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Analysis & Prospect on Waste disposal by Cement Kiln Co-processing

Huaxin Cement Co., Ltd.

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Advantages of the Cement Kiln Co-processing technology

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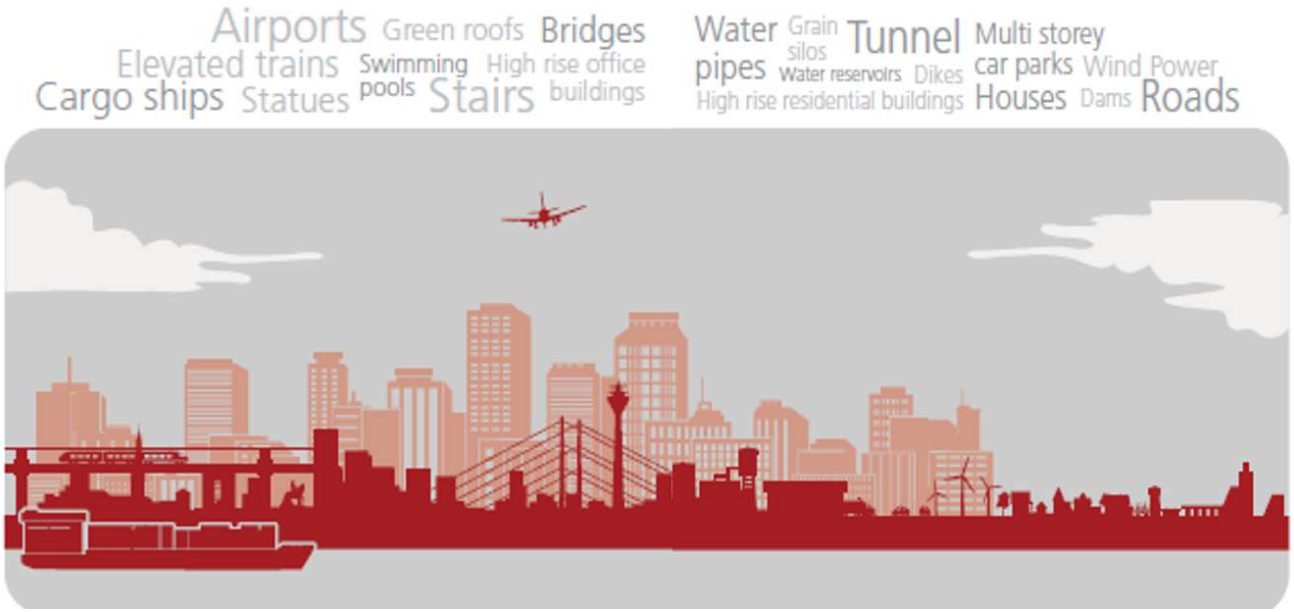
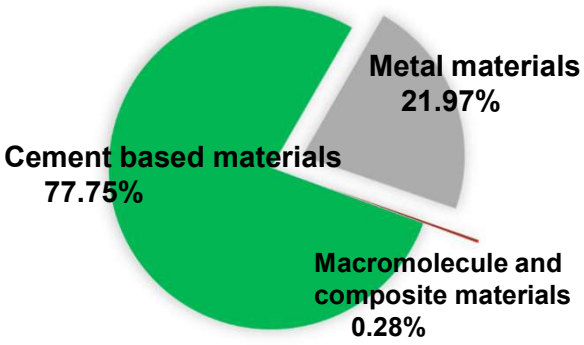
Background — The rigid demand of social development for cement

- ✓ ***Cement is an important and basic material for economic construction***
- ✓ ***The continuous development of cement industry is a critical supporter for social development.***





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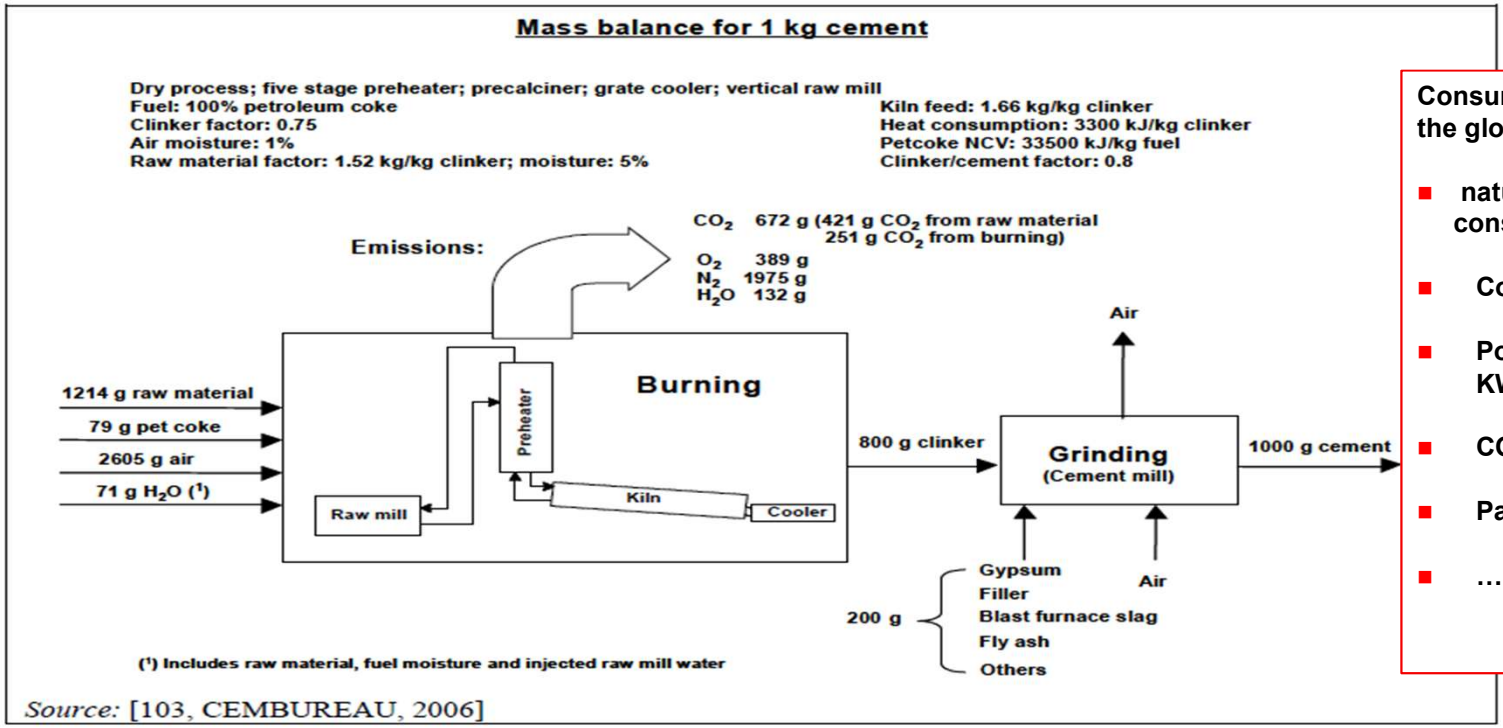
Background — Huge pressure on global cement industry from energy saving and emission reduction



Consumptions and emissions of the global cement industry:

- **natural materials consumption：3.6bt/a**
- **Coal consumption：≈0.4bt/a**
- **Power consumption：360b KWH/a**
- **CO2 emission：2.35bt/a**
- **Particle emission：600kt/a**
- **……**

The CO2 emission and the coal consumption of cement industry takes 7% and 5% of the world's total respectively.

Source: *BAT Reference Document for the Production of Cement, Lime and Magnesium Oxide*

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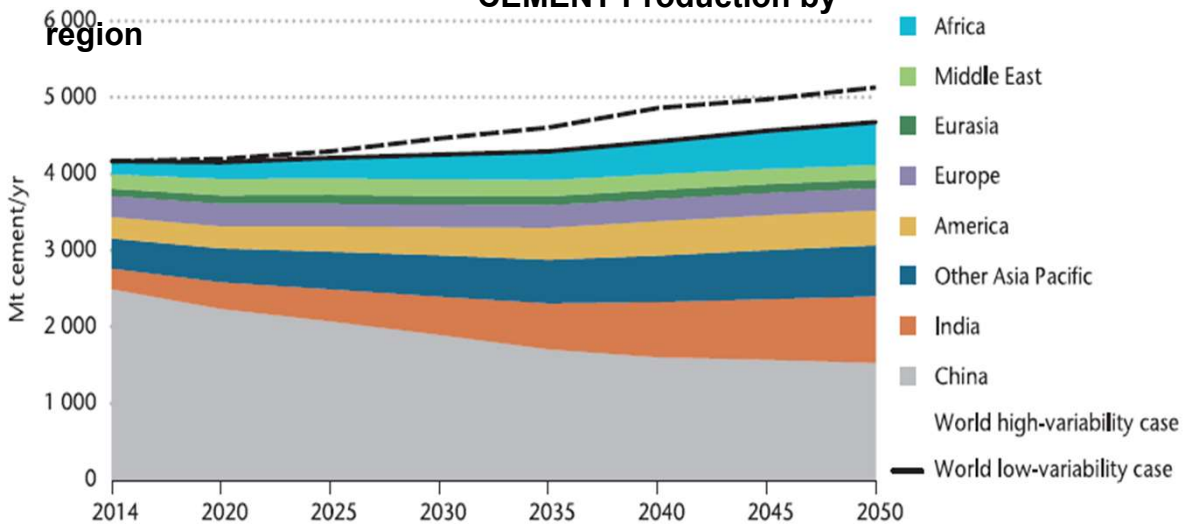
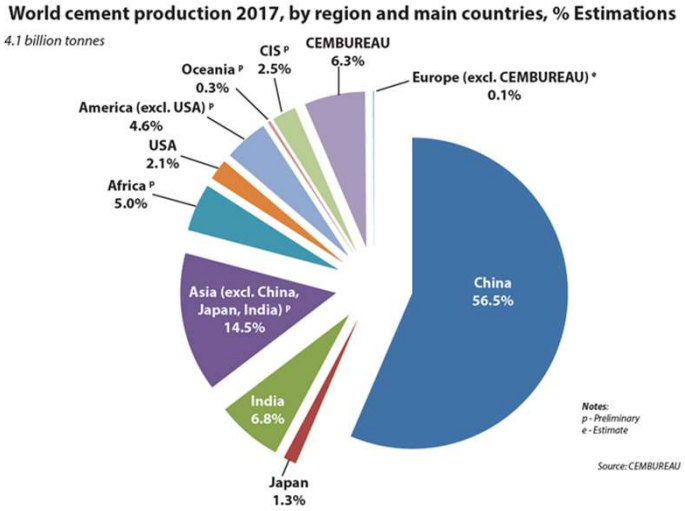
Background — Huge pressure on global cement industry from energy saving and emission reduction

CEMENT Production by region





Traditionally, cement industry is a industry of high energy consumption and high pollution. Cement production consumes large sums of limestone, coal and other non-renewable resources, and releases pollutants like GHG (production of 1t cement releases 0.6-0.8t CO2) . Because the huge cement production capacity, the total pollutants emission is also huge.

