THE CEMENT INDUSTRY IN EGYPT:

Challenges and innovative Cleaner Production solutions

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Abstract

Egypt has increased cement production from 4 million tons in 1975 to 46 million tons in 2009, and now accounts for around 1.5% of global cement production. Dust emissions contribute about 6% of the PM_{10} in Greater Cairo reaching as much as 30% in areas nearby the cement plants. New regulatory standards, expected to be ratified in 2010, will reduce dust emission limits from 300 to 100 mg/m^3 for existing plants and from 100 to 50 mg/m^3 for new plants. Online monitoring by the Egyptian Environmental Affairs Agency (EEAA) of the 72 main stacks in the 16 cement plants provides real time information on dust emissions. New plants are 98% compliant and older plants 92% compliant with the emission limits. Little routine monitoring is done on SO_X and NO_X emissions. Cleaner production and pollution prevention opportunities for the cement sector include: 1) use of alternate fuels in cement kilns; 2) NO_X reduction; 3) reduction of dust emissions; 4) use of silica fume waste to produce new cement products; 5) reuse of bypass dust; and 6) treatment of hazardous waste.

Keywords

Egyptian Cement, Cleaner Production, BAT, Alternative fuel, bag house.

1. Introduction

The Egyptian cement industry increased in size and capacity during the last 30 years. In 1975 the Egyptian Cement Industry was comprised of four factories, which produced 4 Million tons/year. Now there are 16 factories, which produce 46 Million tons cement/year[1].

The government continues to support the expansion of the cement industry because of rapidly increasing demands for cement; consequently, they have approved the construction of an additional six cement factories in 2006-2007 and another 8 factories in 2010[2]. The satellite image in Fig. 1 shows the locations of the 16 cement factories in Egypt.

[1] Eng. Ahmed Hegazy (July 2010). Environmental Quality Sector Director-Egyptian Environmental Affairs Agency, personal interview.
[2] Industrial Development Agency (July 2010). February 2010 IDA board meeting minutes of meeting.

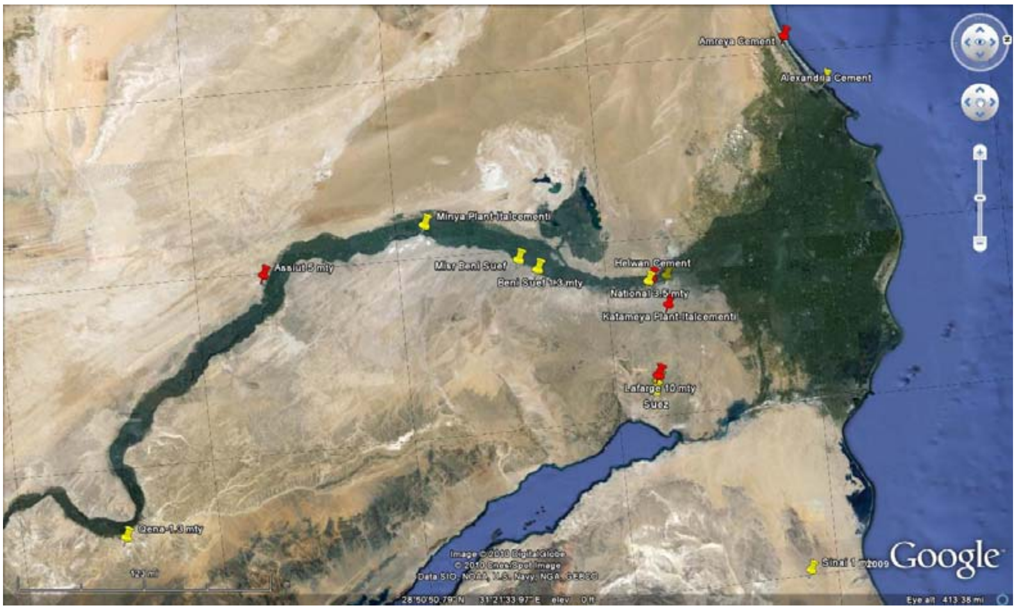

Figure 1. Cement factories in Egypt are highlighted with yellow or red indicators.

The cement industry in Egypt contributes about 6% of the PM10 in greater Cairo and brings the PM10 concentration as high as 30% of the total pollution in the vicinity of the factories. Of the 16 factories currently operating in Egypt, only seven are in compliance with the national environmental regulations on air emissions[3]. The pollution prevention/cleaner production investments needed to achieve full compliance of the cement industry has been estimated to be in the order of 0.5 Billion USD[4]. While this level of investment will be dominantly pollution prevention there will be savings from better energy use, reuse of bypass dust and improved health and safety of workers and of nearby communities.

This paper is concerned with the environmental assessment of cement producing facilities in Egypt with regard to their environmental compliance, and their corporate sustainability responsibility (CSR). A comparative analysis was performed between subsidiaries of multinational companies and their Egyptian counterparts. Factors affecting the current environmental performance of Egyptian cement facilities are discussed and plans for their improvement are proposed. The proposed action plan includes measures for sustainable development as well as for social responsibility with special emphasis on the use of alternative fuels and other cleaner production concepts, tools and technologies.

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[3] Eng. Kawthar Hefny (July2010). Air Quality Department Director-Egyptian Environmental Affairs Agency, personal interview.
[4] Eng. MaysounNabil (July 2010). Industrial Unit Manager – Egyptian Environmental Affairs Agency, personal interview.

This paper is part of an integrated research study for the lead author's PhD, on Cleaner Production, Cleaner Products, Industrial Ecology and Sustainability in Erasmus University, Rotterdam, The Netherlands. The research objectives are:

1. To motivate Egyptian cement industrial leaders to make improvements "beyond compliance";
2. To integrate strategic policies & practical tools toward Cleaner Production in all cement industries in Egypt;
3. To develop a series of case studies of the triple bottom line (TBL) benefits of improved environmental auditing/environmental management in the implementation of cleaner production concepts, tools and strategies in several major, heavily polluting cement companies in Egypt.

2. Cement Production

During the last 50 years, global cement production has increased from 200 million tons per year to over 1.8 billion tons per year; the related processes contribute 7% of global CO_2 emissions.[5]

2.1 Global Cement Production

Information from European Cement Association (CEMBUREAU 2006-2008) shows the following facts[6]:

1. The global production is increasing steadily, with a steep increase since the 1990s due to Asian countries' rapid production. Fig. 2 shows the production of cement between 1950 & 2006.

[5] Joseph Davidovits (2010) Geopolymer Institute, a research institution based in Saint-Quentin, Picardie, France.

[6] CEMBUREAU (2010). World Statistical Review report 1996- 2008.

