Cement Sector in Africa & CDM
Investing in Clean Technologies and Energy Savings

Key Sheet
May 2009
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Introduction

Background

In 2006, the World Bank launched Carbon Finance Assist (CF-Assist), a capacity building and technical assistance program to enable the full participation of developing countries and economies in transition in the Carbon Market. The World Bank, an active partner of the Nairobi Framework, plays a critical role in the Carbon Market and has committed itself to ensuring carbon finance business development in Africa. This Framework, initiated in 2006 by the United Nations Organizations has the specific target of helping developing countries, especially those in Sub-Saharan Africa, to improve their level of participation in the CDM. The Framework consists in three main objectives, considered to be key priority targets in order to move the CDM forward, i.e., (i) building capacity in developing CDM project activities, (ii) promoting investment opportunities for projects, and (iii) improving information sharing and the exchange of views on CDM activities.

To deliver on this commitment, the CF-Assist Program undertook a series of studies in the transportation and the cement sectors. More recently, CF-Assist coordinated the production and dissemination of the World Bank’s study on Low-Carbon Energy Projects for Development in Sub-Saharan Africa, which explores the potential for projects, based on approved CDM methodologies.

Within its four-year existence, CF-Assist has been instrumental in the overall effort of the World Bank by implementing capacity and institutional building programs in nearly 50 countries, and helping identify more than 200 carbon finance projects. The ultimate goal of this effort is to expand business opportunities for cost-effective energy savings and clean technology transfer that will be of benefit to economic sectors.

Targeted Audience and Aims of the Key Sheet

Many developing countries, particularly those of Sub-Saharan Africa are lagging behind in the development of CDM projects. To overcome the barriers to the CDM, a study entitled “Cement Sector Program – Barriers to CDM Projects Development in the Cement Sector in Africa” was commissioned by CF-Assist in 2008. The study includes (1) an analysis and assessment of existing barriers faced by project developers in the cement industry and (2) recommendations based on lessons learned from projects in India, the second largest registered CDM cement project host country. The study also looks at existing investments in the cement industry and identifies new carbon mitigation opportunities in the most relevant areas: (a) energy efficiency, (b) waste heat recovery, (c) fuel switching with biomass
and (d) clinker substitution with alternative raw materials.

The realization of CDM projects is primarily dependent on the dynamism of the private sector. However, CDM promotion requires strong support on the part of governments through an investment-friendly institutional framework and preferential incentives for carbon reduction projects. This key sheet is intended for private and public sector players such as cement plant managers and directors, bankers and financiers, government agency representatives and consultants. In fact, being aware of the barriers and hurdles for CDM promotion and keeping up-to-date with CDM developments is crucial for decision-makers.

This key sheet has been produced based on the “Cement Sector Study” findings. Specifically, the key sheet will:

- Serve as a background document for information and awareness-raising of industry decision-makers on the benefits of carbon finance
- Contribute to strengthening the confidence of policy-makers on CDM opportunities in energy intensive industries
- Form the basis for CDM promotion
- Help establish the link for project investors and developers through information on opportunities in the cement sector and other avenues for partnership.

Greenhouse Gas Emissions at a Glance

Worldwide, the cement industry is one of the most energy intensive sectors and also a significant source of greenhouse gas (GHG) emissions, accounting for about 5% of the annual global anthropogenic carbon dioxide emissions. This represented 1,800 million tonnes of CO₂ emissions in 2005 from the use of fossil fuels, the chemical reaction during clinker processing and the use of electricity to grind raw materials and finished cement. In the case of developed countries, in 2006, 661 kg of CO₂ were generated by each tonne of cement produced compared to 752 kg in 1990. At the global level and across countries, the average CO₂ intensity ranges from 0.65 to 0.92 tCO₂ per tonne of cement with a weighted average 0.83 tCO₂/t.

Figure 1: Average Net CO₂ Emissions (kgCO₂/tonne cement) in Developed Countries

Source: WBCSD
According to the World Business Council for Sustainable Development (WBCSD), 80% of future CO₂ emissions from the cement sector will be generated by developing and in transition countries; particularly because they need to build much needed infrastructures, such as housing, roads, hospitals and schools. However, CO₂ emissions do not increase as rapidly as the level of cement production because of improvements in the emissions intensity of the cement making process.

**CDM works**

**The CDM, a New Approach for the Cement Industry**

The Clean Development Mechanism (CDM) was established under the Kyoto Protocol as one of the three flexibility mechanisms to encourage industrialized countries (Annex I) to develop projects that reduce greenhouse gas (GHG) emissions in non Annex I countries as an alternative to more expensive emission reductions in their own countries. The CDM offers the opportunity to (1) reduce production costs using incentives from the Carbon Market, (2) implement clean energy technology projects, (3) improve cost-effectiveness and (4) reduce the risks associated with such technologies.

The current CDM system requires project-by-project assessment of baseline settings and proof of “additionality” on the basis of a rather subjective assessment of the project developers’ intention.

Demonstrating “additionality” is key for the CDM process as it provides evidence that the “project outcomes” go beyond what would have occurred under business-as-usual activities. This subjective approach has resulted in some difficulties associated with project approval and high transaction and monitoring costs.

