Contribution of Japanese Cement Industry towards Addressing Environmental Issues

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TAIHEIYO CEMENT

Contents of Today's Presentation

1. Current data on the Japanese cement industry
2. Status of recycling in Japan
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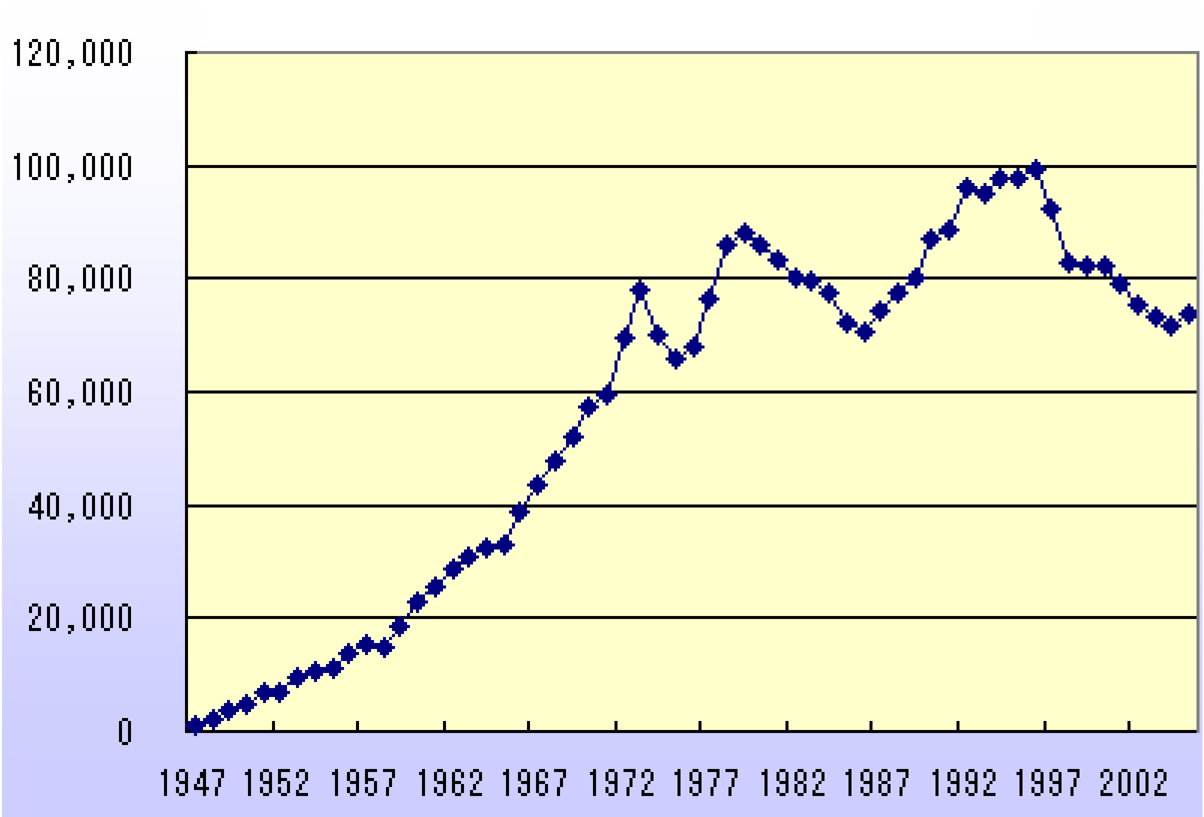
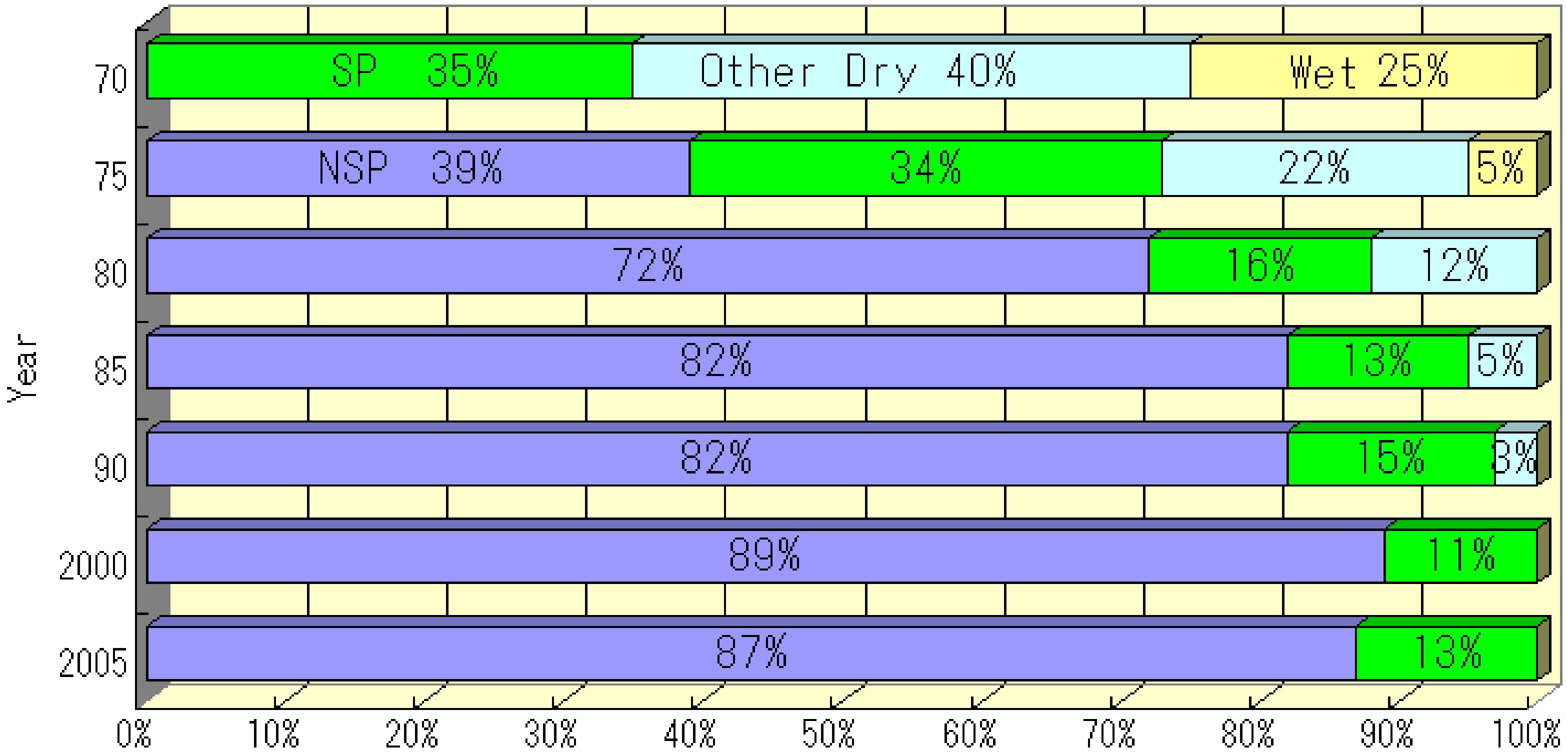
4. Turning municipal incinerator ash into a resource
5. Chlorine by-pass technology
6. Conclusions

Cement production of Japan

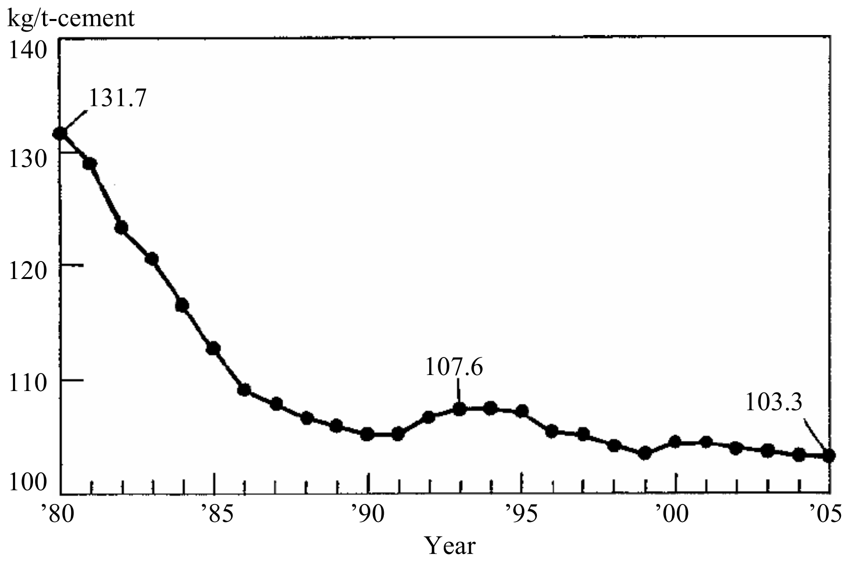


Kiln Type

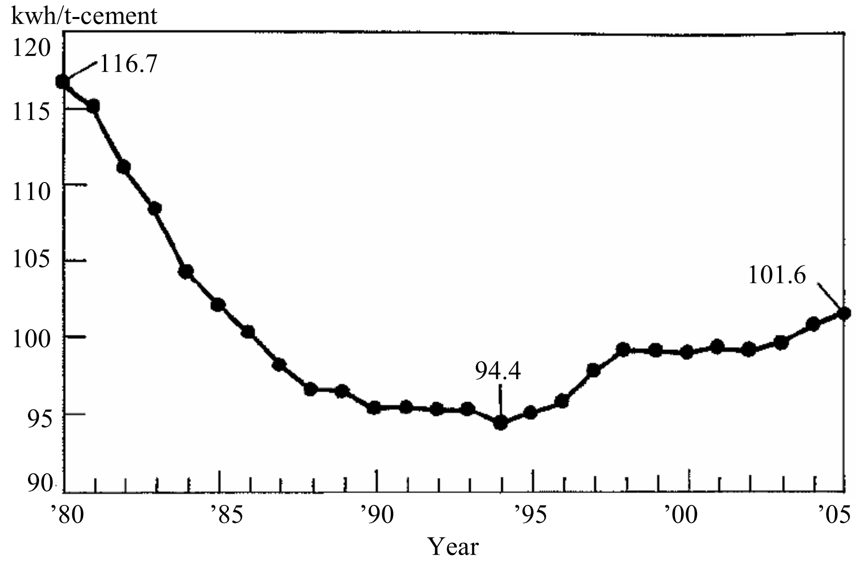


Notes;NSP=Precalciner-type SP kiln SP=Suspension Preheater type kiln

Heat consumption (Coal equivalent)



Electric power consumption



Types and Sales of Cement

(unit : million tons)

Cement Type	Year	80	%	90	%	2000	%	2004	%	2005	%
Portland Cement	Ordinary	71.7	89.3	62.2	76.3	49.4	69.5	39.4	68.8	39.6	68.1
	High early strength	1.5	1.9	3.5	4.3	3.2	4.6	2.5	4.4	2.6	4.6
	Others (A)	0.3	0.4	0.3	0.3	0.4	0.5	0.6	1.1	1.0	1.7
	Sub-total	73.5	91.6	66.0	80.9	53.0	74.6	42.5	74.3	43.2	74.4
Blended Cement	Blast-furnace slag	5.0	6.2	14.9	18.3	17.3	24.4	14.3	25.1	14.4	24.8
	Fly-ash	1.6	2.0	0.5	0.7	0.7	1.0	0.4	0.6	0.5	0.8
	Others (B)	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0
	Sub-total	6.8	8.4	15.6	19.1	18.1	25.4	14.7	25.7	14.9	25.6
Total		80.3	100.0	81.6	100.0	71.1	100.0	57.2	100.0	58.1	100.0