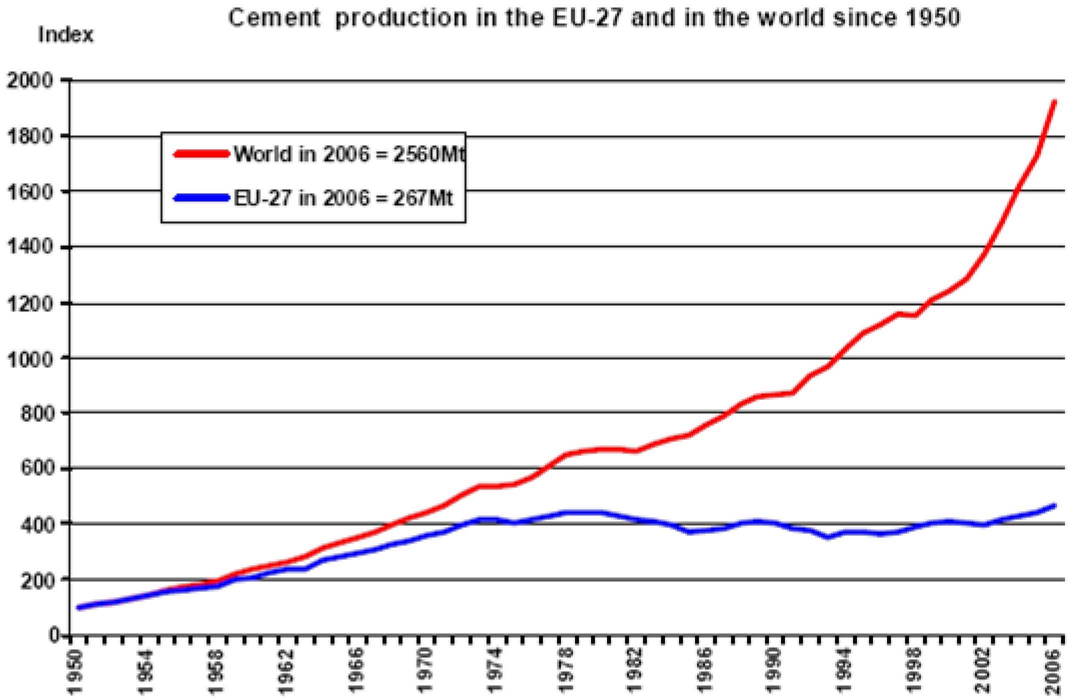

Figure 2. Cement production globally since the 50s

(source. 72 CEMBUREAU, 2006-2008- 168,TWG CLM,2007)

2. The largest cement manufacturing country is China. Other Asian countries combined, are in second place while the EU is in third place in cement production.

Table 1: World cement production by geographic regions in 2006

Region	% in 2006	Region	% in 2006
China	47.4	USA	3.9
Other Asia	13.2	CIS	3.4
EU -27	10.5	Japan	2.7
India	6.2	Other Europe	2.5
Other America	5.8	Oceania	0.4
Africa	4		

(source. 72 CEMBUREAU, 2006-2008)

3. Cement production in 2006 in the EU-25 was 267.5 Million tons and consumption was 260.6 Million tons. Approximately 28 Million tons were imported and 32 million tons were exported. The largest producers and consumers were Spain, Italy and Germany.

4. There are 268 cement production plants with kilns and 90 cement production plants without kilns in the EU 27. Table 2 shows the plant's distribution in different countries.

Table 2. Cement production plants in EU-27

EU member State	Cement plant with Kilns	Cement plants without kilns (cement mills only)
BE	5	4
BG	5	--
CZ	6	1
DK	1	--
DE	38	20
EE	1	--
IE	4	--
EL	8	--
ES	37	13
FR	33	6
IT	59	35
CY	2	--
LV	1	--
LT	1	--
LU*	1	1
HU	4	--
MT	--	--
NL	1	2
AT	9	3
PL	11	1
PT	6	2
RO	8	1
SI	2	--
SK	6	--
FI	2	--
SE	3	--
UK	14	1
Total	268	90
***Including one clinker plant**		

(source. 72 CEMBUREAU, 2006-2008)

5. By 2007, the dry process is used in 90% of the cement production facilities in Europe, however 2.5% was produced via the wet process and the remaining 7.5% was produced via the semi-dry, semi-wet process.
6. There are several fuels used in cement plants, including coke, oil and biomass. Table 4 shows different type of fuels used in EU-27.

Table 3. Percentages of consumption of different fuels in the EU-27 cement producing facilities.

Type of fuel	% in 2006
Petcoke	38.6
Coal	18.7
Petcoke and coal	15.9
Fuel oil including high viscous fuel oils	3.1
Lignite and other solid fuels	4.8
Natural gas	1
Waste fuel	17.9

(source. 72 CEMBUREAU, 2006-2008)

2.2 Cement Production in Egypt

The Egyptian cement industry increased in size and capacity during the last 30 years. In 1975 the Egyptian Cement Industry comprised four factories, which produced 4 million tons/year. Now there are 16 factories, producing 46 million tons/year of clinker primarily from dry kilns with only a small amount from 7 wet kilns in 3 companies. Egypt's production is estimated to be 1.5% of the world production (year 2008). Table 4 shows the production & energy consumption of each of the Egyptian cement producing companies.

Table 4. Cement company's clinker production and energy consumption in Egypt

No.	Company	Line	Clinker Production
1	Amreya cement (Cimpor group)	Kiln 1, Kiln 2	1,900,483
2	Amreya cimpor (Cimpor group)	ACCC Kiln 1	1,352,098
3	Sinai cement (Gray)	Kiln 1, Kiln 2	3,350,221
4	Bani suef cement	Kiln 1	1,573,844
5	Alexandria cement (TITAN)	Kiln 1	1,500,005

6	Misr Qina	production line	1,859.730
7	National cement	Kiln 1 (wet), Kiln 2 (wet), Kiln 3, Kiln 4	3,031.951
8	Suez cement (Suez plant) (Italcementi group)	Kiln 1, Kiln 2	2,100,710
9	Suez cement (Kattameya plant) (Italcementi group)	Kiln	845,810
10	Suez Cement (Torah plant) (Italcementi group)	Kiln 5, Kiln 7, Kiln 8, Kiln 9	2,474,412
11	Helwan (Italcementi group)	Dry Kiln 1 (plant 2), Dry Kiln 2 (plant 2), wet Kiln 2(plant 1), wet Kiln 3(plant 1),wet Kiln 5(plant 1), wet Kiln 6 (plant 1), wet Kiln 1(plant 3), wet Kiln 2(plant 3)	4,009.340
12	El Minia (Italcementi group)	Kiln	287,666
13	El Arabeya cement	Kiln 1	2,030,428
14	CEMEX (Assiut cement)	Kiln 1, Kiln 2, Kiln 3	4,706,112
15	Lavarge Cement	Kiln 1, Kiln 2, Kiln 3, Kiln 4, Kiln 5	8,295,478
16	Misr bani suef (TITAN)	Kiln 1	1,573844
Total			40,892,132

3. The Environmental Status of Cement Companies in Egypt

Air Emission Standards

In 1994 Egyptian Environmental Protection Law Number 4 and its executive regulations was issued for protection of the Egyptian environment. Limits for dust emissions from cement plants were 300 mg/m^3 for plants established before 1995, 200mg/m^3 for plants installed after 1995 and before issuance of the new amendments and 100 mg/m^3 for new plants. Nitrogen oxides (NOx) and Sulfur oxides (SOx) emission limits were set at 300 mg/m^3 and 4000 mg/m^{3}l respectively.

