Cement Industry, Climate Change and Kyoto Protocol: Canadian Perspective

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Introduction

The major challenges facing the cement industry globally are the CO_2 emissions associated with cement clinker production, and the worldwide concerns about climate change. This paper attempts to review the Canadian position on climate change and its potential impact on the cement industry. Canada was one of the first countries to sign the Kyoto Protocol, on April 29, 1998. Formal ratification came more than four years later – on December 17, 2002 under the Liberal federal government. But Canada's continued participation in Kyoto seems to be rather questionable following the election of a minority Conservative government in January 2006. The election of a Conservative government brought about a reversal in Canada's climate change policy. In September 2006, Environment Minister said that Canada had no chance of meeting its targets under the Kyoto Protocol. Conservatives while opposing to the Kyoto Protocol, favour instead a 'made-in-Canada' solution to the environmental challenges the country is facing. On October 19, 2006, the government tabled Canada's new 'Clean Air Act' that targets both air pollutants and greenhouse gases.

Under both the earlier Liberal programs and the new 'Clean Air Act' and accompanying 'Notice of Intent', the Canadian cement industry has been identified as one of the Large Final Emitters (LFE) of greenhouse gases (GHG). At the same time, however, the cement industry is a unique one as approximately 60% of its CO_2 emissions are due to the disassociation of limestone – fundamental to all known methods of manufacturing cement – as opposed to fuel use. The cement industry has been in the process of discussing, consulting and negotiating with government officials its options and targets for GHG reduction.

In order to prepare its position, the Cement Association of Canada (CAC) representing the cement companies active in Canada was authorized by its members to survey the situation as related to the clinker and cementitious materials production, related energy use and GHG emissions based on the "CO_2 Protocol" developed under the "Cement Sustainability Initiative" by the World Business Council for Sustainable Development (WBCSD).

1.0 Canadian Cement Industry

The Canadian cement industry is diversified and primarily integrated with the construction aggregates and concrete products sectors. At the end of

2004, sixteen cement plants operated in Canada, consisting of fifteen gray clinker plants and one which produces white cement. Cement is produced in five out of ten Canadian provinces. Geographically, industry capacity is concentrated in the province of Ontario, accounting for 8.035 Mt capacity, just over 51% of the total Canadian capacity. Quebec, with 16.8% capacity ranks second, with British Columbia and Alberta accounting for the majority of remaining output (Fig. 1). The two largest cement plants in Canada, with 1.883 Mt and 1.844 Mt clinker capacities respectively, are both located in Ontario.

According to the most recent figures available, the reported kiln capacity in 2004 was about 16,634 Mt, a 0.4 Mt increase from 2003 reported levels [1]. The average kiln capacity has increased from about 300,000 t/y in 1980 to over 610,000 t/y in 2004; the average kiln age based on clinker capacity is reported to be about 20 years, according to the Cement Association of Canada / Portland Cement Association.

Fig. 1: Distribution of the Canadian cement plants

Coal and coke have been the dominant fuels used in cement kilns since 1990 and continue to be the primary fuels utilized by Canadian cement plants. Although natural gas provides fewer emissions, all cement plants that were using natural gas in the past have been left with no other option but to switch to coal due to concerns about its availability and high prices. Waste-derived fuel was used as a primary fuel by only one plant and as an alternative fuel by a further six plants (Fig. 2). The cement industry has improved its energy efficiency by almost 30% since the 1970's (Fig. 3), thus also reducing CO_2 emissions and contributing to cleaner air. In terms of energy consumption (total fuel and power), at 4.48 GJ/equivalent tonne, the Canadian cement industry is slightly more efficient than that of the U.S. at 4.76 GJ/equivalent tonne (2004 data), although not as energy efficient as some of the Western European or the new Asian state-of-the-art cement plants [2,3].

