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CDM POTENTIAL IN THE CEMENT SECTOR: THE CHALLENGE OF DEMONSTRATING ADDITONALITY

By
Shakeb Afsah
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Authors contact: Shakebafsah@performeks.com/ ph: 202-390-0340

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INTRODUCTION

The cement industry is a critical part of the international climate management strategy because globally this sector produces nearly 1.4 billion tons of CO₂ or nearly 6% of all man-made CO₂ emissions (McCaffrey, 2002). Therefore the cement industry has attracted considerable international attention, and sizeable resources are expected to be deployed for reducing CO₂ emissions from cement production. Within the framework of the Kyoto Protocol, the Clean Development Mechanism (CDM) is expected to become a critical project-level vehicle for funding activities that will lead to sustainable reduction in CO₂ emissions.

As expected, the potential for carbon financing through CDM has triggered considerable interest among cement companies that have production in Annex II countries. While it is obvious that energy and CO₂ intensities of cement production is very high, it does not readily translate into guaranteed carbon financing through CDM. Project proponents may find that proving additionality and building a defensible baseline scenario for cement sector projects can be a challenge because historical evidence shows that cement companies have successfully reduced CO₂ emissions from energy efficiency improvements without any carbon financing. All CDM activities proposed by cement companies will therefore be subjected to a rigorous review for whether or not it is a business-as-usual (BAU) project.

This report shows that there are real opportunities for CDM activities in the cement sector. Given the energy intensive nature and the process features of cement production, there are potentially many opportunities for energy efficiency improvements and CO₂ reduction. There are two channels that provide the best opportunities for the CDM. These are increased production of blended cement and the use of alternative or secondary fuel in cement production. Accordingly, this guideline will focus primarily on these two channels of CO₂ reduction. Also the topics in this report are structured to mirror the analytical requirements of a project design document (PDD).

This report also concludes that there are important information gaps and uncertainties that can substantially increase the cost of preparing the project design document (PDD). This situation will therefore lead to less than the optimal level of CDM activities in the cement sector. To address the problem of incomplete information, this report has compiled information and analyzed data from divergent sources to develop guidelines on topics covering additionality, evaluation of baseline and monitoring plan. Since generalizations can be misleading, this report does not prescribe any internationally applicable benchmark or universally applicable methodology because each potential project has sufficient uniqueness and exceptions that. The report emphasizes that cement companies will need data and information

that go beyond the project sites, and may require regional, national or international level information to make a credible case for additionality.

This report has nine sections. The first section provides a brief review of the existing literature. The second section gets into the basics of cement production, and identifies the types of cement sector project that are most likely to emerge as CDM activities. The third section provides an overview of the global cement industry. The fourth section focuses on the CDM projects pertaining to blended cement production, and the fifth section is on CDM projects based on alternative fuel use. Each of the fourth and fifth sections is divided into several sub-topics covering the issues of additionality, baseline analysis, calculation of CO₂ reduction and monitoring issues. The sixth section presents some guidelines for monitoring CO₂ emissions. The seventh section describes some of the factors that could hinder CDM projects. The eighth section provides some basic data on critical indicators that could be helpful to project proponents during the PDD preparation. The last section discusses the recommendations for strengthening CDM activities in the cement sector.

1. REVIEW OF EXISTING INITIATIVES

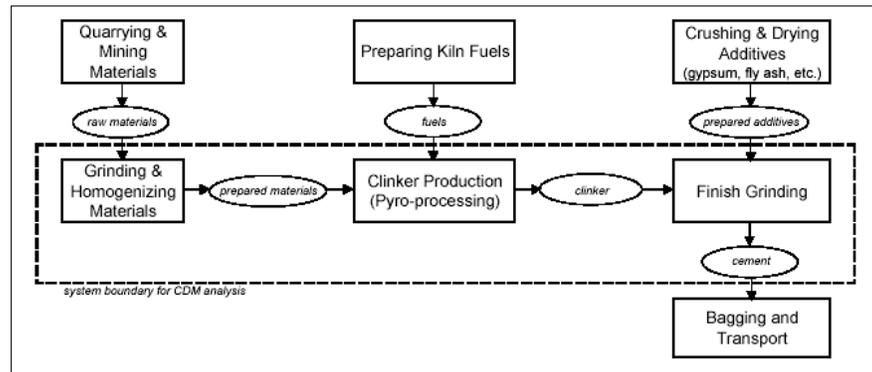
There is no doubt that public and private interest in supporting CO₂ reduction from cement production is strong. In February 2000 World Business Council for Sustainable Development (WBCSD) initiated the Cement Sustainability Initiative (CSI; see www.wbcdcement.org) which led to a detailed report titled “Toward a Sustainable Cement Industry” in March 2002. As part of this study, there are several sub-studies that are available from http://www.wbcdcement.org/final_reports.asp. Similarly the cement sector was one of the industries reviewed by OECD’s evaluation of emission baselines issues for project-based mechanisms (OECD 2001). This sector is also covered extensively in various studies by the Energy Analysis Department at Ernest Orlando Lawrence Berkeley National Laboratory in the US (for various reports visit <http://eetd.lbl.gov/ea/ies/iespubs/ieupubs.htm>).

The existing studies on the cement industry adequately cover the issues of energy efficiency improvements, sustainable development, general baseline issues and emissions monitoring and thus are useful for providing broad guidelines. But these studies are not tailored to assist project proponents in the preparation of PDD. The current report fills this gap by keeping the focus of analysis and recommendations on the practical needs of potential project proponents as they prepare the PDD.

2. CO2 EMISSIONS FROM CEMENT PRODUCTION

Since there are many good references for cement production, this section is brief and will draw from existing reports. A simple sketch of the cement production process is shown in Figure 1. Cement is produced by processing a mixture of raw materials (main constituents are limestone, chalk, and clay) in intense heat (temperature in the range of 1400°C). The process step associated with maximum CO₂ generation is clinker production (pyro-processing). During this process intense heat removes all moisture, and carbon dioxide is separated from calcium carbonate, thereby creating a new compound called clinker. Finally clinker is quickly cooled and blended with other additives and ground to make cement.

Figure 1: Cement Production Process

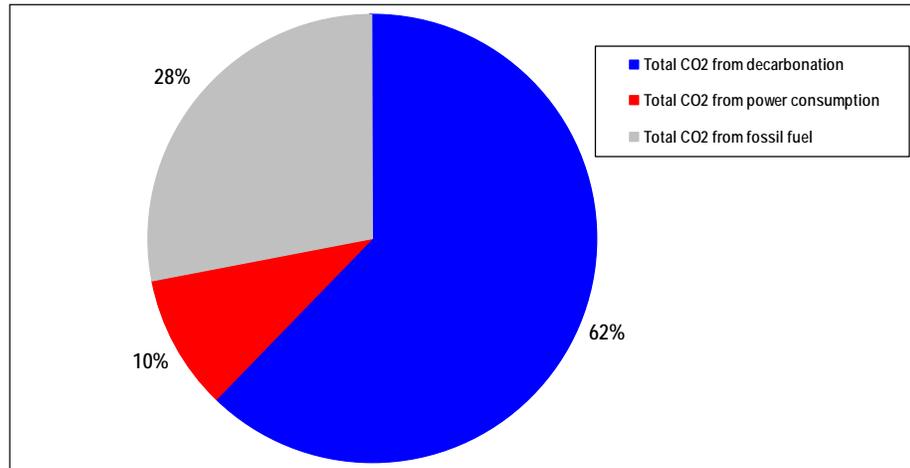


From: "Evaluating Clean Development Mechanism Projects in the Cement Industry Using a Process-Step Benchmarking Approach", Michael Ruth, Ernst Worrell, and Lynn Price, July 2000

While energy use is an important contributor of CO₂ emissions, cement stands out as a unique sector because considerable amount of CO₂ is generated as process emissions from clinker production. According to Cembureau, the European Cement Association, CO₂ is generated from three independent sources during cement production. These are:

1. De-carbonation of limestone in the kiln (about 525 kg CO₂ per ton of clinker),
2. Combustion of fuel in the kiln (about 335 kg CO₂ per ton of cement), and
3. Use of electricity (about 50 kg CO₂ per ton of cement)

Figure 2: CO2 Emissions By Process



Using data from Germany, Figure 2 shows that nearly 62% of the total CO₂ generated from cement production was through the de-carbonation process averaging a CO₂ intensity of 0.435 kg of CO₂/kg of cement, followed by 28% from fuel use with CO₂ intensity of 0.196 kg of CO₂/kg of cement. Consequently, this guideline will focus on projects that aim to increase production of blended cement which reduce CO₂ emissions from the carbonation process, and the use of alternative or secondary fuel in cement production as a substitute for fossil fuel.