Following ratification of Law 9 for the environment in 2009 the Ministry of State for Environmental Affairs and the Egyptian Environmental Affairs Agency (EEAA) developed new air emission standards, which are expected to be ratified by Parliament towards the end of 2010. The new standards for cement plant's dust emissions will thereby be more in line with international standards with 100 mg/ m^3 for old plants and 50 mg/ m^3 for new plants, SOx is 400 mg/ m^3 and 600 mg/ $m^3$for NOx

Cement Process Emissions

Cement, mostly Portland cement, is made from a mixture of calcium carbonate (generally limestone), silica, iron oxide and alumina. A high temperature kiln fuelled by natural gas or heavy fuel oil heats the raw materials to a partial melt at 1450^0 C, transforming them chemically and physically into clinker. Clinker is then ground with gypsum, flue ash and/or sand to make cement.

Fig. 3 shows the main sources of pollutants from cement production using the dry process.

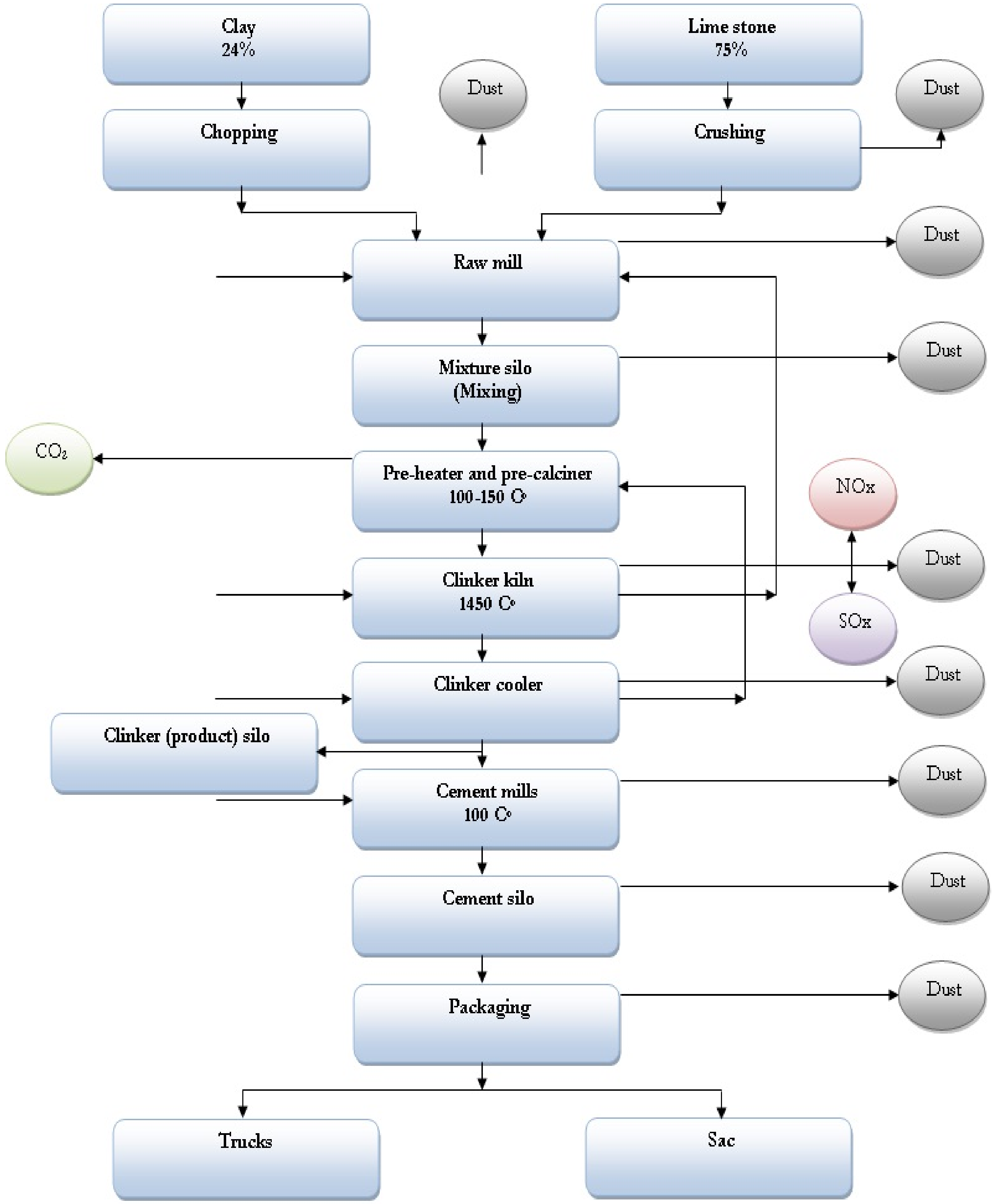

Figure 3. Pollutants from Cement manufacturing – dry process

Dust Emission Control Equipment

Electrostatic precipitators are widely used in the cement plants in Egypt to filter dust emissions. Table 5 shows the different dust filtration systems in use by the 16 cement companies.

Table5. Cement companies dust filtration system in Egypt

No.	**Company**	**Dust filtration system**	**No.**	**Company**	**Dust filtration system**
1	Amreya cement (cimpor group)	Electrostatic Precipitators (EP)	9	Suez cement (Kattameya plant) (Italcementi group)	EP & GB
2	Amreya cimpor (cimpor group)	EP	10	Suez Cement (Torah plant) (Italcementi group)	EP
3	Sinai cement (Gray)	EP & Baghouse (BH)	11	Helwan (Italcementi group)	EP
4	Bani suef cement	EP	12	El Minia (Italcementi group)	EP
5	Alexandria cement (TITAN)	EP	13	El Arabeya cement	EP
6	Misr Qina	EP & BH	14	Cemex (Assiut cement)	EP & BH
7	National cement	EP	15	Lavarge Cement	EP
8	Suez cement (Suez plant) (Italcementi group)	EP and Gravel Bed filter (GB)	16	Misr bani suef (TITAN)	EP & BH

Real Time Monitoring and Compliance

Since the main pollutant considered from the cement industry in Egypt is dust, EEAA installed real-time monitoring systems in all 72 main stacks of the cement companies. Table 6 shows the level of stack emission compliance during 2009 in each plant. [7]

[7] Industrial department database (2010). Central Department for improving the industries – EEAA . August 2010.

Table 6. Cement companies compliance percentage in Egypt during 2009

No.	Company	Average Compliance %	No.	Company	Average Compliance %
1	Amreya cement (cimpor group)	92	9	Suez cement (Kattameya plant) (Italcementi group)	95.9
2	Amreya cimpor (cimpor group)	86.3	10	Suez Cement (Torah plant) (Italcementi group)	97.8
3	Sinai cement (Gray)	99.3	11	Helwan (Italcementi group)	98.1
4	Bani suef cement	97.1	12	El Minia (Italcementi group)	99.9
5	Alexandria cement (TITAN)	99.2	13	El Arabeya cement	99.7
6	Misr Qina	99.4	14	Cemex (Asyot cement)	99.1
7	National cement	97.1	15	Lavarge Cement	99.9
8	Suez cement (Suez plant) (Italcementi group)	99.5	16	Misr bani suef (TITAN)	99.2

. In 2008, emissions from different types of companies were as follows:

1. 92% of the emissions from the plants constructed before issuance of the executive regulation did not exceed 300 mg/m3.
2. 96.3% of the emissions from the plants constructed after issuance of the executive regulation did not exceed 200 mg/m3.
3. 98.4% of the emissions from the plants constructed after the modification of the executive regulation of Law 4 in 1994 did not exceed 100 mg/m3.

