production, Exports, Energy Sources and Pollutant Releases.

5.2.1. Cement Production and Shipments

Table 37 shows production, shipments and total sales of cement (masonry and Portland) in Canada from 1989 to 2001. As the information in the table demonstrates, after a sharp decline, there has been a fairly significant increase in production, shipments and sales of cement since 1992. Also worth noting is that the largest increase in sales that occurred since 1993, took place in 1994, the year that the North American Free Trade Agreement (NAFTA) came into effect.

Table 34. Cement Production and Shipments, 1989 to 2001, Kilotonnes

YEAR	PRODUCTION	SHIPMENTS	TOTAL SALES*	ANNUAL CHANGE
1989	11,746	10,614	12,375	
1990	11,083	10,953	11,554	-7%
1991	9,446	9,409	9,650	-16%
1992	8,612	8,594	9,036	-6%
1993	9,284	9,393	9,721	8%
1994	10,457	10,584	11,004	13%
1995	10,600	10,442	10,762	-2%
1996	11,003	11,216	11,605	8%
1997	11,790	11,725	12,041	4%
1998	12,168	12,578	12,307	2%
1999	12,643	12,626	12,046	-2%
2000	12,753	12,612	12,854	7%
2001	12,793	12,985	13,161	2%
Change 93 to 00	38%	38%	35%	

*Includes imports
Source: Statistics Canada Table 303-0001

5.2.2 Canadian Cement Exports

Table 38 shows exports of cement from Canada for 1989 to 2000. Exports increased substantially between 1992 and 2000. This increase is totally attributable to Portland cement. As was the case with total sales, the largest increase in exports occurred between 1992 and 1994, indicating that demand in the U.S. has a direct impact on Canadian production.

Table 38. Canadian Cement Exports, 1989 to 2001, Kilotonnes

YEAR	PORTLAND	MASONRY	TOTAL	ANNUAL CHANGE
1989	3,005	66	3,871	
1990	2,883	33	2,916	-5%
1991	2,633	35	2,669	-8%
1992	2,321	32	2,353	-12%
1993	3,069	273	3,096	32%
1994	3,776	278	3,803	23%
1995	3,799	315	3,831	1%
1996	4,285	547	4,339	13%
1997	4,383	299	4,413	2%
1998	4,667	267	4,693	6%
1999	4,010	275	4,037	-14%
2000	4,557	260	4,583	14%
2001	4,721	267	4,748	4%
% Change 93 to 00	54%	-2%	53%	

Source: Statistics Canada Catalogue No. 44-001, 1993 to 2001.

5.2.3. Cement Industry Plants and Employees

Table 39 below shows that as production, shipment, sales and exports have increased, so too have the number of cement establishments in Canada, from 22 in 1993 to 28 in 1999. In contrast to this, the total number of employees working in the cement industry in Canada declined between 1993 and 1999 by 9%.

Table 39. Cement Industry Establishments and Employees, 1993 to 1999

YEAR	NUMBER OF ESTABLISHMENTS	TOTAL EMPLOYEES (PERSONS)
1993	22	2,802
1994	22	2,793
1995	X*	2,815
1996	X*	2,710
1997	25	2,572
1998	30	2,686
1999	28	2,565
Change 93 to 99	20%	-9%

X* data not available due to confidentiality concerns.
Source: Statistics Canada Table 301-0003

5.2.4 Fuel Consumption in the Canadian Cement Industry

The Canadian cement industry consumed roughly 2.5 percent of all energy in the manufacturing and mining sectors in 2000 (Nyboer, John, CIEEDAC, Development of Energy Intensity Indicators for Canadian Industry, 1990 to 2000, March 2002, Appendix). Table 40 shows fuel consumption by the Canadian cement industry between 1990 and 2000. The figures indicate that in the early 1990s, there was a general decrease in the amont of fuel consumed by the industry because of decreased production. However, since 1993, there has been a general increase in the amount of fuel consumed by this industry, from 53,215 TJ in 1993 to 64,043 TJ in 2000. That is a 20% increase in total fuel consumption. Coal is the dominant fuel used by the cement industry, with natural gas a distant second. Coke produced from coal has also increased over the time period. Also worth noting is the increase in consumption of wood waste and waste fuels. Wood waste increased from zero TJ in 1993 to 35 TJ in 2000. Similarly, consumption of waste fuels increased by 46% between 1993 and 2000. Still, waste fuels make up a small percentage of total energy use in the industry, with the highest percentage – nearly nine percent of the total – in 1999.

Table 41 shows a provincial breakdown of fuel consumption for the cement industry in Canada. Note that only Ontario and Quebec are included in the table due to confidentiality concerns with other regions that produce cement. Together, Ontario and Quebec make up a significant portion of total fuel consumption in Canada by the cement industry, ranging from 63% to 68% of total consumption over the study period. It is interesting to note that fuel consumption in Quebec in 2000 is virtually the same as it was in 1993. In contrast to this, Ontario has experienced a significant increase in fuel consumption over the study period, from 20,819 TJ in 1993 to 29,319 TJ in 2000. That is a 41% increase in fuel consumption in just 7 years. Thus, it would appear as though the majority of the increase in fuel consumption experienced at a national level is attributable to increases in Ontario. Unfortunately, figures for waste fuel and wood waste consumption are not available at the provincial level.

