Cleaning up China's cement Sector
China Environment Forum, Washington D.C., USA

The Energy Management and Emission Control with Chinese Cement Industry

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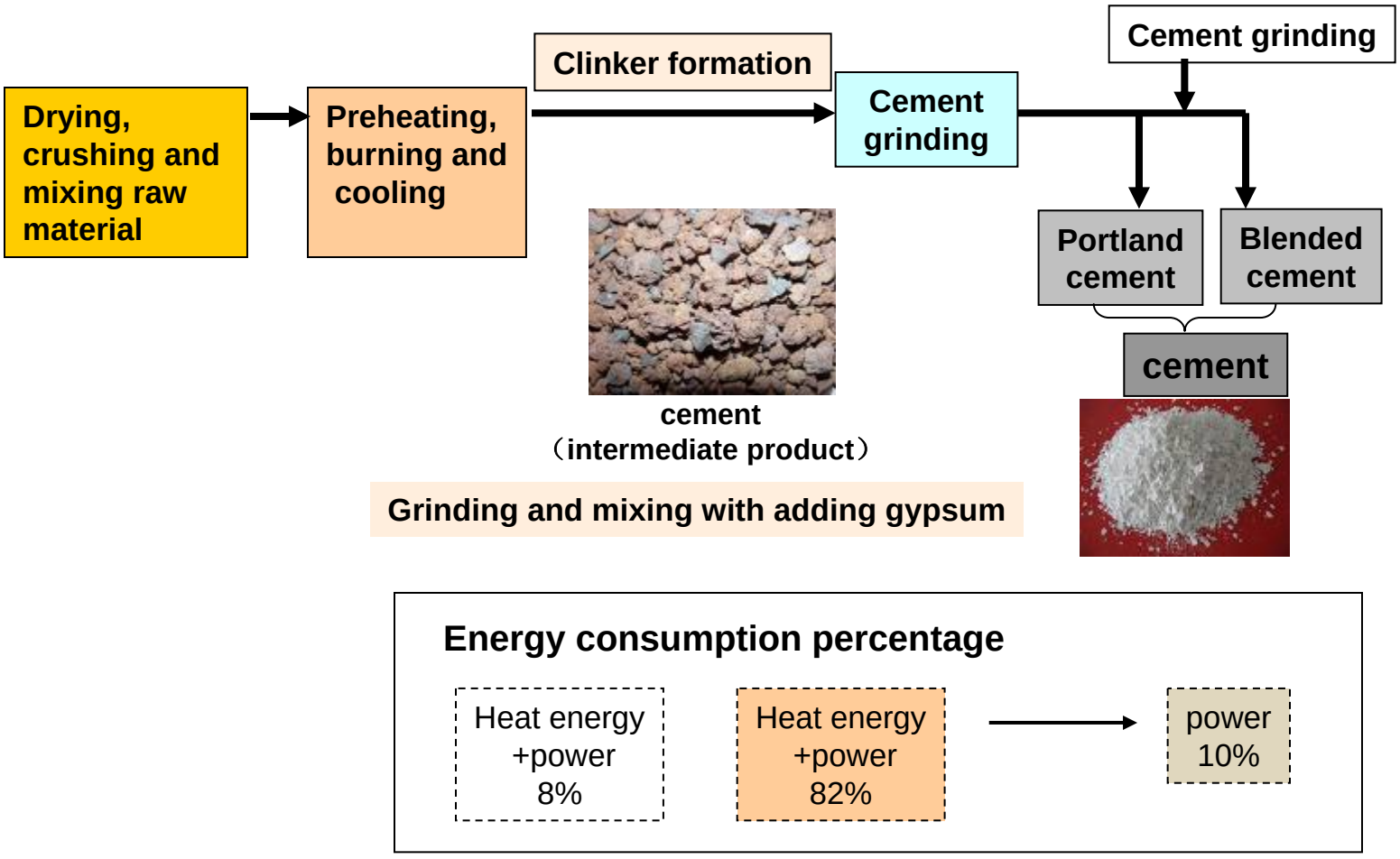
2008.5.16

Cement production process (1)



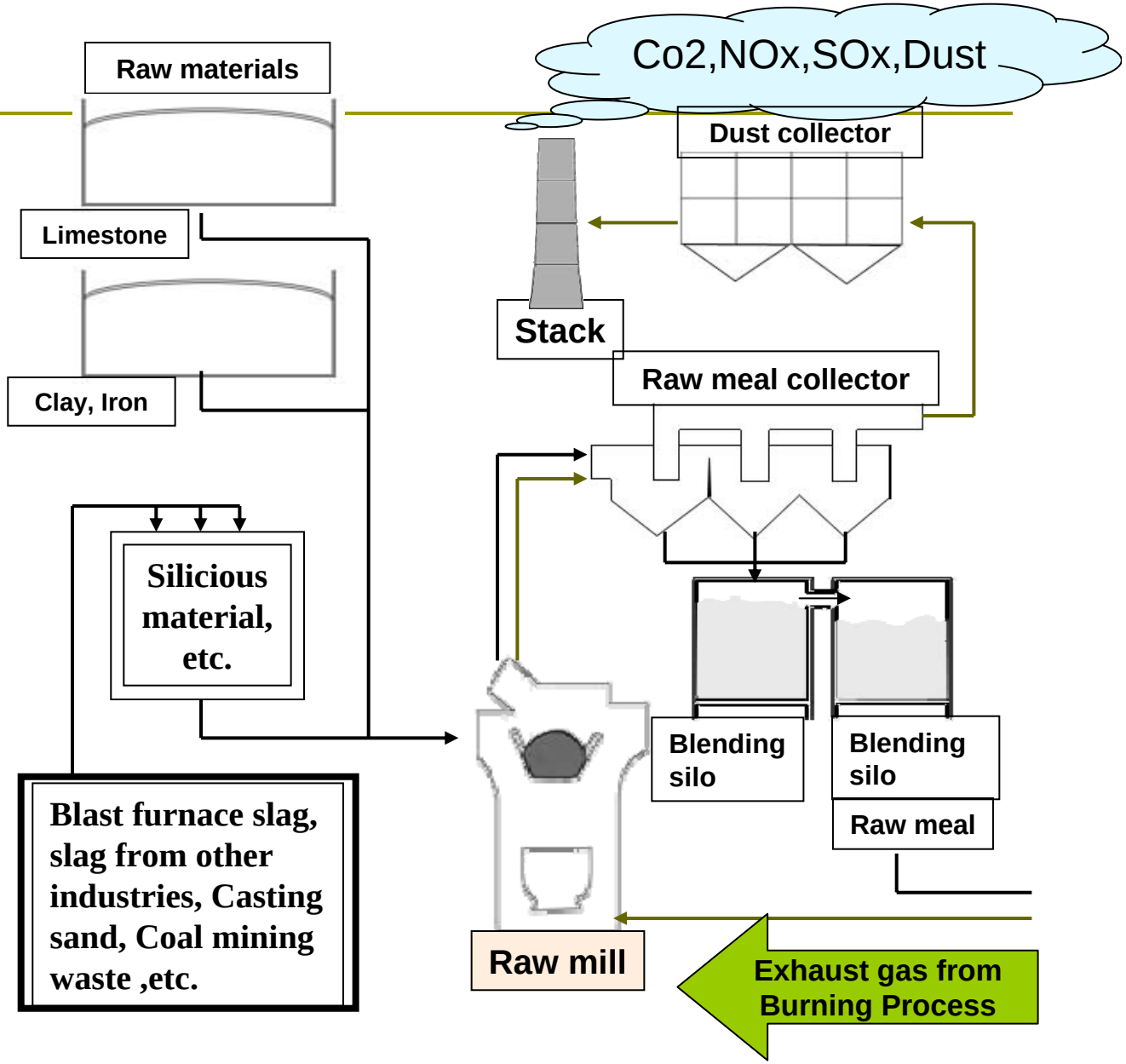
Cement production process (2)