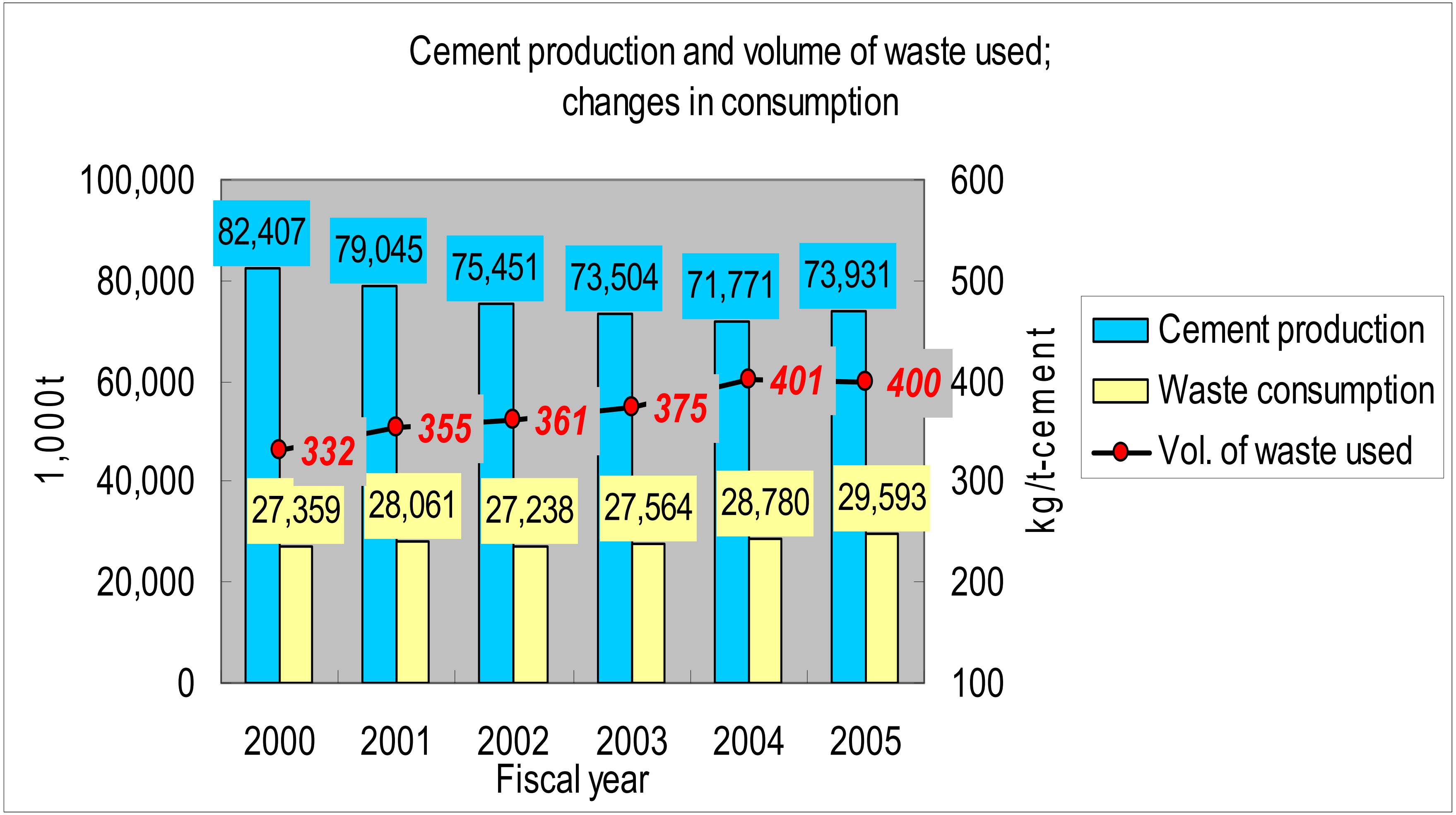
Note: (1)Other Portland Cement (A) includes Moderate Heat Cement, Sulphate Resisting Cement and Composit Cement.
(2) Other Blended Cement (B) includes Pozzolan Cement and Composit Cement.

Contents of Today's Presentation

Waste Material Used in Cement Industry

Item	fiscal year				
	2001	2002	2003	2004	2005
Blast furnace slag	11,915	10,474	10,173	9,231	9,214
Coal ash	5,822	6,320	6,429	6,937	7,185
Gypsum by-product	2,568	2,556	2,530	2,572	2,707
Dirt, Sludge	2,235	2,286	2,413	2,649	2,526
Soil from construction	−	269	629	1,692	2,097
Non-ferrous slag	1,236	1,039	1,143	1,305	1,318
Unburned ash, soot, dust	943	874	953	1,110	1,189
Molding sand	492	507	565	607	601
Steel manufacture slag	935	803	577	465	467
Wood chips	20	149	271	305	340
Waste plastic	171	211	255	283	302
Coal tailing	574	522	390	297	280
Recycled oil	204	252	238	236	228
Waste oil	149	100	173	214	219
Used tire	284	253	230	221	194
Used clay	82	97	97	116	173
Bone-meal feed	2	91	122	90	85
Others	428	435	378	452	468
Total	28,061	27,238	27,566	28,782	29,593
Rate of consumption (kg/t-cement)	355	361	375	401	400

Recycling in the Japanese Cement Industry



Advantages of Waste Recycling at Cement Plants

1. No generation of waste by-products
2. Detoxification of waste material
3. Reduced natural raw-material consumption
4. Reduced production of greenhouse gases
5. Contribution to creation of a local recycling society (->Disposal site life extension)

Cement Materials and Chemical Composition

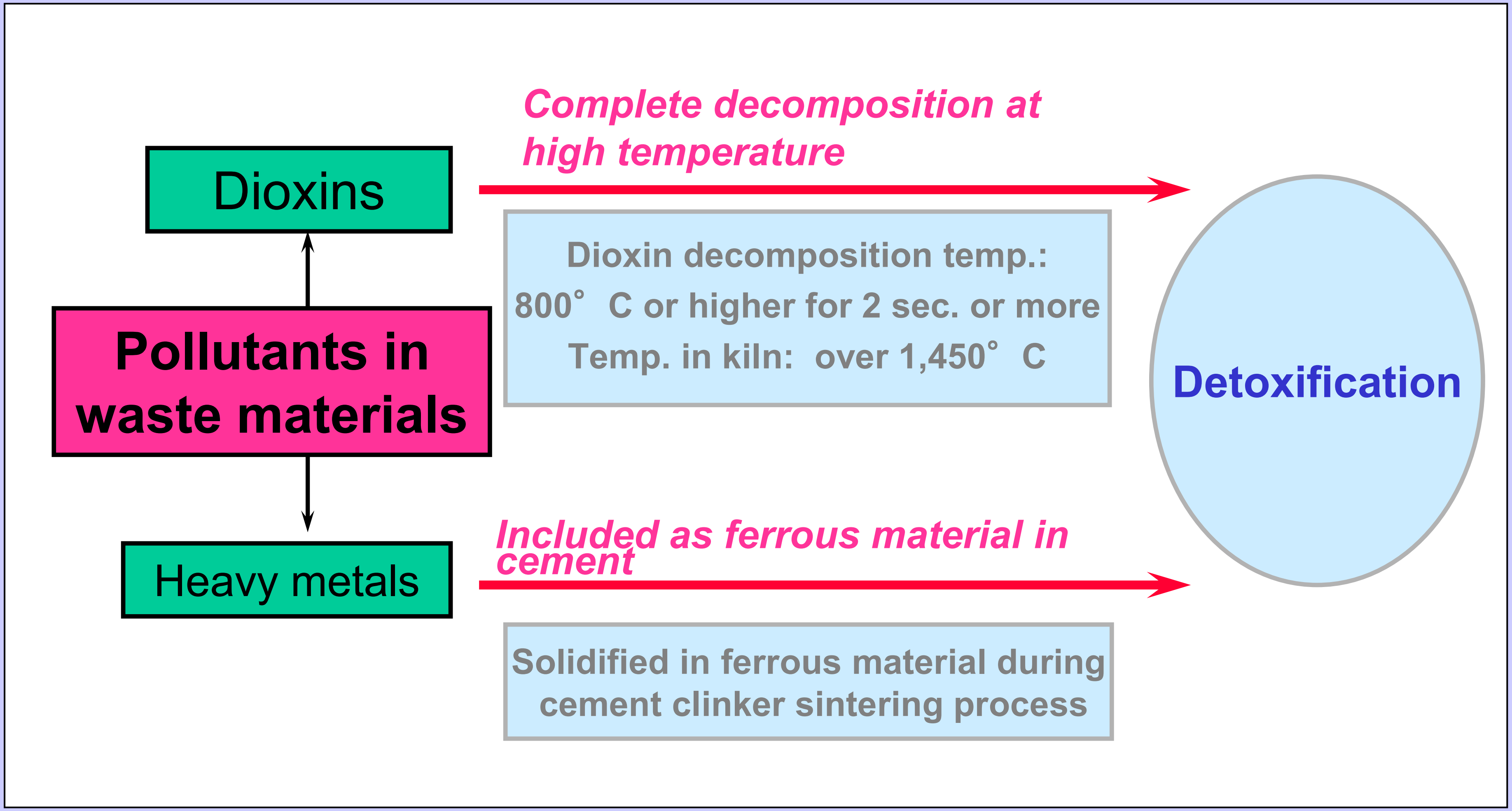
Cement materials and chemical composition

Raw material	Component	Portland cement	Recycled resources: Ash	Recycled resources: Water purifier sludge	Recycled resources: Sewage	Recycled resources: Waste tires
Limestone →	CaO	64-65%	23.0%	13.9%	10.1%	0.1%
Clay (Silica) →	SiO_2	20-21%	27.3%	33.0%	30.7%	---
Clay (Silica) →	Al_2O_3	5%	14.3%	16.2%	19.5%	0.05%
Iron →	Fe_2O_3	3%	6.2%	4.8%	5.2%	5-20
				(Combustible materials)		95-80

(Natural materials, for reference)

	CaO	SiO_2	Al_2O_3	Fe_2O_3
Limestone	47−55%	< 4%	< 2%	< 2%
Clay	< 5%	45−78%	10−26%	3−9%
Silica	< 2%	77−96%	2−10%	< 5%
Iron material				40−90%

Treatment of Pollutants



Cement Industry Recycling of Waste and By-products Extends the Life of Disposal Sites (estimated)

(A)	Remaining volume of industrial waste disposal sites	179,410,000m^3
(B)	Volume transported to disposal site per year	40,000,000m^3
(C)	Remaining disposal site volume times no. of years (C=A/B)	4.5 Years
(D)	Volume of cement recycled per year	19,500,000m^3
(E)	No. of years remaining for disposal site if cement were not recycled (E=A/(B+D))	3.0 Years
(F)	Length of extension of life of disposal site resulting from cement plant recycling (F=C-E)	+**1.5 Years**

