International overview on trace element legislation and control

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CRF Seminar on the control of mercury and trace element emissions
London, 20th April 2016

What does the IEA Clean Coal Centre do?

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  - comprehensive assessment reports on all aspects of clean coal technology
  - Webinars
  - technical workshops on clean coal issues
  - Clean Coal Technologies Conference
- Capacity building activities and demonstration projects in developing countries with UNEP and US State Department

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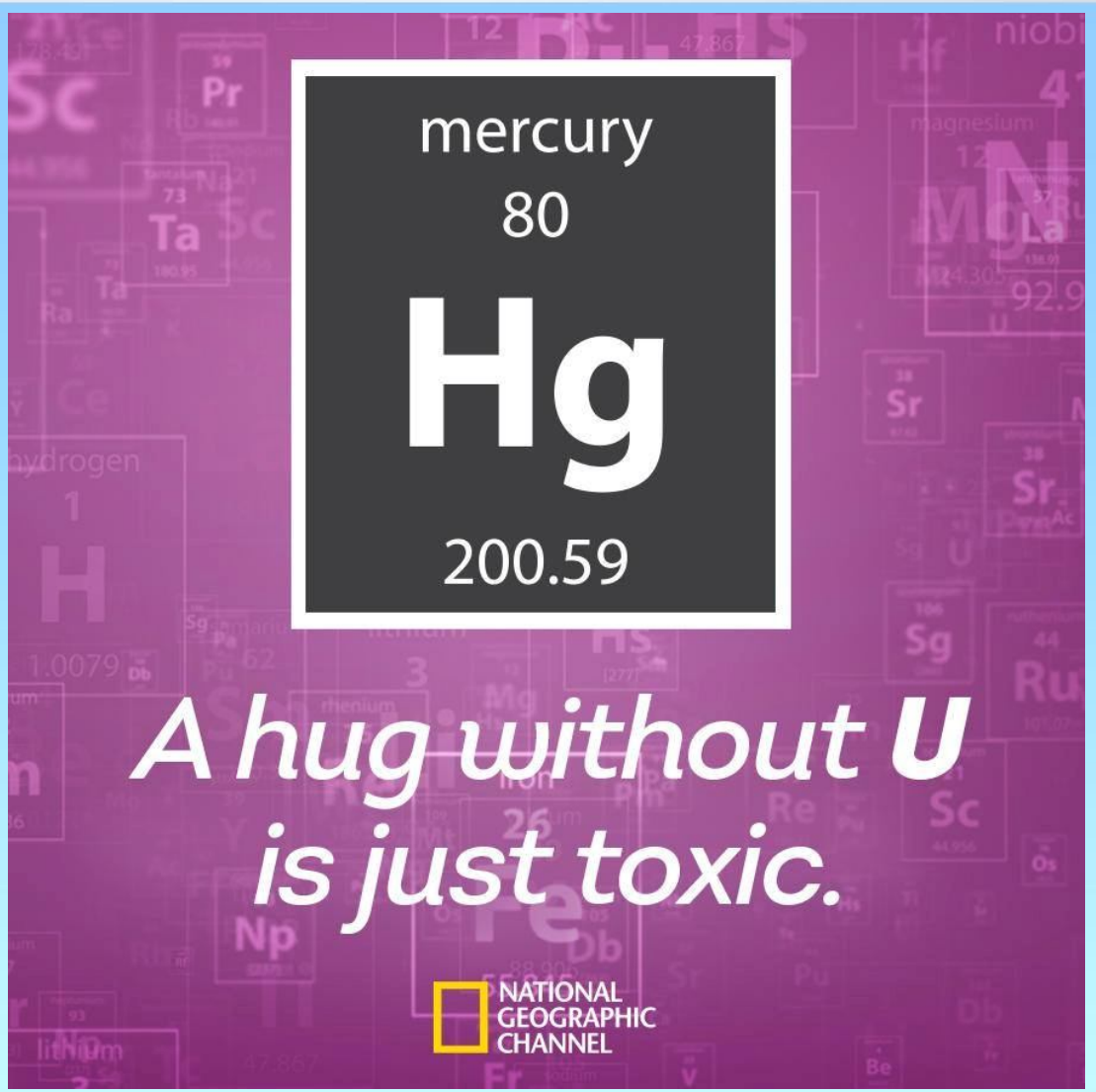
Mercury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Existing legislation on mercury

UN Minamata Treaty	**Treaty signed October 2013**	**Ratification by Parties to UNEP and subsequent introduction of control measures**
USA	**Regulations in place**	**Emission limits set at 1.4 – 15.3 µg/ m^3**
China	**Regulations in place**	**Current levels are 30 µg/ m^3**
EU	**Regulations expected in 2016**	**1 – 9 µg/ m^3 , depending on plant thermal input (< or >300 MW) and whether new or existing plant**
India	**Draft Notification in place since April, 2015**	**30 µg/m^3 on all installations, except those smaller than 500 MW installed before December 31, 2003**

First national Hg limits were set in Canada

Canada-wide Standard – provincial caps for 2010		
Province	**Estimated emissions (2003-04), kg/y**	**2010 cap, kg/y**
Alberta	1802	590
Saskatchewan	710	430
Manitoba	20	20
Ontario	495	0
New Brunswick	140	25
Nova Scotia	150	65
Total	2695	1130

Recently MATS set in the USA

- The Mercury and Air Toxics Standards (MATS) have evolved after several rounds of work (via CAMR and related vacated rules)
- MATS applies to fine particulates, SO_2, NOx, and several trace elements
- Reduction for Hg is based on the performance of the top 12% performing plants in the country

