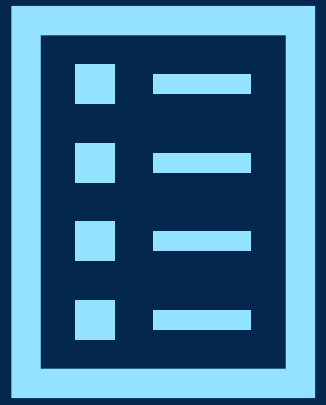
Mercury point source emissions in South Africa
Developments in the Energy and Petrochemical sector

Eskom presenters: Bryan McCourt, Xolani Ngubeni, Lindi Vilakazi
Sasol presenters: Sandra de Vos, Lynn Breet

AGENDA

What will you be hearing today?



1. Sasol and Eskom Background
2. Key Differences Between Sasol And Eskom

3. South Africa’s Coal Composition and Mercury Content
4. Eskom’s Plan For Enhancing Mercury Testing And Emission Characterization In Eskom's Coal Fleet

5. Overview of Sasol’s Boiler Mercury Sampling Campaign
6. Lessons Learned from Eskom and Sasol

Sasol and Eskom are at the forefront of developing a deeper understanding of mercury emissions and are taking proactive steps to address mercury emissions in our processes

Background: Sasol and Eskom

Sasol, a global chemicals and energy company

Sasol has more than 70 years of experience in the production and marketing of fuels and chemicals. Our business is global, but our roots are strongly grounded in our South African Operations

The Sasolburg site consists of two steam plants with **12 operational coal fired boilers**, designed for a maximum of up to **155 t/d steam per boiler** and used either within the process or to generate electricity

The Secunda site consists of 2 steam plants and has **17 operational coal-fired boilers** designed for a maximum **of 540 t/d steam per boiler** (almost 4 times the capacity of Sasolburg)

Sasol's South African operations are dependent on coal and gas as primary feedstocks and utilizes steam for its processes and electricity generation

Sasol

Eskom

Eskom, South Africa's Primary Energy Provider

Ownership of Eskom vests in the South African Government. Eskom was established in 1923 by an Act of Parliament

Eskom has **29 power stations** with a total normal capacity of **46 788 MW**. Eskom has **7.1 million customers** and supplies **90%** of South Africa's electricity

Eskom is supporting South Africa/s **Just Energy Transition** to transition towards a low carbon climate resilient economy and society in a manner that does not impede socio-economic development but does result in an increase in sustainable jobs

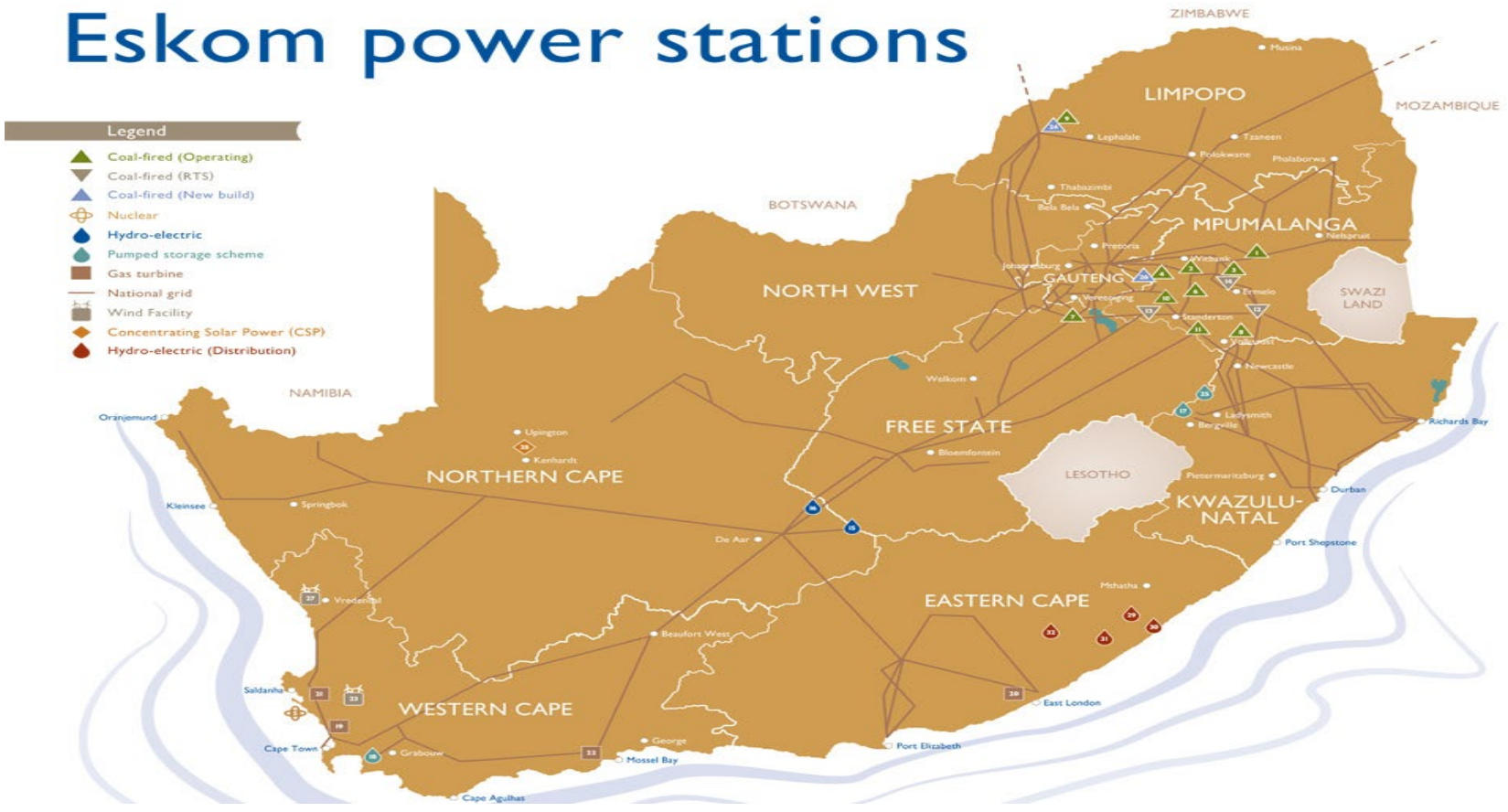
Eskom's processes utilize steam to produce electricity for the national grid. Electricity from coal makes up 84% of Eskom's supply

