ESCAP
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Session 1
The state of transboundary air pollution in Northeast Asia

Mercury Emission from Coal Combustion in Japan

Prof. Hiroshi Moritomi
Gifu University, Graduate School of Engineering, ERES

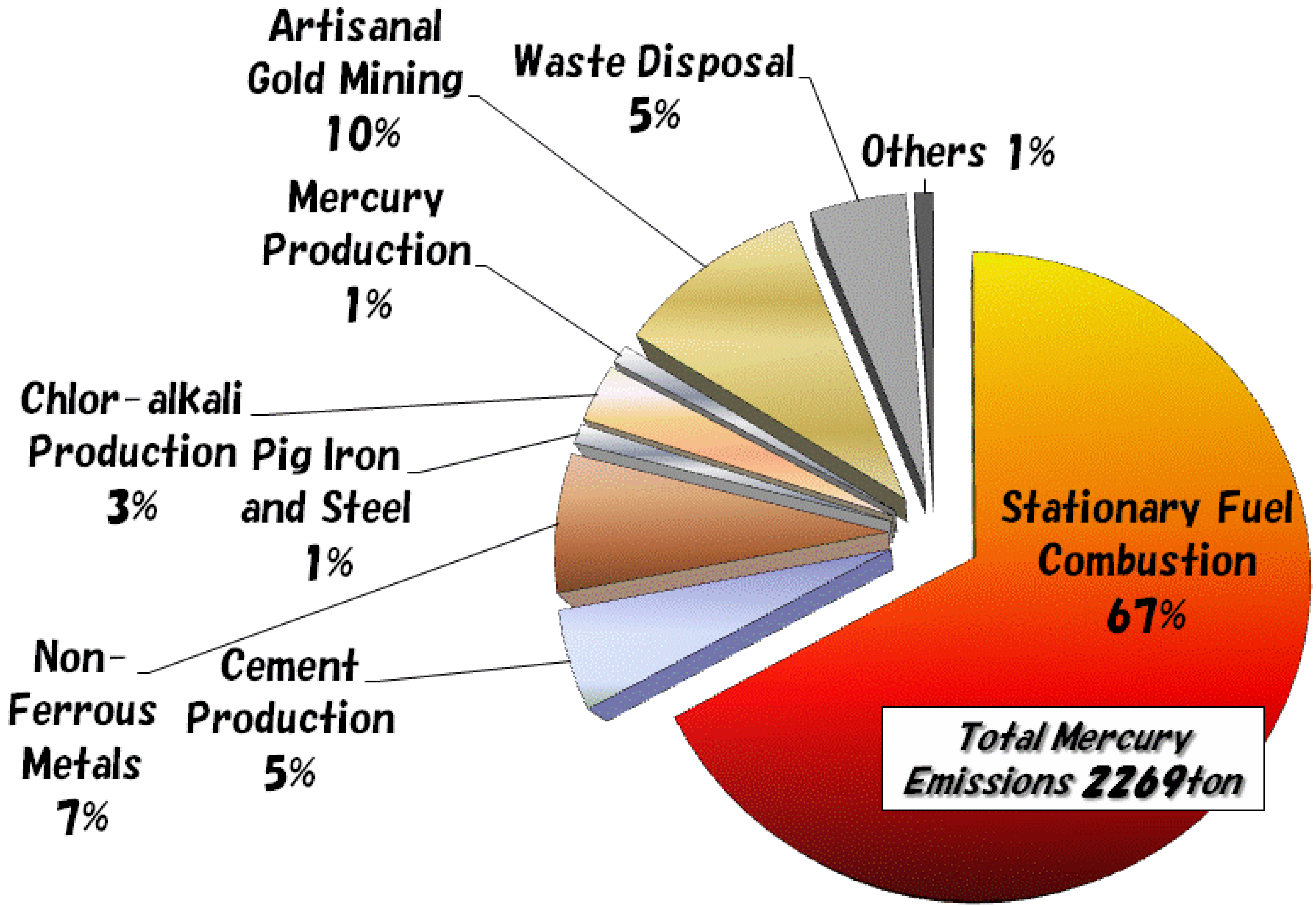
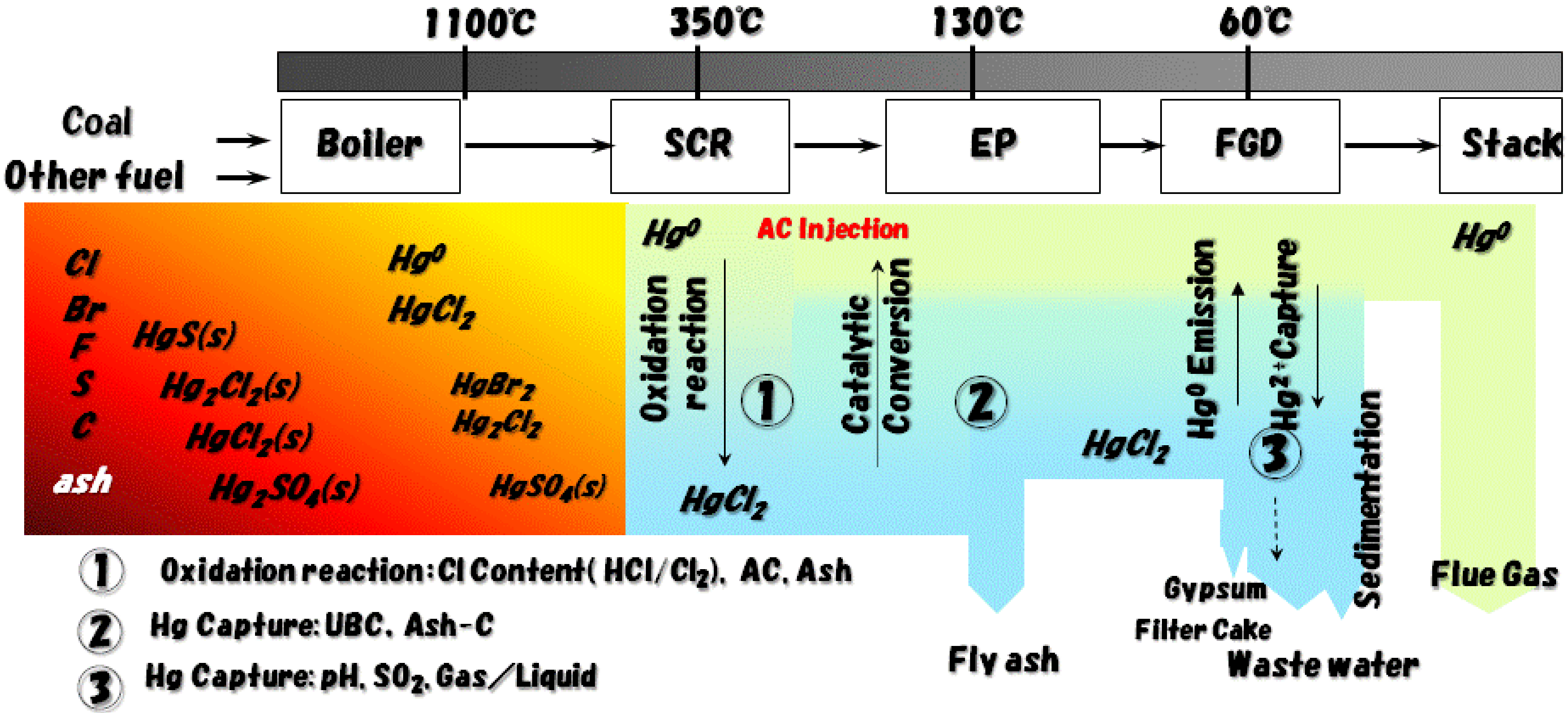


Fig. Anthropogenic mercury emissions, total 2269 ton at 2000.



