European Power Plant Suppliers Association
Developing the Future

Mercury Control
SciFi or State-of-the-Art Technology?

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Flue Gas Cleaning Working Group Chairman
EPPSA

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Power-Gen Europe
G109, Auditorium Centre, First Floor
Amsterdam, The Netherlands

www.eppsa.eu

Content

I. EPPSA

The European Power Plant Suppliers Association

- The European Power Plant Suppliers Association (EPPSA) is the voice, at European level, of companies supplying power plants, components and services. EPPSA members, located throughout Europe, represent a leading sector of technology with more than 100,000 employees.
- EPPSA actively promotes awareness of the importance of flexible and efficient, state-of-the-art thermal power generation and its crucial contribution to ensuring a clean, secure, and affordable energy supply.
- EPPSA believes increased investment in Research, Development and Demonstration is a key factor in driving EU competitiveness as well as ensuring an affordable low emission power supply.

Virtually all thermal power plants in the EU are built by members of EPPSA or equipped with their components, and provide around 50% of Europe’s electricity.

EPPSA members provide the most advanced thermal power technologies in the world.

I. EPPSA

Our Members

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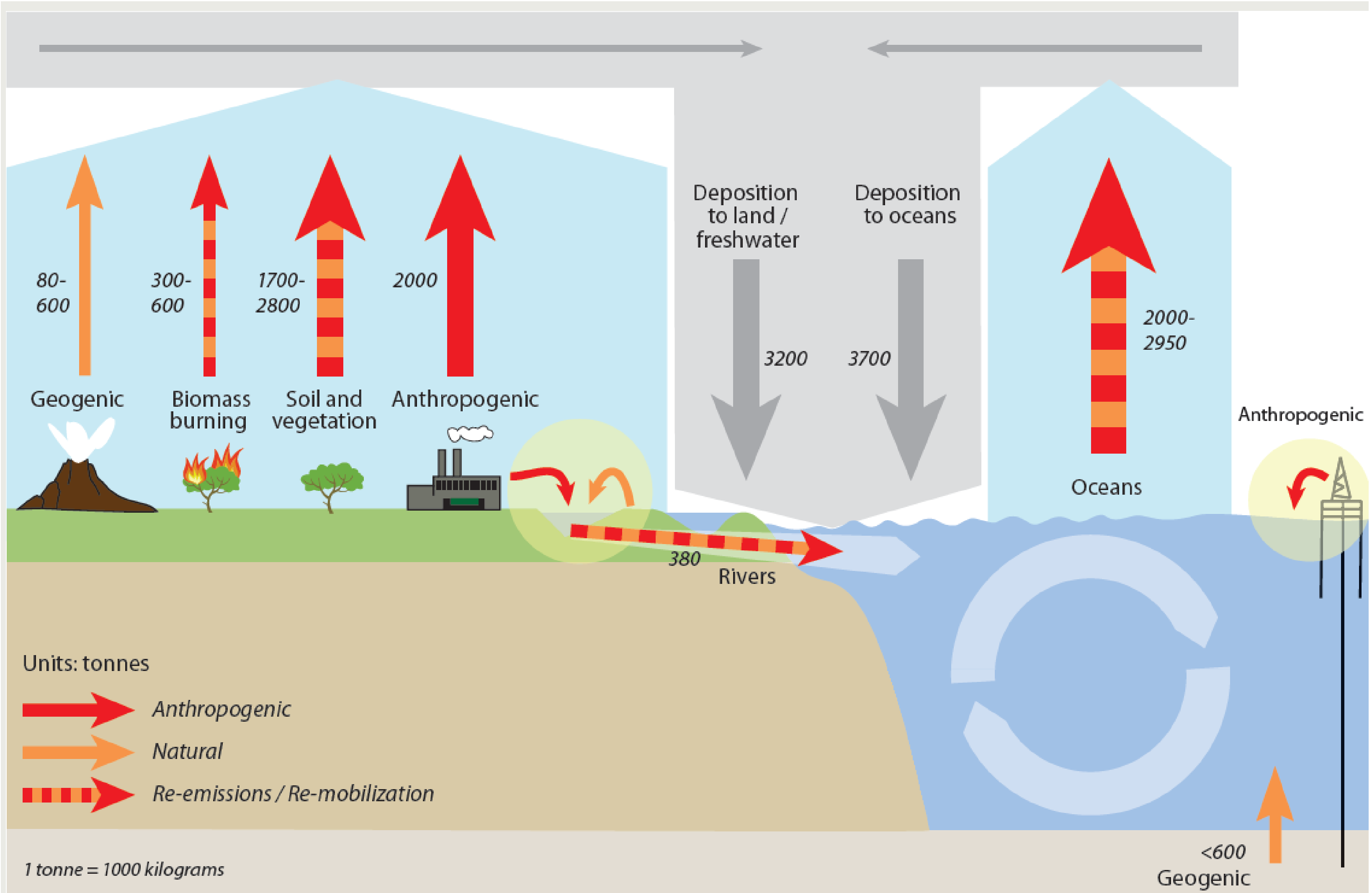
II. Mercury as global pollutant