Table 40. Fuel Consumption of Cement Industry, 1990 to 2000, TJ

CONSUMPTION (TJ)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	CHANGE 93 TO 00
Coal	23,794	20,333	21,244	21,480	23,017	23,730	23,071	26,250	25,041	28,224	30,192	41%
Coke	573	2,234	158	294	272	464	445	288	186	441	916	212%
Petroleum Ck.	7,633	5,030	7,584	8,931	7,178	9,621	9,850	7,095	8,727	9,683	8,263	-7%
Natural Gas	16,313	14,814	13,106	12,676	12,423	14,673	12,141	13,411	14,422	12,286	11,916	-6%
Electricity	6,812	5,999	5,778	5,850	6,244	6,518	6,441	6,749	6,881	7,219	7,305	25%
Middle Dist.	92	114	80	64	234	79	110	123	81	86	62	-3%
Heavy Fuel Oil	2,111	1,710	2,341	1,702	1,484	2,014	2,069	1,841	2,389	2,999	2,156	27%
LGP/Propane	15	15	23	23	37	0	0	0	0	1	1	-97%
Wood Waste	0	0	0	0	0	142	103	94	93	71	35	NA
Waste Fuels	1,563	731	1,167	2,185	4,422	3,764	3,767	1,895	5,932	6,003	3,197	46%
Total Energy	**58,909**	**50,985**	**51,485**	**53,215**	**55,311**	**61,005**	**58,997**	**57,746**	**63,752**	**67,013**	**64,043**	**20%**

Source: CIEEDAC. 2002. A Review of Energy Consumption and Related Data: Canadian Portland Cement Industries 1990 to 2000. See www.cieedac.sfu.ca for more information.

Table 41. Provincial Fuel Consumption, Cement Industry, 1996 to 2000, TJ

	1993			1994			1995			1996		
Fuel	**Ontario**	**Quebec**	**Canada**	**Ontario**	**Quebec**	**Canada**	**Ontario**	**Quebec**	**Canada**	**Ontario**	**Quebec**	**Canada**
Coal/Coke	16,879	7,670	30,031	19,062	9,075	33,253	19,844	8,362	33,969	19,356	8,367	33,520
Natural Gas	687	1,454	11,644	1,036	1,325	12,429	1,453	2,344	14,673	1,024	1,490	12,141
Diesel	83	90	290	117	37	226	121	29	229	207	49	369
Heavy Fuel Oil	739	125	1,196	934	1,275	2,365	1,089	670	2,015	1,120	669	2,069
Electricity	2,431	1,269	5,850	2,748	1,483	6,495	2,769	1,530	6,703	2,841	1,491	6,673
Total	**20,819**	**10,608**	**49,011**	**23,897**	**13,195**	**54,768**	**25,276**	**12,935**	**57,589**	**24,548**	**12,066**	**54,772**
% Of Canada	**42%**	**22%**	**100%**	**44%**	**24%**	**100%**	**44%**	**22%**	**100%**	**45%**	**22%**	**100%**

	1997			**1998**			**1999**			**2000**		
Fuel	**Ontario**	**Quebec**	**Canada**	**Ontario**	**Quebec**	**Canada**	**Ontario**	**Quebec**	**Canada**	**Ontario**	**Quebec**	**Canada**
Coal/Coke	20,887	7,116	33,801	20,165	7,236	33,382	24,030	7,429	38,079	22,750	7,633	38,946
Natural Gas	928	908	13,355	1,598	795	14,424	1,298	532	13,429	1,901	711	11,916
Diesel	65	27	111	53	0	137	71	27	230	44	29	241
Heavy Fuel Oil	1,166	396	1,834	1,254	195	2,336	1,264	1,257	2,966	1,261	716	2,130
Electricity	3,046	1,441	6,856	3,077	1,455	6,992	3,216	1,562	7,285	3,363	1,535	7,305
Total	**26,092**	**9,888**	**55,957**	**26,147**	**9,681**	**57,271**	**29,879**	**10,807**	**61,989**	**29,319**	**10,624**	**60,538**
% of Canada	**47%**	**18%**	**100%**	**46%**	**17%**	**100%**	**48%**	**17%**	**100%**	**48%**	**18%**	**100%**

Source: By request from CIEEDAC. Some information can be found in: CIEEDAC. 2002. A Review of Energy Consumption and Related Data: Canadian Portland Cement Industries 1990 to 2000.

Note: Total in table 38 does not equal total in table 37 due to exclusion of wood waste and waste fuel in table 38 and different data sources.

5.2.5 Cement Industry Pollutant Releases

Table 42 shows greenhouse gas emissions associated with the cement industry in Canada. Overall, the cement industries contributed 7.3 percent of all greenhouse gas emissions from manufacturing and mining industries in Canada (Nyboer and Laurin, March 2002, Appendix). Table 42 shows both greenhouse gas emissions attributable to the burning of fuels, as well as that attributable to the cement making process itself (calcination), since turning limestone into clinker by definition includes the production of carbon dioxide. In fact, process-related greenhouse gases roughly double combustion-related greenhouse gases. Given the 20% increase in fuel consumption – measured by Terajoules -- experienced by the cement industry between 1993 and 2000, one would expect to see a similar increase in greenhouse gas emissions attributable to the burning of fuels in the cement industry over the same time period. Indeed, the figures below indicate that between 1993 and 2000, the cement industry realized a 21% increase in greenhouse gas emissions. The largest increases are the result of emissions from coal and coke. It is important to note that the estimates of greenhouse gas emissions are calculated by emissions factors, which means actual greenhouse gas emissions could vary according to the exact make-up and quality of the fuels used. Coke from coal, waste fuels, coal and petroleum coke have relatively high greenhouse gas emissions factors – all in the range of .085 per terajoule -- while natural gas has an emissions factor of roughly 0.05.