3. INTERNATIONAL TRENDS IN CEMENT PRODUCTION

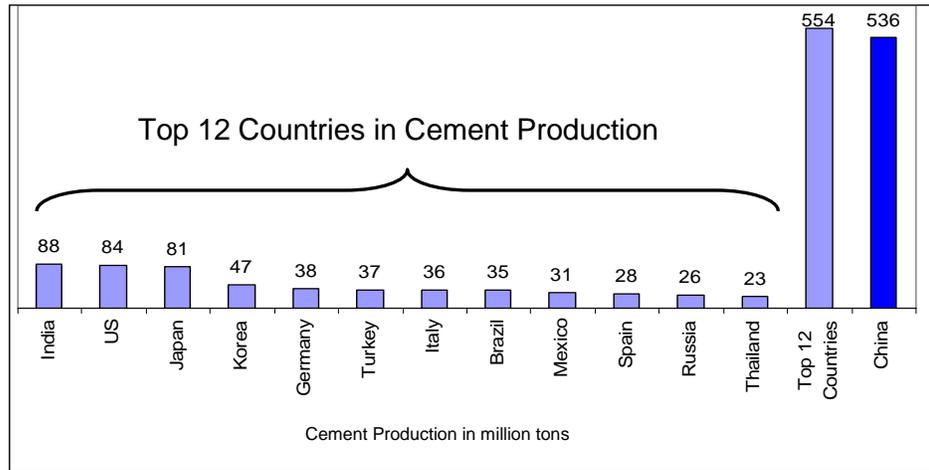
The international cement industry has gone through an impressive transformation in terms of energy efficiency improvements as well as the market penetration of blended cement. However considerable differences still persist in cement markets across countries. This may be because cement quality is regulated, and therefore national standards can heavily influence the types of cement sold in a market. In this section we briefly review the global cement production structure, European cement industry and the international energy use trends in the cement sector. These three aspects were selected because of their relevance to CDM and particularly to help project proponents develop a credible baseline scenario.

3.1 Global Cement Industry

Global cement consumption in 2001 was 1.7 billion metric tons, with the Asia/Pacific accounting for 59%, Western Europe 12%, Middle East/Africa 11% and other regions 18%. (Cement World, Freedonia 2002). Global cement growth rate is expected to be around 4%, and the by 2006 the cement demand is expected to be around 2 billion metric tons. The bulk of this growth is expected to be in Asian countries where investment in infrastructure is still lagging behind.

As shown in Figure 3a, China's cement consumption alone accounts for as much as the combined consumption of the other top twelve countries. Even India, which has population levels comparable to China, is considerably less in cement consumption, perhaps due to cement consumption deficit.

Figure 3a: Leading Global Cement Producers

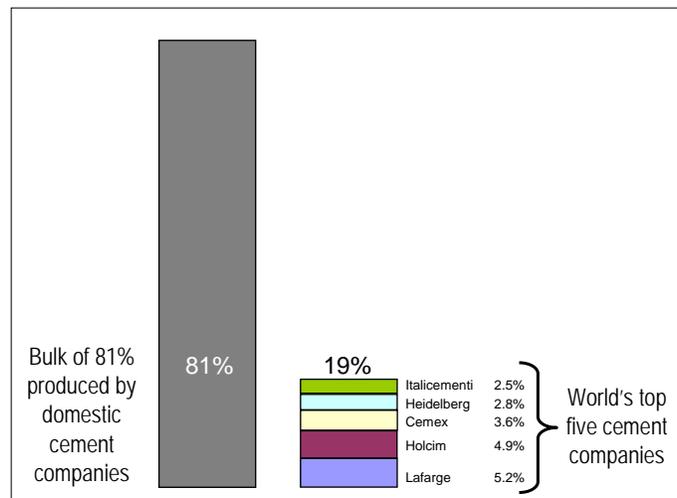


China and India present an interesting comparison for climate management strategies. As shown in Table 1, China and India have the same energy intensity and comparable CO2 intensity even when their clinker ratios are different. It appears that in India, energy efficiency is high enough that it can offset the additional energy consumption due to higher clinker use. Comparatively, China with lower clinker factor has comparable energy and CO2 intensities as India because its energy intensity is not very efficient. This is explainable due to the fact that energy price is high in India. Also, in China considerable amount of cement is produced using wet kilns and small producers (WBCSD 2002). There is no doubt that India and China are important countries for cement industry related CDM projects, but the strategy in the two countries could be very different.

| Countries/Region | Clinker Factor (%) (mid 1990s) | Energy Consumption (MJ/kg clinker) (2000) | CO2 Intensity (kg CO2/kg of cement) (2000) |
|------------------|--------------------------------|---|--|
| China | 0.83 | 4.71 | 0.9 |
| India | 0.89 | 4.71 | 0.93 |

Another interesting feature of the cement industry is that the leading international cement companies account for only around 20% of the total cement production (Figure 3b). This implies that domestic producers could be a very important target group for CO₂ reduction. It is also likely that domestic producers are perhaps less aware of the CDM opportunities compared to the international companies. It is not a surprise that out of the three potential CDM activities of the cement sector, two are from international companies (Heidelberg and Holcim) and one is a domestic company (Birla Cement, India). For PCF and other international organizations, it will be essential to ensure that CDM does not create a problem of adverse selection, whereby the bulk of potentially eligible cement projects do not happen due to information failure or high project preparation cost.

Figure 3b: CDM Potential-Key Segment



3.2 European Cement Industry

Europe as a region has a very climate friendly production and market structure for cement. Market penetration of blended cement is strong in the EU market and the region has seen considerable improvement in energy efficiency and the use of alternative and secondary fuel. Also EU has very clear cement classification system which was developed after nearly thirty years of extensive discussions and research.

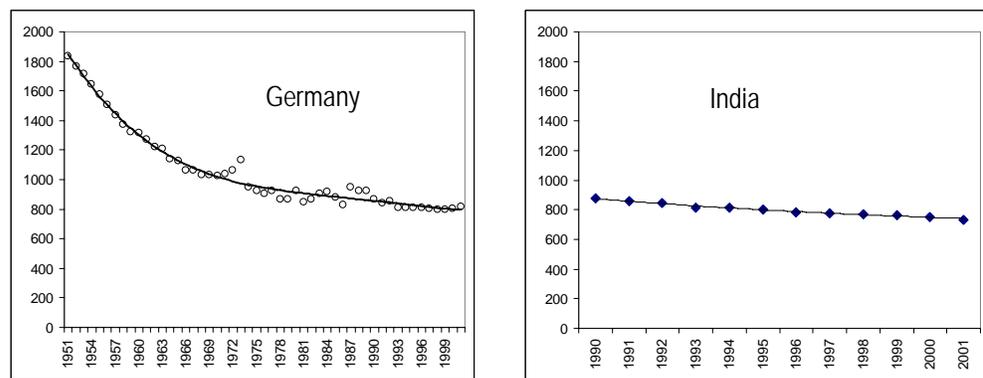
There are three factors that have contributed to the climate friendly developments in the EU cement market. First the high price of energy creates a strong incentive for energy efficiency. Second, environmental awareness level of consumers is high and it creates a strong platform for marketing blended cement that produce less CO₂ compared to the Ordinary Portland Cement (OPC). And finally, well organized waste management infrastructure in several countries enable cement producers to procure alternative fuel at a relatively low cost and use it as a substitute for fossil fuel in kilns.

Looking at the long term cement industry trend in Europe, it is possible that over time the European experience could spread to the other parts of the world. However, it is hard to predict the time frame over which such a technological diffusion could happen. In this context, the CDM could play a critical role in accelerating the climate friendly technological changes in the cement sector in developing countries.

3.3 International Energy Use Trend

Energy cost being as high as 30-40% of the total production cost of cement (Cembureau, 1977), energy efficiency improvement has been at the core of cement industry's competitive strategy. Consequently, the last two decades have seen a significant reduction in energy intensity of cement production. Most importantly, these improvements were driven by private incentives alone. As shown in Figure 4, it appears that energy efficiency improvement, as measured by thermal efficiency indicator, has been substantial in both developed and developing countries. The explanation for this common international trend is simple--for companies to stay competitive, it is essential to trim their energy consumption levels.