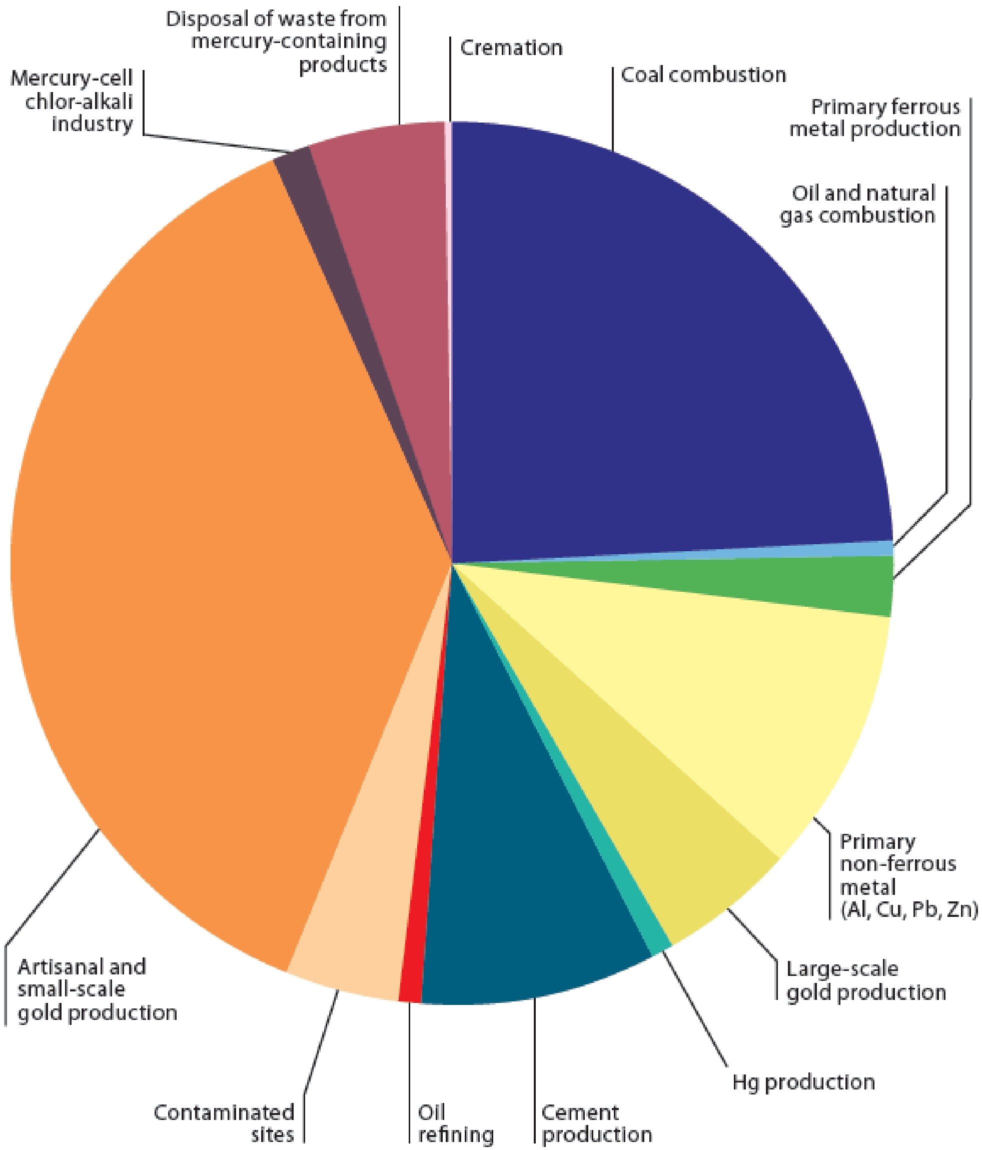
Global mercury emission cycle



Source: Global mercury assessment 2013, UNEP

II. Mercury as global pollutant

Anthropogenic sources of mercury emissions



Main players are:

- Gold production (~42%)
- Cement production (~10%)
- Coal combustion (~24%)

Source:
Global mercury assessment 2013, UNEP

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III. Mercury: Facts and figures / Speciation across flue gas path

- Natural mercury occurrence mainly represents Cinnobar (HgS), very rare also genuine mercury. Other compounds are rather seldom (HgO, AgHg, CuHg)

