A Process-Step Benchmarking Approach to Evaluating Energy Use at New Cement Plants

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ABSTRACT: Energy efficiency projects in the industrial sector provide a source for reducing greenhouse gas emissions under a Clean Development Mechanism (CDM) scheme as laid out in Article 12 of the Kyoto Protocol. The CDM offers a mechanism for developed countries to meet greenhouse gas (GHG) reduction requirements by gaining offsets from projects they fund in developing countries. To receive these offsets – known as Carbon Emission Reduction Units (CERs) – the project should demonstrate "real, measurable, and long-term benefits" and the reductions should be "additional to any that would occur in the absence of the project."(UNFCCC, 1997) In other words, energy-efficiency CDM projects must be compared against some baseline to quantify the carbon reduction, and this baseline should reflect, as closely as possible, what would have happened in the absence of the CDM project.

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OVERVIEW

To establish a CDM evaluation tool for cement production that addresses the three stages identified above and uses a benchmarking approach, it is necessary to establish benchmark performance values for each of the three stages. Then a project can be compared against the benchmark to determine the projected level of carbon dioxide reduction the project will accomplish.

The formula for calculating carbon emission reductions at a cement plant is given below. This formula takes into account only energy use at the three key process stages: raw material preparation, clinker production, and cement grinding. A benchmark value is used at each stage to measure the carbon emissions avoided.

$$C(t) = \sum_f m_f q_f \cdot \underbrace{\left(b_K \cdot X_K(t) - K(t)\right)}_{\text{clinker production}} + q_e \cdot \left[\underbrace{\left(b_M \cdot X_M(t) - M(t)\right)}_{\text{raw materials}} + \underbrace{\left(b_G \cdot X_G(t) - G(t)\right)}_{\text{cement grinding}}\right] \quad (1)$$

C(t) = carbon dioxide emission reduction at the plant in year t (tonnes CO2)

mf = percentage of fuel f in total primary fuel use for year t (%)

Carbon contents:

qf = carbon content of fuel f (tonnes CO2/GJ)

qe = carbon content of electricity (tonnes CO2/kWh)

Outputs:

XM(t) = output of raw material at the plant in year t (tonnes)
XK(t) = output of clinker at the plant in year t (tonnes)

XG(t) = output of ground cement at the plant in year t (tonnes)

Energy Use:

M(t) = total plant electricity use for raw materials preparation in year t (kWh) K(t) = total plant energy use for clinker production in year t (GJ)

G(t) = total plant electricity use for cement grinding in year t (kWh)

Benchmarks:

bM = energy benchmark for raw meal production (kWh/tonne raw meal)

bK = energy benchmark for clinker production (GJ/tonne clinker)

bG = energy benchmark for cement production (kWh/tonne cement)

In the cement production process, carbon dioxide emissions can be grouped as "energy-related", referring to emissions that result from the combustion of fossil fuel, and "process-related", referring to the emissions from the decomposition of calcium carbonate. Process-related emissions are not accounted for in Equation (1) because they are not a matter of efficiency or performance; instead they are related to the total amount of clinker produced and not to the technology used. These emissions can be reduced on a per tonne of cement basis by decreasing the amount of clinker per tonne of cement (the clinker-to-cement ratio). This is referred to as "blended cement". This aspect has been left out of Equation (1) because it presents some difficult issues that will be addressed in Section VI. For now, the calculation is neutral to the clinker-to- cement ratio.

Determining the value to assign as benchmarks for the above equation is not a simple task. To reflect the intent of the Kyoto Protocol, CDM projects should receive credit only if the reductions they cause are additional to what would have happened without CDM. Therefore it is important for benchmarks to represent what would have occurred in the absence of CDM. Cement production is highly competitive and efficient equipment is the norm. It is plausible to consider setting benchmarks for the cement process steps from: (1) average annual performance data from individual plants across the industry, (2) actual performance data from recently constructed plants, or (3) documented best technology information. While the first of these options would allow us to generate a trend of energy performance at newly added facilities over time, and therefore might indicate a future trend for plants, data availability makes this a difficult approach. Following this approach would require performance data at each process step for each plant in a country, as well as information on the vintage or age of each component. This would be extremely difficult or impossible to obtain for most countries. Furthermore, there may not be enough plants built in a given region, or the plants in a region may be too old, for a reasonable trend to be observed.