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Source: *Technology Roadmap - Low-Carbon Transition in the Cement*

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Background — Huge pressure on Chinese cement industry from energy saving and emission reduction

Chinese cement industry NOX and dust emission		
Year	NOX(kt)	Dust(kt)
2016	1,603	608
2014	1,917	649
2012	1,979	671

The Ministry of Ecology and Environment of China(previously the Ministry of environmental protection) started to publish the NOx and dust emission situation of the cement industry from year 2012.

2016 power consumption cement companies above designated size		
Year	Coal consumption (mt)	Power consumption (b kwh)
2016	210	168

2014 CO2 emission of Chinese cement industry		
Year	CO2/t	CO2 in total
2014	~ 650kg/t	~ 1.51bt

Cement industry is an important producer and discharger of waste gases, it is estimated that the limestone consumed by cement industry equals to 20% or above of the total material consumption of the country, the coal consumption of the industry takes more than 84% of that in the whole building materials industry; the emission of particles, Co2 and NOx of the industry occupies 10%-15%, 15% and 12%-15% of the total emission of the country respectively. For the huge production capacity, the emission scale in general is also huge.

Currently, China faces great pressure in environment protection, the cement industry as a big consumer of energy and a polluter should consider the emission reduction on the standpoint of the whole national economic system (includes cement industry and other industries) .

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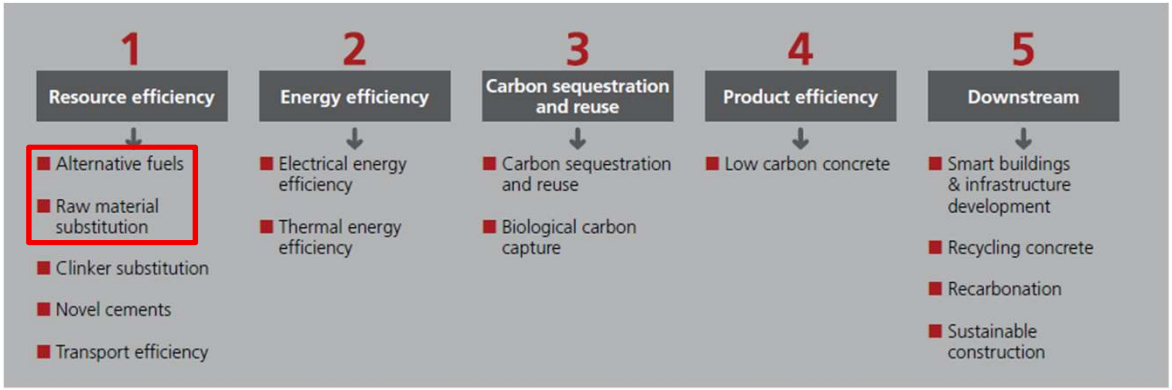
Background — Cement kiln co-processing is an important path for cement industry to pursue green and sustainable development

《The role of CEMENT in the 2050 LOW CARBON ECONOMY》

5 parallel routes

—— CEMBUREU



《Technology Roadmap – low carbon transition in the cement industry》

Carbon emissions reduction levers

—— International Energy Agency

- *Improving energy efficiency*
- *Switching to alternative fuels*
- *Reducing the clinker to cement ratio*
- *Using emerging and innovative technologies*

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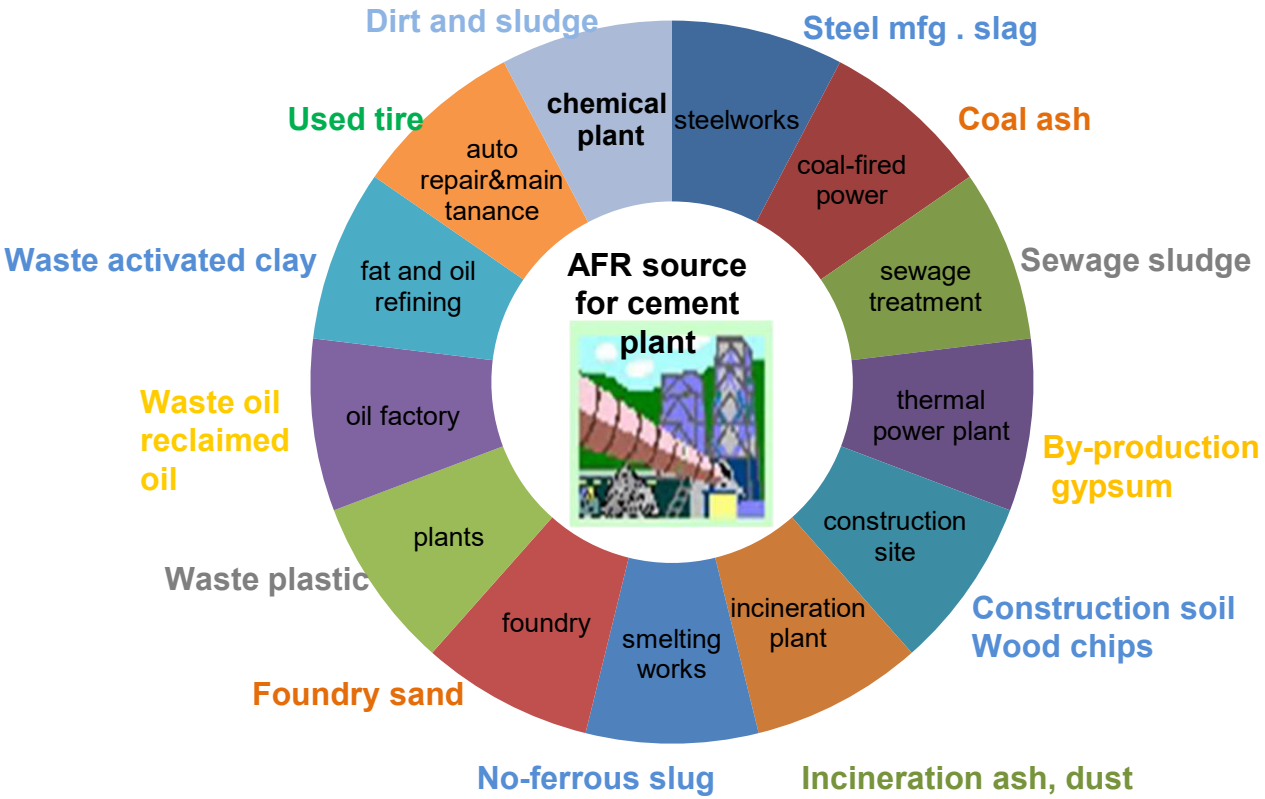
Waste Disposed by Cement Kiln Co-processing



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Merits of the Cement Kiln Co-processing

For the industry

Positive externality

Reducing the CO2 intensity of cement manufacturing

Safe and harmless disposal of waste，reduce the volume of landfilled waste

Reducing the dependence on fossil fuels and mineral raw materials

Minimizing public investment cost in new dedicated facilities

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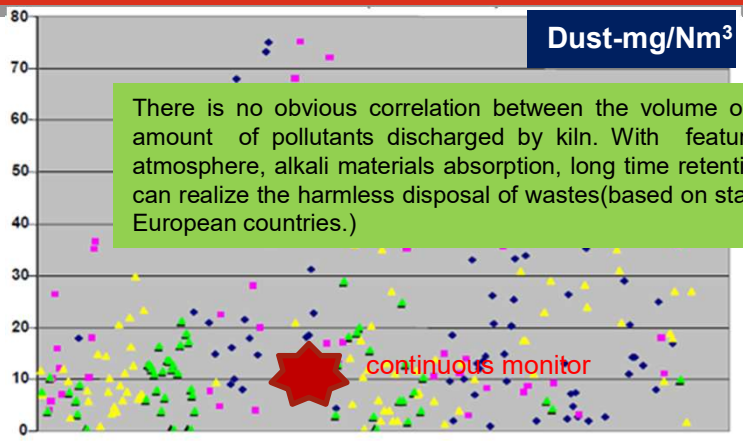
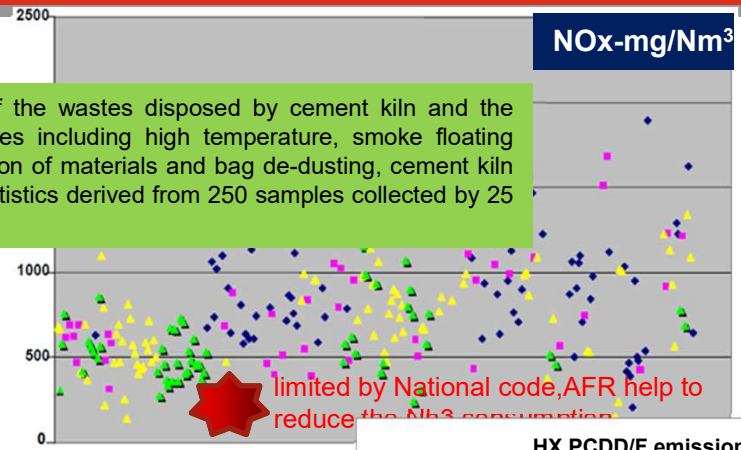
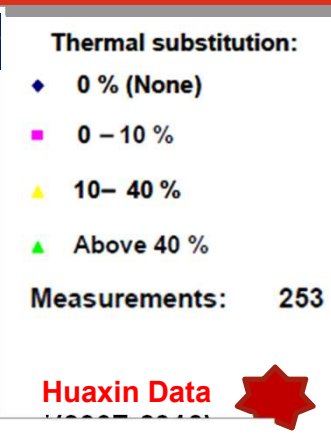
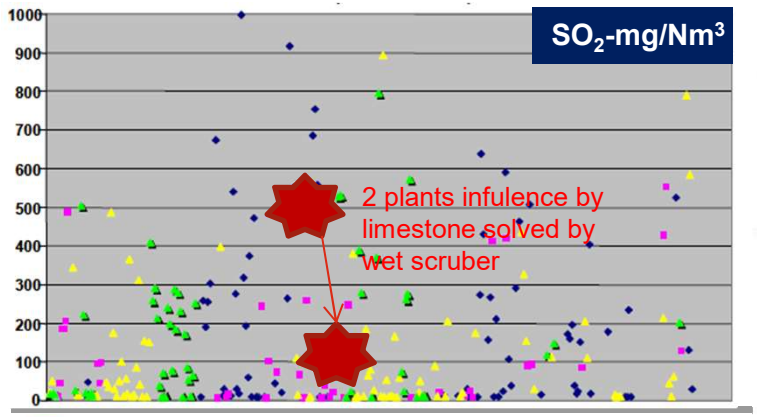
Advantage — disposal in a harmless way

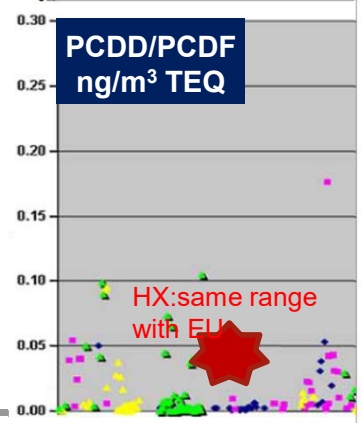
There is no obvious correlation between the volume of the wastes disposed by cement kiln and the amount of pollutants discharged by kiln. With features including high temperature, smoke floating atmosphere, alkali materials absorption, long time retention of materials and bag de-dusting, cement kiln can realize the harmless disposal of wastes(based on statistics derived from 250 samples collected by 25 European countries.)

