Cleaner Production and Circular Economy for Cement Industrial Sector in China

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Executive Summary

The Chinese cement industry is the largest of that sector in the world. Until early 2004, it continued to grow well, driven by strong demand for construction and new housing in many urban centers. The industry is highly fragmented, characterized by very large numbers, about 85%, of small, vertical shaft-kiln type facilities which operate at village and township levels. There are a few modern rotary kilns, same as those used in the EU and USA with energy efficiency and less pollution and material consumption.

The Chinese government has imposed the macro economic control measures for some overheated industries, and cement manufacturing is one of them. In accordance with the control measures announced in Spring this year, the NDRC (National Development and Reform Commission), one of the nation's leading industrial watchdogs, announced that full implementation of control would be strengthened by restrictions on land use and bank loans to prevent a repeat of overheated investment in that sector, which witnessed an alarming 80% growth rate in 2003.

NDRC considers that future investment in cement industries should be directed to the improvement of production facilities to reduce the cost of unit production, to meeting the challenges of energy efficiency and the shortage of raw materials including coal and electricity as well as water, and to the implementation of Cleaner Production (CP) and the Circular Economy (CE) in that industrial sector.

Introduction

The Chinese cement market is the largest in the world. Driven by demand especially in the housing construction sector, it will continue to grow if not checked. At present, the production amount of cement in China is about 800 million tons per year, and consumes a huge amount of commercial grade coal, 150 million tons, next only to coal-fired power plants. The existing backgrounds for the industry are summarized as follows, based on the State Statistics Bureau of China, 2002:

Approximate number of facilities: 4,600;
Average facility size: 80% less than 25,000 tons/yr;
Modern international facility size: one million tons/yr;
Size multiplier: 40.

Data in Table 1 illustrates the importance of the cement industry related to other sectors in China.

Table 1. Summary of the Chinese Cement Industry

Economic Index	**Cement Industry**	**Chinese Industry**	**% of cement industry**
Economic indexes	1544.49	110410.81	1.40
Total production value of industries (100 million RMBs)	1440.10	108186.49	1.33
Sales income (100 million RMBs)	46.48	5620.35	0.83
Total assets (100 million RMBs)	4,649	178,876	2.60
Total of enterprises	149.13	5472.49	2.73

(Source of information: The State Statistics Bureau, 2002)

Figure 1 indicates the values and changes of cement products imported to and exported from China from 1999 through 2002.

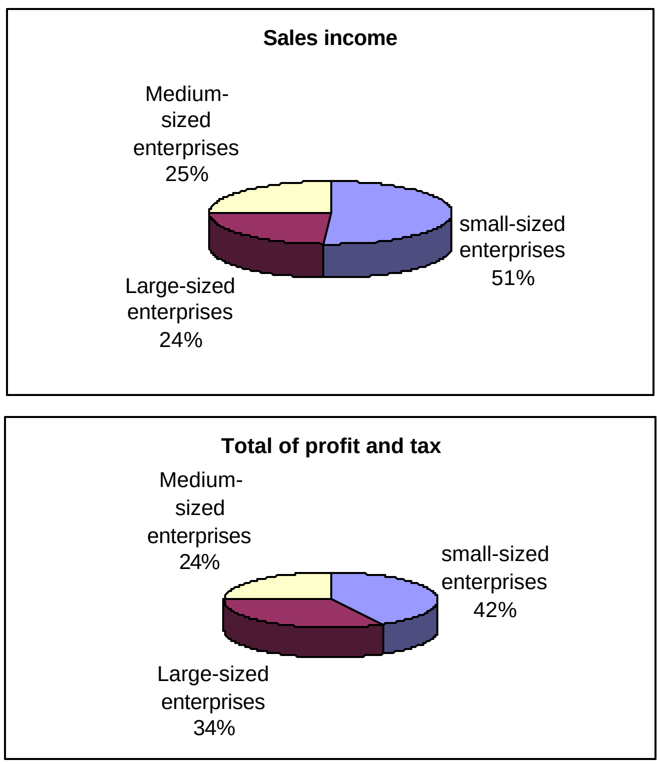

Figure 1. Cement product imported and exported
Information source: Statistical data from the General Custom Administration.