This thesis author made investigations among different cement industries with the EEAA staff; we found that the main deficiencies of the current system include:

1. Differences between the ways companies and the EEAA calculate readings from emissions detectors. In the EEAA, one reading, one second sample, each one minute is the reading; on the other hand, it is and average of six minutes readings in the companies.
2. No routine monitoring of SOx or NOx;
3. High allowable limits of SOx and unrealistically low NOx limits;
4. Lack of constructive communication between companies and the EEAA staff.

Currently, companies are changing their filtration systems to baghouse systems, due to improvements in the baghouse technologies that produce heat and alkalinity resistant fabrics and result in more efficient removal of dust particles. Nearly all the companies with less than 98% compliance are in the process of replacing the main EPs with baghouses or adding a baghouse after the EP.

5. CP and Pollution Prevention Opportunities for Cement Plants in Egypt.

The United Nations Environment Programme (UNEP) defined Cleaner Production (CP) as: *"CP is the continuous application of an integrated preventative environmental strategy to processes, products and services to increase efficiency and reduce risks to humans and the environment".*[8]

CP can be achieved in cement industries by:

1. Good Housekeeping: appropriate provisions to prevent leaks in joints and conveyers and to achieve proper, standardized operation and maintenance procedures and practices;
2. Better Process Control: smooth and stable kiln process and process monitoring keeps higher efficiency operating and lower rates of waste and emission generation;
4. Equipment Modification: replacing EP with BF in addition to old equipment replacement leads to lower rates of waste and emission generation;
5. Technology Change: Wet process shall be replaced with Dry process. Consumption of energy in dry process (200J/Kg) is half used in wet process. Also NOx emissions from dry is 1/3 out from the wet process (1.5 kg NOx/ton clinker in dry, 4.5 kg NOx/ton clinker in wet). [9]
6. On-Site Recovery/Reuse: In Egypt, due to raw material high alkalinity, wastes of bypass generated which reaches 10% of the clinker produced. Bypass dust can be used in

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[8] United Nation Industrial Development Agency (UNIDO) (2010). Cleaner and Sustainable Production Unit -Resource Efficient and Cleaner Production (RECP)-Cleaner Production. Found on line at: http://www.unido.org/index.php?id=o5152. Visited at 2010-08-03

[9] Integrated Pollution Prevention and control (2009). Reference Document on Best available Techniques in the cement and lime Manufacturing Industries – May 2009

producing mortars cement or can be used in roads.[10]

7. Production of Useful By-Products: Silica fume is emitted in ferroalloy and chemical companies. Silica fume materials can be used as additives to cement and used in sulfur resistant concrete.

8. Product Modification: Using different additives to clinker and cement produces different types of products. This leads to human health protection and nature conservation. Widen the usage of these types according to specific needs reduces wastes, energy and raw materials.

There are CP opportunities in cement manufacturing in Egypt, which are illustrated in the following examples.

5.1 Use of Alternative Fuels

In Europe and the USA, the cement industry has been using alternative fuels prepared from waste materials for more than 20 years, and high substitution rates are being achieved. The waste derived fuel (WDF) projects are driven by high conventional fuel prices, high landfill tax charges on waste deposits and on fossil CO^2 savings in emission trading schemes. The cement kiln is a safe and secure disposal route for combustible wastes due to the high temperatures, long residence times and an alkaline atmosphere in the cement kiln. Additionally, there are no residues left since the ash becomes part of the product. There are no significant changes to the emissions from the cement plant using alternative fuels.

An example of an international experience, CEMEX in Costa Rica has successfully implemented a United Nations Certified Clean Development Mechanism (CDM) project that substitutes conventional fossil fuels such as petroleum coke, fuel oil, and natural gas with more environmentally friendly local biomass products such as rice husks and wood chips. Cemex’s Costa Rican operations currently have a 20% alternative fuels substitution rate and CEMEX claims that this project alone helps them to avoid 21,000 metric tons of CO_2 from being emitted annually. In Japan, where there is a shortage of space for waste, up to 350kg of waste per ton of cement are used as an alternate fuel.

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[10] Hanan El Hadadry (2010). Successful stories of using bypass in roads – UNIDO NCPC Director, Cairo (March 2010)

In the developing countries, WDF projects are beginning to move forward depending on the financial and regulatory situations in the different countries. In some cases these are resulting from profitable Clean Development Mechanism (CDM) projects and in others they are moving forward because of very high fuel prices.

In Egypt the Government has doubled the price of heavy fuel and energy intensive sectors, such as the cement industry, now pay nearly twice as high price for natural gas as other industrial sectors. In addition the Cabinet of Ministers and Ministry of Electricity ratified and applied new electricity tariffs in August 2010 on high electricity consumers like the cement industry[11]. The increase in price is 50% in the peak energy consumption periods (7:30-11 pm in summer and 5-9 pm in winter). Cement manufacturing is energy intensive; it accounts for 30-40% of production costs.[12]This increase in price is one of the main drivers to use new energy sources like alternative fuels in cement manufacturing. Also, it should be a driver to find ways to increase energy efficiency in all phases of the life-cycle of the production and usage of cement.

Some cases and trials are in progress for using alternative fuels such as refuse derived fuel (RDF) and agricultural wastes. They can be counted as Cleaner Production options since the benefits result in:

1. Reduction in the quantities of material going to the landfill or to dedicated incinerators;
2. Energy recovery from combustible wastes;
3. Conservation of fossil fuels for future generations;
4. Net reduction in emissions;
5. An opportunity to utilize biomass, taking advantage of the CO_2 trading rules;
6. Reduction in cement production costs.

[11] Egyptian Cabinet of Ministers announcement (July 2010).

[12] Integrated Pollution Prevention and control (2009).Draft Reference Document on Best available Techniques in the cement and lime Manufacturing Industries – Executive summery May 2009.

So far in Egypt, little waste is being used as fuel. The fuels likely to be used are agricultural wastes such as rice straw, which is currently burnt in the fields in the Nile delta causing extensive air pollution, and RDF, which can be produced from municipal wastes, and also thereby diverts it from deposition in landfills.

Italcementi, Cimpor, Lavarge and CEMEX are in different stages of implementing fuel substitution processes. Currently, CEMEX cement in Assiut is substituting approximately 15.2% of their fuel with agricultural wastes and is planning to expand to replace 50% of their energy by such wastes by 2014. Italcementi and Amreyah Cement will complete pilot trials for the use of rice straw and RDF in their cement kiln and Lafarge is seriously studying implementing the first RDF plant in Egypt as well as assessing the collection and use of rice straw in one kiln. Table 7 presents data on the fuel substitution work that was done by some companies.