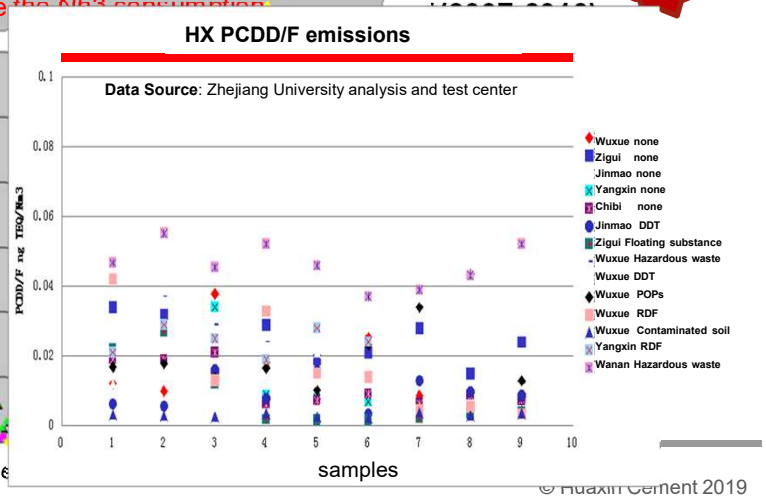












Source: *BAT Reference Document for the Production of Cement, Lime and Magnesium Oxide*

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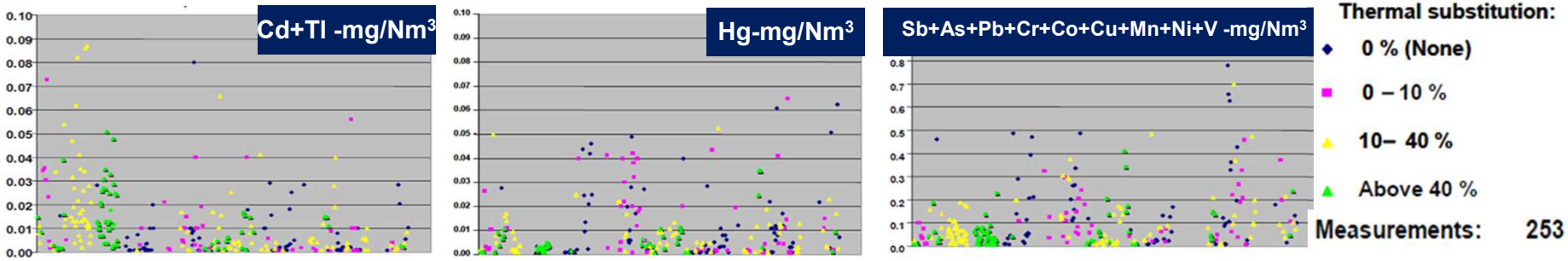
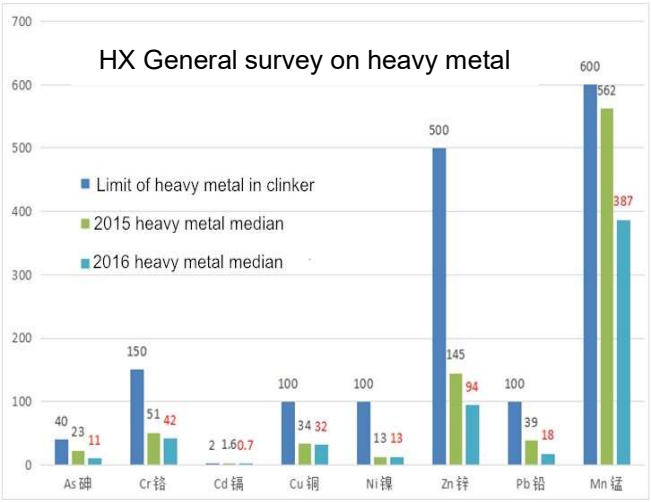
Advantage — disposal in a harmless way





- *Most of the non-volatile heavy metals (Ba、Be、Cr、As、Ni、V、Al、Ti、Fe、Mn，Cu、Ag, etc.) be solidified in clinker;*
- *Heavy metals that difficult to volatile including Sb、Cd、Pb、Se、Zn、K、and Na, etc. be circulated in preheating system, and then be solidified in clinker;*
- *Hg is a highly volatile heavy metal, and only a small portion of it can be absorbed, so the mount in feeding must be strictly controlled*

Huaxincement :2015 the number of samples is 110, the number of samples in 2016 is 124 .heavy metal elements were decreased, especially the manganese content and chromium content witnessed a significant decline.
For the cement kiln co-processing production lines of MSW and SS, it is the key to strengthen the control on the type and amount of raw materials containing heavy metals during the control of clinker heavy metal content!

Source: *BAT Reference Document for the Production of Cement, Lime and Magnesium Oxide*

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Advantage — CO2 emission reduction

- ***The utilization of alternative fuels can help to reduce the use of fossil fuel. Most alternative fuels have a lower CO2 emission factor compared to traditional fuel, and could reduce the CO2 emission in the process of disposing the alternative fuel.***

- ***Furthermore, cement kiln co-processing can also help to reduce the methane discharged by landfill. About 60% gases released by the landfill is methane gas, whose global warming potentiality is 21 times of the CO2. Take reference of the average European level, the fuel substitution rate was 36% in 2012, and that helped the reduction of 16.5mt CO2 emission.***

Comparative CO_2 emission factors of some fuels (kg CO_2/GJ)						
petcock	Coal	Natural gas	Tyre	Waste oil	MSW	Plastic
101	96	54.2	85	74	8.7	75

Fig. Greenhouse gas emissions from waste landfilling, incineration, and co-processing (CEMBUREAU 2009)

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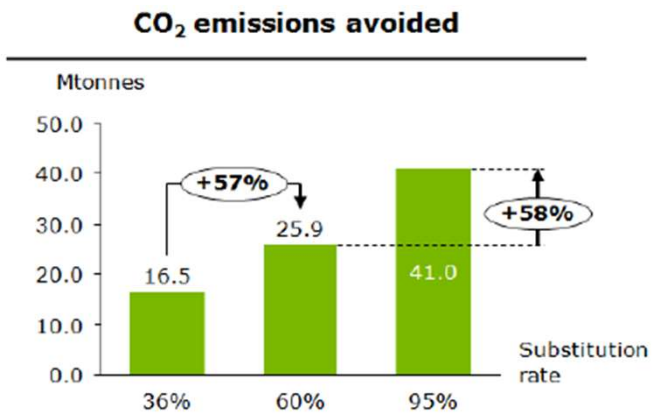
Current Status and Developments of Kiln Co-processing — EU

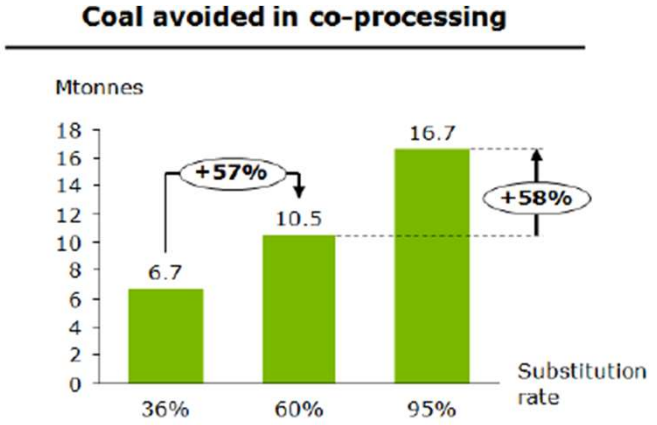
EU is the pathfinder of cement kiln co-processing, and its related technology and practice runs ahead of the world. EU formulated the Waste Framework Directive(2008/98/EC), The Industrial Emissions Directive(2010/75/EU), Waste Shipment Regulation (1013/2006) and other policies to regulate the industry.

According to CEMBUREAU:

In 2012, on EU level the cement industry co-processed 9.8 mt waste, with substitution rates at 36%,

- avoid the emission of about **16.5 Mt of CO2, saved 177 PJ of primary energy, equaling 6.7 Mt of coal**.
- providing a processing capacity **equal to 65 WtE** plants with an average capacity of 150 ktons/a
- co-processing capacity represented a value of between **5.4 and 9.8 Billion EUR** in WtE plants





Source: Market opportunities for use of alternative fuels in cement plants across the EU - ECOFYS

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Current Status and Developments of Kiln Co-processing — EU

Types of alternative and basic fuels used by the cement industry in the EU 28 .

The amount and the types of alternative fuels were both increased among the years, and the types mainly include waste plastics, tires, biomass fuel and sewage sludge, etc.

Source： *Cembureau, 2015*

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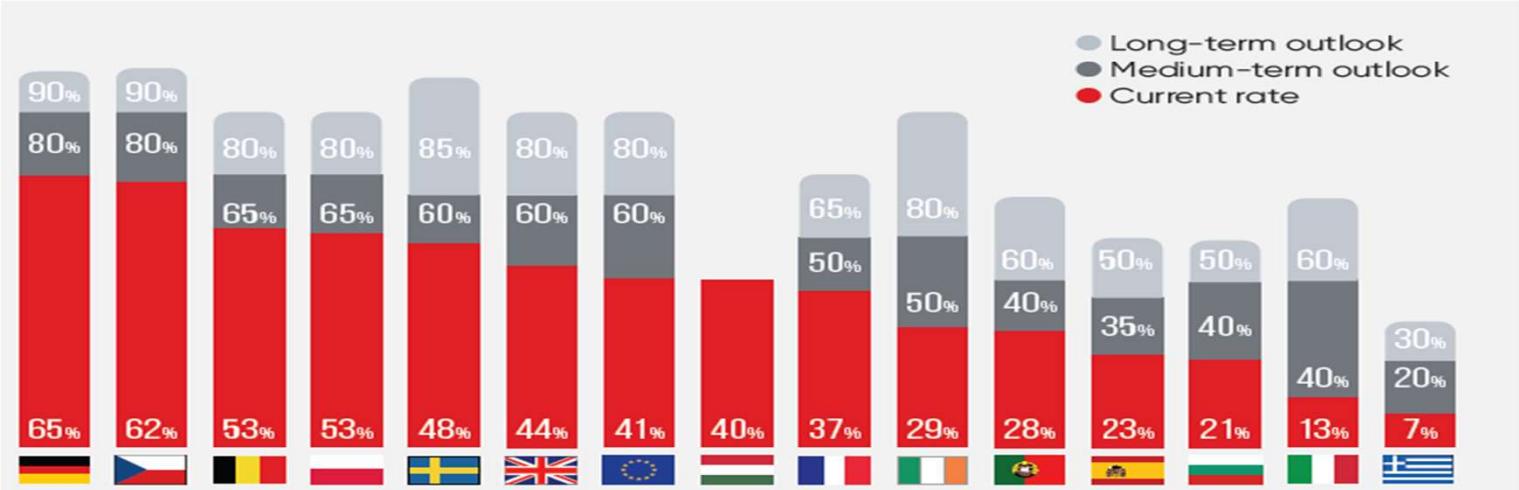
Current Status and Developments of Kiln Co-processing — EU

