OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

22846

Building Materials Industry (cement and brick) Case Study

"Evaluation and Adjustment of China's Sustainable Industrial Planning and Policies"

Final Report

2002/8

China Development Strategy Institute
for Building Materials Industry

No.11 Beishuncheng street, Xizhimen
Beijing China
Zip: 100035
Fax: 0086-10-62252035

Building Materials Industry (cement and brick) Case Study

"Evaluation and Adjustment of China's Sustainable Industrial Planning and Policies"

Final Report

2002/8

China Development Strategy Institute for Building Materials Industry

No.11 Beishuncheng street, Xizhimen

Beijing China

Zip: 100035

Fax: 0086-10-62252035

Table of Contents

Preface

Background

This report summarizes the findings of a case study on the sustainable development of the building materials industry carried out by China Development Strategy Institute for Building Materials Industry (CDSIBMI). The case study is a part of the project of the Department of Development Planning (DDP) of the State Development Planning Commission (SDPC) with UNIDO on sustainable industrial development, entitled "Evaluation and Adjustment of China's Sustainable Industrial Planning and Policies".

The objective of the case study is to formulate different strategies for the sustainable development of Chinese building materials industry (but see also below); to evaluate these different plans from the viewpoint of their contribution to sustainable development; to select the most appropriate development plan, and to identify policies that support this plan. For each plan or scenario developed, the following information will be provided:

- Investment requirements over the years;
- Impact on production cost and product quality;
- Impact on employment;
- Impact on use of energy and environmental pollution.

In the conclusion of the report, one of the development plans is recommended on the basis of its contribution to sustainable development, and policies to implement this plan as well.

Since Chinese building materials is very large and complex, the study narrows down on two subsectors that are of primary importance within the building materials industry, cement and bricks. This selection was based on a number of factors, including high dependence on natural resources, high energy intensity, high pollution, an important share in the total value added of the building materials industry. See also the summarizing table below.

The decisive factors resulting in cement and bricks as distinguished sectors in the study

Factor	Cement	Bricks
• High dependence on natural resources	Yes	Yes
• Capital intensity	High	---
• Labor intensity	High	High
• Energy intensity	High	High
• Pollution	High	High
• Demand increase	Stable	Stable
• Contribution to China's economic development	Large	---

To implement the subproject, China Development Strategy Institute for Building Materials Industry has composed a team of experts. In the process of drawing up the report, CDSIBMI has also relied on international data supplied by an international expert, Mr. Graham Smith, who was funded by UNIDO. An early draft of the report has been commented by Mr. Casper van der Tak, the International Project Director (IPD) of UNIDO project.

From a methodological viewpoint, the study has relied on the gathering of (national) statistical data, literature review, consultation of development plans and policies issued by the government, and consultation of international data supplied by the international expert. This primary material was used in a data processing effort. In addition, some firms and plants were investigated to obtain a better idea of critical coefficients needed in the study. These materials were used to draw up different development strategies for the "building materials industry" (actually the two sub-sectors selected, cement and bricks).

The study team also formulated a model to be able to comprehensively analyze the impacts of different development plans from a sustainable development perspective. This was used to recommend one of the development strategies. The report ends with recommendations for policies to implement the recommended strategy.

1. An Introduction to the Chinese Building Materials Industry

This chapter deals with the development of building materials industry in China, especially the respect of 3E. Two sub-sectors, cement industry and bricks industry are distinguished in discussion due to their important influence on 3E. At the beginning of this chapter, the trade range of building materials industry is defined. Then, considering general information of building materials industry and its two sub sectors, cement and bricks industries as well. Several issues, including economic situation, enterprises and their ownership, production, technology, employment, pollution, energy consumption, etc., are set up to discuss respectively.

1.1 Basic Situation of the Chinese Building Materials Industry

1.1.1 The trade range of building materials industry

The Building materials industry in China, according to the limits of jurisdiction of governmental economic administrative departments under the former system of planning economy, included not only building materials that are directly used in construction, but also a part of non-metallic minerals mining and processing industries, and a part of inorganic non-metal synthetic and composite materials industries as well. But the steel materials and wood materials used in construction were not within the limits of the jurisdiction of those government institutions responsible for the Chinese building materials industry. In a very practical sense, the jurisdictional borders defined the Chinese building materials industry. The detailed industrial divisions of the thus-defined Chinese building materials industry are shown in table 1.

Table 1 The detailed industrial divisions under the limits of jurisdiction of building materials industry

Mining and processing industries of non-metallic minerals under building materials industry	Industries of manufactured products of non-metallic minerals under the building materials industry	
• Limestone mining industry • Architectural decorative stone mining industry • Mining industry of other clays, sand and gravel • Asbestos mining and processing industry • Mica mining and processing industry • Graphite mining and processing industry • Gypsum mining and processing industry • Gem and jade mining and processing industry • Crystal mining and processing industry • Talc mining and processing industry • Mining and processing industries of other minerals	• Cement manufacturing industry • Cement manufactured products industry • Concrete construction structural members manufacturing industry • Asbestos cement manufactured products industry • Manufactured Industries of other cement products • Brick and tile manufacturing industry • Lime manufacturing industry • Architectural stone processing industry • Manufacturing industry for light-weighted building materials • Manufacturing industry for building water-proofing and sealing materials • Manufacturing industry for thermo-insulating materials	• Manufacturing industries for other brick and tile, lime and light-weighted building materials • Architectural glass manufactured products industry • Manufacturing industry for industrial technical glass • Manufacturing industry for architectural and sanitary ceramics • Asbestos manufactured products industry • Mica manufactured products industry • Manufacturing industry for glass fiber and its products • Manufacturing industry for glass-fiber reinforced plastics • Manufacturing industry for other mineral fibers and their products • Manufacturing industries for other non-metallic minerals • Machine-building industry for building materials

It is estimated that the total number of enterprises in the building materials industry in China at present is more than 200 thousands. Up to the end of 2000, the number of above-scale enterprises[1] was 12731, which achieved a gross industrial output value (fixed price) of 239 billion RMB in that year with an increment of industrial output of 84 billion RMB and a gross profit and taxes of 26.3 billion RMB (see Table 2), accounting for 3% of the national totals respectively.

Table 2 The number and sales revenue of above-scale enterprises by the end of 2000

Name of industries	Number of enterprises	Sales revenue (million RMB)
Sum of whole industry	12731	288118
1. Mining and processing industries of non-metallic minerals	1286	20055
● Limestone mining industry	200	3747
● Architectural decorative stone mining industry	336	4979
● Mining industries of other clays, sand and gravel	355	4608
● Asbestos mining and processing industry	29	465
● Mica mining and processing industry	4	100
● Graphite mining and processing industry	43	996
● Gypsum mining and processing industry	74	998
● Gem and jade mining and processing industry	9	100
● Crystal mining and processing industry	1	14
● Talc mining and processing industry	33	1164
● Mining and processing industries of other minerals	202	2882
2. Industries of manufactured products of non-metallic minerals under building materials industry	11445	268063
● Cement manufacturing industry	4529	115216
● Cement manufactured products industry	1096	21412
● Concrete construction structural members manufacturing industry	478	7738
● Asbestos cement manufactured products industry	81	1225
● Manufacturing industries of other cement products	32	507
● Brick and tile manufacturing industry	1540	14619
● Lime manufacturing industry	154	1575
● Architectural stone processing industry	659	10652
● Manufacturing industry for light-weighted building materials	205	4423
● Manufacturing industry for building water-proofing and sealing materials	165	3076
● Manufacturing industry for thermo-insulating materials	164	2622
● Manufacturing industries for other brick and tile, lime and light-weighted materials	115	1869
● Architectural glass manufactured products industry	228	18445
● Manufacturing industry for industrial technical glass	110	5176
● Manufacturing industry for architectural and sanitary ceramics	811	28367
● Asbestos manufactured products industry	94	1521
● Mica manufactured products industry	24	463
● Manufacturing industry for glass fiber and its products	139	4623
● Manufacturing industry for glass-fiber reinforced plastics	228	7619
● Manufacturing industries for other mineral-fiber and their products	10	107
● Manufacturing industries for other non-metallic minerals	583	16807
● Machine-building industry for building materials	189	3256

[1] What is referred to as "Above-scale enterprises" refers to all state-owned enterprises and those non-state –owned enterprises which have annual sales of 5 million RMB and more. These are the division criteria of the State Statistic Bureau of China.

1.1.2 The condition of building materials industry related to the "3Es"[2]

- Economy

The building materials industry is an important raw material industry in China, which plays a fundamental role in the development of national economy in China. In the recent 10 years the annual growth rate of the industry has seen over 10%. It's gross profits and taxes and industrial added value have accounted for about 3 percent of the national industry total respectively in the same period.

- Energy consumption

The building materials industry is an industrial sector using dominantly certain kilns and furnaces in the production, which consume a large amount of energy and emit large amounts of dust and waste gases (CO_2,NO_x,SO_x and other harmful gases, such as Fluor and Fluor-complex, etc.) every year. According to the statistics, the production of building materials industry burned primarily 129 million tons of standard coal[3] in 1997, accounting for 9% of the total energy consumption of the whole country and 13% of the total national industrial energy consumption.

- Pollution

The building materials industry discharges over 2 million tons of SO_2 every year, accounting for some 14% of the total discharge in the country. The emission of dusts and fumes is about 14 million tons, accounting for about 55% of the total emission of the whole industry in the country.

- Employment

The building materials industry is one of the more labor-intensive industrial sectors, and plays a very important role in the generation of employment in China, especially in the absorption of surplus labor forces in the rural areas by village and township enterprises. It is estimated that the total number of employees in the whole industry amounts to some 15 million, making up 8% of total employment in whole industrial sectors, of which some 3 million people are in the above-scale enterprises.

Data sources : Energy Resources Department of the former State Administration for Building Materials Industry of China, the State Statistical Bureau, "China Statistical Yearbook 2001"

1.2 The General Condition of Chinese Cement Industry

The basic characteristics of cement industry in China are the huge production, the rapid development speed and the backwardness of technology and equipment in general. In the year

[2] Economy, employment and environment, referring to economic issues, social issues and environmental issues – the different components of sustainable development.

[3] Standard coal is a thermal unit. Heat of 1 standard coal is equivalent to 7000 kcal.

2000, there were altogether over 7000 cement plants in China, of which, 4529 are of above-scaled enterprises and over. Employment in the cement industry was1.66 million and the cement production capacity was 715 million tons. The cement output in the same year(2000), however, was 582 million tons (about 1/3 of the world total). Hence the utilization of production capacity was 81.30 %. The cement clinker[4] output of the year was 437 million tons.[5]

Data source: A Compilation of Statistical Data of Building Materials Industry, 2000

Since the reform and opening up to the outside world in China in 1978, the cement industry has developed at a full speed. In 1978 the cement output in the country was 65 million tons, and it had increased to 582 million tons in 2000, with an absolute increment of 516.35 million tons, and an average annual increase rate of 11%.

Fig. 1 and Fig.2 show the increase and the increase rate of cement output in the whole country respectively over the years since1986.

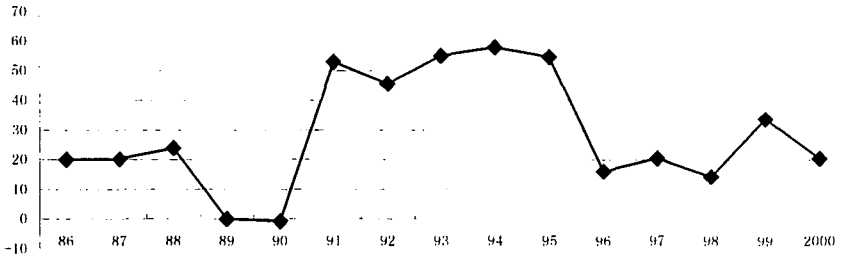


Fig.1 The net increment of cement outputs over the years since 1986

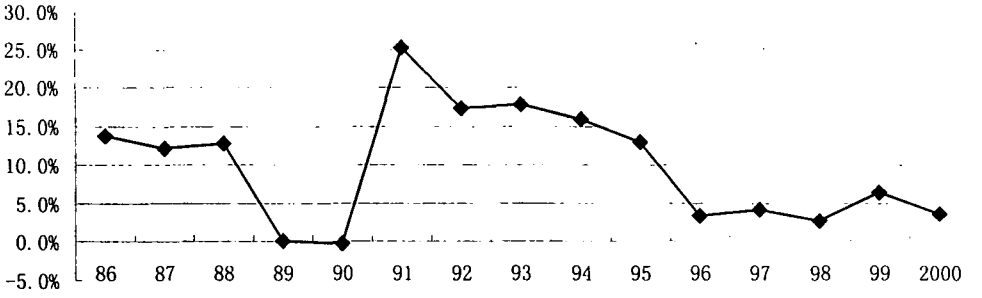


Fig.2 The increase rate of cement outputs over the years since 1986

Data source: A Compilation of Statistical Data of Building Materials Industry.

[5] Cement clinker refers to an intermediate product resulted after burning of raw mineral materials, like limestone and so on, in cement kilns. Cement is produced after grinding of blended materials from clinker, retardant, admixture and so on in a proper proportion.

In 1999, the number of above-scale cement enterprises was 4642, among them 1271 were state-owned cement enterprises, 1648 cement enterprises of collective ownership, 168 cement enterprises funded with capital from Hong Kong, Macao, Taiwan and abroad, 1555 private cement enterprises or those of other ownership. The total capital of above-scale cement enterprises in 1999 was 262.21 billion RMB, among them 83.67 billion RMB for the state-owned enterprises, 49.1 billion RMB for the cement enterprises of collective ownership, 29.76 billion RMB for the cement enterprises funded with capitals from Hong Kong, Macao, Taiwan and abroad and 99.68 billion RMB for the private cement enterprises or those of other ownership. The structure of ownership of cement enterprises in China is shown in Fig.3 and Fig.4.

The proportion of cement enterprises of different types

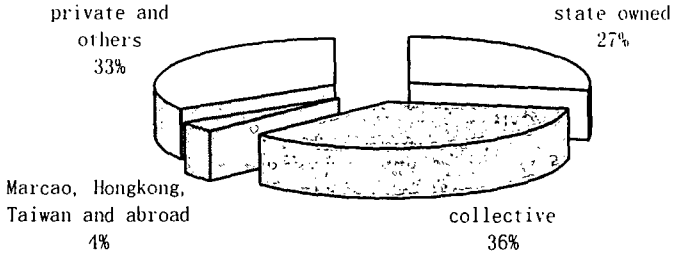


Fig.3 The proportion of cement enterprises of different types

The proportion of total capitals of different economic types of cement enterprises

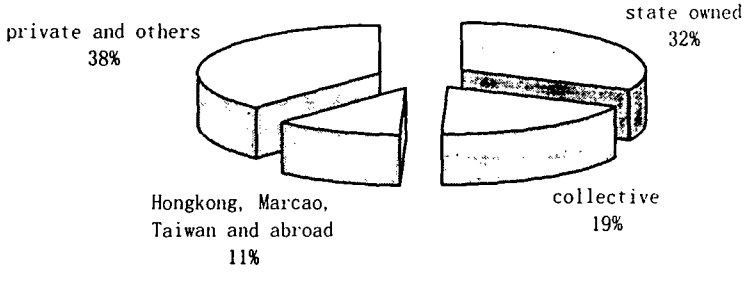


Fig.4 The proportion of total capitals of different economic types of cement enterprises

Data source: a compilation of statistical data of building materials industry

Since 1985, China has been the largest cement producing country in the world.

Nevertheless, the total standard of technology and equipment of the industry is quite backward. In developed countries, the advanced precalciner/preheater process[6] is adopted basically for cement production. The shaft kilns, however, are still mainly used in cement production in China. Of the total cement output of 580 million tons in 2000, 72% was produced by shaft kilns. Of the rather small proportion of cement production in which rotary kilns was used, only 12% were using precalcier/preheater process which represents advanced production technology.