- During the combustion process mercury usually decomposes to elemental mercury (T>1000°C)

- Depending on flue gas path and flue gas composition mercury oxidation may take place ($Hg + X_2 \rightarrow HgX_2$ with X = Cl, Br, I) depending on X- concentration and if/or not SCR

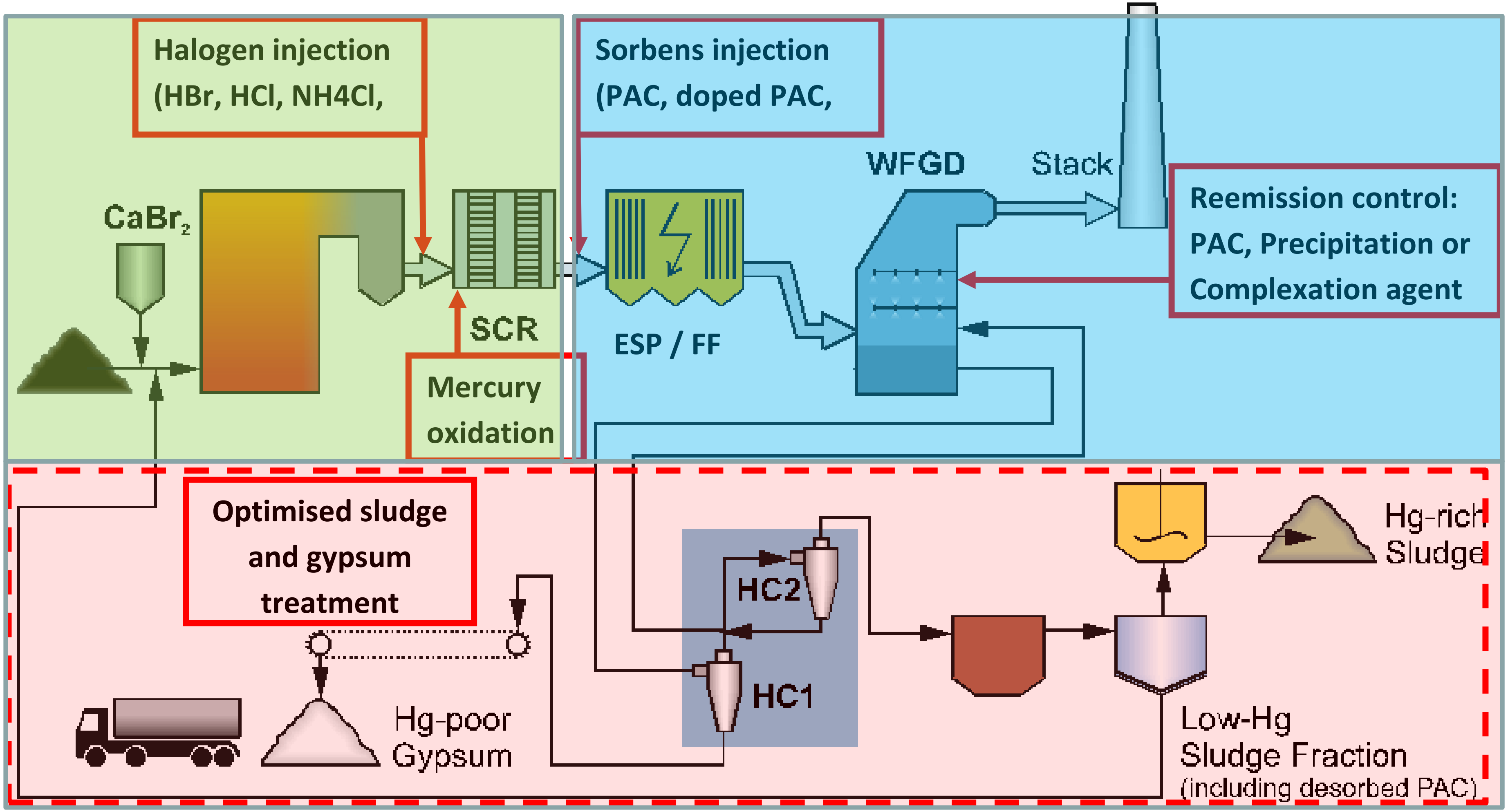
- Elemental mercury ($Hg_{el,}$ Hg_0) is nearly insoluble in water, hardly adsorbs on sorbent surfaces (except special doped activated carbon grades) and is very volatile