Goal:

At 95% substitution rate， co-processing waste 25.8 Mt per year

- avoid the emission of about **41 Mt of CO2, saved 439 PJ of primary energy, equaling 16.7 Mt of coal**.
- providing a processing capacity **equal to 105 WtE** plants
- **Additional** avoided expenditures in new WtE plants between **8.6 to 15.6 Billion EUR**



Status and prospects of co-processing of waste in EU cement plants (2017) Ecofys

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Source **:** *LET'S CONTINUE BUILDING A CARBON-NEUTRAL EUROPE-CEMBUREAU*
Market opportunities for use of alternative fuels in cement plants across the EU - ECOFYS

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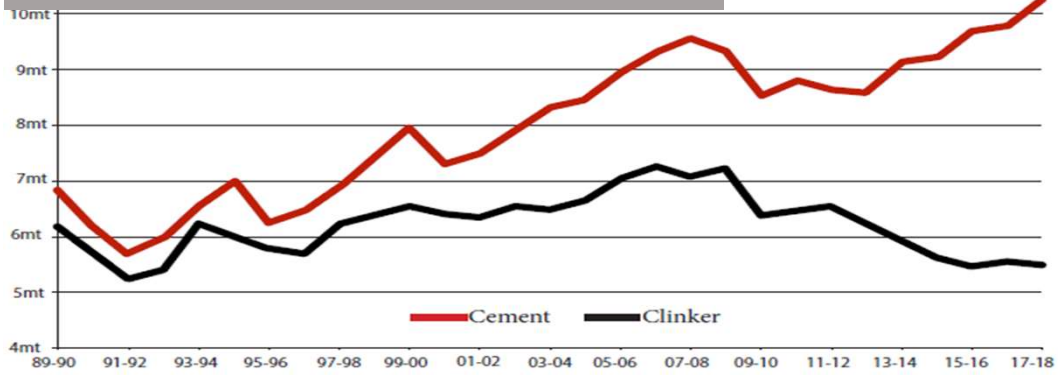
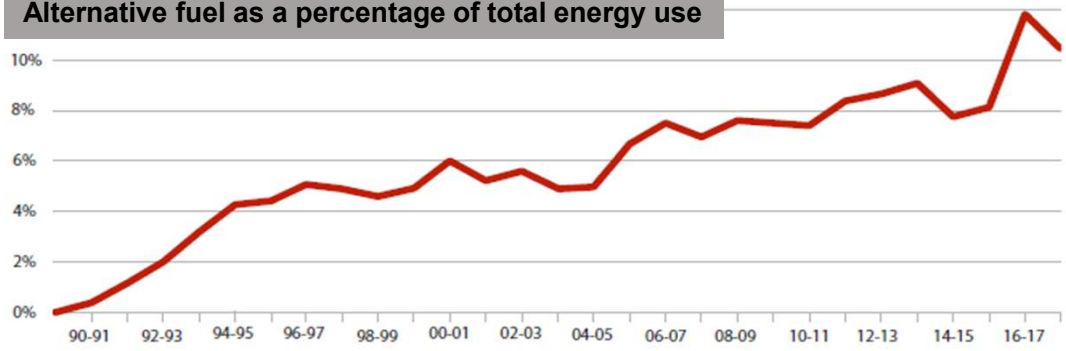
Current Status and Developments of Kiln Co-processing — Australia

Cement & clinker production (million tonnes)



Alternative fuel as a percentage of total energy use



- Since 1990 the increased use of alternative fuels in the cement manufacturing process has resulted in a significant reduction in both fuel and power use in Australia.
- In 2017-2018 over 10 percent of all fuels used in the Australian cement industry were derived from alternative sources

⇨

Mainly included:

- used oil
- demolition timber
- solvent fuels.

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Source: *Australian cement industry statistics 2018 – cement industry federation*

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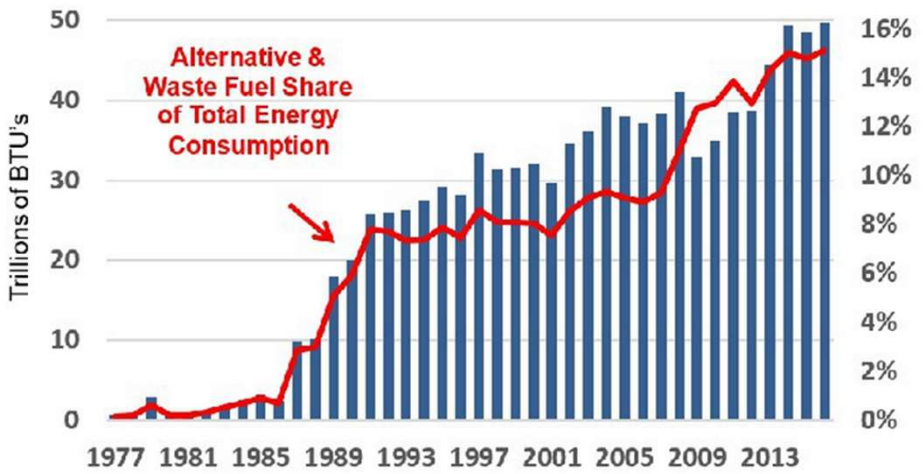
Current Status and Developments of Kiln Co-processing — USA

American cement industry began to use organic wastes in cement kiln in 1974, and started to promote the use in the whole industry in 1987, and some of the kilns were allowed to use waste materials as replacement of traditional fuel by 100%. Currently, 75 % of American cement plants use alternative fuels. The substitution rate of alternative fuel in American cement industry was 15% in 2016.

Alternative fuel use in US			
	2004	2010	2014
Total Reporting Plants	96	88	87
Plants using AF	62	64	65
Percent	64.6	73.8	75
Types of AF used			
Tire derived fuel	44	39	40
Waste oil	16	16	15
solvents	12	11	11
others	28	45	62



Alternative and waste fuel usage in the U.S. cement industry

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Source: *Development of alternative fuels in the U.S. cement industry– ZKG 1-2/ 2019*

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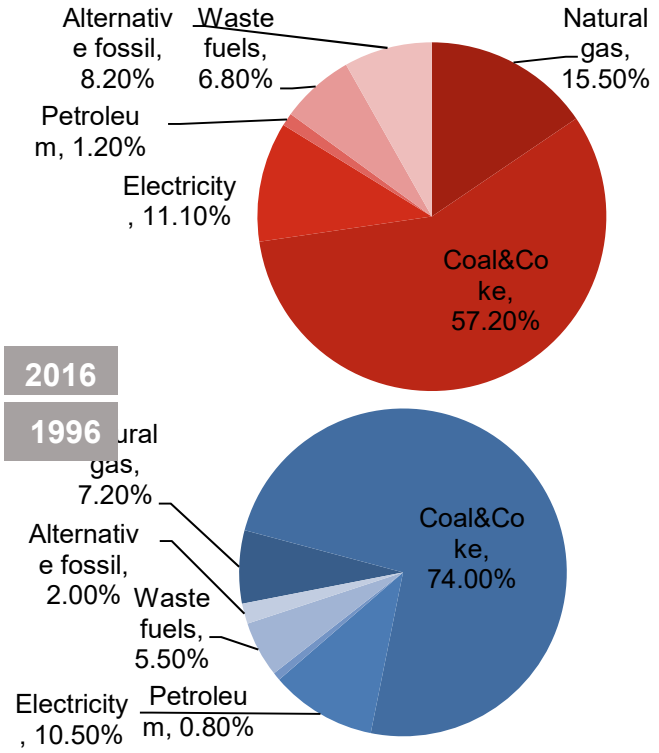
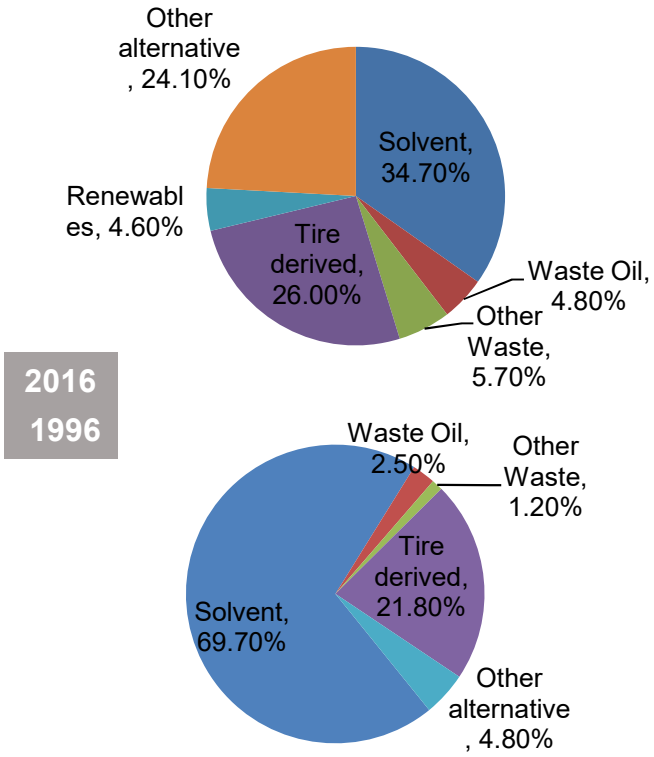
Current Status and Developments of Kiln Co-processing — USA



Change in energy mix of fuel usage in the U.S. cement industry 1996-2016



Source of alternate fuels in the U.S. cement industry 1996-2016

- *From 1996 to 2016. Coal and coke, once occupied the dominant share of fuels, has dropped from 74 % to just over 57 %.*
- *The use of other wastes and alternative fuels including refuse derived fuels, agri-waste, ashes, biofuels, biomass and etc. increased.*
- *Generally, there is still great potential for American cement industry to develop the comprehensive use of municipal wastes and industrial wastes as alternative fuels.*

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Source: *Development of alternative fuels in the U.S. cement industry– ZKG 1-2/ 2019*

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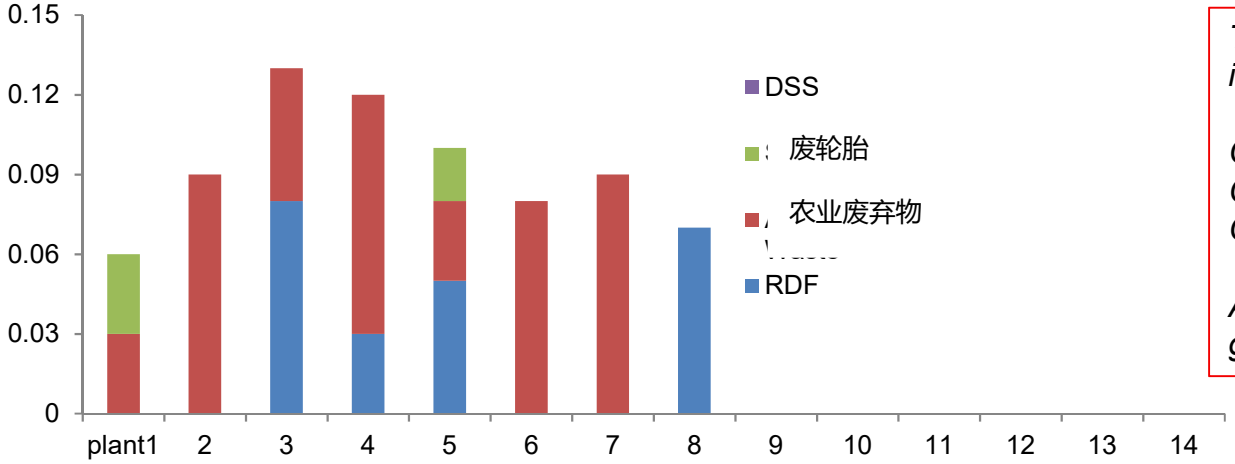
Current Status and Developments of Kiln Co-processing — Egypt

The potential for alternative fuel usage in Egypt is supported by ongoing uncertainty about the availability of fuels as a result of foreign exchange pressures, the heated political debate over GHGs emissions and health impacts, and the overall risks concerning the renewal of coal permits. Many cement plants have continued expanding their use of alternative fuels as a key solution.