[6] Classification of cement production processes

Type of production processes		Type of kilns	Characteristics
Rotary kiln	New-type Dry process	Precalciner kiln Preheater kiln	The scale of single production line is large. High level of automation. Low energy consumption. Clean production. High productivity.
	Semi-dry process	Lepol kiln	The scale of single production line is 0.2-0.3 million tons/year. Energy consumption is higher than that of new-type dry process, but is lower than that of old-type dry process and wet process.
	Old-type dry process	Dry-process plain kiln	The scale of production is small. High energy consumption. Heavy pollution.
	Wet process	Wet-process kiln	The production scale is about 0.2 million tons/year. High energy consumption. Heavy pollution.
Shaft kiln		Diameter of kiln 11.8-3.0	Small production scale. The energy consumption is higher than that of new-type dry process. Low level productivity. Heavy pollution.

In 1980s and the early days of 1990s, the demand of cement[6] in China had been increased dramatically owing to the pull of the quick growth of the Chinese economy. A strong market demand had resulted in all-round growth of cement production with shaft kilns featuring a low standard of technology and equipment, less investment and quick profits. Hence the shaft kilns became the main production technology in use in China.

The precalciner/preheater process for cement production in China started to be used in the late 1970s. With the completion and putting into operation of large production lines with precalciners of international advanced technological standard in Jidong Cement Co. Ltd., Ningguo Cement Co. Ltd. etc., the complete set of equipment of which was imported in the

[6] Cement varieties:

1.by strength: 325#, 425#, 525#:

2. By application:

- Ordinary cement: Portland cement, Portland blast furnace cement, Portland fly-ash cement, Portland pozzolana cement etc.
- Special cement: white cement, oil well cement, cement for joints, expansive cement, super high early strength cement, etc.

early days of 1980s, the state established the direction of energetic development of the new-type cement production technology of precalciner/preheater process with precalcining kiln as the core. In 1990s, the technology and equipment of Chinese precalciner/preheater process had been maturing with each passing day and getting into a fast development period. By the year 2000, China had set up 138 cement production lines using the precalciner/preheater process with a capacity of 700--4000 t/d, forming a total annual production capacity of some 79 million tons.

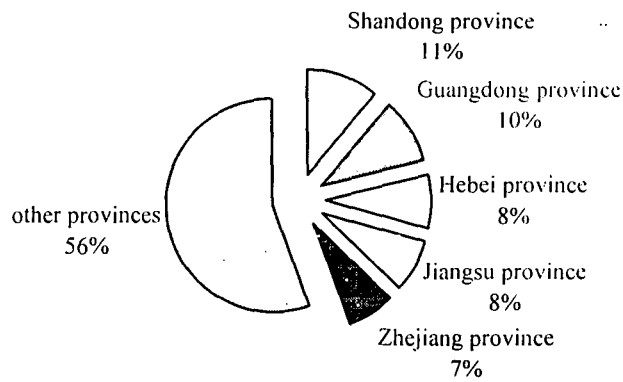
Table 3: The survey of cement production in China in 1999

Technology	Number of plants	Production volume Million tons	Production value Million yuan RMB
Shaft kiln	6550	430	9
Rotary kiln	1300	152	4
Of which: new-type dry process	138	65	2

Data source: a compilation of statistical data of building materials industry

As mentioned above, there were altogether over 7000 cement plants in China in the year 2000. They supplied 582 million tons cement to the market. Cement plants spreads everywhere in china. However, Shandong province, in the east of China, is the top province in the cement production. The following fig. 5 shows distribution of cement production in China.

fig5: The distribution of cement production in 2000



In the middle and late period of 1990s, Chinese cement industry had experienced a change due to the influence of economic situation at home and abroad:

- The situation of "supply falls short of demand" over a long period of time was over and a buyer market appeared;
- Market competition intensified resulting in falling prices and falling profits of enterprises;
- The problems with environmental pollution, high energy consumption, and so on

brought about by the significant proportion of cement produced by shaft kilns and low standard of technology and equipment, have been worsening day by day;

- Owing to the quality problem of shaft kiln cement products, the structural contradiction with products demand in market has been becoming prominent increasingly.

1.3 The General Condition of Brick Materials Industry in China

The brick materials industry is a vital component of the building materials industry in China. The brick is the dominant product of walling materials. The main varieties of existing brick materials include: solid clay brick, hollow clay brick, non-clay brick, clay brick with more than 30 % of added industrial wastes (including fly ash, coal gangue and so on), and whole coal gangue brick and so on.

The brick materials industry in China is of numerous and is scattered widely. There are totally 119,000 production enterprises in the country with about 6 million employees, scattered in cities, villages and townships all over the country. With the rapid expansion of the cities in China, the brick materials industry has gradually moved to villages and townships. Up to 1990s, the village and township enterprises have become the principal force of brick and tile industry in China.

In 1998, the total output value of brick materials industry in China was 86.6 billion RMB, and output reached 721.32 billion pieces of standard brick [7]. The following tables break down the production on the items of output and technology using in the production of bricks. Hoffman kilns are mainly used in making kinds of bricks except of sand brick. The production of solid clay brick accounts for about 77% of the total of all kinds of bricks.

The coal consumption was 64.92 million tons. It consumed 1.4 billion m^3 of clay and damaged 0.8km^2 of farm land and discharged nearly 170 million tons of CO_2. At the same time with damaging the farm land and environment pollution, the brick materials industry utilized more than 60 million tons of industrial wastes every year, making a certain positive contribution to the improvement of environment and the saving of resources.

Table 4: the production of bricks in china in 1998

Products	Output (in billion pieces of standard brick)
Bricks in total	721
● Solid clay brick	557
● Hollow clay brick	25
● Clay brick with more than 30% of added industrial wastes	34
● Shale bricks and sand brick, etc.	106

[7] *Standard brick: 240 × 115 × 53 mm*

Table 5: the technology using in the production of bricks in 1998

Technology	Amount of enterprises	Output Billion pcs	Production value Billion yuan RMB
Hoffman type of kiln	118880	714	85
Tunnel kiln	120	7	1

2. A Comparative Analysis of the Cement and Brick Materials Industry in China with those of International Standard

A comparison of cement and bricks industry between Chinese and international standard is made in this chapter. The comparison mainly concentrates on the respects, productivity, technology, energy consumption, and pollutants discharge. Two sub-chapters are set up for cement and bricks industry respectively in discussion. Some general ideas of comparative analysis are summarized at the first; the following is the comparison of key indexes in every sub-chapter.

2.1 Cement Industry

2.1.1 Outline

The gaps of techno-economic indexes between only a few of advanced enterprises in Chinese cement industry and international advanced enterprises are not too large. However, the gaps between the whole nation's average standard of enterprises and the international advanced standard are quite large. The gaps exist in the following aspects :

- Low labor productivity;
- Heavy dust emission and short of controlling measures;
- High energy consumption.

2.1.2 A comparison of key indexes

Table 6: A comparison of key indexes

Item	Average level		Advanced level	
	Domestic	International	Domestic	International
Productivity (ton/person.year)	351	2100	5000	6000
Heat Consumption for Clinker burning (kcal/kg)	1094	900	720	700
Comprehensive energy Consumption for cement (kg standard coal /t)	162	160	140	136
Density of dust discharging (mg/Nm^3)	300	80	50	30

Data source: A Compilation of Statistical Data of Building Materials Industry and a survey of well-known cement experts of our institute.

From the above table we can see that the gaps between only a few of cement works of advanced standard and the international advanced standard are not too large. However, there are many backward cement enterprises in China, that results in large gaps between the average Chinese standard and international advanced level, especially, the serious gaps exist in labor productivity and the concentration of dust emission.

- Judging by the labor productivity, the international average level is 2100 t / person. year.,

while the domestic average level is only 351t / person.year. (It is merely 16.7 % of the international one). The technology and equipment of part of large-sized production lines of precalciner/preheater process constructed recent years, however, have caught up with the international standard, and the gap in productivity is rather small compared with the advanced international ones.

- For the dust emission, since the shaft kilns are mainly used in domestic cement production and the environmental facilities in shaft kiln plants are imperfect that there are no normal dust collecting equipment provided for the most shaft kilns, it is a common practice when the dust emission exceeds the standard limit. The average concentration of dust emission is about 300 mg/Nm^3, which is as much as four times of the average international level. However, the advanced and large-sized production lines of precalciner/preheater process equipped with perfect environment protection facilities have only a rather small difference to the international advanced ones.
- In the respect of energy consumption, the shaft kiln that is a dominate production in cement industry in China, compared with precalciner/preheater kilns, hasn't much high heat consumption in burning and power consumption as well due to its own production technology. Hence there is a less difference between the Chinese cement industry and the international average level on the respect of energy consumption. The average heat consumption of clinker burning in China is 1094 kcal / kg, which is 21 % higher than that of international index. The comprehensive energy consumption of cement in China in average is 162 kg standard coal / t, which is a little bit higher than the international index. And the difference in energy consumption index between the large-sized advanced production lines with precalcining kiln in China and the international advanced level is not big.

2.2 Brick Materials Industry

2.2.1 Outline

The most important difference between the brick materials industry in China and the international standard is not in the production itself, but in the fact that a lot of clay bricks are still used in China, while only limited clay bricks production exist abroad, instead, various waste-utilized brick materials and new-type walling materials are used. The main problems existed in the Chinese brick materials producing enterprises and the low management standard, low standard of technology and equipment, low labor productivity, heavy labor intensity and poor environmental condition for production.

2.2.2 A comparison of key indexes

The comparison of key indexes of Chinese brick materials industry with the international advanced ones is as follows:

Table 7: The comparison of key indexes of Chinese brick materials industry with the international advanced ones

Items	Average level		Advanced level	
	Domestic	International	Domestic	International
Labor productivity (10,000 pcs /man. year.)	12	200-300	80	400
Comprehensive energy Consumption (t standard coal /10,000 pcs)	1.001	2.46*	1.537	8.081*
In it : coal consumption (t /10,000 pcs)	0.9	2.05*	1.4	
Power consumption (kwh/10,000 pcs)	250	417*	340	
Production cost (RMB/10,000 pcs)	900	9635*	1400	
※pollution index (hydrogen fluoride discharged) (mg/m^3 air)	6—50	≤10*		

*Notes : (1)The indexes with * are all conversed from the data provides by foreign expert Mr. Smith.*

(2) Other indexes are selected in accordance with the data collected by our institute or from the case surveys.

(3) The "advanced level", mentioned in above table, indicates just that the technology and equipment used are of advanced standard, and does not represent that the indexes are advanced.

(4) standard piece of brick: 240×115×53 mm

In China, the executive norms of permitted maximum discharging level of harmful pollutants from various industrial furnaces and kilns in different areas and different installation time of the furnace and kiln are different. The details are shown in the following table:

Table8: The standard of pollutants discharge

Name of harmful pollutants	The grade of pollutants discharge	Discharging level (mg/m^3)	
		Industrial furnace and kiln installed before 1, January , 1997	Industrial furnace and kiln newly installed, reconstructed and extended after 1, January 1997
SO_2	1	1200	Discharge is not allowed
	2	1430	850
	3	1800	1200
Fluor and Fluor-complex	1	6	Discharge is not allowed
	2	15	6
	3	50	15
Dust	1	100	Discharge is not allowed
	2	250 - 300	200
	3	400 - 500	300 - 400

From the above table of indexes comparisons we can see that the labor productivity in brick materials industry in China is lower the international standard. Its labor productivity is only 1/5 of international advanced ones taking even the most advanced production line in China. Judged by the production cost and comprehensive energy consumption of brick material

manufacturing, we can see that those in our country are obviously lower than those in the developed countries. Looking at the indexes of pollution, we know that the requirement to the norm of discharging level for fluorine and fluoride from the industrial furnaces and kilns installed before 1997 was rather low. Though the difference in norms has not been considerable when comparing the norms of discharging level of fluorine and fluoride from the industrial furnaces and kilns newly installed, reconstructed and extended in China after the first of January, 1997 with the international ones, there has been a difference in the practical intensity of implementation at home and abroad. In developed countries, for example, in Britain this norm is executed compulsorily, while in China, the intensity of implementation and supervision of the norm is not so strong. Many enterprises do not properly think over or pay much attention to the gas discharging and environment facilities in their process arrangement. The above norms are practically impossibly achieved in production. So the real polluting indexes are higher than the levels in foreign countries.

3. An Analysis of the Major Reasons Resulting in Differences between the Cement and Brick Materials Industry in China and the International Advanced Standard

Based on chapter2, this chapter analyses the reasons resulting in difference between China and international advanced standard in cement and bricks sectors, particularly on the respects of labor productivity, energy consumption, and discharge of pollutants. Cement industry and bricks industry are separated in the discussion.

3.1 Outline

3.1.1 the main reasons resulting in low labor productivity, high energy consumption, heavy discharge of pollutants and deficiency in strength of control in Chinese cement industry are as follows:

- The sharp and sustained increase of market demands, resulted by economic growth and expansion of engineering construction;
- Supply of domestic funds is deficient and the channels for introducing of foreign capitals are uneasy and not smoothed;
- The above-mentioned two factors resulted in emergence of thousands of small enterprises and expansion of their capacities;
- Though the absolute increment of number of advanced large-scaled enterprises is not a few, their increase rate is lower that for small enterprises. The large number of small enterprises, backward technology and equipment, the slow development rate of advanced and large-scaled enterprises and irrational structure of cement industry are the most critical reasons resulting in emergence of above mentioned problems.
- The policies of environmental protection and energy conservation formulated by the government have not been implemented effectively in the small enterprises.
- China has abundant coal resources. The coal price in coal-rich areas is relatively cheap. The pressure of energy saving on the enterprises is rather small.
- The state-owned and free-of-pollution enterprises are in an awkward position.
- Low management standard in enterprises.
- The poor working, operation and welfare conditions for the employees.

3.1.2 the main reasons resulting in differences between the brick materials industry in China and abroad.

- Over 75% of buildings in China are constructed by using solid clay bricks, while this kind of building materials is already seldom used, instead, the wastes-utilized brick materials and new-type walling materials are used.
- The economic development level in China is low. The building constructors lack enthusiasm in application of wastes-utilized bricks and new-type wall materials, since the production cost for solid clay bricks is low. Use of the latter can decrease for them the

engineering cost.

- The natural drying method for the green body of bricks and internal firing technology of bricks are mostly applied in the process of their production, that makes energy consumption at home lower than that abroad.
- The backward level of production technology leads to low labor productivity and poor working, labor insurance and welfare conditions.
- Since the labor cost is low and the government encourages the enterprises to enlarge the employment opportunity, the enterprises, considering to reduce the production cost, are not eager in pursuing the improvement of technology and raise of labor productivity.
- Most of brick manufacturing plants are located in junctions of small townships, where the environmental protection consciousness is less and the requirements to environmental protection standard are lower than in urban areas.
- Most of brick manufacturing plants are of village and township ownership or private ownership. The quality of employees and the management standard there are low.
- The consciousness of peasants in protection of land is not so strong. Though the government issued plans and policies on prohibition from occupation and destroying land, applying administrative measures, there is lack of strong economic measures.

3.2 The Analysis of the reasons for cement industry

3.2.1 Production size of enterprises

In 2000, the average production size of enterprises above limit in the cement industry of the whole nation China was 157,000t, which was only equivalent to 18 % of the international average level. The principal cause of low average size of enterprises is that the main part of cement output in Chinese cement industry came from the shaft kilns (which accounted for 72% of the total). However, the capacity of a single shaft kiln in production is low (it is less than 100,000t per year in general).

If only taking the large-and-medium-sized cement enterprises as an example, the raise of production scale of enterprises was relatively fast. China, at present, has possessed the production line which has reached the international advanced standard, with a production capacity of 7200 t /d clinker by a single kiln (equivalent to an annual cement output of 2.5 million tons) and has formed a batch of large enterprises with the sizes of 2-3million tons per year. So, as a whole, with the strengthen elimination of backward manufacturing process by the state in recent years, as well as the further development of precalciner/preherter process and the reform of investment managing system, the average production size of enterprises will speed up to increase step by step.