United Nations Environment Programme

2013 Minamata Convention on Mercury - Target Areas for Control and Reduction:

- Coal Combustion
- Chlor-alkali Sector
- Products
- Air Transport and Fate Research
- Artisanal and Small-scale Gold Mining
- Waste Management
- Supply and Storage
- Cement and Non-ferrous Metals Production

The Minamata Convention - requirements

- Parties have obligations to reduce mercury from the coal sector under Article 8 - emissions to atmosphere
  - National Plan to be submitted to the Conference of the Parties within 4 years
  - New sources must comply with BAT/BEP (best available technology/best environmental practice) within 5 years
  - Existing sources –measures to be introduced within 10 years

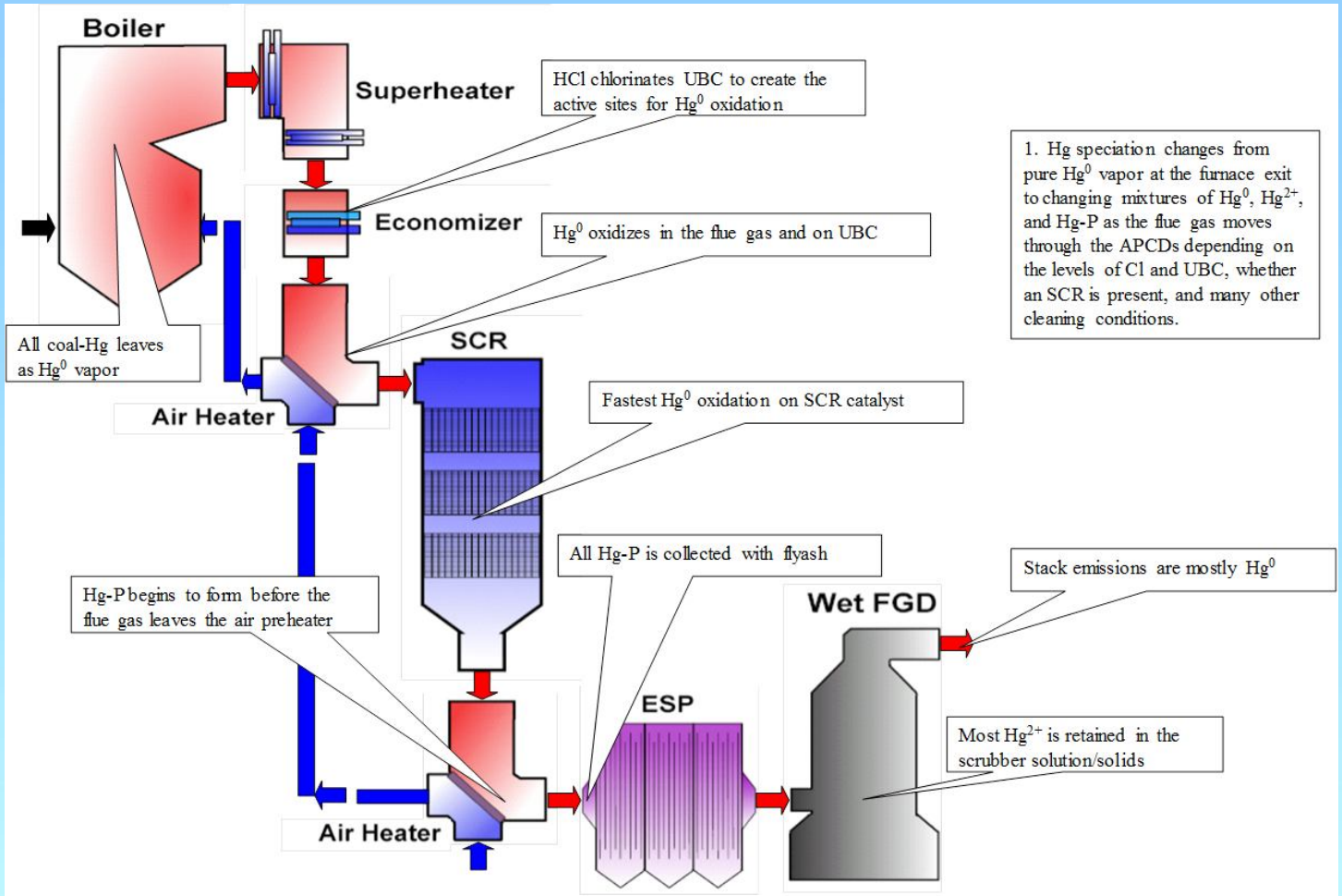
What does BAT/BEP mean for coal?

- Defined at country level, based on economic, geographic and technical considerations
- Could be anything from fuel switching/cleaning, through co-benefit effects to mercury specific control technologies

How does the EU definition of BAT/BEP differ from the UNEP definition?

- Guidelines for both cover exactly the same processes and options
- EU BREfs are more detailed
- EU has a proposed emission limit range (1-9 µg/m^3), the UNEP guidelines do not

