Mercury emission inventory enhancement for the coal sector

PROF LESLEY SLOSS

MACQUARIE University SYDNEY · AUSTRALIA

June 2024

Thanks to the US Department of State, the International Centre for Sustainable Carbon, BCRC-Asia, and the Indonesian Government for this project of work

MACQUARIE University SYDNEY · AUSTRALIA

Full report freely available from www. sustainable-carbon.org

Improving data quality and applicability in the coal sector

Using emission factors to estimate emissions

Improving data

Focussing on the important differences

Pakistan has ratified the Minamata Convention on Mercury (Dec 2020)

MINAMATA CONVENTION ON MERCURY

"EACH PARTY SHALL ESTABLISH, AS SOON AS PRACTICABLE AND NO LATER THAN FIVE YEARS AFTER THE DATE OF ENTRY INTO FORCE OF THE CONVENTION FOR IT, AND MAINTAIN THEREAFTER, AN INVENTORY OF EMISSIONS FROM RELEVANT SOURCES"

A PARTY WITH RELEVANT SOURCES SHALL TAKE MEASURES TO CONTROL EMISSIONS AND MAY PREPARE A NATIONAL PLAN SETTING OUT THE MEASURES TO BE TAKEN TO CONTROL EMISSIONS AND ITS EXPECTED TARGETS, GOALS AND OUTCOMES

Creating an emission inventory

A detailed approach

Most inventories are produced using a “top-down” approach:

Total coal burned x emission factor x retention factor

A far more appropriate approach is “bottom-up”:

Data for each unit x specific emission factor x specific retention factor

Emission factors for coal

EMISSION = EF x RF x AV

Approach	Emission Factor, EF Relates to the mercury content of the coal	Retention factor, RF Subtracts mercury that ends up in ash etc	EF x RF Estimates the amount of mercury released per unit of coal fired	Activity value Multiplies to cover all coal used in each source	Comments
UNEP Toolkit*	Generic – 0.05 g/kg	Generic - minus 10%	0.045 g/kg	Coal burn, t	Assumes all plants and coals are identical. Targets busier units, often unfairly
2017 UNEP Project	Coal analyses Results averaged across the fleet	iPOG[#] model of generic national plant	Convert to g/TJ Applies to all plants and takes average plant efficiency into account	Coal burn, t	EF and RF are now more accurate for the national coal fleet BUT still assumes all plants and coals are identical
Advanced projects (eg Indonesia)	Coal analysis on a unit-by-unit basis	iPOG analysis on a unit-by-unit basis	Unit-specific emission factor	Unit-specific plant activity	Produces a unit-specific emission estimate

* https://web.unep.org/globalmercurypartnership/mercury-emissions-coal-fired-power-plants-indonesia

https://web.unep.org/globalmercurypartnership/interactive-process-optimization-guidance-ipog%E2%84%A2

Plant sampling for EF and RF

SAMPLES TAKEN AT PLANTS IN INDONESIA

Coal

Ash

Stack

- Sampling of coal as delivered and as fed into the boiler
- Coal samples from numerous mines were analysed and results collated
- Monitoring and mass balances are challenging but are still more useful than generic emission factors