3.2.2 Energy consumption

In 2000, the average heat consumption for clinker burning in the whole country is 1094 k cal /

t (equivalent to 156.35 kg standard coal / t clinker), and the comprehensive energy consumption for cement is 161.81 kg standard coal / t. All of them are higher than the international average standard.

From the analysis of energy consumption and pollutant discharging indexes in the cement production enterprises with technical equipment at different levels in the country, we can see that the main reasons resulting in a high energy consumption are that the amount of cement produced with the precalciner/preheater process, which represents the development direction, account for only 12 % of total cement production capacity in China, while the share of cement produced with traditional shaft kilns, the quality of which is unstable and the production of which brings about resource waste and environment pollution, accounts for 72% of the total.

- The production energy consumption of cement produced by precalciner/preheater process is lower, with average heat consumption in clinker burning of about 950 kcal/kg. The heart consumption level of clinker production lines with a capacity of 2000 t/d and over, established recent years is about 750 kcal/kg, which is near to the level of the similar kilns in the world. As a contrast, the specific heat consumption of clinker sintered by wet-process is largely at a level of 1400-1500 kcal/kg. The specific heat consumption of dry process plain kiln is a little less than that in wet-process.
- The specific heat consumption of clinker sintered by shaft kilns is about 1000 kcal/kg, and the grade of clinker is low, the product quality is unstable.

3.2.3 Labor productivity

In 2000, the average labor productivity in the cement industry of the country is 351 t/person that is only 16.7 % of the international average level. The low labor productivity is not only caused by the condition of the country, but also is influenced by the backward technology and equipment in Chinese cement industry. There are nearly 1.3 billion people in China. and the employment is a practical problem faced by the Chinese government. The state-owned enterprises and the enterprises of collective ownership are mostly in a such awkward position: on the one hand, they, considering their own interest, should reduce the number of employees to raise the benefits and heighten the labor productivity; on the other hand, they should also bear the responsibility to implement the administrative instructions assigned by the government to arrange and enlarge the employment. These two items are often a contradiction that is difficult to resolve. It is a common fact that the state-owned enterprises (especially the old SOE) are over manned. A cement enterprise with the rotary kiln and an annual capacity of over 200,000 t in the western China, for example, has more than 2000 staff and workers, but in fact 1000 people are enough for its actual needs. Another instance is that the total number of employees for a clinker production line with a capacity of 4000 t/d (annual cement output is some 1.5 million tons), newly constructed in the country, needs only about 500 people.

However, a shaft kiln cement production line with a capacity of less than 100,000 t per year also needs 300-400 fixed working members. The labor productivity of the later is lower than that of the former by more than 10 times. The technical equipment structure of the industry with the backward shaft kiln production process as the main body is an important reason resulting in the low labor productivity.

3.2.4 Production cost[8]

The backwardness of technology and equipment, small size of enterprises, low labor productivity and lower standard of management are the major factors that influence the production cost of cement industry. The average specific product cost in Chinese cement industry in 2000 was 161 RMB (the costs on management and the financial affairs in the period are excluded), converted into USD19.5.

The backwardness of technology and equipment means a higher consumption of raw materials, especially higher energy consumption. The energy cost makes up about a half of the total costs[9] in the cement production, and this is an important reason why the competing ability of cement production with wet-process is falling in China in recent years. The small size of enterprises results in impossibility of formation of an economical size and relatively high expenses on fixed cost of unit product, therefore it influences to some extent the competitive ability of small-sized cement enterprises in the markets. Though the priority of low labor cost in China, it is weakened in a great deal by the excessive redundant personnel in many enterprises, and in some cases it converts the original superiority to the inferiority. In recent years, the management of large-and medium-sized SOE in cement industry in China is commonly strengthened, however, many enterprises are still slipshod in management. and some of them are in a losing state of management, so that the production cost of the enterprises has correspondingly raised.

It should be clarified that though the shaft kiln in cement production lags in technology, it has

[8] The cement production costs are the expenses happened in the production process of the cement enterprise for the actual consumption of direct materials, direct wages, other direct expenses and expenses for organizing and managing production in the various production workshops, ie manufacturing expenses. Various expenses of administrative and managing departments of the enterprise in managing and organizing management activities, ie management expenditure, various sales expenses happened in selling of products, ie selling expenditure, and net expenditure for interest and remittance loss happened in the production and management periods of the enterprise, i.e. financial expenditure are not included.

[9] The total costs of cement consists of four parts: production cost, Various expenses of administrative and managing departments of the enterprise in managing and organizing management activities, ie management expenditure, various sales expenses happened in selling of products, ie selling expenditure, and net expenditure for interest and remittance loss happened in the production and management periods of the enterprise, i.e. financial expenditure.

still a great vitality in China. This is because the production with shaft kilns has a lower requirement to the labor quality, and the average salary for the employees is very low. Besides, the level of energy consumption for shaft kiln itself is not so high. The cost of initial investment is low due to a not high standard of the equipment for the enterprises with shaft kilns, all these make the production cost of cement produced with shaft kilns have a certain ability in competition. If there is no strict restriction on product quality and environmental protection, etc., which are the non-economic factors, the cement produced by shaft kilns would still have a room to exist at present and even in a considerable long period.

3.2.5 Pollution indexes

According to the statistics, the amount of fume and dust discharged from the cement industry in China in 1999 was about 10 million tons, which accounted for 40% of the total discharge in the whole country. The amounts of CO_2, NO_x, and SO_2 discharged by the industry are about 390 million tons, 0.58 million tons and 0.88 million tons respectively.

- The heavy discharge of dust is mainly caused by the incomplete allocation of environmental facilities and doing things simply and thriftily by the most enterprises with shaft kilns.
- The large discharging amounts of CO_2, NO_x, SO_2 and other harmful gases are mainly related to the huge total output of cement in the country (about 1 ton CO_2 discharged with each ton of produced clinker).

Generally speaking, the environmental indexes in large-and medium-sized SOE are better, especially for the newly constructed production lines in recent years. They are equipped with high standard technical equipment and a close attention was paid to the environmental protection at the very beginning of the project. The local small cement enterprises with low standard of production equipment put less investment in environment protection, since the investment in modification of environmental facilities may increase inevitably, the cost of production. Additionally, with the improper management and indifference in the consciousness of environmental protection, the problem of pollutant discharge in these enterprises is difficult to resolve.

3.3 An Analysis of the Reasons in the Brick Materials Industry

3.3.1 An analysis of the reasons resulting in low productivity

The average labor productivity in the brick industry in China is 120,000 pcs/m · a. The lowest one is just 70,000-80,000 pcs/m · a, and the highest one is 800,000 pcs/m · a .The main reasons resulting in low labor productivity in brick industry in China are as follows.

- The extremely backward technique, equipment and production technology of brick-making. In most of enterprises of Chinese brick manufacturing industry a manual or semi-mechanization operation is applied in the working sections of batch preparation,

molding, cutting, palletizing and up to firing and brick unloading. The green body mainly dried with air that causes a long production period. Considering main production equipment, a small Hoffmann kiln or even an earthen kiln is mostly used, kiln mastering and products unloading from the kiln are usually relying on man-power plus small carts.

- The average production scale is small. The average production scale of brick manufacturing enterprises in China is only about 6 million pcs (standard brick)/a. With the low mechanization in production and disposition of relatively much labor-forces, they belong to lowly technically equipped and labor-intensive ones.
- Being backward in management and short of stimulation mechanism. The former pattern of planning economy is continuing to be used in the management in the Chinese brick manufacturing industry. In account of employment rate, the personnel disposition usually is relatively high. Furthermore, the relatively low quality of employees is a common practice. The management standard is relatively low and the management is backward. The labor intensity of production workers is very high. Nevertheless, their wages and living conditions are very low and bad. The initiative of the production workers can hardly be brought into full play. All these factors result in the low labor productivity in Chinese brick manufacturing industry.

3.3.2 An analysis of the factors resulting in low energy consumption

The average comprehensive energy consumption in the Chinese brick manufacturing industry is 1.001t standard coal/10,000 pcs. The highest energy consumption is 1.54t standard coal/10000pcs, and the lowest one is 0.28t standard coal/10000pcs. The main factor resulting in low energy consumption in the Chinese brick manufacturing industry is the differences in the levels of production technology and equipment.

- Although the overall level of production technology and equipment in the Chinese brick manufacturing industry is very low with the low degree of mechanization and automation. Furthermore, a air-drying is generally applied in the overwhelming majority of the brick manufacturing enterprises. Consequently, relatively speaking, the coal and electricity consumption is rather low.
- Being restricted by the clay resources and requirements to improvement of the environment and the increase of comprehensive utilization rate of resources, the overwhelming majority of the Chinese brick manufacturing enterprises are applying internal combustion technology, namely, the industrial wastes, such as fly ash and so on, are added in and mixed with batch, or the coal gangue is totally used in the production of sintered bricks. As a result, at the same time with the saving of the clay, the wastes are utilized, the environment is improved and the most important is that the heat value of the wastes is utilized, so that the coal is saved and the energy consumption is greatly decreased, especially, in the case of manufacturing of coal gangue sintered bricks, no coal is used in the brick-making,

consequently the energy is fully saved.

3.3.3 An analysis of factors resulting in low production costs[10].

The average production costs in the Chinese brick manufacturing industry are 900 RMB/10000pcs, with the highest ones of 1400 RMB/10,000pcs and the lowest ones of 600 RMB/10,000pcs.

The main factors resulting in low production costs in Chinese brick manufacturing industry are as follows:

- The low level of production technology and equipment. The investment in purchasing equipment is small which will result in a low production cost to a certain extent.
- The low raw materials cost. Since the overwhelming majority of the brick manufacturing enterprises are the village and township enterprises, they mostly use local clay in burning bricks, that doesn't cost them much, so the costs are very low. Additionally, slag or other industry wastes used for the production of bricks are basically free except their handling and transportation.
- The cheap labor cost. The all village and township enterprises employ the peasant workers or temporary workers as the production workers. Their wages are very low and they scarcely have welfare treatment. Even though for the management personnel the wages are also not so high. As a result, the wage cost is very low.
- The consumption of fuel and electricity is low, so the costs are naturally low.

3.3.4 An analysis of factors resulting in high pollution indexes in Chinese brick materials industry

- The differences in production process

The overwhelming majority of Chinese brick manufacturing enterprises applies conventional Hoffmann kiln burning technology using coal as its fuel. In the burning process a certain amount of waste gases of sulphur and nitrogen oxides emerges. There are usually no waste gas treatment facilities installed in the production process to lower the production cost. The emerged fumes and gases directly discharge through chimneys into the atmosphere. Consequently, the pollution indexes are relatively high.

- The differences in management. The ownerships of brick plants in China are mainly of the village and township. Employees in these plants are commonly in low education degree and their consciousness of environmental protection is rather faint. They careless

[10] The production costs of brick materials mainly include expenses in raw materials, fuel materials, coal, electricity, expenses for manpower and manufacture. Various expenses of administrative and managing departments various sales expenses happened in selling of products, ie selling expenditure, and net expenses for interest and remittance loss happened in the production and management periods of the enterprise, i.e. financial expenditure are not included.

environment protection in their manipulation. Additionally, as the scales of enterprises are small in general and their distribution is scattered, it is rather difficult to control their environment result for staff in responsibility of environment protection. Furthermore, these enterprises are protected by localities protectionism for their own benefits. As a result, the relevant state laws and regulations of environmental protection cannot be effectively implemented in these localities and enterprises.

- In brick industry, stimulation and restriction mechanism and rewards and penalties system toward environment protection are not complete that mainly results in the high pollution indexes in the Chinese brick manufacturing industry.

4. The Existing Relevant Plans and Policies Approved to Implement in the Building Materials Industry in China

This chapter explains the existing relevant plans (strategies) and policies approved to implement by government authorities in the building materials industry in China. These plans (strategies) mainly include The Cross-century Development Strategy of the Building Materials Industry in China; The Tenth Five Year Plan (2001-2005) of the Building Materials Industry. Relevant Policies covering four issues: Industrial technological policy of the building materials industry; some suggestions on "To control the total output, to regulate the structure"; detailed rules and regulations on the execution of "To control the total output, to regulate the structure"; two guiding principles, named "developing the large (size production) and restructuring the small (size production)" and "limitation, elimination, restructure and upgrade" in the development of cement industry.

4.1 Outline

4.1.1 In 1995, the State Administration for Building Materials Industry of China firstly issued and began to implement "the Cross-century (21 century) Development Strategy of Building Materials Industry in China" and put forward a strategic objective for the development of building materials industry, " to develop the industry from a large one into a strong one, to make the industry strong by relying on using new technology and equipment".

4.1.2 The Tenth Five Year Plan of Building Materials Industry, issued by the State Economic and Trade Commission of China in 2001, defines to concentrate effort on industry restructuring and put emphasis on the sustainable development in the period from 2001 to 2005.

The focal points of development of cement industry are as follows:

To energetically develop large and medium-sized cement production using the precalciner/preheater process;

To transform backward production plants;

To prohibit plants without business license from cement production;

To enforce the implementation of emission norms for environmental protection;

To encourage enterprises to reduce energy consumption and to improve the environment of plants and their surroundings.

The focal points of development of brick materials industry are as follows :

To encourage the development of new-type walling materials;

To encourage the brick materials plants to enlarge the production of waste-utilized products;

To prohibit new construction or expansion of clay solid brick manufacturing plants

To take stricter controlling measures in the respect of burning bricks and destroying land;

To strengthen the implementation of policies using economic measures, such as levying taxes and fund, etc.

4.2 The Cross-century Development Strategy of the Building Materials Industry in China.

In 1994,the State Administration for Building materials Industry of China put forward and started to formulate "the Cross-century Development Strategy of Building Materials Industry in China". The "Strategy" has been formally implemented within the whole industry since 1995. It makes a series of strategic plots for the long-term development of building materials industry.

The Strategy clearly and definitely raises that the building materials industry should be developed " from a large one into a strong one, to make itself strong by relying on using new technology and equipment". This is a fundamental objective and policy for the development of the building materials industry. To realize this Strategy, 4 transformations should be carried out in the building materials industry, namely the transformation of the production mode from the quantity-speed pattern, in which the priority is given to the increase of output, into quality-benefit one, in which the priority is given to the improvement of product quality and matching capabilities; transformation of development mode from the labor-fund intensive pattern into the technology-fund intensive one; transformation of production management mode from small-sized extensive one into large-scaled intensive one; transformation of market orientation from a pattern, in which the priority is given to the domestic market into a pattern, which is open to the both domestic and international markets. The general strategic goal is to transform the building materials industry into a modernized raw materials and manufacture industry with ability to compete in international market, to adapt to speed development of national economy, and to be a pillar industry together with construction industry. The goal is achieved by some certain ways, by steps and stages and with respective key points in 30 to 40 years. Namely, in the first stage, the Ninth Five Year Plan period, to lay down a solid foundation and put the building materials industry on a development road of virtuous circle. In the second stage, from 2001 to 2010, to make part of the industry and part of areas modernized firstly. In the third stage from 2011 to 2030, to modernize the whole building materials industry.

To ensure the Strategy to be implemented effectively, 8 strategic countermeasures have been put forward.

- To keep on deepening reform and opening up to the outside world to form a mechanism which is suitable to the

development of the socialist market economy.

- To invigorate the building materials industry by relying on science, technology and education, to devote major efforts to transformation of economic growth mode of the building materials industry.
- To devote major efforts to developing new-type building materials and manufactured products, taking the change of construction markets as a guide.

- To devote major efforts to cultivating new growth point of the economy, to develop fully the resources of non-metallic minerals and energetically develop the inorganic non-metallic new materials industry.
- To set up an energy-saving, land-saving and water-conserving production system and an effective administrative system of environment protection, supervision and monitoring.
- To give energetic support to development of the building materials industry in middle and west parts of the country, giving full play the superiority and pushing on progressive growth.
- To raise fund from diversified channels to adapt the reform of the investment system.
- To strengthen the management of the industry, to do well in adjustment and control of the administrative structure and levels to promote the healthy development of the building materials industry.