Mercury behaviour is complex



Mercury control options

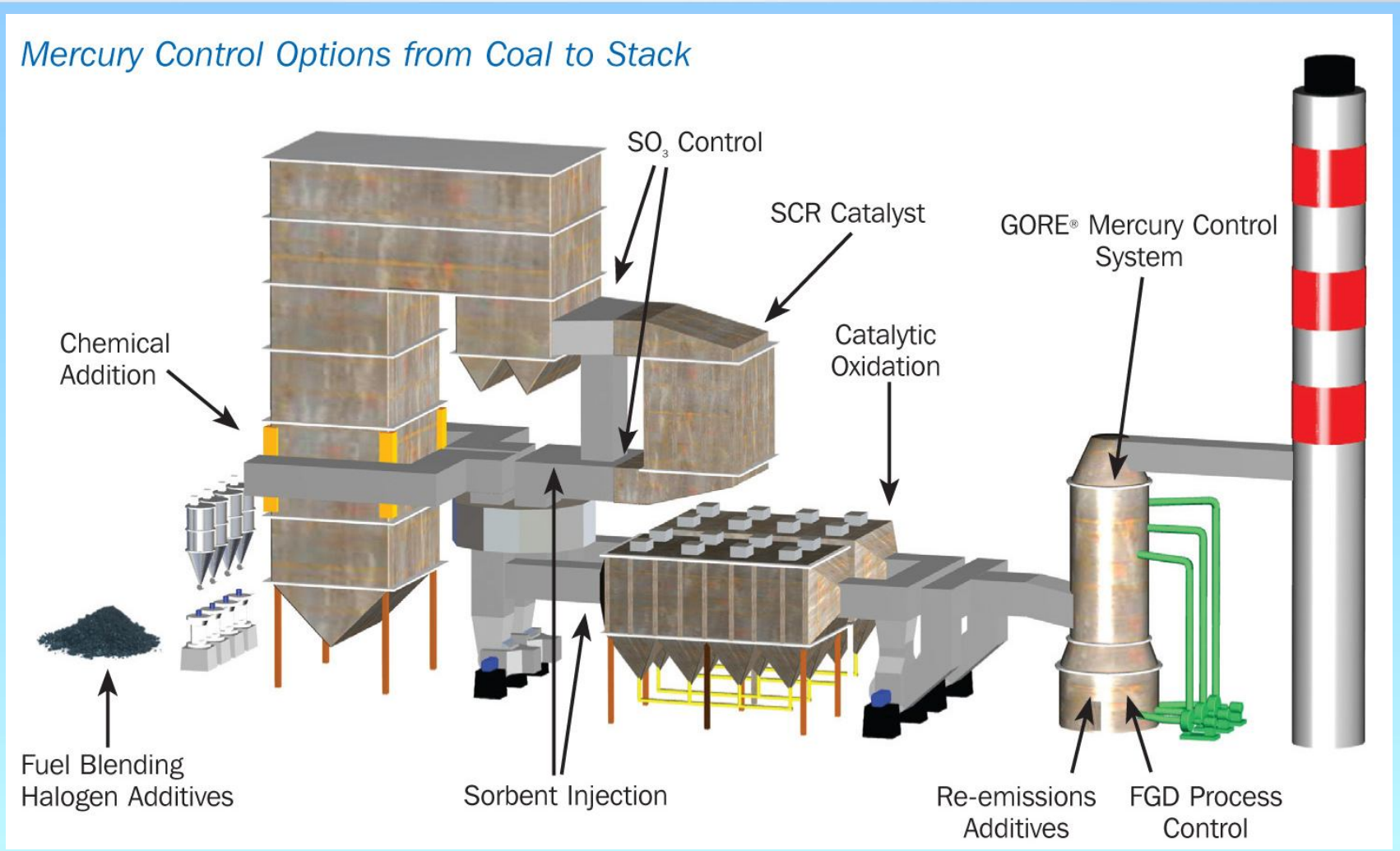


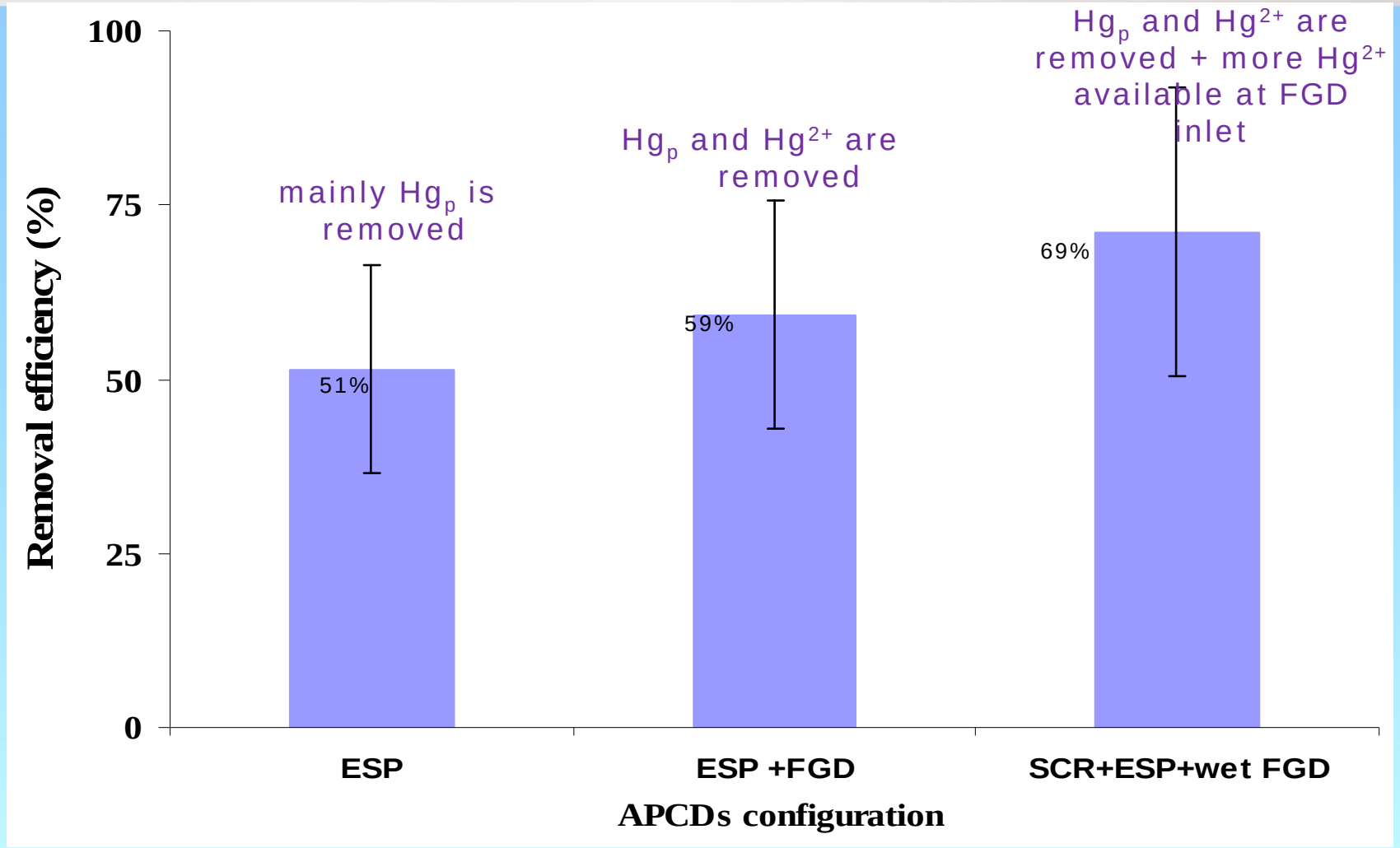
Figure from aecomprocesstechnologies.com