Eskom Research Testing and Development
Mercury in Coal Results

Xolani Ngubeni

July 2024

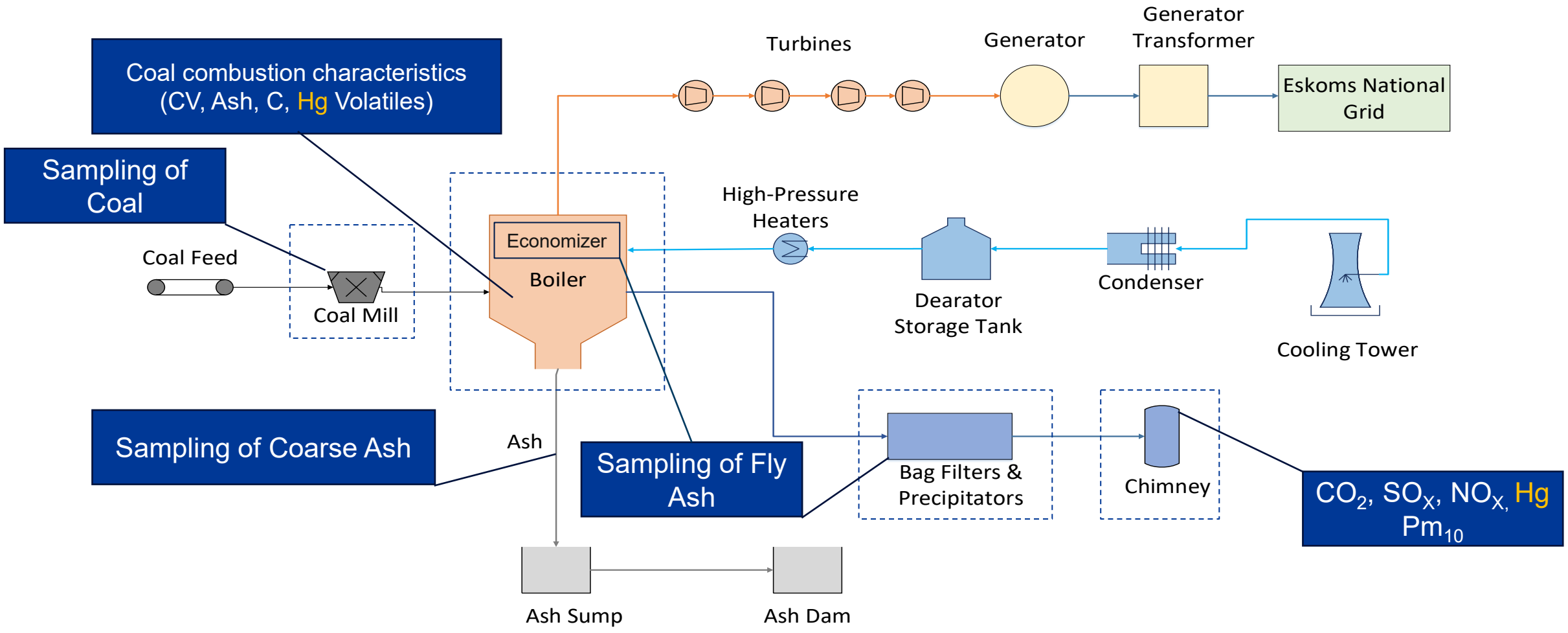
Location of Eskom's coal fired power plants and coal sources



Fourteen coal-fired power stations situated in Mpumalanga, Limpopo, and Free State provinces, supplied by multiple mines. Includes newly constructed stations Kusile and Medupi

Eskom's stations have held environmental licenses for many years. Emission reduction technologies include fabric filter plants, high-frequency transformers, and flue gas desulfurization at the newest station

Overview of Eskom's pulverized fuel boiler: Mercury sampling points and coal quality impact



Sasol takes Hg samples at the same location points in its process

Variability in South African coal qualities supplied to Eskom power stations

Pulverise Coal (100% passing - Sieve Size: 212 μm)

Coal Qualities

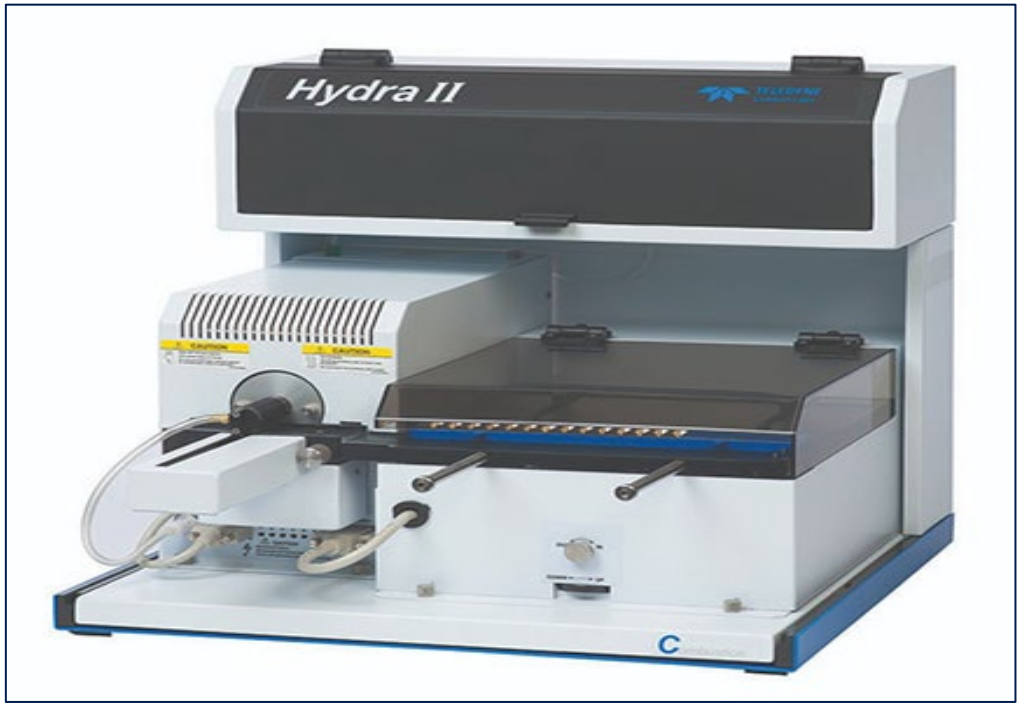
Power Station	Moisture (%) AD	Ash Content (%) MF	Volume (%) MF	Total Sulphur (%) MF	Calorific Value (MJ/Kg) MF
All	2.0 - 5.0	18.0 - 43.0	18.0 – 28.0	0.70 – 1.6	16.0 - 26.0