4.3 The Tenth Five Year Plan (2001-2005) of the Building Materials Industry

- Guiding principle

The guiding principle of development of the building materials industry in China from 2000 to 2005 is to actively develop high and new technology and products, control the sum of the output, enhance the strength of elimination of backward technology and products, push on the reorganization of assets of enterprises, give priority to cultivating large companies and enterprises groups, which have autonomous intellectual property, outstanding major business, strong core of leadership, strong international competitive ability, invigorate the medium-sized and small enterprises, promote a sustained, steady and healthy development of the building materials industry, taking the change of market as a guide, the enterprises as the main body, the adjustment of structures as the guiding line, the scientific and technological innovation and system innovation as a motive force, the technological transformation of enterprises, improvement of product quality, conservation of energy, land, water, utilization of wastes and environmental protection as the key points.

- Development objectives

The anticipated annual average growth rate of added value of the building materials industry is 7-8%.

Up to 2005, the average scale of cement manufacturing enterprises will be enlarged from an annual output of 100,000 tons (for all enterprises) to 250,000 tons. The cement output by precalciner/preheater process will reach 120 to 130million tons, accounting for 20% of the total cement output. The proportion of the special cement[11] output will account for 3% of the

[11] Special cement refers to a series of cements which possess certain specific characteristics and can be applied in special construction projects, such as white Portland cement, oil well cement, moderate heat and low heat Portland cement, highway cement, sulphate resisting Portland cement and so on.

[10] New-type walling materials refer to all wall materials except for solid clay bricks.

total cement output. The proportion of bulk cement will reach 30%. The output of new-type wall materials[12] will reach an amount equivalent to 300 billion standard pieces of bricks will account for 40% of the total output of wall materials.

A remarkable progress will be achieved in research and development of key technology and equipment for the development of the industry. The technology and equipment of production line of precalciner/preheater process with a daily capacity of 2000 to 5000t of clinker will reach the advanced international standard of 1990's. To actively develop extra-large cement production line with a daily capacity of over 8,000 t and to form a technology and equipment research, development and building system. To realize basically the localization of technology and equipment building for new-type wall materials.

In the field of energy utilization and environmental protection, to push on all round clean production and come up to the environmental protection standards. Up to 2005, the average energy consumption of major building materials products should be decreased by 20%. In production of cement and wall materials (including brick materials), to research and develop actively diversified energy and resource utilization ways and to achieve an annual conservation of energy of 19 million tons of standard coal and to decrease the emission of dust of 2.1million tons.

- Key Points of Development of the Industry

During the Tenth Five Year Plan period, the precalciner/preheater process of cement production will be greatly developed. On the one hand, the production lines of the precalciner/preheater process with a capacity of 4000 t/d will be developed by some large enterprise groups, and on the other, a number of key enterprises shall be encouraged to renovate kilns with backward process which are still used in production at present, such as wet process kilns, Lepol kilns and dry process plain kilns, to be the kilns of the precalciner/preheater process with a capacity of more than 2,000 t and over per day. The industry should attach much attention to and further strengthen the protection of environment, taking the control and governing of pollutions and protection of environment as the vital conditions for existence and development of the industry. At the same time, clean production shall be promoted, and to actively make use of such industrial wastes as coal gangue, slag, fly ash, phosphogypsum, desulfogypsum, and to research and develop new approaches to make use of the wastes left in city construction, daily life wastes, used oil, and worn-out tyres. The industry shall develop and perfect such technologies and processes so as to apply the energy resource of poor quality, and industrial wastes to the production of cement, and on the premises that the quality of cement is guaranteed, to develop cement production gradually to become an energy-saving, waste-utilized and environmental protective and sustainable "green industry".

[12] New-type walling materials refer to all wall materials except for solid clay bricks.

Taking promotion of quality, energy-saving, land-saving and waste-utilization as its key measures in production, the wall materials industry shall strictly prohibit the use of solid clay bricks in 170 large and medium-sized cities across the country within the next three years, while actively leading other areas to use new type wall materials instead of solid clay bricks. It shall also develop non-clay hollow products, concrete blocks, various kinds of light-weighted sheets and boards, and composite materials and other technological products and equipment. By 2005, the output of new-type wall materials will account for 40 percent of the total of wall materials, whereupon 200,000 mu of farmland will be saved, and 20million tons of exhausted CO_2 will be reduced and 90 million tons of coal gangue and 45 million tons of fly ashes will be used comprehensively.

4.4 Relevant Policies

To guarantee the building industry to develop in a healthy, sustainable and stable way, and according to the national economic development program and the cross-century development strategy of building materials industry, the relative departments of the central government and the former State Administration for Building Materials Industry have proposed and worked out relevant guiding principles and policies and regulations on new problems and new features which may stem out from production in different periods. The major ones include:

4.4.1 Industrial technological policy of the building materials industry

- The Development objectives related to the sustainable development of cement and brick materials industries

To study and develop a complete set of equipment and technology for production lines of large-scale precalciner/preheater process so as to gradually create a series of the precalciner/preheater process technology and equipment with an autonomy of intellectual property and to reach the world advanced standard.

The technology and equipment and the quality of key and leading products of new-type building materials must reach the standard that has been attained by the developed countries in the corresponding period. And a complete applied technological system for such products shall be built up.

The industry shall essentially solve the problems in the fundamental theory of eco-building materials and their application. To develop eco-building materials. In the entire industry, the energy-saving technologies and automatic technologies, and environment protective technology, low-quality raw materials and wastes comprehensive utilization technologies shall be adopted so as to make the industry to be an energy-saving, waste-utilized and environment protective green industry.

- Orientation and key points of technological development in relation to the production of cement and brick materials.

This section includes two major parts: The policies of comprehensive utilization and eco-environment protection, and the key points of technological development and manufacture of equipment, involving eight articles about the use of wastes and technologies, of which those relative to cement and brick materials are as follows:

Superfine slag and fly ash shall be used as the admixture to produce cement and as mixed materials for concrete so as to reduce pollutants. The researches on the application and development of environmental load reduced cement with B-minerals as the predominate component shall be carried out so as to reduce the usage of dose per unit of limestone and to lower down the finishing-burn temperatures of clinker and the discharges of CO_2 and NO_2, and to apply coal of low volatility and anthracite and poor quality fuel in the process in the cement production lines with precalciner/preheater process.

The production of new-type wall materials using industrial wastes of coal gangue, stone coal, fly ash, cinder, desulfogypsum and phosphogypsum, and such low grade materials as shale, faulty earth, rivers and lakes silt and non-wood plant fibers as the raw materials shall be emphatically developed.

To undertake the renovation projects on improvement of recycling use of resources, protection and improvement of the environment of mines and the comprehensive utilization of mine tailings and rock wastes. To energetically support the development and application of coal series kaolin. To perfect and popularize the technology of comprehensive utilization of serpentine. To strengthen the development, utilization and researches on paragenetic and associated minerals.

4.4.2 Some suggestions on "To control the total output, to regulate the structure"

In September 1998, the State Economic and Trade Commission issued a series of relevant policies, which contained the guiding principles and measures of " To control the total output, to regulate the structure".

The guiding principle includes the readjustment of product mix up, structures of technology and organizations, elimination of out-dated technology and equipment, renovation of old enterprises, striving for the realization of energy saving and reduction of materials consumption, paying attention to environmental protection and pollution governing, and comprehensive utilization of resources and extreme conservation of farmland, and introducing and utilizing foreign capital, technology, and management to promote the production and operational level and competing ability of the building materials industry.

The major measures to be taken include that the departments at various levels in charge of building materials industry must implement some suggestions on "To control the total output, to regulate the structures" of the building materials industry and control the total output of products by means of economy, law, finance and taxes and creditableness to support the development of new-type building materials and promote the regulation of structures. For

instance, they should implement the "circular on the list of the first group of the names of technologies and equipment causing serious pollution to environment (atmosphere) to be eliminated", eliminate all the out-dated technologies and products as quickly as possible. They should strengthen the formulation and revision of standards for products and quality management and intensify the supervision over the product quality and environment, and grasp the opportunity provided by the drive of furthering reform of state-owned enterprises to promote the regulation of organizational structure.

4.4.3 Detailed rules and regulations on the execution of "To control the total output, to regulate the structure"

The detailed rules and regulations were issued by the former State Administration for Building Materials Industry in May 1999. They involve 3 parts, namely the principles to be observed, the targets and time limit, and the measures. The content relevant to cement and brick materials includes:

To ban production of those enterprises without production permit issued by government authorities; to close down earthen kilns, common shaft kilns, and the mechanized shaft kilns with a diameter of 2.2m and below; to eliminate the production lines of dry process plain kilns and wet-process kilns with a diameter of 2.5 and below. To prohibit the newly constructing and expanding the shaft kilns, wet process kilns, Lepol kilns, and dry process plain kilns and the expansion and renovation of those mechanized shaft kilns with a diameter of 2.2m or below. To support the construction of cement production lines of the precalciner/preheater process with a capacity of 2000t/d and over. To emphatically encourage the technical renovations of the existing enterprises with advanced techniques.

Production lines of simple circular kilns, earthen kilns, small shaft kilns shall be eliminated in wall materials production. The newly constructing or expanding of solid clay bricks production should be prohibited as well the usage of this kind of material. Supporting the development of new-type wall materials, such as aerated concrete blocks, fly ash burnt bricks, coal stone bricks, shale bricks and various kinds of hollow bricks.

4.4.4 The guiding principles of "developing the large and restructuring the small" and "limitation, elimination, restructure and upgrade" in the cement industry

The principle of " developing the large and restructuring the small enterprises" is a guiding principle, with which the government controls the examination and approval of new construction and expansion projects. It contains two aspects :

- For the newly developed projects the priority should be given to the renovation and expansion of enterprises. To energetically develop the large and medium-sized cement projects with the precalcing process as the main technology and having production rational scales (According to the current effective standard, they are those projects with a daily

capacity of 2000t and over). To speed up the renovation of wet process technology.

- Combining the renovation of shaft kilns with the development of large cement enterprises to expand large and medium-sized enterprises. In addition, the total capacity of shaft kilns eliminated should be in equivalent with or over the capacity of expansion. Some shaft kilns could be rebuilt into grinding stations. All efforts mentioned above aim at of remarkably reducing pollution, lowering down consumption of energy and improving the quality of product.

The principle of " Limitation, elimination, restructure and upgrade " is another guiding principle put forward by the Chinese governmental department for the development of existing enterprises in the future. The details are as follows:

- To limit repeated construction of projects with out-dated and backward technology;
- To eliminate ordinary shaft kilns extra-small-sized mechanized shaft kilns that haven't a complete set of equipment and consume too much energy and cause serious pollution, and quality of products of which is unstable, and those small rotary kilns with a diameter of 2.4m or below.
- Those enterprises without a license for production shall be definitely closed down. To transform well-founded enterprises with mechanized shaft kilns into those with advanced rotary kilns;
- To renovate surrounding small cement enterprises while building new enterprises or expanding enterprises with precalciner/preheater process;
- New technology shall be applied to renovate most of mechanized shaft kilns, to solve the problems with quality of product, pollution and high consumption of energy.
- To upgrade general level of the cement industry shall be upgraded on the basis of limitation, elimination and restructure.

4.4.5 The catalog of directions of development of new-type building materials and products

The catalog was issued by the State Administration for Building Materials Industry in July 1999. It contains mainly four parts: the principles to be adhered in the process of development of new-type building materials, technological products to be developed, technological products to be developed in control and technological products, development of which is to be prohibited.

The catalog clearly stipulate the details about building materials, development of which is encouraged, in control or to be prohibited in the four categories of new-type building materials including new-type wall materials, new-type waterproof and sealing materials, new-type heat-insulating materials, and fitting and decorative materials to lead the new-type building materials and their products to develop in a healthy and orderly way, so as to solve such remaining problems in the development as low technological level and low grade of

products, small production capacity and development of production without a clear and definite orientation.

5. Analysis of Conventional Development Modes of China's Cement and Brick Materials Industries in the Tenth Five Year Plan

This chapter discusses the Business As Usual development on the basis of Tenth Five Year Plan particularly. The first two subchapters discuss the development trend and priorities in development for each industrial sectors, cement and bricks industry respectively. Of which, these respects are covered: installing new capacity, closing down old capacity, upgrading technology and accuracy capital needed for retrofits.

The following subchapter makes a forecast of demand for cement and bricks in 2005 and 2010 and analysis the demand and supply of various grade products of cement and bricks.Analysis of Issues Related to 3E in the Existing Development Modes is put in the last subchapter. It shows that Chinese government and relevant firms have made great efforts to improve the existing situation related to 3E. However, there is a long way to go to resolve some disadvantages that have existed for a long time.

5.1 Cement Industry

5.1.1 Development trend

In line with the development program of cement industry in the period of the Tenth Five Year Plan (2001-2005) the cement industry in China will undergo restructuring and optimization along with its development, with great attention to its technological upgrading, and responding to the sustainable development. Elimination of its outmoded technologies by way of technological innovation and scientific progress should be speeded up. Repeated construction of low standard plants should be prohibited strictly with renovation of existing enterprises by means of precalcining technology should be quickened to facilitate the structural adjustment and optimization of the industry. At the same time reorganization of this sector will be promoted with large enterprises and /or groups supported for growing and expansion. With entrance of China into WTO, the cement industry will see more marked internationalization. Resources and energy should be saved and utilized soundly, and environment protection strengthened.

5.1.2 Priorities in development

Newly-added capacity of cement will be realized mainly through renovation and expansion. Based upon the existing enterprises, the modernized cement production lines will be enlarged, resorting to advanced precalcining technology. On the other hand, it is planned to carry out technological renovation of the existing wet process kilns, Lepol kilns and suspension preheater kilns by means of advanced adaptable technology with high efficiency environment protection and energy saving techniques. Repeated construction of low standard facilities is strictly prohibited. All cement production lines except those using precalciner/preheater process are not allowed to build.

- Erection of a number of precalciner kilns

The cement output from precalciner kilns is expected to be doubled by the end of the Tenth

Five Year Plan period i.e. the production capacity of clinker from precalciner kilns will reach 120 million tons and that of such cement 130 million tons . The construction fund need for this is expected to be 30 billion RMB.

- Renovation of a number of existing enterprises

The existing wet-process kilns, Lepol kilns and suspension preheater kilns will be subjected to technological up-grading to increase an output of 18 million tons, and an output of 7 million tons will be added after the existing new type dry kilns of the precalciner/preheater process reach their capacity and productive targets with improvement of the availability of production capacity.

The mechanized shaft kilns with a diameter larger than 2.2 meters listed in and to be eliminated by the end of the Tenth Five Year Plan period should undergo technical renovation as required by the industrial and technical policies with the emphasis on improving their product quality and labor productivity and diminishing dust pollution. Some production lines equipped with shaft kilns should be upgraded by use of advanced and adaptable techniques for shaft kiln, and some plants with such kilns will be rebuilt into grinding stations for large enterprises.

Fund input for the renovation described above is expected to reach 10 billion RMB.

- Elimination of part of outmoded production capacity

On the basis of eliminating 100 million tons outmoded production capacity (shaft kilns with a diameter to 2.2m and below) set by the Ninth Five Year Plan (1995-2000), additional 50 million tons cement production capacity characterized by unstable quality and poor environment protection will be abolished.

- To develop the industry towards wastes utilization and environment friendly production

The cement industry will gradually realize clean production. Meanwhile it should play greater part in salvage of industrial wastes, for example, fly ashes, gangue and limestone tailing, and utilization of secondary energy resource in treating urban garbage, wasted oil, tire, harmful wastes, etc.

5.2 Brick Materials Industry

5.2.1 Development trend

During the period of Tenth Five Year Plan, the brick materials industry will tend to close and eliminate backward plants of clay solid bricks, further reducing land destroyed and occupied, and diminishing resources wasted. On the other hand, environment friendly wall materials of new kind will be developed to replace clay solid bricks to meet the market demand and save land, energy and resources.