Hg Removal in Particulate Control Devices

Control type	Bituminous	Sub-bituminous	Lignite
ESP (coldside)	36% (0-63%)	9% (0-18%)	1% (0-2%)
ESP (hotside)	14% (0-48%)	7% (0-27%)	None tested
Fabric filter	90% (84-93%)	72% (53-87%)	None tested

- **Hg capture in particulate control devices depends on the coal type but can be negligible or >90%.**
- **Hg capture can be enhanced**

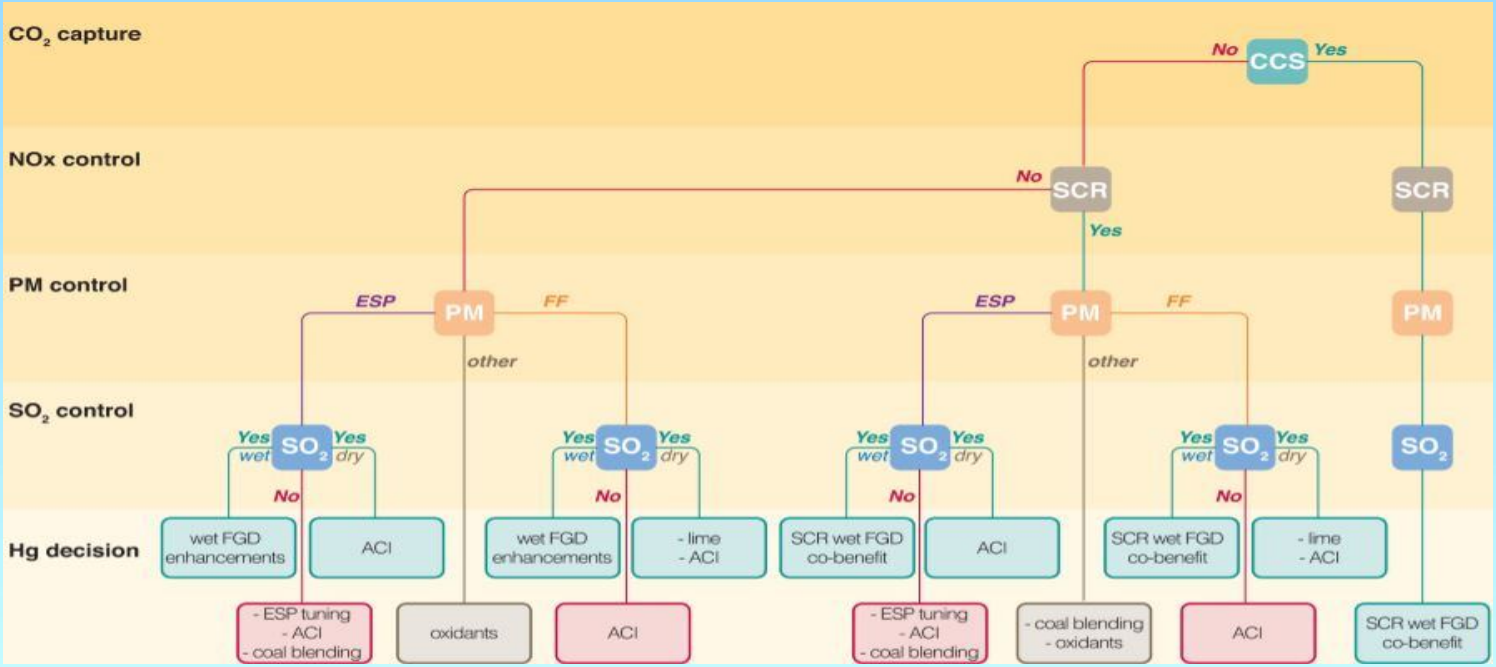