Table 42. Total Greenhouse Gas Emissions by Fuel Source, Cement Industry, 1990 to 2000, Thousand Metric Tons

FUEL	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Coal	1,922	1,642	1,714	1,732	1,861	1,919	1,865	2,123	2,005	2,260	2,423
Coke	49	192	13	25	23	39	38	24	16	37	78
Petroleum Ck.	640	422	636	749	602	807	826	595	701	779	665
Natural Gas	814	739	652	629	608	727	601	663	713	608	591
Middle Dist.	6	8	5	4	17	5	8	9	5	6	4
Heavy Fuel Oil	156	126	173	126	110	149	153	136	174	218	157
LGP/Propane	0	0	1	1	2	0	0	0	0	0	0
Wood Waste	0	0	0	0	0	12	8	8	8	6	3
Waste Fuels	134	62	100	187	381	323	323	162	509	515	274
Total GHG Emissions from Combustion	**3,721**	**3,191**	**3,294**	**3,453**	**3,604**	**3,981**	**3,822**	**3,720**	**4,131**	**4,429**	**4,195**
Process Carbon Dioxide	5,391	4,414	4,440	4,525	5,332	6,035	5,722	6,156	6,198	6,474	6,679
TOTAL GHG Emissions	9,112	7,605	7,734	7,978	8,936	10,016	9,544	9,876	10,329	10,903	10,874

Source: CIEEDAC. 2002. A Review of Energy Consumption and Related Data: Canadian Portland Cement Industries 1990 to 2000. See www.cieedac.sfu.ca for more information.

Along with greenhouse gas emissions, the cement industry is also responsible for releasing several pollutants. Not surprisingly given the large amounts of coal burned by the industry, the cement industry is a leading emitter of nitrous oxides in Canada. As the amount of coal burned over the decade has increased, so too have kilograms of nitrous oxides (see table).

Table 43. Nitrous Oxide Emissions for Canadian Cement Industry, 1990 to 1999, Kilograms

FUEL	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Coal	101,088	86,886	89,087	91,588	96,962	100,269	97,834	110,112	104,010	115,308
Coke	0	0	0	0	0	0	0	0	0	0
Petroleum Coke	0	0	0	0	0	0	0	0	0	0
Natural Gas	28,431	25,044	25,796	25,772	27,769	28,643	29,065	30,007	28,698	28,799
Middle Distillate	4,658	3,206	5,005	2,588	1,460	2,626	5,492	5,574	5,894	7,022
Heavy Fuel Oil	1,363	1,124	1,240	924	968	1,187	1,161	1,073	1,308	1,625
Waste Fuels	0	0	0	0	0	0	0	0	0	0
Total	135,541	116,261	121,129	120,873	127,161	136,177	142,508	158,182	151,981	167,133

CIEEDAC. 2002. A Review of Energy Consumption and Related Data: Canadian Portland Cement Industries 1990 to 2000

Canada's National Pollution Release Inventory requires certain industries in Canada to report emissions of a set of pollutants on an annual basis. The table below shows pollutant releases from the cement industry in Canada between 1994 and 2000. Release of these pollutants is shown in tonnes per year and as the total line indicates, there has been a substantial increase in total releases over the study period.

In 2000, the number of chemicals requiring reporting was expanded. For comparison over the study period, the above table includes only those chemicals released in 2000 that required reporting prior to 2000. Table 40 shows releases associated with the expanded set of chemicals that now require reporting in Canada.

Table 44. National Pollution Release Inventory Data for Canadian Cement Industry, 1994 to 2000, Tonnes

CHEMCIAL	1994	1995	1996	1997	1998	1999	2000
Zinc (and its compounds)	9.32	0.00	0.00	0.00	0.00	0.10	0.37
Lead (and its compounds)	5.73	0.00	0.00	0.00	0.00	13.14	0.00
Ethylene glycol	0.14	0.10	0.00	0.00	0.00	0.00	0.00
Xylene (mixed isomers)	0.13	0.00	0.002	0.20	3.06	0.01	3.62
Tetrachloroethylene	0.13	0.10	0.001	0.10	0.00	0.00	0.00
Dichloromethane	0.13	0.10	0.001	0.10	0.08	0.01	0.09
Toluene	0.13	0.10	0.001	0.10	2.51	0.03	3.03
Trichloroethylene	0.13	0.10	0.001	0.10	0.00	0.00	0.00
1,2-Dichloroethane	0.13	0.10	0.001	0.00	0.00	0.00	0.00
Chloroform	0.13	0.00	0.00	0.00	0.00	0.00	0.00
Manganese (and its compounds)	0.10	0.00	0.00	0.00	0.00	28.00	36.59
Ethylbenzene	0.00	0.00	0.001	0.10	0.00	0.00	0.00
1,1,2-Trichloroethane	0.00	0.00	0.00	0.10	0.00	0.00	0.00
Chromium and its compounds	0.00	0.00	0.00	0.00	0.01	1.01	27.51
TOTAL	**16.19**	**0.60**	**0.01**	**0.80**	**5.67**	**42.31**	**71.21**

Source: National Pollution Release Inventory Databases. See http://www.ec.gc.ca/pdb/npri/npri_home_e.cfm for more information.