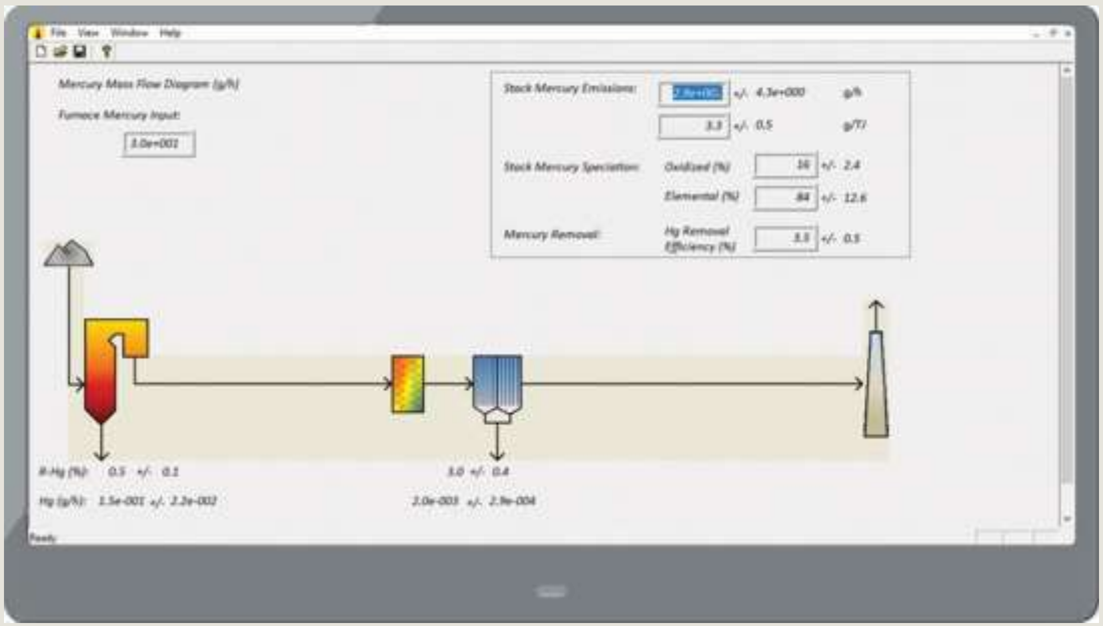
Creating the dataset

REAL DATA FROM PLANTS
MISSING DATA ESTIMATED THROUGH PROXY CALCULATIONS

Unit/plant details	Unit performance	Emission controls	Fuel quality
Unit and plant name	Operational load	Flue gas desulphurisation	Calorific value
Location	Utilisation/capacity factor	In boiler additives	Mercury content
Generating capacity	Specific energy consumption	NOx burners or SCR	Sulphur content
Certified operating and commissioning date	Annual coal consumption	PM controls	Chlorine content

Using the iPOG

INTERACTIVE PROCESS OPTIMISATION GUIDANCE TOOL



- Input unit-specific data
- RF estimated from plant configuration, coal chemistry and control technologies in place
- Results based on extrapolation and modelling of data from thousands of real data sets
- Used to focus on RELATIVE emission rates, not “actual”
- Image

Demonstration to follow

Creation of the dataset

LIVING DOCUMENT TO BE UPDATED REGULARLY
PROVENANCE OF DATA TO BE RECORDED

No	Power unit	2020	Capacity (MW)	2020	2020	Total electricity production/gross (MWh)*	Installed	2020 Purnomo			Annual operating hours (hour/year)		2020 Purnomo + Baruya	2020 Purnomo + Baruya	2020 Purnomo + Baruya	Stack Mercury Emission				
	Power unit	WEPP UNIT NAME	Installed	Commissioning Date (WEPP)	Remaining life as of 2020 (40yr life)	Total electricity production/gross (MWh)*	Annual utilisation	Operational load	Fuel Consumption (ton/year)	Specific Fuel Consumption (ton/MWh)			coal mercury content	coal sulphur content	coal chlorine content	Check if iPOG?	Annual Hg Emission, coal input, kg	Hg Emission intensity, g/MWh	Annual Hg Emission, iPOG prediction, kg	Remaining Plant Life Hg Emission, kg
No	Power unit	WEPP UNIT NAME	Installed	Commissioning Date (WEPP)	Remaining life as of 2020 (40yr life)	Total electricity production/gross (MWh)*	Annual utilisation	%	Fuel Consumption (ton/year)	Specific Fuel Consumption (ton/MW	hours/y	SOx control (WEPP)	ug/kg	%	%	Result (g/h)				
	PLTU Celukan Bawang	CELUKAN BAWANG	142	2015	35	274,827.00	22.09	89.20	150,000.00	0.546	7,970	SWFGD	44.6	0.19	0.023	2.4	6,690	24	360	12,600
	PLTU Celukan Bawang	CELUKAN BAWANG	142	2015	35	274,827.00	22.09	89.20	150,000.00	0.546	7,970	SWFGD	44.6	0.19	0.023	2.4	6,690	24	360	12,600
	PLTU Celukan Bawang	CELUKAN BAWANG	142	2015	35	274,827.00	22.09	89.20	150,000.00	0.546	7,970	SWFGD	44.6	0.19	0.023	2.4	6,690	24	360	12,600
	PLTU Paiton Unit 5	PAITON-II NO 1	610	2000	20	3,549,546.25	66.42	100.00	1,618,332	0.456	6,416	SWFGD	26	0.19	0.024	5.5	42,077	12	8,901	178,017
	PLTU Paiton Unit 6	PAITON-II NO 2	610	2000	20	3,549,546.25	66.42	100.00	1,618,332	0.456	6,699	SWFGD	26	0.19	0.024	5.5	42,077	12	8,901	178,017
	PLTU Paiton Unit 7	PAITON-I NO 1	615	1999	19	3,584,327.53	66.53	106.52	1,947,206	0.543	6,146	SWFGD	40.89	0.118	0.0078	12	79,621	22	23,368	443,963
	PLTU Paiton Unit 8	PAITON-I NO 2	615	1999	19	3,584,327.53	66.53	106.03	2,218,145	0.619	7,025	SWFGD	40.89	0.118	0.0078	14	90,700	25	31,054	590,027
	PLTU TJB Unit 1	TANJUNG JATI-B NC	710	2006	26	4,469,025.09	71.85	93.07	1,826,044	0.409	7,619	WLST	13.3	0.7	0.023	2.4	24,286	5	4,383	113,945
	PLTU TJB Unit 2	TANJUNG JATI-B NC	710	2006	26	4,879,123.00	78.45	93.07	1,944,636	0.399	8,215	WLST	13.3	0.7	0.023	2.3	25,864	5	4,473	116,289
	PLTU TJB Unit 3	TANJUNG JATI-B NC	721.8	2011	31	4,563,981.90	72.18	91.59	1,780,111	0.390	8,411	WLST	27.5	0.52	0.026	3.2	48,953	11	5,696	176,587
	PLTU TJB Unit 4	TANJUNG JATI-B NC	721.8	2012	32	4,201,636.40	66.45	91.59	1,679,439	0.400	7,807	WLST	27.5	0.52	0.026	3.4	46,185	11	5,710	182,723