The cement plants in Egypt was divided into 3 group according to the scenario:*

G1- AFR Early Movers
G2- Plants moving to use AFR
G3- Plants taking no action on AFR

And the TSR by 2025 for each group is 40%,30%,10%,respectively.

AFR TSR for 14 Cement Plants interviewed in April 2015 in Egypt.

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Source: *Unlocking Value: Alternative Fuels For Egypt's Cement Industry - international finance corporation*

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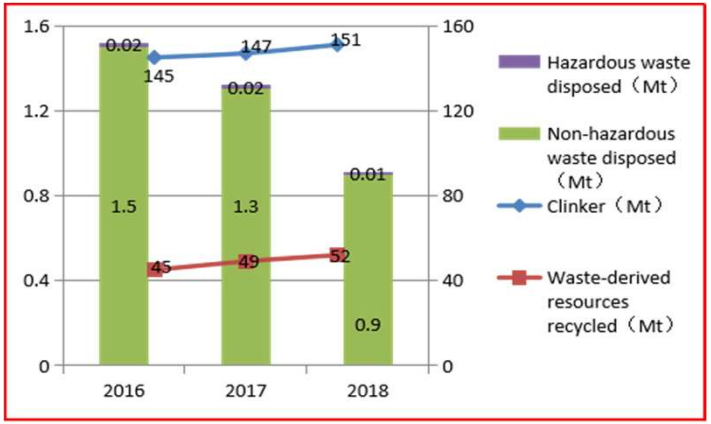
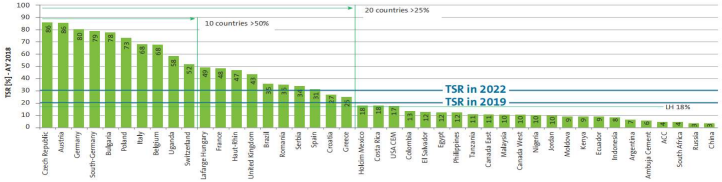
AFR — LafargeHolcim Cement group

	Unit	2016	2017	2018	2022 target	2030 target
Products and solutions						
Net sales (note 1)	bn CHF	26.9	27.0	**27.5**		
Total raw material consumption – all segments	Mt	537	548	**541**		
Clinker produced	Mt	145	147	**151**		
Clinker consumed	Mt	144	146	**149**		
Mineral components (slag, fly ash etc.) consumed	Mt	50	52	**56**		
Cement produced	Mt	194	198	**205**		
Mineral components processed and sold externally	Mt	4	4	**3**		
Cementitous material produced (note 2)	Mt	199	202	**210**		
Aggregates produced	Mt	250	259	**252**		
Asphalt produced	Mt	11	11	**11**		
RMX produced	M m³	49	46	**47**		
Clinker factor (average % of clinker in cements)	%	73	72	**72**		
Net sales of sustainable solutions (note 3)	%	-	8	**11**		
Producing assets included in the evaluation						
Producing companies	#	61	61	**60**		
Clinker producing sites	#	144	140	**139**		
Grinding and blending sites	#	61	64	**64**		
Aggregates sites	#	493	489	**464**		
Asphalt sites	#	80	84	**82**		
Ready-mix sites	#	1,278	1,270	**1,221**		
Kilns operated	#	194	180	**180**		
Quarries operated	#	714	709	**680**		
Recycling and waste						
Waste-derived resources recycled – all segments (note 4)	Mt	45	49	**52**	60	80
Alternative raw materials substitution rate	%	10.0	10.7	**11.2**		
Non-hazardous waste disposed	Mt	1.5	1.3	**0.9**		
Hazardous waste disposed	Mt	0.02	0.02	**0.01**		



Thermal Substitution Rate (TSR) averages 18% in 2018



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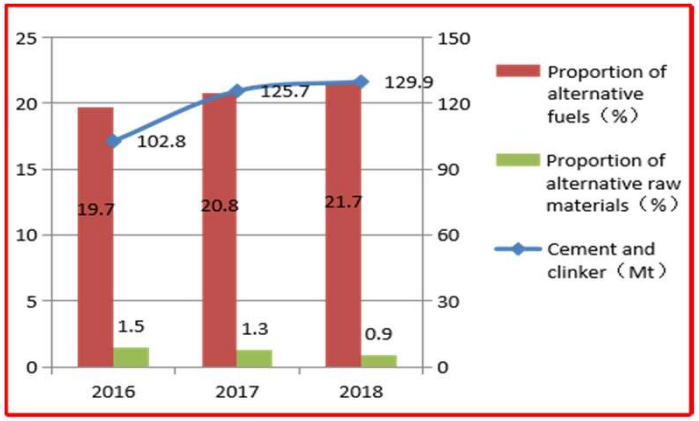
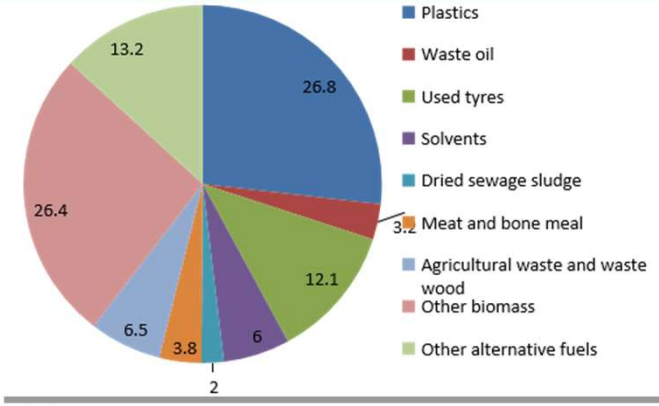
AFR — Heidelberg Cement group





		1990	2016	2017	2018	Unit
Energy/raw materials	Alternative fuel mix for clinker production:					
	– Plastics	1.6	25.3	25.3	26.8	%
	– Waste oil	29.0	6.8	3.4	3.2	%
	– Used tyres	17.1	11.8	11.8	12.1	%
	– Solvents	30.8	4.3	7.6	6.0	%
	– Dried sewage sludge	0.0	2.5	2.1	2.0	%
	– Meat and bone meal	0.0	4.0	4.2	3.8	%
	– Agricultural waste and waste wood	0.0	3.7	3.7	6.5	%
	– Other biomass	6.3	25.0	27.4	26.4	%
	– Other alternative fuels	15.1	16.6	14.6	13.2	%
	Proportion of alternative fuels (incl. biomass)	2.9	19.7	20.8	21.7	%
	Clinker content in cement	81.8	75.2	75.3	74.7	%
	Proportion of alternative raw materials:					
	– Clinker	n/a	3.6	2.7	3.1	%
	– Cement	n/a	12.0	11.1	11.3	%
		2008	2016	2017	2018	Unit
Emissions	Absolute NO_x emissions	84,571	92,814	119,642	114,514	t
	Specific NO_x emissions	1,585	1,343	1,373	1,263	g/t clinker
	Absolute SO_x emissions	27,007	21,746	31,989	31,858	t
	Specific SO_x emissions	506	315	367	351	g/t clinker
	Absolute dust emissions	17,043	8,031	7,862	7,272	t
	Specific dust emissions	319	116	90	80	g/t clinker
	Proportion of clinker produced in kilns with continuous or discontinuous measurement of all emissions:	65	86	87	83	%
	Proportion of clinker produced in kilns with continuous measurement of dust, NO_x, and SO_x emissions:	87	83	88	90	%
	Mercury:					
	– Specific emissions	n/a	0.028	0.034	0.030	g/t clinker
	– Number of kilns reporting	n/a	77	107	112	
	Dioxins and furans:					
	– Specific emissions	n/a	0.018	0.059	0.035	µg TEQ/t clinker
	– Number of kilns reporting	n/a	78	111	125	

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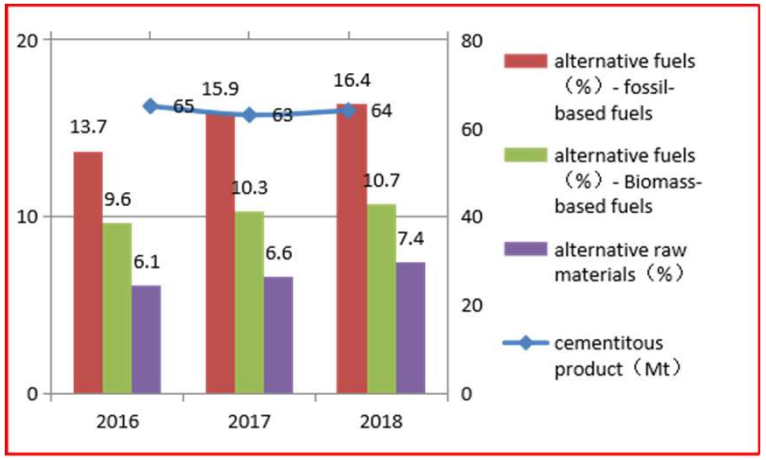
CARBON STRATEGY AND ENERGY	2016	2017	2018
Scope 1 CO_2 emissions (million ton)	44.2	42.9	43.4
Scope 2 CO_2 emissions (million ton)	3.6	3.6	3.6
Clinker Factor (Cementitious) (%)	78.4	78.4	78.6
Alternative raw material rate (%)	6.1	6.6	7.4
Specific heat consumption (MJ/ton clinker)	3,905	3,913	3,987
Specific power consumption (kWh/ton cem)	120	120	121
Fuel Consumption (TJ)	206,343	201,681	208,154
Power Consumption (GWh)	7,779	7,542	7,761
Total Energy Consumption (GWh)	65,097	63,564	65,582
Fuel Mix (%)			
Primary Fuels	76.7	73.8	72.9
Petroleum coke	45.4	39.0	37.0
Coal	25.0	28.0	25.8
Fuel oil + Diesel	2.0	3.8	4.4
Natural gas	4.3	3.0	5.8
Alternative Fuels	23.3	26.2	27.1
Fossil-based waste	13.7	15.9	16.4
Biomass waste	9.6	10.3	10.7
Power consumption from renewable energy in cement (%)[9]	25	26	26

WASTE MANAGEMENT	2016	2017	2018
Hazardous waste sent for disposal (thousand ton)	95.1	95.3	106.4
Non-hazardous waste sent for disposal (thousand ton)	276.5	250.5	307.7
Total waste sent for disposal (thousand ton)	371.6	345.8	414.1
Total consumption of waste-derived sources from other industries (million ton)[5]	–	12.5	13.2
Ratio of consumption from waste-derived sources from other industries vs. waste sent for disposal[5]	–	36	32