5.2.2 Priorities in development

The development will be towards sintered hollow bricks, especially those with high slag

admixture, porosity, thermo-isolation and strength, non-clay sintered hollow bricks.

Clay hollow bricks made from river silt, shale bricks and sand-lime bricks.

To meet the multiple demands of construction market, in addition to bricks of new kind, the industry will develop load-bearing and non-load-bearing concrete hollow blocks, aerated concrete bricks and various light-weighted slabs.

The "Green" wall materials should be developed and widely spread. For example, utilization of usable industrial slags in large quantities will be pursued to replace part of all natural resources for making wall materials. Some kinds of agricultural wastes can be used to substitute wood fiber for making artificial slates, and human body friendly fibers can also be used to replace asbestos fiber in manufacturing cement boards, calcium-silicate slabs, etc.

- Newly-added capacity

During the period of Tenth Five Year Plan production capacity is expected to grow by 18 billion pieces each year, totaling 90 billion pieces in five years. New products will cover mainly new-type wall materials, including coal gangue and fly ash sintered bricks, clay sintered bricks of river silt, various concrete hollow products, and aerated concrete blocks and different kind of light-weighted slates.

- Technical standards of newly-added production capacity

Sintered bricks: Focus will be put on development of production lines of hollow bricks with a capacity of 30 million or more pieces per year, employing tunnel kilns and widely introducing the new technology for manufacturing sintered bricks with high slag admixture or full coal gangue sintered hollow bricks. Their technological equipment shall reach the world advanced level in the early 1990s of 20^{th} century.

Concrete hollow products: Mechanized and automatic production lines with a capacity of 100,000 m^3/a or larger is to be realized emphatically by use of stationary molding and indoor curing. Their technology and equipment will be up to the world advanced level in the middle 1990s of 20^{th} century.

Aerated concrete: The mechanized and automatic production lines with a capacity of 100,000-200,000 m^3/a shall be developed with such technologies introduced as stationary casting, quiescent maintenance in warm chambers, demolding curing, and suction conveying technology. Their technology and equipment will reach the world advanced level in the early 1990s of 20^{th} century..

Light-weighted slates: The technology and equipment in production of gypsum plaster boards shall reach the contemporary world advanced standard and those of other light-weighted slates will reach the world advanced level in the middle 1990s of 20^{th} century..

- Fund input in newly-added capacity

It is estimated that around 45 billion RMB will be needed to add 90 billion new-type wall materials.

- Production capacity to be eliminated in the Tenth Five Year Plan period

The eliminated capacity: Production capacity for manufacturing poor-quality bricks is expected to be eliminated by 18 billion pcs each year, totaling 90 billion pcs in five years in the Tenth Five Year Plan period. They are mainly clay solid bricks, which are not only poor in quality but consuming much more energy, damaging the ecology and severely wasting resources.

Plants to be eliminated include those plants using earthen kilns, manual or semi-mechanized plants using simple circular kilns, and those that severely damage land.

- Technological renovation targeted at saving energy and resources and improving environment

Technological renovation in this field will be related to the production capacity of about 5 billion pcs of bricks per year, with input nearly 1 billion RMB.

5.3 Prediction of the Overall Demand for Cement and Bricks in 2005 and 2010 and Analysis of the Demand and Supply of Various Grade Products

5.3.1 Review of Chinese cement market

The production and sale of cement products in China has gradually shifted from the state controlled unified distribution system to the market regulated one dominantly at present. And the market will be gradually switched from the seller's to the buyer's one.

In the 1980s, 20th century, China's cement market opened up gradually, and the dominantly market-regulating economic mode was formed, resulting in a relatively stable picture of cement production and sale.

In the earlier 1990s, China's economy entered a period of rapid growth with capital construction projects soaring across the country. Since the cement industry is closely linked to the development of the national economy, its products were sold very well in that time, leading to a remarkable increment of economic benefits in favor of the cement enterprises. Driven by the economic interest, shaft kiln cement plants emerged rapidly in most areas of the country. In the period of 10 years in the 1990s the annual cement production capacity in the whole country saw a swift increase from 270 million tons to 700 million tons, including 110 million tons of rotary kiln cement and 320 million tons of shaft kiln cement.

However, in the late 1990s, two major reasons that economic crisis occurred in the Southeast Asia and "soft landing" policy were implemented by Chinese government slowed down the growth of Chinese economy. As a result, the cement industry fell into a low valley, characterized by excess capacity, and unstable quality of shaft kiln cement rose highly, fierce market competition emerged and enterprise benefits went down. Up to 1999, owing to the growing domestic demand motivated by the government, reform of the state-run enterprises, elimination of outmoded operations and the development of the west China, the cement market began to rise eventually. Hence the market is still the buyer' one.

Characteristics of China's cement market are as follows:

------The national cement market as a whole can be described as overall oversupply but deficiency in high-quality products. Since 1995 the oversupply of cement products emerged in most areas, and in most provinces and regions was seen the over-production. Only a few provinces, due to their remote or hilly location and/or poor distribution of resources, had shortage of cement production seen in small areas with the price a bit higher.

By the end of 2000, among the total cement production capacity nationwide of 720 million tons, the production capacity of rotary kilns amounted to 197 million tons, 28% of the total, and that for the precalciner/preheater process amounted to 83.70 million tons, accounting for about 12% of the total. The cement production capacity with shaft kilns took up 72% of the total. Overall oversupply and severe shortage of quality cement reflected the structural contradictions of the cement industry.

------The cement consuming picture is now characterized by much higher consumption, 65% of the total in the East and low consumption, 15% of the total, in the West. However, with China's West development strategy implemented further, such consumption structure has been started to change, and consumption ratio in the West tends to go up.

------Regarding the products mix, the demand for quality cement (broadly referred to rotary kiln cement) is increasing constantly. With quality consciousness in people's mind being ever stronger, consumers pay ever increasing concern about the quality deficiency of shaft kiln cement, and the advantage of rotary kiln product stands out, resulting in its demand going up in the market. In addition, the huge construction of infrastructure and key projects that started in recent years have enlarged the demand for rotary kiln cement. As a result, a shortage in supply of rotary kiln cement has been seen, which stimulated the price of rotary cement to go up in a number of areas, 30-50 RMB per ton higher that of shaft kiln cement of the same grade.

------China's cement market has been rising after low valley in last few years.

After its development peak in the earlier 1990s, the cement industry encountered severe loss in three years' period from 1996 to 1998. About 40% of enterprises in the industry lost benefits. And sale price also decreased for five years. Fortunately, since 1999 some makers have turned into profit, and since 2001 the cement price has been rising. The loss-profit balance, nationwide averaged ex-factory price and the averaged ex-factory price of key cement enterprises are shown in Table 9, Fig.5 and Fig.6, respectively.

Table 9 Loss-profit balance of cement enterprises in recent 5 years

Year	Number of all enterprises	Number of loss-enterprises	Coverage of loss-enterprises (%)	Sale earnings (Billion RMB)	Total profit (Billion RMB)
1996	6609	2336	35.35	106.452	-2.295
1997	6403	2612	40.79	107.880	-3.537
1998	4506	1841	40.86	108.605	-2.288
1999	4642	1775	38.24	113.213	0.512
2000	4529	1714	37.84	115.216	0.763

Data source: " the Statistical Yearbook of Building Materials in China " published by the Chinese Association of Building Materials Industry.

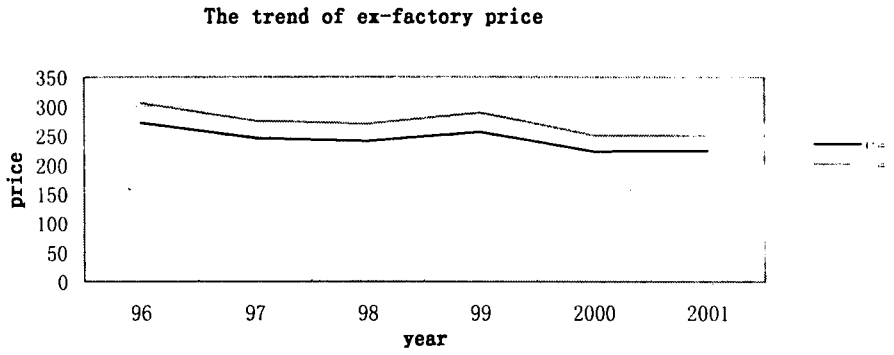


Fig.5 Trend of ex-factory price of cement (unit : RMB/t)

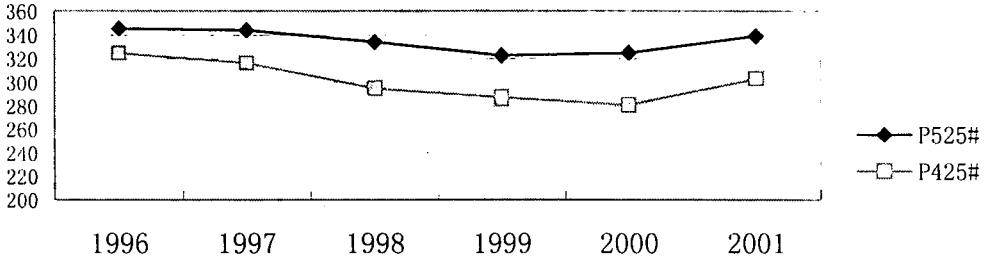


Fig.6 Averaged ex-factory price of the key cement enterprises, issued in May each year in-between 1996-2001(unit:RMB/t)

Data sources : Statistical data of the former State Administration for Building Materials Industry. The Supervisory Commission of Quantitative Economy Of Building Materials.

5.3.2 Prediction of the gross demand for cement in China in 2005 and 2010

- Major criteria for prediction

a) Chronological statistics of domestic cement consumption in China (source: The State Statistical Bureau)

b) Determination of the economic growth rate in China in the next 10 years

c) Prediction of the gross output value in building materials industry

d) Collection and determination of other data concerned

- Prediction methods and results

Three methods, i.e. chronological extrapolation, theoretical curve and regression analysis are selected for prediction, and the results are given in Table 10.

Table 10 Prediction results by three methods

Unit: 100 million tons

Year / Method	2005	2010
Chronological extrapolation	6.3	7.4
Theoretical curve	7.0	8.2
Regression analysis	7.1	9.0
Averaged value	6.8	8.2

Based on the prediction results by three methods described above and the qualitative analysis of the actual cement consumption, the gross demand for cement in China is estimated as :

- about 640 million tons in 2005
- about 720±30 million tons in 2010

5.3.3 Prediction of the demand nationwide for rotary kiln cement in 2005 and 2010

On the basis of the prediction of national gross demand for cement and the input-output table published by the State Statistical Bureau, the dependence of major cement consuming sectors upon cement demand is analyzed, and the overall national demand (including that for separate sectors) for rotary kiln cement in 2005 and 2010 is predicted roughly as 200 million tons and 280 million tons respectively, see table 11.

Tab.11 Demand forecast for rotary kiln cement in 2005 and 2010

Unit: million tons

Item	2005	2010
1. Construction industry	140.00	200.00
1.1 Capital construction	110.00	140.00
Including:		
Urban house building	80.00	100.00
Basic industry (including infrastructure)	30.00	40.00
1.2 Production maintenance	20.00	30.00
1.3 Rural area	20.00	30.00
Including house building	10.00	20.00
2. Other sectors	60.00	90.00
Including manufacturing industries	40.00	50.00
3. National total	200.00	280.00

5.3.4 Prediction of gross demand for brick materials in 2005 and 2010

Clay bricks are of limited products. Some clay bricks must be eliminated or replaced by new wall materials gradually according to "the Tenth Five Years Plan of Building Materials Industry". On the other hand, along with the development of new-type wall materials and other substitutes social gross demand for brick materials in the future tends to slow down at a

slight pace. Gross demand predicted for brick materials in 2005 amounts to 652 billion pcs, among them 450 billion pcs of clay solid bricks and 202 billion pcs of non-clay bricks, slag blocks with 30% slag content and clay hollow bricks. The demand and supply will essentially balance with each other.

The demand for brick materials in 2010 is predicted as 595 billion pcs.

5.4 Analysis of Issues Related to 3E in the Existing Development Modes

5.4.1 The Chinese government has paid great attention to the sustainable development of the industry. The Tenth Five Year Plan gave full considerations to economic development, population growth, labor employment, conservation and better utilization of energy, water and mineral resources and the control of plant and community surroundings. Balance among these aspects are strived to harmonize the development for all society.

5.4.2 China is still a developing country with backward economy and funds deficit, consuming large amount of materials at low level. So much work should be done to better solve the relations between economic development, population growth, environment improvement, employment and social insurance.

5.4.3 Chinese building materials industry is not sound in respect of its structure, characterized by numerous of medium-sized and small local plants with outmoded and simple technologies and equipment, low utilization rate of resources, poor labor conditions and low productivity. Discharges from such plants and their living areas much impact the community environment. This indicates that long-term efforts should be made to sustain the development of building materials industry in China.

5.4.4 In the present development program and policies for this industrial sector emphasis is put on the economic restructuring with promoting the advanced while eliminating the backward. To reach such dual goal large amounts of funds will be needed, which is a thorny problem for the authorities and multiple enterprises to take into consideration. China's gross output of cement in 2001-2005 will be controlled at 600 million with nearly zero growth rate. Among this figure, the production by the new precalciner/preheater process will reach 120-130 million tons (i.e. output doubled), and the ratio of rotary kiln cement will increase from 26% in 2000 to 33% in 2005. Furthermore, a number of key cement enterprises will be supported to create 30 large-scale cement groups across the country, with their capacity reaching 120 million tons/a (15% of the total production capacity). As a result, the cement industry will be more concentrated and its overall competitive ability strengthened.

However, it should be noted that kilns still are the major part of China's cement industry, and

their technology and equipment have not yet been renovated critically. For reforming such operations fund input is needed and more environment protective measures will result in higher production cost. All these will to some extent constrain small plants to advance in respect of 3E.

It is planned by the government to cut down 100 million tons of outmoded cement production capacity by the end of 2000. According to the data published by the State Commission of Economy and Trade by the end of 2000 63.35 million tons cement production capacity by shaft kilns has been already eliminated, and additional 36 million tons production of its kind is not abolished due to various resistance, which should be done in the Tenth Plan to reach the target. Further abolishing of 50 million tons capacity has been set in the Tenth Five Year Plan. Therefore, in line with the target planned a total of 87 million tons capacity of shaft kilns must be eliminated during the Tenth Five Year Plan period, which is an arduous task.

5.4.5 Developing the advanced while eliminating the backward is the basic way to sustainable development. But the present levels of economic development and consumption have determined that there is a large gap between the market demand for new products and the government expectations.

- The Chinese government has constantly been promoting the development of rotary kiln cement, especially high strength cement produced by precalciner/preheater process. However, at present construction units are not eager to use such cement in large quantities due to their long-term habits. To change this situation needs mutual action of all sectors, such as suppliers, contractors, design and regulatory organizations.
- Due to production cost, sale price and other factors construction units prefer low price cement to cut down their engineering costs, neglecting how its is produced.
- Chinese government has long strived for promoting bulk cement to reduce the packing expenses, resources consumption and plant operational cost. But since the facilities for delivery and acceptance of such cement at the plants and users are both not completed, there also exists a gap between the real application and the government expectation.
- The authority has long promoted the application of novel walling materials and prohibited clay solid bricks. However, production cost of the former is mostly higher than that of the latter and builders cannot completely understand the administrative requirement. As a result, outdated products are prohibited but new ones lack demand, and existing enterprises of walling materials are put in a dilemma.

5.4.6 China has abundant raw materials for making cement and brick materials. But from the administration to the society, particularly producers, do not completely and truly understand the economic and social importance of conserving and saving such resources with more effective utilization.

China is rich in limestone resources, with total 1500 billion t. By the end of 1998, there were reported 1191 cement limestone deposits nationwide with over 50 billion t of proven reserves. In line with the present production capacity they can meet the demand for 40-50 years.
Also, there are abundant clay resources for making both cement and brick materials, especially in the west area. They can completely meet the production demand.