Conclusions and comments

Minamata inventories

- The Convention requires at least a Level 1 calculation for coal sector emissions, which Pakistan has produced

- A Level 2 or 3 approach, (bottom-up, using more coal and plant-specific data) will make cost-effective compliance easier

Thank you

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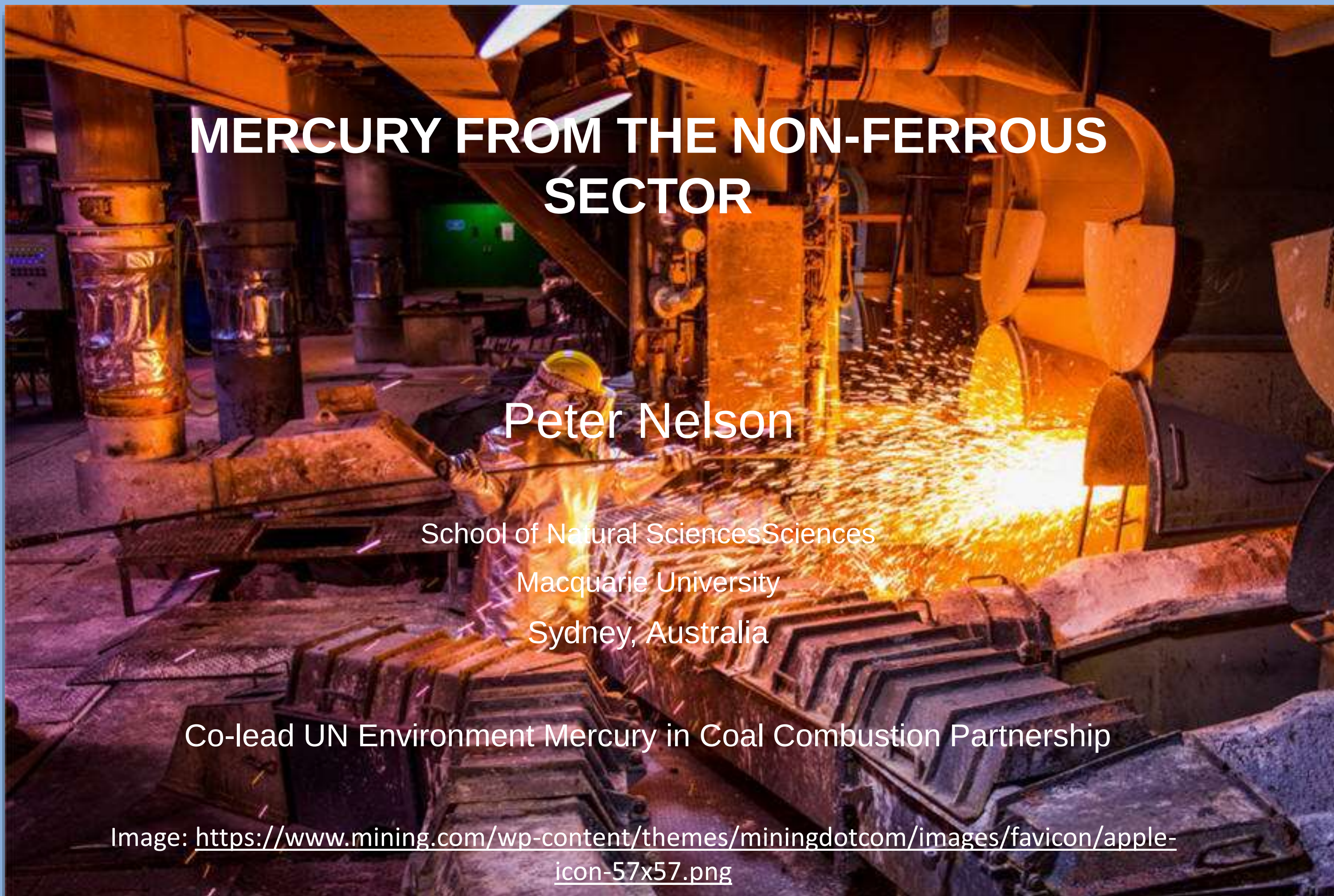

MERCURY FROM THE NON-FERROUS SECTOR

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Macquarie University

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Co-lead UN Environment Mercury in Coal Combustion Partnership