Main sources of co2:
-Power consumed for raw materials grinding
-Fuel for drying raw materials

In modern plants, exhaust gas Heat from burning process is used for drying raw materials

Main stack gas:
CO2,NOx,Sox,Dust
Alternative raw materials:
Blast furnace slag, ashes

Use of alternative ..... Raw materials (wastes And by-products)



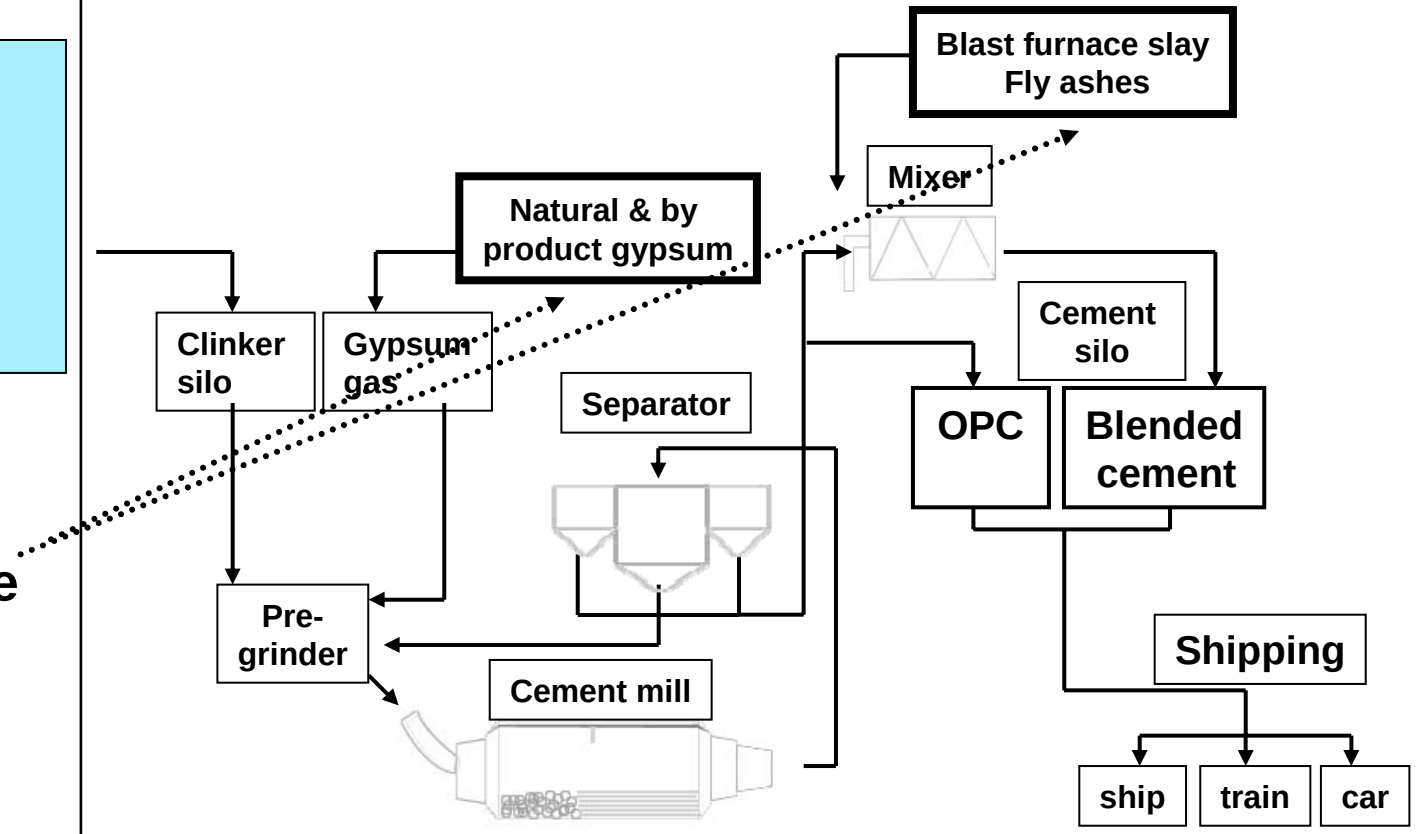
Cement production process (3)

Main Sources of CO2:

-Power consumed for cement grinding

-Fuel for drying admixtures

Use of admixture (by-products)



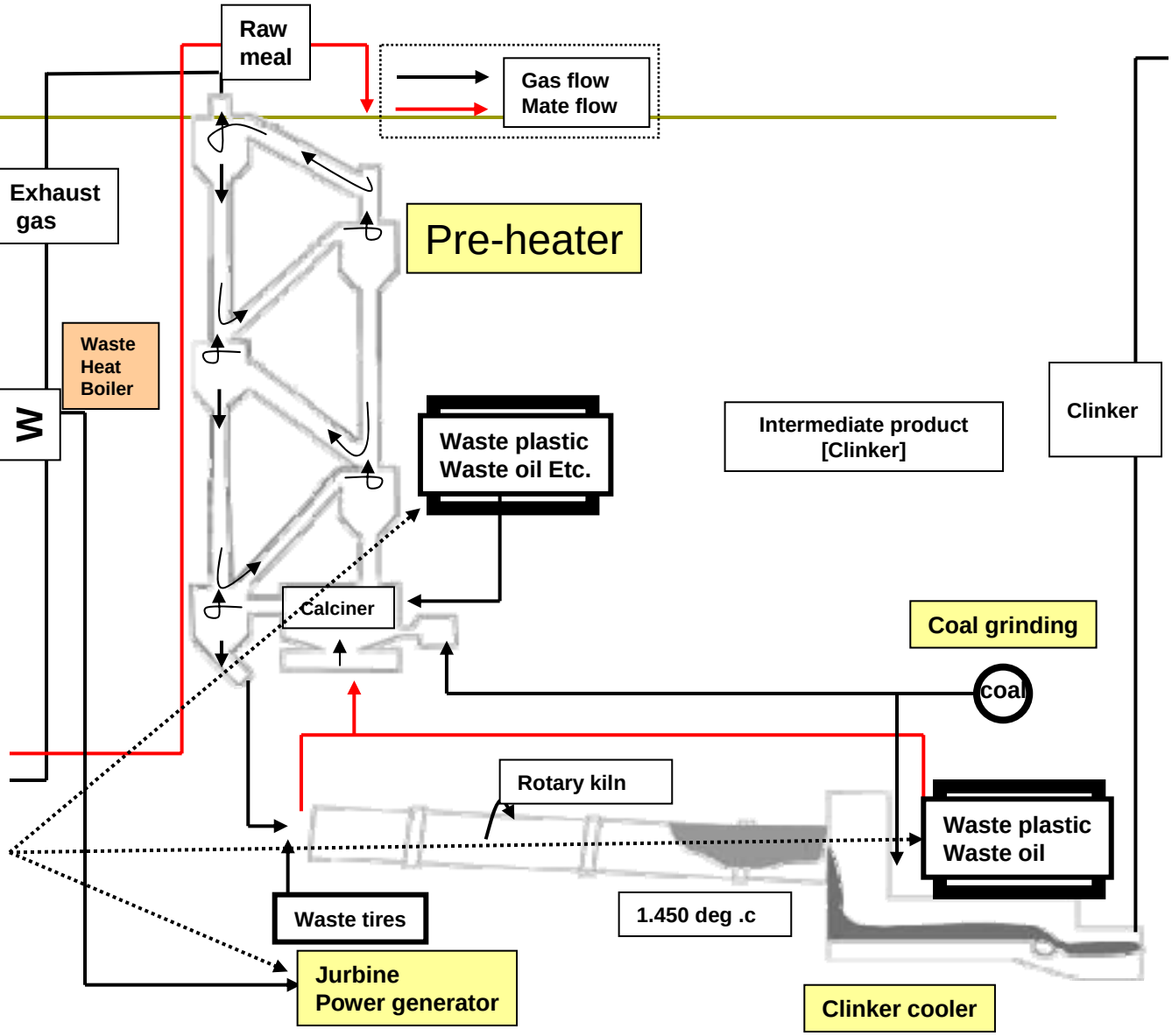
Cement production process (4)