GHG emissions can be dramatically decreased through low emission cement processing as well as reducing the energy input or energy source. CDM possibilities pertain more or less to the different phases of the whole manufacturing process as shown in figure 2. Four types of possible projects are described in Table 1. These include: waste heat recovery and use, fuel switching or substitution, increasing the blend of additives and energy efficiency.

The most commonly used approved methodologies are:

i. ACM 0005: Displacement of clinker and substitution with fly ash or other additives

ii. ACM 0003: Partial substitution of fossil fuels with alternative energy materials including biomass by-products

iii. ACM 0004: Another group of projects was registered to introduce technologies aimed at capturing the waste heat gas
**Reducing impacts**

- Quarrying activities have impacts on the local landscape and ecology and can cause noise and traffic problems for local communities. Holcim has established a number of systems to manage our quarries responsibly. These systems help to minimize noise, transport and visual impact, to reduce the use of natural resources and to optimize quarry rehabilitation.

- Clinker production requires intensive use of raw materials and energy, and also results in emissions to the atmosphere, the most significant being CO₂. Holcim is reducing its demand for natural resources and its CO₂ emissions per tonne of product by replacing fossil fuels and raw materials with waste and industrial by-products.

- Dust, NOₓ, SO₂ and VOC emissions are subject to continuous monitoring under a new Holcim standard. Heat recovered from the kiln and clinker cooler is recycled for preheating the raw meal, reducing thermal energy consumption.

- Use of secondary cementitious materials reduces the amount of clinker required per tonne of cement. This reduces our CO₂ emissions per tonne of cement and our consumption of natural raw materials. Distribution is via the most cost-effective method to market—70% is by road, the remainder by rail and ship. Transport by road can be a source of nuisance and traffic safety risk, which we aim to limit.

Source: Adapted from Holcim Publication
Table 1: Technology Description and CDM Project Types

<table>
<thead>
<tr>
<th>Project Type</th>
<th>Approved Methodologies</th>
<th>Technology Description</th>
</tr>
</thead>
</table>
| Waste Heat Recovery                   | AM0024, ACM0012, ACM0004, AMS III.Q | • Capture of waste heat vented at the pre-calciner and/or cooler end of kilns and use to preheat raw materials and fuel  
• Heat recovery at boilers and generation units and production of electricity. |
| Alternative Fuels                     | ACM0003, ACM0002, AM0049, AMS I.D, AMS III.B | • Use of renewable resources for less resource-intensive processes such as grinding,  
• In pyro-processing, fossil fuels can be partly replaced by alternative fuels such as gas or unconventional masses (tires, plastics, textiles or rubber, etc.) |
| Changing Blending/Mix of Cement       | ACM0005 | • Increase in the proportion of additives, such as limestone, pozzolana and fly ash in the fine grinding process thereby reducing the clinker content. |
| Energy Efficiency                     | AMS II.D | • Multi-technology options including: upgradation of preheaters, upgrading clinker coolers, optimization of grinding media, automatic controls, variable speed drives, efficient motors, etc. |

generated in the clinker-making process (i.e. in cement kilns) to produce electricity instead of only venting the waste heat into the atmosphere.

iv. Approved small-scale methodologies especially: AMS II.D on energy efficiency and fuel switching measures for industrial plants, AMS III.B on switching fossil fuels and AMS I.D.

Overview of the CDM Project Portfolio

According to the World Bank’s 2008 State and Trends of the Global Carbon Market report, the market more than doubled to reach USD 64 billion in 2007 from USD 31.2 billion in 2006. The market is still driven by the European Union Emission Trading System (EU ETS) market, which alone accounted for USD 50 billion in 2007.

The transactions value of project-based markets (CDM, JI, voluntary market, etc.) was USD 13.6 billion in 2007 (USD 6.5 billion in 2006). The CDM accounted for the vast majority of project-based transactions, at 87% of the volume and 91% of the value. Africa ranks fourth with 5% of the transaction market. Projects in Africa have been contracted to supply about 50 MtCO$_2$e to
the market so far, with more than 20 Mt-\(\text{CO}_2\text{e}\) transacted in 2007 alone.

In the case of Africa, two interesting lessons could be drawn from the CDM pipeline. The first concerns the increase observed in the trend of CDM project development. From 2 projects in 2004, the number of projects submitted per annum increased to 25 in 2008. The second interesting fact is that new countries have entered the list of countries that have submitted projects for registration. Most of these new countries are francophone: Congo Democratic Republic, Mali, Senegal, Madagascar, but also Zambia and Cote d’Ivoire to some extent.

**CDM Projects in the Cement Sector**

The cement sector is a significant source of greenhouse gases, which makes the sector interesting for \(\text{CO}_2\) emissions mitigation options. As of January 2009, 203 CDM projects were initiated by the cement industry. A total of 52 cement-related CDM projects were registered, 12 were rejected, 121 projects are at the validation stage (of which 13 are located in India, 78 in China and 3 in Africa) and 18 projects have been submitted for registration or are being corrected. The dominance of China and India in carbon trading under the CDM is beginning to influence the business dynamics of these countries in various sectors. According to the Confederation of Indian Industry (CII) estimates, companies have started adopting cleaner, sustainable technologies and earned about USD 341 million in 2007 just by selling their carbon credits. Out of the 52 projects registered, 25 (48%) are being developed by the Indian cement industry and will account for a total volume of 2.2 million \(\text{tCO}_2\text{e}\) per year over the first commitment period (2008–2010).