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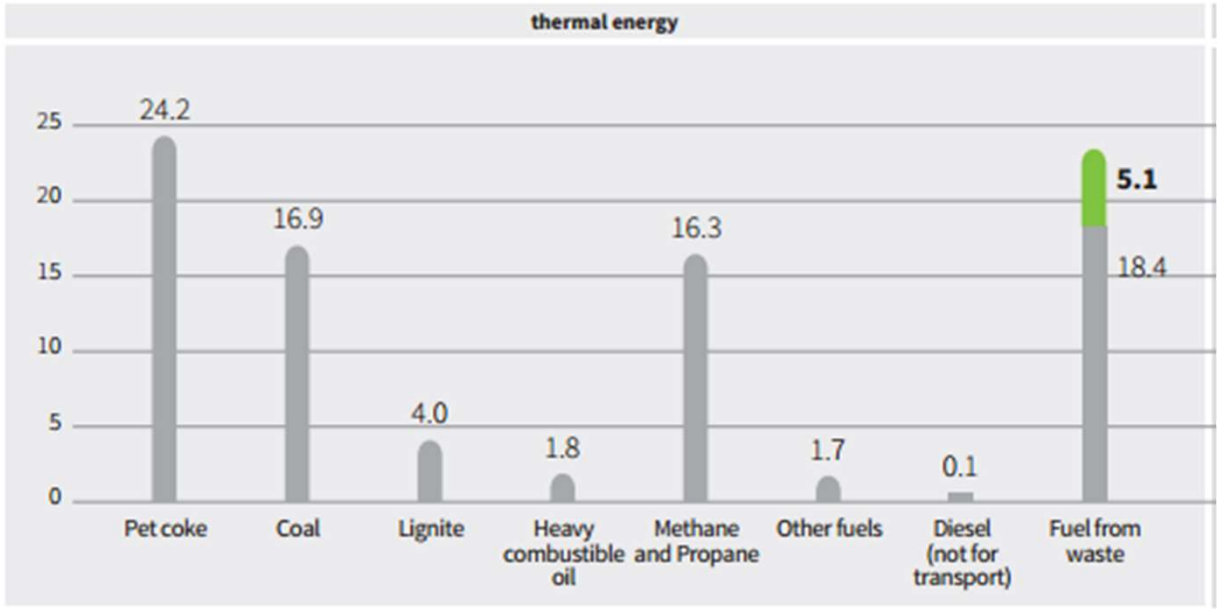
Percentage breakdown of energy consumption by type and source (2018)

In 2018, the total energy consumption was 104,772 TJ



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Current Status and Developments of Kiln Co-processing — China

The development and prospect of cement kiln co-processing in China					
Time	Status	Municipal solid wastes		Sewage sludge and hazardous wastes, etc.	
		Number of kiln	Disposal capacity（kt/a）	Number of kiln	Disposal capacity（kt/a）
2009 year end	In operation			1	30~50
2010 year end	In operation	1	80~100		
2013 year end	In operation	12	1,800	22	660
Jun. 2017	In operation	43	2,500~3,000	33	3,600
	Under construction	20	2,000	20	2,000
2020 year end（planned）	In operation	150~200	25,000	150	15,000

In 2016, about 76 kiln lines in China disposed more than 3mt of original wastes and 3.6mt of sewage sludge and hazardous wastes, but the total coal substitution rate in clinker production was only 1.8%, it is still a big gap to cross to reach the goal for 2020, that is 10%-15% of kiln lines in China(about 200kilns) to use wastes derived alternative fuel, and the coal substitution rate to reach 20% or above in clinker production.

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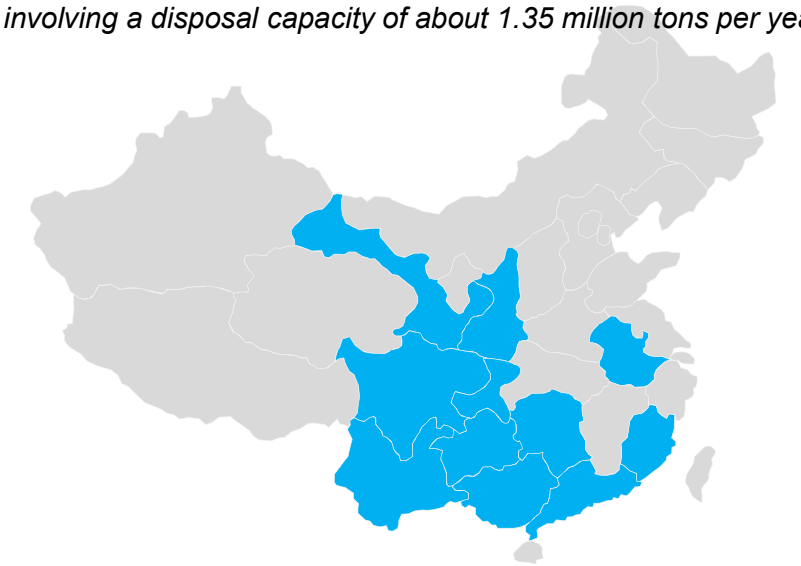
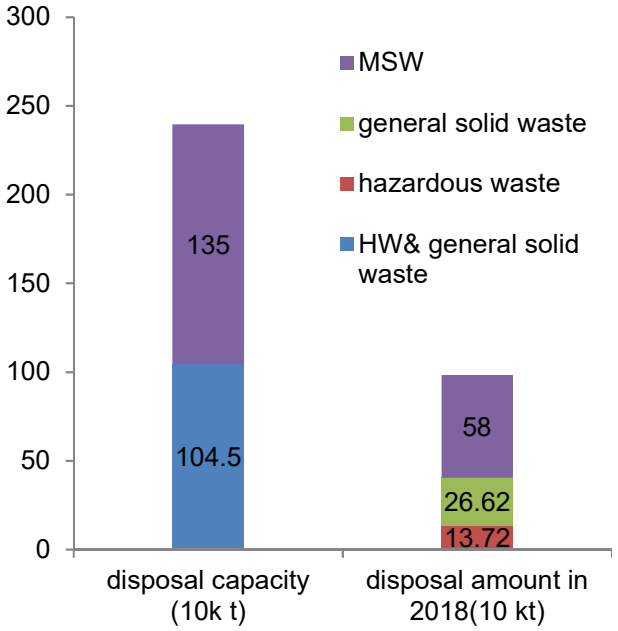
Current Status and Developments of Kiln Co-processing — China — Conch

The total cement kiln co-processing capacity has reached 2.4 million tons per year, of which:

- *11 projects have been completed for solid waste disposal business with annual disposal capacity of 1.045 million tons.*
- *16 cement kiln waste co-processing projects have been completed, involving a disposal capacity of about 1.35 million tons per year.*





Source: *2018 annual report of conch venture*

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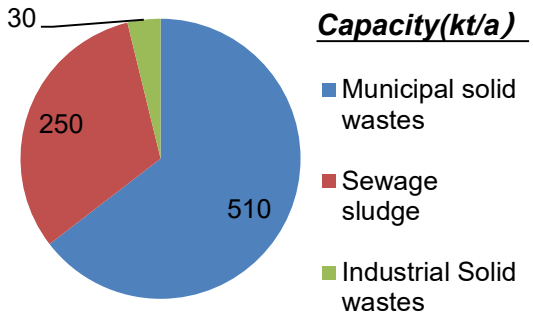
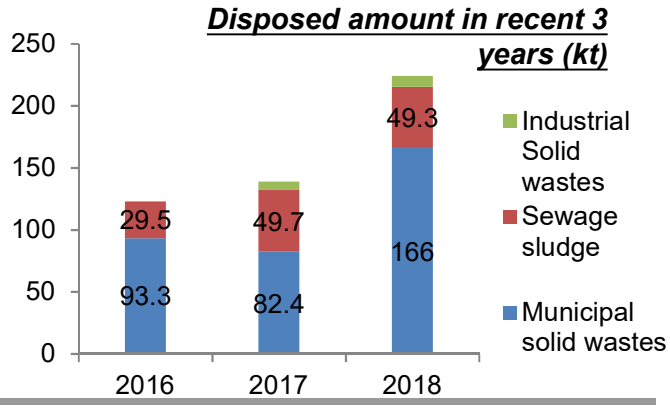
Current Status and Developments of Kiln Co-processing — China — CRC

location	type	capacity	status
Binyang, Guangxi	Municipal solid waste	300t/d	In operation
Tianyang, Guangxi	Municipal solid waste	500t/d	In operation
Nanning, Guangxi	Sewage sludge	300t/d	In operation
Guangzhou, Guangdong	Sewage sludge	300t/d	In operation
Changjiang, Hainan	Industrial hazardous waste	30000t/a	Trial operation
Midu, Yunnan	Municipal solid waste	300t/d	Trial operation
Fengqing, Yunnan	Municipal solid waste	300t/d	Trial operation

indicator	Unit	2016	2017	2018
Municipal solid waste	ton	93,300	82,400	166,000
Sewage sludge	Ton	29,500	49,700	49,300
Industrial hazardous waste	ton	-------	6,700	8,700





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Source: 2018 Chinaresources Report on Social Responsibility

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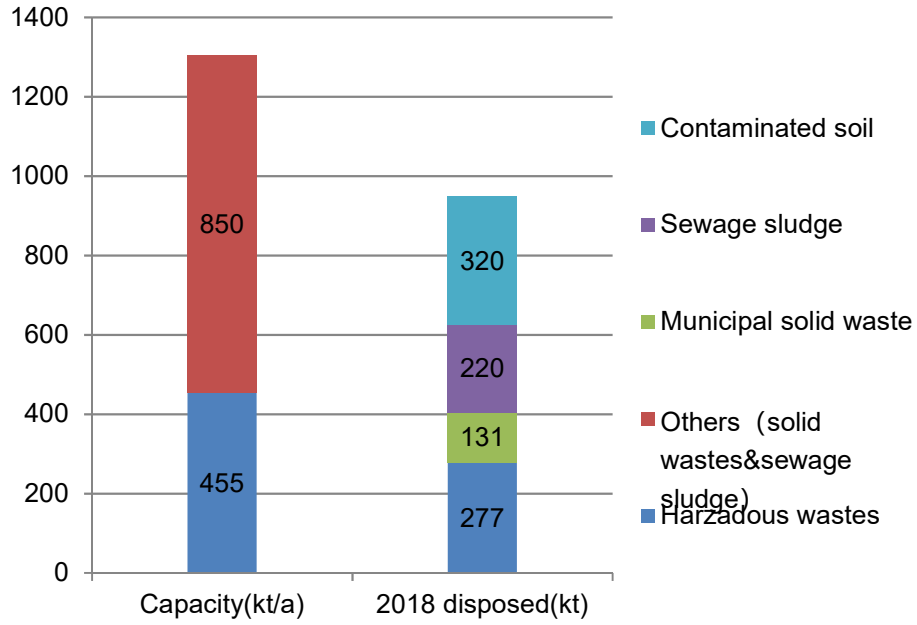
Current Status and Developments of Kiln Co-processing — China — Others