The Canadian cement industry is well integrated into the global scene. Approximately 91.5% percent of Canada's cement industry (in terms of clinker capacity) is owned by foreign multinationals and global leaders such as Lafarge SA of France, Holcim Ltd. of Switzerland, Votorantim Group of Brazil, Heidelberg Zement AG of Germany and Italcementi of Italy, which also have operations in the US and elsewhere. The Canadian cement industry is, therefore, integrated into a North American market with a focus on the Canadian and northern US competitive arena with potential longer-term considerations for global operations.

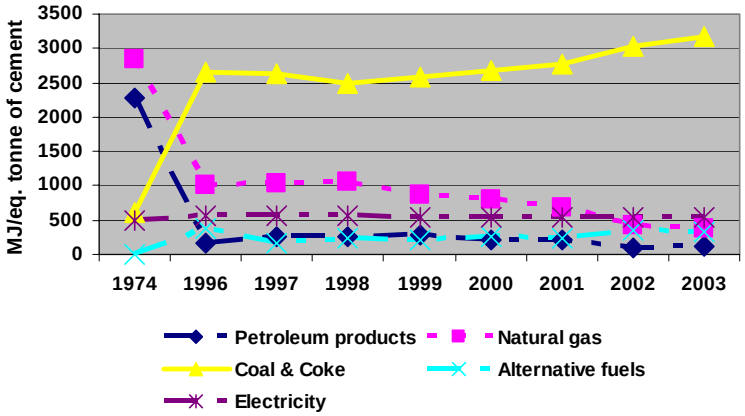

Fig 2: Kiln fuels used by cement industry, 1974-2003

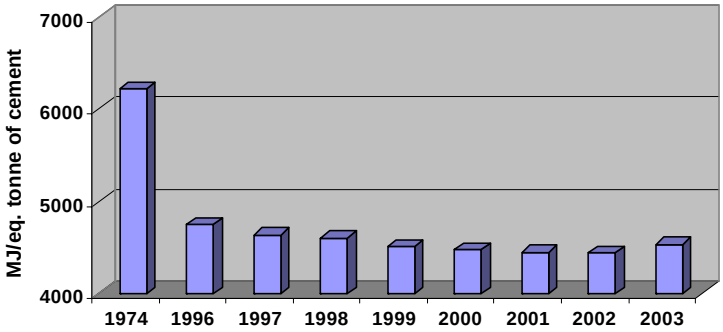

Fig 3: Improvements in kiln fuel efficiency, 1974-2003

All cement manufacturers are members of the Cement Association of Canada. In 2004, there were twenty seven kilns in the Canadian cement plants, comprised of 23 dry process kilns and 4 wet kilns, two of these being inactive. Nine out of the total of 27 kilns, with a total capacity of 8.70 Mt, were built and commissioned after 1980. The Canadian cement industry is a rather modern industry, with about 44% and 29% of cement, respectively, (based on the clinker) produced in modern precalciner and preheater kilns, 20% in long dry kilns, and only 7% in wet kilns.

Canada's cement industry provides employment for about 2,600 people,

and in 2005 contributed $.1.6 billion to the Canadian economy. Shipments of cement in 2003 were estimated to be 14.1 Mt valued at CDN$1.50 billion, based on preliminary data (2). The Canadian cement industry is cyclical, depending on Canadian as well as global economic circumstances. In 2003, the domestic consumption was about 9.33 Mt. A significant portion of Canadian clinker and cement production, about one third (5.06 Mt), is exported to the U.S.A. Although the U.S. cement industry expanded its production by 27% over the 1990-2001 period, it is a significant net importer. Historically, Canada had been the primary exporter into the U.S., using the low-cost water highways along the West Coast, Great Lakes, St Lawrence River and Seaway and the Eastern Seaboard. However, the cement producers in the developing world have some competitive advantage over Canadian production when accessing the U.S. import market, and imports volumes from Thailand, China and Korea have rapidly approached those from Canada.

2.0 Global Perspective

From the global point of view, the Canadian cement industry is a small player. Canada's capacity is only 0.75 percent of the world total. While small by global standards, this does represent 12.7 percent of the total U.S.-Canada capacity. The U.S. cement capacity represents about 5.1% of the global total, while the third North American player, Mexico, with its 30 cement plants, accounts for about 1.75%.