The bituminous coal supplied to Eskom's power stations falls within the coal quality parameters specified in the table above

Mercury content analysis in solids: Eskom utilizes internationally recognized analytical instruments for mercury in solids

Lumex Mercury Analyzer RA-915M

Hydra IIc Mercury Analyzer

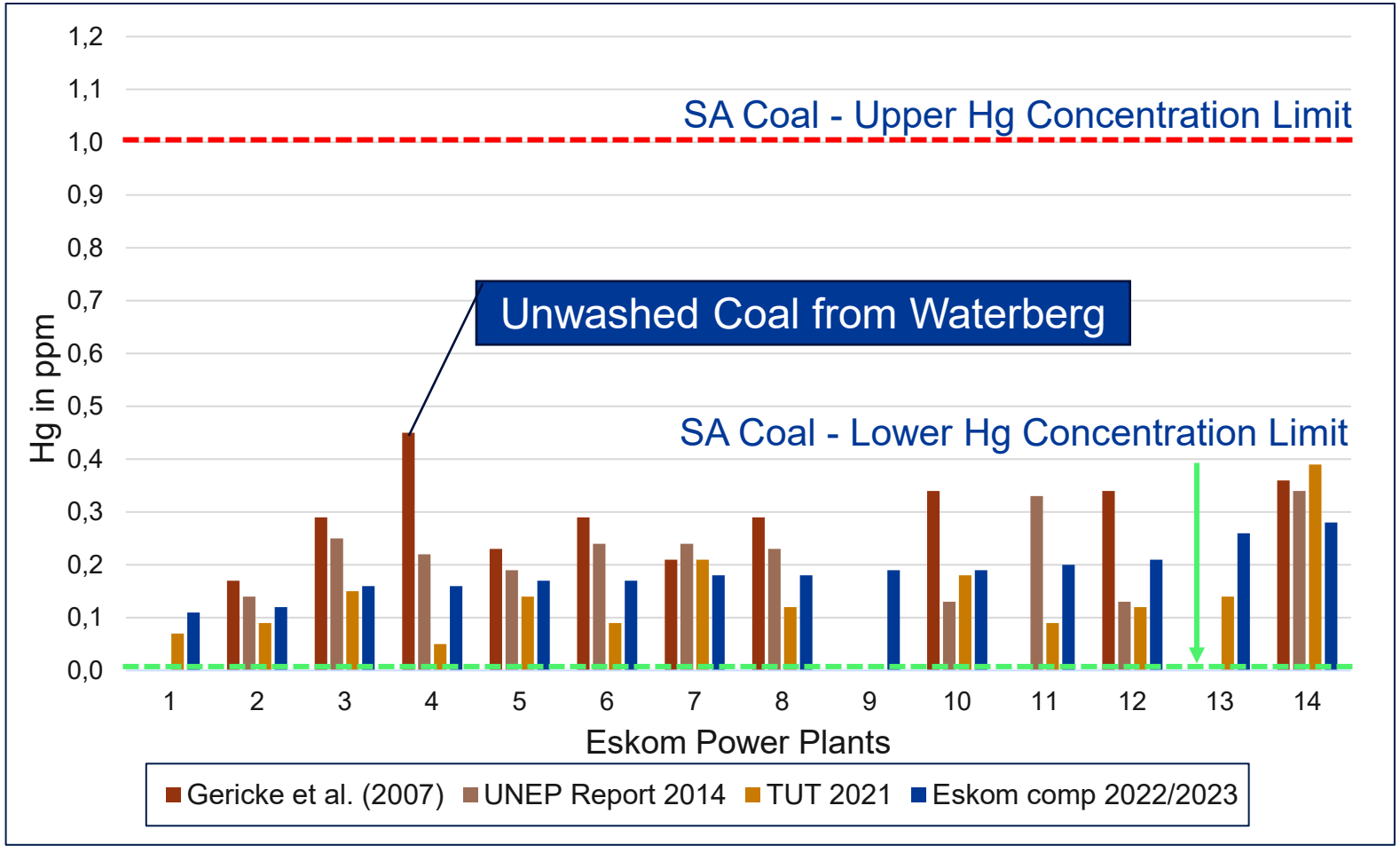


US EPA Method 7473 - Mercury In Solids And Solutions By Thermal Decomposition, Amalgamation, And Atomic Absorption Spectrophotometry

The **Lumex Mercury analyzer** is a portable analyzer that allows for **direct Mercury measurements** in coal, ash and sorbent traps. The **Hydra IIc** is a fully automated analyzer that measures Mercury in solid and semi-solid samples with **no need for sample preparation**

Comparing mercury content from Eskom coal power stations with literature, including South African data

Influence Of Coal Quality On Mercury Emissions



Hg concentration within various fossil fuels
(Pacyna et al. 2005)

Fuel Type	Country	Hg Concentration (ppm)
Hard Coal(g.ton^{-1})	Europe	0.01 - 1.5
Hard Coal(g.ton^{-1})	USA	0.01 - 1.5
Hard Coal(g.ton^{-1})	Australia	0.03 - 0.4
Hard Coal(g.ton^{-1})	South Africa	0.01 - 1.0
Brown Coal(g.ton^{-1})	Russia	0.02 - 0.9
Brown Coal(g.ton^{-1})	Europe	0.02 -1.5
Brown Coal(g.ton^{-1})	USA	0.01 - 1.0

Eskom Coal Range: (0.05 – 0.45 ppm)

Coal that is combusted by Eskom's and Sasol's power plants falls within the Hg concentration range established by Pacyne et al. 2005.