Combustor type	Fuel	Coal cleaning	Bottom ash	EP	FGD	Stack	
PC	Sub-bituminous	10-50%	(10%)	0-27%	-63%	10-81%	USEPA(1998.2002)
PC	Bitumious	10-50%	(10%)	18-81%	1-41%	2-52%	USEPA(1998.2002)
Stoker			17%	17%(Dust)		56%	Wang et al.(2000)
Small PC			7%	23%		70%	Wang et al(2000)
MSW incineration				30-60%	6-40%	15-60%	Pirrone et al.(2001)
Incineration			1.8%	13.9%	77%	7.3%	Nakamura(1994)

Fig. Effects of Flue Gas Treatment Equipment on Hg Reduction

Table Control Technology of Mercury Emission

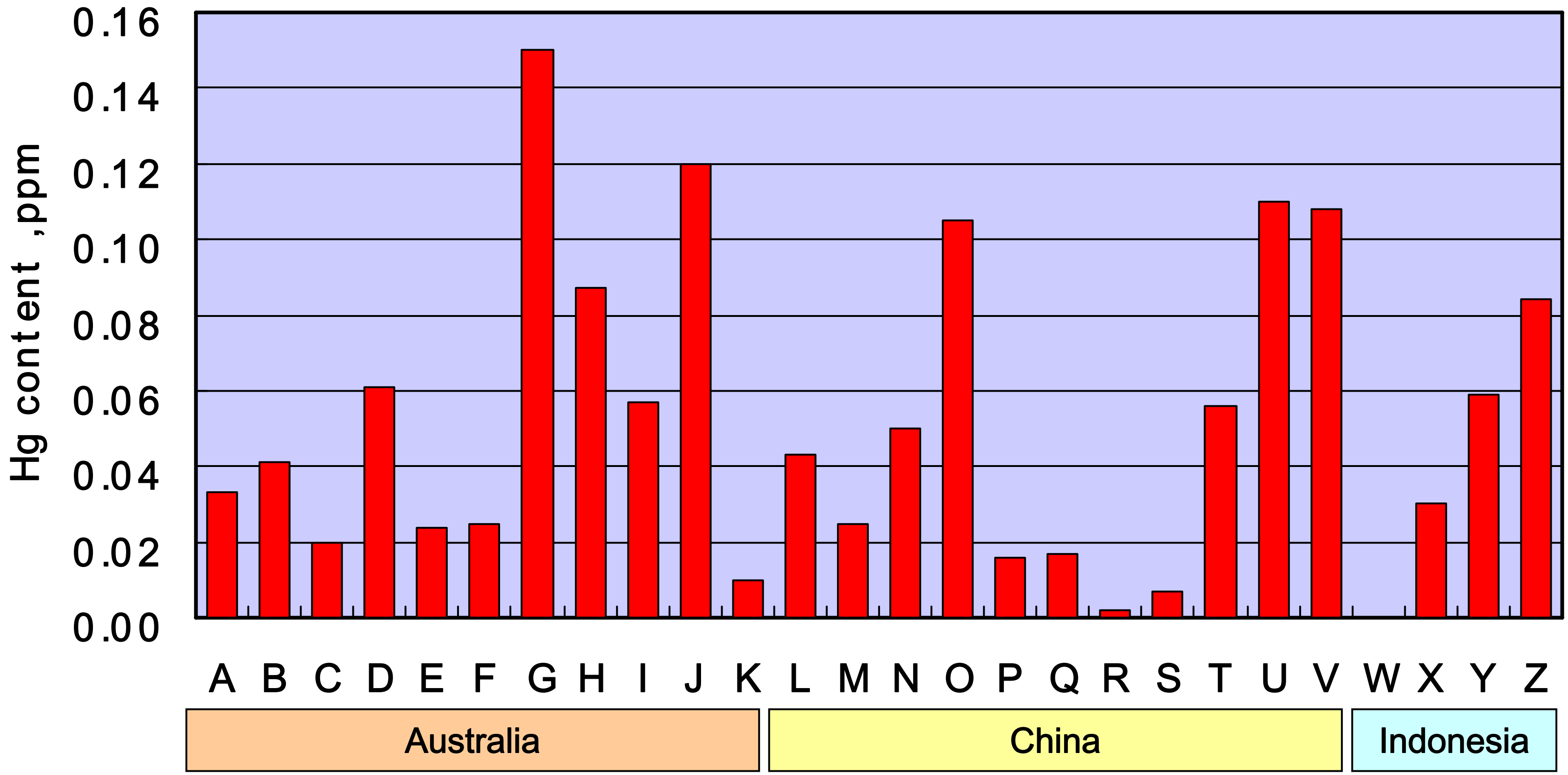
Technology	Efficiency	Other effects
DeNOx (SCR)	Unknown	30-60% NO_x
DeNOx (SCR)	SCR +Wet Scrubber	70-90% NO_x
Low NO_x burner	Unknown	>50% NO_x
Coal Cleaning	0-78%	48% SO_2
Wet scrubber	>90% Hg^0 (No Hg^{2+})	80-90% SO_2
SCR +Wet scrubber	>80% Hg Bituminous coal	>90% SO_2 and >90% NO_x
Dry scrubber + EP + Baghouse	6-9% USEPA 約63%	80-90% SO_2
ESP	0-82% (Low temp ESP USEPA 36% Bituminous USEPA 3% Sub-bituminous	>99% PM
Baghouse	0-73% USEPA 90% Bituminous USEPA 72% Sub-bituminous	>99% PM
High efficiciency EP	0-50% (in testing)	>99% PM
Wet EP	約 30% (in testing)	56% PM (in testing)
EP + Baghouse	34-87% (in testing)	>99%(in testing)
AC Injection	80% Bituminous+EP+COHPAC 55-60% Sub-bituminous+EP	—
Changing fuel	>99% LNG	>99% SO_2 and PM control; 50-75% NO_x

Mercury emission from coal power station

	USA	Japan
Mercury in coal	85ppb	50ppb(2 /3)
Mercury from Stack	5 4 %	30%(1/2)
Coal consumption	900MT	1 0 0MT(1/ 9)
Mercury emission	41t/y	1.5t/y(1/27)