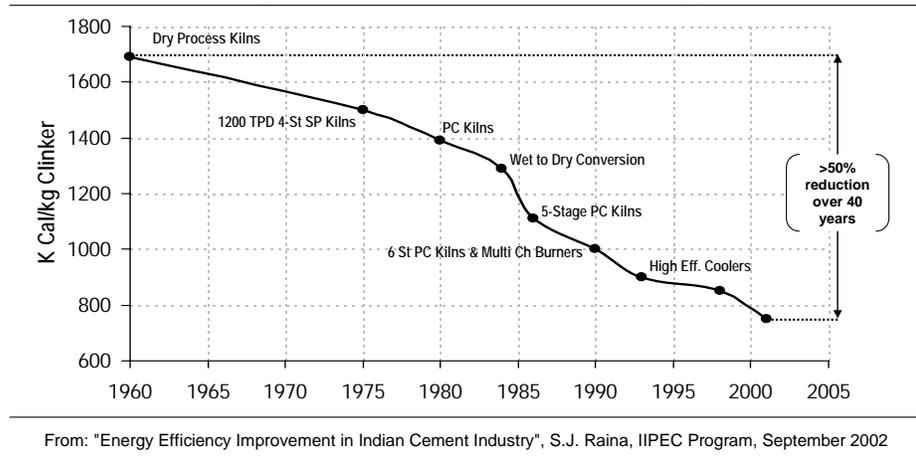
Figure 4: Fuel Use Trend (Kcal/kg Clinker)



Long term energy use trend in the cement sector embodies critical strategic information for CDM. In countries or companies, where the energy efficiency curve has flattened out, it is a sign of maturity and additional improvement in energy efficiency is expected to be difficult and expensive. Cembureau makes this point through the data on energy use trend for France (Cembureau 1998). A similar energy use profile is visible for the fuel use curve for Germany (Figure 3). The energy efficiency improvements of the last thirty years in the cement industry can be attributed to technological progress. As shown in Figure 4, the cement industry has seen continual improvement in the kiln technology. High energy cost and the need to stay competitive have led to impressive technological achievements.

It is clear that for the cement sector market forces have spurred some amazing energy efficiency innovations. As a result, the global cement industry (both at the company as well as the industry levels) now has a strong

Figure 5: Evolution of Kiln Technology



skill base and organizational capacity for technological innovation. However, for the skeptics, this raises an important question about the need for carbon financing for future reductions in energy use. It appears that creative climate management policy can motivate a new generation of energy efficient technologies in the cement sector. In this respect CDM could be a very powerful channel for shaping public policies and consumer preference towards climate friendly cement products.

In contrast, for countries and companies that are still at comparatively inefficient energy use levels, it implies that private incentives have failed to drive energy efficiency improvement. In such cases, it will be necessary to evaluate the effect of company specific management failures, and national policy factors. For cement companies that are laggards on the energy efficiency improvement curve because they still use wet kilns or are small scale producers, proving additionality and establishing eligibility for CDM could be difficult.

Conversion of wet kilns into modern dry kilns is well under way in the cement industry. In fact, the bulk of cement production today is from dry kilns. Because of considerable savings in energy and improvement in clinker quality, conversion of wet kilns into dry kilns is a profitable project. Companies that still use wet kilns and hope to seek carbon financing for converting wet kilns into dry kilns may find it hard for their projects to qualify as CDM activities.

Also, there is a trend towards consolidation of cement production. There are economies of scale in cement production, and wherever policies allow it, small scale cement producers are likely to be replaced by large producers that can operate high capacity kilns which are energy efficient. In this context, small scale cement producers will find it extremely hard to qualify for carbon financing.

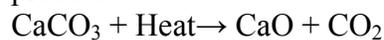
The next two sections of this report focus on practical issues pertaining to potential CDM projects that aim to increase the production of blended cement and the use of alternative fuel in kilns.

4. CDM PROJECTS BASED ON BLENDED CEMENT

Unlike other energy intensive industries like steel, fertilizer, and others, where CO₂ reduction is primarily through energy efficiency improvements and fuel use changes, the cement sector has the unique feature of reducing CO₂ through product modification. Increasing blended cement output or modifying existing blended cement to lower clinker content offers a unique opportunity for reducing CO₂ considerably.

4.1 How Does Blended Cement Reduce CO₂?

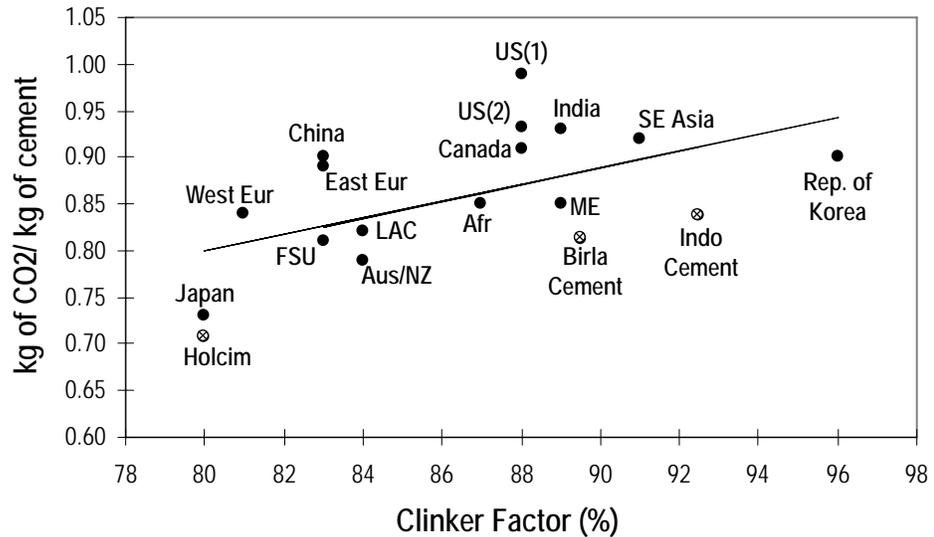
As discussed earlier, an important source of CO₂ emission is decarbonation of limestone (calcination) that occurs during clinker production. Clinker is produced when calcium carbonate under intense heat gets transformed into calcium oxide and carbon dioxide according to the following chemical process:



The most traditional type of cement called Ordinary Portland cement (OPC) requires 95% clinker to ensure that compressive strength of cement is adequate to comply with the safety standards that typical construction requires. In comparison, blended cement contains lesser share of clinker compared to OPC, but comparable properties. Substitution of OPC by blended cement will lead to reduction in CO₂ emission per unit cement. Less clinker requires less energy, leading to reduction from fuel and electricity use also. As shown in Figure 6, higher clinker factor is indeed associated with higher CO₂ intensity.

Because OPC continues to dominate the production of cement, accounting for nearly 80% of the total global output (Freedonia 2002), there is considerable scope for introducing blended cement in the global market.

Figure 6: Clinker Factor and CO2 Intensity



1. Dark bullets show the national level values for clinker factor and CO2 intensity. These are compiled primarily from WBCSD report.
2. US(1) and US(2) show values reported in two different sources
3. Data for Holcim, IndoCement and Birla cement are taken from their PDDs

4.2 Assessment of Additionality

The guidelines provided by the 10th meeting of the Executive Board on 29-Jul-03 (CDM-EB, Annex 1) state that:

“2. Examples of tools that may be used to demonstrate that project activity is additional and therefore not the baseline scenario include, among others:

(d) An indication that the project type is not common practice (e.g. occurs in less than [$x\%$] of similar cases in the proposed area of implementation, and not required by a Party’s legislation/regulations.”

Using this guideline, the key indicator for evaluating that blended cement is not a common practice in a market is through the market share data of blended cement. However, the evaluation of market share of blended cement can be complicated because there is no internationally accepted standardized classification system for blended cement, which results in a wide variation in blended cement’s definition and standards across countries. Therefore, to evaluate that blended cement is not a common practice in a CDM project context, assessment must be made at a national level.