In comparison with international levels, the Chinese cement industry has significant impacts on the environment as well as inefficient utilization of resources. This has resulted from the obsolete industrial structure, including products, technical level, facility size and the unacceptable configuration of the industry.

Industrial structure

The high-quality cement produced by the modern technology of rotary kilns accounts only for 19% the total national product. The average capacity of a plant is rather small, and many plants each have annual sales less than 5 million RMB per year. At one time, there were 7000-8000 cement production facilities, and as many as 4000 were ordered to close prior to 2004. Those which remained open (90 %) have high-energy consumption (which accounts for 9% of the total energy used in China), and their facilities are poor in scientific and technical capacity, and 90% are outdated and obsolete. The overall labor productivity per capita is only about 64% of the average level of all industrial sectors in China. Even some of large and medium-size state-owned cement enterprises have similar problems.

Tables 2, 3 and 4 contain data for the industry:

Table 2. Size and production of cement enterprises

Classification	Total No. of plants	Total industrial production values in 2002 (100 million RMB)	Values in 2001 (100 million RMB)
Whole industry	4649	1225.10	1068.97
Large size	136	253.25	224.12
Medium size	619	319.91	286.51
Small size	3894	651.94	558.34

Ref. Same as Table 1.

Table 3. Economic and production values of cement enterprises

Ownership	Total enterprises	Production value in 2002 (100 M. RMB)	Production value in 2001 (100M RMB)
Whole industry	4649	1225.10	1068.97
State-owned	870	227.74	209.28
State-private jointly owned	1221	236.01	215.98
Publicly owned (stocks traded)	1290	456.06	390.62
Privately owned	1098	206.37	167.74
Joint ventures of Chinese-foreign, and exclusively foreign owned	165	98.75	84.71
Other types	5	0.68	0.63

Table 4. Sales income of cement industries

Ownership	2002 Sales income (100 Million RMB)	2002 Sales income as % of all industries in China	2002 Sales income (100 Million RMB)	2001 Sales income as % of all industries in China
Public enterprises	544.74	37.83	474.34	37.41
State owned	282.32	19.60	258.96	20.43
State-private owned	266.66	18.52	245.74	19.38
Private owned	223.26	15.50	82.41	14.39
Joint ventures; foreign owned	122.36	8.50	105.67	8.33
Others	0.71	0.05	0.68	0.05

Reference: same as in Table 1 for 3 and 4

Figure 2 illustrates the sales income, the total profit and tax paid by cement industries

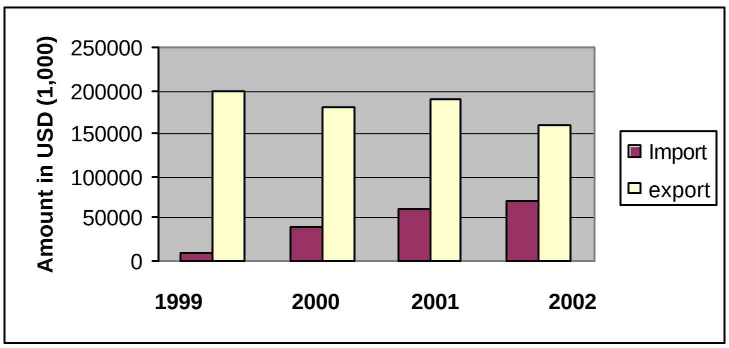

Figure 2. Comparisons of sales income, profit and tax paid

Geographical locations:

Most of the cement plants are located in the dense population areas along the east cost of China, on the middle or down-stream banks of the Yangtze River, and are near large and medium-size cities. In 2002, cement industries located in ten provinces accounted for about 70% of the total sales. These provinces are (in descending order) Shangdong, Zhejiang, Guangdong, Jiangsu, Hebei, Henan, Sichuan, Hubei, Anhui and Hunan. The total income from sales in 10 cities accounted for 20%. These cities are: Tangshan, Guangzhou, Zaozhuang, Huzhou, Tangshan, Guangzhou, Zaozhuang, Huzhou, Yantai, Beijing, Jinan, Nanjhing, Zibo and Hangzhou.

Market description:

Table 5 gives the production capacity of the top ten cement enterprises in China and those of the world. In market structure terms, it represents a scattered competitive case that can hardly make an impact on Chinese economy, but with unfair competitive activities and inadequate technical innovation capacity.