USA：EPA(1999), Japan：Idemitsu Kosan

Mercury content in coals used in Japan



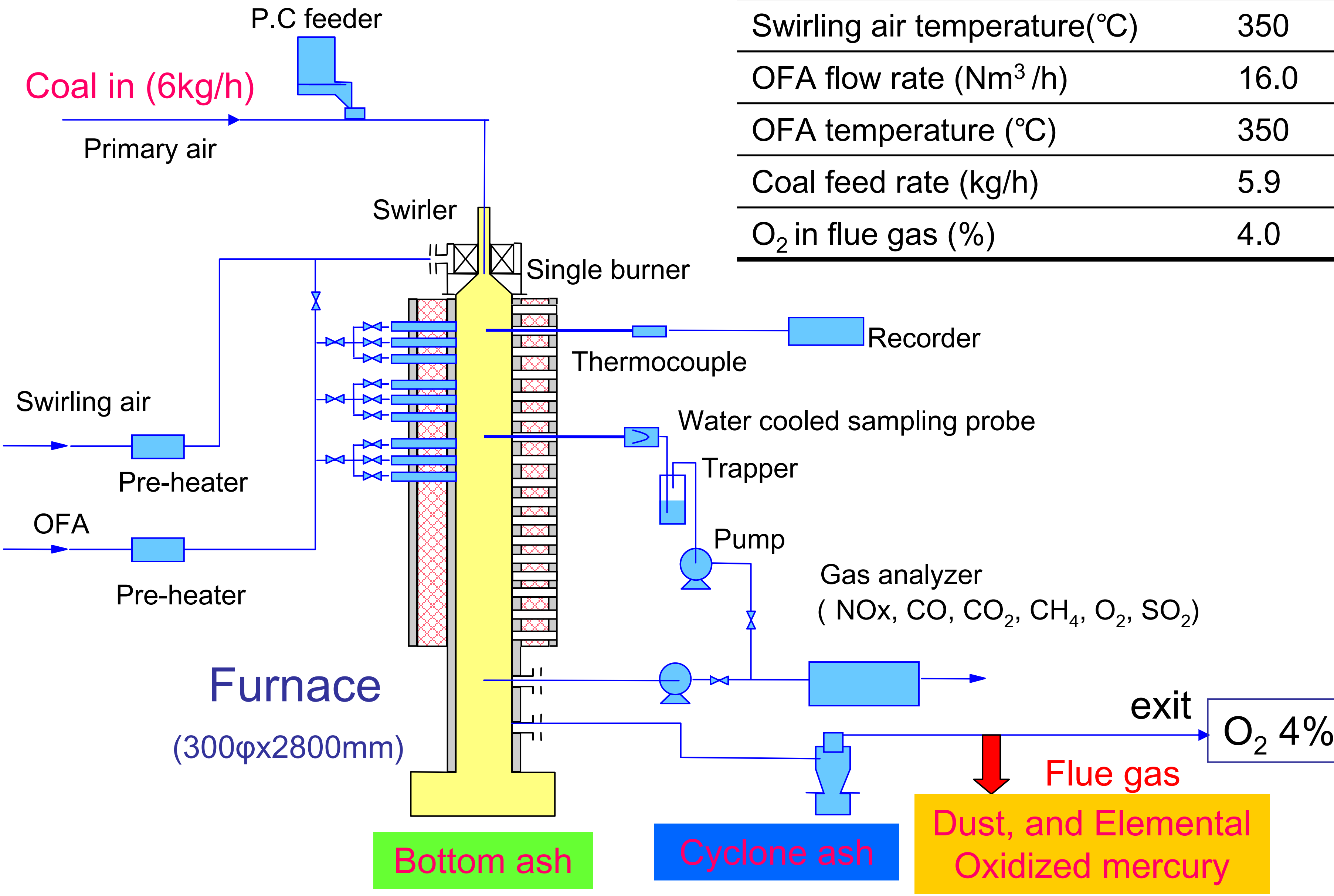
Mean content : 47 (µg/kg, ppb) , Range : <10 ~ 190 (µg/kg)

Coal properties

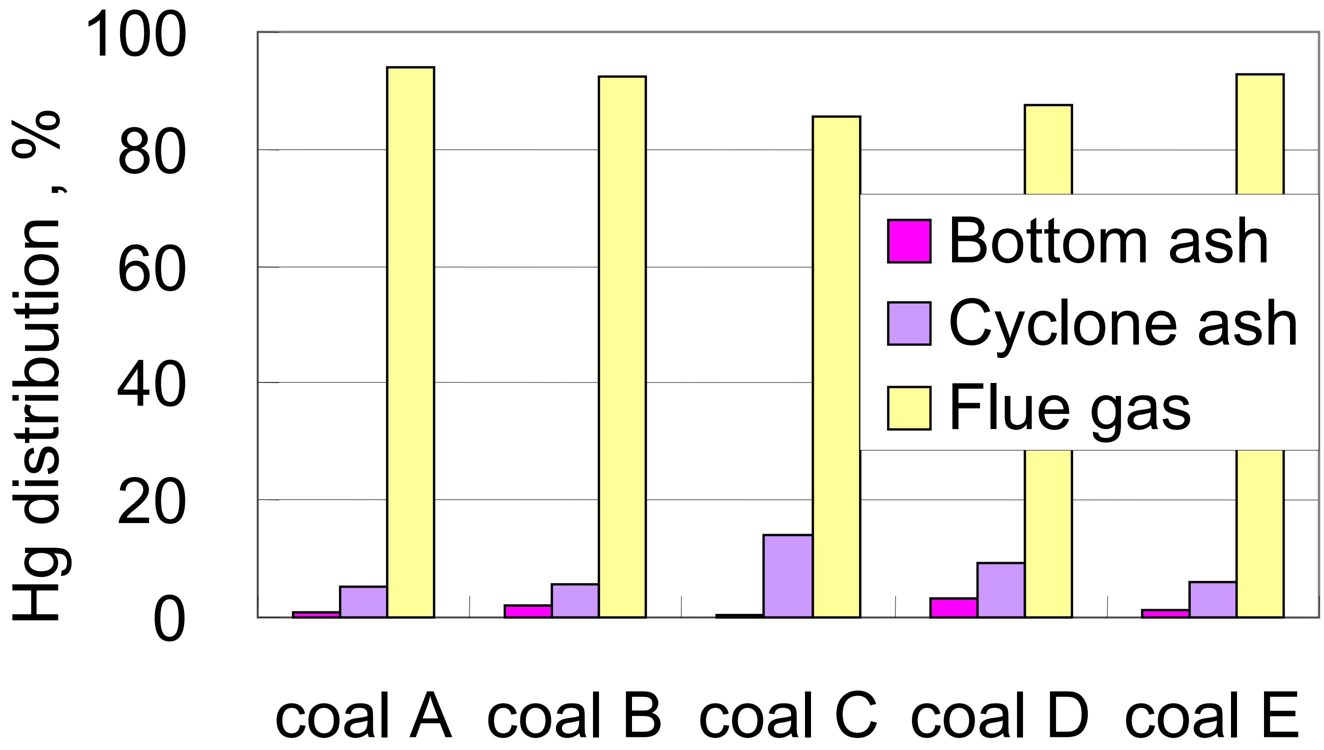
	Proximate analysis , as received wt%				Ultimate analysis, daf wt%					ppm	ppb
	Volatile Matter	Fixed Carbon	Moisture	Ash	C	H	O	N	S	Cl	Hg
Coal-A	33.1	55.4	1.7	9.8	82.8	5.3	9.8	1.6	0.6	233	114
Coal-B	27.4.	57.7	2.3	12.6	85.4	5.2	7.3	1.9	0.3	408	49
Coal-C	27.6	60.0	4.2	8.2	82.9	4.8	10.0	2.0	0.3	176	29
Coal-D	26.0	58.8	4.6	10.6	81.1	4.4	12.0	1.8	0.67	2304	44
Coal-E	40.9	41.5	3.1	14.5	78.2	5.9	13.6	1.3	1.08	176	119