Note: Japan Cement Association estimate

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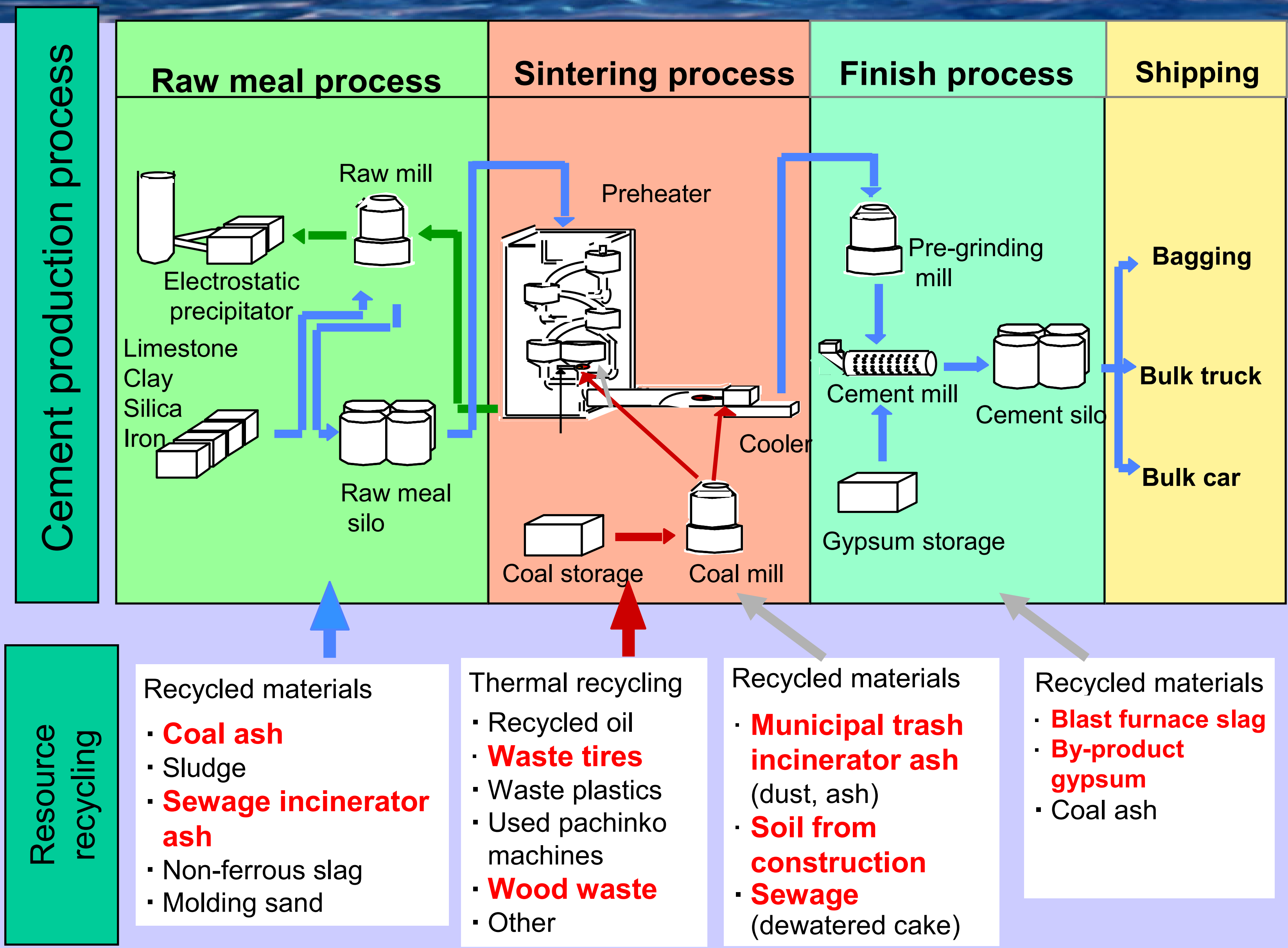
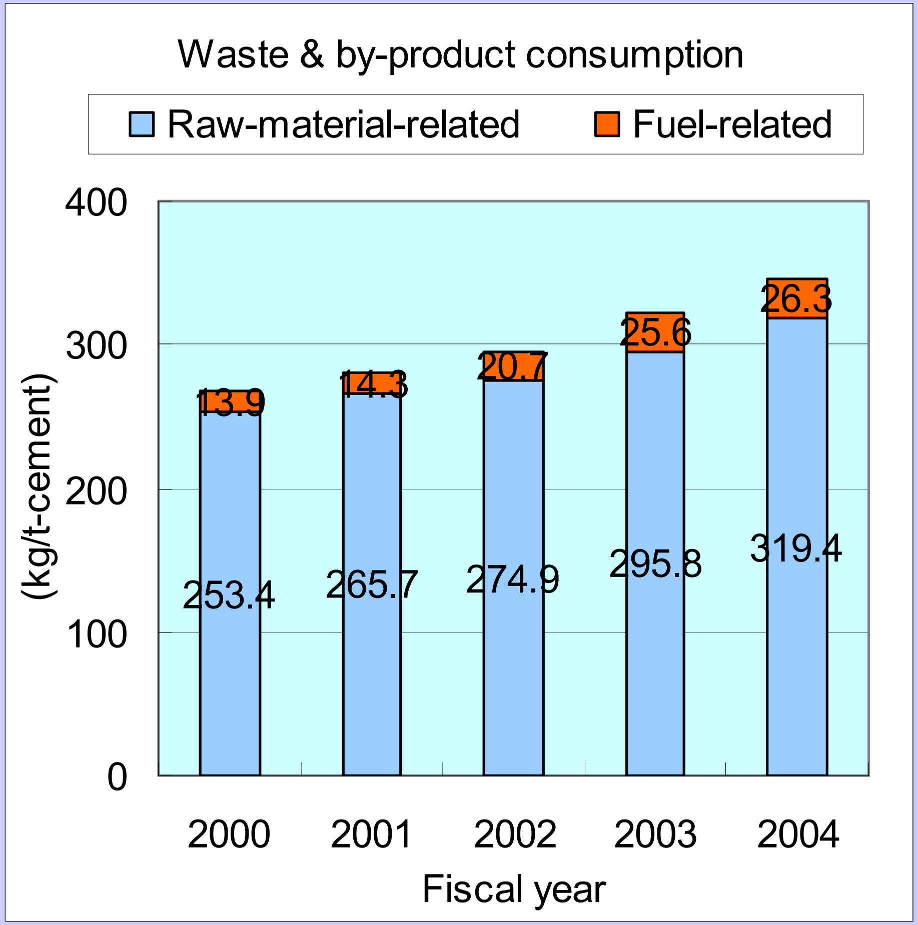
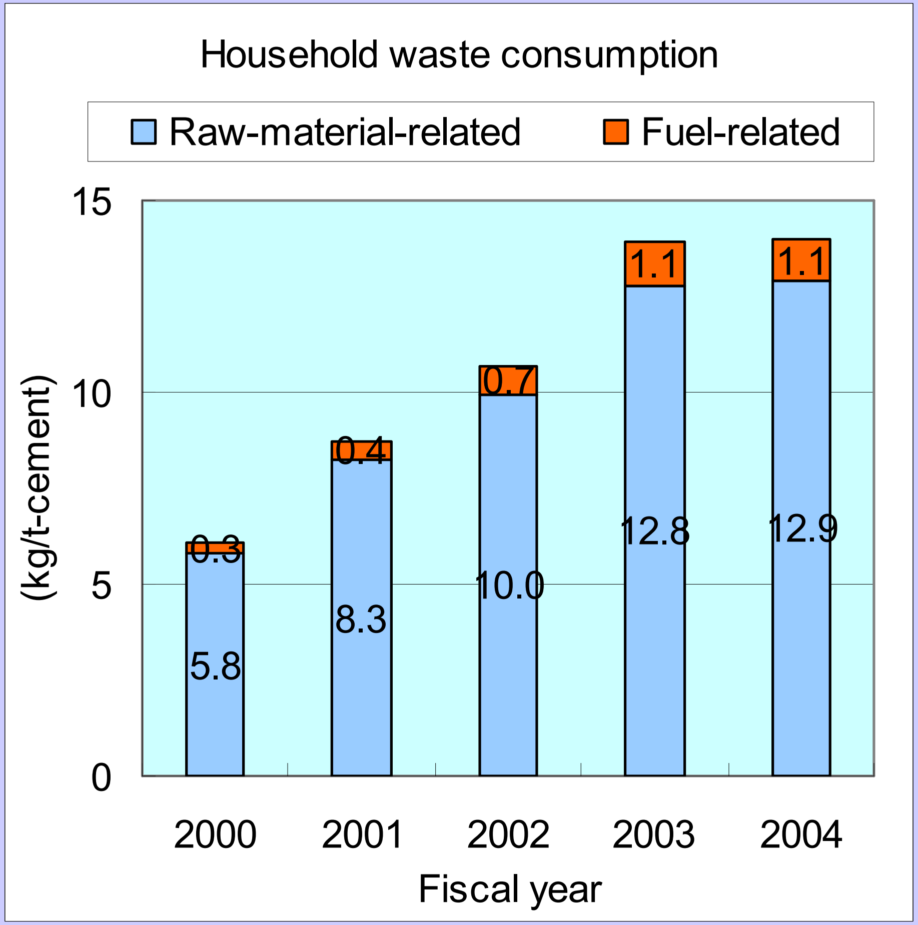
Cement Production Process and Resource Recycling