Note that the above table shows releases only. It does not account for transfers of pollutants for either recycling or disposal reasons. This is due to the fact that from 1994 to 1997, reporting of off-site transfers for recycling was done on a voluntary basis only. Thus, the transfer dataset over the study period is incomplete. As such, it is not included in the above table. In 1998, reporting of transfers to recycling facilities once again became mandatory.

Beginning in 2000, reporting of mercury, 17 kinds of polycyclic aromatic hydrocarbons (PAHs), hexachlorobenzene, dioxins and furans became mandatory. Releases and transfers of mercury must now be reported if 5 kilograms or more of mercury is manufactured, processed or otherwise used during the year. Releases and transfers of 17 different PAHs must be reported if the substance was incidentally manufactured resulting in the release or transfer to a total of 50kg or more during the year. Any release of dioxins and furans or of hexachlorobenzene must also be reported.

Table 46. 2000 Additional National Pollution Release Inventory Data for Canadian Cement Industry

CHEMICAL	UNITS	BC	NS	ON	QC	TOTAL
Hexachlorobenzene	gram(me)s	704.42	71.80	400.80	275.95	**1452.98**
Pyrene	Kg	0.13	0.00	27.80	6.00	**33.93**
Flouranthene	Kg	0.22	0.00	77.28	8.30	**85.80**
Phenanthrene	Kg	1.53	0.00	229.10	0.00	**230.63**
Mercury	Kg	30.69	7.97	164.16	29.94	**232.76**
Selenium	Tonnes	0.00	0.00	0.00	0.00	**0.00**
Dioxin/Furan	g TEQ(ET)	0.01	0.12	0.00	0.32	**0.45**
Mangenese (and its compounds)	Tonnes	0.00	34.56	2.02	0.01	**36.59**
Benzo(g,h,I)perylene	Kg	0.00	0.00	0.05	0.05	**0.10**
Benzo(e)perylene	Kg	0.00	0.00	0.25	0.00	**0.25**
Indeno(1,2,2-CD)Pyrene	Kg	0.00	0.00	0.02	0.20	**0.22**
Beno(b)flouranthene	Kg	0.00	0.00	0.14	1.05	**1.19**
Benzo(k)flouranthene	Kg	0.00	0.00	0.20	0.75	**0.95**
Benzo(a)pyrene	Kg	0.00	0.00	0.26	0.11	**0.37**
Dibenzo(a,h)anthracene	Kg	0.00	0.00	0.59	0.40	**0.99**
Benzo(a)anthacene	Kg	0.00	0.00	0.31	0.90	**1.21**
Sulphuric acid	Tonnes	0.00	0.00	48.42	0.00	**48.42**
Ammonia	Tonnes	0.00	0.00	151.85	0.00	**151.85**
Dioxin/Furan	g TEQ(ET)	0.00	0.00	0.77	0.00	**0.77**
Dibenzo(a,I)pyrene	Kg	0.00	0.00	0.00	0.15	**0.15**
7H-Dibenzo(c,g)carbazole	Kg	0.00	0.00	0.00	0.07	**0.07**
Dibenzo(a,j)acridine	Kg	0.00	0.00	0.00	0.15	**0.15**
Phenanthrene	Kg	0.00	0.00	0.00	110.00	**110.00**
Copper	Tonnes	0.00	0.00	0.00	0.01	**0.01**
PAHs	Kg	0.00	0.00	0.00	384.76	**384.76**

Source: National Pollution Release Inventory Databases. See http://www.ec.gc.ca/pdb/npri/npri_home_e.cfm for more information.

5.2.6 Canadian Cement Industry Trends: Summary

Table 47 summarizes several of the trends presented above. The table indicates that since 1993 Canada has experienced an increase in cement production, energy consumption, greenhouse gas emissions and exports of cement.

Table 47. Summary of Trends for Cement Industry, 1990 to 2000

FACTOR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	CHANGE 93 TO 00
Production (kilotonnes)	11,083	9,446	8,612	9,284	10,457	10,600	11,003	11,790	12,168	12,643	12,753	37%
Energy (TJ)	58,909	50,985	51,485	53,215	55,311	61,005	57,997	57,746	63,752	67,013	64,043	20%
GHG Emissions (kilotonnes)	3,721	3,191	3,294	3,453	3,604	3,981	3,822	3,720	4,131	4,429	4,195	21%
Exports (kilotonnes)	2,916	2,669	2,353	3,096	3,803	3,831	4,339	4,413	4,693	4,037	4,583	48%

It is interesting to note that energy consumption and greenhouse gas emissions have not increased at the same rate as cement production and exports. This implies that the cement industry in Canada has become increasingly energy efficient since 1993. Table 10 demonstrates this trend more explicitly. The table below shows energy and greenhouse gas emissions per unit of cement production and exports. Energy and greenhouse gas emissions per unit of cement production and exports increased between 1990 and 1992 and have declined since 1993. Thus, the cement industry in Canada is using less energy and emitting fewer greenhouse gas emissions per unit production and per unit of exports today than in 1993. Despite these efforts, improvements in energy efficiency have not been enough to offset total increases in production. Absolute emissions of greenhouse gas emissions have thus, still increased.

Table 48. Energy Consumption and Greenhouse Gas Emissions per kilotonne Cement Production and Exports, 1990 to 2000.