There is more likelihood of compiling a reliable dataset for the other two options. For example, when new plants are constructed, the manufacturer often gives a "guaranteed" value for the performance of the kiln, and the manufacturer will compensate the facility owner if the value is not met. Thus, actual performance data from recent plants may be available because plant owners are monitoring actual kiln production compared to guaranteed values. Through a thorough literature search on new plants and perhaps communication with manufacturers, it may be possible to collect enough data to use this approach. Documentation on the best available technologies for all processes is obtainable from cement associations, such as Cembureau, the European Cement Association, and may be the most simple method for establishing benchmark values (see Table 1). We use such values for benchmarks in the examples presented in the next section.

EXAMPLES OF THE USE OF A PROCESS-STEP BENCHMARKING APPROACH FOR CEMENT PLANTS

In this section we look at two examples to illustrate the benchmarking approach outlined in this report. The energy benchmark values, against which project performance values are compared, are taken from the technological estimates shown in Table 1. We set the benchmark at the highest end (i.e. least efficient) of these estimates. Since most new plants coming on now are more efficient than this value, we assume this is the least strict benchmark that might be set7. Therefore our examples give the greatest amount of carbon reduction likely to be credited for a given plant. We evaluate two hypothetical plants using this benchmark. The first one is based on the actual performance data reported for a cement plant in Thailand. For the second example the hypothetical plant performance data are taken from the lowest (i.e. most efficient) technological estimates in Table1.

Performance data from "best practice" Technologies. Table 1 presents a hypothetical scenario in which the benchmark and performance values are taken from the best-practice estimates in the first 3 rows of Table 1, (Cembureau 1997). Benchmarks need to be strict enough to avoid rewarding for emission reductions that would have occurred anyway, while at the same time allowing some room for improvements so that efficient projects actually receive some incentive. To create this hypothetical scenario, the benchmark value is set at the high end of the best available technology estimates in Table 1. For performance values, the lowest estimates are used; this represents the best possible plant, and therefore the largest potential emissions reduction. By choosing a benchmark at the highest best available technology level and assuming a new plant operating at the lowest best available technology level, the example illustrates the maximum amount of credit that would likely be granted.

Table 1: Evaluating Carbon Dioxide Emissions of a Hypothetical Plant Using a Best Available Technology Benchmark.

Process Step Output[a]	Benchmark	Performance	Plant	Energy Saved	Carbon Content[b]	Carbon Avoided
Raw Materials Preparation	20 kWh/ tonne raw material	10 kWh/ tonne raw material	3.4 Mt raw material/yr	34 GWh/ yr	Elec: 0.16 tC/ MWh	5.6 kt C
Clinker Production	3200 MJ/ tonne clinker	2900 MJ/ tonne clinker	2.0 Mt clinker/yr	600 MJ/ yr	Fuel Oil: 21 tC/ TJ	12.6 kt C
Cement Grinding	36 kWh/ tonne cement	25 kWh/ tonne cement	2.1 Mt cement/yr	23 GWh/ yr	Elec: 0.16 tC/ MWh	3.8 kt C
TOTAL ANNUAL SAVINGS: 10.4 kg C /tonne cement						**21.9 kt C**

Carbon Emission Reduction Credits. In a CDM regime, projects would be awarded one Carbon Emission Reduction (CER) unit for each tonne of carbon avoided. If the Thai plant and hypothetical plant were approved CDM projects, they would accrue 0.032 CER and 0.0104 CER per tonne of cement, respectively. In an emissions trading scheme these CERU would have a market value. If the value of the CERs ranges from $10 to $50, then the value per tonne of cement can be calculated as shown in Table 4. This table shows that under the best available technology benchmark used in our examples, the Thai plant might expect to earn emission credits equal to roughly $0.03 to $0.16 per tonne of cement. An optimally performing plant would accrue credit around $0.10 to $0.52 per tonne of cement manufactured.