Main sources of co2
-Fuels for burning (max temperature:1,450 deg .C)
-Calcination of CaCO3
-Power for drives
-Power for coal grinding

Alternative fuels:
-Waste plastics ,tires, oil

What's Pre-heater?:
-Heat exchanger between kiln exhaust gas and raw meal
-Natural desulfurization tower
CaO+SO3=CaSO4

Use of cementfitious Materials Fuel (wastes and by-products)



Cement manufacturing process

- Raw materials consumption

  ----1.5 tons of raw materials, 0.05 ton of gypsum and 0.2 ton of cementitious materials (fly ash, GGBS, etc.)/ton of cement

- Fuel consumption

  ----0.12 ton of standard coal (7000kcal/kg)/ton of cement

- Electrical power consumption

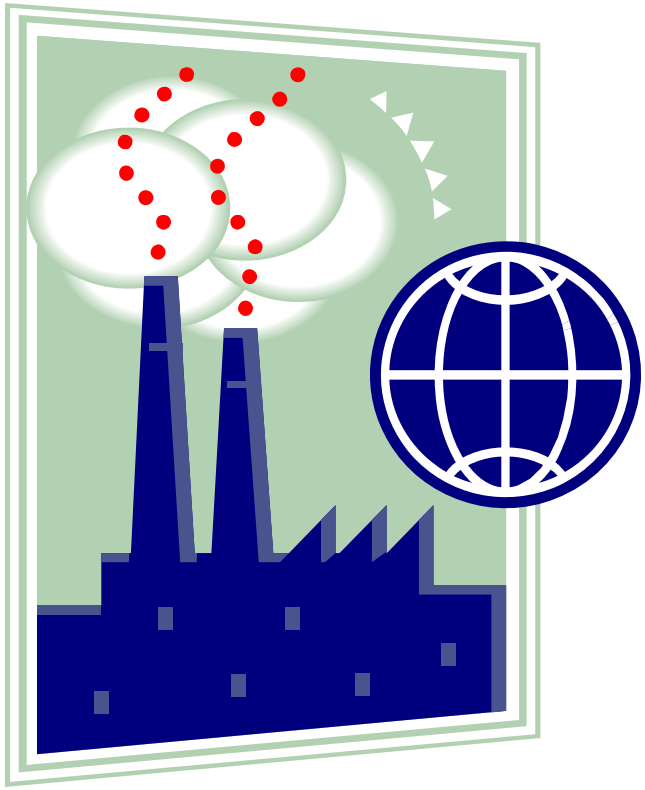
  ----110 kWh power/ton of cement

- GHG (mainly CO_2) emission

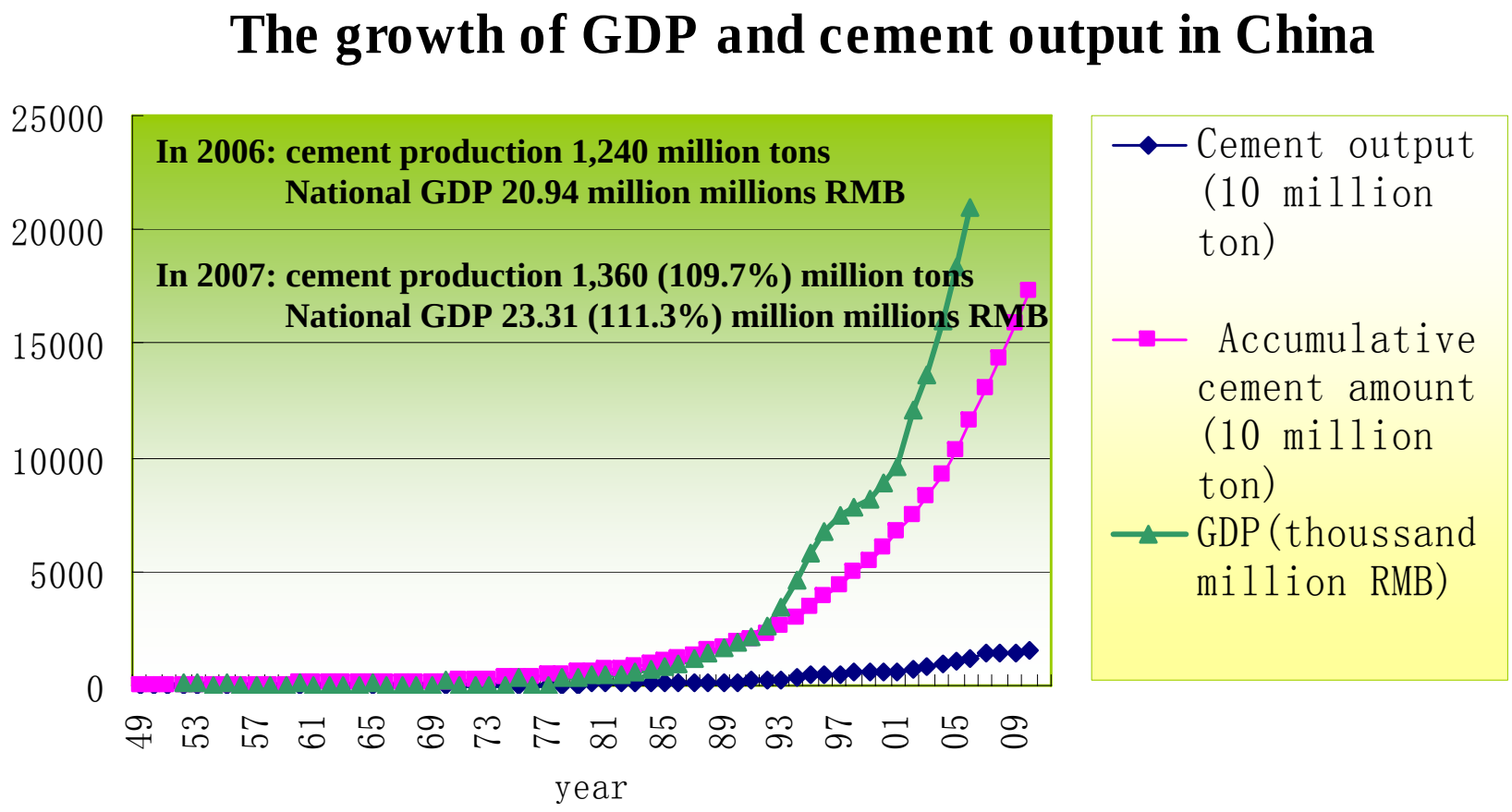
  ----0.85 (limestone decomposition 0.5 ton, fuel combustion 0.3 ton, power use 0.05 ton)/ton of cement