Table 7. Fuel substitution initiatives in Egypt

Initiatives of the companies	Cost	Fuel Subst.	Agri-Waste	RDF/ SSW	Other
			Tons x 10^3 per year		
Suez Cement Helwan Plant, Cairo (Italcementi group)	$7.0m	10-30%	166 15%	93 10%	54 5%
Suez Cement – Katameya Plant, Cairo (Italcementi group)	$4.2m	10-30%	89 20%	37 10%	
Amreya Cement, Alexandria (Cimpor)	$1.64m	~10%			
Lafarge Cement, Suez	$10.4m	Kiln 2		72	
	$3.9m	Kiln 1	120		
(note $10.4m includes $6.5m for pretreatment at landfill)	Existing	Kiln 4			23
Cemex Cement, Assiut (CDM appl.)	$2.36m	15-21%	275 21%		

In Egypt, the waste management facilities are under-developed and there are no landfill taxes to stimulate the usage of RDF; thus it is not anticipated that there will be a rapid increase in substitution rates without further increases in energy prices. They are expected to continue to rise significantly in line with Governmental policy to phase out energy subsidies by 2017.

The rate of substitution in Egypt will depend on financial drivers and availability of alternative fuels. The drivers will depend largely on the price differential per unit of energy between the conventional fuels and the alternative fuels. That in turn, depends on the country's energy policies and waste management policies. Without legislation on waste the availability of suitably priced waste derived fuels will be low.

On the basis of these arguments the substitution rate of alternative fuels in the Egyptian cement plants is not expected to rise above 30% and the more remote or older plants will use less.

The anticipated overall quantities required for fuel substitution in cement plants in Egypt can be estimated as follows:

The cement production capacity in Egypt is about 46 million ton, equivalent to 40 million ton of clinker. Most of the cement plants in Egypt are reasonably modern thus, we can assume a fuel efficiency of about 3.3 GJ/ton clinker. Assuming that the alternative fuel of choice is a biomass such as rice straw with a calorific value of 14 GJ/ton, and applying the target of 30% substitution, the requirement for fuel for the Egyptian cement industry is:

Tons required = 30% × 40 M × 3.3/14 = 2.8 million tons

This fuel could be made up of rice straw, cotton stalks, maize cobs, RDF, or dried sewage sludge. All these fuels have similar calorific values and the annual production is estimated to be:

- 4.9 million tons of rice straw
- 6.7 million tons of maize stalks and cobs
- 1.9 million tons of cotton stalks
- 1 million tons of RDF
- 100,000 tons of sewage sludge

Total 14.6 million ton

Taking a further assumption of only 25% of this production being collectable, there could be: 3.4 million tons available. The 2.8 million tons of alternative fuels likely to be required by the Egyptian cement industry could be fully accommodated within the 3.4 million tons suitable for use as fuel. Not all cement plants will be within a suitable area to collect rice straw or other agricultural waste and these plants could use an RDF fuel and in other cases the financial opportunities will determine an RDF use rather than rice straw. In order to obtain an order of magnitude increase in alternative fuels, it is assumed that half this alternative fuel requirement will come from agricultural waste and half will be from RDF. The requirements of the Egyptian cement industry are thus set at 1.4 million ton of rice straw fuel or equivalent and 1.4 million ton of RDF.

In Egypt, clearly we have no measurements of the quantity of pollution emitted from the burning of rice straw in the fields of the Nile delta. We can however, make some rough estimates:

- Burning straw in the fields produces black smoke, signifying incomplete combustion. We can assume that about 80% of the carbon burns completely and 20% is a residue of un-burnt carbon, and 80% of the un-burnt carbon is left in the fields while 20% is emitted as smoke. Analysis shows that there is 36% carbon in rice straw.
- Similarly we can assume that 90% of the ash from the rice straw is left in the fields and 10% is released into the atmosphere by the convection currents generated by the burning. Analysis shows that the ash content of rice straw is 16%. Using these assumptions we are able to make a comparison as shown in Table 8.

Table 8. Emissions from burning one ton of rice straw in the fields and as a fuel in a cement plant

Source of emission	Burning of one ton of rice straw in the fields	Using one ton of rice straw as a fuel in a cement plant
Un-burnt carbon to atmosphere	15 kg	0 kg
Ash residues emitted to the atmosphere	16 kg	0 kg
Total particulates emitted from 1 ton of rice straw	31 kg	0 kg
CO_2 emitted to the atmosphere	900 kg	0 kg; the CO_2 emitted is from biomass

These data should be accepted as a very rough estimate. If we then multiply by 5 million – the number of tons of rice straw estimated to be burnt in the fields – we see that some 150,000 tons of particulates and 4 million tons of CO_2 are emitted.

The location within the cement manufacturing processes for feeding of alternative fuels depends on the type of fuel. If it contains volatile materials like solvents, they should be fed into the high temperature zones of the kiln system. On the other hand, if it contains organic and inorganic compounds, they should not be fed into the kiln via the normal raw meal supply unless it has been demonstrated by controlled test runs in the kiln or by adequate laboratory tests that undesired stack emissions can be avoided.[13] Figure 4 shows the possible waste feeding points in cement kilns.

A study in 2004 clarified that using alternative fuels in cement kilns is safe and they do not release any Persistent Organic Compounds (POPs) during combustion.[14]

[13] Free book online (2010). Draft Technical Guidelines on Co-processing of Hazardous Waste in Cement Kilns – 22 March 2010. Found online at: http://free-books-online.net/Draft-Technical-Guidelines-on-Co-processing-of-Hazardous-Waste-in-doc.visited at 2010-08-15

[14] World Business Council for Development (2004). Draft formation and release of POPs in cement industry - SINTEF. 2004-03-19