5.4.7 China is rich in low-cost labor resources. The government attaches great importance to employment. The building materials industry is a labor-intensive sector. On the one hand, its enterprises should raise the labor productivity by cutting down workforce; on the other hand, they should respond to the administrative call for enlarging employment. Thus, they are in a dilemma.

5.4.8 There is surplus of labor forces in China, and it is difficult for them to find a job. Enterprises enjoy multiple choices of enrollment. In this case, part of enterprises, especially small and private ones pay less attention to the welfare, labor safety and hygiene, etc, and sometimes breach policies and regulations in their action.

5.4.9 As there are not totally unified concept and targets for sustainable development among the central and local governments and enterprises so that an effective interaction cannot be realized.
Having numerous operations, the cement and brick materials industry has caused various economic and social problems. The central departments have been required to shut down small plants with quota distributed among various areas, even publishing the list of plants to be shut down. Although such enterprises consume more energy, severely pollute the surroundings and damage the ecology and operate with higher labor intensity, they contribute to the local economy; especially, the town/village owned plants are mostly the major financial source of those small communities. Therefore, local authorities cannot follow the central decisions, and even help such operations to escape from supervision and punishment for their local protectionism purpose.
In the process of any project approval the central and provincial/municipal governments pay great attention to the industrial and technological policies, especially the issues related to 3E. But some local authorities often do not pursue such policies. Even some enterprises are fraudulent in applying projects and fail to keep their commitment after a project is approved. A few plants have been forced to equipped with enviro-tech facilities but shut them down when no environmental authority supervises them.
The Chinese laws, regulations and standards related to pollution control are not many differences with other developing nations. Unfortunately, they are completely followed mostly by the state-owned and larger enterprises not by thousands of small and private

operations.

5.4.10 Chinese enterprises of cement and brick materials, specifically thousands of small plants lack skilled personnel. They are operating at low managerial level, and their workers are low in education with poor knowledge, legal concepts, social responsibility and awareness of sustainable development. All this also impacts such development of this industry.

6. Feasibility Analysis on Adjustment of Existing Status

This chapter deals with the possibilities for adjustment of existing condition, covering per industrial subsector, cement and bricks industry respectively. The feasibility analysis, separating different scale enterprises, large and medium-sized enterprises and small plants, covers such respects as technology, retrofit fund and beneficial result (profit) etc.

6.1 Feasibility Analysis on Adjustment of Cement Industry

6.1.1 Feasibility analysis for adjustment of large and medium-sized cement enterprises

The large and medium-sized cement enterprises, except for those in a few areas, should be renovated by the precalciner/preheater process with a production capacity of 2000t/d and over.

- In respect to technology: The precalcining technology has been developed in China for over 20 years. It has experienced 4 stages, i.e., independent R&D, introduction of turnkey plants, digestion & adsorption, and series development, At present the technology of precalcining kiln has fully been mastered in China, and the building of related facilities, and the construction and management of production lines has reached quite high standards. A number of specialists related have been fostered, and export of turnkey plants for cement making has also been realized.
- In respect to construction: In 1999 there were operating 706 large and medium-sized cement enterprises across the country, and a large number of them were favorable for technical renovation and further expansion. Existing enterprises can serve as a basis for further development, which will be beneficial to saving capital fund, reducing period of reconstruction to reach required capacity. As for the raw materials, the major one for cement production--limestone is widely and abundantly distributed in all provinces and regions, except only Shanghai City. At present traffic, transportation and electric power supply have remarkably been improved in all parts of the country, so most of large and medium-sized cement enterprises can be guaranteed transportation and water and electricity supply.
- In respect to finance: The cement industry has been listed as one of the key industries for structural adjustment by the state and, therefore, is expected to be financially sponsored by the state. For the time being more than 20 cement enterprises nationwide have been listed on stock market. They enjoy advantages in operational management, technological equipment, production scale, economic performance and market competitiveness, and thus are capable of fund raising. More important, with the reform of investment administration system and further straight-forward approval of investment projects by the government leading to shorter period of project preparation, the investment process will be speeded up to meet the desire of investors to a larger extent if professional and technical policies are complied with. In addition, since China will soon enter into WTO, foreign investment in the cement industry will augment to some extent, and those joint and/or sole foreign funded cement projects listed

in the Ninth Five Year Plan are expected to be approved and realized.

● In respect of profit: Since the Ninth Five Year Plan period overall prices have dropped down and with the implementation of the policy "lower investment and higher localization" and improvement of project control and management, for the time being the specific cost for technical upgrading of cement projects can be maintained at 500 RMB/t or so and for new projects at about 600 RMB/t, nearly twice lower than that in the Eighth Five Year Plan period. The construction duration ranges from 12 to 18 months, much shorter than before. All this has largely improved the investment efficiency, cutting down the production cost of part of new precalciner/preheater process to the equivalent level for shaft kilns, and improving the economic benefits (sale price of new precalciner/pricheater process cement is higher than that for shaft kilns).

6.1.2 Feasibility analysis for adjustment of small shaft kiln cement plants

● Regarding technology: Since the Eighth Five Year Plan period a lot of work has been done in refitting and upgrading of shaft kiln cement plants, for example, 14 energy-saving techniques have been worked out and spread throughout the country. Marked efficiencies have been recorded in the shaft kiln operations.

● Regarding financial respect: The larger shaft kiln cement plants should pool their funds mainly in developing precalcining process or rebuilding into grinding stations. More smaller shaft kiln plants suffer from low economic benefits due to their own less fund and weak capability in fierce competition on the market in recent years. They lack ability for technical retrofits and dealing with dust pollution.

● Regarding economic benefits: Energy saving oriented reconstruction and dust pollution abatement are good items for investment, which are beneficial to the society and the nation as a whole. But for such enterprises, dust abatement, which needs more fund input and higher operational cost, is regarded as a negative factor for their profits.

● Regarding overall production: The cement output in 2005 is set at 600 million tons. Approximately 100 million tons of backward cement production capacity should be abolished as defined in the Ninth Five Year Plan, and additional 50 million tons production capacity of shaft kiln cement will be shut down as required in the Tenth Five Year Plan, which calls for speeding up the development of the precalciner/preheater process. It can be seen that the state administration has firmly determined to control the gross cement production and adjust its structure. Nevertheless, abolition of backward plants concerns employment, liability, local interests and even the social stability at large, so it is difficult to implement.

As set in the Tenth Five Year Plan a total of 87 million tons(including 36 million tons due to last five-year plan) of the production capacity of the shaft kilns should be eliminated, which is an arduous task. However, over-emission of dust from such small shaft kilns is an unarguable fact of public concern. So abolition goal can probably be attained but only if the state

regulations on environment protection and product quality are strictly pursued.

6.2 Feasibility Analysis on Adjustment of Brick Materials Industry

6.2.1 Feasibility analysis on structural adjustment

The development principle of Chinese bricks industry in Tenth Five Years period is:
Carrying out sustainable development policy; insisting on the saving land and energy; protecting environment; fully utilizing recyclable materials; developing the production of upgraded bricks with high added-value, meanwhile, eliminating the production of clay bricks with high energy consumption and wasting natural resources to restructure the brick industry and upgrade the product mix and technology using in brick industry. The reasons to make achievement in works mentioned above are as follows:

- Resources conservation and pollution abatement constitute China's basic state guideline now actively implemented. China's white paper "Agenda in 21st Century", policies and measures elaborated by the central and local governments on remolding wall materials, especially the regulations published by the central government stipulating that before June 30, 2003 in 170 cities across the country application of clay solid bricks will be critically prohibited--all this has promoted the development of new wall materials and the structural adjustment of this industry. It is the government decision and determination that guarantees the political basis for realizing the above adjustment and advancement.
- Technical capability can be guaranteed. R&D of the production technology and equipment for new wall materials have been improved, and the products can be fully self-sustained with quality approaching or equivalent to that of the same products in developed countries.
- As for the funds needed, in line with the Tenth Five Year Plan 90billion pcs of new-type wall materials will be added in five years, calling for nearly 40 billion RMB in five year's input. Raising such fund will be difficult.
- A sound basis of this industry has been laid. The development of new-type building materials has dozens of years' history in China. In addition to a sound R&D basis, numerous experts engaged in research, production and management of the new-type wall materials sector have been fostered, and a stable competent team organized.

6.2.2 Basic routes for adjustment

- Large scale enterprises: Newly built large enterprises will further move on the track of scaling-up, diversification and conglomeration to become the backbone of this sector. Existing larger enterprises capable of restructuring will advance to "new industry". Number of large enterprises will be enlarged from 120 at present to 500 by the end of 2005 .

Technically in the large brick-marking enterprises large section tunnel kilns and manual drying technology will be adopted. Their cutting, stacking and delivery systems should be further improved regarding mechanization and automation to lighten labor intensity and improve labor productivity. The technology will also be improved with as much as possible

using of fly ash, coal gangue and other refuses or higher slag compositions to increase the product porosity and reduce coal and clay consumption. Enviro-tech measures should be upgraded with attention paid to dedusting and desulphurization and dust emission reduced.

Fund for the above adjustment is estimated at around 5,900 million RMB.

Such adjustment can reduce energy consumption, environment pollution and employment but increase production cost and sale price.

- Medium-sized enterprises: Such enterprises will be refitted in dual-direction. Part of them will advance towards scaling-up and new industry while another will be renovated with improvement of existing production technology and maximum utilization of industrial wastes or more slag compositions where possible.

Technically, tunnel kilns and manual drying process will be employed with mechanized cutting, stacking and delivery systems to enhance the labor productivity, The number of medium-sized enterprises will constantly be enlarged from 2500 at present to 4500 in 2005.

The fund input for the above adjustment is estimated at about 16.1 billion RMB.

The adjustment will lead to a higher energy consumption and lower production cost, and is beneficial to improving environment and reducing employment.

- Small brick-making plants. Such plants will undergo technological upgrading where possible to raise their technical standards or will be shut down or shifted to other operations if unavailable for restructuring.

Adjustment in this field will cost about 2 billion RMB. It will result in a bit higher energy consumption and production cost but environment improved and employment shrunk.

7. Study on the Scheme for the Sustainable Development of Cement Industry

Based on the establishment of development program model with plenty of fundamental data acquired through years operation of our institute and experts commitments, this chapter primarily proposes three scenarios for the sustainable development of cement industry. They are:

Scheme One: maximum economic return

Scheme two: environmental protection

Scheme three: technical progress and scaling-up

7.1 Basis of the Study on the Scheme

- Strategies for the sustainable development of China in 21st century
- The Tenth Five Year Plan for the development of national economy
- Cross-century development strategies for the building materials industry in China
- The Tenth Five Year Plan for the development of the building-materials industry
- Forecast for the demand and supply of the cement market in 2005 and 2010
- Information on the present situation of production and demand of the cement industry and the present situation related to 3E.

7.2 The Basic Philosophy in the Formulation of the Scheme for the future Sustainable Development

The basic definition of the sustainable development of an industry should be as follows: its production should not only meet the needs of peoples at present, but also shouldn't damage the capacity of descendants to meet their needs. In other words, the relationship among three factors of economic development, environment and employment (including social common welfare) should be handled properly to create for the descendants a more glorious and more generous condition of existence.

As for the sustainable development of cement industry, the core is to properly handle relationship among numerous factors, such as economic growth (including meeting the demand of contemporary people for the cement products, profit making for enterprises, increase of taxes recovery for the government), rational utilization of resources, decrease of environmental damage, improvement of welfare for employees and raise of employment.

Analyzing these factors, we can see that the relationships are very complex. They, at least, include the following respects:

- The changes in requirements of concerning sides to the cement industry.
- The changes in demands in cement market.
- The present condition, changes and the extent of guarantee of various corresponding natural resources.
- Fund demand and possibility of investment
- The effects of different production modes and methods on environment.

- Labor force factor (availability of labor force, employment condition in the society, welfare condition of employees)
- Condition of profit making for enterprises (costs, price, profit and taxes)
- The present situation of the economic and social development in China and the economic management system, mode and ability of the government.
- The former and current laws and regulations, policies, standards and norms and their transparency.
- People's consciousness on resources and environment

It is hardly possible to find out in an all-round way and systematically a rational combination of above-mentioned four (perhaps more) aspects. Consequently there are many schemes for sustainable development provided for study, and to study every scheme is impossible. The research group thinks, that the sustainable development of cement industry, in the final analysis, involves the changes in production capacities, production technologies, funds, benefits, environment and employment, in other words, that under the actual circumstances in China, how to find out a relatively optimal way and scheme in which the waste of resources and energy, emission of pollutants and damage to the environment of the society will be reduced as much as possible and the employment opportunity is enlarged in a prerequisite of satisfying the market demands, economic growth and profit making for the enterprises.

Based on above-mentioned philosophy, the research group sums up the study on scheme for the sustainable development of cement industry as to study 10 objective factors as the increase of production capacities in the future, investment, output value, costs, profits and taxes, energy consumption, discharge of pollutants, labor employment, labor productivity and the rate of technical progress.

The development way of cement industry in the future can also be summed up as the following 21 development ways:

- To newly build the cement production lines with precalciner/preheater process with daily capacities of 7000t and above, 4000t, 2000t, 1000t, 700t of clinker;
- To enlarge the production size of the enterprises on the basis of existing production capacity. To build the cement production lines with precalciner/preheater process with daily cement clinker production capacities of 7000t and above, 4000t, 2000t, 1000t, 700t;
- To eliminate shaft kilns in part of shaft kiln enterprises. To transform their production lines into those with precalciner/preheater process with daily capacities of 2000t or 1000t, using the applicable installation and equipment;
- Those shaft kiln production lines, which can not be either transformed into production with precalciner/preheater process or subjected to environmental protective or energy-saving renovation, should be eliminated;
- As for those shaft kilns, limited by the conditions, which can not be transformed into the production lines with precalciner/preheater process, they should be subjected to environment

protective or energy saving or comprehensive renovation, so as to make the production lines energy-saving and environmental protective ones;

- The production lines with rotary kilns other types can be transformed into those with precalciner/preheater process. Part of wet-process kilns, semi-dry process kilns and dry-process plain kilns with higher energy consumption should be eliminated.

Every way has some specific quantitative relationships with those 10 objective factors mentioned above. The fact provides us a possibility to analyze the problems on sustainable development through establishment of mathematical model and using theory of linear programming.

Our target is to find out a way to achieve better investment benefits, smaller resource and energy consumption and smaller discharge of pollutants in the years to come using possible investment on the basis of satisfaction of market demand.

7.3 The Establishment of Model of Development Program and Fundamental Data

The establishment of fundamental data of model of development program is to set up some mathematical relationships of 21 development ways with resource, energy, allocation of labor force, production capacity, benefits, emergence of wastes based on 21 development ways of cement industry in the future. The pattern of the table (table 11) of detailed data is as follows:

Rows: The 21 ways of development of cement industry in the future

Columns: relevant factors, the main of them are capital investment, allocation of labor-force, used land, consumption of limestone, consumption of coal, consumption of electricity, water consumption, total costs, newly added production capacities, newly added output value, newly-added profits and taxes, taxes, discharge of waste water, discharge of dust, discharge of fume, CO_2 emission, SO_2 emission.

The data are determined in accordance with many years experience of our institute in consultation and evaluation works for cement projects referring meanwhile to the standards for the construction of cement enterprises.