Co-benefit mercury removal



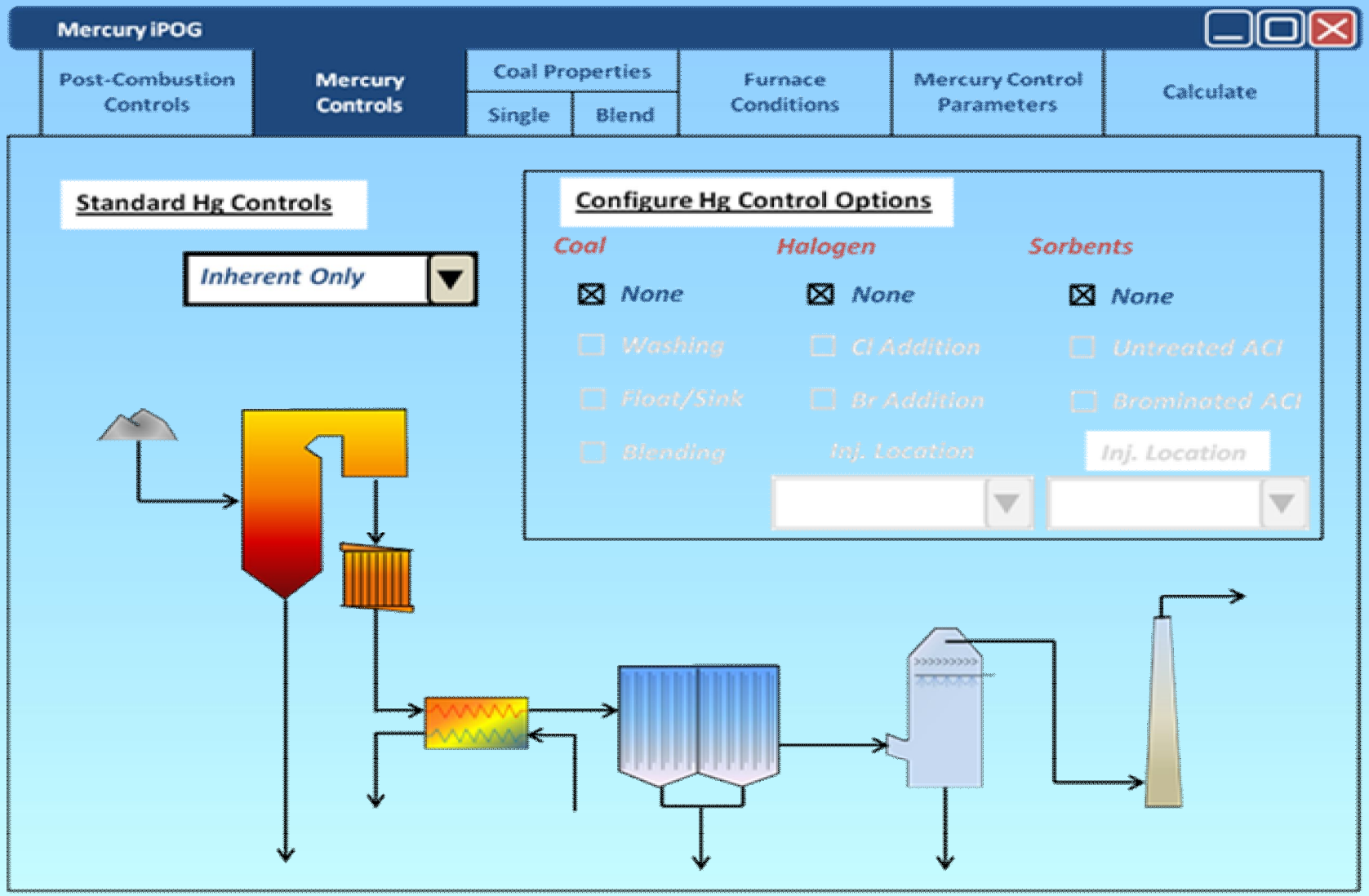
Pudasainee et al., 2009.
Atmospheric Environment 43

UNEP Decision Tree

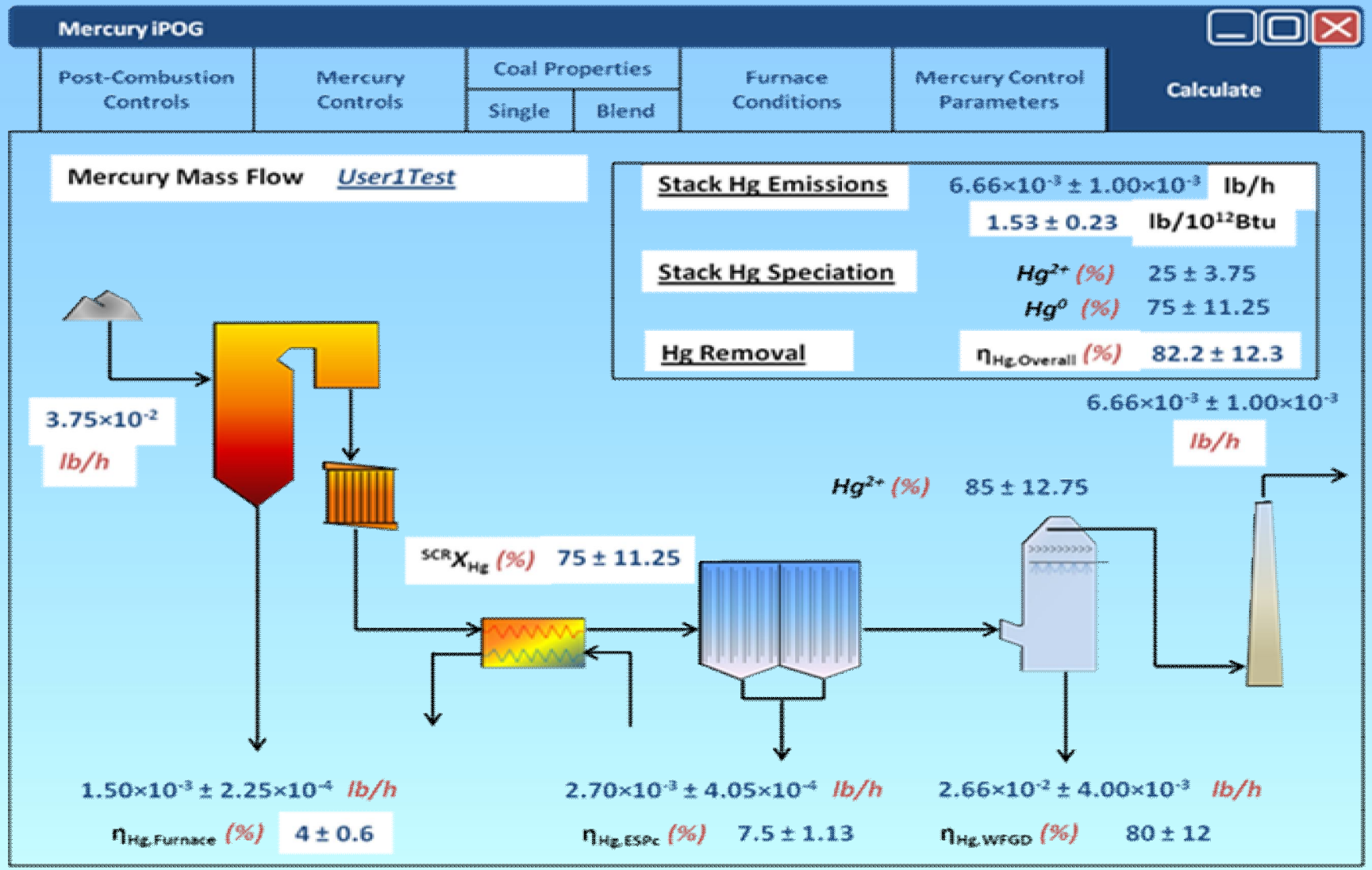
- Basic tool to determine control options for specific plants
- Conditions are very site specific
- Expert help is needed to determine optimal approaches
- Further developed as an interactive programme - iPOG