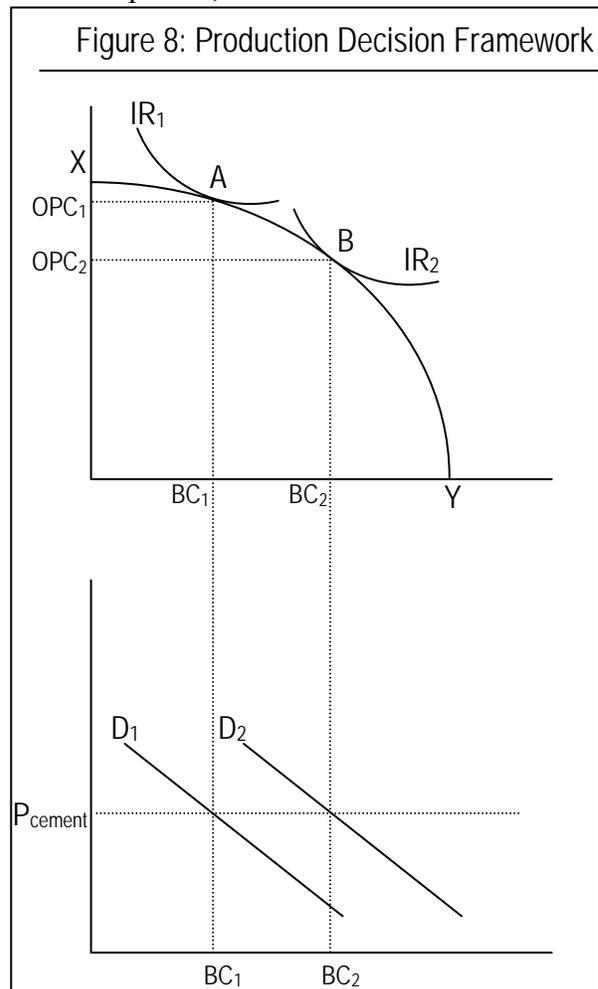
This guideline provides the necessary background information for evaluating that blended cement is not a common practice in a CDM project context. This primer has the following four sections:

- ◆ Firm's Decision to Produce Blended Cement
- ◆ Additionality Decision Steps
- ◆ Cement Classification System
- ◆ International experience in blended cement
- ◆ Factors that limit BC from becoming common practice
- ◆ Recommended benchmarks for establishing common practice in BC

4.2.1. Firm's Production Decision

Typically, a cement company has the option to produce only ordinary Portland cement (OPC) or blended cement or some combination of the two. As shown in Figure 8, various options for producing the mix of OPC and blended cement is shown by the product transformation curve XY. Since a cement company wants to maximize its profits, it will choose a combination of cement products such that the difference between the total revenue from cement products and the total cost of producing it is at the maximum. The profit maximizing is the point of tangency between the product transformation curve and the isorevenue curve (IR).

Within this decision making framework, it is easy to evaluate that the quantity of blended cement a company chooses to produce depends on the preference of consumers. If the demand for blended cement is characterized by D_1 , BC_1 level of blended cement will be produced. If the demand for blended cement is characterized by the demand curve D_2 , a company will produce BC_2 , where $BC_2 > BC_1$.



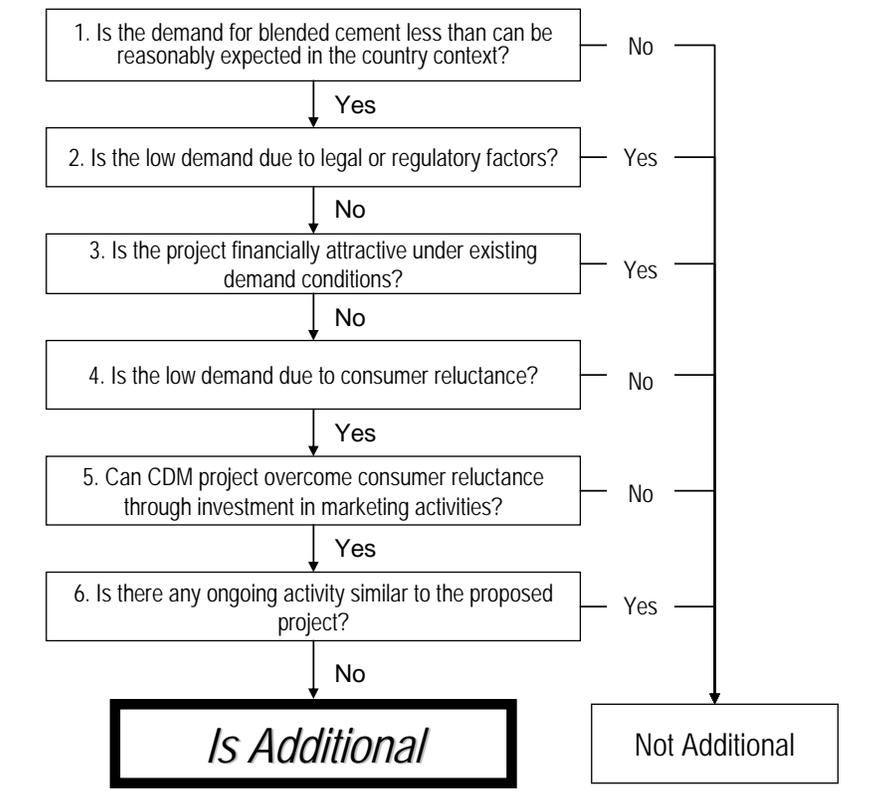
Now it is clear that if a project proponent wants to seek carbon financing for a blended cement project it must show that the market situation in the project market is characterized by point “A” and that the project aims to move to point “B” with the help of additional marketing effort that will shift the demand curve from D_1 to D_2 . The project proponent must explain the market barrier that limits the demand to D_1 in the baseline situation.

4.2.1. Additionality Decision Steps

The PDD requires project developers to provide an explanation of how and why their project is additional and therefore not the baseline scenario. Making a case for additionality is tough because it requires project developers to make predictions about the future knowing well that often the past can be a poor predictor. Because additionality has uncertainty and incomplete information inherent in its concept, it is unlikely that additionality assessment will ever be a perfectly scientific process. Yet project developers are required to make a verifiable and a defensible case for their project. In such a case, it is most critical that project developers follow a set of logical steps that apply quantitative and qualitative information to build a case for additionality.

Accordingly, a six-step additionality assessment process is recommended. As

Figure 9: Additionality Assessment for Blended Cement



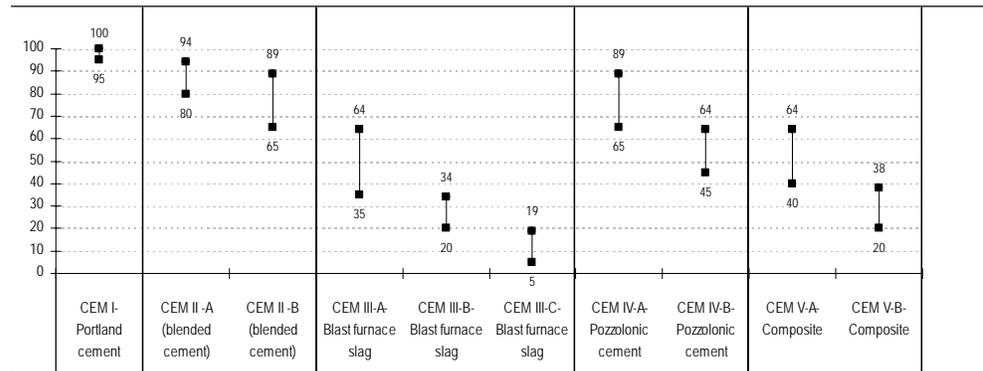
shown in Figure 9, the first step is to show that the market share of blended cement in the project market is less than some justifiable benchmark or norm. Using comparative national, regional or international data can be very useful at this stage. Also, legal and regulatory factors should be eliminated as the reasons for the weak blended cement market. At the next stage, it must be shown that the project is not financially viable on its own. Project developers should apply financial analysis like IRR to show that the blended cement project under the existing market situation fails to meet the company's hurdle rate for projects. Project proponent should also explain that the current demand situation exists due to market barriers. Reasons for consumer reluctance to buy blended cement should be explained. By this stage, it should be established that the proposed project is unlikely to occur under business-as-usual scenario. Next project proponents must show that the proposed project offers a solution to the problem of market barrier for blended cement. And finally, it must be shown that the no project that is similar to the proposed project is under implementation in the project market.

4.2.2. Cement classification system

Cement is a standard product worldwide but it still lacks a common classification system that is applicable in all countries. A national standard typically reflects a classification scheme that is based on local building styles, climatic conditions and the attitude of consumers. Consequently, one finds a wide range of cement types across countries. For example in the seventies, there were nearly twenty types of cement under various national standards in Europe. By 1990 there were fifty cement types sold in Europe under different national standards. In Indonesia, the national standard specifies six types of cement. Comparatively in India, there are seven different types of cement.