- Oxidised mercury (Hg_{ox}, HgX_2) is water soluble and easy to adsorb on carbon containing surfaces; it is very volatile, too

III. Mercury: Facts and figures / Speciation across flue gas path

OXIDATION	SEPARATION	TREATMENT
High Halogenic Content Fuel + SCR DeNOX Catalyst	Absorption into Wet Scrubber + Additives to Minimize Re- Emission	Gypsum-, Wastewater- + Sludge Treatment
Low Halogenic Content Fuel + Oxidation Catalyst	Adsorption on PAC in Fabric Filter/CDS/SDA Systems	
Low Halogenic Content Fuel + Bromine Addition to Fuel		

III. Mercury: Facts and figures / Speciation across flue gas path



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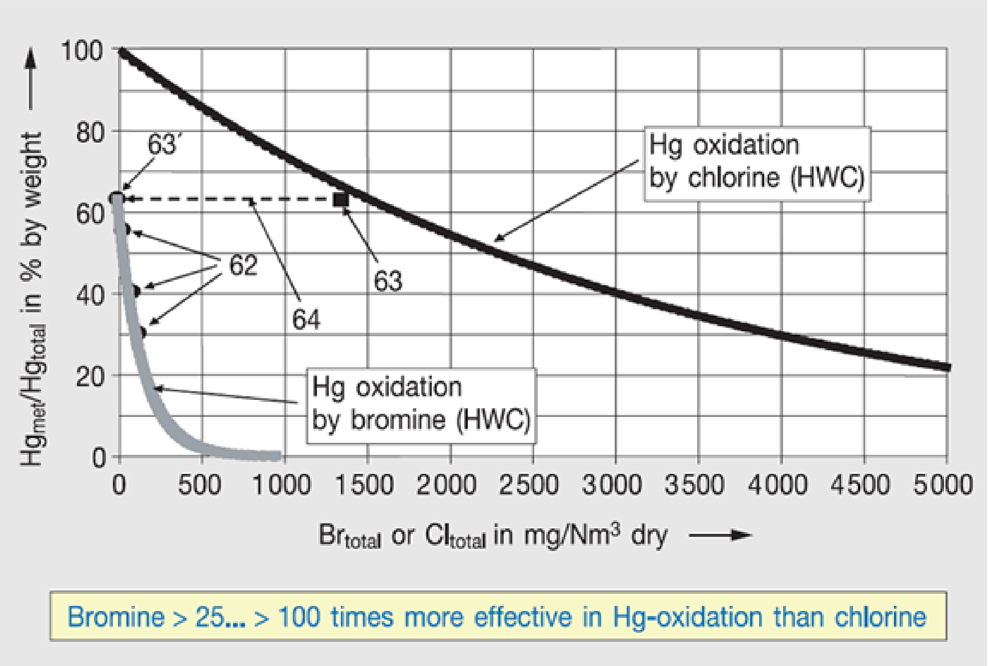
III. Mercury: Facts and figures / Speciation across flue gas path