Eskom’s approach to mercury testing and emissions characterization across its fleet

Presented By: Lindi Vilakazi

July 2024

Strategic plan for advancing mercury testing and emission characterization in Eskom's coal fleet

1. Establishing mercury testing capabilities (skills and equipment)
2. Developing testing methodologies
3. Developing equipment analytical methodologies
4. Conducting baseline testing on four stations before the mercury testing program is rolled out to the rest of the fleet
5. Collecting representative coal and mercury emissions data to provide representative mercury emission characterization (different mining regions)
6. Using the data collected to develop Hg mass balance calculations and emission factors
7. Assessing the effectiveness of the different APCD currently installed (ESP vs FFP vs FGD)
8. Rolling out the verified Hg testing program to the rest of the Eskom coal fleet

Developing station-specific mercury emission factors for Eskom using US EPA-Based mass balance approach

Emission control technology	US EPA ERF (%)
Fabric Filter Plant (FFP)	89
Cold Side Electrostatic Precipitator (CS-ESP)	36
FFP + CS-ESP	62.5
FFP + Wet Flue Gas Desulphurisation (WFGD)	90

Eskom Current Methodology

- Uses ERFs from the US EPA's Integrated Planning Model
- Factors based on US EPA's Information Collection Request (ICR) data
- ERFs vary with emission control technology like dust handling and SO_2 reduction plants

Eskom Research Initiative

- Aims to develop station-specific mercury emission factors
- Follows US EPA's approach using measurements to create a mass balance
- Determines reduction factors for accurate mercury emission data at Eskom's power stations

The development of station-specific mercury emission reduction factors is critical to report accurate and representative mercury emission data

Sampling points for solids and mercury in flue gas: Baseline testing overview

Figure 1: Sampling point locations in a power station equipped with an ESP or FFP

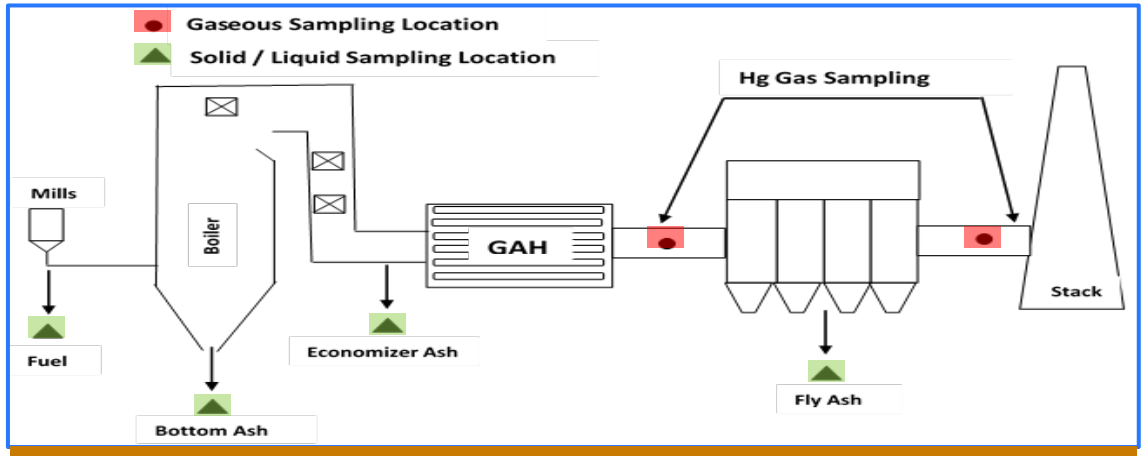
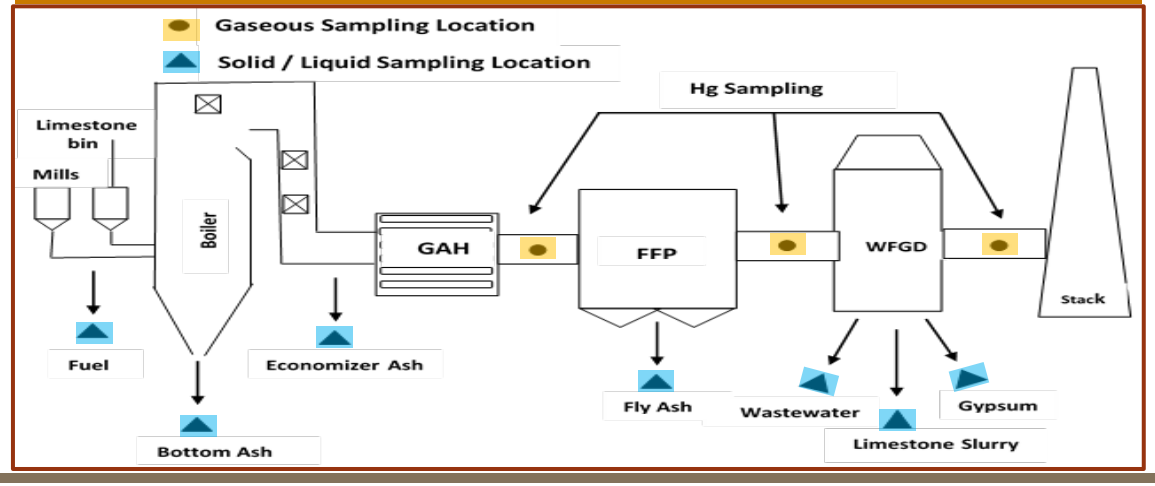