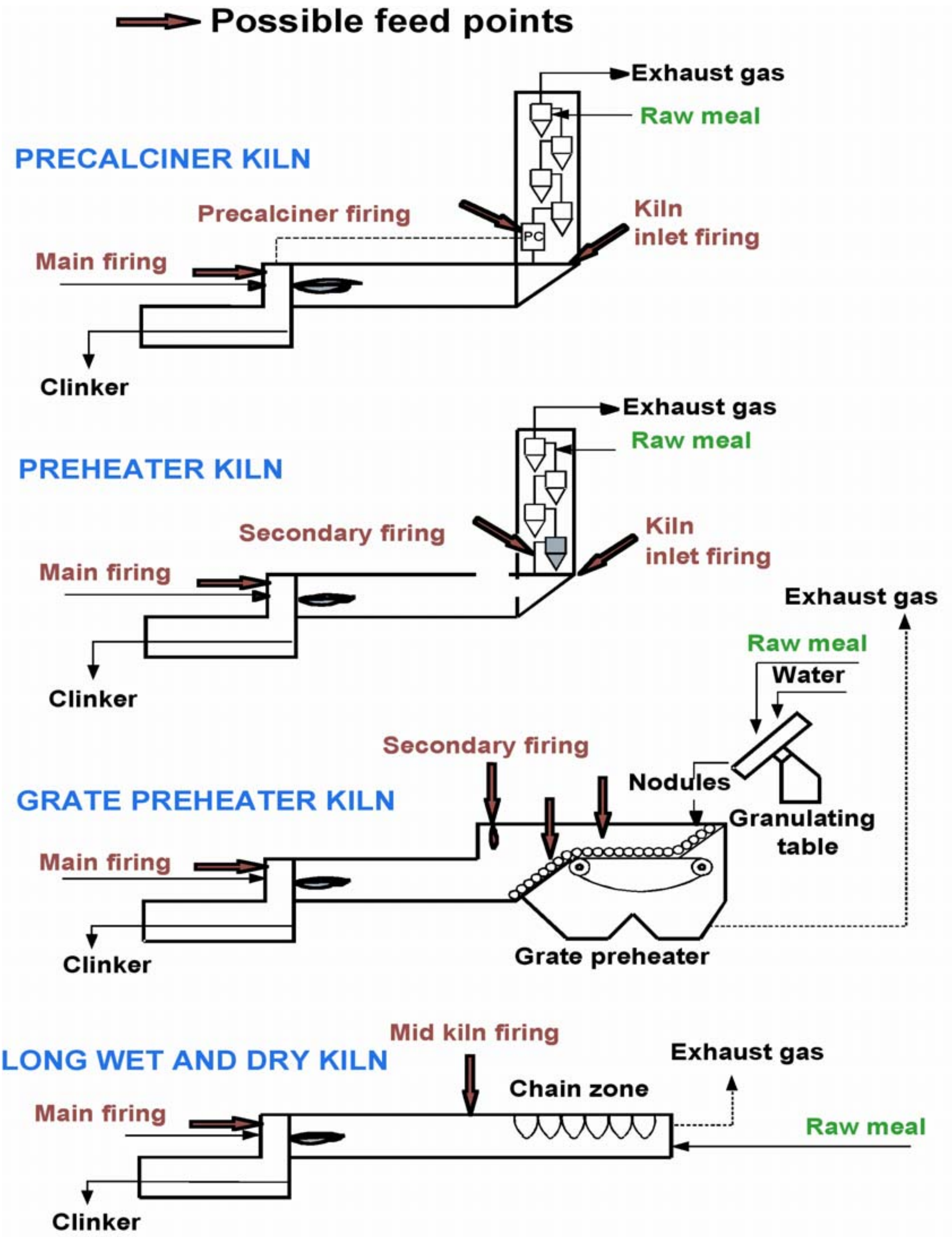

Figure 4. Typical waste feed points

5.2 NOx reduction

Currently, the cement companies are reluctant to implement NOx emissions abatement measures since these emissions are not currently measure continuously in the online monitoring system. Executive regulation of law Number 9 of 2009 is currently being evaluated by the Egyptian Prime Minister. The new limit of NOx emissions is 600 mg/m3. The companies are encouraged to implement de-NOx projects to prevent violating the law and to also reduce energy consumption.

NOx emitted is due to oxidation of nitrogen present in air and fuel during combustion in uncontrolled combustion systems. Air-fuel ratio controls during combustion reduce the emissions and improve combustion efficiency. This is directly reflected in energy conservation.[15]

Meanwhile, fuel wastage is significant due to NOx emissions. Control and reduce the amount of fuel in kiln burners reduces fuel costs. Using Selective Non Catalytic Reduction slows, in some cases, a reduction of NOx (as NO_2) from 1000-1200 mg/m^3 to 200 mg/m^3.

Table 9 shows typical de-NOx practices and the estimated percentages of NOx reduction.[16] Note that the first four measures are considered Cleaner Production options and the last two are end-of-pipe options.

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[15] Dr. Basel Al-Yousfi (2001) Regional Industry Officer United Nations Environment Programme, Regional Office for West Asia, paper on “Applications of Cleaner Production in Cement Manufacturing Industry- *Reducing NOx Emissions” presented in* 3rd International Conference and exhibition on Environmental Protection in Cement and Building Materials Industries 9-11 October 2001.

[16] Voluntary environmental initiatives for sustainable industrial development (2004). United Nation Environmental Program, Division of Regional Cooperation, Regional Office for West Asia (ROWA), UNEP publication (March 2004). Found online at: http://www.unep.org/pdf/rowa/ROWA92-867-2480-0.pdf. visited at 2010-08-04

Table9. De-NOx typical practices and estimated % of NOx reduction

Item	**Technique**	**Description**	**% NOx reduction**	**CP vs EOP**
1	Fuel-Air ratio optimization and Process Modifications	• Changing feed mix content to require less heat in clinker production • Fuel switching to lower Nitrogen content fuels • Increase heat recovery thermal usage through increase solid-gas heat transfer like more recovery of heat from clinker cooler, heat transfer from kiln to raw mills and solid/gas mixing in pre-calciner and pre-heater.	Less than 25	CP
2	Use low-NOx burners	Allows reducing flame, fuel stream turbulence, adjust Air-fuel mixing and produces fuel rich zone.	20-30	
3	Staged combustion	Where combustion is firstly done in rich and high temperature environment and the combustion is completed in a secondary, lower temperature stage.	30-45	
4	Mid-kiln firing in long kilns	Using additional combustion area in conventional kilns, usually in a secondary firing zone with lower temperatures to complete preheating and calcinations of raw materials.	20-40	
5	Using SNCR	Using Selective Non Catalytic Reduction is done mainly in pre-heater and pre-calciner kilns using ammonia and urea (no catalyst).	30-70*	EOP
6	Using SCR	Selective Catalytic Reduction is done by using ammonia in the presence of a selective catalyst.	80-90	

**High differences in percentage are due to high dependence on other conditions like temperature, molar reagent ratio and time.*

5.3 Reducing dust emissions

In the last few years, fiber technologies have improved and new production techniques have been discovered. At the beginning, woven fabrics from wool and cotton were used. Later, rayon was used followed by synthetic fibers like polyester and nylon.

Recently, needlefelt fabrics are replacing woven fabrics. A new kind of nonwoven fabric is currently on the market called, hydroentangled nonwoven fabrics," Durapex fabrics." They are made using high pressure water jets instead of barbed needles. The two main advantages of this type are:

1. It does not damage fibers during manufacturing;
2. The production does not produce large needle holes or an uneven fiber distribution.17

Many of the cement companies in Egypt are in the process of changing the kiln, raw mills and cement mills from EP to BF. Performance standards specified for the new BF are generally less than 50 mg/well below the current 300 mg/m3and the planned limits of 100 mg/m^3. Italcementi (Tourah Plant), Amreya Cement and Amreya Cimpor are currently changing 6 large EP filters to BF with an estimated cost of 50 Million USD. The expenditure is driven by the need to meet regulatory compliance and by the head office's environmental policies to reduce emissions from their global operations. There is little direct financial benefit to the companies from such installations.

A recent study done by the Egyptian Ministry of the State for Environment Affairs, using International experience, showed the advantages and disadvantages of using EPA & BF[18]. The results are shown in Table 10.

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[17] Chemical processing web magazine (2003). Filtration for future "Chemical plants stand to benefit from several new and emerging filtration technologies" article. Found online at: http://www.chemicalprocessing.com/articles/2003/120.html

[18] Assessment report on pollution reduction in cement plants (2010). Egyptian Pollution Abatement Project – Second phase publications, Egyptian Environmental Affairs Agency. July 2010.

