
# The Co-benefit Study on Greenhouse Gases Mitigation and Air Pollution Control in China

Chinese Research Academy of Environmental Sciences

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# Contents




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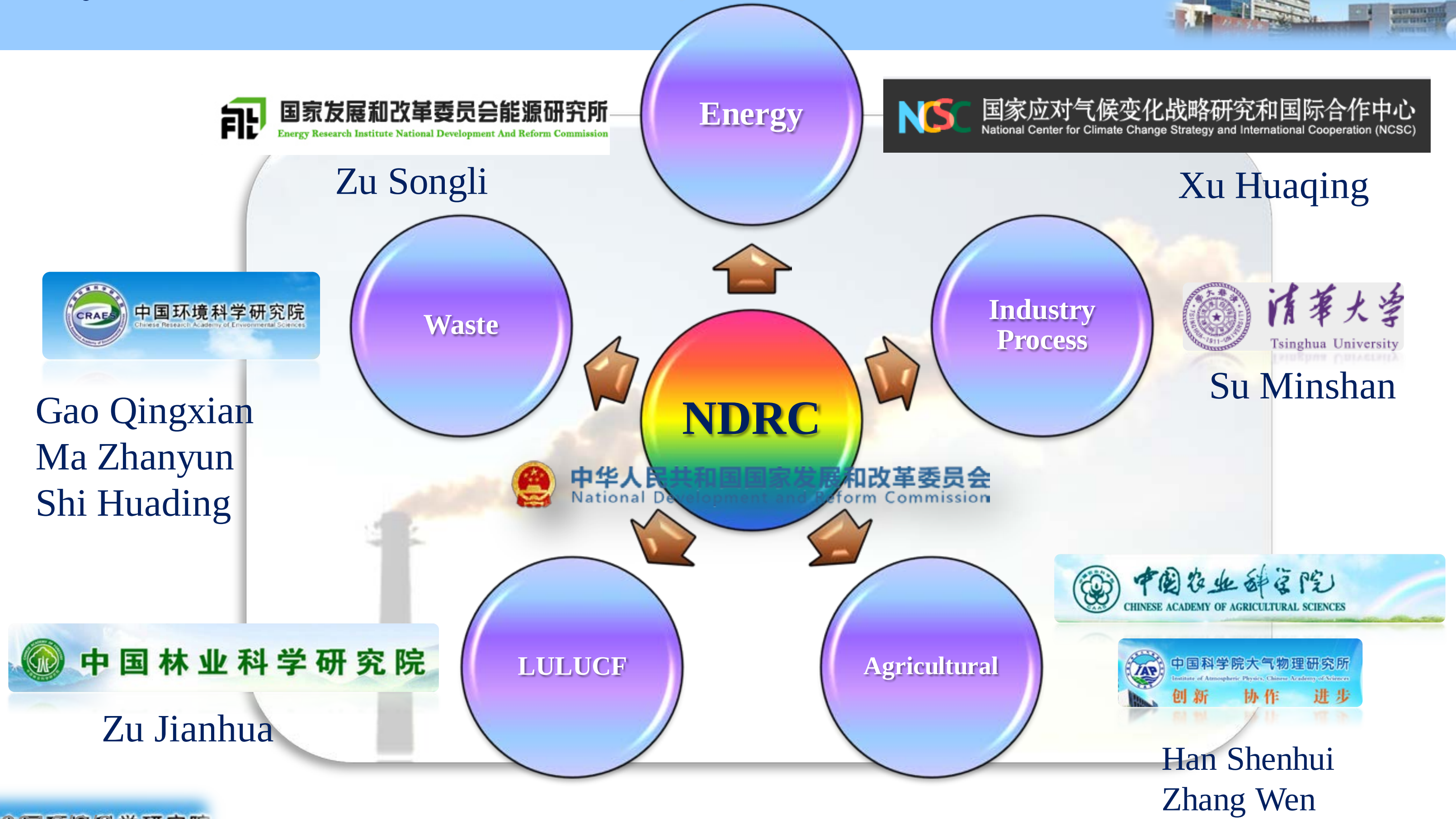
# NGIT Brief----National Greenhouse Gases Inventory Team