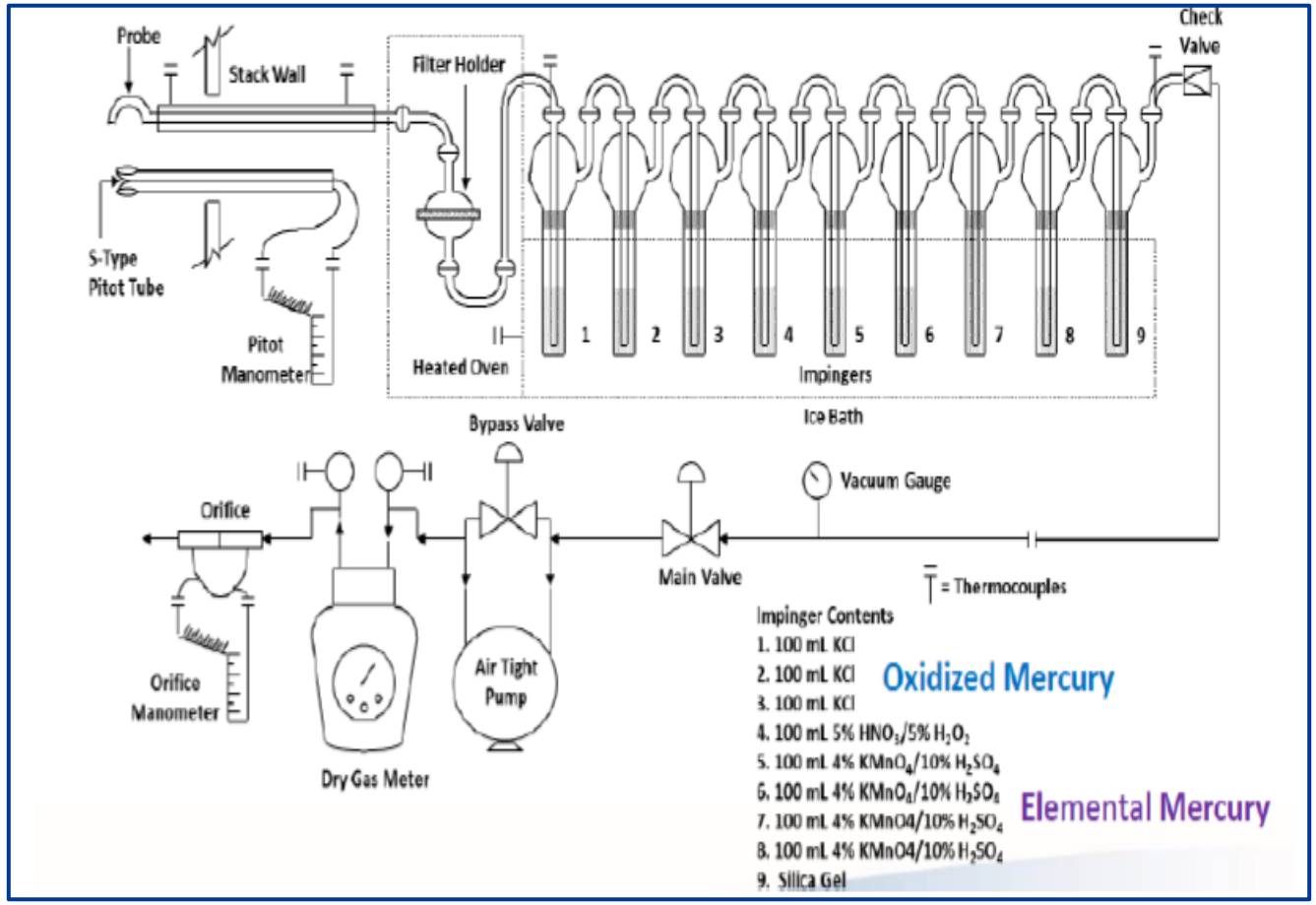
Figure 2: Sampling point locations in a FGD plant



Process Stream		Mercury Target Species			
	Location	Particulate-Bound Hg	Oxidised Hg	Elemental Hg	Total Hg
Flue Gas Samples	Inlet and Outlet of ESP	X	X	X	X
	Inlet and Outlet of FFP	X	X	X	X
	Inlet and Outlet of FGD	X	X	X	X
	Stack		X	X	X
Solid Samples	Coal Feeders				X
	ESP and FFP Hoppers				X
	Economiser Outlet				X
	Scrubber/Limestone, Gypsum				X
Liquid Samples	Scrubber/Limestone slurry		X	X	X
	Water makeup		X	X	X

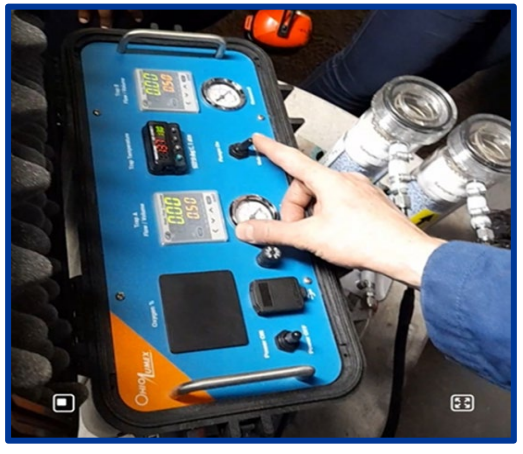
The diagrams above illustrate the various sampling points and mercury species in flue gas and solid samples. Sasol's flow scheme aligns with Figure 1

Mercury speciation analysis using the wet chemistry sampling system (Ontario Hydro Method) for Hg species identification