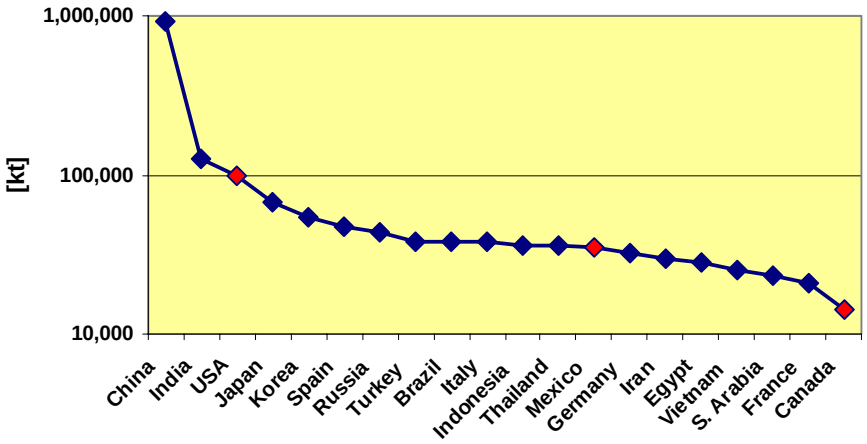

Fig 4: Top world cement producers [kt], 2004

3.0 Cement Manufacture and Environment

The major challenges facing the cement industry globally are the CO_2 emissions associated with cement clinker production, and the worldwide concerns about global warming and climate change. While protecting its competitive position, the Canadian cement industry supports the federal government intent to improve the health of Canadians and their environment through an integrated, nationally consistent approach to reducing industrial air pollution.

The cement industry, as any industry burning fossil fuels, is generating GHG emissions. Unlike most industries, however, less than half of the emissions produced by the cement industry are attributable to combustion of fuels. The calcination of limestone – fundamental to all known methods of manufacturing cement – generates about 60% of the CO_2 emissions produced by the process. The cement industry currently emits 0.73 to 0.99 tonnes of CO_2 for every tonne of cement produced. The emissions per tonne differ because the types of equipment, process energy efficiencies, and product compositions vary from country to country [4]. The World Business Council for Sustainable Development (WBCSD) "Cement Sustainability Initiative" reports that cement production accounts for approximately 5% of the world's anthropogenic CO_2 emissions. When all greenhouse gas emissions are taken into account, the cement industry is responsible for about 3% of total GHG (CO_2 equivalent) emissions [4,5].

4.0 Canada's GHG Emissions Initiatives and Cement Sector

In its efforts to fulfill its commitments under the Kyoto agreement, previous federal government focused its efforts on Large Final Emitters (LFE). The purpose of Environment Canada's (EC) LFE system was to secure Green House Gas (GHG) emissions reductions from Canada's largest industrial emitters. Canada's LFE include more than 700 companies in the mining and manufacturing, oil and gas, and thermal electricity sectors. The cement manufacturing industry was included in the LFE system. To establish GHG emissions target reductions, EC took into account two types of emissions: fixed process emissions and fuel-derived emissions. Under the LFE system, fixed process emissions received a zero percent target reduction during 2008–2012, the Kyoto Protocol period. All other emissions received a 15 percent target reduction to be achieved during the 2008-2012 period, from the benchmark year 2000. EC's stated objective was to secure from the cement industry a reduction of 0.7 Mt GHG (or about 6% of the total 12 Mt of GHG emissions for the benchmark year 2000) under a Business as Usual (BAU) scenario taking into consideration a 3.3% growth in emissions as of the benchmark year 2000 to the Kyoto Protocol period. In 2005, the cement industry developed and reached an agreement in principle on a formula to calculate CO_2 intensity reductions by all the Cement Association of Canada (CAC) members and Environment Canada's LFE.