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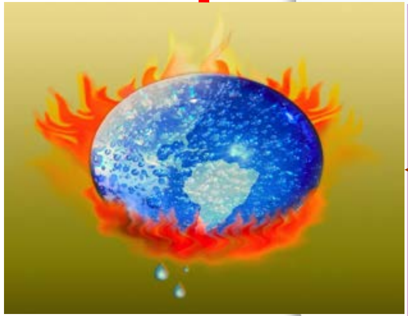
Pollutants characters
Photochemistry
Transportation and deposition
Visibility
Acid deposite
Oxidation ability
……

Climate change impact on atmospheric pollution



Atmospheric pollution impacts on climate change

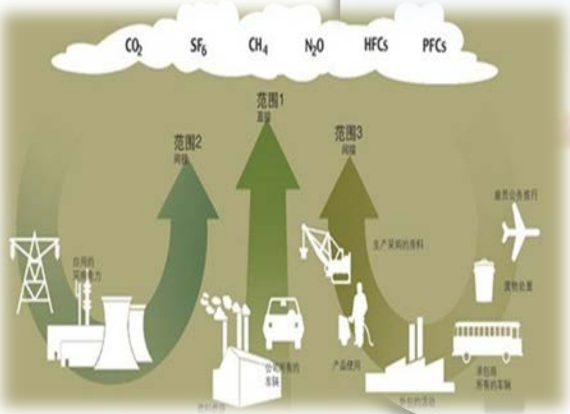
Clouds
Aerosol
Direct and indirect raditive forcing
SLCP

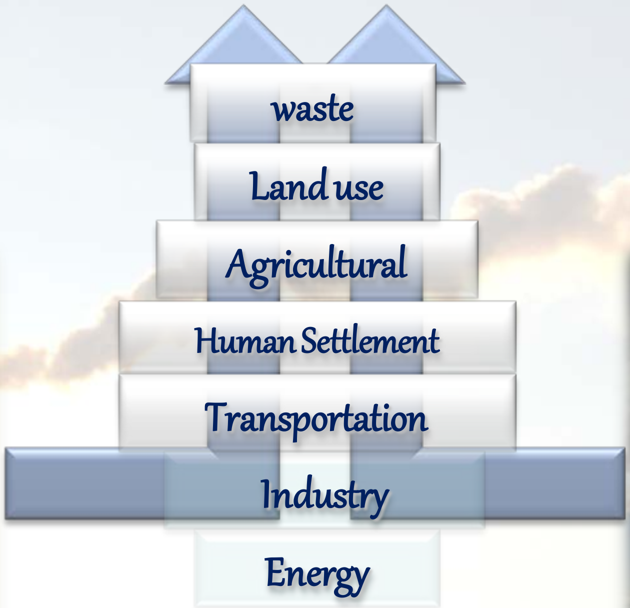
**Climate Change**

**Atmospheric pollution**


$NF_3$ $SF_6$ PFCs HFCs $CH_4$ $N_2O$ $CO_2$

BC Pb Hg Ge $H_2S$ CO VOCs NO $NO_2$ PMs $SO_2$



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# The Connotation of Co-benefit --Same-measures property

Enhance Afforestation etc.

Develop circulate economy

Renewable energy

Low Carbon technology

Industry policies

Energy Saving

Desulfurization and denitrogenation

Enhance Afforestation

Cleaner production

Technique reform

Clean energy

Energy Saving

waste

Land use

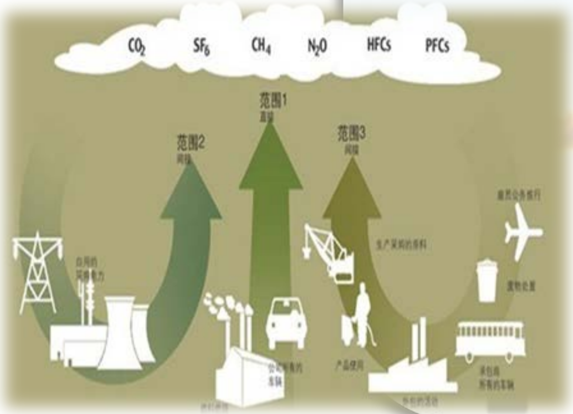
Agricultural

Human Settlement

Transportation

Industry

Energy





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# The Connotation of Co-benefit --Principle

The Co-benefit principle **is to maximize synergetic control effects. It consists of two aspects:**

- Physics------the resources utilization maximized and pollutant emissions minimized.
- Economy----the economic efficiency maximized, and ensuring resources saving and enhancing control measures.