Changes in Consumption of Waste Materials and Household Waste by Taiheiyo Cement





Background of Development on AK System

-The recycle process of urban waste as a raw material of cement

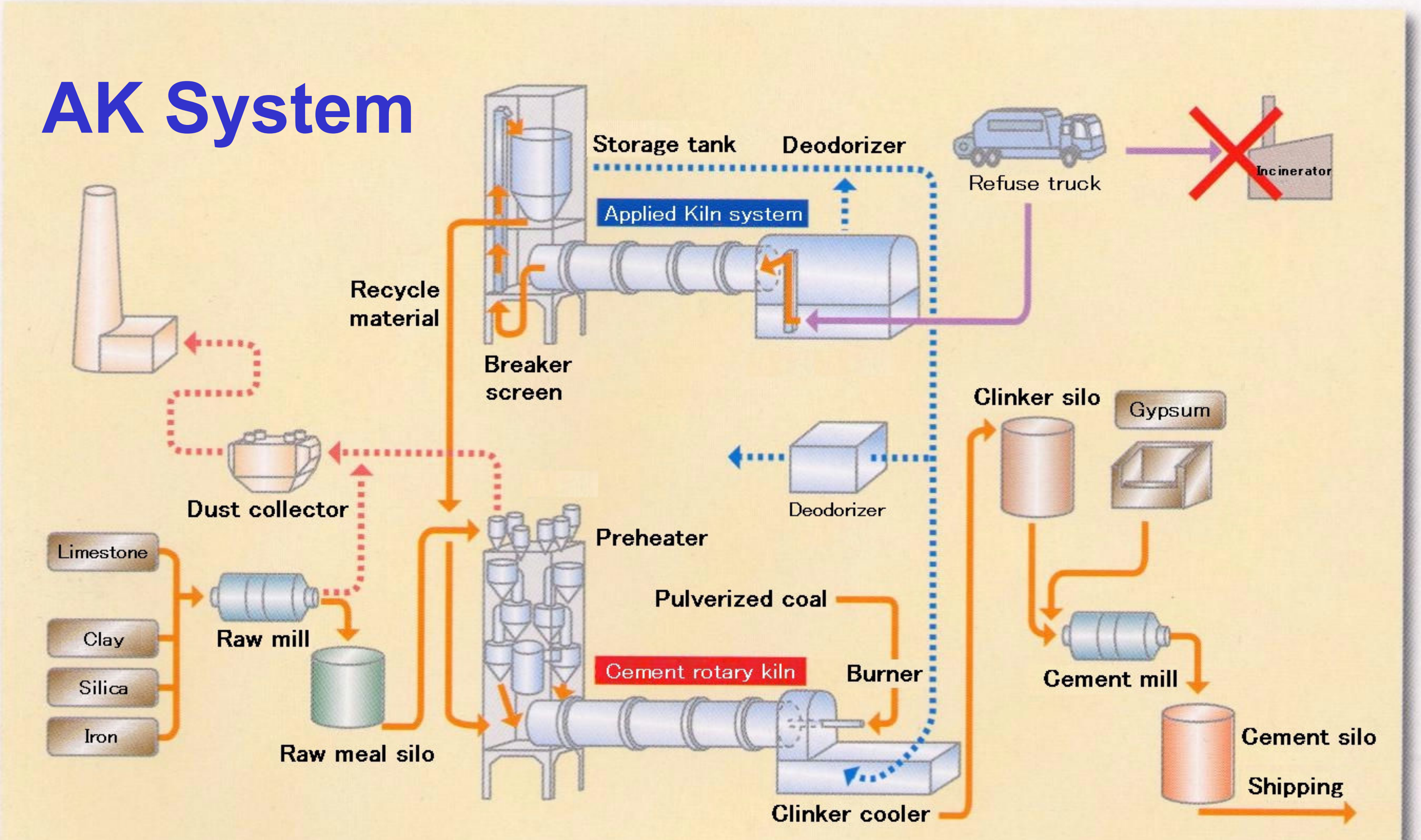
- Hidaka City, Saitama prefecture, operates a MSW incinerator since more than 30 years and was forced to build a new incinerator to replace worn out one until December 2002.

- For a long time (from 1993) , Taiheiyo Cement Corporation had been asked by Hidaka city to co-operate to solve the city's MSW issue. Taiheiyo Cement Corporation and Hidaka city had continued the discuss about a new MSW treatment technology.

- In 1999, Taiheiyo Cement Corporation proposed our "AK System" to Hidaka City and Hidaka City decided to apply "AK System" to solve the city's MSW issue in June 2000.

- The idle kiln in our Saitama factory was converted to a Digester (one of the main facility in AK system) and the demonstration test was carried out from March of 2001 to October 2002.

AK System



- Operation started at Saitama Plant in February 2002
- 15,000t/y of Hidaka City's trash turned into resources

Overview of the AK system

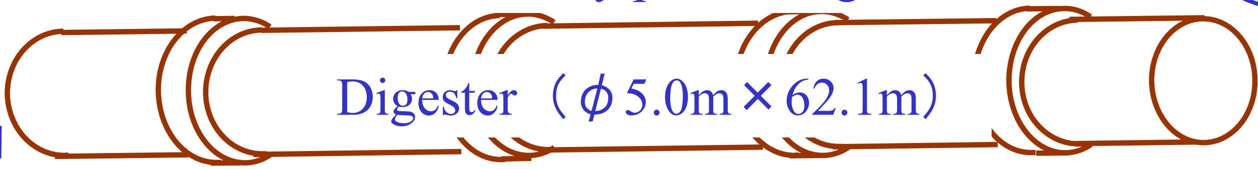
Three days of aerobic digestion turns organic contents of waste into soil-like cement raw material.

Breakdown of waste into finer pieces accelerates aerobic digestion.

Mechanical breakdown process begins immediately as tons of MSW are tumbled onto itself, breaking open bags, and pulping the waste.