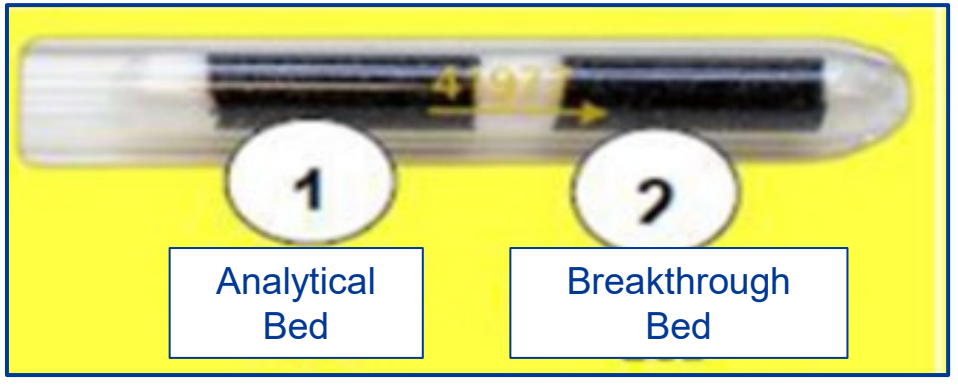


The **Ontario Hydro (OH) method is not recommended** as it is demanding, complex, costly, and time-consuming

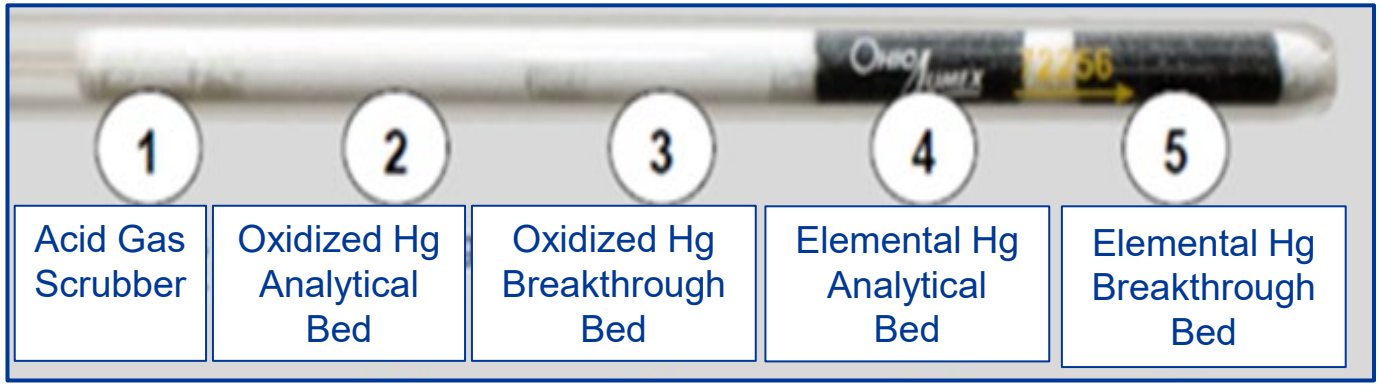
Exploring the US EPA method 30B sampling system: Equipment used in stack sampling for baseline testing



US EPA 30B Method – Total Hg



US EPA 30B Method – Speciation



Eskom and Sasol have adhered to internationally accepted standards throughout its testing programme

Sasol Mercury Research work

Presented by : Dr Sandra de Vos

Sasol has spent ~R14 Billion ($700 Million), since 2018, on environmental projects and has progressed significantly toward compliance with the MES[1]

Since 2015, we have implemented several projects aligned with our commitment to progressively reduce our emissions in accordance with our air quality roadmaps to meet the MES and we have already **met compliance milestones for 98%** of our emissions sources[2]

Over and above the PM (ESP upgrades) and NOx (low NOx burners) abatement installation at our coal-fired boilers within South Africa, Sasol has investigated innovative solutions to allow the latest technologies to be compatible with our mature plants[3] such as **co-feeding bio sludge to gasification and high organic water to bioprocesses** within our Secunda Operations in South Africa

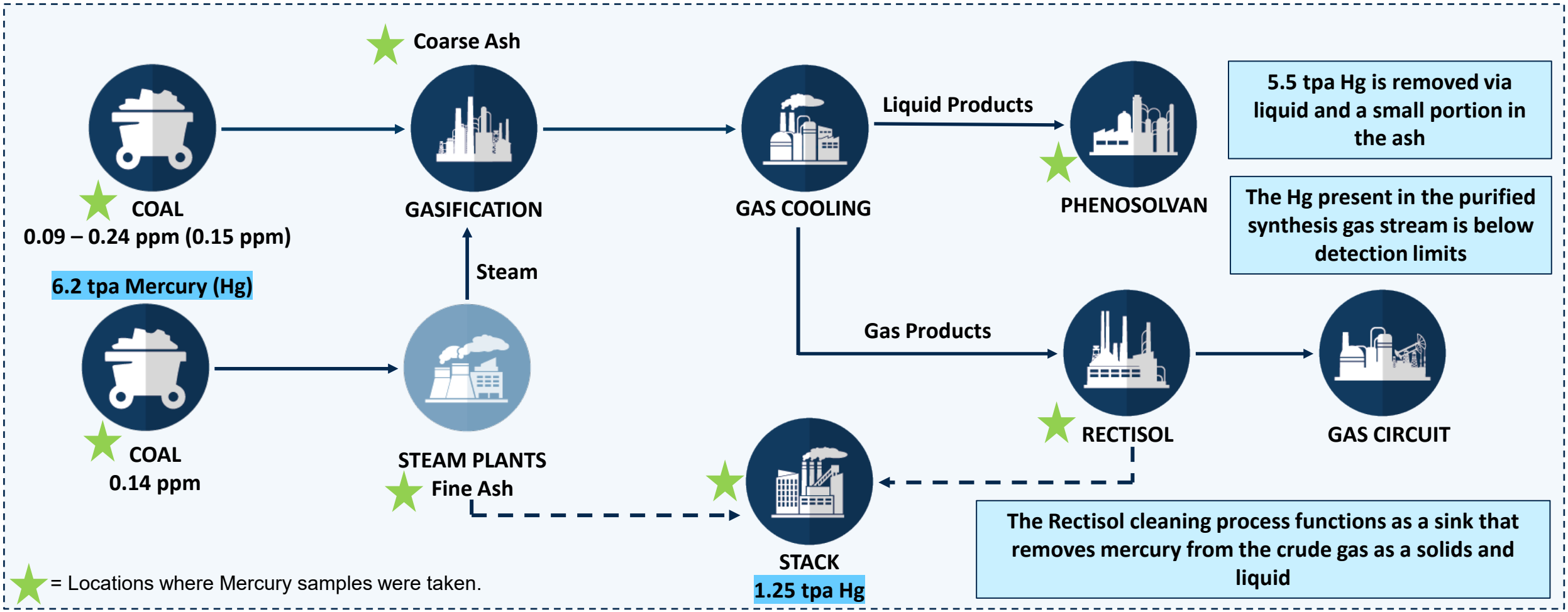
The solution to re-use the stream will result in shutting down the biosludge and high organic water (HOW) incinerators which will **reduce ~ 430 kg/a of total mercury emissions** to the atmosphere from 2025 for the Secunda Operations facility