iPOG - inputting control options



Example of predicted emissions



Technologies required to comply with MATS

Installation of control technologies under MATS in 2015, GW		
Control technology	**Base capacity**	**Total capacity with MATS**
Wet FGD	80	174
Dry FGD	29	51
FGD upgrade	-	63
Dry sorbent injection	9	52
SCR	146	146
ACI	49	148
Baghouse/fabric filter	90	191
ESP	0	34

Installation rates of technologies in the USA (free report from IEA CCC)

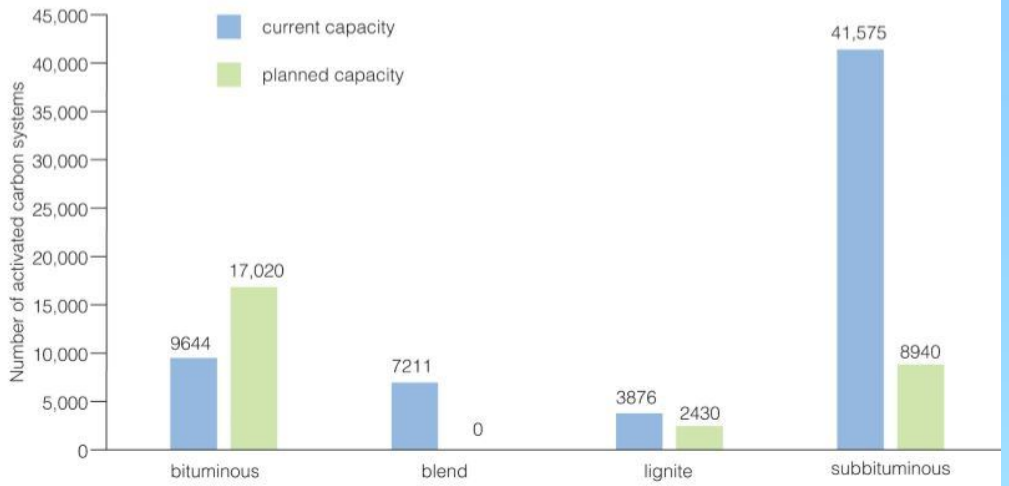


Figure 25 Activated carbon systems for mercury control in place (or under construction) and planned for the USA and Canada, MW (ICAC, 2014)

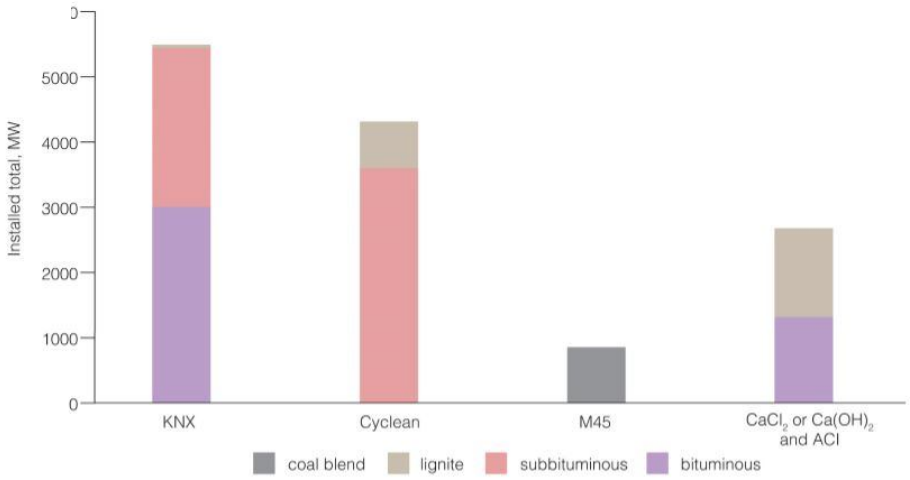
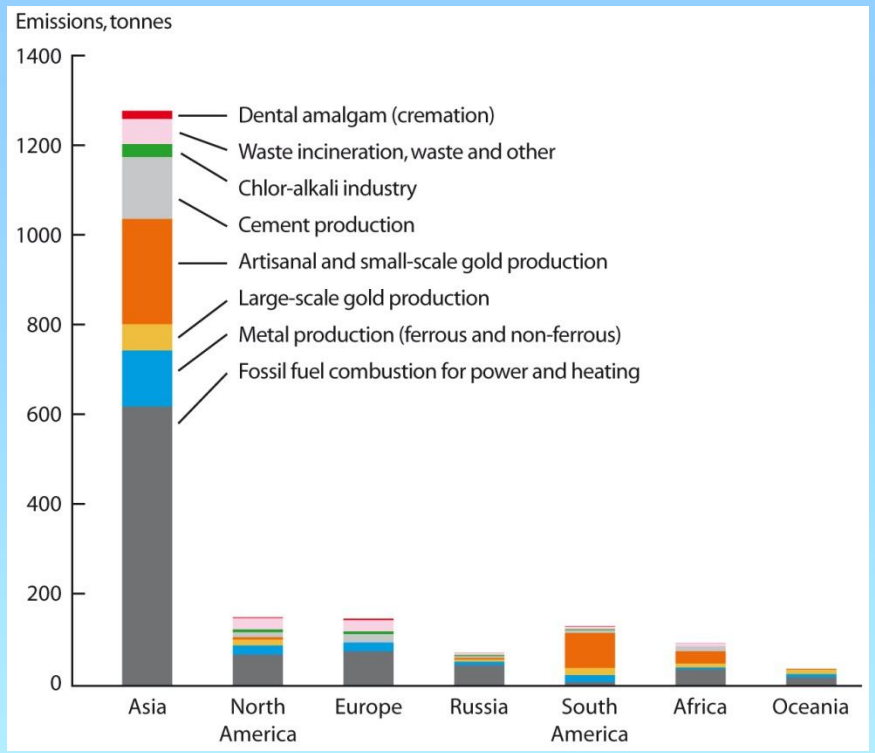