Day 2

Three-day processing



MSW

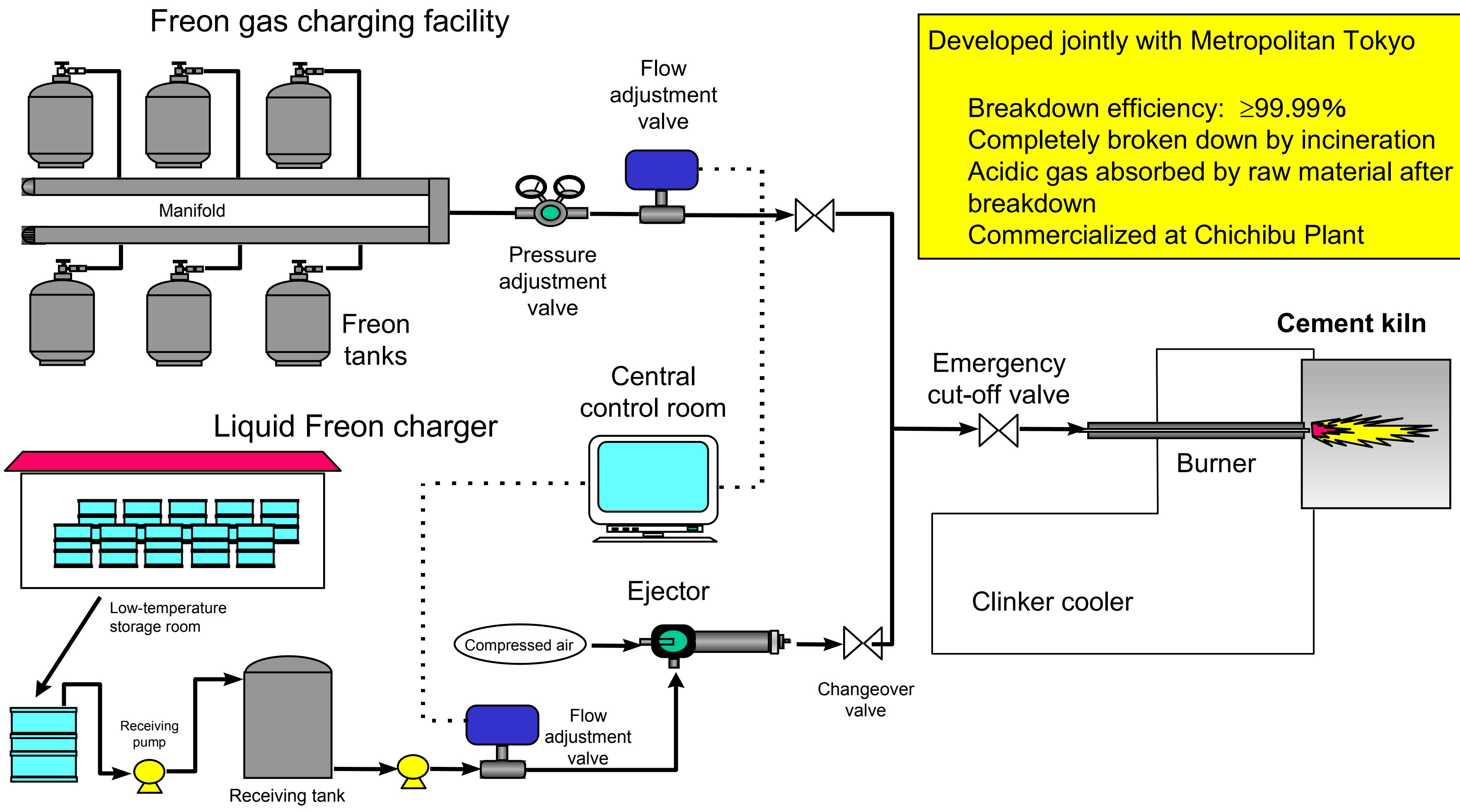
Digested MSW

Crushing, Sieving, Separating

Cement raw material

Municipal solid waste (MSW) of Hidaka city

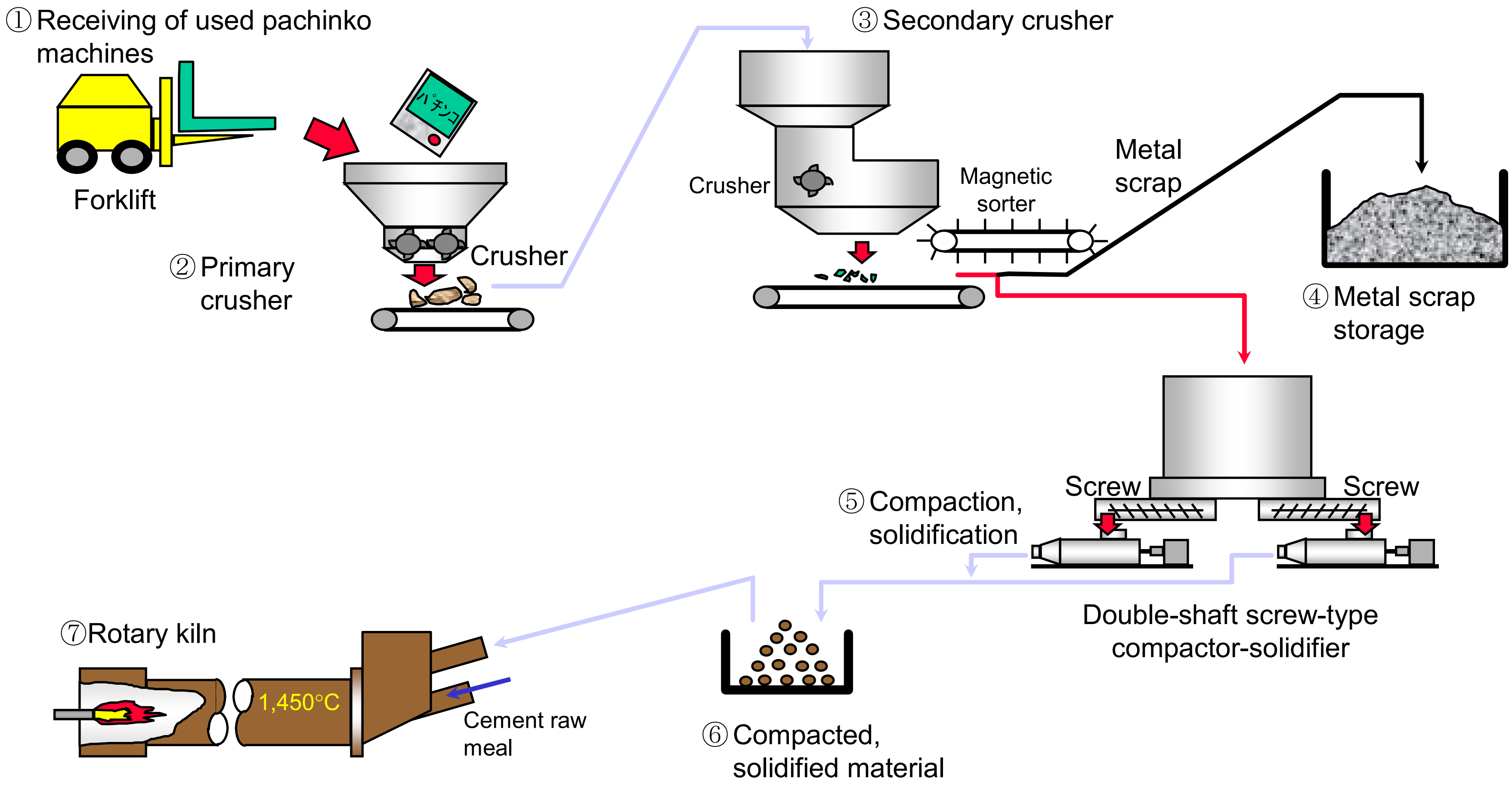
Freon Breakdown



Developed jointly with Metropolitan Tokyo

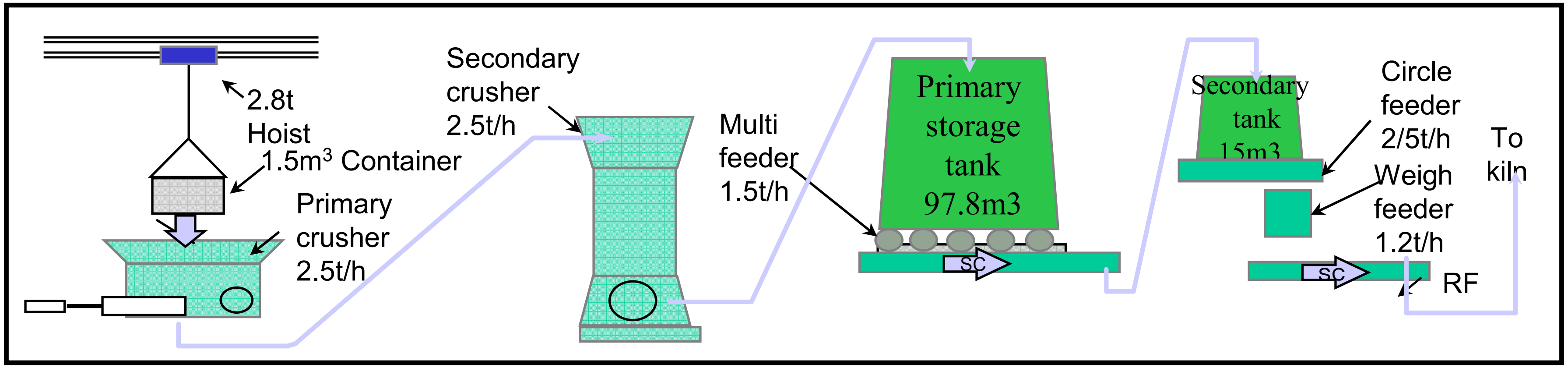
- Breakdown efficiency: **≥99.99%**
- Completely broken down by incineration
- Acidic gas absorbed by raw material after breakdown
- Commercialized at Chichibu Plant

Treatment of Used Pachinko Machines



Treatment of Waste Plastics

1. Outline of treatment facilities



2. Types of waste plastics expected to be treated

Source	Composition	Shape	Volume (t/y)
Sekisui Chemical Musashino Plant	PE foam	Rolled sheets	210t
	Bridge PE	Rolled sheets	1,440t
	Compacted products	Block	720t
Hitachi Chemical Yamazaki Plant, Mie Structural Products	PET, PE, phenol	Rolled film	2,640 t
Other	PET, PE	Rolled film, etc.	1,380 t
	Total		6,390t

Remarks

Planned volume of waste plastics treated 6,500t/y

Start of operation Dec. 1998

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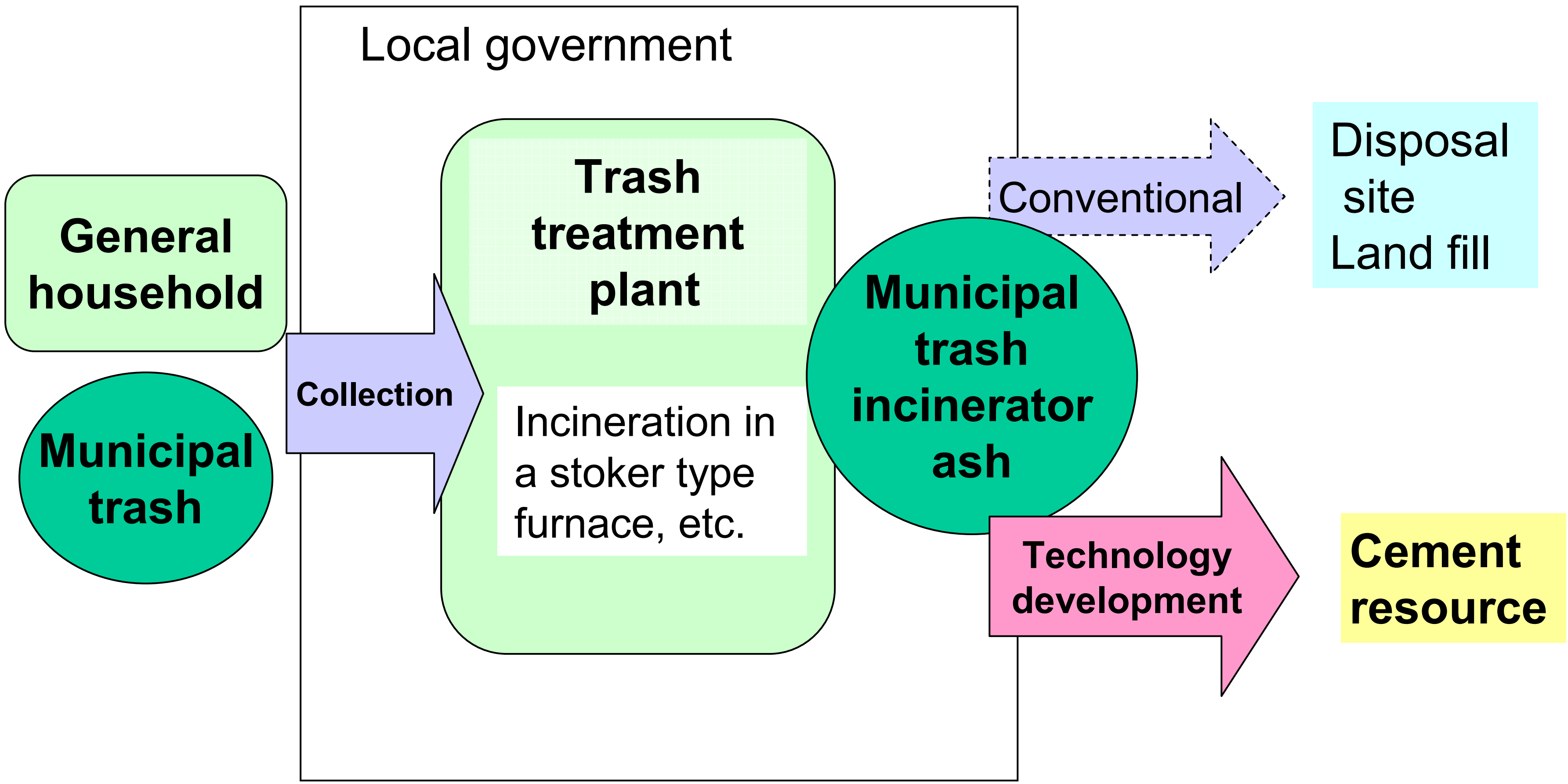
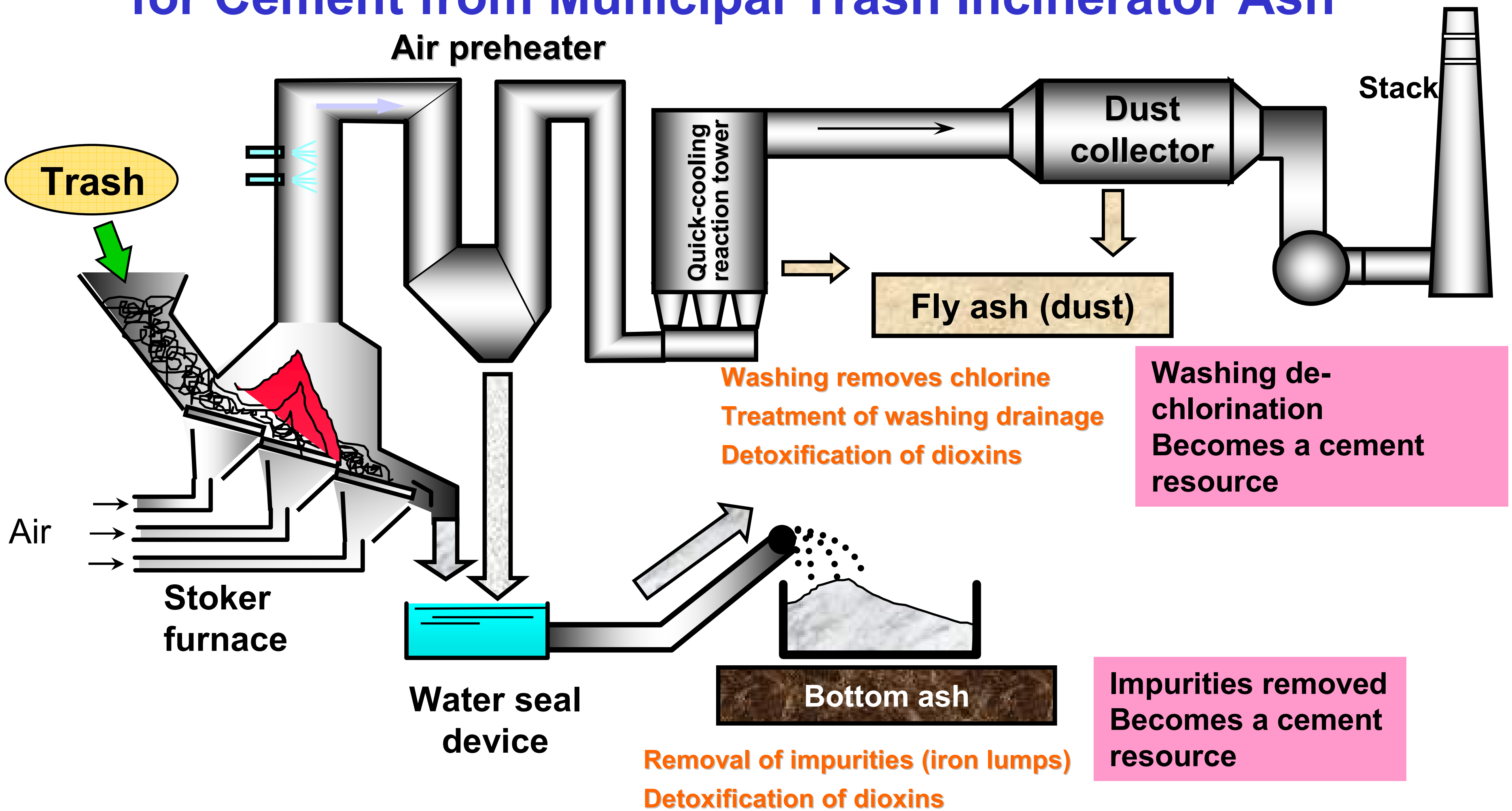
Development of Technology for Turning Municipal Trash Incinerator Ash into a Resource



Concept for Development of Creating Resource for Cement from Municipal Trash Incinerator Ash



Bottom ash Treatment Technology

Ash properties	Problems
Moisture 25-30%	Adheres to transporter; clogs chute
Contains calcium component	Solidifies during storage

Fly ash De-chlorination Technology

Technical problems

- High chlorine content (10-20%) -> De-chlorination technology
- Heavy metals in drainage water -> Proper treatment
- Dioxin content (fixed within the cement,breakdown)

Sample Treatment Water Composition After Each Operation

	Unit	Concentrate composition	Treatment water composition for all processes			Permissible sewage discharge value
			Carbonation	Chemical treatment	Filter	
Pollutants						
Cadmium	mg/L	0.69	0.01	0.01	N.D.	0.1
Lead	mg/L	250	0.4	N.D.	N.D.	0.1
Total mercury	mg/L	0.001	0.001	N.D.	N.D.	0.005
Alkyl mercury	mg/L	N.D.	N.D.	N.D.	N.D.	N.D.
Hexavalent chrome	mg/L	N.D.	N.D.	N.D.	N.D.	0.5
Environmental items						
Copper	mg/L	0.09	0.4	0.04	0.04	3
Zinc	mg/L	7.1	0.5	0.1	0.05	5
Chrome	mg/L	0.02	0.012	N.D.	N.D.	2
Suspended matter	mg/L	450	42	17	4	600
DXNs	Ng-TEQ/L	1,200	7.9	0.46	0.09	10

Results of Breakdown of Dioxins in Exhaust Gas

- Dioxins in fly ash are not dissolved out on the water side; they remain in the washing cake and/or caked precipitate from the drainage water treatment process.