- Dust emission

  ----0.02 ton/ton of cement

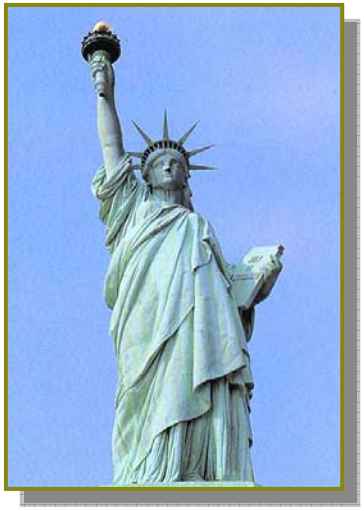


Current Status of cement industry in China



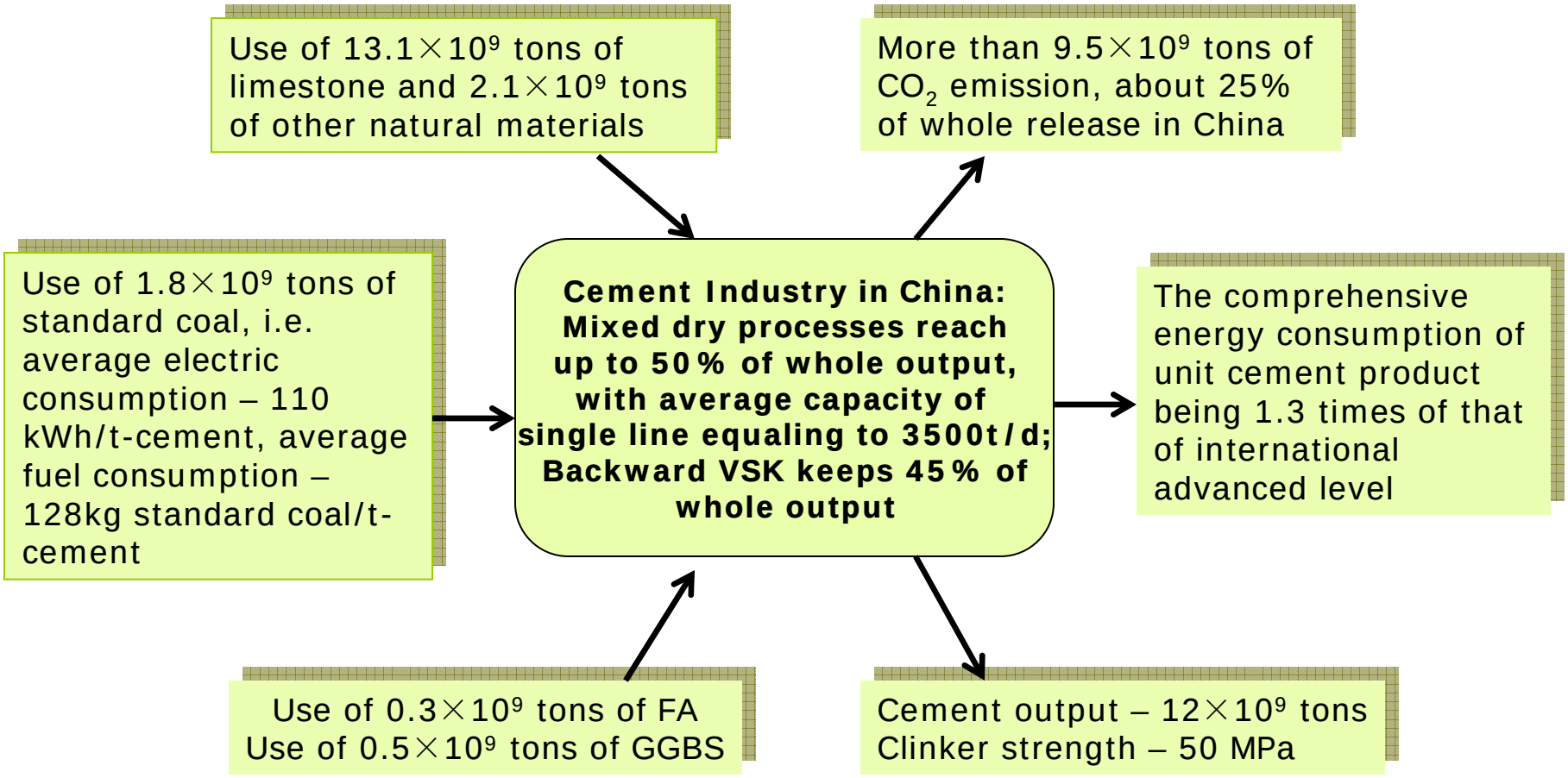
Sino-America comparison

Country	Population (10^9)	GPD (10^9 US$)	Cement output (10^9 tons)	Cement amount per capita (ton)	Cement accumulative amount per capita (tons)
China	13.1	23,318	13.6	0.946	21.2
USA	3.01	130,500	~1.0	0.332	21.6