The most common variety of cement is the Ordinary Portland Cement (OPC), and every national standard has OPC as one of the main cement types. The salient feature of OPC is the high proportion of clinker which is around 95% or higher. But within OPC there are sub-categories that vary considerably across countries.

Figure 10: Clinker Content (%) in EU Cement Classification System



The cement classification issue gets considerably complex for non-OPC variety of cement. The most common non-OPC variety of cement is called blended cement. In many cases blended cement is called mixed cement or composite cement. Blended cement is produced by reducing the proportion of clinker and increasing the proportion of additive materials. However, the classification of blended cement gets extremely complicated at the sub-category level because there are several alternatives for additive materials.

Perhaps, the most advanced and comprehensive cement classification system is the EU standard called DIN EN 197-1, which was finalized in December 2000 after nearly thirty years of work. Even then, it is not practical to apply the EU standard as a benchmark for cement classification because it is not easy to map other national standards for blended cement into an EU cement category. EU's standard is categorized into five main categories ranging from CEM I to CEM V. Within each CEM group there are sub categories A, B and C. Overall the EU standard defines twenty seven different types of cement, with nineteen of these categorized as CEM II blended cement type. The clinker content in the different cement categories is shown in Figure 10. EU classification system illustrates the difficulty of cement classification which depends on multiple aspects like clinker factor, additive type, strength class etc.

4.2.3. International experience in blended cement

Given the wide variation in the classification system for blended cement across countries, an international comparative analysis can be applied for illustrative purposes to understand some broad market trends. The market share data on blended cement is not easily available but for some countries where blended cement is a common practice, market share and trend data can provide some insight into the long-term nature of how blended cement penetrates a cement market that is dominated by a well established product like OPC. Figure 11 shows the market share and growth rate data for blended cement in Japan. By 2002, blended cement accounted for around 26% of the cement market, but the data on market share growth rate shows that the

market grew at an average annual rate of just around 1%, and therefore, it took more than twenty years for blended cement to reach the current market status in Japan.

Information on blended cement market trends in Germany¹ confirmed

that it takes around ten years to establish blended cement as a viable substitute for OPC in a market. As shown in Figure 5, the share of CEM II cement type that represents the blended cement variety in the EU has now a market share of 51.9%. In Australia, blended cement accounted for 20% of the market share in 1999 and in South Africa the share of blended cement increased from 45% in 1999 to 61% in 2002. However, in the case of South Africa it is not clear how long it took for the blended cement market to grow to the 45% level in 1999.

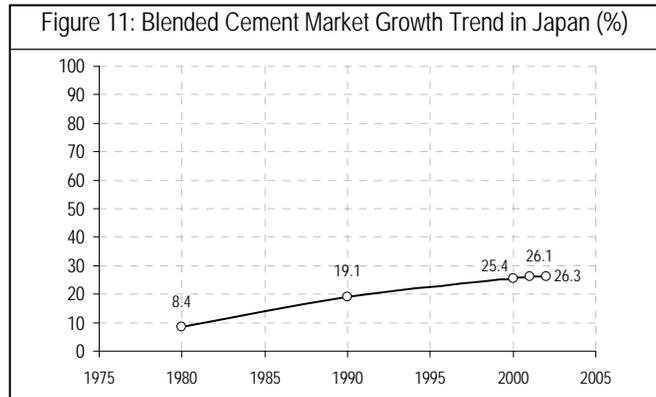
The positive environmental features of blended cement are helpful, but the bottom line for consumers remains workability, durability and homogeneity. Blended cement must demonstrate the test of time like OPC has for hundreds of years now, before consumers show a readiness for trying this new cement. The longevity aspect of concrete structures is a strong factor that explains the cautious behavior of consumers with respect to blended cement.

4.2.4. Factors that Limit Blended Cement from Becoming Common

Practice

There are potentially four types of barriers that could explain the low demand situation that blended cement faces in many markets. These include:

1. **Investment Barrier:** Shift from OPC to blended cement requires significant investments, and in some situations country risk and economic uncertainties make project financing difficult
2. **Technical Barrier:** The level of technical know how and skilled labor needed to install the equipment, modify existing facilities and operate new process may not be available
3. **Market Barrier:** Significant marketing efforts and investment are needed to overcome negative consumer perception and to introduce new cement types.



¹ Based on presentation and discussion with Dr. Martine Schneider, German Cement Association

4. **Regulatory Barrier:** Additional efforts may be needed in terms of technical capability and investment to secure the supply of alternative fuels, particularly biomass.

Strength and durability are key features that cement consumers look for in a quality product. This is not surprising because cement is typically used in structures that are designed to last long periods of time through diverse climatic conditions. In this context, the type of cement that has stood the test of time is the Ordinary Portland Cement (OPC). Given the long historical roots of OPC in the construction industry; the preference for OPC in consumers' minds is deeply engrained. Consequently, OPC is still the most common cement type currently produced and marketed. According to the World Cement 2003, OPC still accounts for nearly 80% of the cement sold worldwide.

Market barrier due to consumer reluctance about buying blended cement is the most challenging hurdle for cement producers. Partha Sarthy and Chakravarty (1999), in the book "Indian Cement Industry: Emerging Trends", explain that the consumer's lack of awareness about the benefits and comparability of blended cement with OPC is a major factor that has led to the slow growth of blended cement market. The authors also mention that there is a false perception that blended cement has lower strength compared to OPC. These perceptions were strengthened by the experience of some failed structures that were built using blended cement in the seventies. When such beliefs about blended cement are paired with observations of hundred years old structures built using OPC, it only creates a natural hesitation about purchasing blended cement. Therefore, there is a strong status quo effect regarding OPC use that has hindered the acceptance of a new type of product like blended cement. This analysis of consumer reluctance was further confirmed by Scot Horst (2001) who attributes the reason for the limited use of blended cement to "the natural human reluctance to divert from well known standard procedures".

Based on the market successes of blended cement in Europe and Japan, it is safe to conclude that the market barrier can be overcome but that it is a long process. Some examples of activities undertaken to promote the market for blended cement include:

1. The German Cement Association has a very strong R&D program that regularly tests the strength and the workability of blended cement and publishes its results in a format that enables comparability between OPC and blended cement.
2. In December 2002, the City of Berkeley in California adopted a resolution requiring, whenever technically feasible, procurement of cement will specify the use of blended cement in city buildings and

other construction. Such initiatives by governments go a long way in dispelling the negative perception about blended cement.

3. In the US, the Slag Cement Association (SGA) was created in 2001 to help educate engineers, specifiers and contractors and producers in the proper use of slag cement, a type of blended cement.

4.2.4. Recommended Benchmarks for Establishing Common Practice in BC

Both qualitative and quantitative benchmarks are needed for establishing that blended cement is not a common practice in a CDM project context. On the qualitative side, some reference points that will provide guidance for common practice assessment include:

1. Is there a well defined national standard for blended cement?
2. Does the national cement industry association have initiatives directed towards promoting blended cement?
3. Does the industry association collect and track data on blended cement production and sales?
4. Is there any regulation that prohibits or discourages the use of blended cement?

On the quantitative side, recommended benchmarks for establishing common practice in blended cement include:

1. Market share of blended cement: less than 20% shows an underdeveloped market and signals that the use of BC is not a common practice
2. Annual growth rate of blended cement market share: if faster than the growth rate of OPC, it is sign of market acceptance and signals that BC use is becoming a common practice
3. Share of cement plants that produce blended cement: if > 25%, it shows common practice

4.3 Calculation of Baseline CO₂ Emissions

The baseline emission rate is calculated using the following approach:

1. Based on the baseline scenario, quantify the market share of various cement products. Let the market share of each cement product in any given year be represented by S_{it} , where S is the market share of cement type “i” in the year t. Use the most conservative approach for selecting market share.
2. Using the national cement standards, identify the most conservative clinker factor of each cement product. Let K_i be the clinker factor for the cement type “i”.
3. Calculate the weighted average clinker factor for each year of the project period using the formula $\sum (S_{it} \cdot K_i)$

Using IPCC recommendation for tons of CO₂ per ton of clinker of 0.525, the Baseline Emission Rate (tons of CO₂ per ton of cement) for each of the project year = $\left[0.525 \times \sum (S_{it} \cdot K_i)\right]$

5. CDM PROJECTS BASED ON ALTERNATIVE FUEL USE

Use of alternative fuel in the production of clinker in cement plants is of immense value from climate and environmental management perspectives (See Figure 6). Over the last ten years, the use of alternative fuels by cement plants in Europe has saved around 2.5 million tons of coal. However, the use of alternative fuel in cement companies around the world still remains very limited.