Bench-scale PCF

Primary air flow rate (Nm^3/h)	6.0
Swirling air flow rate (Nm^3/h)	36.0
Swirling air temperature(℃)	350
OFA flow rate (Nm^3 /h)	16.0
OFA temperature (℃)	350
Coal feed rate (kg/h)	5.9
O_2 in flue gas (%)	4.0

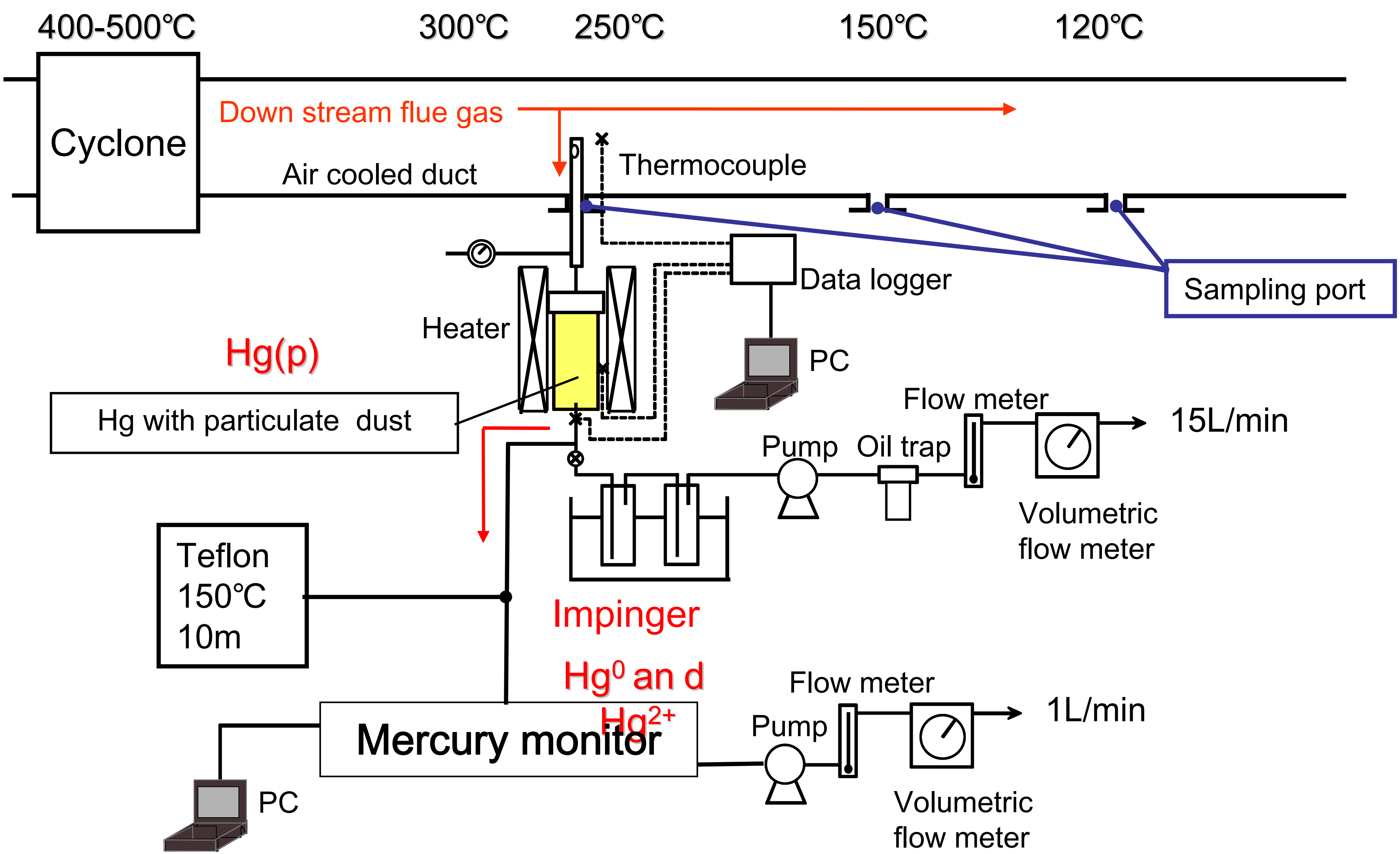


1) Mercury speciation with large particles at medium temperature