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**Targets for co-benefit control：** Pollutants Emission Sources and Greenhouse Gases Emissions

- Executive Subject： people, a conscious intervention activities.
- Executive Object: All kinds of process,

  **the emission source, technical and policy etc.**


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# The Connotation of Co-benefit --Goal

- **To ensure** normal activities (production and daily life),
- **To maximum** save economic resources and material resources ,
- **Do not** produce waste,

under this premise, **to realize the minimizing pollutant emissions and greenhouse gas emissions**.


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- **To clarify the mechanism of co-benefit control**
  - To identify the boundary and clarify the process
  - To quantify all kinds of emissions (pollutants and GHGs) 【include direct and indirect emissions】
  - To identify positive and negative co-benefit effects in each link
- **To formulate co-benefit control scheme**
  - According the control key points to design the scheme
  - To quantify the co-benefit control effects
  - To improve co-benefit control scheme
- **To enhance co-benefit control management and assessment**
  - To build supervision and management system
  - To enhance communication and sharing
  - To carryout co-benefit control effect assessment


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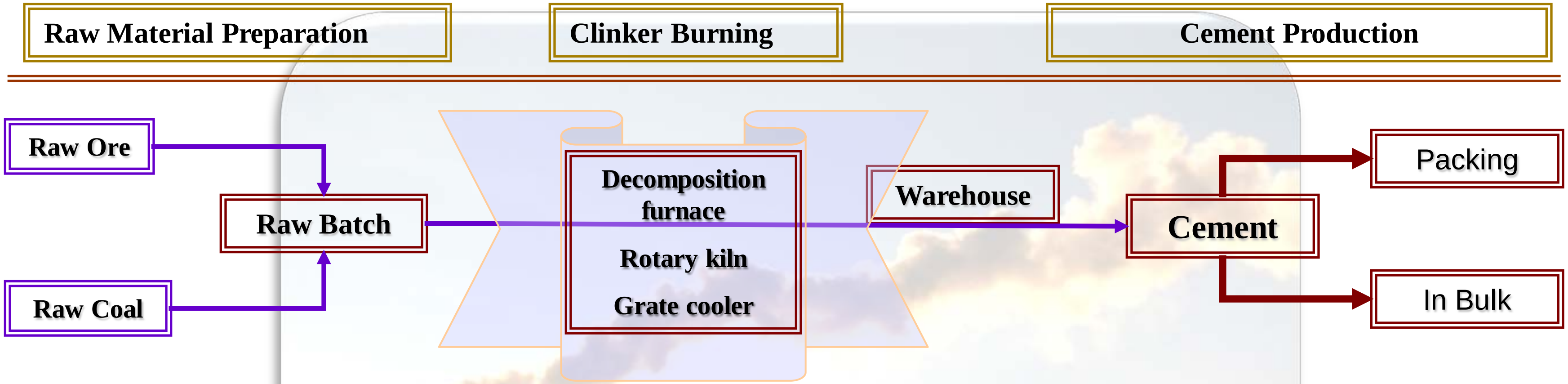
# The Mechanism of Co-benefit ---- {Cement}




Sources
【material pile、transportation】
【broken】
PM
Indirect $CO_2$

Source:
【burning 】
【 transportation、electricity】
PM、 $SO_2$、 $No_x$
Direct and indirect $CO_2$

Sources
【 material pile、transportation 】

PM
Indirect $CO_2$



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# The Mechanism of Co-benefit ---- {Iron and Steel}

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**Raw Materials** | **Sintering** | **Steel-making**

**Raw Ore** → **Warehouse**

**Subsidiary** → **Warehouse**

**Sintering and iron-making**

**Coking, blast furnace**

**Electric furnace, converter**

**Steel-making** | **Continuous casting** | **Steel rolling**

Sources
【material pile、transportation】
【broken】
PM
Indirect $CO_2$

Source:
【burning 】
【 transportation、electricity】
PM、F、 $SO_2$、 $No_x$
Direct and indirect $CO_2$