Sasol has committed to reduce its dependence on coal, as part of our decarbonistation strategy and over time, this strategy is expected to have a significant positive impact on our atmospheric footprint

Note 1: Minimum Emissions Standards (MES) are improvement standards prescribed for specific substances related to specific activities. **Note 2**: The remaining sources form part of the last part of our compliance journey to enable compliance of our mature plants with the same standards applicable to newly commissioned plants by 1 April 2025 following postponements granted. **Note 3:** Some of our operations are >60 years in operation.

Sasol has proactively undertaken Mercury-related research, within its entire value chain, within our operating airsheds since 2006

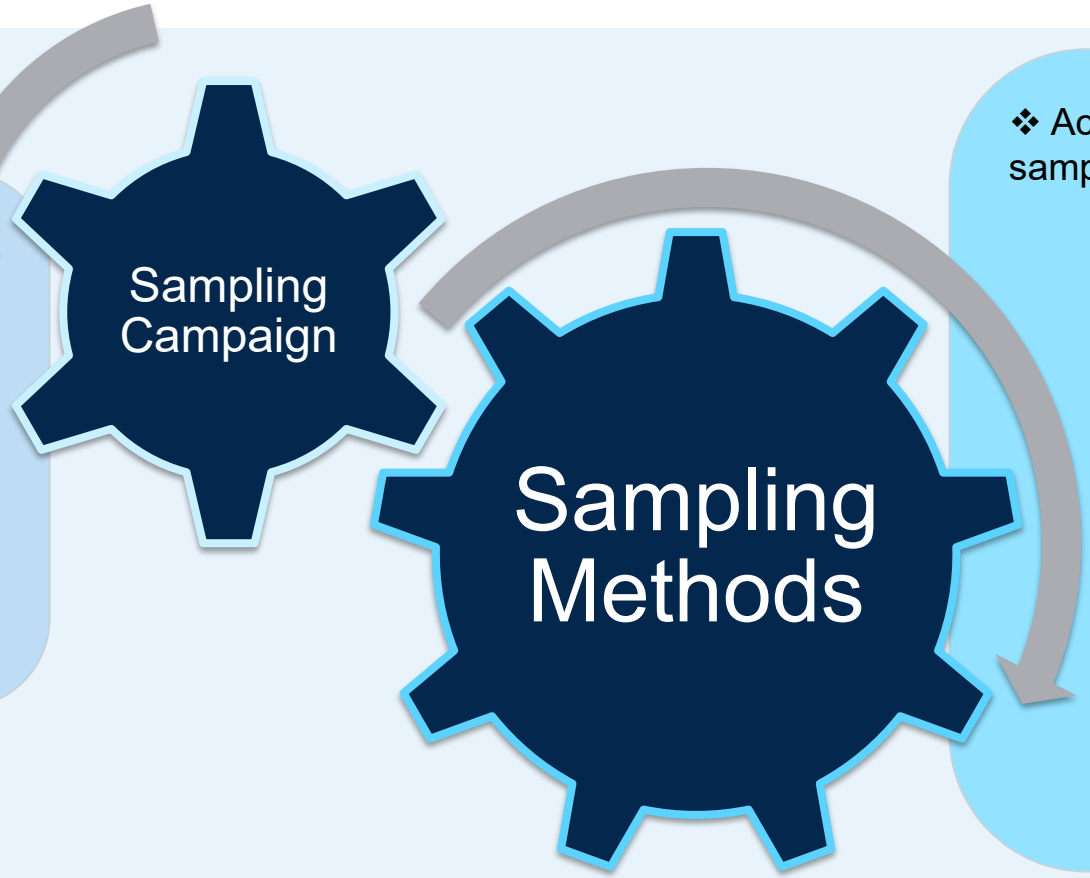
Various projects conducted over a period of four years were executed to understand the mercury speciation and balance over the factory value chain with focus on Sasol's steam plants



Wagner N.J, Hlatshwayo T.B, Ginster M., 2008

Sasol conducted the first speciation sampling campaign over the steam plant boilers for both Sasolburg and Secunda in 2020

❖ Dedicated sampling campaigns are generally conducted over several days to develop a trend of mercury emissions as a function of coal properties and boiler operations
❖ This is to inform the baseline (5 – 6 samples per day)



❖ Accredited methods were used during the sampling:

- Sampling and storage was done correctly using standard methods **(ASTM)**
- The accredited laboratory is familiar with routine analysis of Hg at low concentrations in solids, liquids, and gases. Appropriate calibration standards and reference materials to be included
- Sorbent trap method based **on EPA Method 30B from Ohio Lumex (OLM30B)** was used
- EPA method 29 can be used if only total mercury is required