Table 2: Carbon Emission Reduction Credits for Two Example Plants with Values Over a Range of CER Value

Lampang Performance		Hypothetical "Best" Performance
carbon avoided (kg C/t cement)	3.2	10.4
Carbon Emission Reduction (per tonne cement)	0.0032	0.0104
Value, at $10/CER ($/t cement)	0.03	0.10
Value, at $50/CER ($/t cement)	0.16	0.52

In order to understand the importance of these economics, we would want to compare the investment costs of the standard "benchmark" technology with the additional costs of the projects that are needed to exceed the benchmark performance. The magnitude of this incremental investment can then be compared to the potential revenue from the CERs accrued and other benefits including reduced energy expenses. This would partially answer the question as to whether CDM credits offer an incentive for investing in high-efficiency technology. We did not collect the technology cost information needed for this evaluation for this project. An approximation of the economic importance of these CDM credits can be seen by comparing the range of estimated values to the price of cement – approximately $40 to $80 per tonne, but with large regional variation. The values calculated in Table 4 are roughly 1 percent or smaller than the cement price. Further economic analyses into cement production cost factors and the incremental costs of efficient technologies are needed before it is possible to evaluate the economic implications of CERs at this level.

ISSUES FOR CEMENT INDUSTRY BENCHMARKS

BLENDED CEMENTS

In the finish grinding stage of cement production, clinker is mixed with additives and ground to a fine powder. These additives affect the strength, curing time, and other characteristics of the final product, concrete. The most commonly used cement type in the U.S. – Portland cement – has a clinker-to-cement ratio of 95%. By increasing the amount of additives in the mix, i.e. lowering the clinker-to-cement ratio, less clinker is needed so energy use in clinker production decreases per tonne of cement, even though the efficiency of the process may not have improved. At the same time, lower clinker production means that less CO_2 is emitted from dissociating calcium carbonate during the calcination phase of clinker production. These cements with lower clinker- to-cement ratios are called "blended cements". Increasing the fraction of additives with respect to Portland cement leads to longer curing times, but ultimately greater strength in the final product.

The use of blended cements reduces energy consumption as well as offers an opportunity for improved industrial ecology, since the additives can be waste from steel making (blast furnace slag) or from coal combustion (fly ash). Blended cements are very common in Europe and many developing countries (Hendriks et al., 1999). However, there are some non-technological barriers to expanded use of blended cements. One barrier is that building codes in many countries, including the U.S., dictate the chemical and/or physical characteristics of cement used for construction. Restricting properties such as setting time may limit the use of blended cements, therefore discouraging their production. Another barrier is that the additive materials needed may not be available to many cement manufacturers.

The formula for evaluating carbon reductions given in Equation (1) is neutral to the clinker-to- cement ratio. In other words, reductions resulting from lowering the clinker-to-cement ratio are not quantified in the evaluation. If projects that involve the production of blended cements are to be considered for CDM credits, then a value needs to be introduced to Equation (1) that links clinker production and cement production. This can be done by introducing another benchmark value: the benchmark clinker-to-cement ratio. Up to this point, carbon reductions were calculated at the individual process step, based on the how much product was made at that step and how much energy was used. Introducing the benchmark clinker-to-cement ratio changes the calculation slightly. For example, if the clinker-to-cement ratio benchmark is 0.9, then for every

1 Mtonne of cement is produced, we anticipate 0.9 Mtonne of clinker will be produced. If in fact the plant produced cement with a clinker-to-cement ratio of 0.8, then it only needs to produce 0.8

Mtonne of clinker. By avoiding production of 0.1 Mtonne of clinker, the plant saves energy and eliminates emissions from calcination.