The remaining 27 CDM projects stem from China (17), Indonesia (3), Israel (1), Malaysia (1), Argentina (1), Uruguay (1), Colombia (1), Peru (1) and Costa Rica (1).

**Drivers of India’s Success in the CDM**

The success of the Indian cement industry in the CDM is driven by a combination of determining factors:

- **Government Policy and Regulatory Framework Influencing the Cement Sector**: By establishing an Energy
Conservation Act in 2001, the Government of India has played a critical role in influencing the cement industry. The new regulatory framework has been a catalyst for the promotion of energy efficiency in the industrial sector, including India’s cement sector. The Bureau of Energy Efficiency (BEE) created under this Act identified cement companies as energy intensive industries, requiring them to report periodically on their energy consumption and efficiency levels. The result was an increase in CDM projects through energy efficiency improvements in cement processes.

- **Indian Industry Organizations Providing Technical Assistance**: The leading role played by the Indian industry organizations that provide assistance to and raise the awareness of industry managers is recognized as critical to the success of the CDM. These organizations have created the dynamics for clean technologies in the Indian cement sector and promote energy efficiency with data for benchmarking as a means to reduce production costs and to cope with energy shortages and coal availability constraints. They have increased the awareness of the CDM sector opportunities.

- **Assistance by External Donors and Agencies**: The sector has benefited from bilateral technical assistance programs. Showcases of cement plant practices, achievements and capabilities in India in the field of efficient cost-effective technologies through bilateral assistance from the GTZ through the Indo-German Energy Efficiency Program and from NEDO/Japan for waste heat recovery demonstration projects have been recorded.

- **Large Groups Playing a Champion Role**: The largest Indian cement companies like the Aditya Birla Group, Orient Cement, Binani Cement, Shree Cements, ACC, India Cements, Gujarat Ambuja and Lafarge all played a pioneer role in initiating CDM projects using their own funds.

- **Enabling Environment**: Enhancement of the overall CDM project development environment, including an operational Designated National Authority (DNA) and the availability of qualified local consultants that enable project development, data collection and an interface between international consultants and carbon credit buyers and project participants.
The lessons learned from India show that most CDM projects in the cement industry were largely through the initiative of industry management where the awareness programs of industry associations and other government agencies in the field played a supportive role in influencing the decision-making. CDM projects were taken up to take advantage of additional benefits for energy efficiency projects or to make them more financially attractive.

**CDM Projects in Africa’s Cement Sector**

No project has been registered by the African cement industry yet. However, this pattern is changing with four CDM projects under registration. The four projects are:

- Senegal’s SOCCOCIM CDM fuel switching project using Jatropha plantations and biomass residues to substitute 40% of the coal burnt in kilns (see Box 1),

**Box 1: SOCCOCIM Partial Substitution of Coal by Jatropha Fruits and Biomass Residues in the Production of Portland Cement in Senegal**

SOCOCIM INDUSTRIES (Senegal), a member of the VICAT Group since 1999, is an integrated cement manufacturing facility located in Rufisque. The installed capacity for clinker production is 1,350,000 tonnes per year. The cement plant was using coal as fuel for its clinker production and small quantities of heavy fuel oil (HFO) for start up.

The purpose of the CDM project is the partial replacement of a fossil fuel, coal, by Jatropha fruits and biomass residues for combustion in the cement kiln. The project uses the approved consolidated ACM0003 methodology.

The project scenario consists in Jatropha nursing, planting, cultivation, transport and processing in the cement plant to replace about 40% of the imported coal. The total upfront investment for 11,000 ha is estimated to represent EUR 20 million, and the adaptation of the plant process will require an additional EUR 8 Million.

The transport and processing of 300 t/day of Jatropha fruits and other biomass is a major challenge for SOCOCIM INDUSTRIES.

Overall, about 96,000 tonnes of biomass is annually required for the kiln operation. At full implementation, GHG emission reductions are estimated at about 162,000 tCO₂e per year.

The project’s profitability will be very low without the sale of CERs with a payback period of 9.1 years and a return on capital employed (ROCE) of 6.3%, and the profitability will be modest with the inclusion of CER sales (payback period of 7.9 years and ROCE of 7.6%).

*Source: PDD SOCOCIM on UNFCCC Website*
Nigeria’s WAPCO CDM blended cement projects in the Shagamu and Ewekoro Plants (see Box 2),

Egypt’s CEMEX Assuit CDM project for the partial substitution of fossil fuels by renewable plantation biomass and biomass residues.

EAPCC in Kenya has submitted a PDD for increasing the blend in cement production using substitute raw materials at its Nairobi plant.

Under the CF-Assist sectoral study, a new project is being developed. It reached the Project Design Document (PDD) stage in early 2009 (see Box 3).