Boiler

Relevant influencing variables in pulverised coal boilers grades on mercury oxidation degree in the boiler and boiler realated ducts.

- Native halogen concentrations (Cl, Br, I)
- Hg/X_2 ratio
- Sulfur concentration
- Alkaline components in fly ash
- Arsen, raw gas moisture,….



Estimated mercury oxidation degree boiler downstream:

- Hg_{ox} 0–40%
- Hg_{ox} (dosage of bromine into boiler) up to 90%

Iodine causes oxidation problems inside the absorber; Fluorine is no effective oxidation agent

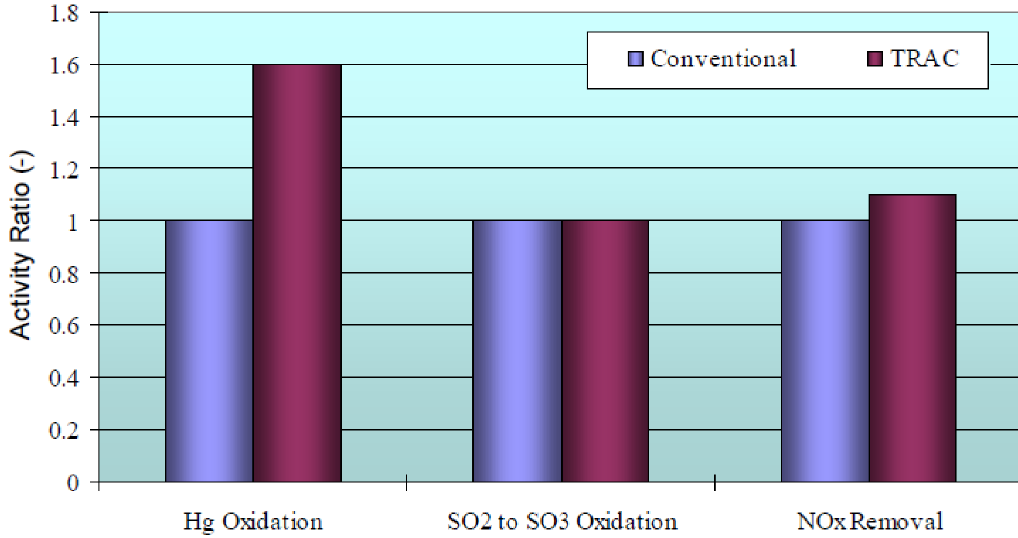
Mercury oxidation catalyst

- Latest development in catalyst technology combines high mercury oxidation degree at very low halogen concentration

- Although mercury oxidation is boosted, SO_2 → SO_3 conversion will not be influenced negatively

- Catalytic reduction of NOx still in operation at high performance level

- Mercury oxidation catalyst usually intalled in rear layer ı to minimise ammonia carry over (which reduces oxidation efficiency)