Table 12 Fundamental Data for the Model of Sustainable Development Program

Index	Investment	Employment	Lime stone consumption	Coal consumption	Total cost	Capacity increment	Output value increment	Tax & profit increment	dust discharge	SO2
Coefficient	a	b	c	d	e	f	g	h	I	j
Development way	Million yuan	People	1,000 tons	Ton (standard coal)	Million yuan	1000 tons	Million yuan	Million yuan	ton	ton
Build up 7200t/d precalcining production line	1900	700	2800	22.4	568.65	2500	598.29	74.51	6.50	310
Build up 4000t/d precalcining production line	900	500	1680	13.4	325.35	1500	358.97	60.55	4.50	195
Build up 2000t/d precalcining production line	400	400	840	6.9	163.70	750	176.28	25.80	3.00	105
Build up 1000t/d precalcining production line	210	300	390	3.5	81.58	350	80.77	4.84	1.75	65
Build up 700t/d precalcining production line	160	260	270	2.6	60.19	250	56.62	0.40	1.30	50
Expand existing production line to 7200 t/d	1650	550	2800	22.4	540.40	2500	598.29	102.76	6.50	310
Expand existing production line to 4000 t/d	710	450	1680	13.4	305.65	1500	358.97	80.25	450	195
Expand existing production line to 2000 t/d	300	350	840	6.9	153.00	750	176.28	36.50	3.00	105
Expand existing production line to 1000t/d	170	250	390	3.5	76.04	350	80.77	10.38	1.75	65
Expand existing production line to 700 t/d	130	220	270	2.6	55.84	250	56.62	4.75	1.30	50
立窑改造为 2000t/d 新型干法生产线	240	-1600	174	-1.2	20.37	0	34.76	20.72	-124.20	-1080
Retrofit of shaft kiln to 1000 t/d precalcining kiln	130	-550	81	-0.3	14.09	0	14.66	3.01	-57.26	-488
Retrofit of 3 sets of wet kilns 3 to2000 t/d precalcining kiln	110	-1000	101	4.8	-15.04	0	3.21	21.94	-33.00	-195
Retrofit of Small size shaft kiln	11.4	100	95	1.47	18.75	96	22.15	4.62	-1.20	
Retrofit of shaft for energy-saving and environment protection	3	-75		-0.09	-0.09	0	0	0.09	-14.31	0
Technical innovation for energy-saving	1	-75		-0.09	-0.44	0	0	0.44	0	0
Technical innovation for environment protection	2	-75		0	0.35	0	0	-0.35	-14.31	0
Close down shaft kiln	0.3	-250	-73	-0.89	-15.57	-88	-16.17	-1.41	-15.28	-139
Eliminating wet process	0.8	-500	-219	-3.89	-59.58	-250	-57.69	-1.29	-12.50	-100
Eliminating semi-dry process	1	-680	-318	-4.48	-78.29	-340	-78.46	-5.27	-23.80	-130
Eliminating outdated dry process	0.4	-350	-124	-2.42	-34.37	-140	-31.71	0.60	-9.80	-50

7.4 The Setting-up of Selectable Schemes

Based on the theory of linear programming and collected data of cement industry, the study team proposed three schemes for the sustainable development of cement industry.

Scheme One: maximum economic return

As Chinese building materials industry is relatively backward with low economic return, to change the backwardness is a key resolution for building materials industry at present and henceforth for a certain period. Scheme one finds out the maximum profits and taxes recovered from per ton of cement produced by the future cement industry in a prerequisite of satisfying principal demand of the market and under the restrained condition of rational investment scale (it is determined in accordance with investment volume to cement industry in China in the past 5 years). The result shows that investment should be put into building of production lines with precalciner/preheater process with a daily clinker production capacity of 2000t, which are of reasonable size and have a quite good benefit index. As for kilns of types other than those with precalciner/ preheater process, they should be subjected to appropriate renovations if the funds are available. The number of shaft kilns subjected to be eliminated and transformed will account for about half of their total. Environment protection and energy consumption will serve as the supplementary ones to meet the national minimum requirement

The mathematic model is detailed as follows:

- Objective functions

  $Y_{\text{tax \& profit}} = (929000+\Sigma X_i h_i) / 0.9(70301+\Sigma X_i f_i)$

  $(i=1,2.....21)$

- Main binding factors

a. Total investment $\leqslant$50 billion yuan

Foundation: The total investment is estimated to reach 50 to 60 billion yuan RMB for cement industry in the period of 1995-2000; It's expected to decline to 50 million yuan RMB in the period of 2001-2005 as retrofit of existing production facilities is emphasized on the industry development which must require lower capital investment than building up new plants.

b. Total capacity $\leqslant$764.70 million tons

Foundation: the total demand of cement is predicted to 650 million tons. The effective capacity is expected to 85% of installed capacity.

c. The number of production lines with capacity of 4000t/d $\leqslant$30

By the end of 2000, nine production lines had been operating. Considering present states of capital investment and economy development all over the country, it is impossible to set up more than 30 production lines in the next five years after 2000, experts forecast.

d. The number of production lines with capacity of 2000t/d $\leqslant$120

By the end of 2000, the number of production lines with capacity of 2000 t/d was 30. It is expected to be less than 120 by the end of 2005.

d. The number of production lines with capacity of 1000t/d $\leqslant$The number of production lines with capacity of 2000t/d

According to the industrial policy, building up 1000 t/d production line is not encouraged. Therefore, the development of 1000 t/d production lines must be limited.

f. the total capacity of shaft kilns closed down should less than the total present capacity of shaft kilns

f. The eliminated number must less than 50% of present number for rotary kilns

According to industrial policy, the elimination and retrofit focus on shaft kilns. It is limited in retrofit or closing down of some precalcining and rotary kilns that depend on the intention of enterprises.

- Evaluation: $Y_{\text{tax \&profit max}}$

The detailed result is in table 13

Scheme two: environmental protection

In this scheme, environmental protection, i.e. the discharge of pollutants in cement industry is the objective function, the aim is to find the least cost solution that satisfies the basic demand of the market and taking the control of rational investment size as the restraining condition. In view of a fact that the existing rotary kilns of other types (those types of kilns with wet process, semi-dry process, small-sized dry process and other processes) are not included in the category of elimination according to present industrial policies, and they can not be completely closed down or eliminated in the 5 to 10 years to come in a view of national conditions. The number of elimination of these rotary kilns was restrained ultimately within 50% of the total. The result of calculation on the model shows, that achievement of discharging norm for all existing cement enterprises is required. Hence, the obtained scheme is to establish an appropriate number of production lines of the precalciner/preheater process along with the transformation and the elimination of the other types of kilns within the restrained scale. The existing shaft kilns are all subjected to comprehensive renovation and a renovation regarding environmental protection except for those to be eliminated.

- Objective functions

$Y_{\text{dust discharge}} = 9720200 + \Sigma X_i i_i$

$(i=1,2.....21)$

- Main binding factors

The same as in scheme 1

- Evaluation: $Y_{\text{dust discharge min}}$

The detailed result is in table 13

Scheme three: technical progress and scaling-up

This scheme emphasizes the technical progress, meanwhile the possibility of new construction, transformation and elimination was considered in the light of specific conditions in China. The research team and experts combine the prospects of scheme one and scheme two to formulate scheme three. The scheme consist of a batch of large-scaled modernized production lines with a daily production capacity of 7200t and above, which reflect the update

technical standard, 128 production lines with a daily production capacity of 2000t and above through new construction, expansion or transformation, and to eliminate 778 shaft kilns, so as the overall level of the technology and equipment in the cement industry will be upgraded to a new stage.

The specific indexes for each scheme are shown in the Tab.12.

Table13: The concrete indexes for each scheme

Schemes of development			Scheme 1	Scheme 2	Scheme 3
Objective functions		Unit	Top in profit and tax	Least in pollution	Technical progress
Production	Capacity (each line)				
lines	7200	tons/day	0	0	3
	4000	tons/day	18	8	8
	2000	tons/day	119	84	120
	1000	tons/day	0	35	100
	700	tons/day	0	2	15
Elimination of shaft kilns		Set	481	703	778
Total number of shaft kilns		Set	3442	6558	5248
Elimination of wet-process kilns		Line	16	11	34
Total number. of wet-process kilns		Line	81	81	62
Elimination of semi-dry process kilns		Line	5	5	5
Elimination of old dry-process		Line	212	212	134
Renovation of small rotary kilns		Line	152	152	91
Mean profit and tax per ton		RMB/t	23.36	19.68	20.44
Investment		Billion RMB	50.00	50.00	80.00
Dust emission		kt	8750	1280	3530
Coal consumption for cement		kg/t	106.7	106.9	105.7
Labor productivity		t/capita	510	590	570
Unit cost		RMB/t	183.8	184.9	189.1
Labor force		1000 people	-308	-555	-442

8. Comparative Analysis of Submitted Scheme

This chapter analyzes the submitted three schemes of chapter7. The following sub-chapters are set up for discussion in this chapter:

Estimation of newly added investment required by each scheme;

Analysis of the production cost for each scheme;

Analysis of the influence on employment for each scheme;

Analysis of the influence in the utilization of energy for each scheme;

Results achieved in prevention of environmental pollution by implement each scheme

8.1 Estimation of Newly Added Investment Required by Each Scheme

For the Scheme One and Scheme Two, we restrain the total amount of investment in 50 billion RMB in the light of the objective fixed in the Tenth Five Year Plan of cement industry. Under this precondition, the calculation results show that the production lines with a clinker production capacity of 2000t/d, 4000t/d, 1000t/d with relatively advanced technology, rational investment and good economic indexes are the stresses of construction (including technological transformation) in the scheme one and scheme two. The overall investment required for the lines are 49.82 billion RMB and 49.97 billion RMB respectively. As far as the total sum of investment, the investment amount of 50 billion RMB may be a relatively conservative figure, and the possibility to realize and exceed 50 billion RMB of fixed asset investment is realistic in the cement industry. As for the level of the technology and equipment, the industry applies mainly the mature and applicable technologies. The industry has a considerable gap with the world advanced level in the production scale and technological sophistication.

Scheme Three emphasizes the factors of the technical progress without a restriction for the scale of investment. China has a vast territory, a broad prosperity of market and abundant resources of limestone, among which some deposits are large and of high grade. In the region with abundant resources and preferential condition for investment, it is preferable to construct the clinker production lines with a daily capacity of 7000 t and more. Considering that the development and construction of large cement clinker production lines is the orientation to be supported and encouraged for the development of the industry, so the scheme suggests the construction of three production lines with a daily capacity of 7,000 t. With the reform of operational system in China, Chinese government weakens gradually its function in control and management of construction projects. The enterprises expand their power of autonomous decision-making. As the low investment, fair benefits, as well as the right of local government to examine and approve the projects, there will be a considerable increase of production lines with daily capacity of 1000 t and below, though it is not supported according to the national industrial policy. By the calculation on computer, the total sum of the investment for this scheme is 80 billion RMB.

8.2 Analysis of the Production Cost for Each Scheme

In 2000, the unit cost of cement product for each unit dropped down to below 200 RMB for the first time, namely 197 RMB. The unit production cost calculated for the three submitted schemes are reduced at a certain range and reach 183.8 RMB/t, 184.9 RMB/t and 189.1 RMB/t respectively. The main reasons for the fall of the costs are that all newly added capacities are those with the new advanced precalciner/preheater process with their consumptions of heat and electricity for cement production being lower than those of shaft kilns. Simultaneously, the standard of management is universally upgraded as the production scales of enterprises are enlarged, which leads to the fall of production costs to a certain extent.

8.3 Analysis of the Influence on Employment

At present, Chinese cement industry depends on labor-intensive enterprises, with a total of 1.656 million employees in 2000. In the submitted schemes a priority is given to the new precalciner/preheater process, the levels of technologies, equipment, automation and management of which will be highly upgraded compared with those in the existing enterprises at present, so that the fixed numbers of labor posts can be reduced. The calculation results show a reduction of 308,000, 55,500 and 44,200 employees respectively for the three schemes. Under the current economic system in China, the reduction of the fixed members by more than 30% will possibly result in social problems in connection with the unemployment, though it will facilitate the increase of labor productivity for enterprises.

8.4 Analysis of the Influence in the Utilization of Energy

At present, the average comprehensive consumption of coal in cement production is 120 kg standard coal /t. In the submitted schemes, the consumption of practical coal are reduced at different rates and the utilization of energy is more reasonable. The results of calculation are 106.7kg standard coal / t, 106.9 kg standard coal / t and 105.7 kg standard coal / t respectively. As shown above from the results, that the Scheme Three leads to a lowest consumption of coal in kind in the process of cement production, which is fundamental for the reduction of emission of waste gas.

8.5 Results Achieved in Prevention of Environmental Pollution

Dusts, exhaust gases (carbon dioxide and nitride, etc.) and noises are the main pollutants in cement production. There are many types of production technologies in cement enterprises in China, of which the majority are those with shaft kilns and the number of cement enterprises using the precalciner/preheater process occupies a relatively little proportion. Dusts and exhaust gases mostly emit from the production lines of the numerous shaft kiln enterprises, as the emission from the new-type precalciner/preheater process production lines reaches the

standards. In order to control the emission of dusts, it is essential to eliminate or transform the existing shaft kilns. In accordance with the calculation results from submitted schemes, 481, 703 and 778 shaft kiln production lines will be eliminated respectively and the pollutants emission indexes will reach 8.749 million tons, 1.283 million tons and 3.531t respectively. Thus it can be seen, the key to depress the pollution in the cement industry of China is to eliminate, renovate and upgrade the cement production lines of shaft kilns.

9.The Recommended Scheme for the Sustainable Development of the Cement Industry

On the basis of analysis in chapter8, according to the basic principles for the determination of the sustainable development plan, this chapter recommends the submitted scheme three, the development scheme of technical progress and scaling-up pattern for the sustainable development plan of cement industry.

9.1 The Basic Principles for the Determination of the Scheme for the Sustainable Development:

- In the light of the trend of the global economic development, the progress in science and technology plays more and more important roles and has become a fundamental impetus in the development of the cement industry with implementing the strategy of invigorating the country by relying on science, technology and education. There is nothing but the application of the advanced technology and equipment for production to settle the matters on the sustainable development for the cement industry radically.
- The development of economy with the improvement of economic benefits for the building materials industry and the change of its backward situation is a precondition for the realization of the sustainable development.
- China is a developing country with an undeveloped economy. The economic developments in different regions are quite different, and there are different understandings for the sustainable development. Minority of regions, giving the priority to the local interests and near future interests, ignores the sustainable development of the economy. Consequently, the macroscopic regulation and supervision of the governments is one of the most effective means for the realization of the sustainable development. Along with the economic development and heightening people's consciousness, the concept for sustainable development will gradually become the conscious behaviors of enterprises. As to the existing shaft kilns, at least 80% of the enterprises should precede energy conservation, environment protection and comprehensive transformation to satisfy the need for the sustainable development except of those determined to be eliminated in the state related policies. For those rotary kilns except for those of the precalciner/preheater process, the transformation and the elimination are still the enterprises' behaviors at present. They have a certain advantage over the shaft kilns. The number of rotary kilns subjected to transformation will not exceed one third of the total.

9.2 Recommended scheme

On the basis of the determination of the above three submitted schemes, we once again convened the specialists and experts to analyze and attest the submitted schemes and determine the Scheme Three as a recommended one at last.

The general concept of this scheme is to build up modernized large production lines and

optimize the management, upgrade the qualities of products and increase profit of enterprises through technical progress, restructuring industry, the elimination and transformation of the backward production; to pursue clean production by the application of advanced technologies and equipment; To achieve the energy conservation, decrease of material consumption, reduction of pollution and finally realize the sustainable development by the elimination and transformation of the shaft kilns and dry process plain kilns bringing about severe pollution and wet-process kilns with high energy consumption.

With the overall investment of 80.1 billion RMB, the scheme suggests the new establishment of 3 clinker production lines with a capacity of 7200 t/d, the renovation or new establishment of 131 production lines with a capacity of 2000 to 4000 t/d. 5248 sets of shaft kilns, 62 lines of wet-process kilns and 91 lines of small rotary kilns are involved, and 951 lines of shaft kilns, wet-process kilns, semi-dry-process kilns and old dry-process kilns with an overall capacity of 741.5 million tons are proposed to be eliminated. Having implemented the scheme, the overall capacity of cement production will reach 766.55 million tons, in which the capacity of rotary kilns will be 342.06 million tons, accounting for 45% of the total capacity of the country, that of the precalciner/ preheater process will be 242.89 million tons, accounting for 32% of the total. Compared with the situation at present, 160 million tons of the cement production capacity with the precalciner/preheater process will be newly added, and the pollution of dusts and exhausted gases will drop 64%, the entire labor productivity will be improved by 61%, the energy consumption and production costs will greatly decrease.