In parallel, Lafarge East Africa is also undertaking four CDM projects. Three of the projects are for fuel substitution (the Hima Plant in Uganda, the Bamburi and Mombasa Plants in Kenya and the Mbeya Plant in Tanzania). The average annual

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**Box 2: Lafarge Cement WAPCO Blended Cement Project at the Shagamu Cement and Ewekoro Cement Plants in Nigeria**

The project aims to manufacture and sell a new type of cement (hereafter referred to as “blended cement”) categorized under a new cement standard (Nigerian standard CEM II/A-L 32.5N). The project is being implemented at the two WAPCO Cement production sites located in Shagamu and Ewekoro, both in Ogun State in South West Nigeria. The production capacities of the two cement works are 1.32 million tonnes and 1.0 million tonnes of cement per year for Shagamu and Ewekoro respectively.

The main barrier to a successful introduction of blended cement onto the Nigerian cement market has been identified as an aversion of consumers to a change to any cement other than OPC, which has been the only type on the market. WAPCO has developed and successfully implemented a significant marketing effort to reduce this barrier.

The blended cement project intends to gradually reduce the clinker content of WAPCO’s Shagamu cement production and that of Ewekoro Cement Works by about 86.6% and 84.7% in 2005 to 75% in 2017. The methodology used is ACM0005.

The baseline scenario was the current practice in Nigeria where the amount of non-gypsum additive materials in OPC is limited to 6%, thus resulting in a clinker factor above 89% for the CEM I brand of cement (where the gypsum content is about 5–6%). This clinker factor can be achieved without major investments. WAPCO worked jointly with the Nigerian Cement Manufacturing group, the SON, relevant governmental agencies, cement users, etc., to propose a new blended cement standard.

The baseline benchmark considered in the project is a clinker-to-cement ratio of 0.908 for the two plants and the country benchmark is 0.89. Baseline emissions are 0.8483 tCO₂e/tonne Blended Cement (BC) and 0.8185 tCO₂/tonne BC for the Shagamu and Ewekoro plants respectively.

The clinker-to-cement ratio in the project scenario is 0.75. At terms, projects emissions are estimated at 0.3688 tCO₂/tonne BC for Shagamu and 0.4603 tCO₂/tonne BC for Ewekoro.

The expected emissions reduction from the project is 1,324,140 tonnes CO₂ per year with respectively 865,789 tCO₂e and 458,351 tCO₂e for Shagamu and Ewekoro.

Source: PDD WAPCO, UNFCCC Website
Box 3: PDD under Development: Waste Heat Recovery Project at the EAPCC Plant in Kenya

The East Africa Portland Cement Company (EAPCC) is among the largest electricity consumers. As such, it has been asked to switch its production activities to nighttime to avoid countrywide power failures. Electricity constitutes the most expensive energy input for EAPCC. Hence, EAPCC is considering captive power generation to shift its energy source from grid electricity to coal to cut down power bills and operation costs by 30%.

The electricity from the waste heat recovery unit will replace the coal-based power plant planned by EAPCC to address the electricity shortages faced by the company. EAPCC carried out an audit of its clinker kiln to assess the possibility of cogeneration and the audit report recommended a capacity of 2.5MW. The amount of electricity to be generated was estimated at 15 GWh per annum representing about 21 kWh per tonne of cement. The baseline was taken as to be the coal-based power plant.

The technology is new to the country and to the company, since WHR has not been tried and tested in the cement industry in Kenya. Besides, the payback period is long, over seven years based on the prefeasibility study carried out by Integrated Energy Solutions, Kenya.

Based on the data generated by the preliminary audit, the study team evaluated the CDM opportunities. The project falls under the small-scale project activities eligibility criteria, as the installed capacity is less than the size limit of 15 MW. Moreover, the annual electricity to be generated is less than 60 GWh. The initial assessment indicated that the following SSC methodologies could be combined:

- AMS I.C - Thermal energy for the user with or without electricity.

It was assumed that each MWh produced would displace 1 tCO₂e from a coal-based captive plant initially planned by EAPCC. Therefore, the GHG emissions reduction was evaluated at 15,000 tCO₂e per year.

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Financial Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total project costs</td>
<td>USD 7.7 million</td>
</tr>
<tr>
<td>Electricity Rates</td>
<td>USD 0.1/kWh</td>
</tr>
<tr>
<td>O&amp;M Costs</td>
<td>10% of investment costs</td>
</tr>
<tr>
<td>Interest Rate</td>
<td>10%</td>
</tr>
<tr>
<td>Income Tax</td>
<td>30%</td>
</tr>
<tr>
<td>Debt Ratio</td>
<td>70%</td>
</tr>
</tbody>
</table>

The preliminary financial analysis indicated that the internal return rate (IRR) can be significantly improved when the CDM is considered. CDM revenues over a 10-year period represent about 20% of the total investment costs.

emissions reduction objective is about 41,000 tonnes CO₂ per site. In the Bam- buri Mombasa cement plant, the overall objective is to reduce CO₂ emissions per tonne of cement produced by 20% over a 20-year period. The fourth is for increasing the pozzolana content at Bamburi Cement, Nairobi.
**CDM Business opportunities in AFRICA**

CDM can offer attractive opportunities for supporting the development priorities of host countries as reflected in national development plans, in sectoral environmental plans and in social development strategies. In essence, the function of this flexible mechanism is to assist the trade of carbon credits and offsets between Annex I and non-Annex I countries on a competitive basis. The cost-benefit analysis of CDM projects includes other factors, such as environmental protection, the population’s health as well as social, political and economic impacts in a view to ensure a win-win situation for all participating countries. Thus, the trading of GHG emission offsets under the CDM represents a cost-effective and flexible market-based mechanism for achieving the overall targets of reductions in GHG emissions.