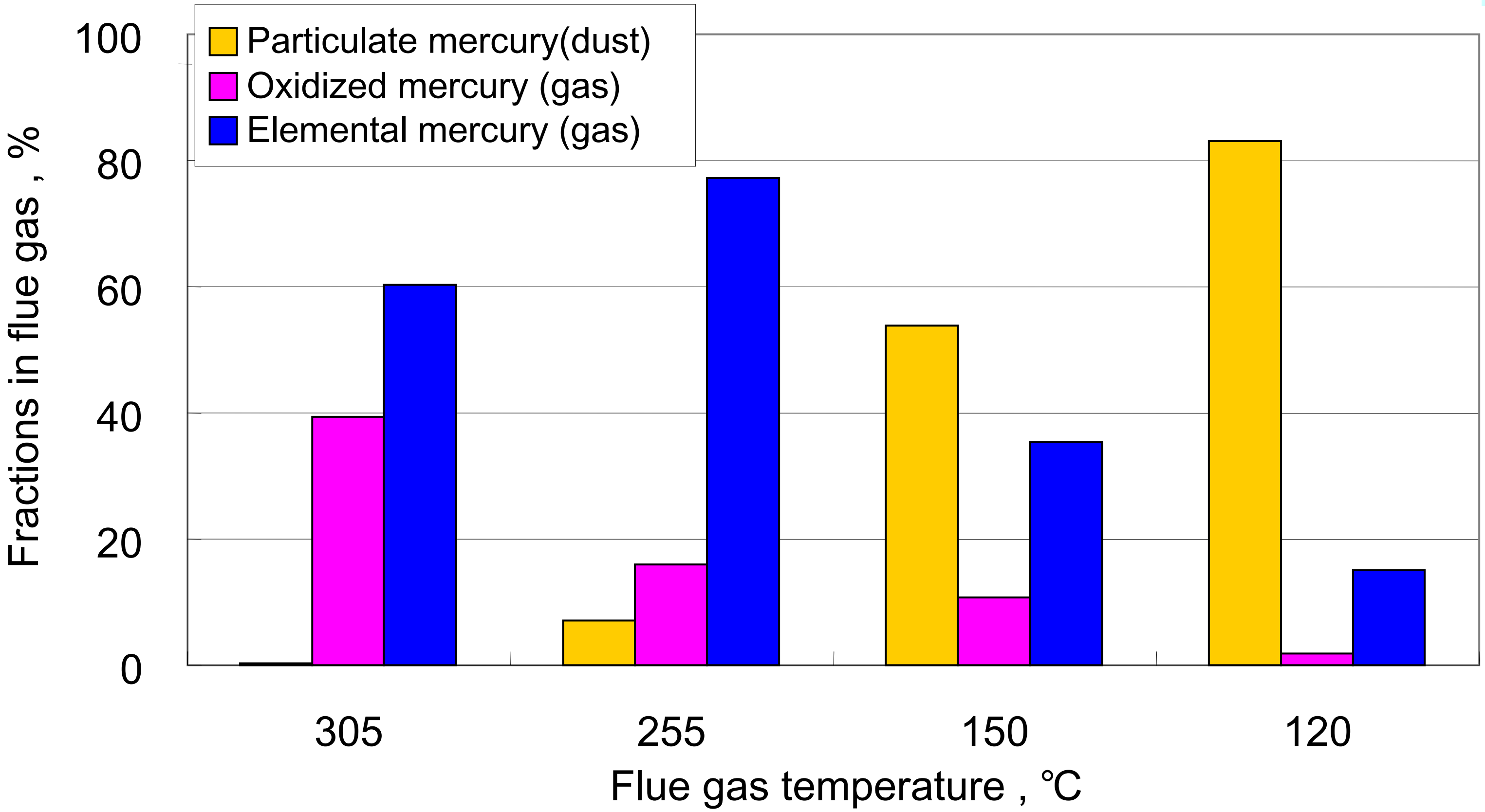
Almost of Hg to flue gas >> BA and CA

Flue gas sampling system



2) Mercury speciation in flue gas at low temperature

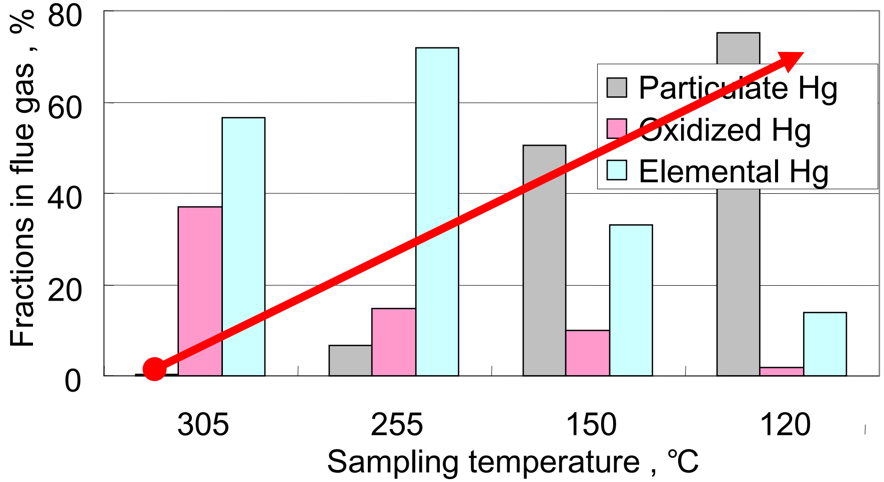
[recovered, %] : in sample / in coal A



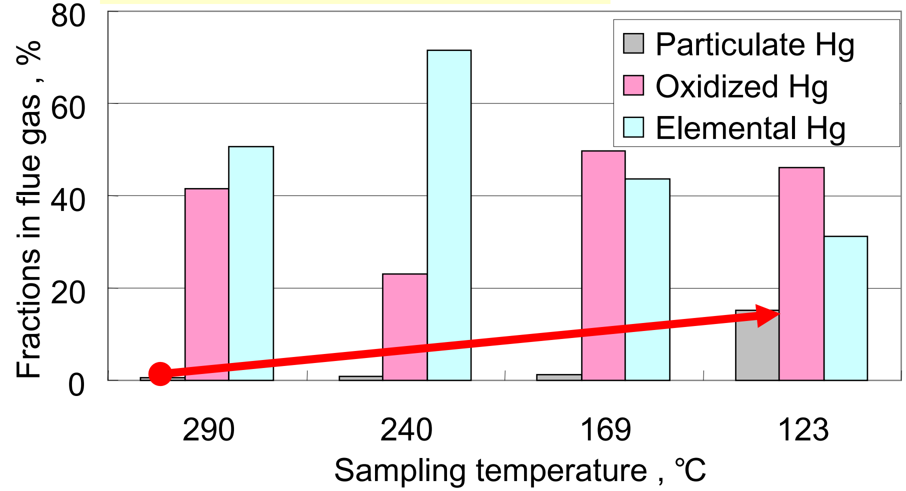
Mercury in dust is increased with decrease in flue gas temperature.