Image: https://www.mining.com/wp-content/themes/miningdotcom/images/favicon/apple-icon-57x57.png

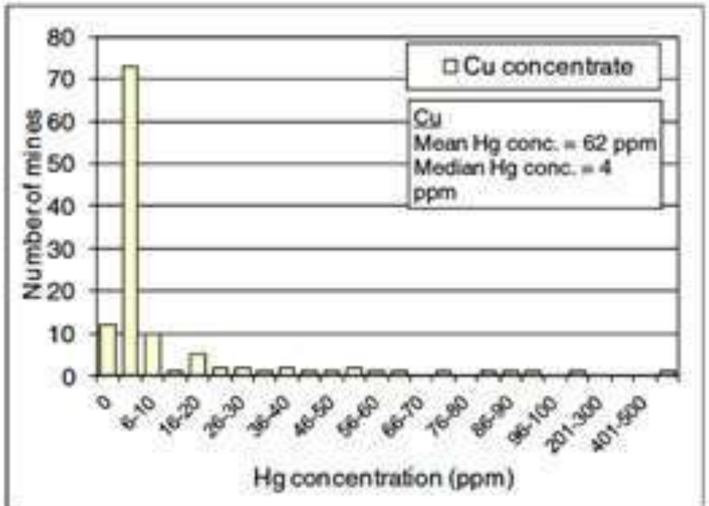
Non Ferrous Metals in Article 8 Minamata Convention

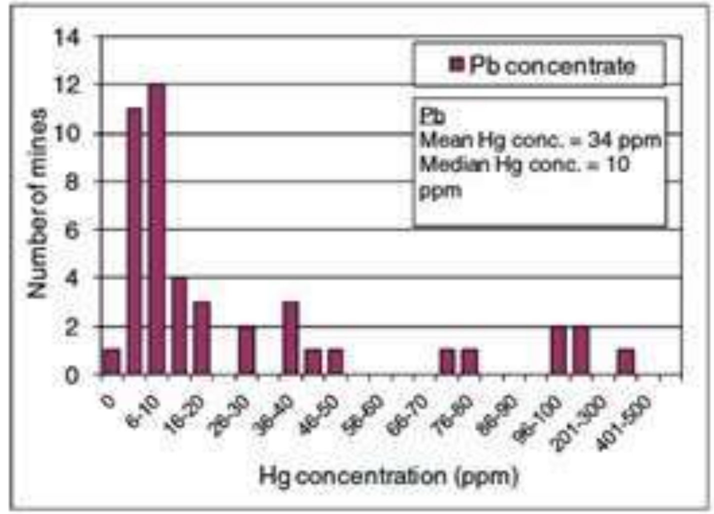
- Smelting and Roasting only
- Metals:
  - Copper
  - Lead
  - Zinc
  - Industrial Gold

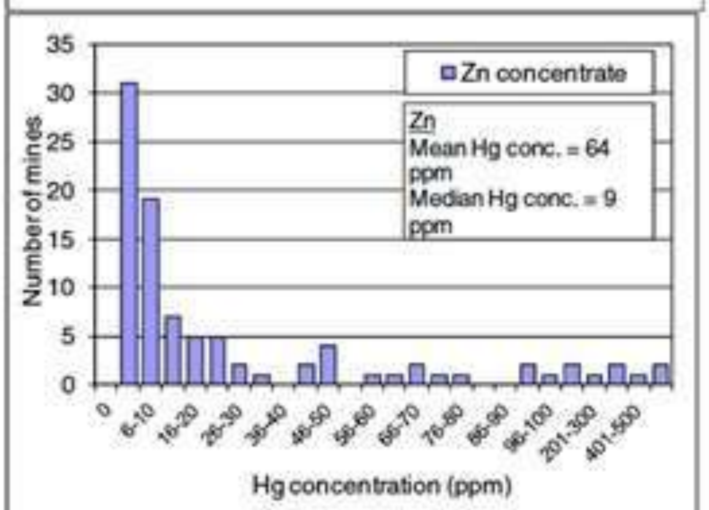
TABLE 1: ESTIMATED QUANTITIES OF MERCURY EMITTED TO AIR FROM ANTHROPOGENIC SOURCES IN 2015, BY DIFFERENT SECTORS (UNEP 2019A)

Sector	Mercury Emissions (range), tonnes	Sector % of total
Artisanal and small-scale gold mining (ASGM)	838 (675-1000)	37.7
Biomass burning (domestic, industrial and power plant)	51.9 (44.3-62.1)	2.33
Cement production (raw materials and fuel, excluding coal)	233 (117-782)	10.5
Chlor-alkali production (mercury process)	15.1 (12.2-18.3)	0.68
Non-ferrous metal production (primary Al, Cu, Pb, Zn)	228 (154-338)	10.3
Large-scale gold production	84.5 (72.3-97.4)	3.8
Mercury production	13.8	0.62
Stationary combustion of coal (domestic/residential, transportation)	55.8 (36.7-69.4)	2.51
Stationary combustion of coal (power plants)	292 (255-346)	13.1
Vinyl-chloride monomer (mercury catalyst)	58.2 (28.0-88.8)	2.6
Waste (incineration and other emissions from all waste streams)	162 (129-255)	7.3
Total	**2220 (2000-2820)**	