FACTOR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	93 TO 00
Energy (TJ) per kilotonne Production	5.32	5.40	5.98	5.73	5.29	5.76	5.27	4.90	5.24	5.30	5.02	-12%
GHG Emissions (KT) per kilotonne Production	0.34	0.34	0.38	0.37	0.34	0.38	0.35	0.32	0.34	0.35	0.33	-12%
Energy (TJ) per kilotonne Exports	20.20	19.10	21.88	17.19	14.54	15.93	13.37	13.08	13.58	16.60	13.97	-19%
GHG Emissions (KT) per kilotonnes Exports	1.27	1.20	1.40	1.12	0.95	1.04	0.88	0.84	0.88	1.10	0.92	-18%

5.3 The Canadian Regulatory Framework for the use of Wastes as Supplemental Fuels in Cement Kilns

No specific federal regulations have been established in Canada regarding the burning of hazardous or other wastes as supplemental fuels in cement kilns, or regarding emissions from cement kilns. A non-enforceable National Emission Guideline for Cement Kilns was adopted by Environment Canada in 1991.[39] Although focused on reducing NOx emissions from new kilns, the Guideline states: "…tests with waste-derived fuels have in some cases shown a positive impact on reducing emissions. Regulatory authorities should consider the overall environmental impacts… of using substitute fuels such as solvents, tires, and landfill gases to supplement traditional fuels."[40]

The Canadian Council of Ministers of the Environment (CCME), an intergovernmental body made up of the federal, provincial and territorial environment Ministers, adopted a National Guideline for the use of hazardous and non-hazardous wastes as supplementary fuels in cement kilns in 1996.[41] However, like the Environment Canada Guideline, the CCME Guideline is not legally binding and its implementation is at the discretion of individual jurisdictions. Canada-wide standards for mercury, dioxin and furan emissions from hazardous waste incineration activities adopted in 2000 and

---

[39] http://www.ec.gc.ca/energ/industry/guidelines/cement_e.htm

[40] Environment Canada, National Emission Guidelines for Cement Kilns, pg.3.

[41] National Guidelines for the Use of Hazardous and Non-Hazardous Wastes as Supplementary Fuels in Cement Kilns (Winnipeg: CCME 1996)

2001[42] do not apply to "energy recovery" activities, providing a type of exemption to the cement industry.

The burning of hazardous wastes as supplemental fuels is therefore regulated at the provincial and territorial levels. In general, despite pressures from the cement industry to follow the US approach to permit the general use of hazardous wastes as supplemental fuels in cement kilns,[43] such activities continue to require approval under provincial legislation as hazardous waste disposal operations, and waste manifesting requirements would apply to shipments of wastes to cement making operations for use as fuel.[44] Most jurisdictions rely on the CCME guidelines as the basis for the requirements written into facility approvals regarding acceptable waste quality as fuel and emissions requirements.

In summary, although Canadian governments have been supportive in principle of the use of hazardous wastes as supplemental fuel in cement kilns, such practices still require specific approval under provincial hazardous waste legislation and regulations. No major regulatory changes have been undertaken since the adoption of the CCME guidelines in 1996, and the primary focus of recent proposals has been on the use of used tires rather than hazardous wastes as fuel. The Ontario Ministry of the Environment for example, has recently approved collection and processing facility that will export scrap tires to Mexico.[45]

5.4 Conclusions

- Total Canadian cement production and shipments have risen substantially since 1993, rising by 37% between 1993 and 2000.
- Exports have also increased substantially (48%) over this period. This increase is almost exclusively for Portland cement. Canadian cement exports are almost entirely to the US.
- The number of cement production facilities in Canada has increased 20%, but employment in the sector is down by 9%.
- Energy efficiency of the sector has increased substantially over the past decade. Production rose by 38% between 1993 and 2001, while energy use grew by only 20%, resulting in a 12% reduction in energy use per tonne of production.

---

[42] See the Canada Wide Standard for Dioxins and Furans for Incineration, CCME May 2001 http://www.ccme.ca/initiatives/standards.html?category_id=50#23; and the Canada Wide-Standard for Mercury Emissions, CCME June 2000, http://www.ccme.ca/assets/pdf/mercury_emis_std_e1.pdf.

[43] See, for example, the Cement Association of Canada, http://www.cement.ca/cement.nsf/internetE/9F51AD42A60BFA0205256AFD004EA325?OpenDocument#integrity.

[44] In Ontario, for example, exemptions from hazardous waste approvals requirements are only provided for the burning of wastes as fuel on the site of their generation. Off-site operations using waste as fuel do not fall within the recycling exemptions contained in the province's hazardous waste regulations. See Ontario Regulation 247.

[45] See EBR Posting EBR IA9E1123 re: Entireco Inc., Catham, Ontario, February 2, 2000.

- There has been a significant growth in the use of waste fuels since the early 1990's, with a 46% increase from 1990 to 2000, although waste fuels remain a relatively small portion of total fuel usage (<10%) even at peak levels of use (1999). The portion of total fuel provided from wastes varies significantly from year to year. This is likely a function of both waste fuel availability and cost.
  - Provincial breakdowns of the use of waste fuel in cement kilns are not available.
- The total reported pollutant releases for the sector for 1994 to 2000 rose substantially, particularly releases of manganese and chromium. However this may due to improved reporting rather than actual increases in emissions.
- Although Canadian governments have adopted guidelines that are generally supportive of the use of certain types of hazardous wastes as supplemental fuels in cement kilns, despite pressures from the cement industry, the use of hazardous wastes in this way continues to be regulated as a hazardous waste disposal activity, and requires specific provincial approvals in order to take place. Still, nationwide emission standards for dioxins, furans and other toxics have not been developed for the hazardous or non-hazardous waste burning cement industry.
- In the past few years, the industry has demonstrated a greater interest in the use of scrap tires, rather than hazardous wastes, as supplemental fuel. In addition, in the few years a number of new facilities have been established for the purpose of collecting scrap tires and exporting them to Mexico.