A link can also be made with the raw materials preparation stage, if desired, by introducing a benchmark raw meal-to-clinker ratio. Adding these benchmarks changes the Equation (1) in the following way:

d_K = benchmark clinker-to-cement ratio (tonnes clinker/tonne cement)

d_M = benchmark raw meal-to-clinker ratio (tonnes raw meal/tonne clinker)

then new benchmark values can be calculated on a per tonne of cement basis:

$b^*_K = d_K \cdot b_K$ =energy benchmark for clinker production, cement basis (GJ/tonne cement)

$b^*_M = d_K \cdot d_M$ = energy benchmark for raw meal production, cement basis (kWh/tonne b_M cement)

Since the clinker share per tonne of cement changes, there are reduced emissions from the calcination process that must be accounted for. The carbon emissions evolved from this process are a fixed stoichiometric value:

q_c = carbon emissions from the calcination process (tonnes CO2/ton clinker)

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so equation (1) becomes:

$$C(t) = q_j \cdot \Big[\underbrace{q_e \cdot \left(b^*_K \cdot X_G(t) - K(t)\right)}_{\text{clinker production}} + \underbrace{\left(b^*_M \cdot X_G(t) - M(t)\right)}_{\text{raw materials}} + \underbrace{q_c \left(b_G \cdot X_G(t) - G(t)\right)}_{\text{finish grinding}} \Big] + \underbrace{\left(d_K \cdot X_G(t) - X_K(t)\right)}_{\text{calcination}} \quad (2)$$

There are three important differences between the two equations: (1) the addition of the calcination term in the second equation, (2) the modification of benchmark values to all be on a “per tonne of cement basis”, and (3) the second equation only uses the output of cement (XG), not that of raw materials and clinker.

Table 3: Evaluation of Carbon Dioxide Emissions Reductions in Two Potential CDM Projects in the Cement Industry

	Scenario 1: Efficiency Improvements, No Cement Blending	**Scenario 2: Cement Blending, No Efficiency Improvements**
Benchmarks	20 kWh/tonne raw material ground 3200 MJ/tonne clinker 36 kWh/tonne cement ground	20 kWh/tonne raw material ground 3200 MJ/tonne clinker 36 kWh/tonne cement ground 0.95 tonne clinker/tonne cement
Performance	10 kWh/tonne raw material ground 2900 MJ/tonne clinker 25 kWh/tonne cement ground	20 kWh/tonne raw material ground 3200 MJ/tonne clinker 36 kWh/tonne cement ground 0.65 tonne clinker/tonne cement
Production	3.4 Mtonne raw material 2.0 Mtonne clinker 2.1 Mtonne cement	3.4 Mtonne raw material 2.0 Mtonne clinker 3.1 Mtonne cement
Energy Savings	34 GWh from raw material grinding 600 TJ from clinker production 23 GWh from cement grinding	0 GWh from raw material grinding 2,950 TJ from clinker production 0 GWh from cement grinding
Carbon Reduction	13 ktonne C from clinker 9 ktonne C from elec savings	62 ktonne C from clinker 0 ktonne C from elec savings 152 ktonne C from calcination
TOTAL ANNUAL SAVINGS	**22 ktonne** **10.4kgC/tonne cement**	**214 ktonne C** **69.7 kg C/tonne cement**