Mercury variability in ores







Number of mines and the reported Hg concentrations in

a) Cu concentrates
b) Pb concentrates
c) Zn concentrates

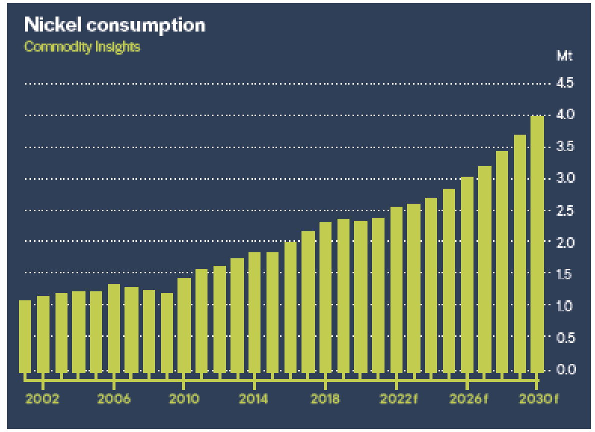
High Temperature Processing releases Hg

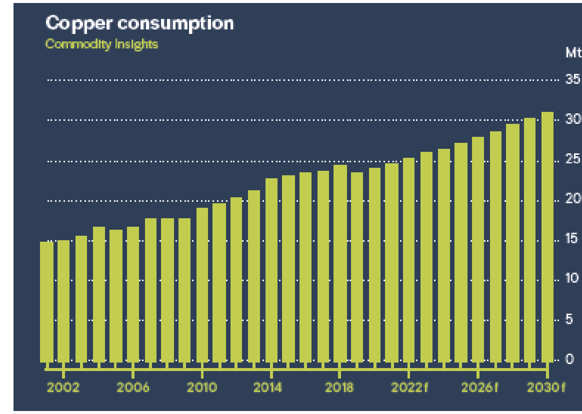
Non-ferrous metal sector in Pakistan (based on MIA, 2019)

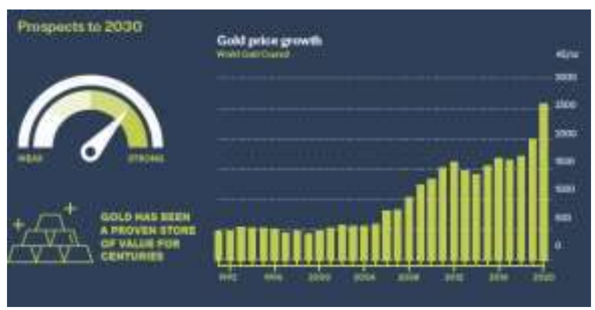
Toolkit Chapter	Source	
5.2.3	Zinc extraction and initial processing	N
5.2.4	Copper extraction and initial processing	N
5.2.5	Lead extraction and initial processing	N
5.2.6	Gold extraction and initial processing by methods other than mercury amalgamation	N
5.2.7	Aluminium extraction and initial processing	Y

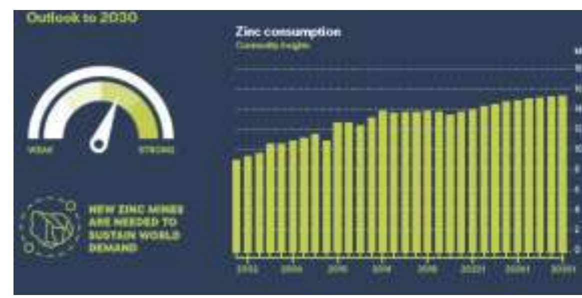
Pakistan has deposits of several minerals including coal, copper, gold, chromite, mineral salt, bauxite and several other minerals; and there are reports of future copper and gold production