6.0 Conclusions

The report finds that the cement industry is a continental industry in North America, although the trends in the sector tend to be driven by US demand. Over the past decade, US demand has exceeded domestic supply by a wide margin. In this context, Canada has emerged as a major source of supply to the US, with major increases in production and particularly exports since the early 1990s. Mexico exports to the U.S. have also outpaced a nearly stagnant growth in production for its domestic market, although anti-dumping tariffs stemming from 1989 have prevented Mexican-based companies from gaining a major market share of the U.S. market. Within the last few years, two Mexican cement companies have been building plants in US to gain access to the market and have become major producers of cement in the US. These investment decisions have not been driven by less stringent environmental regulations, but simply by the economics of tariffs and transportation costs versus investment as a way to enter the U.S. market. Still, the lack of environmental regulations for the cement industry has until now allowed cement manufacturers significant freedom in their choice of fuels and pollution control equipment.

Energy use – and in particular fuel use – is a major price factor in the production of cement. Because of this, companies in all three countries have invested in energy efficiency measures, such as converting wet kilns to dry kilns, or to adding precalciners and predryers to their cement production process, a more efficient process in terms of fuel use. Despite these investments, electric and total energy consumption per unit of output appears to have risen slightly in the US over the past decade. In contrast, the Canadian and Mexican cement industries appear to be more efficient and in general energy efficiency has increased (i.e. energy use per unit of output decreased) over the last decade. In Canada, a number of newer plants have come on-line since the early 1990s in part in response to the increased US demand. The Mexican plants tend to be newer, “dry” process facilities and most have preheaters and/or precalcinators as well. Still, efficiency gains in the early 1990s have not continued at the same pace, and in fact, in recent years there has been a slight decline in energy efficiency, possibly in part because of the shift toward petroleum coke.

In all three countries, the use of fuels has changed significantly over the last five to ten years. In the U.S., there has been a general shift toward coal, petroleum coke and alternative wastes such as liquid and solid hazardous wastes, and a lessening dependence upon natural gas to fuel the cement making process. As in the U.S., kilns in Mexico have been shifting their use of fuels, in this case from an almost universal reliance on fuel oils to fuel oils, petroleum coke and alternative fuels. Interestingly, this new reliance on hazardous wastes has continued at the same time as Mexico has become a signatory to the Stockholm Convention, calling for the control and phase-out of the production of dioxins and furans. In Canada, there has been less of shift in terms of the type of fuel used, although there has been a decrease in the use of natural gas and an increase in the use of coal. This shift may reflect the changing price of natural gas rather than a major change in fuel use.

The volume of ‘alternative’ fuels (tires, solid hazardous waste and liquid hazardous and non-hazardous wastes) used by the cement sector is increasing in all three countries, although it still makes up a relatively small percentage of total waste. In the US and Mexico the industry has emerged as a major manager of hazardous wastes. This has not, however, been the case in Canada where emphasis has been on the use of tires and non-hazardous wastes, including wood waste, as alternative fuels. Cement facilities burning hazardous wastes as fuels in Canada continue to be approved and regulated as hazardous waste disposal facilities despite opposition from the industry.

Air emissions are determined both by the type of fuel burned as well as the types of pollution control equipment used by cement manufacturers. In all three countries, data on emissions is somewhat limited and is often based upon emission factors rather than direct measurement. Cement manufacturing – by its very nature – leads to carbon dioxide (greenhouse gas) emissions, both because carbon dioxide is released in the process of turning limestone into clinker, as well as in the combustion of fuels. In the U.S., continued reliance on coal, as well as the sustained use of petroleum coke, as well as of tires, has probably resulted in increased emissions of greenhouse gas emissions, both as a total and on a per tonne basis. Toxic pollution, including dioxins and furans and heavy metals – mainly as a result of the increased use of hazardous wastes as fuels – appears to have also increased since 1993.

Canadian data suggests that there has been a slight decrease in per tonne emissions of carbon dioxide, although preliminary toxic data suggests an increase in toxics. Unfortunately, data on emissions in Mexico is either not available or inaccessible. Nonetheless, emission factors widely used would suggest that the shift from fuel oils to petroleum coke has probably increased greenhouse gas emissions in the sector over the period. Very limited data from Mexico suggests that the small use of hazardous wastes as fuels in the sector has not led to major releases of dioxins and furans or other toxics, but it is important to note that only very limited company testing has been done thus far to measure such emissions.

The US and Mexico have recently adopted new, more comprehensive emission standards for cement kilns after years of relatively lax regulation and enforcement. The US applies more comprehensive standards to kilns burning hazardous wastes, while the Mexican standards apply to all kilns regardless of fuel type. Nonetheless, these rules are still being implemented and have yet to be enforced. While these regulations are leading to more investment in pollution control equipment, including baghouses, scrubbers and electrostatic precipitators, it is important to note that the standards are significantly less stringent than similar standards for incinerators of hazardous waste, and will continue to allow for increased burning of hazardous wastes. There is also concern that the limited amount of monitoring required, particularly in Mexico, will not gaurantee compliance with the new standards. In fact, the new standards allow for significant increases in the burning of hazardous wastes with limited monitoring might be considered in direct contradiction to the recent ratification by Mexico of the Stockholm Convention on POPs, which calls for increased monitoring and phase-out of such sources of contamination.