Source:
【burning 】
【 transportation、electricity】
PM、F、 $SO_2$、 $No_x$
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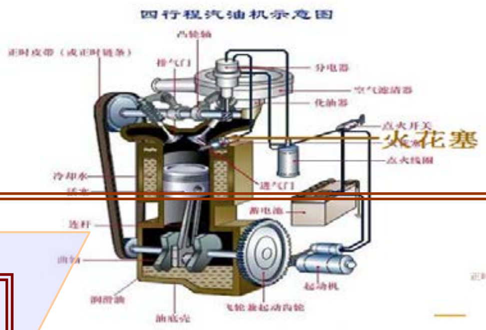
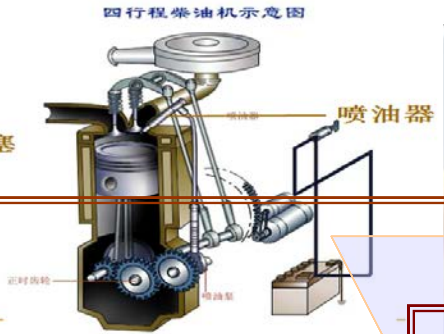
# The Mechanism of Co-benefit ---- {Transportation}




**Gasoline Energy**

**Diesel Engine**

*Steady state emissions*

**large, medium and small load; speed different ;**

**CO, HC and NOx**

*Transient emissions*

**Cold and hot starting, acceleration, the sudden increase in load conditions while moving**

Source:

【burning、transportation、electricity】

PM、 CO 、 HC、 $No_x$ 、 BC

Direct and indirect $CO_2$

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**Pollutants emissions**

**GHGs emissions**

**Co-benefit control**
**Quantitative Assessment**

**Gases:**

- ☐ $SO_2$
- ☐ $NO_x$
- ☐ PM
- ☐ VOCs….

**Progress:**

- ■ Burning
- ■ Transportation
- ■ Warehouse
- ■ Transformation…

**IPCC methods:**

- ☐ $CO_2$
- ☐ $CH_4$
- ☐ $N_2O$
- ☐ F-Gases….

**CMD method**

**Others**



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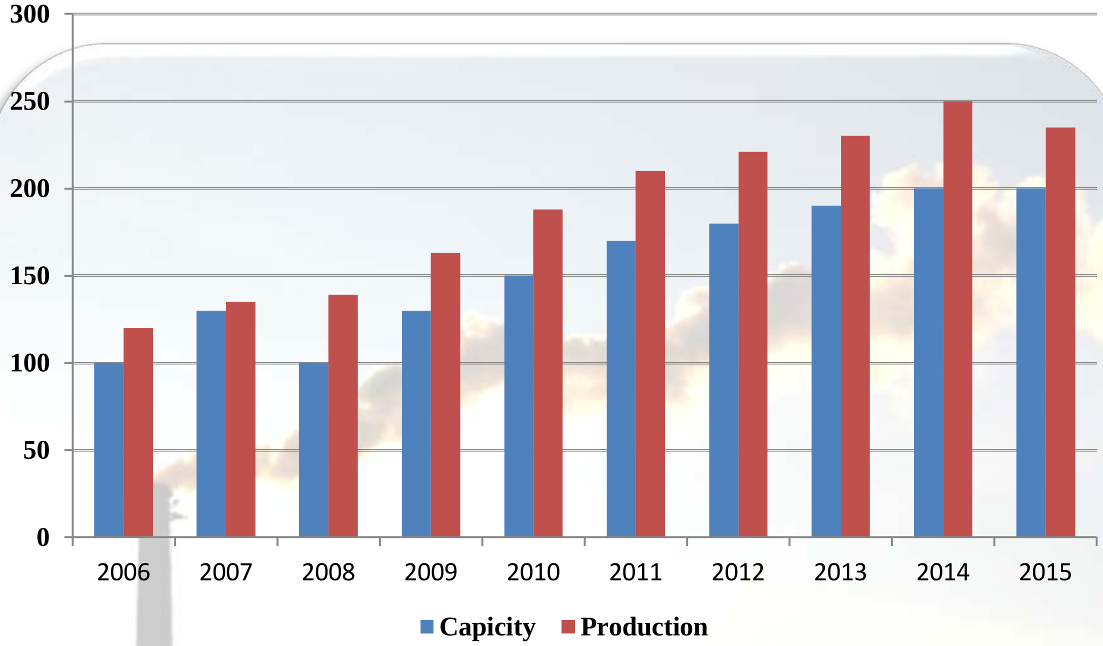
# The Case studies-----Cement