III. Mercury: Facts and figures / Speciation across flue gas path

ESP / BF

Impact on adsorption efficiency

- Gas temperature
- Quality and amount of sorbent (pulverised activated carbon)
- Residual carbon (LOI) in fly ash
- Halogen and SO_3– concentration in flue gas

Estimated sorption degrees	ESP / BF
Sorption[1)] degree for Hg_{ox}	20 – 45% / up to >90%
Sorption[1)] degree for Hg_{el}	10 – 35% / up to >75%

→ Mercury trap: Fly ash (low contamination level)

1): Without additional dosage of sorbent

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III. Mercury: Facts and figures / Speciation across flue gas path

Wet FGD

Impact on mercury separation efficiency across wet FGD

- Oxidation degree of mercury
- Efficiency of dissolved mercury stabilisation in absorber sump
    - Absorber chemistry, salinity
    - Further stabilisation is mandatory (sorption, precipitation)

Estimated separation efficiencies

- Hg_{ox} (stabilised absorber chemistry) up to 95%
- Hg_{el} 0%

→ Mercury trap: Gypsum and waste water sludge (depending on technology, contamination level from low (gypsum) to very high (waste water sludge))

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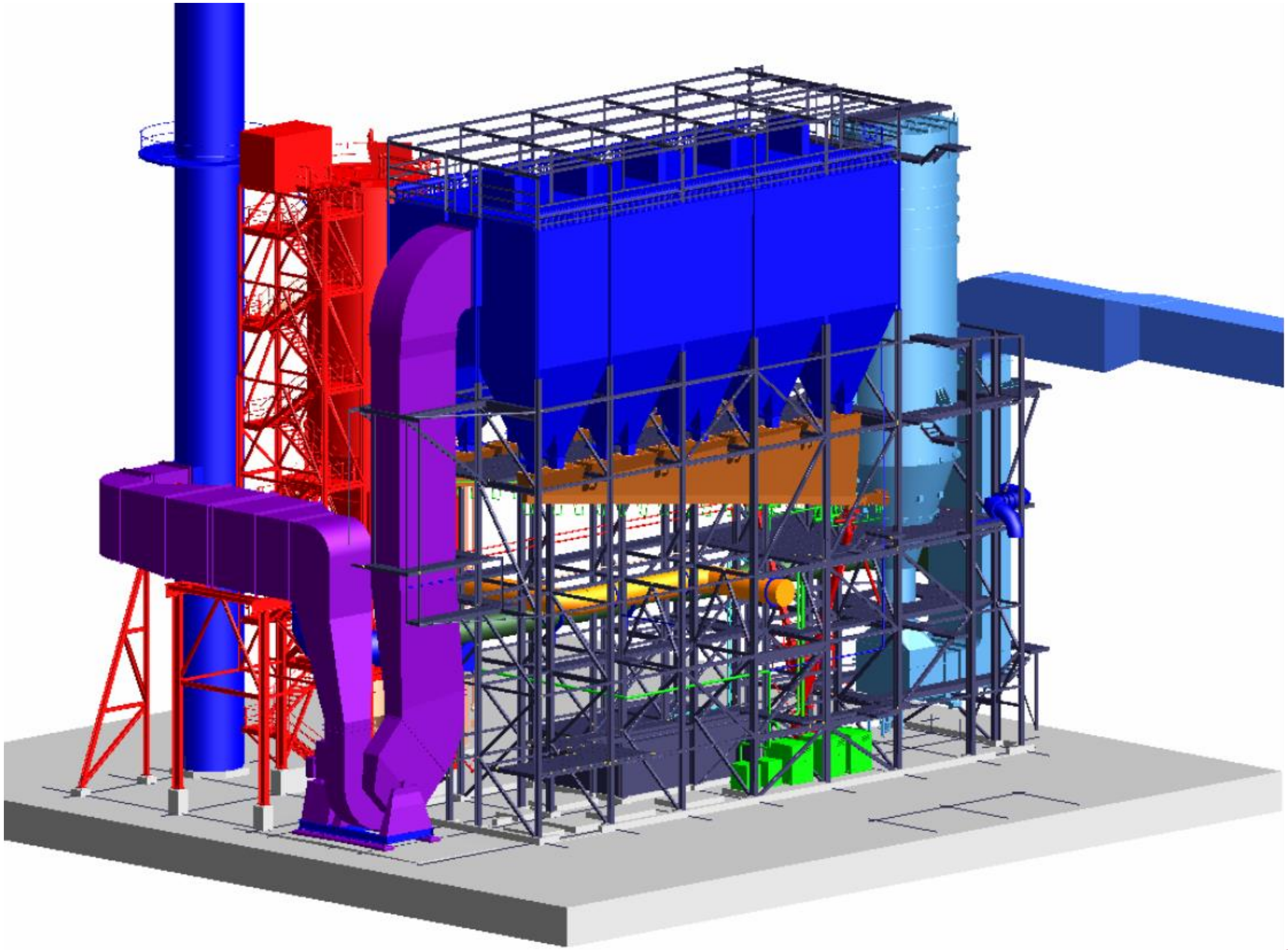
IV. Mercury separation example / Dry FGD