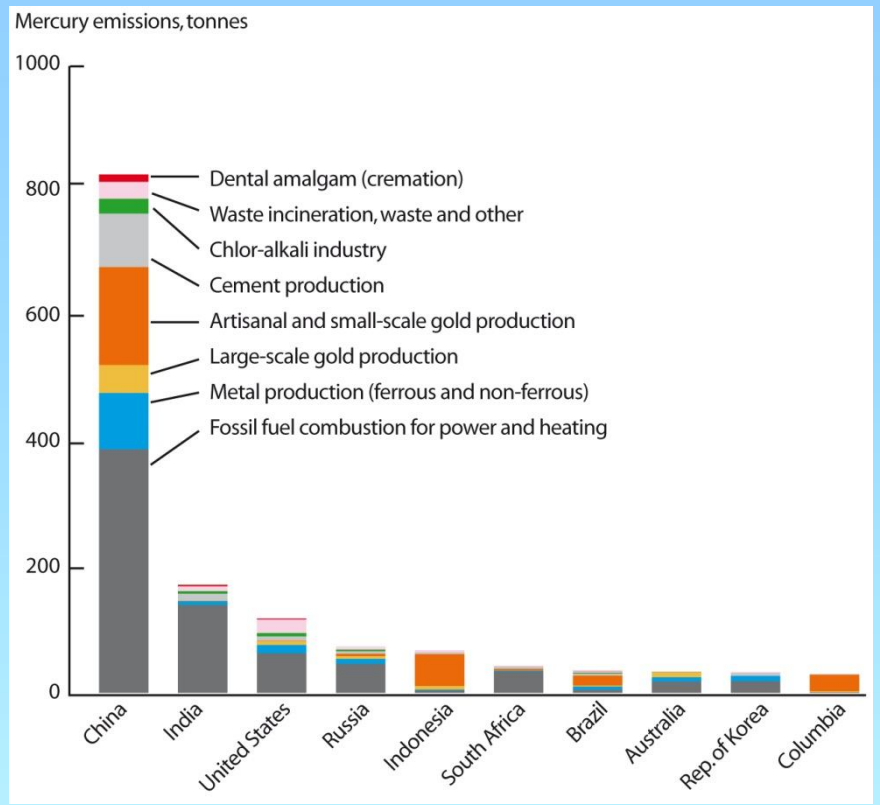
Figure 26 Installation of additive based mercury control systems for challenging coals in the USA, 2013 (based on ICAC data provided via Glesmann, 2014)

New/emerging Hg control systems

Process	Description	Mercury removal	Status
Limestone scrubbers	Wet scrubbing with limestone slurry	75–99% oxidised	Commercial
Airborne Process	Dry/wet sodium carbonate injection and oxidant wash	99%	Commercial
NeuStream™	Ozone injection, dual-alkali scrubber	~80%	Commercial demonstration
SkyMine	Electrochemically produced NaOH scrubbing	90%	Commercial demonstration (on cement plant)
Spray dry scrubbers	Scrubbing with lime slurry, possible additional sorbent	0–95%	Commercial
CFBC scrubbers	Scrubbing with lime slurry, possible additional sorbent	>95%	Commercial
ReACT	Activated coke regenerable sorbent	>>90%	Commercial
Catalytic ceramic filters	Catalyst upstream of sorbent	>90%	Commercial
Max-9	Sorbent plus electrostatically enhanced filter	>90%	Commercial
TOXECON™	Pulse jet filter and sorbent	>90%	Commercial
E-Beam	Electron beam plus wet scrubber	>90%	Near commercial
ECO	Dielectric barrier discharge, wet scrubbing and solvents	>85% oxidised	Commercial
EPS	Oxidation and condensation	95%	Pilot/commercial
Lextran	Ozone injection and wet scrubbing	'some'	Commercial
LoTOx	Ozone injection and wet scrubbing	>90%	Commercial (petrol refineries)
CEFCO	Jet collision scrubbing	'some'	Pilot scale
Ashworth Gasifier-combustor (Clearstack)	Entrained flow air-blown gasifier with limestone	>93%	Near commercial