Mercury is a volatile metal (150 ˚C) and losses during analysis of the solid, liquid and gaseous samples are to be avoided, especially at the low levels in the samples

Sample analysis of boiler coal feed, ashes and flue gases

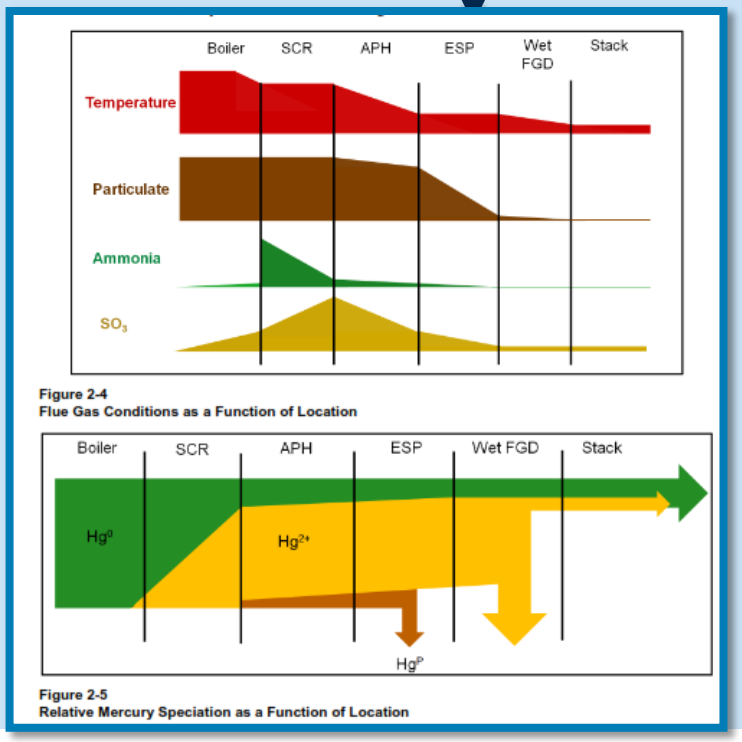
Sample analysis results are used to conduct relative mercury speciation which is strongly dependent on location

	Samples				
Analysis	**Coal***	**Discard coal**	**Fly ash**	**Coarse ash**	**Flue gas**
Proximate analysis	X				
Ultimate analysis (C,H,N,O)	X				
Total Sulphur	X				
CV: heating value	X				
Wet and dry mass	X				
An-isokinetic sampling (Hg^0, Hg^{2+}, Hg^p)					X
Total mercury (ICP-OES (MS)/ DMA/ICP/ CVAAS	X	X	X	X	X
Forms of Hg^0, Hg^{2+}, Hg^p					X

- *Coal samples are taken at a specific time from the feeder to each mill, composited, and the analysis will be done on the composited samples.
- The samples for these emissions is usually combined with the isokinetic sampling of PM and O_2 but NO_x, CO and is not needed for mercury

Sasol only has ESPs with exit Temp ~ 200 ºC

Typical range is 140 – 150 ºC Note 1



Sasol's ESP exit temperature is much higher than the typical temperature range

Note 1: *Source: Electric Power Research Institute (EPRI), "Technical Update Report: Guidelines for Speciated Mercury Field Measurements: 3002006098," Palo Alto, California, November 2015.*

Lessons learnt and conclusions

Presented by: Lynn Breet

Boiler Mercury Sampling Campaign | Lessons Learned

The pathways of mercury and portioning to different streams (solid, ash, and flue-gas) around coal-fired boilers can be established together with the gas-phased speciation (Hg^T, Hg^0, Hg^{2+}, and Hg^P)

Sampling locations, sampling techniques, and calculation methodologies **should be carefully chosen** taking into consideration the low mercury quantities typically collected during sampling

Communication is critical for the success of the campaign through all stakeholders such as plant operators, operations, personal taking coal samples and third party analysis

Detailed planning for the preparation of the **composite sample for solid streams** is critical considering these need to coincide with the flue-gas emission measurements

Independent sampling and quantification for total mercury, speciated vapour-phase and particulate mercury should be carefully evaluated for gas-phase emissions

Dedicated sampling campaigns needs a minimum of **several days** to develop a trend of mercury emissions as a function of coal properties and boiler operations to inform the baseline

Boiler Mercury Sampling Campaign | Additional points for consideration

Application of **industry guidelines to qualify paired sample traps** is critical to the success of the overall sampling campaign

Mercury assessments using the US EPA method 30B at the stack is the **preferred method** due to its simplicity over the Ontario Hydro method

Accounting for **all input and output streams** is required to effectively close the mercury mass balance

Each boiler is unique, and operations vary significantly, although enough data is important, the balance between cost and data needs to be considered

Speciation is a key enabler that informs the identification of the most effective mercury abatement solution considering the overall cost and benefits

Different conditions, such as a higher outlet temperature, **creates challenges** in sampling of the particulate gas phase mercury and finding fit-for-purpose abatement technologies

Although we have conducted a considerable amount of work in the mercury context, more work is still required to understand our mercury footprint across South Africa's Eskom and Sasol operations

Service provider support

Building capacity in South Africa to conduct the US EPA method 30B and to analyze the sorbent tubes as we advance is important

Emissions quantification

Expand mercury emissions quantification to cover the entire fleet

Chlorine content characterization

Evaluate the chlorine content in our coal to understand its impact on converting elemental mercury to oxidized mercury and ensuring more consistent analysis for mercury and chlorine

Method validation

Continue the validation study for the Ohio Lumex analyser and Hydra IIC analyser to ensure accurate results from coal and sorbent trap samples

Inter-laboratory analyses

Perform inter-laboratory analyses on coal and sorbent trap samples to ensure quality assurance

Although US EPA method 30B can be successfully applied in the direct quantification of total and vapour-phase mercury species in the flue gas at the outlet of the particulate control device, there are limitations of particulate-phase mercury determination which will need to be addressed

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