- The cake is charged directly into the kiln where it is broken down and rendered harmless by high-temperature (1,450°C) sintering.

Density of dioxins in exhaust gas

0.0000074 - 0.0025 (ng-TEQ/m^3N)

Development of Ash Treatment System

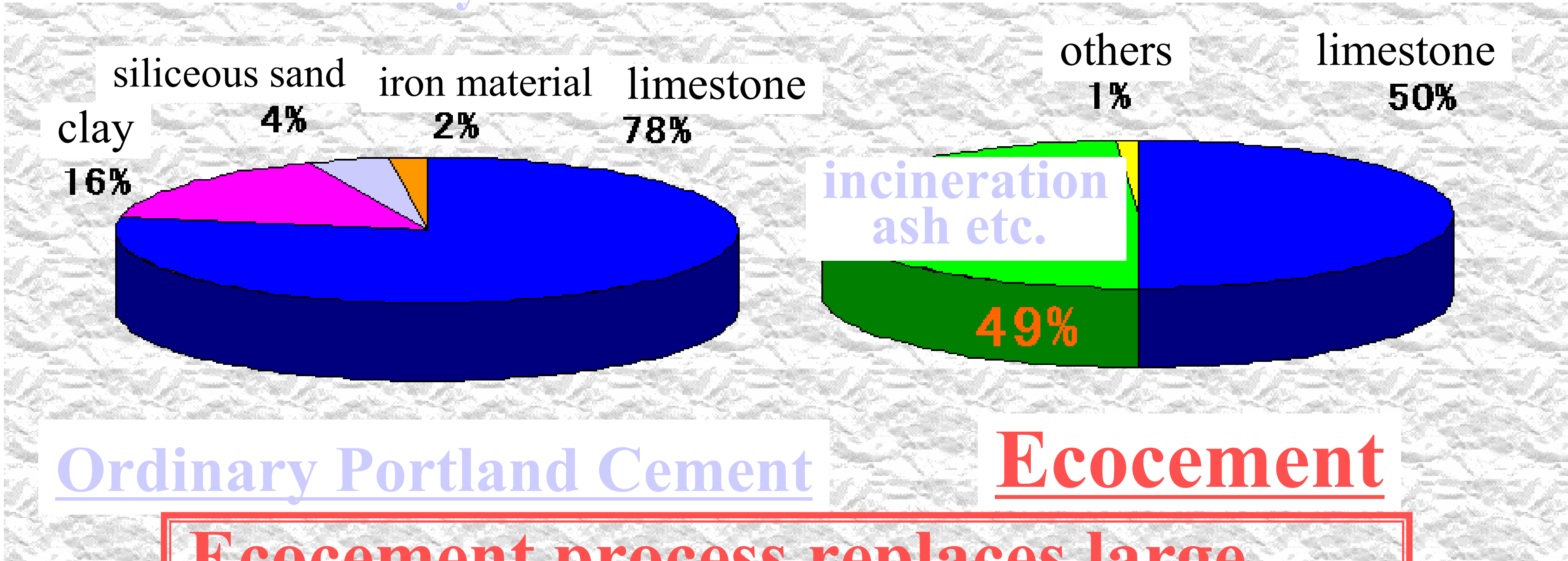
March 1995	**Kumagaya City sounded out on effective use of incinerator ash**
1996-1997	Saitama Prefecture double-plant planned; ash washing and de-chlorination technology adopted for zero-emission promotion and demonstration business
April 1998	**Experimental plant built (treatment capacity, 8,000t/y); demonstration tests of use of municipal trash incinerator ash in cement production begun (joint research by Saitama Prefecture and Kumagaya City)**
Jan. 2000	"Calcining method" approved as one of the dust treatment regulations set by Minister of Health and Welfare
March	Establishment of ash washing system technology recognized by Technical Committee
Nov.	Approval for construction of facilities for treatment of general waste received
Feb. 2001	Agreement reached with Saitama prefectural wide-area waste treatment measures conference on basic items for consignment of wide-area treatment
July	**Industrialization plant operation begun; treatment capacity 63,000t/y**

Incinerator ash collected from areas around northern Saitama; business for use of waste as a resource for cement begun

What is Ecocement

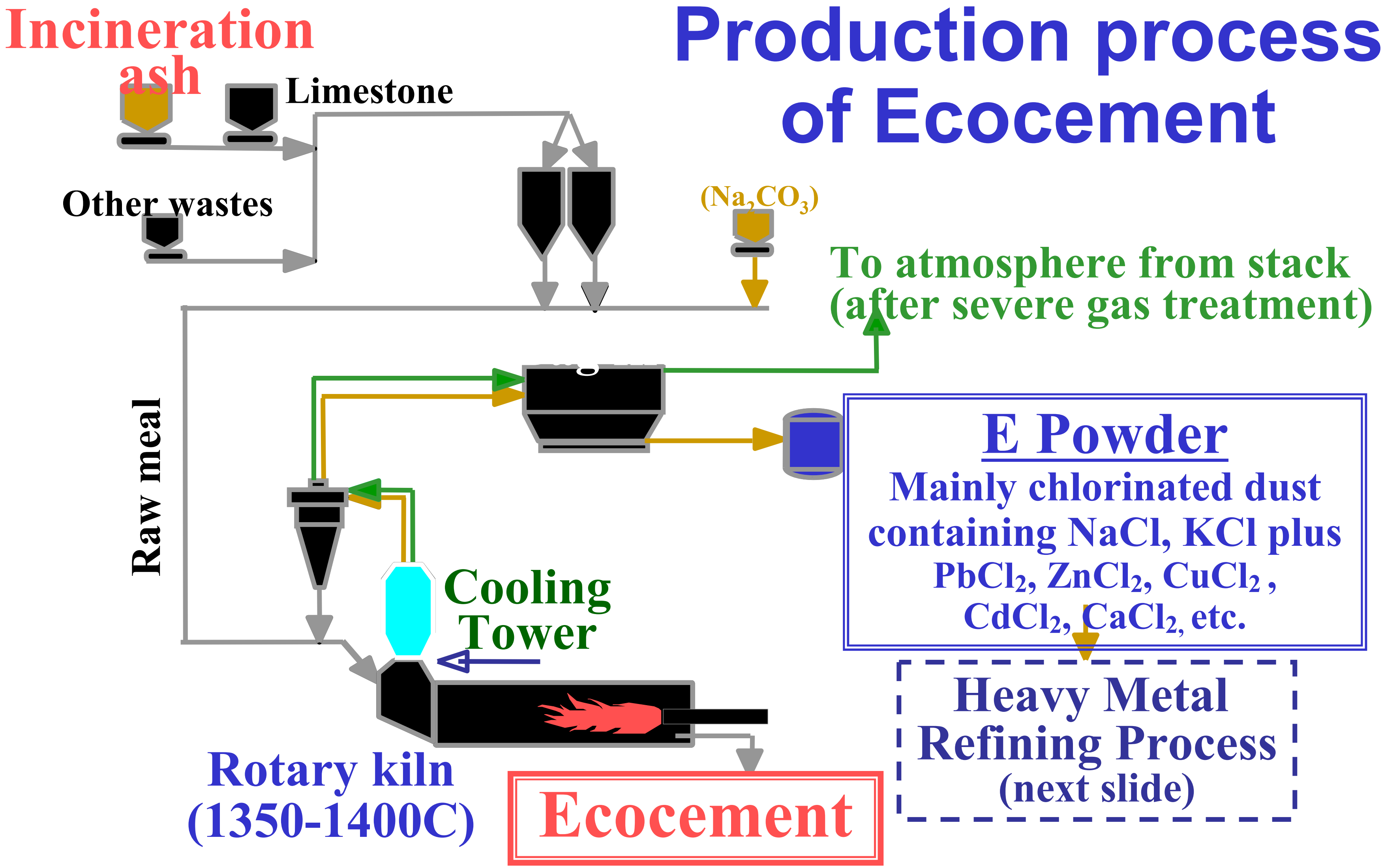
Coinage; Ecology and Cement

Comparison of raw materials for Ordinary Portland Cement and Ecocement



Ecocement process replaces large quantity of natural resources (limestone and clay etc.) with incineration ash etc.

Production process of Ecocement



TAIHEIYO CEMENT

Heavy Metal Refining Process

E Powder

Leaching Process

- Heavy metal rich filtrate
  - **Refining Process**
    - Filtrate (NaCl, KCl) → **Waste water treatment** → **Drainage**
    - **Enriched heavy metal compounds (Pb, Cu, Zn etc.)** ⇩ Raw materials for non-ferrous metal industry
- Calcium rich cake
  - **Refining Process**
    - **Enriched $Ca(OH)_2$** ⇩ Raw material for cement production

Plant view

Leaching process

Enriched metal compounds

Features of Ecocement Process

- **Safe destruction of all toxic organic substances such as DXNs in incineration ash, thanks to high temperature in the Ecocement kiln** (1350 – 1400C)
- **Extraction and enrichment of heavy metal compounds, followed by their recycling at non-ferrous metal industry**
- **Reduction of CO_2 emissions due to less use of limestone**
- **No generation of secondary solid waste, contributing to prolonging the life of landfill site (or even landfill-free)**