Co-processing capacity of BBMG *(Source：Annual Report of BBMG Group)*

Others：

- ***CGGC:*** *Laohekou project, Songzi project and Yicheng project with 470kt/a capacity in total.*
- ***Red lion:*** *17 cement kiln co-processing projects in Zhejiang Province, Fujian province, Guangxi province, Yunnan province and Xinjiang Region with 1800kt/a capacity in total.*
- ***Gold Circle group:*** *5 cement kiln co-processing projects for hazardous wastes and solid wastes with 400kt/a capacity in total.*

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Current status and developments of kiln Co-processing — China — Huaxin

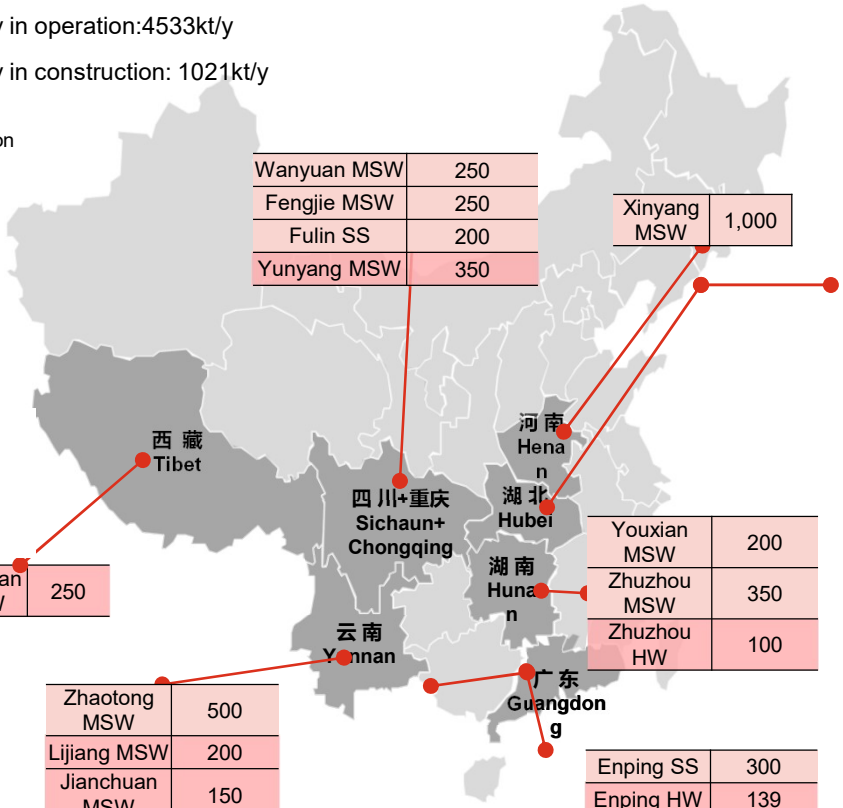
Total capacity in operation:4533kt/y

Total capacity in construction: 1021kt/y

Total Capacity (in operation + in construction):

- MSW: 4212kt/y
- SS: 749kt/y
- HW: 205kt/y
- CS: 216kt/y
- Others: 172kt/y

MSW-municipal solid waste; SS- sewage sludge; HW-hazardous waste ; CS- contaminated soil; FW-floating waste; IW- ordinary industrial waste



Wanyuan MSW	250
Fengjie MSW	250
Fulin SS	200
Yunyang MSW	350

Xinyang MSW	1,000

Youxian MSW	200
Zhuzhou MSW	350
Zhuzhou HW	100

Shannan MSW	250

Zhaotong MSW	500
Lijiang MSW	200
Jianchuan MSW	150

Enping SS	300
Enping HW	139

Plant	T/D
Wuxue MSW+CS+HW+SS	1000+600+32+100
Zigui FW	200
Wuhan Chenjiachong MSW	1,000
Chibi MSW+SS	250+50
Ezhou MSW	1,000
Yingcheng MSW	250
Huangshi SS	100
Wuhan Longwangzui SS	600
Wuhan Nantaizihu SS	300
Daye SS+IW	50+278
Nanzhang MSW	300
Zigui MSW	250
Shiyan MSW	1,000
Wuhan Changshankou MSW	2,000
Yichang SS	180
Nanzhang HW	139
Shiyan HW+SS	20+200
Yidu MSW	350
Badong MSW	250
Wuxue MSW2	300

By the end of 2018, Huaxin has harmlessly disposed MSW of 5044kt, SS of 1819kt, Three Gorges Dam FM of 710k M3 , HW of 113kt and CS of 770kt. The MSW disposed by Huaxin occupies more than 50% share of the MSW disposed by cement kiln co-processing in China, and more than 95% of that in Hubei province.

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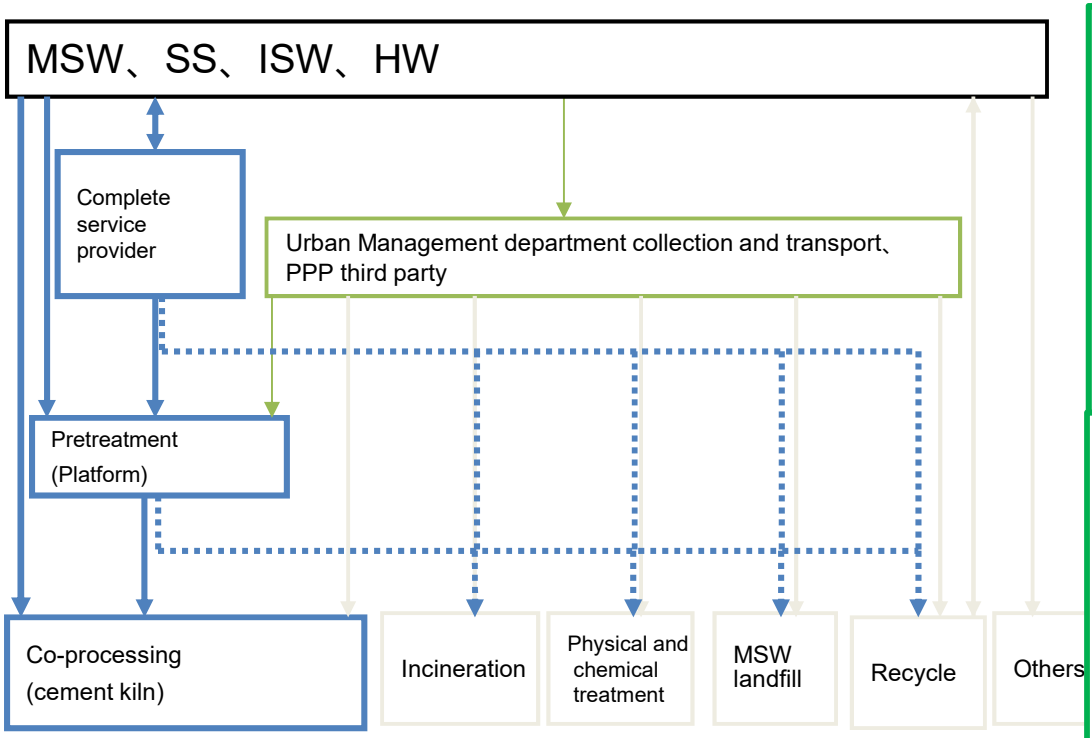
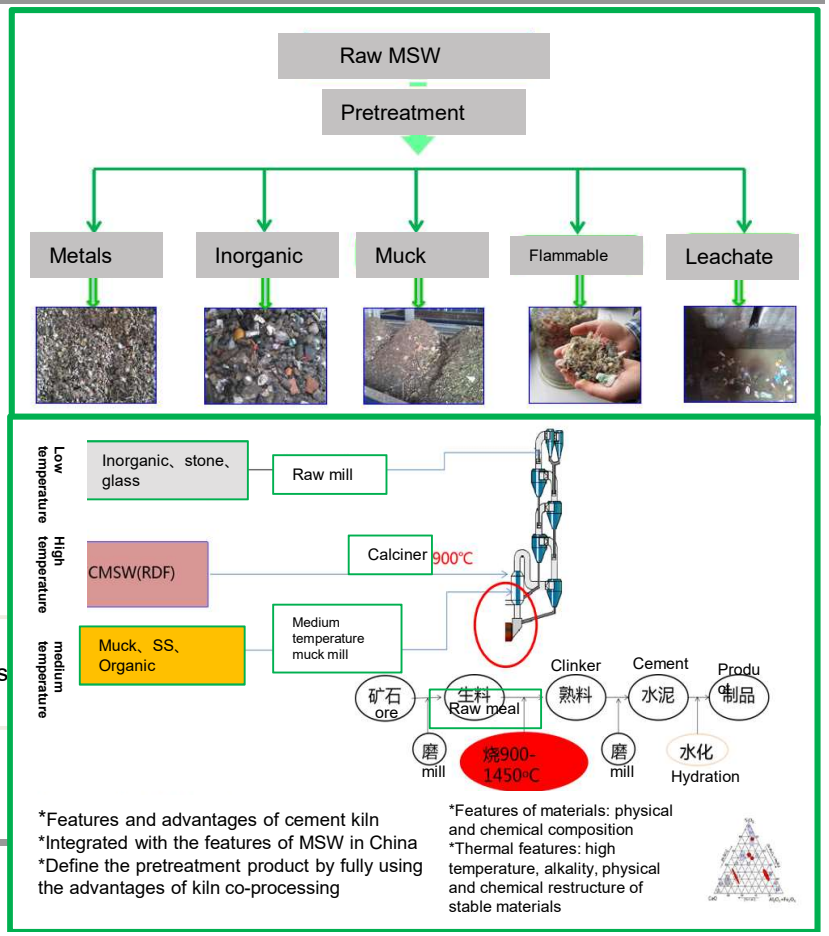
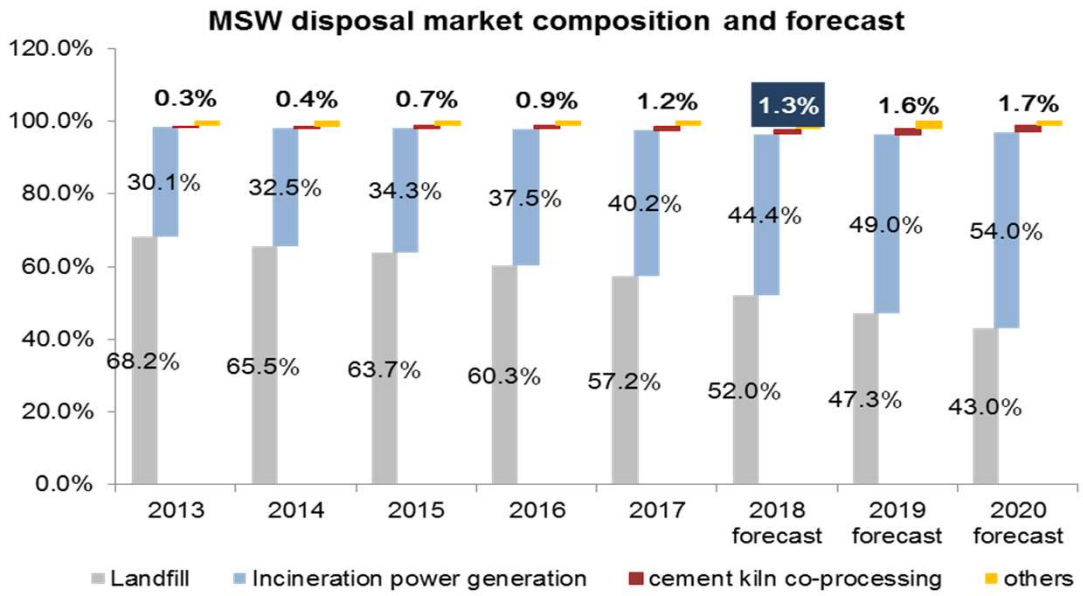
Current Status and Developments of Kiln Co-processing– Business/technology roadmap of Huaxin Cement