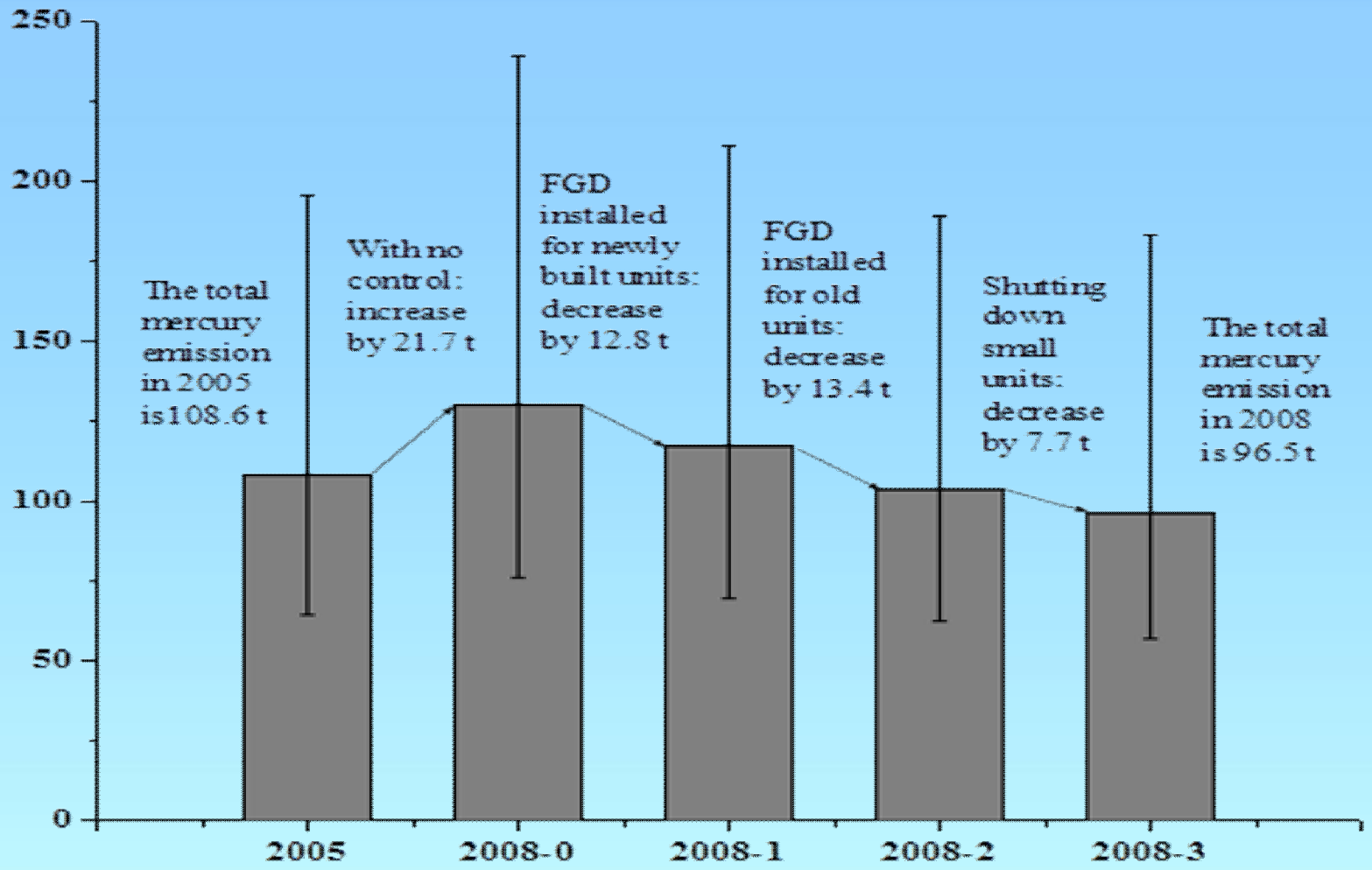
2005 Hg emissions by region and main national emitters





AMAP 2011 Hg Assessment Report, Ch 2
Pacyna et. al., 2010. Atmospheric Environment 44

Co-benefit mercury removal by SO_2 control measures during 2005-2008



Mercury control in SE Asia?

Table 16 Coal combustion for power generation in South East Asia – potential options for Hg reduction

Country	Coal washing	Coal blending	Co-benefit potential (FGD and SCR)	Most promising Hg-specific options
India	high	high	none/very limited	coal washing, blending, plant efficiency improvements, multi-pollutant options such as oxidants and sorbents, possibly in conjunction with advanced particulate control systems
Cambodia	minimal	unknown	? (unknown as yet)	? (unknown as yet)
Indonesia	minimal	unknown	High – 80% capacity has FGD	co-benefit effects, additional oxidants, improvement in efficiency of older plants
Malaysia	unknown	unknown	High – "most" plants have FGD	co-benefit effects, additional oxidants

Mercury control in SE Asia?

Philippines	unknown	unknown	Moderate – "many" plants have FGD	co-benefit effects, additional oxidants, potential for FBC and CFBC specific studies for Hg control
Thailand	? high (low grade coal)	? high (low grade coal)	High – 'most' plants have FGD	co-benefit effects, additional oxidants, improvement in efficiency of older plants Low-grade coal is used – more study needed on the mercury characteristics of these coals
Vietnam	unknown (challenging coal)	unknown (challenging coal)	High on new plants with FGD Low on older units with no FGD	co-benefit effects, additional oxidants on units with FGD, multi-pollutant options on other units

Conclusions

Mercury legislation is becoming increasingly common and control technologies are readily available and affordable

New advanced multi-pollutant technologies are being developed to control ALL emissions from coal-fired plants

Thank you

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