Table10. Advantages & Disadvantages of using BF &EP

Method of dust filtration	Advantages	Disadvantages
EP	• High particulate (coarse and fine) collection efficiencies attainable at a relatively low expenditure of energy during operation. • Collected material recovered dry for subsequent processing or disposal • Low pressure drop • Designed for continuous operation with minimum maintenance requirements • Relatively low operating costs • Capable of operation under high pressure or vacuum conditions • Capable of operation at high temperatures up to 500°C or more. • Relatively large gas flow rates capable of effective handling the required volumes of flue gases	• Very sensitive to fluctuations in gas-stream conditions (in particular, flows, temperature, particulate and gas composition, and particulate loadings) • Certain particulates difficult to collect owing to extremely high or low resistivity characteristics • Explosion hazard may increase when CO values go high after certain limits, this require to trip the EP and dust emission go high at that moment. • Special precautions are required to safeguard personnel from the high voltage • Ozone produced by the negatively charged discharge electrode during gas ionization • Relatively sophisticated maintenance personnel required • Sticky particulates may be difficult to remove from plates
BF	• Extremely high collection efficiency on both coarse and fine particles • Relatively insensitive to gas-stream fluctuation; efficiency and pressure drop relatively unaffected by large changes in inlet dust loadings for continuously cleaned filters • Filter outlet air capable of being recirculated within the plant in many cases (for energy conservation) • Collected material recovered dry for subsequent processing or disposal • No problems with liquid-waste disposal, water pollution, or liquid freezing • Corrosion and rusting of components usually not problems • No hazard of high voltage, simplifying maintenance and repair and permitting collection of flammable dusts • Use of selected fibrous or granular filter aids (precoating), permitting the high-efficiency collection of very fine smokes and gaseous contaminants • Relatively simple operation.	• Temperatures much in excess of 250°C require special refractory mineral or metallic fabrics that are still in the developmental stage and can be very expensive • Certain dusts possibly requiring fabric treatments to reduce dust seeping or, in other cases, to assist in the removal of the collected dust. • Concentrations of some dusts in the collector (~50 g/m^3) like coal forming a possible fire or explosion hazard, if a spark or flame is admitted by accident. • Relatively high maintenance requirements (bag replacement, etc.) • Fabric life possibly shortened at elevated temperatures and in the presence of acid or alkaline particulate or gas constituents, therefore not a preferred choice for kiln bypass gases up to 50 mg/Nm^3 emission level. • Replacement of fabric, possibly requiring respiratory protection for maintenance personnel • Medium pressure-drop requirements, typically in the range 100 mm to 250 mm water column.

5.4 Using Silica Fume Waste to Produce a New Cement Product

Silica fume waste is 100 times smaller in diameter than Portland cement particle size. It is produced in Egypt from two factories in Upper Egypt. KIMA Company and Egyptian Ferrosilicon used to consider these emissions as waste coming from the main process, alloys production, and they used to dump it into landfills.

Analysis of silica fumes in Egypt and Thailand are presented in Table 11.

Table 11. Silica fume analysis in Egypt and Thailand

Oxides /Country	Egypt[19] %	Thailand[20] %
SiO_2	94.52	95.3
Fe_2O_3	0.92	0.28
Al_2O_3	0.66	0.65
MgO	0.5	0.41
H_2O	0.1	--
CaO	0.2	0.27
K_2O	--	0.77
Na_2O	--	0.26

Using silica fume dust in concrete production with different percentages improves the strength of the concrete. A study made in Thailand showed that "*The compressive strength was found to increase significantly with increasing level of silica fume dust used in the mixes. The greatest increase in strength was found in the concrete mix with silica fume dust at 20%. This is thought to be due to improved densification of the cement matrix and also to stronger bonding in the inter-facial zone between the cement paste and aggregates*" (Arnon Chaipanich).

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[19] Adel Mohamed Adel (2010) Head of Silica factory-KIMA factory (June 2010)

[20] Arnon Chaipanich (2006). Department of Physics, Faculty of Science, Chiang Mai University, Chiang Mai 50200,Thailand, " Silica Fume: Its Role in Cement and Concrete Technology" paper (2006).

Only Lafarge Cement is using silica fume dust in their "ready mix" product in Egypt. Other users are large construction companies like Arab Contractors and the Talaat Mostafa Group which uses it in mega projects like "Madenaty and El Abour city" and the new East Port Said Project constructed by large the consortium (Jan De Noul, Bouscaleis, Hyaundai, and Balast Nedham).[21] The price of silica fume dust in Egypt varies from 327-348 USD/ton[22]. Internationally its price is about 205 USD/ton.[23]

Although, the relatively high price of the local silica fume dust, requests for exporting the fume is increasing year-by-year and the local companies are financing projects for silica fume dust filtration and collection to benefit from the silica and also improve environmental quality.

5.5 Using Bypass Wastes as Raw Materials

Due to high alkalinity in the raw materials in Egypt, a bypass fume dust is emitted during calcination in clinker kilns. The percentage of the bypass dust varies from 0.17 to 10% of the clinker produced.[24] Cleaner production practices show that cement bypass dust can be recycled by[25]:

- Reusing it in the process again as a raw material;
- Use it to produce tiles and bricks;

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[21] Port Said Port Authority (2010). General Ibrahiem Sedeek, Port Said Port Chairman, Speech about the port activities. 2010-03-10

[22] (2010).Egyptian Ferrosilicon company, Financial department (June 2010).

[23] Materials Characterization Paper (2010). In Support of the Proposed Rulemaking: Identification of Nonhazardous Secondary Materials-That Are Solid Waste Silica Fume (used as ingredient in clinker manufacture). 2010-03-13

[24] Online monitoring stations database (2009). Environmental Management Sector- Air quality department database (December 2009).

[25] Nelson Leonard Nemerow, Franklin J. Agardy, Joseph A. Salvato (2008). Environmental Health and Safety "for municipal infrastructure, land use and planning, and industry"- Industrial solid waste utilization and disposal.

- Use it in ceramics and glass production;
- Use it in road pavement;
- Use it in the production of soil conditioner by mixing it with organic sludge.

In Egypt, three groups are using the bypass dust within their processes. The first case is Italcementi group (Suez Cement Company –Katamia plant) that is recycling 10% of the bypass dust into the clinker production. The company adds 10% of the bypass dust to 60% clinker and adds gypsum and lime to produce Portland cement that is used in mortar (not in concrete). This type of cement is lower in cost, but is still not low enough to attract more small business clients to use it.

The Italcementi group (Suez Cement Company – Tora plant) experimented with the usage of bypass dust to produce bricks. The experiments covered different percentages of bypass dust with clay and sand. Table 12 shows results of their experiments.

Table12. Break pressures of using bypass with different percentage in brick manufacturing

Item	Bypass percentage	Break pressure (kg/cm^2)
1	100% bypass dust with pressure force molding	120
2	100% bypass dust with pressure force molding and chemical treatment	360-450
3	15-20% bypass dust + clay (with pressure and thermal treatment)	530-940
4	50% bypass dust + 50% clay and sand (with thermal treatment only)	1300

The third example is in CEMEX Company where they have experimented with using bypass dust for paving stones and as a filling material. Their agreement with Asuit University is to use bypass dust to improve soil and/or to use it in low compressive strength paving concrete. They reduced the amount of bypass dust by 77% since the year 2000 to 1.8% per ton clinker produced.