China's cement production and capacity in recent decades (ten million tons)

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# The Case studies-----Cement

**NOx**

High temperature **aerobic burning** of $H_2$ in the air

**HF**

Fluorite ore machine
In the process of calcinations of the raw materials

**Dust**

Raw material preparation system
Clinker burning system
Made from cement system

**$SO_2$**

Raw materials burring
Fuel combustion

**$CO_2$**

$CaCO_3$ decomposition of raw materials
Fuel combustion

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## To speed up the eliminating for backward production techniques
## To develop and promote the new dry process kiln technology

**The comparison of coal consumption of Cement production**

| Product method | Heat consumption of clinker（kJ/kg） | Standard coal consumption of Clinker（kgce/t） | relevant（%） |
|---|---|---|---|
| New dry process kiln | 3260 | 111 | 100 |
| Shaft kiln | 4180 | 143 | 129 |
| Lepol kiln | 4096 | 140 | 126 |
| Hollow dry kiln | 5434 | 186 | 168 |
| Wet kiln | 5852 | 200 | 180 |

## To speed up the eliminating for backward production techniques
## To develop and promote the new dry process kiln technology

The $CO_2$ emissions intensity from different clinker process (t one cement guessed)

| Type of kiln | Production | Coal consumption | Electricity | Total |
|---|---|---|---|---|
| Shaft kiln | 480.65 | 398.34 | 21.50 | 900.50 |
| Wet kiln | 495.74 | 458.99 | 54.74 | 1009.47 |
| Pre heater kiln | 501.81 | 352.64 | 77.43 | 931.88 |
| New dry process kiln | 498.01 | 254.52 | 81.47 | 834.00 |



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# 2 To treat solid waste using cement kiln techniques

CONCH 海螺水泥 Anhui Conch Cement Company Limited (CONCH)

## To Disposal Municipal Solid Waste Using New Dry Process Kiln Processing System

- The cement production capacity is 5000 tons
- The MSW treatment amount is 600 t/d (300 t/d x 2)
- 19.8 thousand tons MSW per year were treated
- The energy saving 13 thousand tons ce per year
- The $CO_2$ reduction 30 thousand tons per year
- The Dioxin emission is about 0.0376 $ng/m^3$