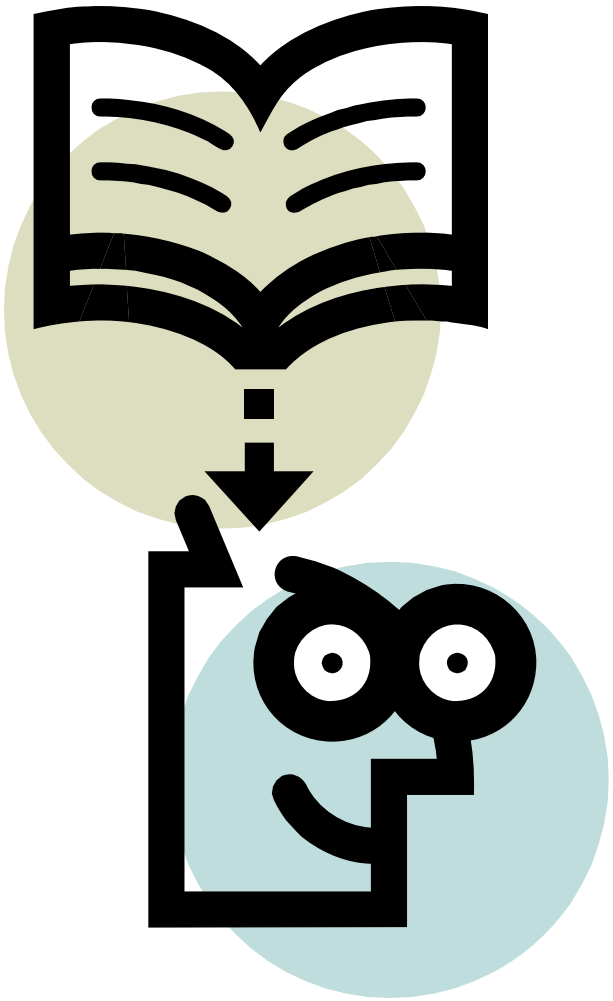


Current Status of cement industry in China

The current situation analysis



Whole national efforts



- **Energy Law**
  - 2. Energy management
  - 6. Energy saving
- **Energy Conservation Law**
  - 2.Energy saving management
  - 3.2 Industry energy saving
- **Environment Protection Law**
  - 3. Protection and Improvement of the Environment
  - 4. Prevention and Control of Environmental Pollution and Other Public Hazards

Whole national efforts

- **"Energy saving and emission reduction comprehensive work plan" issued by the State Council**
- **"National special program to deal with the weather change" issued by the State Council**
- **Energy saving and emission reduction of cement industry have been listed as government's top priority**

- One of key sectors in top-1000 enterprises energy saving action;
- Involving in an activity of key industrial energy efficiency benchmark;
- One of Ten key Energy saving Projects during the "11th Five-year Plan;
- Involving in Energy use quota standards of 26 energy intensive product;

Cement industry energy consumption standard

The norm of energy consumption per unit products of cement

Capacity (t/d)	Comparable standard coal consumption of clinker burning (kg/t)	Comparable comprehensive electricity consumption of clinker burning (kWh/t)	Comparable comprehensive electricity consumption of cement (kWh/t)
≥5000	≤125 (existing) ≤106 (new) ≤104 (future)	≤70 ≤60 ≤58	≤105 ≤90 ≤85
≥2000	≤130 ≤112 ≤106	≤75 ≤65 ≤60	≤110 ≤93 ≤90
≥1000	≤135 ≤120 ≤112	≤78 ≤68 ≤62	≤115 ≤95 ≤92
≤1000	≤140 - ≤115	≤80 - ≤65	≤120 - ≤95
VSK	≤140 - ≤105	—	≤90 - ≤65

Technology Development

- Newly developed precalcining kilns with high energy efficiency and low NOx emission widely used
- 120 cement production lines of installed power co-generation system recently

Power co-generation system

Cement manufacturing line (6000t/d)

Technology Development

Bag house dust collector & electrostatic precipitator used in most cement plants,

Result in:

$\leqslant 20 mg/Nm^3$

Best available technology (BAT)

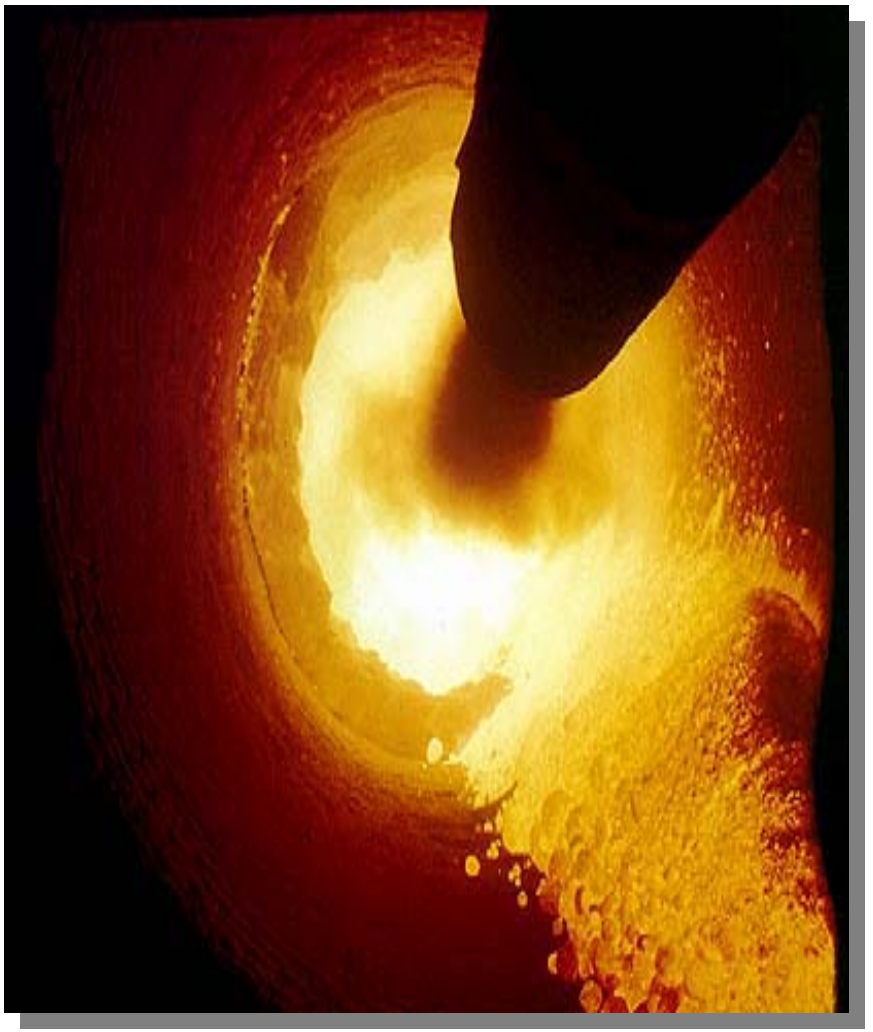
No.	BAT	Note
01	**Efficient transport system**	**Mechanical conveyors use less power than pneumatic system**
02	**High-efficiency roller mills**	**Energy saving of about 17 kWh/t is available**
03	**High-efficiency classifiers**	**Energy saving of about 3 kWh/t is available**
04	**Kiln combustion system**	**Fuel saving of about 2-10% is available**
05	**High-efficiency coolers**	**Energy saving of about 2 kWh/t is available**
06	**Heat recovery for power generation**	**Power generation varies between 20-35 kWh/t-clinker**
07	**Oxygen enrichment combustion**	**-**
08	**High-efficiency grinding system**	**Energy saving of about10 kWh/t is available**
	BAT (under developing)	**Note**
09	**Pre-sintering system**	**Increase production 30%, and decrease energy consumption 20%**
10	**High performance cement added with more than 40% of FA or 80% of GGB**	**Adding 1% more of supplementary cementitious materials means the saving of 2kWh/t and 1.3kg standard coal/t**
11	**Waste fuel use**	**Energy saving depends on the rate of substitution**
	BAT	**Note**
12	**Energy management**	**10% of energy saving is highly possible**

Technology development – AFR (alternative fuel and raw materials)