Table 5: Comparison of production capacity of top plants in China and in the world.

Name	Capacity (10,000 ton)	Location in China	Name	Capacity (10,000 ton)	World Location
Hailuo Group	1,236	Anhui	Lafarge	15,500	France
Bohai Group	848	Hebei	Holcim	15,000	Switzerland
Tianshan Gr.	545	Xinjiang	Cemex	9,900	Mexico
Hua Xin Co.	500	Hubei	Heidelberg	9,900	Germany
Zhonglian Gr	450	Zhejiang	Italcementi	5,500	Italy
Taipingyang	405	Jiangsu	Taiheiyo	5,000	Japan
Linyu	330	Beijing	RMC	2,800	UK
Shangdon Cement	300	Shangdon	Dyckerhoff	2,800	Germany
Fujian Cement	250	Fujian	Siam Cement Gr.	2,300	Thailand
Yatai	250	Shabgdong	Cimpor	1,800	Portugal

Reference: http://www.drccu.gov.cn

Environmental problems:

According to the data in 2000, China produced about 600 million tons of cement and discharged 10-12 million tons of powdered dust, 400 million tons of carbon dioxide, 1 million tons of NO_2 and over 0.5 million tons of SO_2. In view of the size of enterprises and technical indicators, it is obvious that cement plants in China are far behind in technology comparing with those in the world, and Table 6 indicates the differences.

Table 6. Technical level of cement industry between China and the world:

	World Levels	Chinese Level
Ratio of the production capacity of dry kiln type	98.3% in Japan and 96.5% in Italy	About 20%
Avg. size of plants	0.60-1.0 million tons, 2.56 tons in Japan	Less than 0.15 M tons
All labor productivity	3,000 tons/person yr. in France; 15,000 T in Japan	Less than 500 tons/person year
Heat consumption for clinkers	2,900 KJ/kg in Japan	5,121 KJ/kg (avg. for rotary kilns)
Total power consumption	92 kWh/ton	114 kWh/ton
Rate of cement in bulk	80% to 90% or above	20% to 30%

Reference: A study of sustainable development of Chinese industries; Economy and Science Publishing House, Beijing, 2002.

In view of the above facts and analysis, the Chinese cement industry is way behind those in developed countries. Outdated technology and obsolete facilities dominate in middle and small sized enterprises, notably the vertical kilns which are poor in energy efficiency and resource utilization and cause severe pollution.

In developed countries, it is the CO_2 emission problem which needs to be addressed, whereas in China powdered dust is the largest concern.

Because of the seriousness of the production and environmental problems, industrial consolidation has become a necessity. By the end of 2000, China had closed down a total of 3,200 small plants with small size cement kilns and decreased production capacity more than 80 million tons. However, over 300 vertical kilns, with the blessing of local government policy to boost the economy and employment, were built with this out-of-date technology, with an annual production of 30 million tons.

Since 2003, the central government has issued executive regulations to cool down several over-heated and rapidly expanding industries (including the cement sector) by denying construction permits for new plants and by restricting bank loans and financing from the stock market, but still encouraging funding for facility upgrades.

Guided by national policy, the cement industry is trying to establish a number of large corporations and groups to retain the ever growing demand from the domestic market and to compete internationally. Positive measures have been taken to promote the strategic reorganization especially of state-owned enterprises, to expedite the establishment of a structural mechanism to eliminate outdated technology and to reduce severe pollution problems.

By the end of 2003, China had 351 new type dry cement production lines of more than 700 tons/day, of which 188 lines had been put into operation, 138 were under construction, and 25 were ready to be constructed. Among all of them, there are 47 large-size dry clinker lines with a daily production capacity of more than 4,000 tons/day, of which 14 lines are operating, 23 are under construction, and 10 have received permission for building. After completion, China will acquire a yearly cement capacity of 240 million tons with the new type dry cement production technology.