An assessment of the potential of CO₂ emissions reduction in cement plants on a country and regional basis was conducted during the cement sector study. The data is outlined in the following tables (Table 2 and Table 3), based on applicable technologies suitable to the context of the local industry, i.e., Waste Heat Recovery, Use of Alternative Fuels, Blending of Cement and Energy Efficiency.

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**Table 2: Current CO₂ Abatement Cost per Technology**
*(Based on aggregated data and assumptions from other projects and studies)*

<table>
<thead>
<tr>
<th>Project Type</th>
<th>Opportunities</th>
<th>Cost Estimate for CO₂ Abatement</th>
</tr>
</thead>
</table>
| Waste Heat Recovery          | • Interesting, especially in a context where energy costs are high and supply is unreliable  
• 1 MW results in a reduction of 5,000 tonnes of CO₂ per annum | Ranging from USD 15 to 50/tCO₂                                                                  |
| Alternative Fuels            | • Potential for substituting small percentages of fossil fuel by biomass  
• Use of solid wastes, waste tires, non hazardous industrial waste, sludge | Option 1 (Biomass residues): USD 4/tCO₂  
Option 2 (Biomass plantations): USD 12/tCO₂                                                      |
| Changing Blending/Mix of Cement | • 1 tonne of Pozzolona Portland Cement reduces gross CO₂ emissions by 20%  
• 1 tonne of Portland Slag Cement reduces CO₂ emissions by 45% | Ranging from USD 4.38 to 6.24/tCO₂                                                               |
| Energy Efficiency            | • Directly or indirectly reduces the consumption of fossil fuels            | USD 24/tCO₂ (for pre-heater upgradation)                                                         |
Based on this study, the cost-effective mitigation options are (1) alternative fuels and (2) blended cement, with an average abatement cost of 10 US $/ tonne CO₂. Another cost-effective option is Waste Heat Recovery (WHR), particularly in Eastern Africa.

**Waste Heat Recovery Projects**

The technical potential of the total annual emissions reduction for waste heat recovery (WHR) is presented in Table 3. The estimates are derived based on the regional cement production, assumptions used by De Gouvello et al., data from the India Cements project (Vishnupuram cement plant) and the energy audit at the EAPCC cement plant in Kenya.

The calculations also take into account the low capacity utilization in the target regions. The average capacity utilization is 54%. There are significant variations between regions with 76% in East Africa, 48% in Central Africa and 46% in West Africa.

The technical potential of CO₂ emissions reduction through WHR projects represents 2.1 Million tCO₂e per annum. The total investment required was estimated at USD 323.3 million. The regional analysis indicates that efforts should be particularly directed towards major cement producing countries such as Nigeria, Senegal and Togo in West Africa and Ethiopia, Kenya, Tanzania in East Africa.

In Central Africa, only Angola offers interesting opportunities for CDM projects. With the observed current trend in capacity expansions and retrofitting projects to increase the production and the capacity utilization factor, it is expected that the potential for WHR projects will be much higher.

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**Table 3: Emissions Reduction Potential through Waste Heat Recovery**

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of Cement Plants</th>
<th>Installed Capacities (Mt/year)</th>
<th>Actual Production (Mt/year)</th>
<th>Emissions Reduction Potential (tCO₂/year)</th>
<th>Initial Investments (USD million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Africa</td>
<td>13</td>
<td>14.2</td>
<td>7.6</td>
<td>975,700</td>
<td>148.6</td>
</tr>
<tr>
<td>Central Africa</td>
<td>5</td>
<td>3.1</td>
<td>1.9</td>
<td>252,400</td>
<td>38.4</td>
</tr>
<tr>
<td>East Africa</td>
<td>17</td>
<td>9.4</td>
<td>7.0</td>
<td>895,200</td>
<td>136.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>35</strong></td>
<td><strong>26.7</strong></td>
<td><strong>16.5</strong></td>
<td><strong>2,123,300</strong></td>
<td><strong>323.3</strong></td>
</tr>
</tbody>
</table>
higher in the future. A significant feature of waste heat recovery projects for power generation is the high initial investment cost that induces a high CO₂ abatement cost ranging from USD 15–50/tCO₂ depending on the size of the project and other factors such as grid fossil-based electricity displacement.

However, as shown in the case of the WHR project at the EAPCC plant in Kenya (see Box 3), the financial indicators of a WHR project can improve significantly when the CDM is considered and CDM benefits can compensate for about 20% of the project costs over the crediting period.