It is estimated that the Canadian cement industry is a source of some 11.4 Mt of CO_2 (2004), 7.1 Mt due to dissociation of limestone and 4.3 Mt from combustion of fossil fuels to generate the heat required for clinker and cement processing [6]. To put it in perspective, the 11.4 Mt total CO_2 emissions associated with cement production represent about 1.93% of the total Canadian CO_2 emissions and 1.51% of the total national GHG (CO_2 equivalent) emissions (Fig. 5).

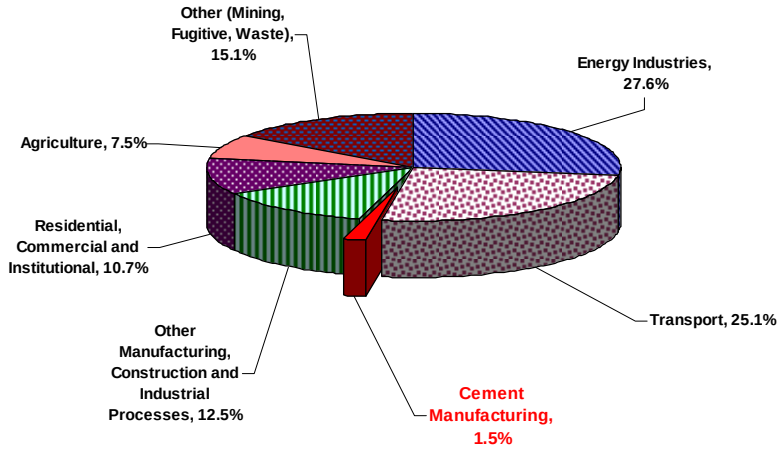

Fig. 5: GHG Emissions by Economic Area vs. Canadian Totals, 2004

The Canadian cement industry, while its total clinker production increased by 30.6% over the 1990 to 2004 time period, mainly through continuing improvements in energy efficiencies, made progress in reduction of the GHG emissions, reducing its contribution to the Canadian total CO_2 emissions from 1.95% in 1990 to the already mentioned 1.93% in 2004, and maintaining its total GHG emissions at around 1.5% (based on CO_2 eq.) of Canada's totals [6,7]. Overall, there has been a declining trend in the GHG emission intensities in the cement sector over the 1990 to 1998 period, with an increase to more or less constant value of about 0.82 to 0.83 t CO_2 eq. per tonne of clinker for the last six years (Fig 6). This rather surprising and disappointing increase can perhaps be explained by the fact that due to the booming construction and demand for cement, industry has been operating at close to full capacity.

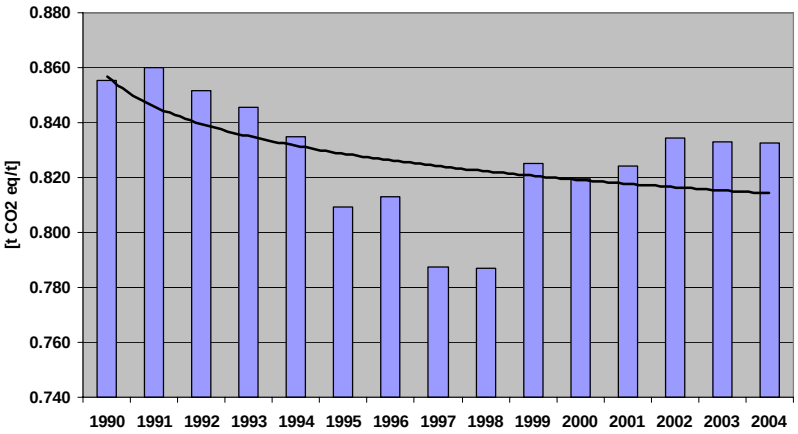

Fig 6: Cement industry GHG emissions per tonne of clinker, 1990-2004

5.0 Recent Developments – Canada's 'Clean Air Act'

Early in 2006, the new, Conservative-led minority government was

formed. Part of the party's platform was to abandon Kyoto and come up with a 'made-in-Canada' approach to reducing emissions blamed for global warming. This government has faced the facts and said that Canada had no chance of meeting its targets of reducing GHG emissions levels to 6% below 1990 levels by 2008-2012 under the Kyoto Protocol. Overall emissions of GHG in Canada have steadily increased from 1990, except for modest year to year declines in 1991 and 2001. In 2004, Canada's GHG emissions were 758 Mt, which is a 26.6% increase over 1990 emissions, and 34.6% above the Kyoto target of 563 Mt. (In this respect, Canada is by far not the only country missing its reduction targets. By 2003, thirteen of the Kyoto signatory parties missed their targets; only four countries made or exceeded their commitments.)