5.1 Assessment of Additionality

To assess that alternative fuel is not a common practice in a cement industry in a CDM project context, the focus of analysis is on financial and regulatory factors. Therefore, the most appropriate reference for the general baseline approach for such a CDM activity is Article 48 (b), which states that “Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment”.

Using a financial analysis framework, we conclude that in most countries use of alternative fuel in cement production is not a common practice. In a few countries where alternative fuel is used as a significant source of heat for clinker production, there are advanced systems for waste management and strict regulations for waste disposal that make the supply of waste at a price that makes the use of alternative fuel in cement plant a financially viable option.

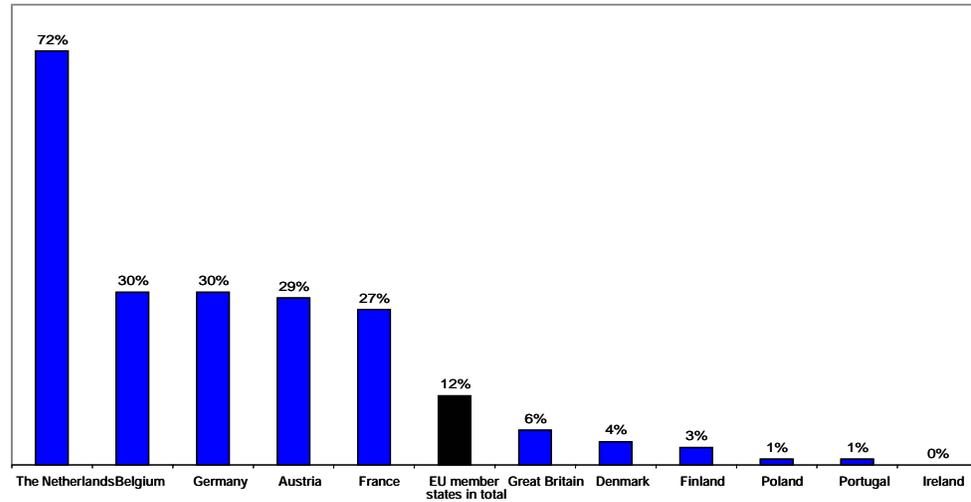
This primer on alternative fuel use in cement plants is organized into three sections. The first section describes the conventional fuel used for clinker production. The second section looks at international trends in alternative fuel use, and the final section discusses various barriers to alternative fuel use that prohibit it from becoming a common practice.

5.1.1. Traditional fuel used is fossil fuel mix

Cement manufacturing is a very energy intensive process, and it typically uses a fossil fuel mix as the primary source for heat. Generally a cement plant consumes around 3200-5500 MJ/t clinker, with coal as the primary fuel. But other fuels like petroleum coke, natural gas and oil are also used.

The share of energy cost can be as high as 40% or more in the total production cost of cement. It is not surprising to find that cement producers have tremendous interest in energy efficiency and cheaper fuel options because it can significantly improve their competitive. Consequently, we find that in the case of European cement manufacturers energy consumption has

Figure 12: Alternative Fuel Use in Europe



From: Presentation "CO2 Reduction in Cement Industry", M. Schneider, VDZ Düsseldorf, Germany, November 2003, Jakarta

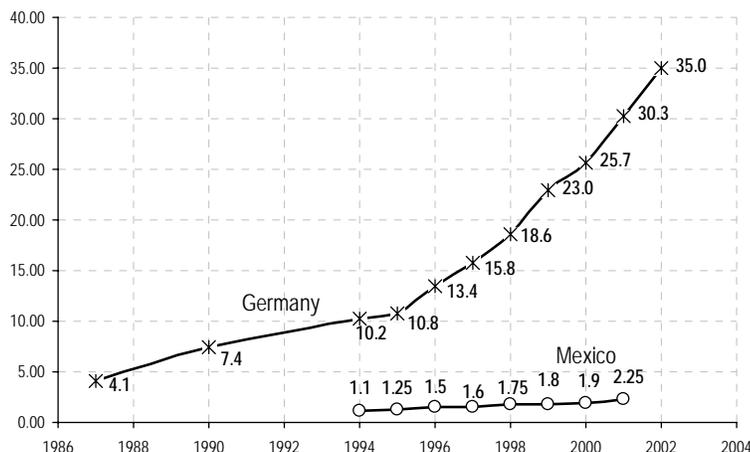
improved by 30% since the 1970s. Also, some EU countries show a very high use of alternative fuel because of its cost advantage over fossil fuel. Therefore, wherever alternative fuel offers a cheaper fuel option, cement manufacturers will use alternative fuel to substitute fossil fuel. However, in most countries alternative fuel is not a common practice. The next section presents some international trends in alternative fuel.

5.1.2. Alternative Fuel Level of Use and Types -International Trends

The best data on alternative fuel use is available for the EU countries. As shown in Figure 12, there is a wide variation in alternative fuel use across EU countries. As explained earlier, cement producers use alternative fuel only if it is financially beneficial compared to the conventional fossil fuel option. The key factors that make the supply of waste a profitable option for cement producers are the waste management regulations and a supporting infrastructure (waste collection, storage and transportation system). Waste management regulations and infrastructure together establish a predictable supply system for waste. In countries like Germany, France and the Netherlands, the waste management regulations and a matching infrastructure is very well developed and it makes alternative fuel a financially attractive option for cement producers.

Regarding the growth trend, the data from Germany shows that currently the use of alternative fuel continues to grow at around 15% annually (Figure 13). Outside the EU, data from Mexico shows that the share of alternative fuel use was around 2% in 2001, but the growth trends are positive.

Figure 13: Alternative Fuel Use (%)-Germany and Mexico



1. Germany's data from "CO2 Reduction in Cement Industry", presentation by M. Schneider, VDZ Düsseldorf, Germany, November 2003, Jakarta
2. Mexico's data from "Energy Use in the Cement Industry in North America: Emissions, Waste Generation and Pollution Control: 1990-2001", M. Jacott, C. Reed, A. Taylor and M. Winfield, 21 February 2003

There is a wide cross-country variation in the types of waste that are used as alternative fuel in a cement plants. Therefore, feasibility of using alternative fuel has a strong national dimension. Through the data on Mexico's cement industry, the table below gives some insight into the types of waste that are used as alternative fuel in a cement plant. The diverse waste types make it very clear that the financial feasibility of using waste as alternative fuel is critically linked to the public infrastructure that makes the supply system predictable and cost effective. Given the dispersed nature of waste sources, it is unlikely for a private cement producer to use alternative fuel because the transportation and quality control costs could be prohibitive.

| Types of Waste | 1994 | 1998 | 2000 | 2001 |
|---------------------------|---------------|---------------|---------------|---------------|
| Liquid Alternative Wastes | 30,000 | 38,325 | 43,581 | 48,532 |
| Tires | 8,000 | 13,500 | 23,160 | 21,254 |
| Solid Alternative Wastes | 3,200 | 10,000 | 77,831 | 91,408 |
| TOTAL | 41,200 | 61,750 | 77,831 | 91,048 |

From: "Energy Use in the Cement Industry in North America: Emissions, Waste Generation and Pollution Control, 1990-2001", Marisa Jacott, Fronteras Comunes Cyrus Reed, Texas Center for Policy Studies Amy Taylor and Mark Winfield, The Pembina Institute for Appropriate Development for the Commission for Environmental Cooperation Second North American Symposium on Assessing the Environmental Effects of Trade, 21 February 2003

In conclusion, it is clear that the alternative fuel is likely to become a common practice in the cement sector of a country only when environmental regulations and waste management infrastructure are well developed. In the absence of a publicly supported infrastructure for waste management, the

private cost of collection, transportation and quality control for waste becomes higher than using the conventional primary fuel for which the supply system is very well established.