There are other promising opportunities to use bypass dust in the Egyptian market. For example, bypass dust can be used up to 50% with glass raw material (silica and sand stone) at temperatures 1250-1450^{o}C. The product is greenish transparent glass, resistant to chemicals. By further thermal treatment, in the presence of 750-900^{o}C for 15-30 min., marble-like ceramic glass can be produced. This product can be used for external decoration, prefabricated walls and other engineering usages, due to its high strength and chemical resistance and atmospheric durability.

Recently, the usage of treated sewerage wastewater in agriculture has increased and is widely covered in the news in Egyptian. This treated water is used to irrigate trees only. Huge amounts of sludge are produced, containing heavy metals and bacteria and usually it is dumped into landfills or is unsafely dumped. Bypass dust can be used as stabilizers due to its high alkalinity. Bypass dustof kill bacteria and fix the heavy metals in the composite and convert them to insoluble metal hydroxides. Treated sludge can be mixed with agricultural wastes like rice straw, which is a major problem in Egypt, to enhance fermentation to produce compost.

4.6 Treatment of Hazardous Waste

The high temperature reached in cement kilns make them a suitable mechanism for safely treating certain types of hazardous waste.

Lafarge disposes of oil well drill cuttings in their plant at Ain Sokhna. This is a safe way of disposing of contaminated drill cuttings and at the same the materials contained are seen as raw material substitution as they replace some of clay used as raw materials. In addition Lafarge has contracts to dispose of 23,000 tons of outdated pharmaceutical wastes.

This application of hazardous waste treatment has been welcomed by the regulators (EEAA) and they would be pleased to see an increase in the quantity of hazardous waste safely treated in this way

6. Corporate Social Responsibility (CSR) in Cement Companies in Egypt

The European Commission's definition of CSR is*:"A concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis."* [26]

Since H.E. Ahmad Nazeif, the Egyptian Prim Minister, launched the 3rd conference of companies social responsibility in Cairo on March 24, 2010, and introduced the Egyptian Social Responsibility indicator in the Egyptian stock market, as the first African and second International country, After India, several companies and enterprises are now using SCR. The four principles of the indicator strategy include respect human rights, protect environment, protect labor and fight corruption.[27]

Although, all cement manufacturing companies with International counterparts, Italcementi, Cimpor, Lavarge and CEMEX, are committed to implement CSR principles, only two groups published sustainability reports including CSR activities namely CEMEX and Italcementi.

Italcementi's suitability report of 2008 shows that the group invested more than Euro 690,000 in 2008 in CSR activities covering local business development, capacity building, education programs, donation and charities and sponsorship.[28] Social responsibility covered three main areas:

1. Health and Safety;

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[26] European Commission webpage (2010).Enterprise and Industry-Sustainable and responsible business, CSR. Found online at: http://ec.europa.eu/enterprise/policies/sustainable-business/corporate-social-responsibility/index_en.htm. visited at 2010-08-20

[27] Dr. Mhmoud Mohey El Din, Egyptian Minister of Investment speech(2010). The lunching of CSR indicator in the Egyptian Stock Market. 2010-03-24

[28] Suez Cement Sustainability report 2008 (2010). Found online at : http://www.suezcement.com.eg/ENG/Sustainable+Development/. Visited 2010-08-20

2. Human Resource Management;
3. Social Indicatives.

Table 13, highlights the main activities and results under each area.

Table13. Main CSR activities & results under each main area

Item	Area	Activates & Results
1	Health and Safety	• Lost Time Injuries (LTI)* decreased by 75% • Severity reduced by 83% • 30% of workers covered under a progress review • Safety management handbook produced • Two new communication tools: Safety alert & best practice bulletin. • Total Recordable Injury rate (TRIR) detected. • Adoption of worldwide standards for occupational exposure limits of workers to dust, noise, respirable silica and vibration. • Information clearance and translation.
2	Human Resource Management	• Make sure that human resource's practices are under national laws and regulation. • Workers have freedom to form trade unions • Labor rights are legal • Increase training hours by 59.24% and to 63.4% in number of trainees. • Increase women's involvement in group activities.
3	Social Initiatives	• Support communities through supporting of education, health and social awareness • Sponsorship of cultural, environmental, leisure and sport facilities and events • Dialogue with local communities • Stockholder engagement. • Introduce charter of values

- *LTI is a function of the number of accidents with lost time in a year per million hour worked including temporary workers.*

CEMEX Company (Assiut cement plant) published sustainability report in 2010. It covers their key sustainability performance indicators that include in cement section CO_2, Dust, NOx, SO_2 and CO emissions, clinker /cement ratio, alternative raw material substitution, bypass dust, alternative fuel substitution, kcal/kg clinker, water, kwh/ton cement and incidents.

Social activities also covered educating retailers, labor and members of the surrounding community. The company also adopted a zero accident strategy. The results are clear since accidents decrease from 6 in 2005 to zero in 2008. The days lost per employee decreased to 1.7 in 2008.
The company enrolled in a school feeding program by supporting 776 children and their families.

The Company built 19 schools in remote villages serving hundreds of young girls. Their activities covered sports and health activities. The company environmental activities includes replacement of EP with BF in line one and planning to replace the second and third kiln EPs with BF and they planted one million trees in the desert. CEMEX opened dialogue with government, Ministries and parliament members. Also, they have continuous cooperation with universities and educational members

Although all the above activities of the cement companies in Egypt, the only cement company of European origin that is part of the European alliance of CSR is Titan S.A.[29] *"The UN Global Compact is a strategic policy initiative for businesses that are committed to aligning their operations and strategies with ten universally accepted principles in the areas of human rights, labor, environment and anti-corruption"*.[30] None of the cement companies in Egypt is a part of the United Nation Global Compact.

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[29] European Commission webpage (2010).Enterprise and Industry-Sustainable and responsible business, European Alliance for Corporate Social Responsibility (CSR). Found online at: http://ec.europa.eu/enterprise/policies/sustainable-business/corporate-social-responsibility/european-alliance/index_en.htm. Visited at 2010-08-20

[30] UN Global Compact webpage (2010). Found on line at: http://www.unglobalcompact.org/AboutTheGC/index.html. visited at 2010-08-20

7. Conclusions and Recommendations

In 2010, Egypt faced water and electricity scarcity. Political, social and environmental factors RE putting pressure on the cement industries to improve their energy, water management and environmental performance.

Three main facts, cement industries must anticipate and consider:

1. Introduction of new environmental law and executive regulations;
2. Introduction of new energy tariffs on cement industry;
3. Introduction of new water tariffs and wastewater discharge regulations.

In addition to these changes, cement industries affiliated with International groups are committed to report to their headcounts and follow their International regulations in energy, water and sustainability activities.

There are several opportunities to introduce CP options in the cement industry in Egypt. The starting point is following the basics of sustain production in the cement industries:

1. Substitute all wet lines with modern dry lines;
2. Guarantee smooth process and flow of materials;
3. Use automatic controlling systems;
4. Continuously monitor emissions and processes;
5. Recover heat and minimize heat losses;
6. Expand in using alternative materials and fuels;
7. Set targets for energy and emissions reduction per ton of clinker produced.
8. Adding De-Nox units.
9. Upgrade de-dusting systems to reduce emissions and consequential emissions on communities.
10. Wider usages of silica fume dust.
11. Use of cement kilns to treat certain types of hazardous waste.

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