On October 19, 2006, the federal government tabled Canada's 'Clean Air Act' (Bill C-30) and the 'Notice of Intent (NOI) to Develop and Implement Regulations and Other Measures to Reduce Air Emissions'. The proposed Bill addresses both 'air pollutants' and 'greenhouse gases'. When it comes to GHG, it is proposed to reduce their emissions to between 45 and 65 per cent of the 2003 levels by 2050. This would mean 340 Mt at 45% reduction up to 490 Mt at 65% reduction from 2003 levels of GHG emissions of 754 Mt. As of the writing of this paper, over the last few weeks, there have been a number of intensive consultations between the federal government and all major industries, including the cement sector.

The cement industry has welcomed the opportunity to respond to the NOI and to submit a proposal for realistic, achievable short term reduction targets for emissions of GHG and air pollutants. As far as the GHG emissions are concerned, the Canadian cement sector contributed 1.93% of total Canadian emissions of CO_2 (or 1.51% of total Canadian GHG emissions) in 2004, based on the Business as Usual (BAU) scenario, as previously calculated by Environment Canada. A formula for calculating CO_2 intensity for the cement sector has already been developed and agreed to in principle by all CAC member companies and Environment Canada. This work should be carried forward under the upcoming regulations. Implementing this approach would result in a reduction of 842,900 tonnes of GHG from BAU in 2015 from a year 2000 baseline. Other GHG, listed in Section 3 of Bill C-30 Section 3 are either not emitted or are de minimus for the cement sector and as such no reduction targets are required.

While CAC has proactively developed the above proposal in response to the rapid targeted timeline and Environment Canada's intent to propose the national and sectoral emissions reduction targets to Cabinet for consideration in early 2007, it has also reiterated that careful considerations of social, economic, and environmental factors are essential to developing such regulations.

6.0 Cement vs. Concrete, and CO_2 Emissions

There is an important point to make with respect to the difference between *cement* and *concrete*. Often, among the general public, these two terms have been used interchangeably. In normal day-to-day lives the semantic difference between the two materials matters little, however, in any technical, engineering, scientific discussion, understanding the distinction is essential. Cement is a fine powder and is the critical ingredient in concrete. Concrete is the actual building material. Cement, and the concrete made from it, is the basis of much of the civilization's infrastructure and much of its physical development [8]. Twice as much concrete is used throughout the world than all other building materials combined. Each year, three tonnes of it are used for every one of the six billion people on Earth. It is a fundamental building material to municipal infrastructure, transportation infrastructure, office buildings and homes. And, while cement manufacturing is resource- and energy-intensive, the characteristics of concrete make it a very low-impact construction material, from an environmental and sustainability perspective. In fact, there are many applications for concrete that contribute to achieving sustainable buildings and infrastructure.

CO_2 embodied in cement is the main source of CO_2 emissions associated with the production of concrete. As concrete mixture typically contains only 9 to 14% cement, however, only about 0.20 to 0.25 tonnes of CO_2 per m^3 of concrete is associated with its production and use. In the context of achieving a decrease in greenhouse gas emissions and possibly meeting specific Canadian emission targets, reduction of the GHG emissions associated with concrete production offers a major, further opportunity, provided this can be done without affecting the required performance of the concrete. Reduction of the CO_2 burden can be achieved by modifying the cement or modifying the concrete. As already indicated earlier, over the past 25 years, the Canadian cement industry has made extensive progress in improving its energy efficiency and related fuel CO_2 emissions. The Cement Association of Canada reports that kiln heat efficiency, measured in GJ/t of clinker, improved 11% from 1990 to 2000, and a further 2% improvement is expected from 2000 to 2010. When expressed in GJ/t of cementitious product, this improvement becomes 16% and 4% respectively [9].