The efficiency scenario leads to energy savings at each step which can then be translated into annual carbon reductions – a total of 22 kilotonnes of carbon or 10.4 kg C per tonne of cement. In the cement blending scenario there are no energy savings from efficiency improvements, but because the clinker-to-cement ratio is benchmarked at 0.95, total cement output of 3.1 Mt leads to an expected clinker production of 2.95 Mt. Since the plant operates with a 0.65 clinker-to-cement ratio, 0.95 Mt of clinker are "avoided", saving 2,950 TJ of fossil fuels, or 62 kilotonnes C if fuel oil is used in the kiln[10]. Also, since 165 kg C per tonne are generated through calcination, an additional 152 kilotonnes of carbon emissions are avoided. The blending project avoids 214 kilotonnes of carbon emissions, or nearly 70 kg C per tonne of cement. This is almost 10 times the total amount avoided by the efficiency project or 7 times when taken on a per tonne of cement basis. Whereas the efficiency project would be worth between \$0.1 and \$0.5 per tonne cement (assuming CER values between \$10 and \$50), the cement blending project would generate revenue between \$0.7 and \$3.5 per tonne cement produced.

This example demonstrates that blending cement can lead to significant carbon emission reductions. These savings can be much larger than those that energy efficiency projects may attain. Even lowering the clinker-to-cement ratio from 0.95 to 0.90 leads to greater reductions than the efficiency project in the scenarios above. From the viewpoint of an investor seeking the most CDM credits, projects that lower the clinker-to-cement ratio will be preferred. This means that the clinker-to-cement ratio benchmark will be extremely important in determining the amount of credits earned. Setting this value would be easy if all the current and planned cement plants in a country have the same clinker-to-cement ratio, if this is not the case, then measuring additional reductions is difficult. If the benchmark ratio is set high, where most producers currently are, then blended cement projects would reap large reductions, and there is no certainty that these reductions are additional. If the ratio is set lower, then plants with high clinker-to- cement ratios will never qualify, despite how efficient their processes may be. Further research on specific blended cement projects in the context of a particular country's cement sector could explore whether benchmarking clinker-to-cement ratio is appropriate or if these projects should be evaluated on a case-by-case basis.

ADDITIONALITY

New Plants. A brief review of the project activities of cement equipment manufacturers over recent years reveals that nearly all new installations of cement plants around the world have included the most up-to-date technologies, including multi-stage preheaters, precalciners, high efficiency separators, and variable speed drives for mills (ZKG, various). If these technologies are most commonly being adopted, there is little room for "additional" carbon reductions from energy efficient technologies. If most new plants coming online have a multi-stage preheater and a precalciner, then kiln energy performance should be around 3.0 GJ per tonne of clinker and the benchmark could be set at this level. However, it is currently unlikely that a plant will attain better than 2.9 GJ per tonne of clinker. This translates to savings of about 2 kg C per tonne cement, with some variation depending of the fuel used. Are these savings large enough to encourage cement manufacturers to aim for the lower intensity? It is difficult to answer that question without knowing the value of the carbon credits and the additional costs of saving that extra 0.1 GJ per tonne. Further research on this topic is required.

Setting the benchmark higher than 3.0 GJ per tonne (as we did in our examples) would allow many existing projects to qualify for CDM credit. This seems to go against the intention of a CDM mechanism, which aims to credit reductions that would not have happened otherwise.

In terms of grinding raw materials and finished cement, there may be more room for CDM to encourage the adoption of advanced technologies. This is because there is a wider range of technologies currently being adopted. Many tube mills, the least efficient of common mills, are still constructed (ZKG, various), and advanced technologies such as horizontal mills, are still being developed and have small market share. This may be where CDM could make a difference.

Modernization. The hypothetical plant example above illustrated that the expected range for energy intensity of cement production is 3.2 to 3.8 GJ per tonne cement if modern, advanced technologies are adopted for new plants12. The national averages for cement production around the world are much higher than this range. Cement plants are a large capital investment and can be used for many decades. Therefore there are many plants operating below the optimal performance level. In the modern competitive cement market, many of these inefficient plants are unable to compete and are being purchased by large multinationals. These companies then face the choice to modernize the facility or to completely rebuild it.