Non Ferrous Metals – Strong Growth







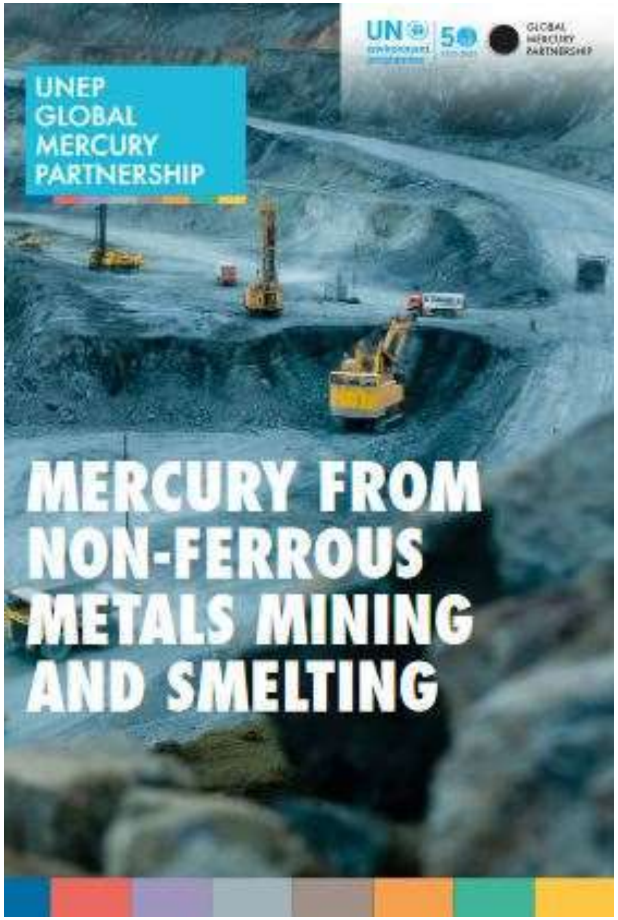


Emission Estimation

Tools for Inventory Development

Inventory Level 2 (IL2)

- a detailed mercury inventory tool
- all factors adjustable to national or local conditions.
- default estimation factors are pre-entered
- requires more reading and experience
- high level of accuracy, provided that the data needed for this are available



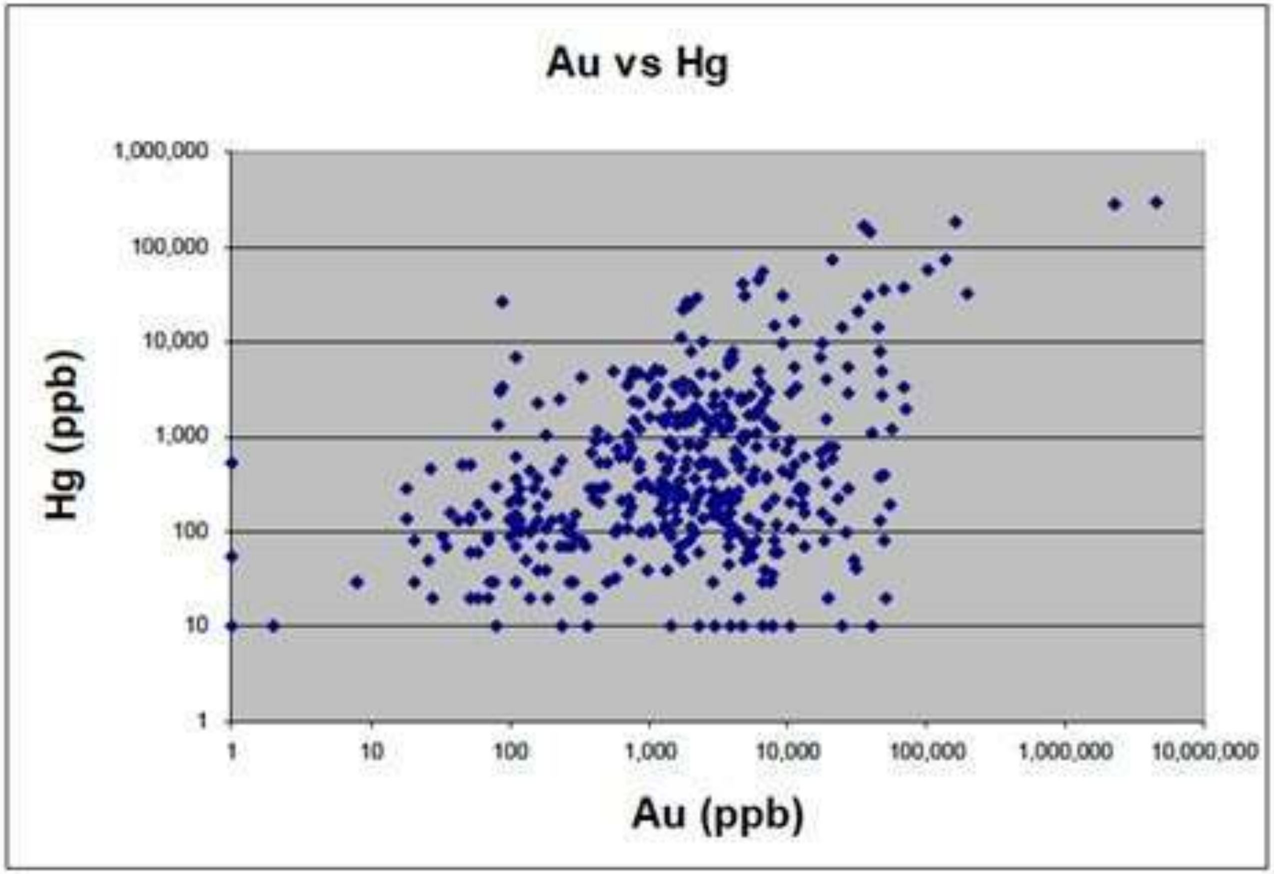
Other resources – Study Report on Non Ferrous Metals