7.0 Global Industry 'Cement Sustainability Initiative'

In an effort that began in 1999, ten global cement companies, including the parents of all the multinationals involved in Canada, came together under the World Business Council for Sustainable Development (WBCSD) to state their joint position on sustainability. More companies have joined since. The process was launched when the Battelle Memorial Institute was commissioned to conduct independent research into how the cement industry can meet sustainability challenges. Battelle's final report, "Toward a Sustainable Cement Industry" [4], was released in March 2002.

The result of this independent study are thousands of pages that provide the analytical foundation for the "Cement Sustainability Initiative Agenda for Action" [5], released in July 2002 and subsequently submitted and officially recognized by the United Nations at the 2002 Johannesburg World Summit on Sustainable Development. The CSI Agenda document outlined the companies' intent to voluntarily implement strategies to protect global climate, enhance employee health and safety, reduce emissions, and use fuels and raw materials responsibly. The Agenda details specific commitments for future company actions, timetables, and mechanisms for further stakeholder engagement. The first report on the program's progress was issued in June 2005 [8], the second coming up in 2007. In keeping with our international counterparts, Canadian cement manufacturers are actively engaged in implementing the strategies set out in the "Cement Sustainability Initiative Agenda for Action', with a particular emphasis on climate protection.

7.1 WBCSD/WRI Cement CO_2 Protocol

In 2001, the Cement Sustainability Initiative (CSI) companies agreed on a methodology for calculating and reporting CO_2 emissions, the WBCSD/WRI 'Cement CO_2 Protocol'. While accounting for the specific needs of the cement industry, the Protocol (Version 1.6), published in October 2001, was closely aligned with the overarching GHG Protocol developed under a joint initiative of the WBCSD and the World Resources Institute (WRI). The 'Cement CP2 Protocol' is fully compatible with the latest guidelines for national GHG inventories issued by the International Panel on Climate Change (IPCC). The Protocol established a common approach to monitoring and reporting all direct and indirect CO_2 emissions from the cement manufacturing process. It comprises two main elements; a guidance document and an Excel spreadsheet [11].

By August 2004, 94% the 619 kilns of CSI member companies had developed CO_2 inventories, which follow the CSI CO_2 Protocol guidelines; as of early 2005, three companies had published emission reduction targets and reported progress. After two years of testing, the Protocol was updated to Version 2.0 based on feedback and comments from the U.S. EPA, IPCC, KPMG, and others. The main changes include an inclusion of emissions from organic carbon in raw materials and revised fuels emission factors, particularly those for alternative fossil and biomass fuels. The Protocol was also modified to take into account technical improvements identified as companies applied it, and to incorporate relevant comments of the recent review of the overarching WRI/WBCSD GHG Protocol. This updated Protocol was released in June 2005 [8,11].

Within the updated Protocol, accounting practices that allow for emission credits and trading to meet the requirements current and future trading systems were also incorporated.

7.2 Cement CO_2 Protocol and Canadian Cement Industry

In order for the Canadian cement industry to prepare its position for negotiations with government on its role and goals in GHG emissions reduction, the Cement Association of Canada (CAC) was authorized by its members to survey the situation as related to the clinker and cementitious materials production, related energy use and GHG emissions in the two benchmark years 1990, 2000 and to develop projections to the year 2010 [10] based on the WBCSD/WRI 'Cement CO_2 Protocol' developed under the CSI and discussed above. The CAC and the industry members found the Protocol to be a very useful tool. There was a 100% participation of the Canadian gray cement industry in the survey and development of the GHG emissions database. Environment Canada (EC) assessed the 'Cement CO_2 Protocol', and found it fully compatible with its intended regulations and accounting procedures. Some of the database numbers and spreadsheets were already used in the discussions and negotiations between the industry and government regulators from the EC's Large Final Emitters (LFE) Group.