- **Huge population, swift economy growth and enormous output of waste materials**
- **600 million tons of industrial wastes and 136 million tons of municipal wastes each year, accumulative amount of 6000 million tons of waste materials**
- **Including: city's waste, sludge, mining residues, industrial byproduct, polluted soils, etc.**
- **Untreated waste materials pollute environment and threat the development of economy and human's health living**

Technology development

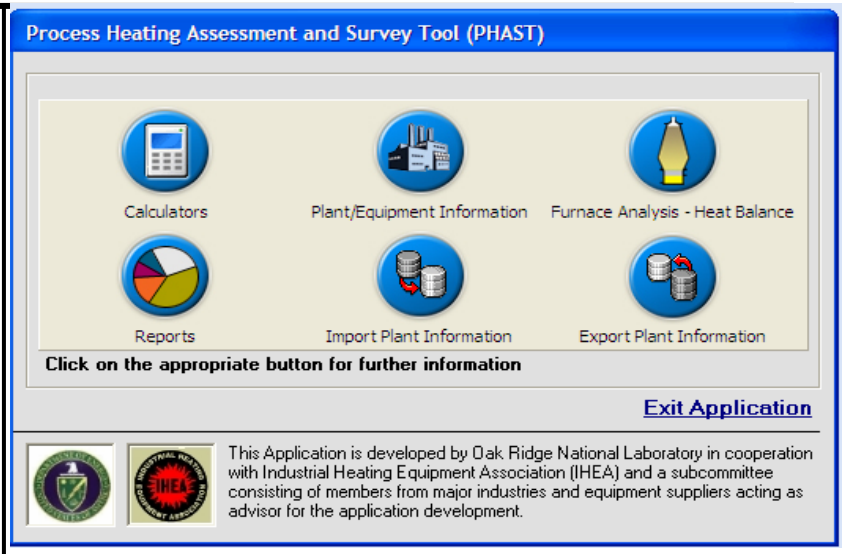
- **Cement kiln can be used to treat some kind of waste materials with several advantages: low investment and operation cost, high environment protection standard**
- **Organic polluters decomposed due to inside high temperature (1800° C)**
- **Certain kinds of heavy metal elements be solidified by cement clinker and finally by cement paste**
- **Mineral elements (CaO, SiO_2, etc.) used as raw materials, composition with heat value used as alternative fuel**

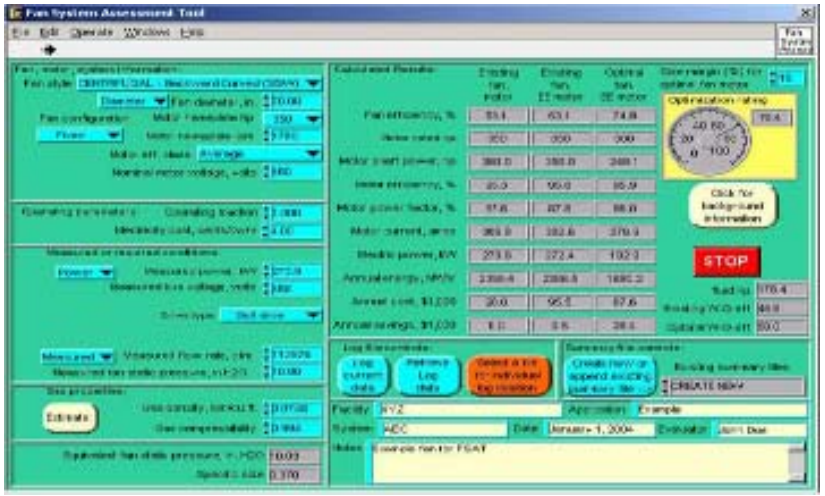


Energy management

Energy saving plan with XX cement plant

- General
  - Gist (establishing a policy)
  - Outline of the plant
  - Developing plan in 11.5
  - Present situation and tasks
- Plan goals
  - Guidance
  - Principles
  - Plan goals (setting goals)
  - Basic ideas
- System analysis (developing a system – tracking energy use)
  - Basic information
  - Power system
  - Manufacturing processes
- Problems' identification (conducting audits)
- Energy saving measures
  - Technical approach
  - Main methods
- Measures in detail (Collecting data, Statistic model, Plant benchmarking – Energy Performance Indicator – Plant input and output, Scope of EPI – from quarrying to dispatch ,Model – energy use, labor hours, quality – data source, Waste fuel correlation)
- Conducting steps (establishing a action plans)
- Guaranteeing conditions
- Inspection and summary
- Report

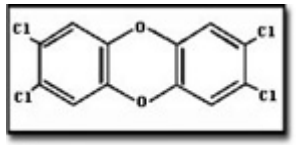




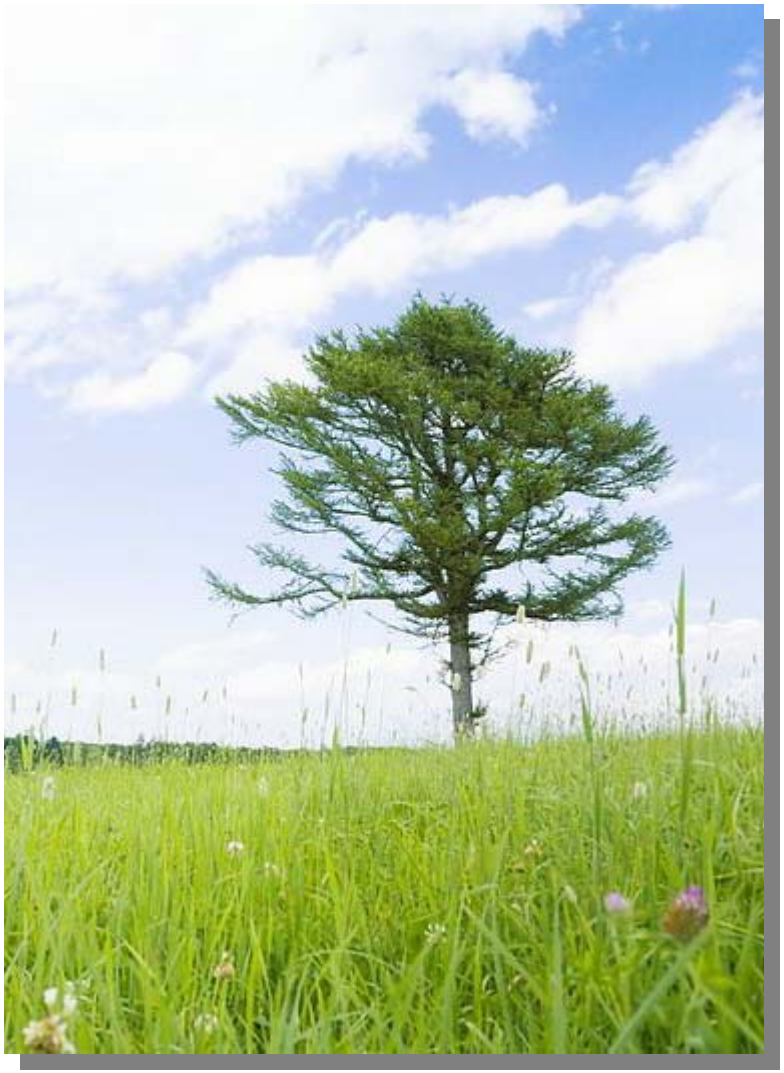
International Cooperation

Increasing Energy Efficiency and Reducing Emissions from China's Cement Kilns

Persistent Organic Pollutants (POPs)