Plant modernization includes a wide variety of measures. Existing equipment can be upgraded, including mills for raw material and cement grinding, clinker coolers, and classifiers. New features can be added, including preheaters, precalciners, heat exchangers, and dewatering equipment for wet process production. Also, management strategies to improve process control and maintenance procedures contribute to plant modernization.

Below are some examples of modernization projects:

- Anhovo, Slovenia – A double branch preheater from the 1960s was replaced with a 5-stage cyclone preheater with a precalciner. Clinker output increased from 1980 tonne per day (tpd) to 2080 tpd and energy use dropped 15%, from 3660 kJ/kg to 3100 kJ/kg (World Cement 1994).

- Rohoznik, Slovakia – A new dynamic air separator was added to the cement grinding mill.

Output of the mill rose from 100 tph to 120 tph and specific power consumption decreased from 45 kWh/t to 40 kWh/t for the production of Portland cement (World Cement 1994).

- Hranice, Czechoslovakia – A wet process plant was converted to dry process. The new plant

has an output of 2735 tpd and kiln energy consumption of 3125 kJ/kg (World Cement 1994).

- Cizkovice, Czechoslovakia – In the only AIJ project in the cement industry13, a new cement crusher and a new preheater system were added. Further details and performance data are not

available yet (UNFCCC 1998).

- Tasek Cement, Malaysia – An existing preheater was replaced with a 5-stage, 2-string

preheater and a precalciner. A planetary cooler was replaced with a reciprocating grate cooler for tertiary air supply. Capacity increased from 2,100 tpd to 5,100 tpd. No energy information is available (Krupp Polysius 1998).

- Testi, Italy – A 4-stage preheater was replaced with a 5-stage preheater and a precalciner.

The rotary kiln was shortened and drives were altered to allow for increased speed. Output increased form 1000 tpd to 1800-2000 tpd. Kiln heat requirements fell from 3560 kJ/kg to

3060-3185 kJ/kg (Sauli 1992).

- Alpena, MI, US – 14 ball mills and a drying system for raw materials were replaced with 2

roller presses and flash driers added to the 2 largest existing ball mills. Power consumption for raw material grinding dropped from 20.7 kWh/t to 17.0 kWh/t (Kreisberg 1992).

Crediting modernization projects under a benchmark methodology raises some questions. If the plant would have continued to operate without the modernization, then the "additional" reductions would be the difference in performance between the old and modernized plants. In many cases these plants would have undergone some improvement or have been closed, so it is hard to assess what would have occurred in the absence of the project.

It is possible to use the process-step approach for crediting modernization and to use the same values as benchmarks. It appears from the results above that modernization can improve energy performance to approximately the same level as efficient new plant additions. Rather than benchmark the entire production, however, it may be preferable to evaluate the savings arising from the process step where modernization has occurred. This allows an improvement project to

FUEL CHOICE

For the calculations of carbon reductions in Section V, the benchmark is given in terms of energy use, not carbon use. For the grinding stage where electricity is the fuel, the amount of electricity savings is multiplied by the carbon content of electricity where the plant is located. The plant cannot use another fuel in place of electricity and has no control over the carbon content of the electricity unless the power plant is located onsite (e.g. cogeneration). For clinker production, the energy reduction is measured from the benchmark and multiplied by the carbon content of the fuel used at the plant. We have not attempted to incorporate fuel-choice options into the benchmark approach, although this could certainly be done by choosing a 'benchmark' fuel and multiplying the energy benchmark by the carbon content of the benchmark fuel. Then the plant's performance would be evaluated by its actual carbon emissions, rather than by its energy use.