8.0 The Cement Industry Commitment to Sustainable Development

8.1 Global Plan, National Implementation

Greenhouse gas (GHG) emission reduction continues to be a priority to the Canadian cement industry. As part of the implementation of its 'Action Plan', the industry is working in four key areas with governments and stakeholders to implement a sector-specific plan for the industry that will achieve the dual objective of maintaining a vibrant Canadian cement industry and helping Canada meet climate change objectives. Four near term GHG abatement opportunities have been identified for the cement industry including:

- energy efficiency,
- alternative fuels,
- innovative cement products and
- innovative concrete products.

These four opportunities are the focus of environmental teams within individual cement companies as well as the focus of the activities that the Cement Association of Canada carries out on behalf of its member companies.

8.2 Energy Efficiency Achieved Through Continuous Innovation

Canadian cement industry progress to date in the area of the energy efficiency is illustrated through the relationship that the industry has established with Canadian Industry Program for Energy Conservation (CIPEC). The Canadian cement industry has played a leadership role in CIPEC and has an active Cement Sector Task Force through which the cement industry was a pioneer in benchmarking performance. CIPEC reports that over the 1990 – 2002 period, the cement industry has reduced overall energy intensity by 12%, decreased direct greenhouse gas

emissions per unit of production by 7.1%, while at the same time product demand increased by 24%. These achievements were made at no small cost to the industry as the majority of the energy reductions resulted from significant capital investments to modernize plant technology. Further to this effort, limited technological options remain for significant gains in energy efficiency. Nevertheless, the industry remains committed to exploring innovative approaches for energy management.

8.3 Alternative Fuels

The cement industry can effectively utilize waste to displace fossil fuel consumption and reduce emissions. Materials commonly used by the industry in Europe and Japan include biomass, tires, used oils and used solvents. Under the leadership of individual provinces, such as that of Quebec, the cement kiln is more frequently being integrated into the recycling hierarchy for some common wastes. However, according to the International Energy Agency (IEA), Canada's performance on energy recovery from waste is among the poorest in the world. Unfortunately, due to regulatory barriers and a negative perception by the general public, between 1995 and 2004, on average, only 6.25% of all kiln fuel used was derived from waste (3). Expanded use of alternative fuels is viewed by the industry as the most significant opportunity to enhance sustainability and reduce consumption of fossil fuels.

8.4 Innovative Cement Products

Supplementary Cementing Materials (SCM) are by-products of other industrial production processes that may be inter-ground to produce blended cements or added to concrete. Increased use of SCM leads to an equivalent reduction of GHG emissions and represents one of the best, technically proven approaches for reducing cement industry emissions. While there is only a limited volume of suitable, economically viable SCM available, the Cement Association of Canada partners with the International Centre for Sustainable Development of Cement and Concrete (ICON) of the Minerals and Metals Branch of Natural Resources Canada to promote the responsible increase in use of these products in Canada (there is a limit to the amount of SCM that can be used without compromising concrete quality).

8.5 Innovative Concrete Products

Innovative concrete products for enhancing sustainability, increasing energy efficiency and reducing emissions are available in every construction market. Examples range from high performance concrete and aerated autoclave concrete to innovative construction methodologies such as tilt-up and insulated concrete forms. The innovative solutions that the industry brings to market are illustrated in the work the industry has undertaken in residential construction, agricultural, as well as in the transportation sectors.

9.0 Commitment to Innovation and Continuous Progress

The first ever Canadian 'Cement Industry Sustainability Report' was released in March 2006 at the GLOBE 2006 Conference and Exhibition in Vancouver [12]. Industry has made a commitment to report publicly every two years on GHG, air emissions, fuels and raw materials, health and safety, local impacts and innovation. The next report is to be published in 2008.

Through critical self examination and continuous innovation in new technologies and concrete applications, the cement industry is a global, Canadian and U.S. leader in sustainability. As a supplier of the building material that is the foundation of Canada's infrastructure, the cement industry is committed to continuous improvement in environmental performance, and an ongoing contribution to Canada's economic performance and exports.

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