In contrast, Canada has no enforceable national emission standards for the sector. National emission guidelines, adopted by the federal government in 1991 only deal with NOx emissions and are not legally enforceable. The CCME adopted guidelines for cement kilns using wastes as fuels in 1996, but again these standards are not legally enforceable. More recent CCME standards for emissions of dioxins and furans and mercury from incinerators have not been applied to cement facilities.

The report also found that Cement Kiln Dust is the major waste stream produced by the cement manufacturing process. Nevertheless, a lack of data makes it difficult to determine what the trend is in terms of generation and management of this waste stream. Limited data from the U.S. suggests that hazardous waste burning increases the amount and toxicity of this waste, although overall the amount of CKD waste generated has declined as cement kilns put CKD back into the production process. In all three countries, regulations regarding cement kiln dust have gaps. While the U.S. began the process of regulating management of CKD, it appears it will delay final implementation until further study of current management practices, despite major, well-documented environmental problems. Standards in Mexico and Canada are similarly ill-defined or non-existent.

It does not appear that companies are investing in cement manufacturing in any country to take advantage of less stringent environmental regulations and enforcement but rather to gain access to the market. Whether or not new pollution control rules in the U.S. and Mexico will cause a shift in investment strategy among the three countries is unclear, although the major factors in decisions about fuel use will probably continue to be price and availability, not energy efficiency, regulations, or environmental cleanliness. It is also unclear whether the burning of hazardous wastes could lead to major shipments of hazardous wastes across international lines for cement kiln incineration, as some have proposed.

This report was not able to determine with precision whether the recent investment by Mexican companies in the U.S. or the consolidation of the industry has led to important technology transfer gains in terms of energy efficiency or pollution control, although initial evidence suggests that plants purchased by the Mexican companies have been upgraded in terms of pollution control and energy efficiency. Further study – including direct surveys and examination of company documents -- could help determine with precision whether the consolidation of the cement industry in North America and NAFTA-led investment, particularly within the U.S., has led to any such improvements.

The report recommends, however, that given the international nature of the cement industry, that some common guidelines and/or regulations be adopted in all three countries. Recommendations include:

- Cement kilns burning hazardous wastes should be regulated as hazardous waste disposal facilities
- Canada needs to adopt updated enforceable emission standards for kilns burning both conventional fuels and hazardous wastes, as have the US and Mexico.
- Energy efficiency standards and greenhouse emission standards for the cement sector should be adopted in all three countries.
- The CEC should initiate a dialogue about the burning of alternative wastes in cement kilns with a specific focus on dioxin and furan emissions and the control of CKD.
- The CEC should continue to strengthen its Sound Management of Chemicals program to emphasize a North American Management Strategy of hazardous wastes and reduction of dioxin and furan emissions.

-

7.0 Bibliography

American Portland Cement Association, 1997. APCA 1995 CKD Survey.

Batelle Industries, Toward A Sustainable Cement Industry, Commissioned by World Business Council for Sustainable Development, March 2002.

"Building May Start This Year on Cement Plant," *The Pueblo Chieftan*, February 17, 2003.

Cámara Nacional del Cemento. Internal Documents Provided to Authors. México, D.F. 2002

Canadian Industrial Energy End-Use Data and Analysis Centre, A Review of Energy Consumption and Related Data: Canadian Portland Cement Industries 1990-2000 (Burnably, B.C.: School of Resource and Environmental Management, Simon Fraser Unviversity, 2002).

Canadian Council of Ministers of the Environment, National Guidelines for the Use of Hazardous and Non-Hazardous Wastes as Supplementary Fuels in Cement Kilns (Winnipeg, CCME, 1996)

Canadian Council of Ministers of the Environment, Canada-Wide Standard for Dioxins and Furans for Incineration (Winnipeg, CCME, May 2001)

Canadian Council of Ministers of the Environment, Canada-Wide Standard for Mercury Emissions (Winnipeg: CCME, June 2000).

Cement America, 'U.S. Cement Producers allege Government Inaction Violates Constitutional Rights," Mar 1, 2002.

Cement Association of Canada, www.cement.ca

CEMEX, *2001 Annual Report* (Mexico, DF: CEMEX, 2002).

CEMEX, "10 Cement Companies Pledge Specific Actions on 6 High Priority Issues for Sustainable Development," July 3, 2003 Press Release. Available at www.cemex.com/qr/mc_pr_070302.asp.

Centro Nacional de Investigación y Capacitación Ambiental (CENICA). Informe de la situación y los conocimientos actuales sobre las principales fuentes y emisiones de dioxinas en México. Segundo Reporte. .México. 2001

Club Español de Residuos (CER). Contribución de la industria del cemento a la gestión de residuos en Europa. Cuadernos del CER Nº 3. España. Septiembre 2001.

Commission on Environmental Cooperation, *North American Regional Action Plan on Environmental Monitoring and Assessment* (Montreal, CA: CEC, June 3, 2002).

Robert Cook “Cement Exports from Mexico,” TED (Trade and Environment) Case Studies: An Online Journal, American University, (Vol. 3, No. 2, June 1994), available at www.american.edu/TED/CEMEX.HTM.