The difficult part of this approach is choosing the fuel to be the benchmark fuel. Many different fuels can be used to fire the kiln during clinker production. The choice is often guided by site- specific conditions; for example, in the United States and in Thailand, coal is the most commonly used kiln fuel because of its abundance and low cost. In Argentina, where natural gas is abundant, nearly all cement kilns are gas-fired (Cembureau 1996). Thus, in some areas there is a potential for reducing carbon emissions from cement production by fuel switching. There is also potential for using alternative fuels including landfill gas, used oils and solvents, waste treatment sludge, plastic waste, biomass, and tires (Pizant and Gauthier 1997). These may have related environmental issues that need to be addressed. Although fuel-switching might be beneficial, it will not be possible in all circumstances due to a lack of infrastructure to supply fuels like natural gas, or a lack of reasonable access to alternative fuel sources. In the benchmarking examples in this report, fuel choice has not been taken into account because we currently lack the information on the fuel being used in marginal (i.e. recently added) facilities, which varies by country, and we do not know the infrastructure or accessibility barriers to fuel-switching.

If fuel choice were to be considered in the benchmark, a further exploration of fuel accessibility by country and region would be needed. That task was not undertaken for this analysis, but its application would be straightforward. In every place that a benchmark value is given in energy units, it would be multiplied by the carbon content of the 'benchmark' fuel. Then the total emissions from the plant would be calculated. Clearly, some decision on the emission factors from alternative fuels would be required if they were part of the CDM project.

To illustrate, we return to the first example presented in this report, where the carbon content of fuel oil was used to determine the carbon emission reductions. Data from Cembureau show that the dominant fuel at Thai cement plants is coal; roughly 90 percent of the production capacity in Thailand used coal as the primary fuel. The data do not reveal what the marginal fuel for cement plants is or what the accessibility of natural gas is for cement producers, but it seems likely that the project in the example would save carbon not just through efficiency, but also through the choice of fuel oil as the kiln fuel. If coal was chosen as the benchmark fuel, then the benchmark for the kiln could be expressed in carbon rather than in energy terms by multiplying the energy benchmark by the carbon content of coal. Then the actual emissions from the plant could be calculated as actual energy use multiplied by the carbon content of fuel oil, and this would show that the plant avoids over 41 ktonnes of carbon at the kiln, not 9.3 ktonnes. This is a large difference, so the decision to benchmark the fuel choice should be done only with sufficient information on marginal fuel use.

Certainly one area where fuel choice should be considered is modernization projects that convert a plant from a dirtier fuel to a cleaner fuel. While this raises all the concerns discussed in the section above on modernization projects, it could be easily implemented by multiplying the benchmark energy value by the old fuel carbon content and actual energy performance by the carbon content of the new fuel. The difference would be the carbon emission reduction.

FLEXIBLE BENCHMARKS FOR GRINDING PROCESS STEPS

First, the hardness of the materials being ground can vary. In some cases the raw materials will vary, but this pertains mostly to changes in the additives. For the blended cements, where the additive share increases greatly and the materials can include volcanic rock and blast furnace slag, the energy requirements for grinding can be higher (Patzelt 1995). Second, the fineness of the final product can vary depending on the specifications of the desired cement.Clearly, more finely ground cement will require more energy.

It is conceivable that some formula could be derived that relates the energy benchmark for grinding to the shares of different additive materials and to the fineness of the final product. If research on this topic has been published in the cement industry literature, this approach is feasible, otherwise, it would require a large amount of research to parameterize such a formula. Some preliminary steps can be taken to determine whether the difference in grinding requirements is small enough such that correcting for it in the benchmarking formula would not be worth the effort such a correction would require.

BENCHMARKS FOR WET PROCESS PLANT PROJECTS

As discussed above, energy use in wet process cement production will be higher because of the need to dry the materials. Although wet process was once needed for efficient raw materials grinding, this is no longer true. Therefore, any new wet process plant should be considered for CDM status only in areas where the raw materials have a high moisture content but then should be compared to a benchmark based on a semi-wet or semi-dry process to encourage the inclusion of a “dewatering” step. There is some potential for converting wet process plants to semi-wet or even to dry processes. These projects could lead to large energy reductions and seem very valid for CDM consideration. These projects are, in fact, plant upgrades and the concerns about additionality and other issues discussed in the section on modernization are equally relevant for these projects.

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