**Alternative Fuels and Fuel Switching**

This appraisal relies on a generic estimation of CER generation from the substitution of fossil fuels with alternative fuels in cement plants, in accordance with methodology ACM0003. Specific ratios are derived from the estimates of CER generation from the Global Environment Centre Foundation/Japanese Ministry of Environment. For the three types of alternative fuels analyzed, the simplified calculations are shown below.

The assessment of the potential for CO₂ emissions reduction in the SSA cement industry through the use of alternative fuels is based on the SOCCOCIM project in Senegal where 40% of the coal currently used will be replaced by biomass from Jatropha plantations and other biomass residues such as rice husks, cotton shells and cashew nutshells. The CO₂ abatement cost is USD 12.6/tCO₂e over a crediting period of 21 years. If investment costs for Jatropha plantations are excluded, the CO₂ abatement cost will drastically decline to USD 3.6/tCO₂e.

The estimate summarized in Table 5 illustrates the ER potential for fuel switching from fossil fuels (coal and heavy fuel oil) to biomass.

The technical potential of using biomass for clinker calcination is estimated at

<table>
<thead>
<tr>
<th>Table 4: Emissions Reduction for Typical Alternative Fuels</th>
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<tbody>
<tr>
<td><strong>Alternative Fuel</strong></td>
</tr>
<tr>
<td>Biomass residues</td>
</tr>
<tr>
<td>Waste originating from fossil sources</td>
</tr>
<tr>
<td>Tires</td>
</tr>
<tr>
<td>Plastic</td>
</tr>
</tbody>
</table>
2.4 million tCO$_2$e and the required investment amounts to around USD 536.0 million. However, these initial investments are estimated on a production ratio basis only. This means that savings of scale are not accounted for. For instance, it is realistic to assume that the marginal cost of additional units of alternative fuel will decrease to a certain extent. It is also realistic to assume that transaction costs might be reduced after a demand-driven alternative fuel distribution capacity or network has been put in place.

It should be noted that sources of alternative fuels can also be tires, plastic, waste oil, etc. Each project will need to assess the potential of alternative fuels present in the surroundings of the cement plant, the availability of the resources and the alternative uses in the country. As many of SSA countries have vast lands, dedicated energy plantations (Jatropha, casurina trees or other species) could be an interesting solution for biomass supply issues as is the case in Senegal and Egypt.

### Blended Cement

Blended cement, as defined in the Standard Specification for Blended Hydraulic Cements (ASTM C 595), is a mixture of portland cement and blast furnace slag or a “mixture of portland cement and a pozzolan (most commonly fly ash).” The use of blended cements in concrete reduces mixing water and bleeding, improves finishability and workability, enhances sulfate resistance, inhibits the alkali-aggregate reaction and lessens heat evolution during hydration, thus moderating the chances for thermal cracking on cooling.

Developing blended cement projects as CDM projects will require setting up a baseline and demonstrating that the proposed project scenario is additional. According to the Global Environment Centre’s

<table>
<thead>
<tr>
<th>Region</th>
<th>Actual Production (Mt/year)</th>
<th>Quantity of Biomass Needed (tonne/year)</th>
<th>Emissions Reduction Potential (tCO$_2$/year)</th>
<th>Initial Investment (USD million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Africa</td>
<td>7.6</td>
<td>646,900</td>
<td>1,099,700</td>
<td>246.3</td>
</tr>
<tr>
<td>Central Africa</td>
<td>1.9</td>
<td>167,300</td>
<td>284,500</td>
<td>63.7</td>
</tr>
<tr>
<td>East Africa</td>
<td>7.0</td>
<td>593,500</td>
<td>1,009,000</td>
<td>226.0</td>
</tr>
<tr>
<td>Total</td>
<td>16.5</td>
<td>1,407,700</td>
<td>2,393,200</td>
<td>536.0</td>
</tr>
</tbody>
</table>
CER Estimation Toolkit, CO\textsubscript{2} emissions reduction associated with an increased share of additives in blended cement could be roughly estimated at 0.009 tCO\textsubscript{2}e per tonne of blended cement produced for each 1% of increased share of additives.

The estimate of the potential for blended cement projects in the SSA cement sector is based on assumptions posited in the study by de Gouvello et al. assuming the clinker content will be reduced from 95 percent to 75 percent (increasing the share of additives by 20%) in Ordinary Portland Cement (OPC) production plants spread over the continent.

The results of the analysis showed that 50 blended cement CDM projects could be developed in 24 countries using the ACM0005 methodology. When packaged, these projects would yield a total emissions reduction of 2.4 million tCO\textsubscript{2}e per annum representing 0.105 tCO\textsubscript{2}e per tonne of cement produced. An estimated USD 105 million would be needed to implement these projects leading to a cost of USD 4.38 per tonne of CO\textsubscript{2} reduced over a 10-year period.

**Energy Efficiency Projects**

The estimated energy savings potential seems to be significant in the SSA cement industry, especially in the socio-economical context of the continent where most of the population does not have access to electricity. As can be noted, the CDM would not constitute the main incentive for the efficient use of electrical energy in many countries. However, electricity savings could be spurred by a reduction in production costs since energy is one of the most expensive inputs for cement manufacturing, and it might be interesting to come up with the following.