Cleaner production (CP) and circular economy (CE) for Chinese cement enterprises

It has been long realized that in controlling industrial pollution and lowering production costs, it is important to have cooperation between enterprises and government, and to make full use of market influences to stimulate industries to take positive measures for improving the environment and thus the economy. In cement industrial sector, though it has made progress recently in these areas, performance is still far from desirable to reach sustainable development goals. In this respect, CP and CE principles have ample room to be maneuvered and implemented, and the results will be fruitful and far-reaching. The following will discuss their impacts on the cement industry in China.

Air emissions:

Major emissions from cement manufacturing plants traditionally are airborne pollutants and powered dust from the kiln and its emissions. Pollutants are mainly SO_2 and NO_2 and particulates from a number of solid processing and handling operations. There may also be trace micro-size materials from combustion of fuels and feedstock. Table 7 lists typical emission limits in several countries.

Table 7: Illustration of emission limits for cement kilns

Emission Items (in mg per standard cubic meter (mg/Nm^3), 10 vol % O_2 except as noted)	**Countries**				
	EU	**USA**	**Australia**	**Brazil**	**China**
Dust	30	0.15 kg/Mg dry feed	100	77	100
NO_2	800 - existing plant; 500 - new plant	-----	940	-----	-----
Mercury	0.05	0.12	3	0.04	-----
HCl	10	120 ppm (v)	200	1.8 kg/h	-----
Dioxin type compounds, PCDD/PCDF (ng/Nm^3)	0.1	0.2	0.11	-----	-----

References: 1. Howard Klee, program manager, "Cement Sustainability Initiative" World Business Council for Sustainable Development, Geneva, 2003;
2. Battelle Report, Columbus, Ohio, USA, 2002

Relatively speaking, SO_2 and NO_2 emissions from cement industries are small, and they represent less than 2% of the total emitted of these compounds in USA and UK. In recent years, as a result of advanced control technology and equipment design, such as EP and bag filter facilities, significant progress has been reached in reducing air emissions from the cement industrial sector. For a new plant today, air pollution emissions are at least 90% less than those from typical facilities built 30-40 years ago.

Micro-size pollutants have been detected and measured in cement kiln stacks. These include metals, e.g. vanadium from fuel oil, dioxins, furans, and PAHs (polycyclic aromatic hydrocarbons.) Since late 1990s, extensive measurements have been made at cement plants in Switzerland, the USA, the UK, Germany, Japan and Australia. In spite of the analytical difficulties due to the extremely low concentrations present, many of these compounds are known to be very toxic, carcinogenic, and persistent (POPs or persistent organic pollutants.) In China the issue has yet to be resolved for the cement sector as well as other industries as a whole.

Dust emission and water pollution

Water pollution is not generally an important issue for cement industries. On the other hand, close attention must be paid to deal the problems of solid waste, especially cement kiln dust, by the application of CP and CE principles.

In recent years, cement industries have carried out CP practice to different levels at different plants. Table 8 indicates the results from 1990 to 2000.

Table 8: Production and energy consumption for different types of kilns

	1990		**2000**	
Kiln type	Production (10,000 tons)	Coal consumption (10,000 tons)	Production (10,000 tons)	Coal consumption (10,000 tons)
Total	21,000	3,900	57,900	9,611
1. Rotary	6,165	1,474	13,125	2,468
Outside decomposition type	950	144	5,790	753
Other recovery type	5,115	1,330	7,155	1,717
2. Vertical	14,835	2,522	44,775	7,164

With some CP practices, it can be seen that the average coal used per ton of cement production has been decreased from 190 kg in 1990 to 166 in 2000. For a production of 5.79 billion tons, this saves 139 million tons of coal.

Regarding to the solid waste minimization processes, the cement sector has actively pursued the reduction of material use and the protection of the environment. Through technical innovation and improvement, and industrial restructuring, powdered dust has been collected and returned to the process, replacing fresh raw materials. Such inner recycling within the plant with different types of dust collection equipment through CP implementation has greatly reduced air pollution and increased energy/resource savings. By estimation in 2000, the dust produced from cement operations in China was more than 8 billion tons, of which about 7 billion tons were collected and recycled with an estimated coat saving from materials of 35 hundred million RMBs.

By CP/CE implementation, the waste minimization/recycling/reuse process is not limited to powdered dust recovery generated by the cement sector. It also extends to wastes from other industries including slugs from steel mills, powdered coal dust from power plants, sulfate gypsum from chemical industries and coal residue from industrial boilers. Table 9 gives the ratios of wastes to raw materials for cement production.