- POPs are a set of toxic chemicals, including DDT, chlordane, PCBs, dioxins and furans
- POPs have been linked to adverse effects on human health and animals, such as cancer, etc.
- POPs persist for long time and travel to regions far from their source of origin
- Some POPs are certain chemical byproducts, such as dioxins and furans
- They are produced unintentionally from most forms of combustion, including industrial processes
- Cement clinker burning in kilns is one of these pyro-industrial processes



China-US Bilateral Cooperation on Persistent Organic Pollutants

- China ratified Stockholm Convention on Persistent Organic Pollutants (POPs) in 2004
- EPA signed Memorandum of Understanding with SEPA December 2003
- Comprehensive management of dioxins/furans from cement kilns
- Goal: Reduce emissions of dioxins/furans from cement kilns
  - Accurate emissions factors for rotary and vertical shaft kilns
  - Source inventory of dioxins/furans from cement kilns in pilot provinces
  - China's National Implementation Plan (NIP) for reducing dioxins/furans emissions from cement production
  - Financing mechanisms and incentives for private sector investment to improve combustion efficiency and control particulate emissions from cement kilns
- Dioxin/furan sampling from 8 Chinese cement kilns in 2006

Our Partners
(Formal Cooperation Agreements and Informal Network)

- **State Environmental Protection Administration (SEPA) – reducing pollution, especially of persistent bio-accumulative toxics (dioxins and other POPs; mercury)**

  China Building Materials Academy (CBMA), Key Dioxin Labs, Provincial Environmental Protection Bureaus

- **Lawrence Berkeley National Laboratory (LBNL) – benchmarking energy performance; economic and environmental co-benefits**

  CBMA, Energy Research Institute, Institute of Technical Information for the Building Materials Industry of China, US DOE, others

- **US Business Council for Sustainable Development (US BCSD) – Cement Sustainability Initiative implementation; by-product synergy/AFR; biofuels**

  China BCSD, World BCSD

- **Asia Pacific Partnership Cement Task Force (APP CTF) – promoting clean development and reducing climate impacts**

  Portland Cement Association, US Department of Commerce, LBNL; CBMA, National Development and Reform Commission, China Cement Association

China-US Bilateral Cooperation on Persistent Organic Pollutants

Sampling Sites

Kiln #	1	2	3	4	5	6	7	8
Province	Shandong	Shandong	Shandong	Henan	Hebei	Xinjiang	Xinjiang	Xinjiang
Kiln Type	5 stage PH/PC	VSK	VSK	PH/PC dry	VSK	VSK	Dry	Wet
Production Volume (t/y)	1.55 M		150,000	1.5 M	135,000	100,000	700,000	200,000
APCD	ESP	FF	FF	FF	Water spray	FF	ESP	ESP

Preliminary Results

Pollutant	Unit	Emission Factors (based on tests of 5 Chinese kilns)				
		Small Vertical Shaft	Large Rotary Dry	Chinese Emission Standards		U.S. Kilns[2]
				Existing Units	New Units	
PCDDs/PCDFs[1]	ng TEQ/m3	0.041 - 1.591	0.035 - 0.518	0.1 ng TEQ/m3	0.1 ng TEQ/m3	$\geq$ 0.016[3]

[1]Polychlorinated dibenzodioxins and polychlorinated dibenzofurans, in nanogram toxic equivalence (TEQ).

[2]Based on industry-wide emissions from the national emissions inventory.

[3]This is based on the regulatory limit. It is assumed all kilns are below this limit.

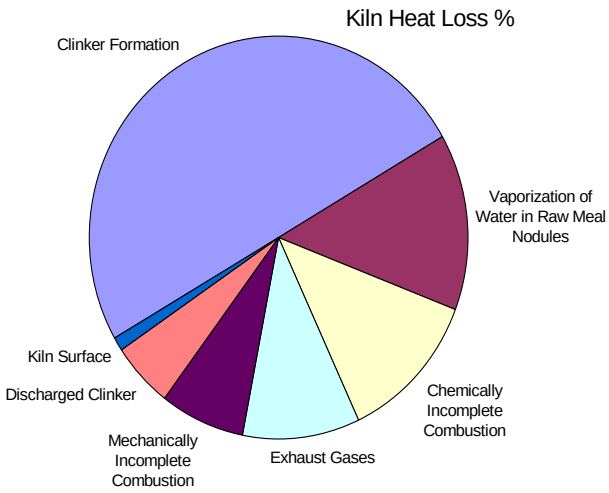
Luzhong Cement Plant: Vertical Shaft Kiln

- Large drum set vertically with a packed mixture of raw material and fuel traveling down through it under gravity
- Kiln is entirely filled with a mixture of raw materials and fuel, with air entering the bottom of the kilns and exhaust gases exiting at the top
- Raw material goes through the various pyroprocessing stages as it travels from the top of the kiln to the outlet at the bottom
- Shaft kilns require constant attention from operators on a platform at the top of the kiln, who monitor burning conditions, control the rate of kiln feed, open and close vent doors, and manipulate the burning material at the kiln surface with long steel poles

Luzhong Cement Plant: Vertical Shaft Kiln

CBMA Report Results			PHAST Report Results		
Heat Loss Category →			← Heat Loss Category		
	Percentage of Total		Percentage of Total		
The heat in clinker formation	50.1				
Heat with discharged clinker	5.2	63.6	62.2	62.2	Net load weight heat
Heat for vaporization of water *	8.3				
Mechanically incomplete combustion heat loss	7.3				
Chemically incomplete combustion heat loss	12.2	19.5	20.2	20.2	Other losses
Heat loss from the surface of kiln	1.2	1.2	1.2	1.2	Wall losses
Exhaust gas loss	10.0		16.4	1.7	Atmosphere loss (CO2 heat)
Heat for vaporization of water*	5.9	15.9		14.7	Flue gas loss
Total with rounding error		**100.2**	**100.0**	**Total with rounding error**	

* Notes:
Total heat for vaporization of water in nodules is divided for heat required to evaporate water from nodules and heat in flue gases due to combustion of volatiles etc. from fuel. Total heat remains 14.1 % as reported in CBMA report