The scope of energy efficiency projects in the cement industry is very large. It encom-

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of Plants</th>
<th>Actual Production (Mt/year)</th>
<th>Emission Reductions (tCO\textsubscript{2}e/year)</th>
<th>Investment Cost (USD million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Africa</td>
<td>21</td>
<td>12.1</td>
<td>1,281,900</td>
<td>56.1</td>
</tr>
<tr>
<td>Central Africa</td>
<td>8</td>
<td>3.0</td>
<td>318,400</td>
<td>13.9</td>
</tr>
<tr>
<td>East Africa</td>
<td>21</td>
<td>7.6</td>
<td>807,300</td>
<td>35.4</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>22.7</td>
<td>2,407,600</td>
<td>105.4</td>
</tr>
</tbody>
</table>
passes system upgradation, specific technologies such as variable speed drives, motors, compressed air, ventilators as well as process controls and energy management systems. Up till now, only a few cement plants have carried out detailed energy audits.

The potential of energy savings distinguishes thermal savings and electricity savings using the average specific energy consumption and a target. Thus, the target for specific thermal energy is 750 kcal/kg of clinker from a baseline of 950 kcal/kg of clinker in integrated cement plants only and electricity is cut down from 120 to 90 kWh/tonne of cement for all units.

The total monetary savings from energy efficiency measures and emission reductions sales in the SSA cement industry could amount to USD 409.6 million in fuel savings, USD 66 million in electricity savings and USD 139.2 million in terms of emissions reduction.

The potential for kiln fuel savings is in the order of 12.5 million gigajoules (GJ) per year from 35 clinker production units across 17 countries in SSA. This represents annual savings of 553,000 tonnes of coal or 345,000 tonnes of heavy fuel oil. The equivalent CO$_2$ emissions reduction could amount to 1 million tCO$_2$ distributed mainly in West Africa (46%) and East Africa (42%) with the majority of the potential in Nigeria, Senegal, Ethiopia, Kenya and Tanzania.

The total electricity savings potential is about 660 GWh/year and GHG emissions reduction is estimated at 319,000 tonnes for

<table>
<thead>
<tr>
<th>Table 7: Assumptions for Energy Savings and Emissions Reduction Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parameters</strong></td>
</tr>
<tr>
<td>Baseline specific thermal energy use</td>
</tr>
<tr>
<td>Project scenario specific thermal energy use</td>
</tr>
</tbody>
</table>
| Emissions factor of coal and heavy fuel oil (HFO) burnt in kilns | • Coal: 0.0946 tCO$_2$/GJ  
  • HFO: 0.0774 tCO$_2$/GJ  
  • Average considered: 0.086 tCO$_2$/GJ |
| Baseline specific electricity use                             | 120 kWh/tonne of cement       |
| Project scenario specific electricity use                     | 90 kWh/tonne of cement         |
| Number of plants considered for thermal energy savings       | 35 plants in 17 countries (excluding South Africa) |
| Number of plants considered for electricity savings          | 49 facilities in 20 countries (excluding South Africa) |
49 cement facilities. Electricity savings and the related GHG emissions reduction in selected SSA cement plants cover integrated plants and grinding units. It clearly appears that, when taken in the perspective of the CDM, the emissions reduction potential is very low or insignificant in some countries like DR Congo, Ethiopia, Uganda, etc. where the saved electricity would mainly be hydro-based.

The estimated energy savings potential seems to be significant in the SSA cement industry, especially in the socio-economical context of the continent where most of the population does not have access to electricity. As noted, the CDM would not constitute the main incentive for the efficient use of electrical energy in many countries. However, electricity savings could be spurred by a reduction in production costs.

### Table 8: Emissions Reduction Potential in SSA Cement Plants from Fuel & Electricity Savings

(Monetary savings are based on: Electricity: US$ 0.1/kWh, Fuel: US$ 0.95/liter; Emissions Reduction: US$ 10/tCO₂e)