Table 9: Changes in wastes and raw materials

	1990	1995	2000
Cement production (1,0000 tons)	21,000	47,600	57,900
Raw materials (10,000 tons)	15,846	33,370	42,267
% used	75	70	73
With powdered cement dust (10,000 tons)	1,060	1,352	2,050
With powdered coal dust (10,000 tons)	8,500	9,956	15,054

The data indicate that with the comprehensive reutilization of wastes, cement produced with the mixing of dusts to replace raw materials is increasing annually. While the enterprises with CP/CE implementation have enjoyed the benefits, a consensus has been reached that in the cement industry many sprawling conglomerates have lost their focus to adopt reforms. The government should step to enforce regulations and compliance.

Although the cement industry in China has made efforts in decreasing energy consumption, minimizing wastes and increasing dust recovery rates, the gap persists in results comparing with its foreign counterparts. Table 10 illustrates such differences.

Table 10: Energy consumption and dust discharge rates

Indicators	**China**	**Developed countries**	**% between the two**
Energy index/ton of cement produced	166	About 110	47
Dust discharge rate (kg/ton)	13	1.0	1300
Product leakage rate	0.3 %	0.03 %	1000

References: Chinese data: in 2000; foreign: in 1995

Using this glimpse, the tough side of the data reveals that Chinese industries, on average, consume 47% more energy and emit 13 times more dust than those in developed countries which have kilns with much larger production capacities (4,000 to 10,000 tons per day) and outside-the-kiln decomposition type facilities which fully utilize the heat in the exhaust gas. Although vertical kilns produce the lowest rate of dust compared with other types, the technology is out-of-date since the quality of the product is poor and unstable, and energy consumption is high. Notwithstanding the types of kilns being used, the control technology and abatement laws must be used for reducing dust emission to protect the environment. In China, specific regulations issued by government for cement industries do exist, but often compromises take place, especially by the local authorities, between economic benefit and environmental deterioration. CP/CE can find an indispensable example here. Dust collected by control devices can be recycled internally as raw material to lower the production cost.

More and more enterprise managers have realized the importance of implementing CP/CE in their plant operations and are handsomely rewarded. However, there still are some under the traditional concept that any collection action merely for the sake of environmental benefit will be a financial burden on the plant. Even as late as 2004, lawsuits have been filed against several cement plants for crop and tree damage caused by the dust emitted. Some plants are lacking any control devices, whereas others let the equipment sit idle to avoid the operational cost. Educational and instructive examples of success must be publicized and useful CP/CE information must be disseminated.

One good example is Nan Xin Cement plant in Suzhou, Jiangsu province (as visited by the writer at the request of SEPA – State Environmental Protection Administration.) By using CP and CE in order to control dust emission and to implement recycling as well as production expansion, the Company invested more than 2 million RMBs to convert wet-membrane collection equipment, the low efficiency type, into a bag house with high efficiency. From the process, the local emission standard for dust has been reached, and in addition, it obtained remarkable economic benefits. The dust collected with the membrane had a high moisture content and was difficult for raw material substitution. With the bag house technique, dust can be recycled and reused. The estimated annual amount of dust collected is more than 8,000 tons. If the original material costs about 100 RMB per ton, an annual saving is of 800,000 RMB, with an addition of 300,000 RMB from the deduction in discharge/emission fees, a total benefit of one million RMB is realized. Extra operation cost and labor amounts to about 700,000 RMB, so the net economic benefit is 300,000 BMB and the amortized capital investment for the equipment can be repaid within eight years.

The provincial authorities have used this example to publicize benefits, and to encourage other plants in the sector to adopt CP/CE principles to fit their individual needs for dust collectors, and to include the recycling unit into the production process management with regular inspection and maintenance to assure its proper operation.

As recently as August 2004, NDRC announced that these three industrial sectors, steel mills, aluminum production by electrolysis, and cement manufacture will be under strict macro-control for their expansions, financing, and CP/CE implementation. In the case of cement industry, no new plant is allowed to be built with a production capacity less than 4,000 tons a day, and it must employ the best available technology and required equipment for pollution control and prevention. Those now under construction without meeting the capacity requirement have to be stopped, and banks are forbidden to provide any financing. This announcement will certainly be an alarm to the industry, and it represents the government's determination to correct past painful experiences when regulations were not seriously acted upon and local authorities turned a blind eye to the deteriorating situation of the environment.