5.1.3. Analysis of Barrier to Alternative Fuel Use

There are potentially four types of barriers that could explain why alternative fuel use is not a common practice in a CDM project context. These include:

5. **Investment Barrier:** Shift from conventional fossil fuel to alternative fuel requires investment in new types of burners, and other process control equipment. In some situations financing could be a concern.
6. **Technical Barrier:** The level of technical know how and skilled labor needed to install the equipment, modify existing facilities and operate new process may not be available
7. **Market Barrier:** Supply of waste in adequate quantity may be a big factor in the decision to use alternative fuel in a cement plant. Waste collection and transportation cost can be prohibitive in the absence of a well managed public infrastructure.
8. **Regulatory Barrier:** Using certain hazardous waste may require a permit from environmental agencies. Waste burning may release gases that need to comply with emission standards

5.2 Calculation of Baseline CO2 Emissions

The baseline emission rate is calculated using the following approach:

4. Based on the historical data on specific heat consumption per unit clinker, develop a conservative scenario for specific heat consumption for each kiln. Let specific consumption for each kiln in a given year “*i*” be expressed as H_{it} , where “*i*” represents each kiln.
5. Let the share of heat from each fossil fuel type be represented by S_k , where “*k*” represents fossil fuel type.
6. Let CO2 emissions per unit heat for each fuel type be represented by C_k .

Then, *Baseline Emissions Rate* ($t\ CO_2 / tons\ of\ clin\ ker$) = $\left[\sum (SH_{it} \cdot F_k \cdot C_k) \right]$

6. MONITORING PLAN

The primary goal of a monitoring plan is to ensure that a project is implemented in accordance with planned performance. The monitoring plan for a CDM activity defines the key data to be collected that will enable the calculation of reduction in CO2 emissions. In the context of a PDD, a good monitoring plan must ensure data quality and completeness, cost-effectiveness in data collection and ease of verification. To achieve these goals, the monitoring methodology must apply a combination of self-

monitoring, internal auditing and third party verification to ensure that data collection is accurate, timely and complete.

The overall monitoring system must also include trained personnel, appropriate measurement instruments, appropriate procedures for assessment and analysis of data, and a user friendly computerized system for data collection, storage, analysis, and reporting.

In this report, the monitoring plan is organized around five types of data. These include parameters related to market penetration of blended cement, clinker production, cement production, types of fuel used, and power consumption, power purchased and generated on-site. Most fundamentally, the monitoring should ensure that data are collected at the most primary level, which in this case is at the individual kiln level. Cement plants generally have advanced control system that ensures that data on clinker production, cement output and electricity use are collected in real time. However, monitoring for a CDM project goes considerably beyond the existing monitoring systems of cement plants. Existing control systems are designed to ensure cement quality and operational flow, but mapping such control systems into monitoring for CO₂ emissions goes beyond instrumentation. A regular data analysis, internal audit and integrating data that are collected on-line with data that are recorded manually will require an expanded monitoring system. To guide the design of a strong monitoring system, detailed lists of parameters are presented in Tables 1 and 2.

7. FACTORS THAT HINDER CDM PROJECTS IN THE CEMENT SECTOR

There are at least two factors that could serve as barriers to CDM activities in the cement sector. These are:

1. High transactions cost associated with project preparation
2. Information constraints

7.1 High Transactions Cost

A PDD must have a very detailed baseline analysis and a monitoring plan. Project proponents often need experts to conduct such analysis, and this cost could be significant. In such a situation, project preparation cost for a CDM activity is compared against the conventional projects within a firm, and may create internal dissension against CDM activities. Also, project proponents may have to interact and seek approvals from government officials. Such activities and requirements may increase the transactions cost of preparing a project under CDM.

7.2 Information Constraint

An essential requirement for CDM eligibility is the evidence of additionality and development of a credible baseline scenario. Such analyses often require historical data, description of counterfactual scenarios and data collection

from sources outside of a firm or industry. Often collecting and organizing such information for a PDD can be extremely demanding and costly for project proponents.

8. HELPFUL DATA FOR PROJECT PROPONENTS

As stated earlier in this report, information gaps can substantially increase the cost of preparing PDD. To address this constraint, the author has provided information from his proprietary knowledgebase for potential project developers in the cement sector. Though the global cement industry has plenty of data, they are not structured within a common database to provide the much needed information for assessing additionality and baseline analysis. Hopefully, these data tables will fill some of the existing data gaps.

The attached data tables include data on indicators from the categories shown below:

| Electricity Consumption | | Fuel Use | |
|--------------------------------|---|------------------------------|--|
| 1 | Specific electricity consumption (GJ/t cement) | 1 | Specific heat consumption (GJ/t cement) |
| 2 | Specific electricity consumption (GJ/t clinker) | 2 | Specific heat consumption (kcal/kg clinker) |
| 3 | Specific electricity consumption (kWh/t cement) | 3 | Specific heat consumption (GJ/t clinker) |
| 4 | Specific electricity consumption (kWh/t clinker) | Clinker and Additives | |
| 5 | Specific electricity consumption-Blasting/transport of raw materials (GJ/t clinker) | 1 | Clinker Factor (clinker to cement ratio) (%) |
| 6 | Specific electricity consumption-Crusher (kWh/t input) | 2 | Clinker Level (%) |
| 7 | Specific electricity consumption-Grinder (raw materials) (kWh/t input) | Total Energy Use | |
| 8 | Specific electricity consumption-Kiln (kWh/t clinker) | 1 | Total Energy Consumption (fuel + electricity) (GJ/t clinker OR MJ/kg of clinker) |
| 9 | Specific electricity consumption-Grinder (clinker) (kWh/t cement) | 2 | Total Energy Consumption (fuel + electricity) (GJ/t cement) |
| CO2 Emissions | | Alternative Fuel Use | |
| 1 | CO2 Intensity (t CO2/t clinker) | 1 | Alternative fuel share in the total fuel use (%) |
| 2 | CO2 Intensity (kg CO2/kg cement) | 2 | Types of Alternative Fuel Used (%) |
| 3 | Total CO2 from power consumption (kg CO2/kg cement) | Cement Market | |
| 4 | Total CO2 from fossil fuel (kg CO2/kg cement) | 1 | Market Share by Cement Type (%) |
| 5 | Total CO2 from decarbonation (kg CO2/kg cement) | | |

9. CONCLUSIONS AND RECOMMENDATIONS FOR PCF

The main conclusions are:

- ◆ The cement sector appears to be an important sector for CO₂ reduction but CDM eligibility will require a strong market barrier analysis for blended cement related projects, and a credible financial analysis for alternative fuel related projects.
- ◆ PCF can play a critical role in developing cement sector projects by providing tools and data inputs that would reduce the transactions cost during project preparation for project proponents. This applies particularly to domestic cement producers in developing countries who may find the cost of preparing a PDD prohibitive.
- ◆ There are many technical improvements in the cement sector that firms are motivated to undertake because of private incentives. Many of these improvements that lead to CO₂ reduction will not qualify as CDM activities. However, because of the potential for carbon financing firms may attempt to package some of these projects as CDM activities.
- ◆ Ordinary Portland cement continues to account for nearly 80% of the total global output. In comparison some countries like Germany and South Africa have managed to increase the share of blended cement in their markets to more than 50%. If 30% of the existing global output of OPC gets substituted by blended cement, considerable amount of CO₂ (around 40 million tons per year) could be eliminated. PCF can play an important role in promoting policy changes that in developing countries where blended cement's market remains under developed.

Table1. Blended Cement.