2) Mercury speciation in flue gas *for coal type*

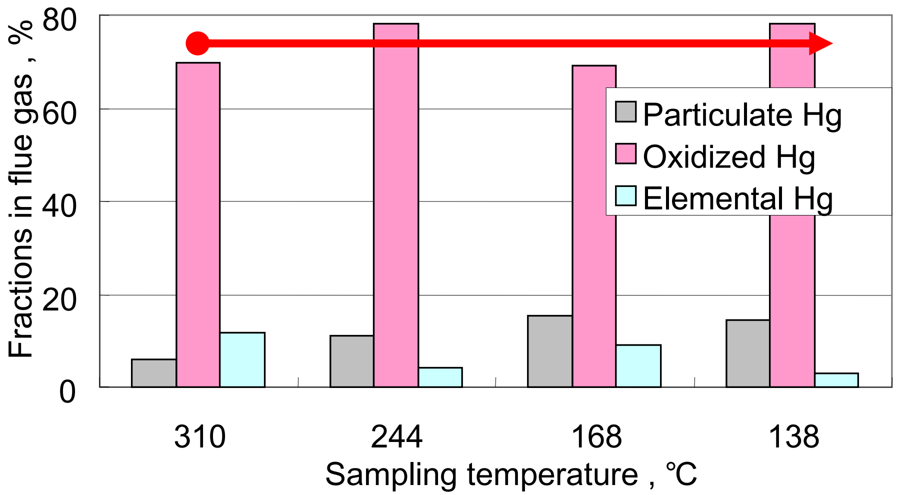
Coal A



Coal E Volatile rich



Coal D Cl rich



Coal A

Lowering temp → Hg(p)↑+ Hg^0↓

Coal E with high volatile

Lowering temperature → a little

Coal D with high Cl

Even high temperature → Hg^+

Unburned carbon content

Chlorine content

Condition of sorbent injection

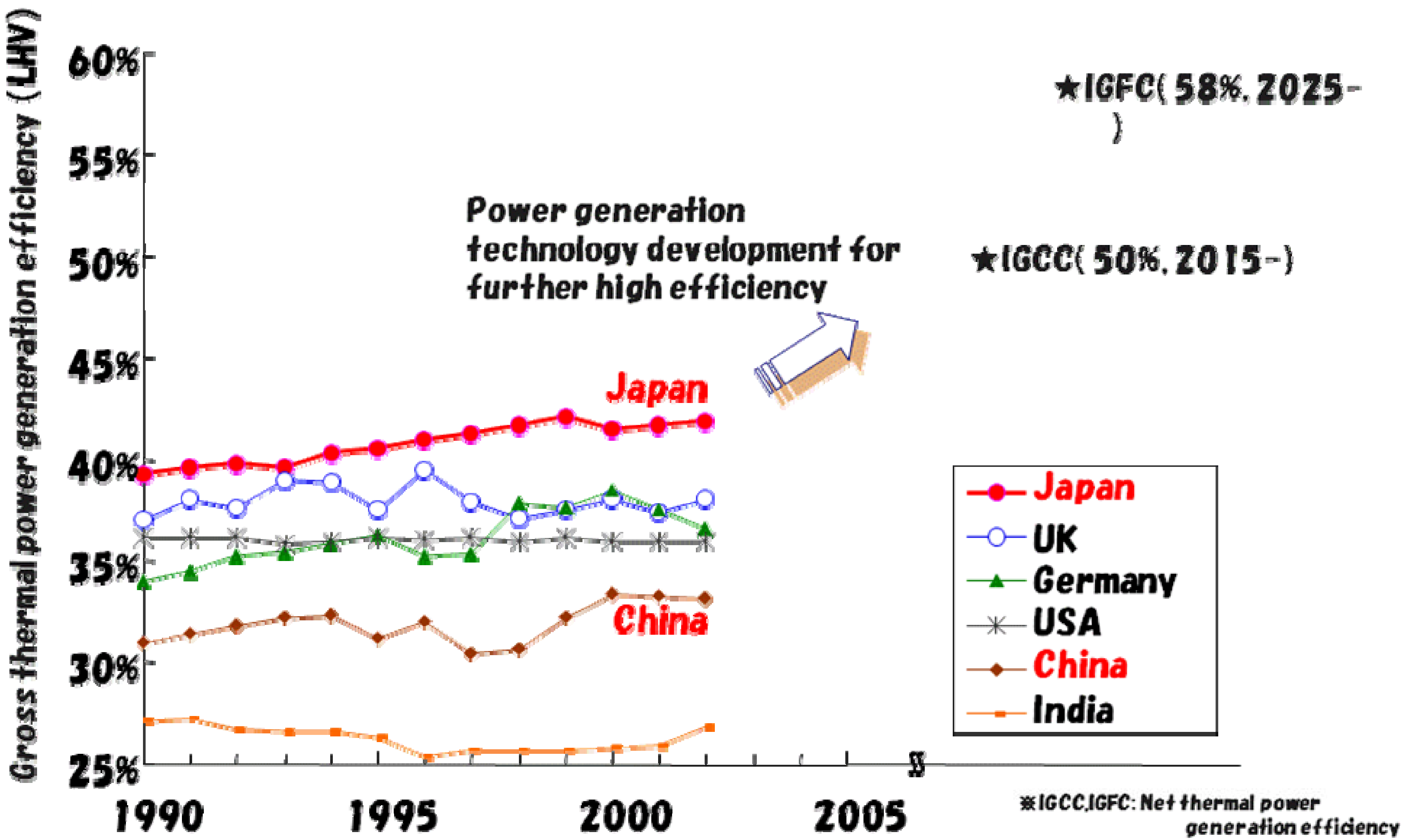
Coal Feed rate, kg/hr	5.9
Residence time, s	
P2 (230℃)	0.706
P4 (170℃)	1.25
P6 (130℃)	1.88

Sorbent feed rate, g/hr	P6 130℃	P4 170℃	P2 230℃
AC from br-coal	42.5	38.9	37.1
Spent catalyst	43.0	38.0	27.8
Coal fly ash	26.9	38.0	23.9

Sorbent			Activated carbon	Coal fly ash	Spent catalyst
Proximate analyses	Moisture	wt%	12.5	1.4	0.8
	Ash	wt%	4.3	66	98.3
	Volatile	wt%	6.5	6	0.9
	Fixed carbon	wt%	76.7	26.6	0
Ultimate analyses	Carbon	wt%	77.2	29.02	0.39
	Hydrogen	wt%	1.91	0.58	0.16
	Nitrogen	wt%	0.22	0.62	0
	Total- Sulphur	wt%	0.2	0.8	0.004
	Mercury	wt%	17	301	<1
Size		μm	<125μm	<100μm	vary
Density		kg/m3	ND	758.7	972.05

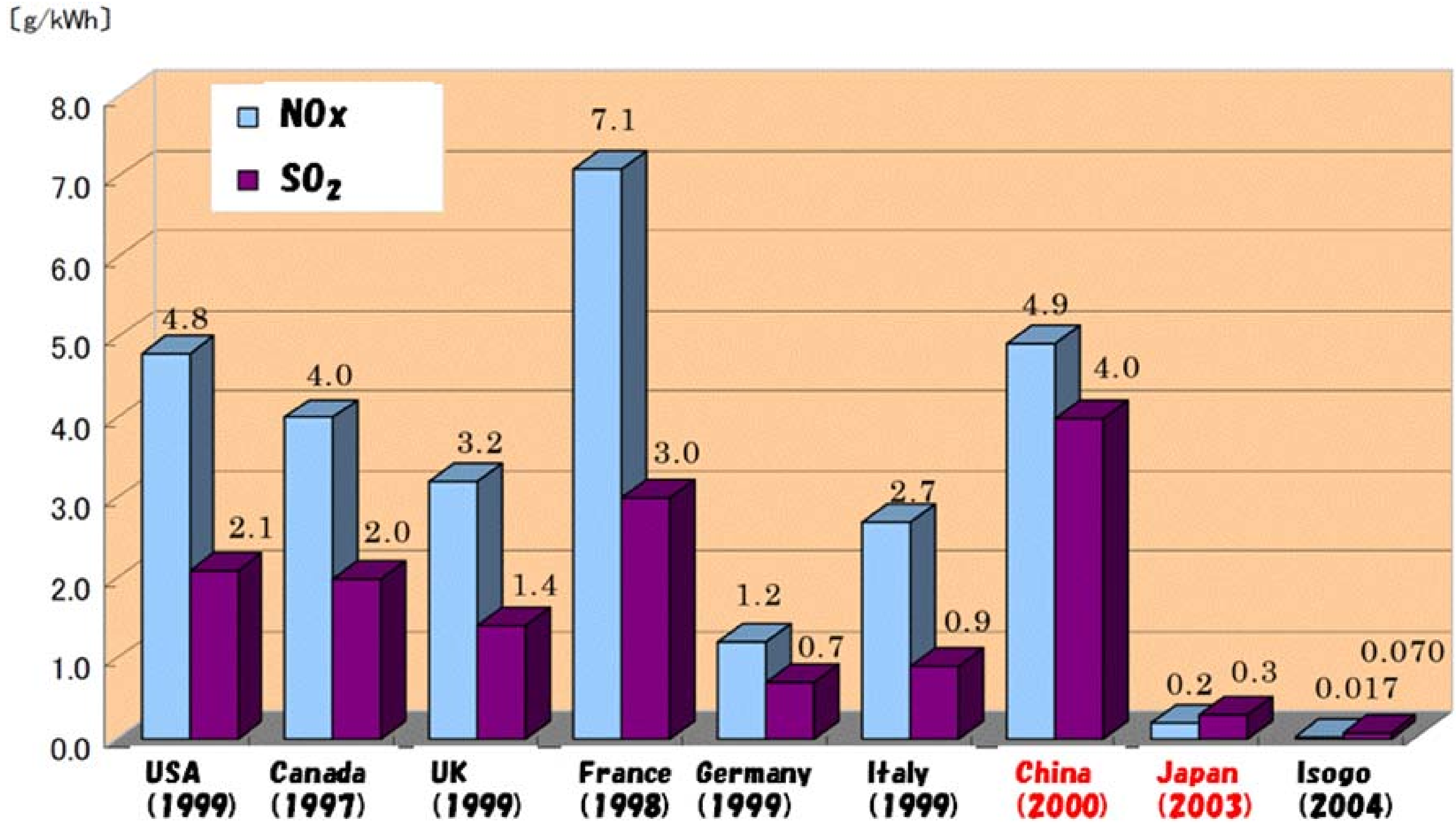
From cyclone
P2=4930mm P4=8360m P6=11790mm Inside diameter=57.2mm