In many other areas for cement manufacturing, CP/CE can find applications. In the Battelle report cited above six critical issues for the industry were identified from the interviews and dialogues with the industries and stakeholders in USA. These issues are directly linked to the integration of normal production processes and the concerns of sustainability.

The Chinese government has adopted such measures for the cement and other applicable sectors. These are:

1. **Climate change:**

World wide, the cement industry produces about 5 % of global man-made CO_2. Cement is a low value-added product, and the average price has been of 50-60 $US/ton since 2000 (however, in China it skyrocketed to about 200$ early in 2004.) As the industry produces an equal weight of CO_2 and clinker, any cost imposed on the reduction of CO_2 emission to the atmosphere and any management plan can have a significant impact on the industry's financial performance. At the present rate of many CO_2 management expenses on the market - in the range of $10 to $25/ton and expected to rise as the public demand its treatment - most Chinese cement enterprises will not be able to foot the bill, unless their production capacities are increased and are big enough to bear the cost.

2. **Responsible use of fuels and raw materials:**

Increasing the use of alternative fuels and materials can reduce the use of virgin materials including limestone and petroleum products, and can reduce CO_2 emission and production costs.

Alternative and substituted materials as fly ash from power plants, steel mill slugs, and pozzolanic substances can be used in cement to replace some of the limestone which is the main ingredient, and the quality of the product is not affected in applications. In China the governmental standard-setting organizations have slowly changed the strict composition criteria into that of cement performance, and as a result a much wider use of blended products can be witnessed.

Alternative or replacement fuels can also be provided by some kinds of wastes - e.g. used tires. Instead of being dumped in a landfill, they can provide an environmentally sound practice by being recycled for society's benefit. However, this causes some concerns and objections from a certain group of people. Unless certain wastes are burned by specially designed incinerators, emission of toxic substances could result from such disposal actions. Consequently, cement companies in many countries, including Canada and the USA, are prohibited or prevented from burning such wastes. In China, the regulation will be changed to allow such burning, subject to the installation of equipment on the stacks for collecting any toxic emissions.

3. **Improving employee health and safety:**

The industry can and must reduce the number of injuries and fatalities for production, and it should be as good as that of the petroleum and chemical sectors.

Techniques for safety and health performance are well known and established, and have been applied successfully. The key factors are:

(1) Incorporating safety into the working culture of the enterprise through continuous reinforcement and education about safe working practices and conditions; establishing safety awards; and awareness-raising of senior management;

(2) A systematic program for tracking, reporting, and analyzing all safety related incidents, including those "near-miss" cases;

(3) Communication and dissemination systems within enterprises or groups to expedite the distribution and sharing all safety-related information to avoid repeated instances; and

(4) Ongoing analysis of incidents, responses, and progress to provide information on continuous improvement.

4. Emission reduction:

The industry must continue to monitor and reduce traditional emissions and pay close attention to concerns and problems related to toxic micro pollutants including metals, PAHs, and dioxins/furans.

In developed countries, the cement industry has reduced substantially emissions of SO_2, NO_2 and particulates through a combination of improved technology and specific regulatory standards. This is often not so in China, especially for those old and small size plants. Particulate emissions from the cement industry accounted for 40% of the total estimated 25 million tons emitted in 1998. In the public's mind, the industry was and continuous to be the worst dust emitter.

Though alternative fuels have been successfully used in many countries, emissions from the burning of such fuels also cause deep concern from the public. An effective emission management system has been adopted in China for the cement industry with specific requirements:

(1) A well defined emission inventory and reporting process with emission reduction cost estimates;

(2) A program for effective communication with the local stakeholders including regulatory personnel. Reporting to the public on emissions and reduction progress is important to engagement in the program;

(3) A program to define the emission reduction targets and timetables. This is of vital importance and of deep concern to the public, and accounts for the economic forecast of the plant, and current and pending regulatory requirements;

(4) In order to win confidence, the industry needs an effective way of monitoring and reporting emissions which can address the safety concerns of the public and product quality concerns of the users. In spite of some measurement in the past,

the Chinese cement industry has not yet made convincing cases that emissions and product quality from kilns using alternative fuels have not been different from conventional ones.