{far less than control standard value (0.1 $ng/m^3$) in most EU country}



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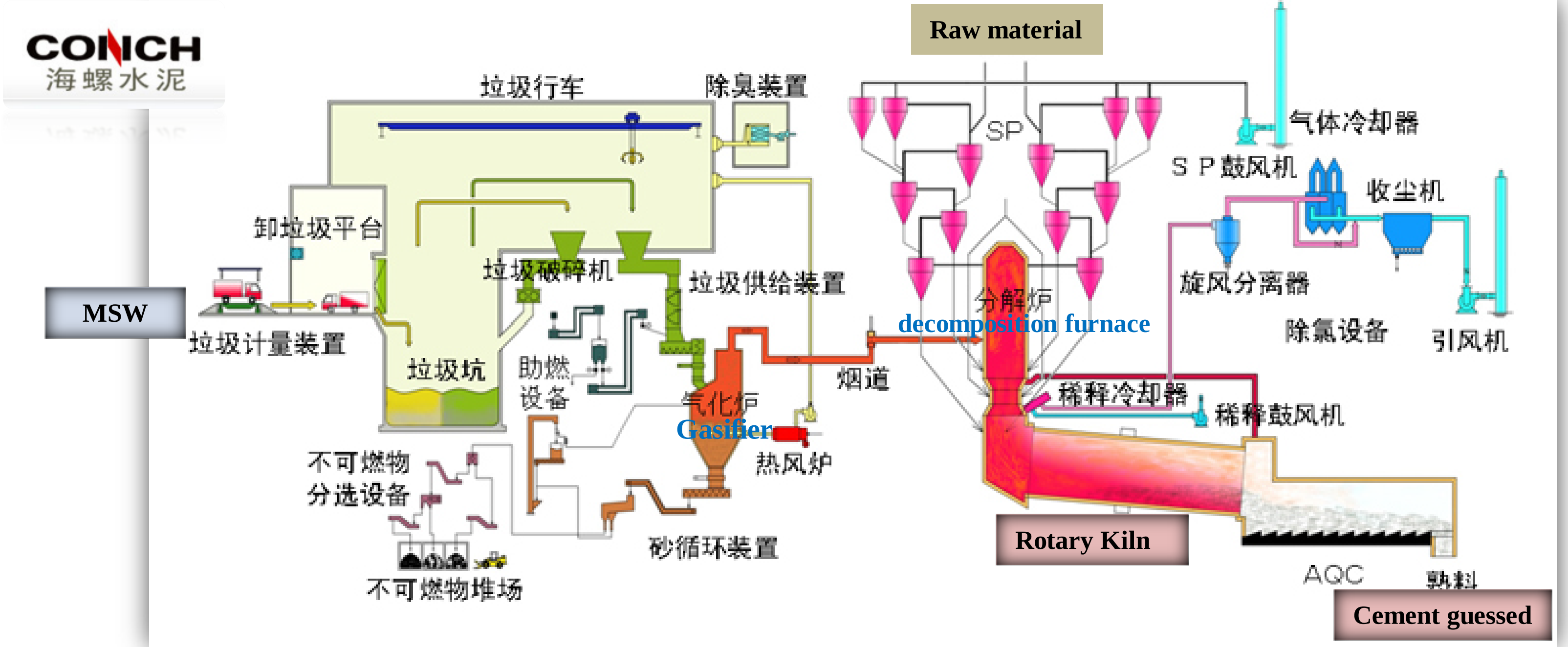
## 2 To treat solid waste using cement kiln techniques



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# The Case studies-----Cement : Co-benefit technology


| Technology | Key point of technology | goal | Positive co-benefit | Negative co-benefit |
|---|---|---|---|---|
| Replace the raw material | The change in additives or use of raw limestone | Reducing $SO_2$ emissions | Reducing CO2 emissions | |
| Raw meal grinding | | Reducing $SO_2$ emissions | | Increase $CO_2$ indirect emissions |
| Add lime hydrate | | Reducing $SO_2$ emissions | Reducing CO2 emissions | |
| set D-SOX cyclone tube | Using the free lime (fCaO) generated in the calciner | Reducing $CO_2$ emissions | Reducing SO2 emissions | |
| Wet scrubber | | Reducing dust and $SO_2$ emissions | | Increase $CO_2$ indirect emissions |
| Kiln grinding as a whole | Introduce the preheater exhaust system of raw material grinding. In raw meal grinding, because of the material by external force, generated a lot of new interface, the absorption of SO2 | Reducing $SO_2$ emissions | | Increase $CO_2$ indirect emissions |
| Bag filter | alkaline material combination of SO2, NO2 acid | Reducing pollutants | | Increase $CO_2$ indirect emissions |
| Fluidized calcination process | to complete cement calcination in fluidized bed of higher heat transfer efficiency, rather than rotary kiln | Energy saving and pollutants reduction | Reducing the Nox and CO emissions<br>Reducing the indirect $CO_2$ emissions | |



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# The Case studies-----Main industries


表 2　我国主要行业 $SO_2$ 减排和 $CO_2$ 协同减排效果

Tab. 2　$SO_2$ and $CO_2$ emission reduction and synergic effects in China's key idustries　$10^4$ t