E.Craig and R.Mirza, "Developement of National Guidelines for the Use of Hazardous and Non-Hazardous Wastes in Cement Kilns in Canada," in Waste Combustion in Boilers and Industrial Furnances: Conference Proceedings (Pittsburgh: AIr & Waste Management Association, 1994).

DPRA Incorporated, Technical Background Document: Compliance Cost Estimates for the Proposed Land Management Regulations of Cement Kiln Dust (St. Paul, Minnesotta, 1998), p. 6.

Energy Information Administration, *Emissions of Greenhouse Gases in the United States, 2000* (Washington, DC: US EIA, October 2001)

Energy Information Administration, *Emissions of Greenhouse Gases in the United States* (Washington, D.C.: U.S.EIA, December 2002).

Environment Canada, National Pollutant Release Inventory Databases, www.ec.gc.ca/pbd/npri/npri_home_e.cfm

Environment Canada, National Emissions Guidelines for Cement Kilns (1991). www.ec.gc.ca/energ/industry/guidelines/cement_e.htm

Grupo Cementos Chihuahua, Annual Report 2001 (GCC: Chihuahua City, Chihuahua, Mexico, 2002).

Ken Humphreys and Maha Mahasenan, *Toward a Sustainable Cement Industry: Climate Change, Substudy 8* (Batelle, Commissioned by World Business Council for Sustainable Development), March 2002.

Instituto Nacional de Estadística, Geografía e Informática (INEGI). El Sector Energético. México. 2002

Instituto Nacional de Estadística, Geografía e Informática (INEGI), Secretaría de Medio Ambiente, Recursos Naturales y Pesca (Semarnap). Estadísticas del Medio Ambiente, México 1999. México. 1999

Instituto Nacional de Estadística, Geografía e Informática (INEGI). Encuesta Industrial Anual 1995 y 1997. México.

N. Martin, E. Worrell, M. Ruth,. L. Price, *Emerging Energy-Efficient Industrial Technologies* (Ernest Orlando Lawrence Berkeley National Laboratory. Berkeley, California) October 2000.

NAFTA, Annex 302.2, Schedule of Canada, Schedule of Mexico, Schedule of United States

North American Working Group for the Sound Management of Chemicals, *Decision Document on Dioxins and Furans under the Process for Identifying Candidate Substances for Regional Action under the Sound Management of Chemicals Initiative*. (Montreal, CA: Commission on Environmental Cooperation, March 31, 1999).

Nyboer, John and Alison Laurin, CIEEDAC, Development of Greenhouse Gas Intensity Indicators for Canadian Industry, 1990 to 2000 (March 2002).

Ontario Ministry of the Environment, Environmental Bill of Rights Registry, http://www.ene.gov.on.ca/envision/env_reg/ebr/english/index.htm

Mark A. Richardson, *An Introduction to Policy and Legal Issues Associated with Burning Hazardous Waste in Cement Kilns: A Briefing Paper of the American Lung Association* (Washington, D.C.: American Lung Association, April, 1995)

Statistics Canada, Catalogue No. 44-001, Table 303-0001

U.S. Environmental Protection Agency, AIRSDATA, *National Emissions Trend Database*, 1996 and 1999.

U.S. Environmental Protection Agency, Toxics Release Inventory Query (www.epa.gov/enviro/tri/)

U.S. Environmental Protection Agency, *The National Biennial RCRA Hazardous Waste Report* (Based on 1991 Data), (Washington, D.C.: US EPA, August 1993).

U.S. Environmental Protection Agency, *The National Biennial RCRA Hazardous Waste Report* (Based on 1993 Data), (Washington, D.C.: US EPA, August 1995).

U.S. Environmental Protection Agency, *The National Biennial RCRA Hazardous Waste Report* (Based on 1995 Data), (Washington, D.C.: US EPA, August 1997).

U.S. Environmental Protection Agency, *The National Biennial RCRA Hazardous Waste Report* (Based on 1997 Data), (Washington, D.C.: US EPA, August 1999).

U.S. Environmental Protection Agency, 40 CFR Parts 259,261,266 and 270, Standards for the Management of Cement Kiln Dust; Proposed Rule, Federal Register, August 20, 1999, p. 45636.

U.S. Environmental Protection Agency, *Environmental Fact Sheet: Management Standards Proposed for Cement Kiln Dust Waste* (Office of Solid Waste: EPA530-F-99-023), August 1999.

U.S. Environmental Protection Agency, *The National Biennial RCRA Hazardous Waste*

Report (Based on 1999 Data), (Washington, D.C.: US EPA, August 2001).

United States Environmental Protection Agency, *Environmental Fact Sheet: Interim Emission Standards for 1999 Hazardous Waste Combustor Rule*, EPA530-F-02-008, February 2002

U.S. Environmental Protection Agency, “Additional Data Available on Wastes Studies in Report to Congresson Cement Kiln Dust,” *Federal Register*, July 25, 2002.

United States Geographic Service, U.S. Bureau of Mines, “Cement” Chapter in *Minerals Yearbook, Annual, 1991 – 2001* (Washington, D.C., USGS).

U.S. International Trade Commission, 2003 Tariff Database, HTS Number 25231000.

Hendrik G. van Oss and Amy Padovani, “Cement Manufacture and the Environment: Part 1, Chemistry and Technology,” *Journal of Industrial Ecology* (Volume 6, No. 1): 98.