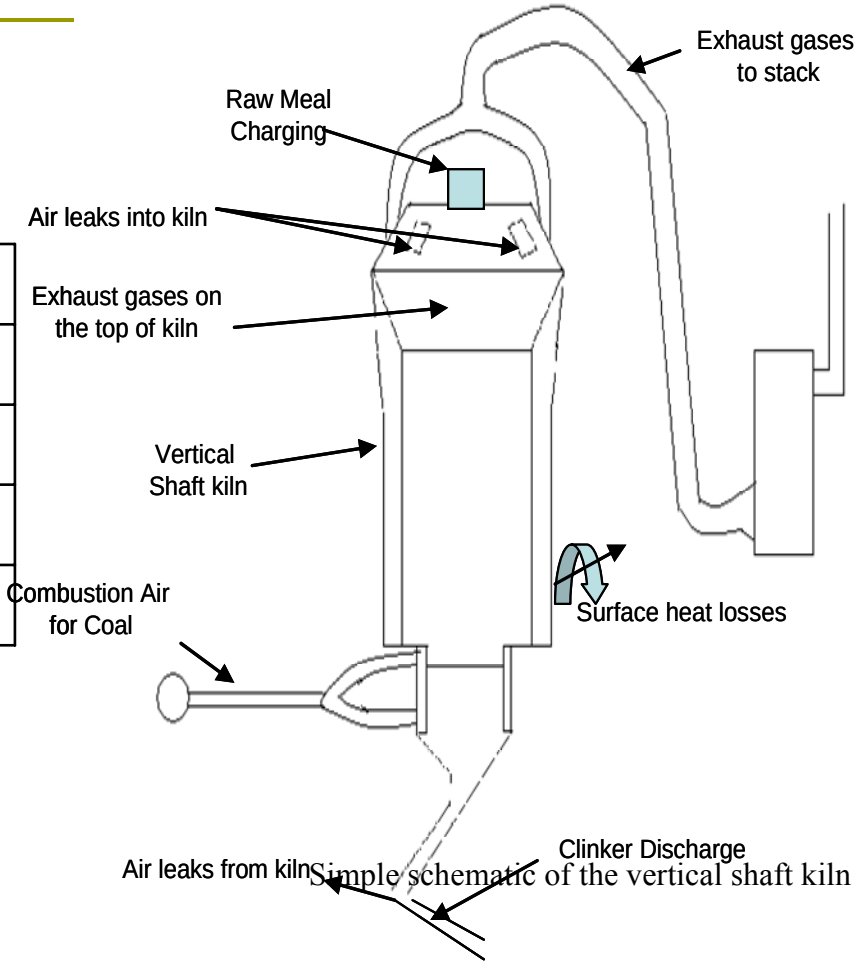


Project Phase Two – Energy Assessment (LZ Cement Plant - VSK)

Exhaust gas composition

CO_2	O_2	CO	N_2
23.6	4.5	1.9	70
28.1	3.8	2.8	65.3
25.7	3.7	2.5	68.1
25.8	4.0	2.4	67.8

- **The energy consumption is higher than average**
- **The exhaust gas contains certain amount of CO**
- **The existence of CO means the energy loss and possible formation of POPs**



Simple schematic of the vertical shaft kiln

Luzhong Cement Plant: Vertical Shaft Kiln

- Audit Findings
  - Energy consumption is 802 kcal/kg clinker

- Suggested Actions to Improve Combustion Efficiency
  - Reduce the water content of the raw meal nodules
  - Reduce the amount of incomplete combustion
  - Reduce and use exhaust gas heat
  - Reduce kiln wall losses by applying an insulating layer to the kiln

Plant energy saving retrofitting

Initial improvement: Kiln body insulation
Reducing the water addition
Seals
Now energy consumption 760 kcal/kg
Reduction 5%

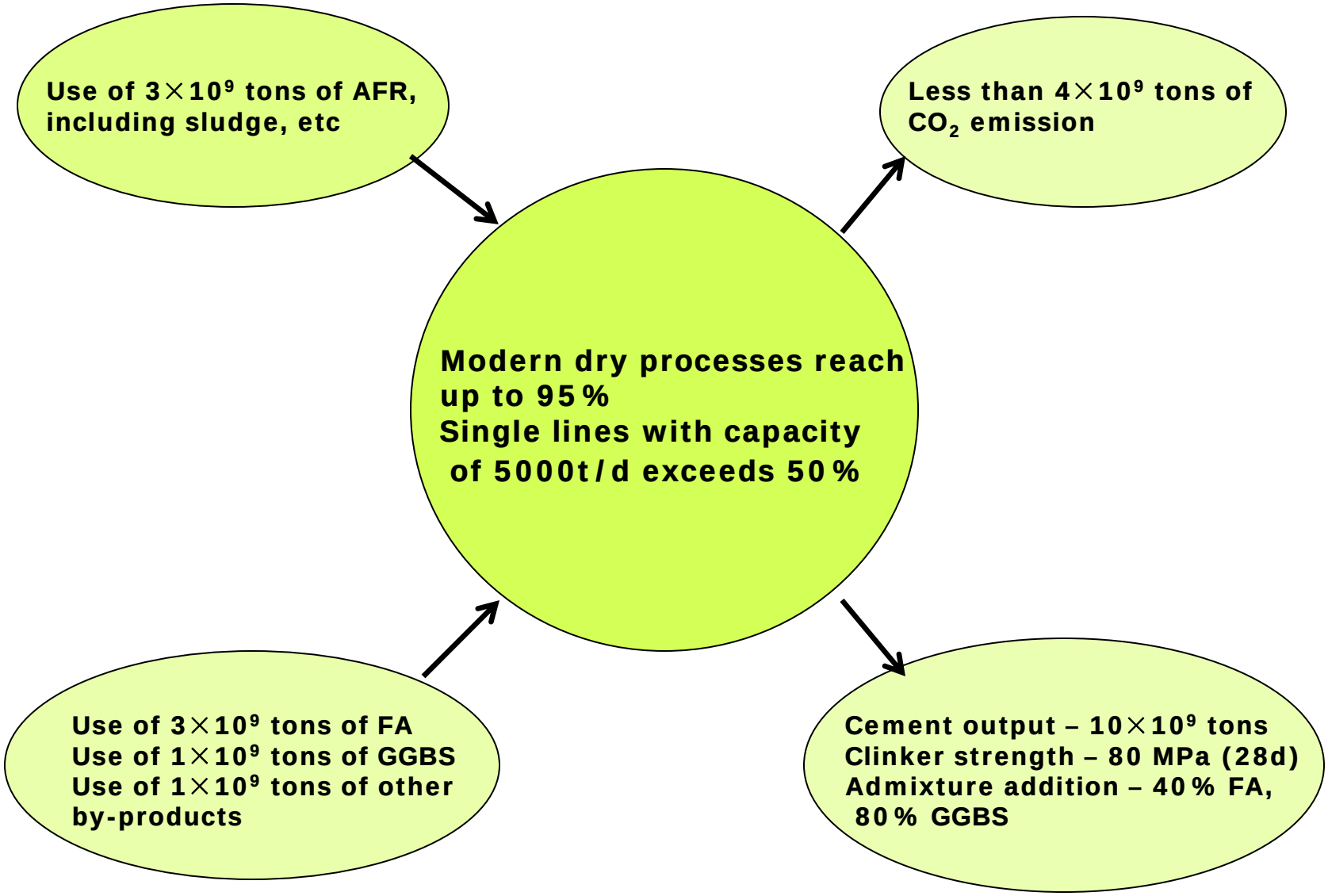
Large-scale modification will be carried out soon
As demonstration line for whole cement industry

The development of Chinese cement industry

The evolution of resources for cement manufacturing

	Past	Present	Future
Raw materials	Limestone Clay minerals	Limestone Clay minerals Industrial by-products	Alterative raw Materials (AR)
Fuels	Oil	Coal	Alterative fuels (AF)
Admixtures	-	20% FA, 40% GGBS	40% FA, 80% GGBS
CO_2 release	1t/t-cement	0.8t/t-cement	0.4t/t-cement

The Future of Cement Industry in China



Thanks 谢谢！

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