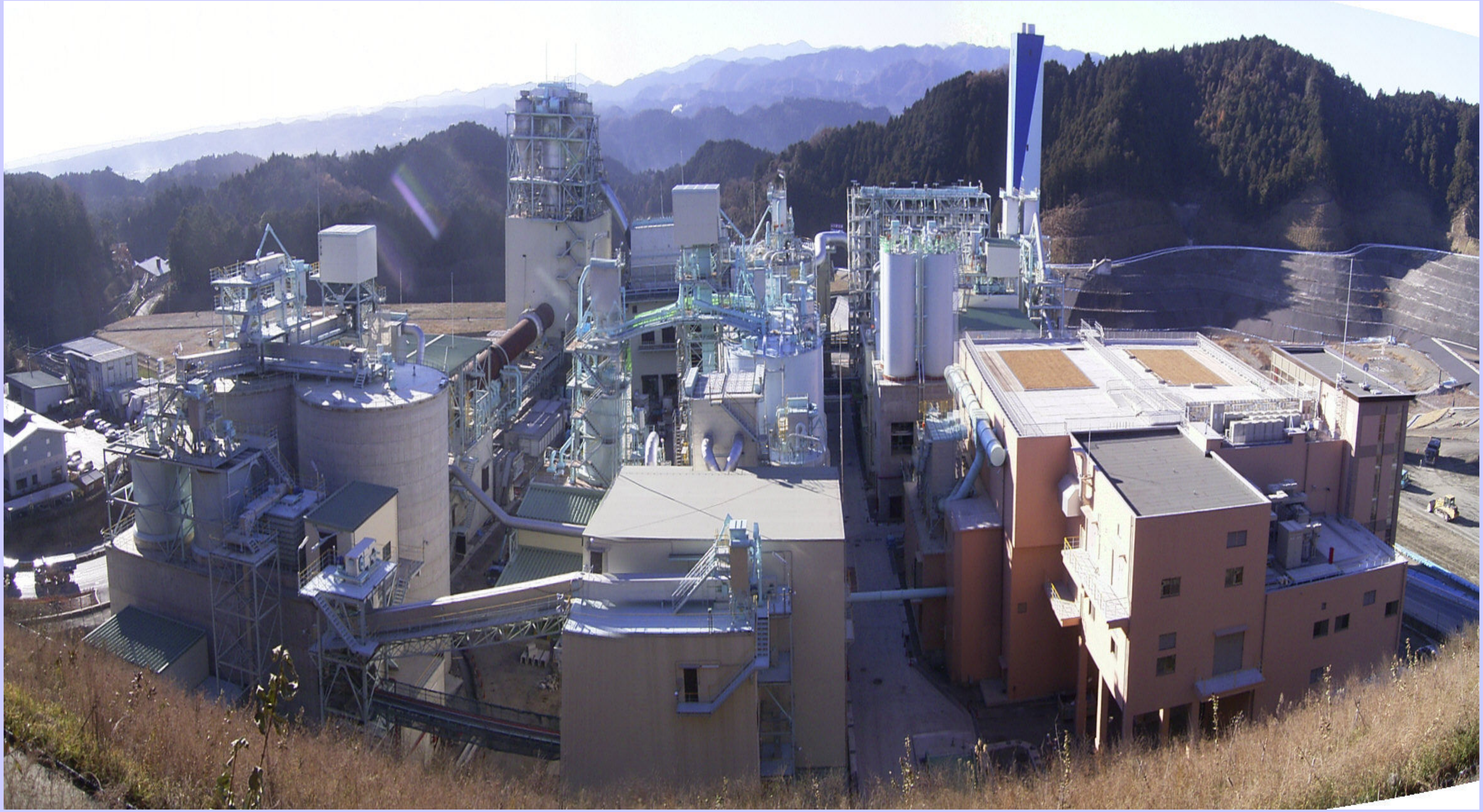
Quality of Ecocement (JIS R 5214)

Quality	Type	Normal Ecocement	Normal Portland cement
Density g/cm^3		–	–
Specific surface area cm^2/g		2500 min	2500 min
Setting time	Initial h-m	1-00 min	1-00 min
	Final h-m	10-00 min	10-00 min
Soundness	Pat method	Good	Good
	Le chatelier method mm	10 max	10 max
Compressive strength N/mm^2	1d	–	–
	3d	12.5 min	12.5 min
	7d	22.5 min	22.5 min
	28d	42.5 min	42.5 min
Chemical composition (%)	Magnesium oxide	5.0 max	5.0 max
	Sulfur trioxide	4.5 max	3.0 max
	Ignition loss	3.0 max	3.0 max
	Total alkali	0.75 max	0.75 max
	Chloride ion	0.1 max	0.035 max

Ichihara Ecocement Plant

Note) Foundations of the kiln were made using Ecocement

Eco-cement Plant in Tama, Metropolitan Tokyo



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Summary of Volatile Component Circulation and Cyclone Clogging Mechanism

Charging of combustible material at kiln end

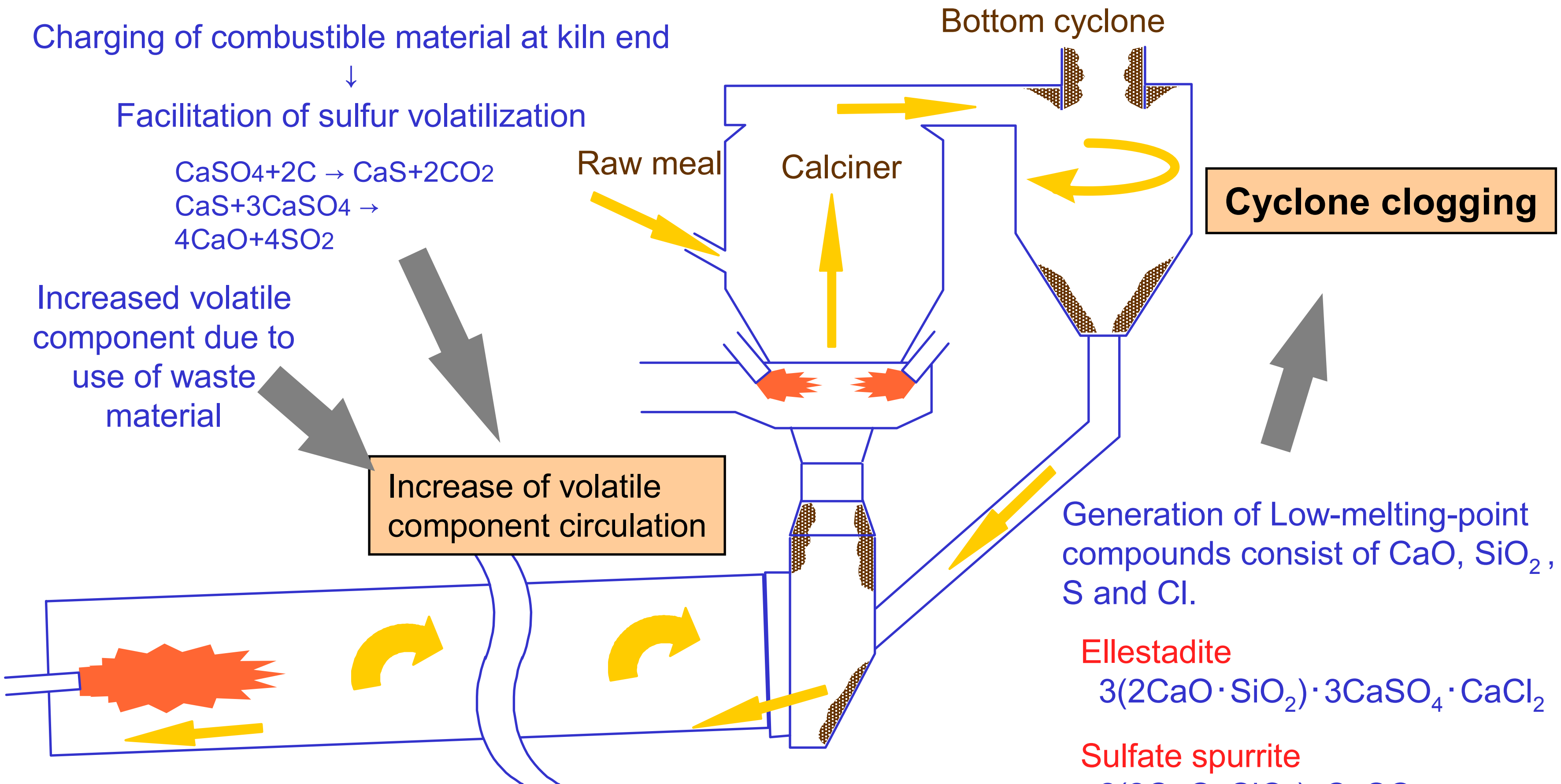
↓

Facilitation of sulfur volatilization

$CaSO_4 + 2C \rightarrow CaS + 2CO_2$

$CaS + 3CaSO_4 \rightarrow 4CaO + 4SO_2$

Increased volatile component due to use of waste material



Generation of Low-melting-point compounds consist of CaO, SiO_2, S and Cl.

Ellestadite

$3(2CaO \cdot SiO_2) \cdot 3CaSO_4 \cdot CaCl_2$

Sulfate spurrite

$2(2CaO \cdot SiO_2) \cdot CaSO_4$

Sample Volatile Component Balance

Kiln raw meal
- Cl: 0.022% (3.7x)
- Na_2O: 0.22% (0.6x)
- K_2O: 0.37% (0.8x)
- SO_3: 0.2% (0.4x)

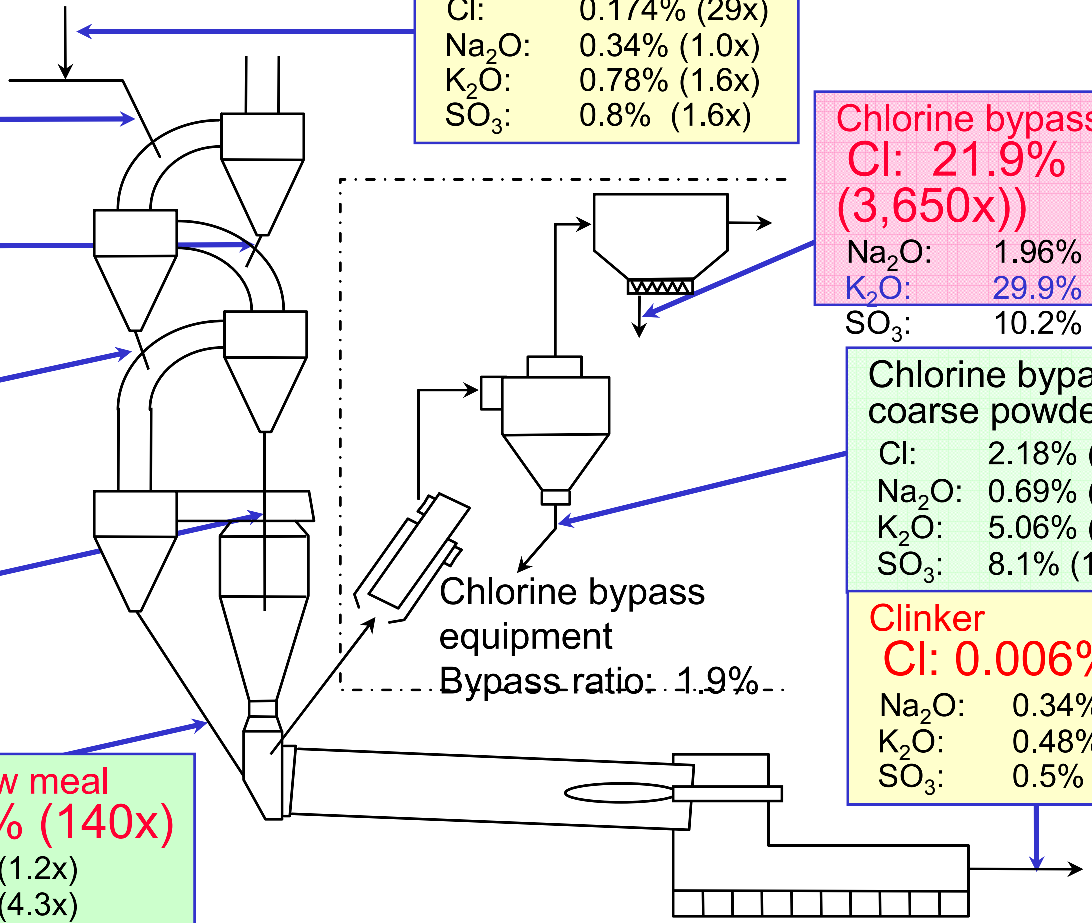
C1 cyclone raw meal
- Cl: 0.108% (18x)
- Na_2O: 0.24% (0.7x)
- K_2O: 0.45% (0.9x)
- SO_3: 0.6% (1.2x)