| 项目 Item | "十一五"期间 During the eleventh Five-year Plan | | | "十二五"前期[1] During the Twelfth Five-year Plan | | |
|---|---|---|---|---|---|---|
| | $SO_2$ 减排(万 t) $SO_2$ emission reduction | $CO_2$ 协同减排(亿 t) Synergic $CO_2$ emission reduction | 协同系数[2] Synergic coefficient | $SO_2$ 减排(万 t) $SO_2$ emission reduction | $CO_2$ 协同减排(亿 t) Synergic $CO_2$ emission reduction | 协同系数 Synergic coefficient |
| 煤电 | | | | | | |
| 结构减排 | 208 – 306 | 4.17 – 5.29 | 173 – 200 | 30 | 1.08 | 360 |
| 工程减排 | 699 – 797 | – 0.048[3] – 0.055 | – 0.687 5 | 350 | – 0.024 | – 0.687 5 |
| 小计 | 907 – 1 103 | 4.12 – 5.23 | 45 – 47 | 380 | 1.056 | 28 |
| 水泥 | | | | | | |
| 结构减排 | 39 – 58 | 1.4 – 1.8 | 311 – 358 | 5 | 0.32 | 640 |
| 工程减排 | – | – | – | – | – | – |
| 小计 | 39 – 58 | 1.4 – 1.8 | 311 – 358 | 5 | 0.32 | 640 |
| 钢铁 | | | | | | |
| 结构减排 | 51 – 68 | 1.5 – 1.9 | 290 – 295 | 11 | 0.34 | 309 |
| 工程减排 | 12 | – 0.000 8 | – 0.687 5 | 5 | – 0.000 3 | – 0.687 5 |
| 小计 | 63 – 80 | 1.5 – 1.9 | 238 | 16 | 0.339 7 | 212 |
| 合计 | 1 009 – 1 241 | 7.02 – 8.93 | 70 – 72 | 401 | 1.72 | 43 |

注:①电力部门的是前 3 年模拟结果,而其他行业则是前两年的模拟结果;②协同系数:单位污染物减排导致的 $CO_2$ 减排强度,即为:$CO_2$ 减排量 or 增排量/$SO_2$ 减排量;③负值表示增排。

Gu Alun et al. (2016)

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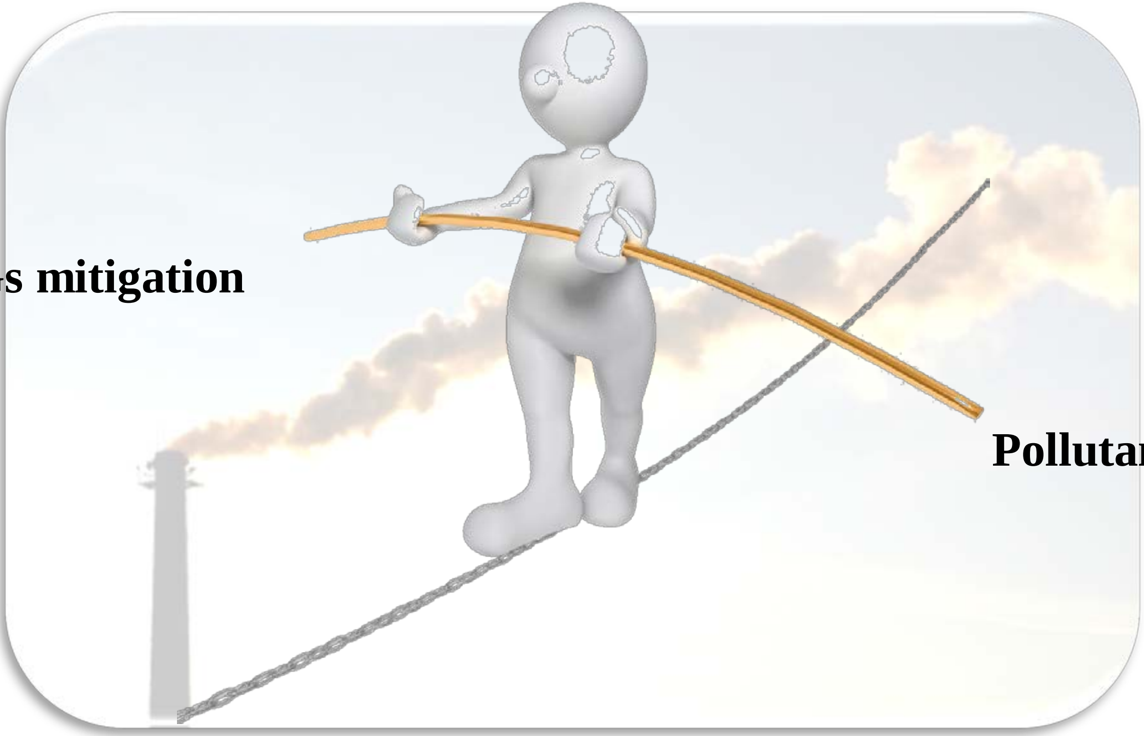
# Thinking

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# 谢谢！

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