Identified uncertainties and knowledge gaps

- Hg content in ores and concentrates, at plant and country level
- Hg air emissions test data
- Hg concentrations in reject material
- Hg distributions between emissions and other releases
- Activity data (amounts of ores and concentrates processed)
- Effects of pollution control technologies, incl. on distribution of Hg between emissions to air, and capture in solid and liquid waste
- Additional quantitative information on how mercury deports to emissions and releases to air, land, water, waste and by-products

DATA REQUIRED FOR BETTER EMISSION ESTIMATES

Mercury concentrations as a function of gold concentrations; samples from the Kalgoorlie deposit (Eviron 2006)



Improving emissions estimations

Improved data (mercury in ore and concentrates, activity data, control technologies and their effectiveness,…)

Individual plant data (often a large task)

Prospects for future development of mineral resources ? The country has the world's second largest salt mines and **fifth largest copper and gold reserves**, and second largest coal deposits

Better understanding of ore characteristics

Gold is typically recovered from ores containing only traces of the metal - main challenge is concentrating

- Techiques:
  - Cyanide leaching; gold must be available for leaching
  - Mercury amalgamation – largely now only used in ASGM
  - Refractory ores – hard to leach ultra-fine mercury; requires pre-treatment (roasting, oxidation, …)

Reducing mercury emissions

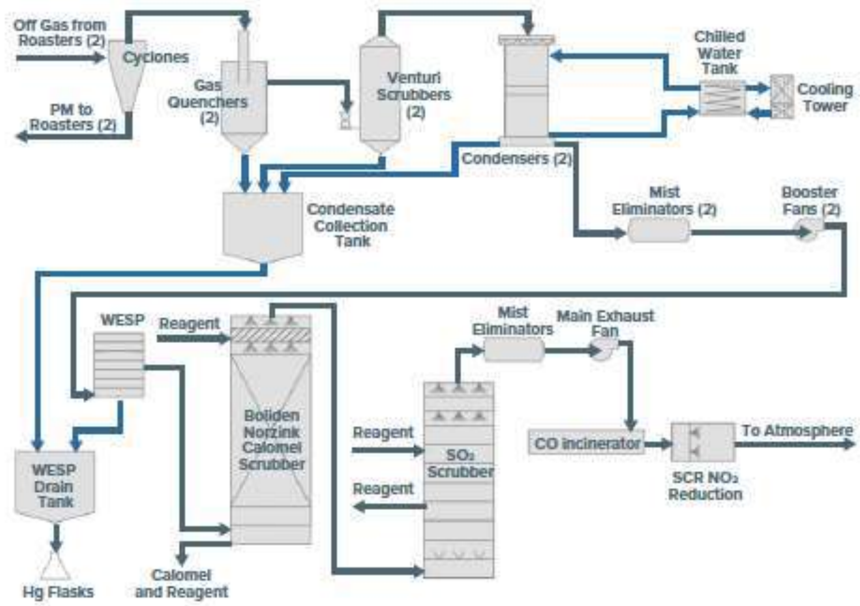
BAT/BEP Reduction of Hg emissions

- Boliden-Norzink process
  - $Hg + HgCl_2 \rightarrow Hg_2Cl_2$ (calomel)
- Selenium filter
  - $Se + Hg \rightarrow SeHg$
- Activated carbon
- Co-benefits of air pollution abatement technologies
  - Particulate matter, SO_2, NO_x

Case Study: Nevada Gold Plant

- Controls employed:

- Cyclone separation
- Gas Quench
- Venturi gas scrubbing
- Gas condenser
- Wet electrostatic precipitator (ESP)
- Calomel scrubber



Mercury Removal Technology	Process Conditions	Advantages	Disadvantages
Carbon Filter beds	Efficiency = 99%	• Effectively removes mercury chloride	• Untreated carbon ineffective in removing elemental mercury
Fixed activated carbon filter beds	Efficiency = 90%	• Sulfur-impregnated activated carbon is commercially available • Removes Hg^0 and other species • Low potential for leaching of mercury from spent carbon	• Spent carbon requires disposal in landfill
Activated carbon injection	Efficiency = 90-95%	• Sulfur-impregnated activated carbon is commercially available • Removes Hg^0 and other species • Low potential for leaching of mercury from spent carbon	• Spent carbon requires disposal in landfill
Lime/limestone scrubbing	Efficiency = 10-84%	• Effective for water soluble species	• Ineffective for elemental mercury • Wastewater requires treatment prior to disposal
Selenium filters	Efficiency = 99.6% Max Hg_{IN} = 9 mg/m^3 Max Hg_{OUT} = 40 µg/m^3	• Successful installation at metallurgical plants	• Limited inlet mercury concentration • Ineffective for species other than elemental mercury • Spent filter requires disposal in landfill
Boliden-Norzink process	Efficiency = 99% Max Hg_{IN} = 5-80 mg/m^3 Max Hg_{OUT} = 20-50 µg/m^3	• Widely demonstrated • Mercury removed as marketable product	• Removes only elemental mercury • Complicated flowsheet • Chlorine gas handling