5. **Managing impacts of cement facilities on land use and local communities:**

Efforts to exercise and use environmental and social impact assessments of the plant must be strengthened, including the publication of quarry management plans, its influence on biodiversity protection, and the handling of plant and quarry closures in a responsible way, environmentally and socially.

In China, the government would like to establish following factors for best practice:

(1) Apply EIA (environmental impact assessment) and social impact assessment for all new cement projects;

(2) In consultation with local communities, develop land use management plans for all such plants;

(3) Share the quarry rehabilitation plans provided by the plants in writing with those communities. Update plans as needed to reflect the current technology and the changing community's requirement;

(4) Develop the necessary advanced planning for plant closures. Dialogues with community leaders should be held at the regular intervals.

6. **Effective communications:**

In the past, the Chinese cement industry has had a low profile and a history of limited engagement with stakeholders outside the area of that industry. In many cases, this reflects the tradition of long-established private enterprises that were often owned and dominated by families.

Learning from developed countries, the Chinese government has encouraged cement plants in the need for communications to the public, and announced that this represents a key element for a "license to operate". In fact, effective ways to communicate must be tailored to the particular audience at the local level. They include:

(1) Identify what needs to be communicated, the background extent of understanding, biases, and public opinion on these issues;

(2) Identify and work together with the decision makers that affect the local facilities;

(3) Understand the local circumstances, environment, and other critical issues;

(4) Engagement with the community on a regular and on-going basis both from a business perspective and by personal contacts through interactions of individual employees.

Recommendations and suggestions for the cement industry in China

In addition to the problems and solutions associated with the cement industry, some specific issues in China need attention both from governmental agencies and enterprises.

On the industry side the issues are:

(1) The need to rationalize enterprise structures, and to seize opportunities to improve overall industry efficiency by closing the small plants and consolidating into modern, large and efficient manufacturers;

(2) Speeding up capacity building with a broad spectrum of business, management, legal systems and socially-conscious company institutions;

(3) Development of key performance indicators for social, environmental and economic objectives.

On the government side:

(1) For a new plant, build the necessity for CP/CE implementation into the EIA (Environmental Impact Assessment) and make it compulsory. Any dust emission control equipment must be designed, constructed, and operational simultaneously with the main plant body.

(2) For existing plants which are emitting dust concentrations over the national or local standards, CP audits are mandatory in accordance with the CP Law. Guide the plants on means to reduce the emissions to within the limits.

(3) Increasing the pollution taxes for overall dust emissions. At present, the tax rate is set at 0.28 RMB per kg, and it represents only about 40% of the operational cost for the dust control process. The result is a lack of initiative and reluctance by industry to install the control devices. It is suggested that governments should raise the fee/tax rates higher than the capital and operational costs in order to stimulate the willingness of enterprise to use such devices,

(4) Managers/administrators of national or local scientific and technical institutions should include overall planning and on environment and technology research and development in their yearly programs. For the cement industry, expanding CP/CE areas and subjects for using waste substances as tires, plastics and other alternative raw materials for the substitutions of virgin fuel (materials.) To enhance further CP/CE plans, provide technical support.

(5) National and local Development and Reform Commissions should negotiate and consult the finance and taxation departments to formulate financial support for those plants with noticeable achievements in benefits to the economy and the environment. For other action plans without any clear economic benefit, the comprehensive utilization of wastes should be encouraged with defined and favorable financial policies and support, in order that the CP/CE implementation can be realized in the cement industry as well as other related enterprises.

(6) The size structure and changes to the sector organization plan (privatization) as announced by the State Council must be conducted and carried out for the purpose of improving the environment, economic viability, and for the capability of competing on the world market by reduced costs.

Conclusion

In retrospect, cement manufacturing together with steel and aluminum are three sectors ordered by the Chinese government to slow down their production capacity, as in recent years overheated investment has witnessed growth rates which are over 100%. Under macroeconomic control measures, investment must be focused and directed towards technical upgrading, the implementation of CP/CE, and preservation of the results and benefits which have been demonstrated.

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