10. The Policies and Measures in the Program for Sustainable Development

This chapter makes a recommendation for policies to implement the plan recommended under chapter9 on the bases of analysis of practical situation of China building material industry and current relevant policies. The following issues are set up for discussion:

- Enhancing the government, the cement enterprises and all sectors concerned to understand sustainable development and take coordinated actions on it furthermore;
- Encouraging and supporting the adoption of advanced production technology;
- Introducing development fund to large and medium scale cement production with precalciner/preheater process;
- Encouraging the application of high grade and top quality cement, bulk cement and new walling materials.
- Normalizing enterprises' behaviors in energy usage and environment control
- Enhancing scientific management
- Revising environmental standards on cement and brick industries and popularizing series of managerial standards to meet the international criteria.
- Strengthening international co-operation.

In 9.2 the Research Group suggests an ideal development scheme, which should be adopted in the future 5 years to keep the Chinese cement industry sustained develop. To realize this scheme, there should be many conditions, furthermore, there should be also a series of matching policies and measures as a support. The followings are the measures suggested by the Research Group.

10.1 Involving Relations with Multiple Sectors, the Sustainable Development of Cement Industry Can Be Realized only by Understanding of the Central Government, the Cement Enterprises and All Sectors Concerned and through Their Coordinated Actions

Among all relations the government understanding and support is of paramount importance.

For the time being China is still in the transition from the planned economy to the market one, so the government ability to adjust economic policies and administrate enterprises' behaviors remains quite strong.

For China's cement industry its buyers' market has been seen for years with cement oversupply, which has resulted in a mind among several economic administrations that the position and role of cement in the national economy is no longer so important as in the years of its shortage. Although they have acknowledged that the cement industry should subject to substantial structural adjustment and technical up-grading for its sustainable development, they adopted only simple administrative measures to call on shutdown of out-moded plants but no real and concrete ones to support the development of more advanced enterprises. For China's cement industry, especially, the structural contradictions were formed long during the period of planned economy, and to remold such situation its state-owned and collective enterprises will be affected to the utmost with much more difficulties.

For this part of enterprises, how to improve their technical standards at expenses with

resources conservation, environment improvement and social insurance to tackle unemployment should be considered by the government, which cannot be resolved only by the enterprises themselves.

It is suggested that financial expenses be borne on the government to help the out-moded state-owned enterprises restructuring or withdrawing from the market, compensating for the losses and social insurance outlay incurred to such enterprises during implementing the liabilities of social sustainable development.

10.2 Elimination of the backward Can be Effective only by Promoting the Advanced, so the Government and Enterprises Should Establish the Basis with Practical Methods to Encourage and Support the Advanced Large and Medium-sized Enterprises Employing New Precalcined Cement Production Technology with the Precalciner/Preheater Process.

The Research Group holds that the recommended scheme is only a directional option beneficial to the sustainable development, meaning in no way that any figure cannot be changed. Basic points of the scheme are described as follows:

For the sustainable development of the cement industry in China it is necessary to properly develop a number of large and modern plants with a capacity over 7200t/d representing the up-to-date technology in this sector and with great efforts to remold, expand and/or build cement production lines of precalciner/preheater process with a capacity between 2000 and 4000 t/h. This is the primary direction for the future development of China's cement industry. Meantime, shaft kilns, wet-process kilns, old and semi-dry process should resolutely be remolded with those infeasible for restructuring eliminated.

Development of the advanced is the direction, target and decisive factor. Due to the limited market volume, the advanced will naturally be developed at the expense of the backward being eliminated.

At present, the market economy mechanism in China is not complete enough. Since there exist local protectionism and unfair competition, sometimes obsolete products still have competitive edge and even the promotion of advanced ones has thus hindered. Therefore, it is a must to shut down such obsolete and small plants. However, in this regard the authorities prefer administrative measure to economic compensation, which is the basic cause of unsatisfactory elimination of the backward in past years.

The Research Group holds that under the conditions of market economy for the part of the authorities necessary economic tools and/or technical measures should be taken instead of simple administrative orders to create an atmosphere beneficial to eliminating the backward.

First of all, large and medium size cement production with precalciner/preheater process should be encouraged and supported. Only by developing the advanced and normalizing the market behaviors cannot naturally the backward survive. However, some administrative authorities sometimes regard the construction of such production plants also as repetition and

put obstacles to their approval, resulting in a number of investors withdrawing such projects due to permission not available.

Secondly, the behavior of enterprises should be normalized through more strong legislation and technical measures.

Lastly, there are numerous small cement plants operating regardless of the national environment control norms, thus causing relatively severe pollution with discharges beyond the norms, and still hundreds of illegal plants operating without legal license. How to tackle such problems as law existing but not obeyed or obeyed but strictly and law violations not punished remains an important issue for the government to resolve resolutely. It is a pleasure to see that the government has been fully aware of the severity.

It is the basic guideline the government should establish to gradually force the obsolete small plants out of the market by applying market mechanism, expanding the advanced, elaborating more strict technical standards and enforcing law.

10.3 Making Effective Policies to Encourage and Introduce Funds Input into Large and Medium Scale Cement Production with Precalciner/Preheater Process

Sustainable development should be ensured by fund input. How to introduce and mobilize various sectors to input funds into such cement production projects is a key to the development.

Chinese cement industry is deficient in its own financial resources with its construction projects costly relying on the bank loan. However, banks prefer to input funds into such projects of higher return and faster recovery as those for personnel expenses, high-tech or infrastructures guaranteed by the government. They do not concern about the expenditure added by the cement industry to improving the environment, and the government cares for it inadequately. Therefore, to allure more funds from the society it is necessary for the government to make a series of policies such as:

Relieving the limitation imposed on approval of large and medium-size cement projects with precalciner/preheater process;

Providing financial compensation for the small plants out of the market and necessary social insurance for their laid-off workers;

Investment expenditure from the financial income of the central government and governments at all levels should be properly inclined towards the development of large and medium-size cement projects with precalciner/preheater process as a guideline; and

Relieving the limitation on securities and bonds issued on the stock market by the existing large and medium-size cement enterprises so as to raise more funds from the society for more cement enterprises.

10.4 Proceeding from the Construction Sector, Wider Application of High Grade and Top Quality Cement, Bulk cement and New Walling Materials Should be Encouraged to

Create More Favorable Climate for the Clients of Superior Building Products.

In order to up-grade the grade and service life of concrete in China and enlarge the application of bulk cement, and new walling materials based on waste-utilization, energy saving, environment protection and light weight common sense and coordinated cooperation with active measures should be established among all members of the construction sector, including investors, contractors, suppliers, design and engineering firms.

Herein, it is indispensable to revise or improve the product standard, design codes and engineering regulations. Especially, it is necessary to revise Chinese classification standards on cement. Not only the testing methodology on cement strength should be switched on the track of the international standards but also the classification standards of cement revised as soon as possible.

10.5 Enforcing the Implementation of Energy and Environment Protection Laws and Policies with Normalizing Enterprises Behaviors in Energy Usage and Environment Control

Publicity of laws, regulations and policies in this field should be enhanced so as to let more enterprises be aware of their true meaning and pleased to put them into action.

Product quality law, environment control law, standards on industrial pollutant discharges and pollution abatement and other regulation are all compulsory for any enterprise to implement unconditionally. All legal executive bodies should pursue them strictly and fairly out of any interference and remedy and/or punish all violations resolutely.

10.6 Enhancing Scientific Management and Improving the Environmental Consciousness of Managers and Staffs

- For all production structures and mining pits during their development, production and shutdown periods the impact on environment should be minimized with their surroundings beautified as possible.
- The ecosystem and biological variety around the plants or affected by their operation must be protected or restored. Especially, the mined-out areas should be rehabilitated to forest or grass lands as possible.
- In the production processes mixing with low-grade raw materials, industrial refuses and municipal garbage must be maximized to improve the utilization rate of raw materials and fuel. Meantime, advanced technologies and managerial expertise should be introduced to more effectively and economically utilize energy and other resources.
- Modern managerial regime of enterprises is to be initiated, and all national norms and standards regarding energy, environment control, labor safety and health care must be followed strictly and consciously with civilized and clean production.

10.7 Environmental Standards on Cement and Brick Material Industries Will be

Revised to Meet the International Criteria

10.8 Great Efforts Will Be Made to Popularize Series of Managerial Standards Such as Certification of ISO9000 Quality System and ISO14000 Environmental System and ISO10040 Environmental Harmony Evaluation. And the implementation of such standards shall be closely linked with the measures for technical transformation to attain physical results.

10.9 The Enterprises Should Enhance Their Welfare Consciousness and Ensure Hygienic Conditions in Production for the Staffs and Workers. Also, they shall improve the labor productivity via training and set up sound welfare provisions.

10.10 Strengthening International Co-operation.

Further opening up to the outside world will be carried on to widely absorb the world capital and advanced technologies for advancing the production of super quality cement and superior brick materials.

Considering that China is both the Largest producer and largest consumer in the world in respect of cement and brick materials, worldwide organizations and developed countries may provide support and aid to the sustainable development of the building materials industry in China, especially in the field of fund, technology, management and new projects.

10.11 The study team notices that during elaboration of its Tenth Five Year Plan the City of Taiyuan, Shanxi Province, China Put Forward the Target to Cut Down SO_2 Emission of the Whole City by 50% in 2005 Compared to 2000 and Introduced the Discharge Right Exchange Mechanism under the Support of Asian Development Bank Via Loan and Technical Aid Fund. This program is under testing, and it is difficult now to evaluate its factual result. However, the Group is very interested in such program to improve environment control through pollution abatement, suggesting that the authorities concerned pay due attention to it and initiate a feasibility study on its wider testing

11. Analysis of Unfavorable Factors Influencing the Sustainable Development

This chapter analyzes the barriers to hinder the sustainable development of building materials industry in China. The analysis mainly concentrated on the following respects: controllability of the government; environment and public welfare consciousness of enterprises; social liability; enterprises' interests of their own; effect of project management mechanism; Unbalanced economic development in various regions; less sound various economic rules and regulations, etc..

In implementing the sustainable development program the building materials industry in China faces some unfavorable factors. The major ones are as follows:

11.1 Controllability of the Government

Although the authority is fully aware of the importance and urgency of the industrial structural adjustment and sustainable development and is making more efforts in this respect, it is rather difficult for it to render more expenditure, especially policy-making and financial support for the sustainable development of building materials industry since China is still in the developing phase encountering difficulties in various sectors

11.2 Environment and Public Welfare Consciousness of Enterprises

Since China is in the developing stage, especially its economy is in transition with the market competition not well regulated, enterprises consider much more about their own interests and adapt themselves to the requirements in this respect only by the government enforcement. It will last long for them to enhance this consciousness and put it into conscious action.

11.3 Social Liability

In recent years Chinese government has done much in publicity and practical work,so environment awareness has been spurred to some extent among the public and society. However, due to the economic limitation, the public, especially most of farmers are still lacking of sound sense of the sustainable development. As a result, damages to their surroundings or ecosystem are often not prohibited legally, even their own legal rights canceled, which results in more law and regulation violations not properly prosecuted.

11.4 Enterprises' Interests of Their Own

Since the building materials enterprises are operating with rather low economic efficiency and profit with shortage in their own funds and are difficult in getting the bank loan, there exists considerable resistance to input more investment or raising cost of/or safeguarding public benefits or long-term social interests at the expense of their own benefits.

11.5 Effect of Project Management Mechanism

For the time being a larger project of building materials should still subject to administration

approval with complete procedures and a project lasts for years during construction. Even some projects cannot be approved after years' preparation and set aside.

11.6 The Economic Development in Various Regions Is Unbalanced

Moreover, There exists Severe Local Protectionism, and Funds Cannot Flow Freely with the Market Separated and Local Monopoly. All This to a Certain Extent Protects the Backward.

11.7 Various Economic Rules and Regulations Are Not Sound and Complete Enough.

There are quite often seen such phenomena as law implementation not strict or law violations not prosecuted in some undeveloped areas.

12. Conclusions of the Study

12.1 As an important raw materials sector in China's national economy, the building materials industry plays an important part in the economic construction, industrial and agricultural production and people's livelihood. Since the opening-up initiated in 1978, the industry of building materials has rapidly grown at the average rate of 10% per year. Now there are over 200,000 enterprises of this industry nationwide, contributing a lot to the economic development and employment.

12.2 Deficient in Financial Resourced and Advanced Technical Equipment Preparation and Driven by the then Huge Demand, China's Building Materials Industry has seen Extensive Expansion during its Growing Period. Compared to the international standards, it is characterized by dispersion of enterprises, especially small plants, low technical content, small variety and low quality and grade of products. Besides, its enterprises consume more energy with low abatement of dust and gas emissions. Furthermore they provide unsatisfactory conditions of labor safety and hygiene, social welfare and insurance.

12.3 For a number of years Chinese government has paid great attention to the sustainable development and promulgated multiple laws, regulations and policies beneficial to sound utilization and saving of resources, environment control, employment, social insurance and labor rights, and the authority of the building materials has also issued series of policies, standards and measures of the same kind. All this has recorded a certain effect. Since China still is in economically undeveloped stage and in the transition of economic legal system, it is indispensable to see over-emphasizing the growth of economic benefits while neglecting environment, ecology and workers' interests and rights. In some areas there appear market blockade of disturbance, unfair competition between enterprises, and present laws not observed or implemented not strictly. All this has engraved the difficulty in implementing the strategy and program of sustainable development.

12.4 For the sustainable development of the building materials industry in China in the future, emphasis will be put on the development of large and medium-sized cement plants of precalciner/preheater process with a capacity over 2000t/d, reformation of the existing out-dated technologies and shutdown of thousands of unsatisfactory small plants. New waste-utilizing energy-saving, light and multi-functional walling materials will be expanded to replace clay solid bricks which cause higher energy consumption heavy pollution and land damage due to earth fetching.

12.5 For implementation of the sustainable development strategy and program of the industry

further mutual understanding and coordinated action are needed among all sectors of interest.

The administration should provide the support in policy-making, financial aid and project approval, strictly enforce law implementation, supervise the public legal awareness and enhance their conscious action for the sustainable development.

Co-coordinated action should be initiated among the customers of building materials, including construction investors, contractors, engineering and design organizations to create favorable conditions for applying top quality and high-grade cement, bulk cement, and new walling materials.

The authority of building materials should assume the important responsibility for strengthened administration, taking effective measures in all aspects related and better integrating economic growth with sustainable development.

International co-operation will be promoted, seeking for more worldwide aid and support

12.6 The Research Group holds that Chinese building materials industry should undergo its structural adjustment and technological upgrading for its sustainable development, which is beneficial to both the society and the industry itself, the latter being the largest beneficiary. However, since China still is in the stage of undeveloped economy and the transition period of economic and legal systems, there may be temporarily some negative situations occurred due to inadequate understanding and co-operation among various sectors of interest concerned, which, surely, will be gradually improved and settled up finally.

Reference materials

1. 《China Sustainable Development Study in The Year 2000》

China Science Academy

2. 《A Overview on the Sustainable Development in Cement Industry》

The World Business Council for Sustainable Development

3. 《The Strategy of Sustainable Development in Cement Industry》

Chen Quande, China Building Materials (newspaper), 2002/1

4. 《The 10th Five Years Development Plan of Building Materials Industry》

Issued by The State Economic and Trade Commission (SETC) in 2001

5. 《The 10th Five Years Development Plan of Cement Industry》

Issued by The State Economic and Trade Commission(SETC) in 2001

6. 《The 10th Five Years Development Plan of New Building Materials Industry》

Issued by The State Economic and Trade Commission (SETC) in 2001

7. An Appraisal on Non-metallic Minerals Deposit's Assuring the Economic Development

Geologic and Minerals Ministry, Administration of Building Materials Industry

8. 《The Trend Study on China Sustainable Development 》

Chief editor: Wang Weizhong published by Business Publishing House

9. 《Control the Emission of Waste Gas in Building Materials Industry》

State Environment Protection Administration