Boiler → Denox → Air Preheater → CDS / SDA → Bagfilter



IV. Mercury separation example / Dry FGD

- Effective separation of mercury requires chemical sorption
  - Elemental mercury needs doped PAC for proper adsorption
  - For oxidised mercury undoped PAC is sufficient

- Sorbent recirculation helps to reduce sorbent demand

<u>**Sorbent metering:**</u>

- Depending on mercury raw gas concentration and emission limit: sorbent dosing quantity is usually about

  → 20 – 50 mg/Nm³
- Mercury reduction rates

  → **up to over 95%**

IV. Mercury separation example / Dry FGD

Estimated costs for 800 MW electrical power boiler -1-

Estimated process (dry FGD):

Boiler → Denox → Air Preheater → CDS / SDA → Bagfilter

Coal flow: ~ 230 t/h bituminous coal

Mercury in raw gas: 20 µg/Nm³, dry
Mercury emission limit: 2 µg/Nm³, dry

Bromide metering: 20 mg/kg coal mass flow
Sorbent demand: 50 mg/Nm³, dry AC (HOK)
Sorbent cost: 200 €/t

IV. Mercury separation example / Dry FGD

Estimated costs for 800 MW electrical power boiler -2-

<u>Investment costs:</u>	
Bromide metering:	~ 500.000 €
PAC metering:	~ 3.000.000 € [2)]
Recovery period:	10 years
<u>Operation costs:</u>	
Consumables (HOK, Bromide, fees, ...)	~ 450.000 €/year
Produced electrical energy:	~ 6.400.000 MWh/year
<u>Related cost per MWh:</u>	**<u>< 15 ct/ MWh</u>**

2): Control of mercury emissions from coal fired electric utility boilers: an update; Strivastava, EPA/600/R-10/006;

V. Mercury separation example / Wet FGD

Boiler → DeNox → Air Preheater → ESP → wet FGD

Source: FGD Lünen, Trianel, Germany

V. Mercury separation example / Wet FGD

- Effective separation of mercury requires oxidised mercury
- Oxidation can be achieved by utilising
  - Bromide dosage onto coal feeder
  - Existing DeNOx equipment with mercury oxidising layer
- Main mercury separation will take place in absorber (input in fly ash will be much lower)
- Stabilisation of dissolved mercury species is mandatory to avoid re-emissions (dosage of precipitation agent or sorbent)
- Dewatering equipment has to be adopted to avoid gypsum contamination

V: Mercury separation example / Wet FGD

Estimated costs for 800 MW electrical power boiler -1-

Estimated process:

Boiler → Denox → Air Preheater → ESP → wet FGD

Coal flow:	~ 230 t/h bituminous coal
Mercury in raw gas:	20 µg/Nm³, dry
Mercury emission limit:	2 µg/Nm³, dry
Bromide metering:	~ 20 mg/kg coal mass flow
Stabilization agent demand:	200 mg/l PAC
Sorbent cost:	1,5 €/kg
Waste water flow:	10 m³/h

V: Mercury separation example / Wet FGD

Estimated costs for 800 MW electrical power boiler -2-

Investment cost:

Bromide metering:	~ 500.000 €
PAC metering:	~ 500.000 €
Adopted gypsum dewatering:	~ 500.000 €
Recovery period:	10 years

Operation costs:

Consumables (PAC, Bromide, fees, …)	~ 370.000 €/year
Produced electrical energy:	~ 6.400.000 MWh/year
Related cost per MWh:	**< 10 ct/ MWh**

VI. Summary

- Mercury is one of the most dangerous environmental pollutants
- Coal-fired power plants are responsible for a huge mercury emission load
- Mercury separation technologies are available to reduce emission levels significantly, both for dry and wet FGD technologies
- Efficient mercury separation technologies cause moderate additional costs which are in a range of:

< 10 ct / MWh for wet FGDs

and

< 15 ct / MWh for dry FGDs

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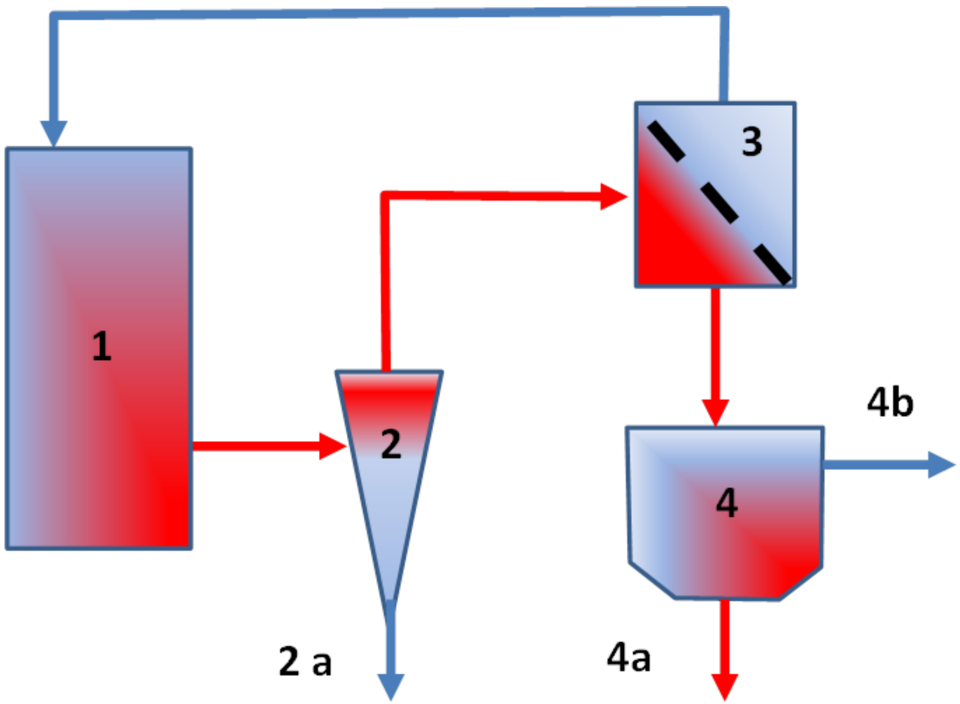
III. Backup / Mercury trap / wet FGD

- Mercury can be stabilised by sorption on the surface of carbon containing particles
- To hinder particular bound mercury to be enriched in FGD gypsum adapted dewatering has to be installed

1: Absorber
2: Washwater Hydrocyclon
2a: Clean gypsum
3: Thickener
4: Waste water plant
4a: Mercury enriched sludge
4b: Clean waste water



→ Mercury trap: waste water sludge

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