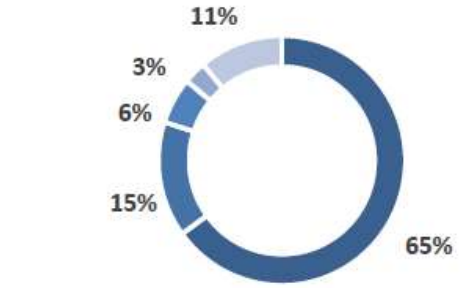




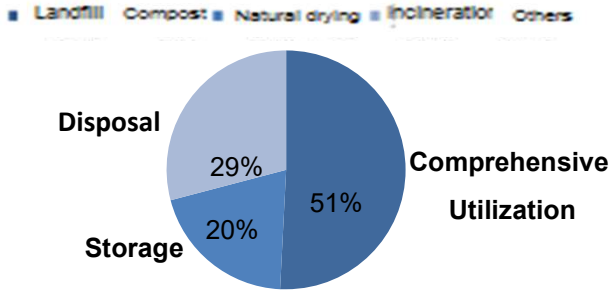
Prospect — problems & suggestions

Based on the long time practice of other countries, we know that it is a must for cement industry to go green and turn itself into an environmental protection industry through conducting co-processing business. But currently, only a small proportion of wastes are disposed by cement kiln co-processing. There is a large room and a big potential for co-processing to achieve.





Sewage sludge harmless disposal in China



Hazardous wastes disposal in China

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Prospect — problems & suggestions

Cement kiln has already been testified as a suitable means for solid wastes disposal, and in many cases, cement kiln co-processing is better in use than traditional incineration. Adequate technology and management can ensure the safe environment and the emission(furan, dioxin and heavy metals) in line with standards, with no impact on the clinker quality and the OEE of cement kiln.

With growing pressure on the world's sustainable development that stems from resources and environmental problems , cement industry in various countries have become active in going green and pursue low carbon and sustainable development. Kiln co-processing, originally a cost saving measure thus became a development strategy in environment management, energy saving GHG reduction, as well as the social sustainable development, and an integral part of cement industry.

Promoting cement kiln co-processing can help cement industry to lower pollutants emission and expand its business scope. Develop cement industry into a green and environment protection industry by providing wastes disposal service is a must trend. In developed countries where cement industry is a mature industry, the industry presents a good image with energy saving and emission reduction, and a cement plant there is not only a industrial producer, and also an integral part of the whole recycling economy.

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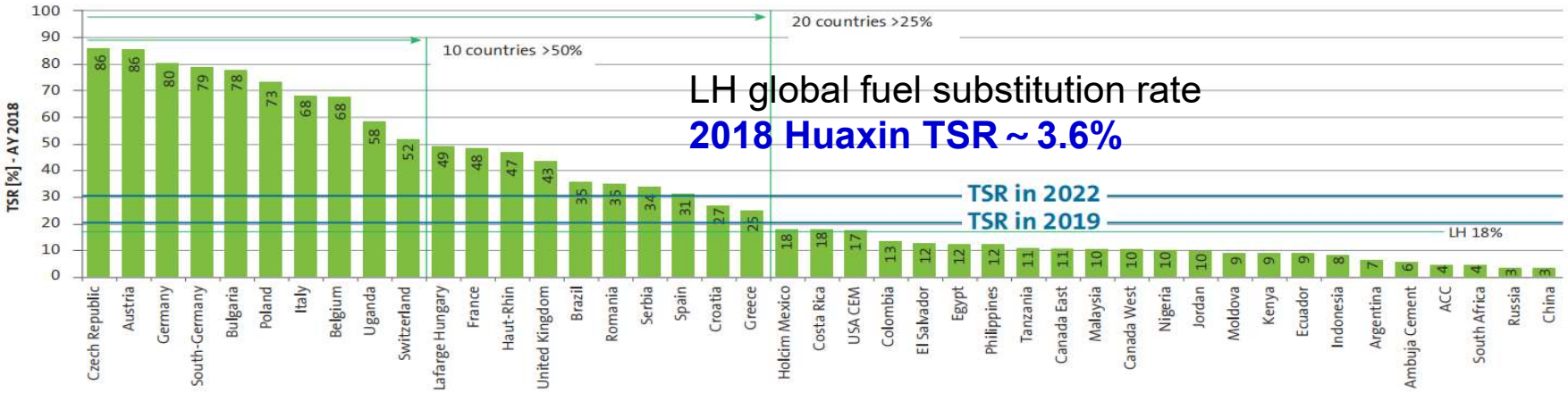
Prospect — problems & suggestions

Thermal Substitution Rate (TSR) averages 18% in 2018



It is still a big gap between developing countries and developed countries in thermal substitution rate. Like China, India, Argentina and Indonesia etc, it was far lower than the proportions of 13% in US, 22% in Japan, 68% in Germany and 90% in Norway. The major reason is that in developed countries, there are various flammable wastes with balanced proportion in calorific value to be disposed through co-processing, while in developing countries, co-processing mainly used to dispose municipal solid waste and sewage sludge that hard to dispose and with only very low calorific value.

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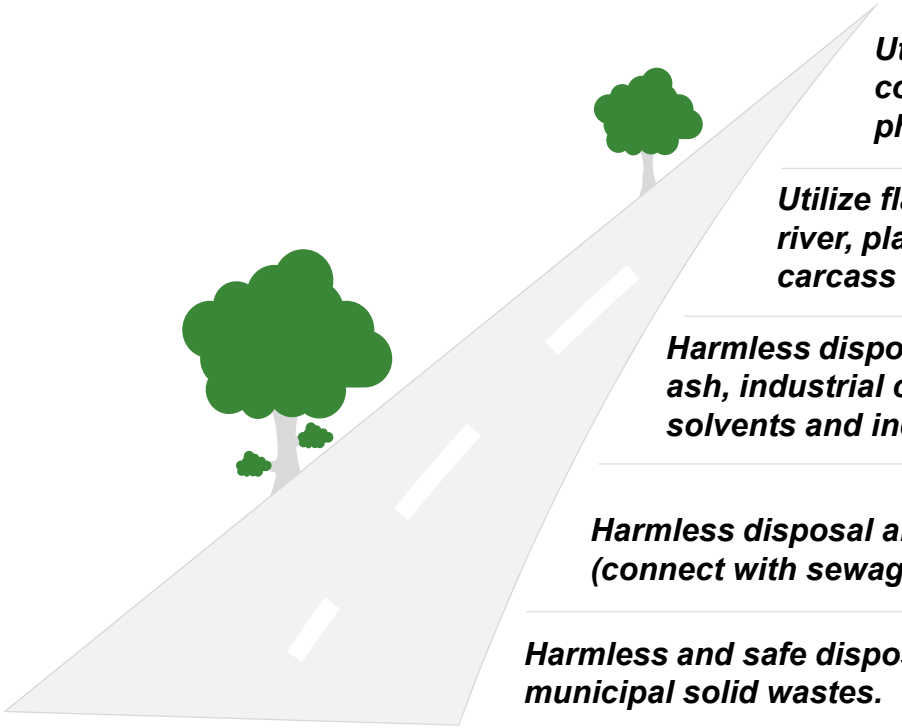
Prospect—Cement industry to become a green industry with environment protection functions



Utilize industrial solid waste as resources(mineral waste, coal ash, furnace slag, steel slag, desulfurization gypsum, phosphogypsum, carbide slag

Utilize flammable waste as resources(floating wastes in river, plastics and leather, fabric, tire, waste oil, animal carcass

Harmless disposal of industrial wastes(incineration fly ash, industrial contaminated soil, various poisonous solvents and industrial rejects, etc.)

Harmless disposal and utilization of sewage sludge (connect with sewage treatment plant)

Harmless and safe disposal of municipal solid wastes.

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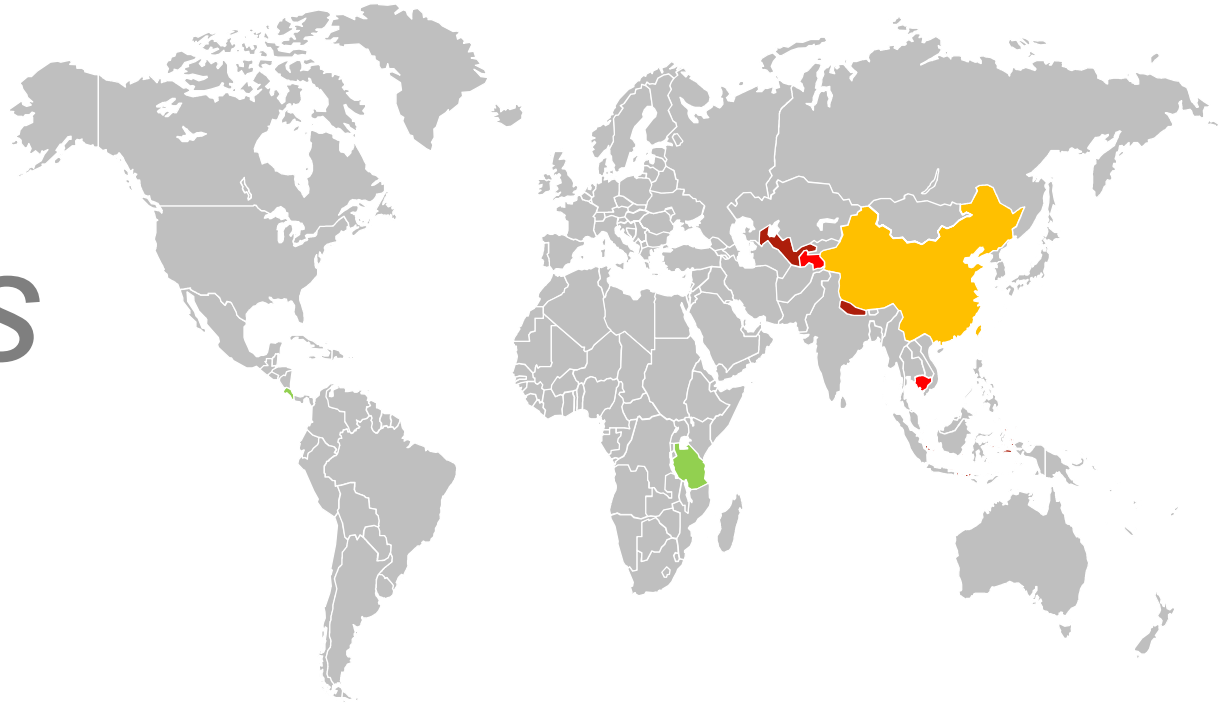
Thanks



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