A. Part I of the baseline methodology: Monitoring of parameters related to market penetration of blended cement

| ID number | Data Type | Data Variable | Data Unit | Measured (m), calculated (c) or estimated (e) | Recording Frequency | Proportion of Data to be Monitored | How Will the Data be Archived (electronic/paper) | For How Long is the Archived Data Kept? | Comment | instrument used to record |
|-----------|-----------|-----------------------|-----------|---|---|------------------------------------|--|---|-----------------------|---------------------------|
| 1 | Mass | Blended Cement | Ton | e | At the beginning of each crediting period | 100% | electronic, paper | According to the crediting period | To test additionality | NA |
| 2 | Mass | OPC | Ton | e | At the beginning of each crediting period | 100% | electronic, paper | According to the crediting period | To test additionality | NA |
| 3 | Mass | Other types of cement | Ton | e | At the beginning of each crediting period | 100% | electronic, paper | According to the crediting period | To test additionality | NA |

B. Part III of the baseline methodology: Data to be collected to carry out baseline methodology

| ID number | Data Type | Data Variable | Data Unit | Measured (m), calculated (c) or estimated (e) | Recording Frequency | Proportion of Data to be Monitored | How Will the Data be Archived (electronic/paper) | For How Long is the Archived Data Kept? | Comment | instrument used to record |
|---|-----------|----------------------------|-----------|---|--|------------------------------------|--|---|---------|---------------------------|
| Monitoring of parameters related to clinker production | | | | | | | | | | |
| 1 | Mass | Raw meal production | Ton | m | Recorded continuously and reported monthly based on actual silo stock level changes | 100% | electronic, paper | 2 years after the end of the crediting period | | Weighing feeders |
| 2 | Mass | Clinker production | Ton | m,c | Recorded/calculated and reported monthly | 100% | electronic, paper | 2 years after the end of the crediting period | | Weighing feeders |
| 3 | Mass | Clinker ground | Ton | m,c | Measured/Calculated and reported monthly and adjusted according to actual silo stock level changes | 100% | electronic, paper | 2 years after the end of the crediting period | | Weighing feeders |
| 4 | Mass | Clinker for OPC | Ton | c | Calculated and reported monthly and adjusted according to actual silo stock level changes | 100% | electronic, paper | 2 years after the end of the crediting period | | |
| 5 | Mass | Clinker for blended cement | Ton | c | Calculated and reported monthly and adjusted according to actual silo stock level changes | 100% | electronic, paper | 2 years after the end of the crediting period | | |

| ID number | Data Type | Data Variable | Data Unit | Measured (m), calculated (c) or estimated (e) | Recording Frequency | Proportion of Data to be Monitored | How Will the Data be Archived (electronic/paper) | For How Long is the Archived Data Kept? | Comment | instrument used to record |
|--|------------|--|-----------------------------|---|--|------------------------------------|--|---|---------|---------------------------|
| 6 | Mass | Clinker sold | Ton | m | Measured per shipment (truck, train or vessel) | 100% | electronic, paper | 2 years after the end of the crediting period | | Scale or vessel draft |
| Monitoring of parameters related to cement production | | | | | | | | | | |
| 7 | Mass | Additive Materials and Gypsum | Ton | m | Recorded daily and reported monthly and adjusted according to actual stock changes and quantities received | 100% | electronic, paper | 2 years after the end of the crediting period | | Weighing feeders |
| 8 | Mass | Total OPC cement production | Ton | c | Calculated and reported monthly and adjusted according to actual silo stock level changes | 100% | electronic, paper | 2 years after the end of the crediting period | | |
| 9 | Mass | Total blended cement production | Ton | c | Calculated and reported monthly and adjusted according to actual silo stock level changes | 100% | electronic, paper | 2 years after the end of the crediting period | | |
| 10 | Ratio | Clinker to cement ratio | Fraction | c | Recorded daily and reported monthly | 100% | electronic, paper | 2 years after the end of the crediting period | | |
| Monitoring of emissions related to fuel consumption (to be monitored for each type of fuel independently) | | | | | | | | | | |
| 11 | Quantity | Fuel type | Units of mass or volume | m | Recorded continuously and reported monthly and adjusted according to stock change | 100% | electronic, paper | 2 years after the end of the crediting period | | Scale |
| 12 | Heat Value | Fuel calorific value | Mcal or MJ per unit of mass | m,c | Monthly | 100% | electronic, paper | 2 years after the end of the crediting period | | Calorimeter |
| 13 | Heat | Total heat consumption per kiln | Mcal or MJ | c | Calculated and reported monthly | 100% | electronic, paper | 2 years after the end of the crediting period | | |
| Monitoring of emissions related to power consumption (to be monitored for each production line independently) | | | | | | | | | | |
| 14 | Power | Electricity consumption for raw meal preparation and pyro-processing | KWh | m | Recorded daily and reported monthly | 100% | electronic, paper | 2 years after the end of the crediting period | | KWh meter |
| 15 | Power | Electricity consumption | KWh | m | Recorded daily and reported monthly | 100% | electronic, paper | 2 years after the end of the | | KWh meter |

| ID number | Data Type | Data Variable | Data Unit | Measured (m), calculated (c) or estimated (e) | Recording Frequency | Proportion of Data to be Monitored | How Will the Data be Archived (electronic/paper) | For How Long is the Archived Data Kept? | Comment | instrument used to record |
|-----------|-----------|-------------------------------------|-----------|---|-------------------------------------|------------------------------------|--|---|---------|---------------------------|
| | | for finish grinding | | | | | | crediting period | | |
| 16 | Power | Electricity consumption for packing | KWh | m | Recorded daily and reported monthly | 100% | electronic, paper | 2 years after the end of the crediting period | | KWh meter |
| 17 | Power | Power purchased from the grid | KWh | m | Recorded daily and reported monthly | 100% | electronic, paper | 2 years after the end of the crediting period | | KWh meter |
| 18 | Power | Power generated | KWh | m | Recorded daily and reported monthly | 100% | electronic, paper | 2 years after the end of the crediting period | | KWh meter |

Monitoring of parameters related to power purchased from the grid

| ID number | Data Type | Data Variable | Data Unit | Measured (m), calculated (c) or estimated (e) | Recording Frequency | Proportion of Data to be Monitored | How Will the Data be Archived (electronic/paper) | For How Long is the Archived Data Kept? | Comment | instrument used to record |
|-----------|-------------------------------|---------------|-------------|---|---------------------|------------------------------------|--|---|---|---------------------------|
| 19 | Emission factor/unit of power | CO2 emissions | Ton CO2/Mwh | estimated | Every 2 years | 100% | electronic, paper | 2 years after the end of the crediting period | Calculated based on national electricity statistics | NA |

Monitoring of parameters related to power generated on-site (for each type of fuel independently)

| ID number | Data Type | Data Variable | Data Unit | Measured (m), calculated (c) or estimated (e) | Recording Frequency | Proportion of Data to be Monitored | How Will the Data be Archived (electronic/paper) | For How Long is the Archived Data Kept? | Comment | instrument used to record |
|-----------|------------|------------------------|-----------------------------|---|---|------------------------------------|--|---|---------|---------------------------------------|
| 20 | Quantity | Fuel type | Units of mass or volume | m | Recorded continuously and reported monthly and adjusted according to stock change | 100% | electronic, paper | 2 years after the end of the crediting period | | Scale (flow meter or weighing feeder) |
| 21 | Heat Value | Fuel calorific value | Mcal or MJ per unit of mass | m,c | Monthly | 100% | electronic, paper | 2 years after the end of the crediting period | | Calorimeter |
| 22 | Heat | Total heat consumption | Mcal or MJ | c | Calculated and reported monthly | 100% | electronic, paper | 2 years after the end of the | | |

| ID number | Data Type | Data Variable | Data Unit | Measured (m), calculated (c) or estimated (e) | Recording Frequency | Proportion of Data to be Monitored | How Will the Data be Archived (electronic/paper) | For How Long is the Archived Data Kept? | Comment | instrument used to record |
|-----------|-----------|----------------------|-----------|---|---------------------|------------------------------------|--|---|---------|---------------------------|
| | | for power generation | | | | | | crediting period | | |

Table 2. Alternative Fuels.

| ID number | Data Type | Data Variable | Data Unit | Measured (m), calculated (c) or estimated (e) | Recording Frequency | Proportion of Data to be Monitored | How Will the Data be Archived (electronic/paper) | For How Long is the Archived Data Kept? | Comment | instrument used to record |
|--|------------|---------------------------------|-----------------------------|---|---|------------------------------------|--|---|--|---------------------------|
| Monitoring of parameters related to clinker production | | | | | | | | | | |
| 1 | Mass | Clinker production | Ton | m,c | Recorded/calculated and reported monthly | 100% | electronic, paper | 2 years after the end of the crediting period | | Weighing feeders |
| Monitoring of emissions related to fuel consumption (to be monitored for each type of fuels and each kiln - fossil fuels and alternative fuels - independently) | | | | | | | | | | |
| 2 | Quantity | Fuel type | Units of mass or volume | m | Recorded continuously and reported monthly and adjusted according to stock change | 100% | electronic, paper | 2 years after the end of the crediting period | Default CO ₂ -emission factors for each fuel type | Scale |
| 3 | Heat Value | Fuel calorific value | Mcal or MJ per unit of mass | m,c | Monthly | 100% | electronic, paper | 2 years after the end of the crediting period | | Calorimeter |
| 4 | Heat | Total heat consumption per kiln | Mcal or MJ | c | Calculated and reported monthly | 100% | electronic, paper | 2 years after the end of the crediting period | | |