C2 cyclone raw meal
- Cl: 0.204% (34x)
- Na_2O: 0.24% (0.7x)
- K_2O: 0.58% (1.2x)
- SO_3: 0.5% (1.0x)

C3 cyclone raw meal
- Cl: 0.353% (59x)
- Na_2O: 0.26% (0.8x)
- K_2O: 0.84% (1.8x)
- SO_3: 0.8% (1.6x)

C4 cyclone raw meal
- Cl: 0.850% (140x)
- Na_2O: 0.42% (1.2x)
- K_2O: 2.05% (4.3x)
- SO_3: 3.3% (6.6x)

EP dust
- Cl: 0.174% (29x)
- Na_2O: 0.34% (1.0x)
- K_2O: 0.78% (1.6x)
- SO_3: 0.8% (1.6x)



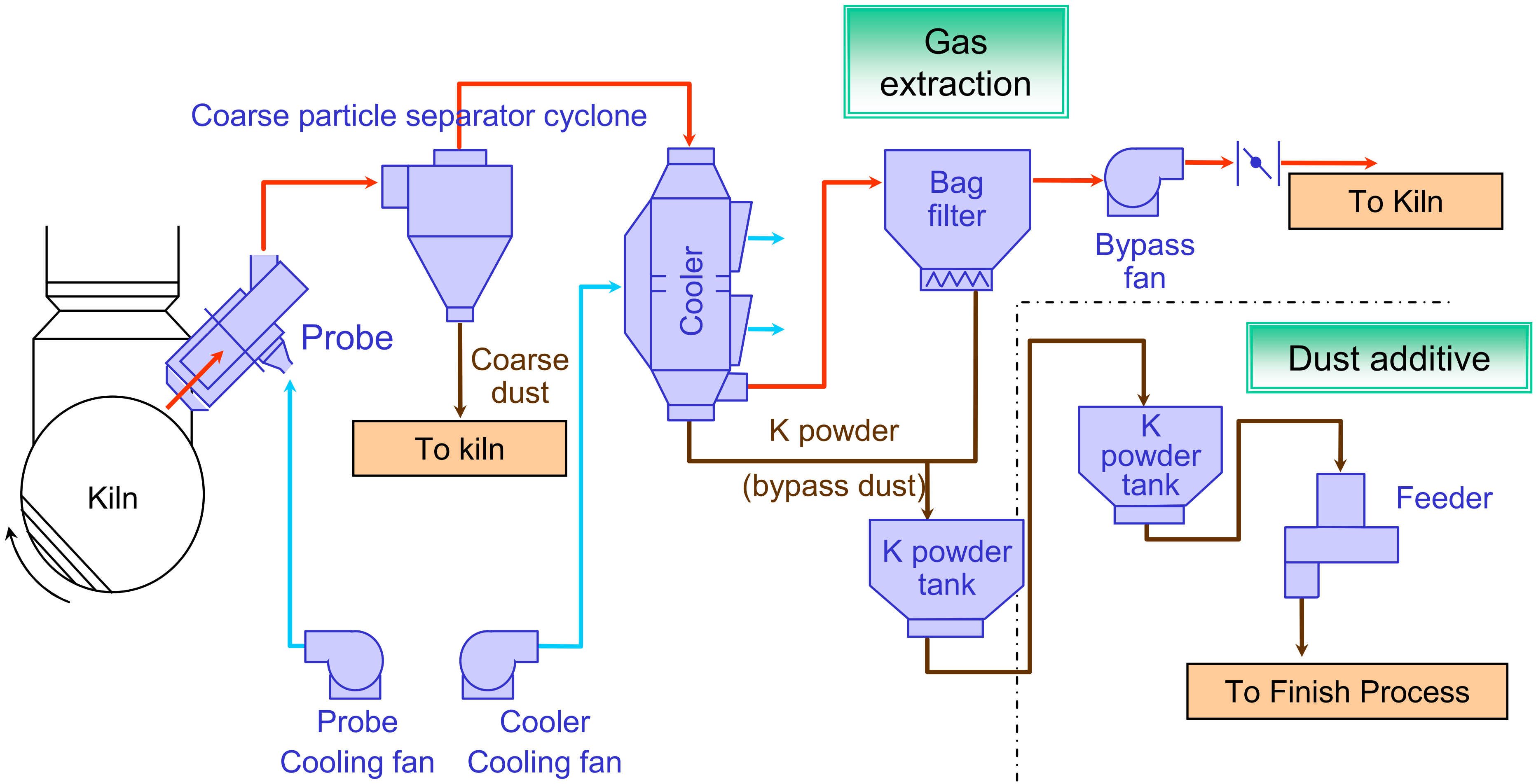
Chlorine bypass dust
- Cl: 21.9% (3,650x))
- Na_2O: 1.96% (5.8x)
- K_2O: 29.9% (62x)
- SO_3: 10.2% (20x)

Chlorine bypass coarse powder
- Cl: 2.18% (360x)
- Na_2O: 0.69% (2.0x)
- K_2O: 5.06% (11.0x)
- SO_3: 8.1% (16x)

Clinker
- Cl: 0.006%
- Na_2O: 0.34%
- K_2O: 0.48%
- SO_3: 0.5%

Note: values in parentheses are in relation to clinker

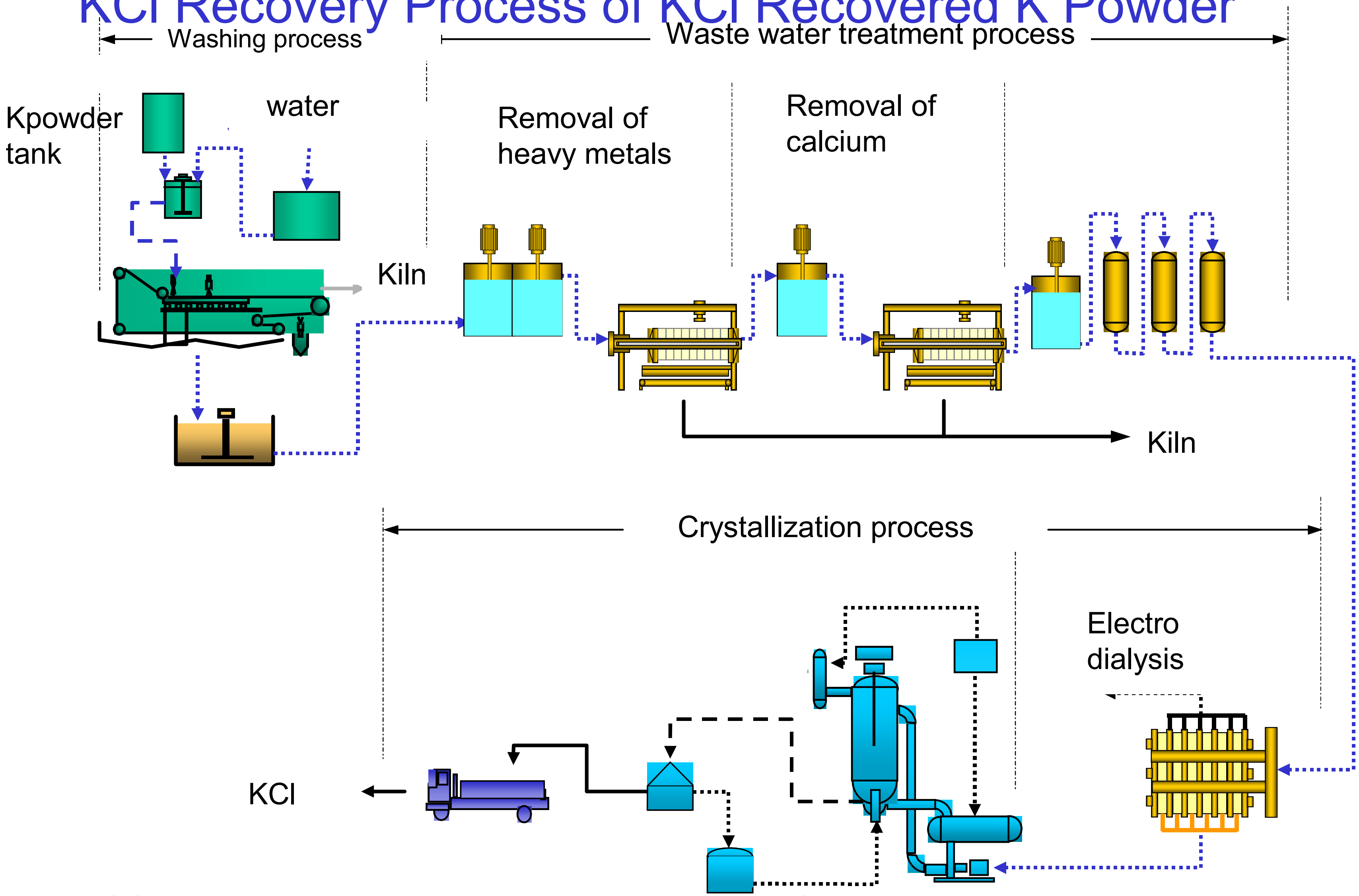
Chlorine Bypass System Flow Chart



Volume of Municipal Trash Incinerator Ash That Can Be Used in Cement Kilns

	Without chlorine bypass	**Chlorine bypass type 250**	**Fly ash washing desalination**	**Chlorine bypass type 250 + Fly ash washing desalination**
Permissible chlorine input vol. (clinker conversion)	15ppm	216ppm	15ppm	216ppm
Ash chlorine density	1.4%			
Fly ash chlorine density	15.0%		0.45%	
Permissible vol. of ash kg/t-clinker	0.2	2.4	0.9	13.3
Permissible vol. of fly ash kg/t-clinker	0.1	1.2	0.5	6.6
Permissible vol. of incinerator ash (ash + fly ash) **kg/t-clinker**	**0.3**	**3.6**	**1.4**	**19.9**
Input chlorine from source fuels other than urban trash incinerator ash is 20ppm (clinker conversion). Ratio of ash to fly ash is 2:1 depending on volume produced; fly ash washing desalination efficiency is 97%.				

KCl Recovery Process of KCl Recovered K Powder



Quality Target and Actual Performance of KCl Recovered K Powder

	Target	Actual performance
K_2O	57% min	60%
Ca	1000 mg/kg max	100mg/kg max
SO_4	1000 mg/kg max	100mg/kg max
Heavy metals	10 mg/kg max	0.2mg/kg max

Conclusions

The contents of this report can be summarized as follows.

① In Japan, energy saving technologies in the cement production have been developed, and at the same time as many types of advanced recycling technologies of waste materials.

② The amount of waste materials and by-products utilized in 1 ton of cement produced in the Japanese cement industry has reached an average of 400 kg.

③ By treatment technologies, represented by the chloride bypass process, the incineration ash of municipal waste containing chloride compounds has been utilized increasingly in the cement production process.

④ Three unique methods of utilizing municipal wastes, fly ash washing system, ecocement system, and AK system were in practical use and the method to be selected varied depending on actual conditions in each region.

We want to contribute to the creation of a recycling society.

Thank you for your attention