<table>
<thead>
<tr>
<th>Source of Energy</th>
<th>West Africa</th>
<th>Central Africa</th>
<th>East Africa</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fuel</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Facilities</td>
<td>13</td>
<td>5</td>
<td>17</td>
<td>35</td>
</tr>
<tr>
<td>Estimate of Clinker Production (Mt/year)</td>
<td>6.9</td>
<td>1.8</td>
<td>6.3</td>
<td>15.0</td>
</tr>
<tr>
<td>Thermal Savings Potential (GJ/year)</td>
<td>5,735,500</td>
<td>1,483,900</td>
<td>5,262,200</td>
<td>12,481,600</td>
</tr>
<tr>
<td>Annual Energy Cost Savings (USD million)</td>
<td>188.2</td>
<td>48.7</td>
<td>172.7</td>
<td>409.6</td>
</tr>
<tr>
<td>Emissions Reduction (tCO₂e/year)</td>
<td>493,200</td>
<td>127,600</td>
<td>452,500</td>
<td>1,073,300</td>
</tr>
<tr>
<td>Carbon Revenues over 10 Years (USD million)</td>
<td>49.3</td>
<td>12.8</td>
<td>45.2</td>
<td>107.3</td>
</tr>
<tr>
<td>Major Countries</td>
<td>Nigeria, Senegal, Togo</td>
<td>Angola, DR Congo</td>
<td>Kenya, Ethiopia, Tanzania</td>
<td>—</td>
</tr>
<tr>
<td><strong>Electricity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Facilities</td>
<td>22</td>
<td>7</td>
<td>20</td>
<td>49</td>
</tr>
<tr>
<td>Estimate of Cement Production (Mt/year)</td>
<td>11.7</td>
<td>3.0</td>
<td>7.3</td>
<td>22.0</td>
</tr>
<tr>
<td>Electricity Savings Potential (GWh/year)</td>
<td>350.6</td>
<td>90.3</td>
<td>219.5</td>
<td>660.4</td>
</tr>
<tr>
<td>Annual Electricity Cost Savings (USD million)</td>
<td>35</td>
<td>9</td>
<td>22</td>
<td>66</td>
</tr>
<tr>
<td>Emissions Reduction Potential (tCO₂e/year)</td>
<td>253,900</td>
<td>18,500</td>
<td>46,600</td>
<td>319,000</td>
</tr>
<tr>
<td>CDM Revenues over 10 Years (USD million)</td>
<td>25.4</td>
<td>1.85</td>
<td>4.7</td>
<td>31.9</td>
</tr>
<tr>
<td>Major Countries</td>
<td>Nigeria, Senegal, Togo</td>
<td>Low potential</td>
<td>Low potential</td>
<td>—</td>
</tr>
</tbody>
</table>
since energy is one of the most expensive inputs for cement manufacturing.

**Conclusion**

As detailed in this sheet, Africa’s cement sector offers substantial opportunities for developing attractive CDM projects. According to the review conducted under CF-Assist supervision, there is an untapped potential for cost reductions in SSA cement manufacturing facilities using existing technologies. However, some specific actions must be launched by key stakeholders, i.e. cement plant managers, government policy-makers and the international community. The strongest commitment should originate in the private sector, more particularly from CEOs in the cement industry whose leadership can serve as the catalyst to introduce changes in favour of the promotion of cleaner technologies and support to business expansion recognizing the sustainable development issues faced by the global economy.

Therefore, the following actions are recommended to the target groups:

**a) For Top Industry Management**

1. Undertake study tours in Asia (India and China) to learn about their successful approaches and discuss how the CDM contributed to the expansion of cement industries in the area.

2. Adopt, on a voluntary basis, best practices regarding cement manufacturing, by promoting clean investments:

   - Best practices can help reduce up to 15% of the energy costs. Plant managers can set energy and $\text{CO}_2$ targets and implement data acquisition to correct production processes and achieve better energy use.

3. Ensure that the technical managers and staff of cement plants are aware of energy efficiency and best practices.

4. Promote the adoption of Energy Management Systems (EMS) within the Industry:

   - Most plants seek to be certified under ISO 9000 and 14000 by installing an environment management system. An energy management system could be coupled to the current practices to record the plant’s energy performance and $\text{CO}_2$ intensity.

   - Setting up an energy management system requires the allocation of resources, including energy managers and an energy management budget.

4. Conduct energy audits and assess CDM opportunities at the plants and develop an action plan to reduce production costs using the carbon finance incentives:

   - Energy audits could be the first step in identifying potential energy savings and cost reductions. The audits should go beyond current investigations in looking at CDM opportuni-
ties using existing technologies and methodologies.

- An action plan for project implementation can be derived from the assessment, based on a company’s priorities and strategic planning. Low cost measures can be the starting point.
- The energy audit reports should be updated periodically and the plant’s key performance indicators, derived.

5. Encourage information sharing throughout the industry by developing benchmarking.

6. Promote national and regional research on blended cement.

b) For Financing Institutions

1. The community of local and regional financing institutions should be proactive in informing members and participating organizations about the benefits of carbon finance:

   - Increase the awareness of local bankers and regional financing institutions of the opportunities that carbon finance offers. Members should be informed about the lending opportunities in the carbon business, particularly in the CDM sectoral approach.

2. Local and regional financing institutions should work closely with international financing institutions (AfDB, WB) and other multilateral organizations to design tailored capacity-building programs on the CDM for African bankers.

3. The community of local and regional financing institutions should establish an information sharing system for their members.

c) For African Governmental Institutions

1. National policy-makers should develop a legal and regulatory framework to support CDM development in their countries.

2. Establish financial and economic incentives for project developers in energy intensive sectors.

3. Provide adequate financial and human resources to the National Designated Authorities (DNA) to allow them to support CDM in the cement industry.

Contacts

For more information about the Cement Sector Study, please visit www.cfassist.org or contact the CF-Assist Support Team at the following address:

- Carbon Finance Assist
  The World Bank
  1818 H Street
  NW Washington, DC 20433, USA
  Phone: +1 (202) 473–8537
  E-mail: cfassist@worldbank.org
  Web: www.cfassist.org