Trends of coal-fired power generation efficiency in each country

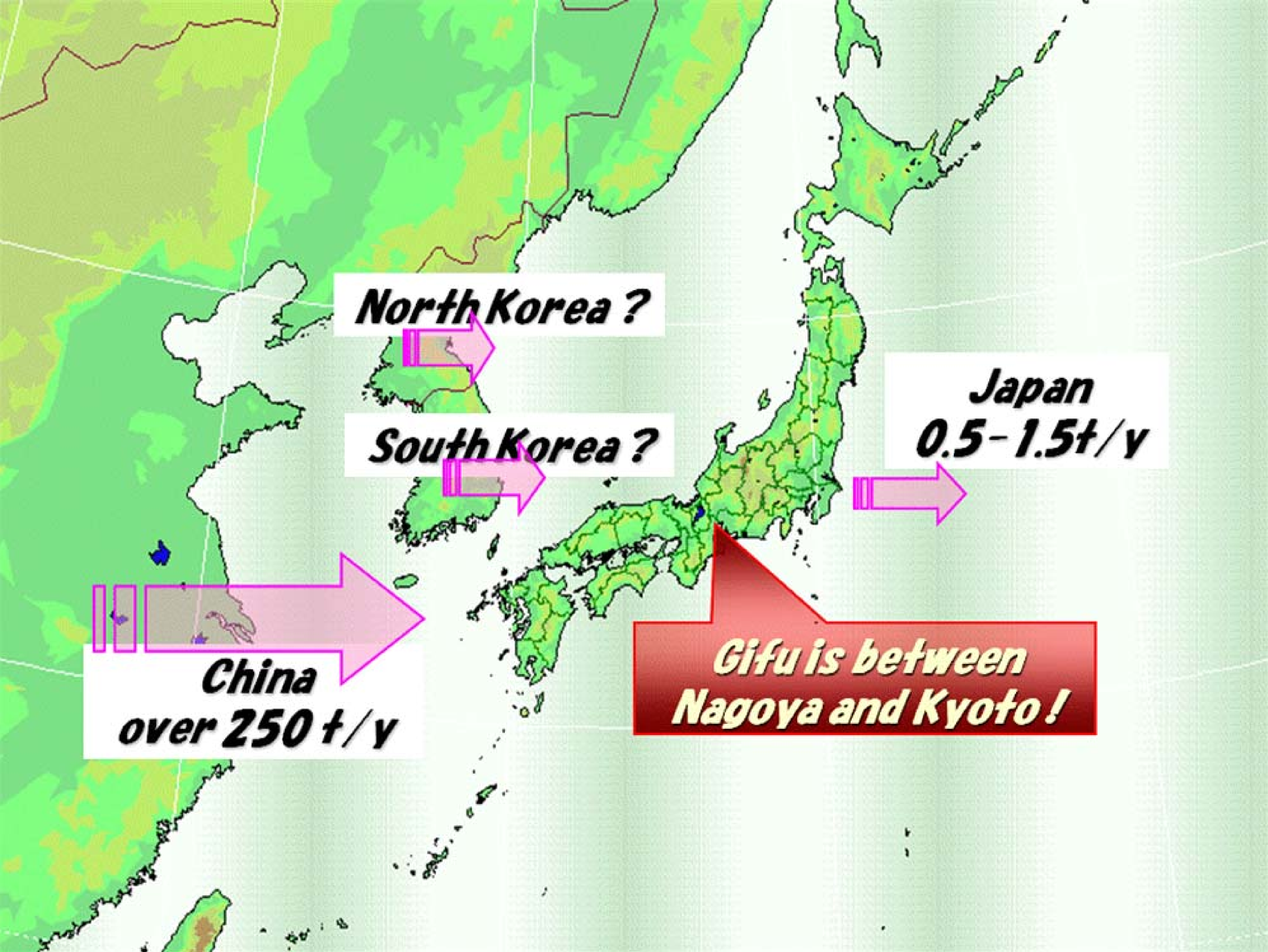


Source: Ecofys Comparison of Power Efficiency on Grid Level 2004

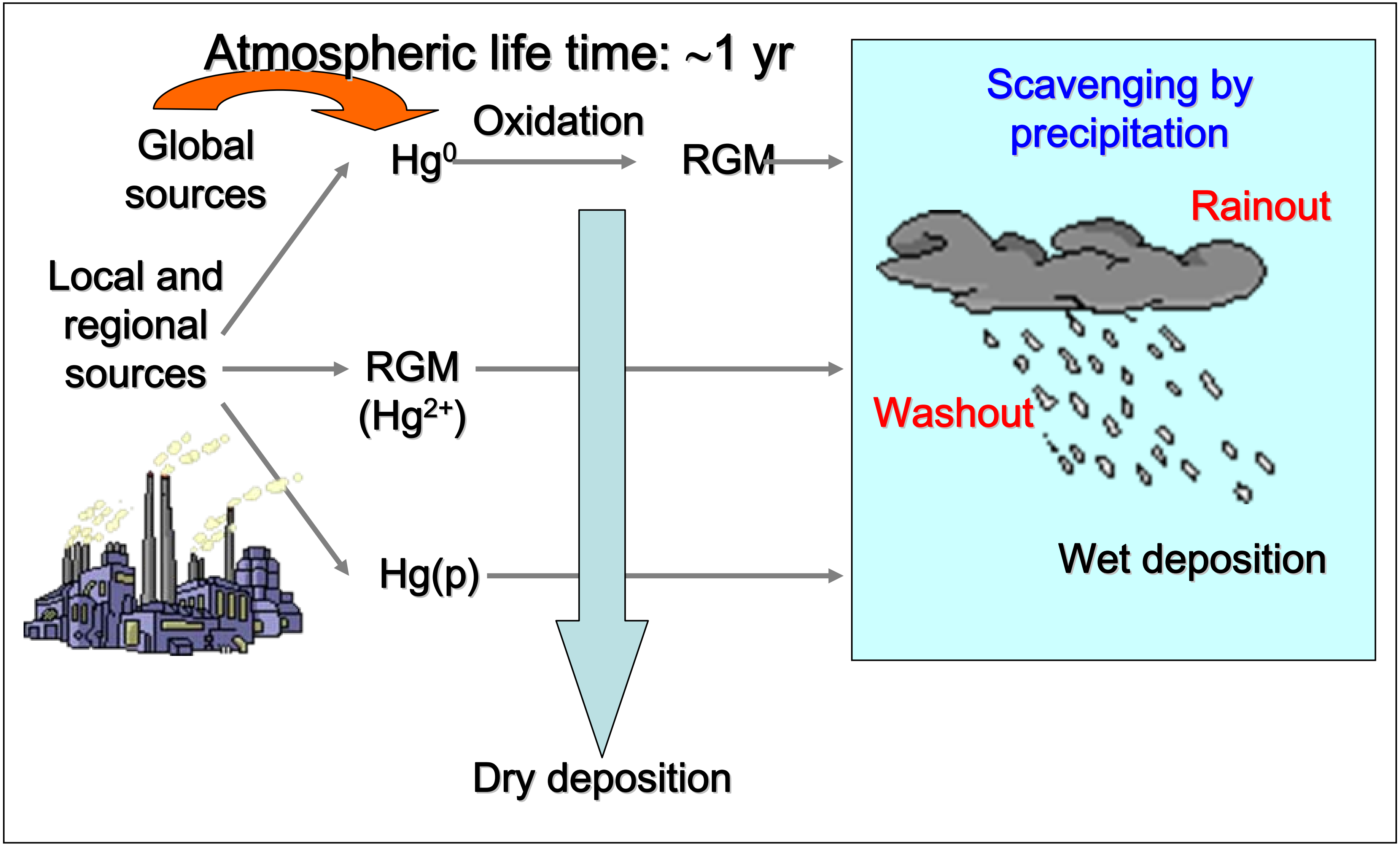
Emission of NOx and SO_2 from each country, g/KWh



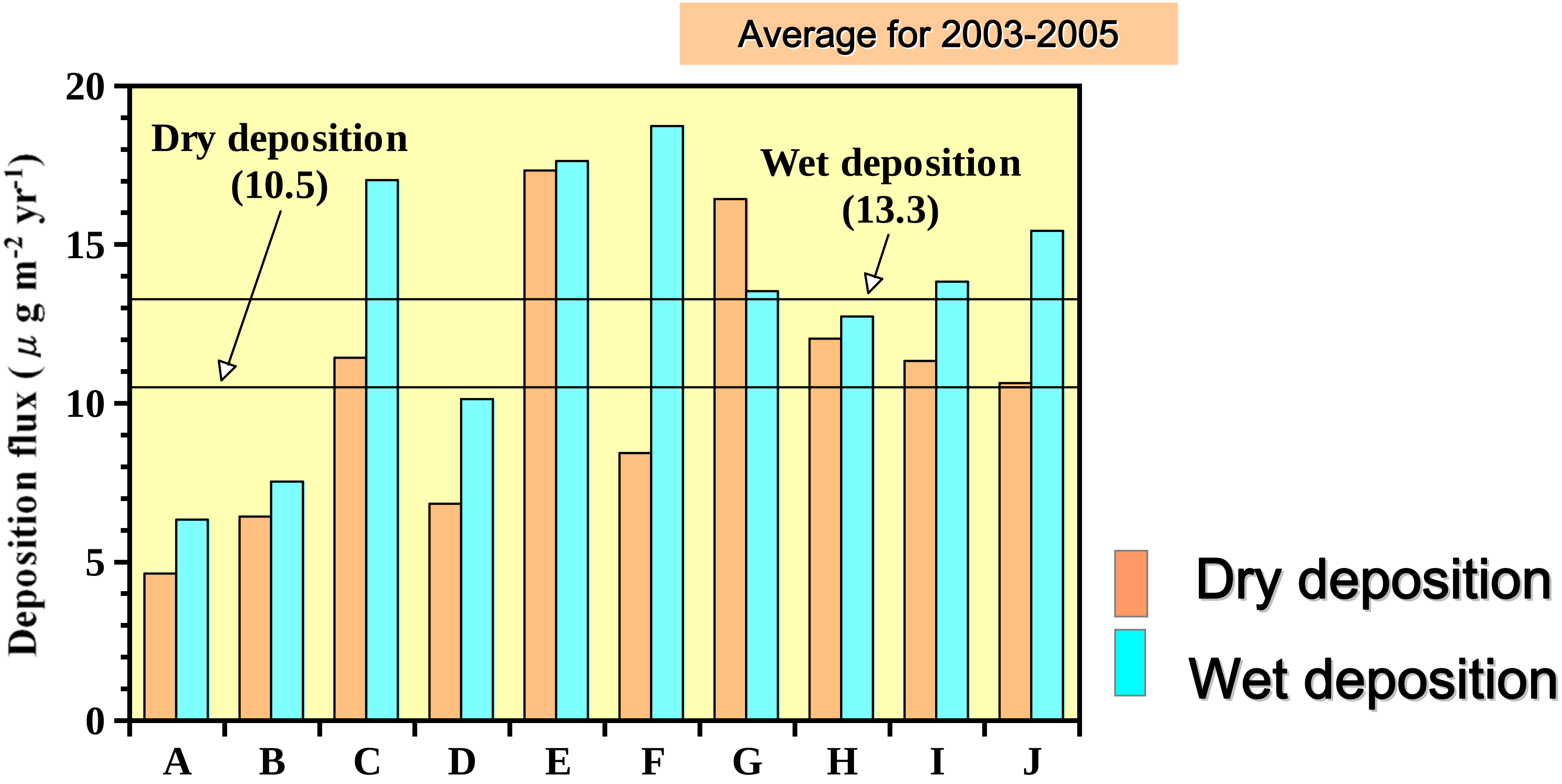
Data from METI


North Korea ?
South Korea ?
Japan
0.5-1.5t/y
China
over 250 t/y
Gifu is between
Nagoya and Kyoto !

Atmospheric deposition of mercury



Dry and wet deposition fluxes of mercury around power station site



CRIEPI : Sakata's data

Conclusions

Under the practical conditions of flue gas cooling process of PC boilers, the test results support the following conclusions:

1. Mercury transformation depended on chlorine content in coal and unburned carbon in flyash dust.

2. Excessive activated carbon could capture elemental mercury but a little of oxidized mercury.

3. When using inorganic sorbents, there was a trade-off relationship between oxidized mercury and elemental mercury and the total captured mercury was lowered.

“Earlier” is “better”

“If slowing, it is not in time.”

Think about what we can do !