Introduction: Minamata Convention on Mercury, Article 8, emissions inventories

Workshop to enhance inventories and strategies under Article 8 of the Minamata Convention in Pakistan, 6 June 2024

Alexander Romanov, UNEP-GEF Chemicals and Waste (alexander.romanov@un.org)
on behalf of the Secretariat of the Minamata Convention on Mercury

Funded by the European Union

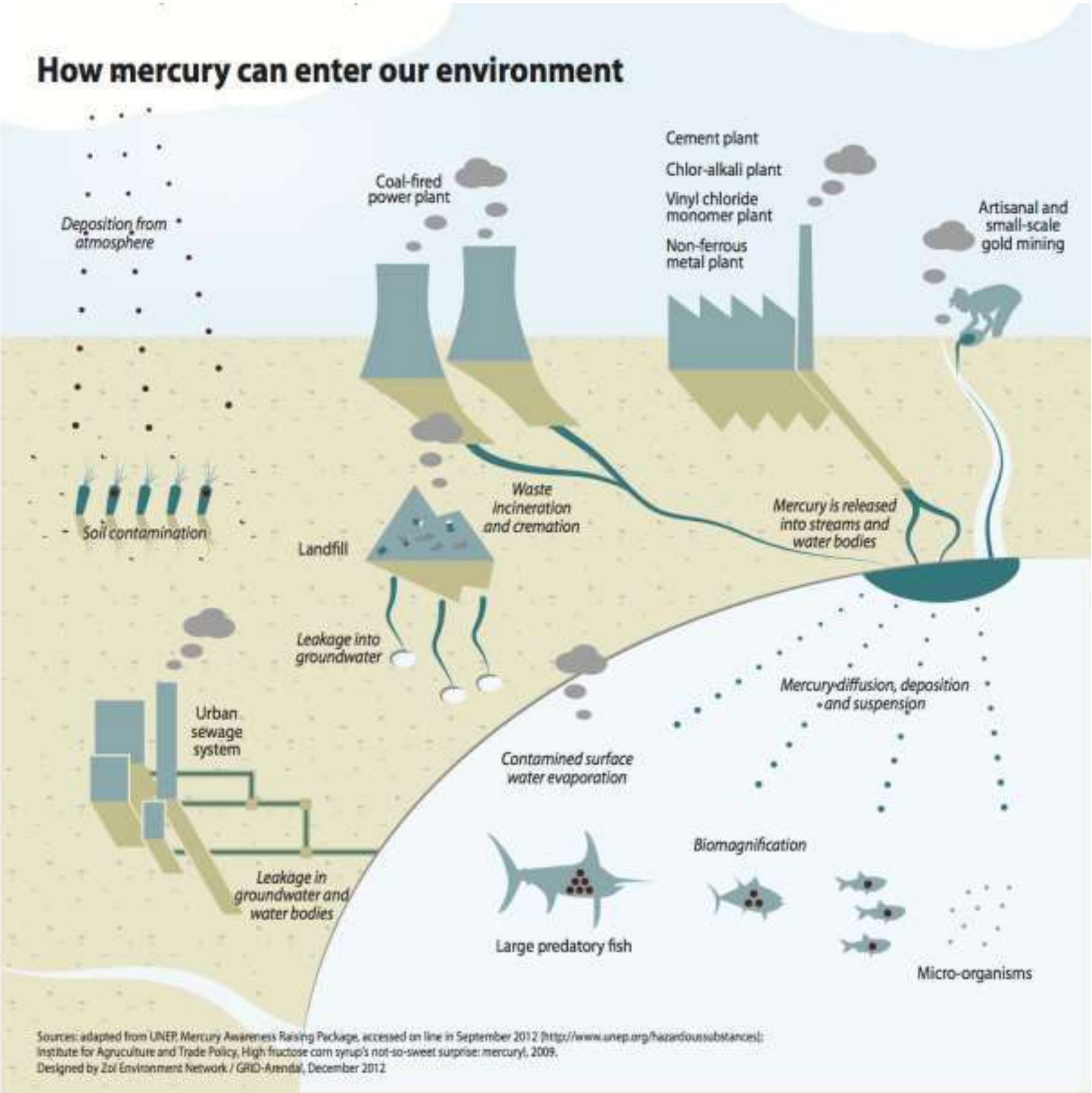
Mercury around us

MINAMATA CONVENTION ON MERCURY

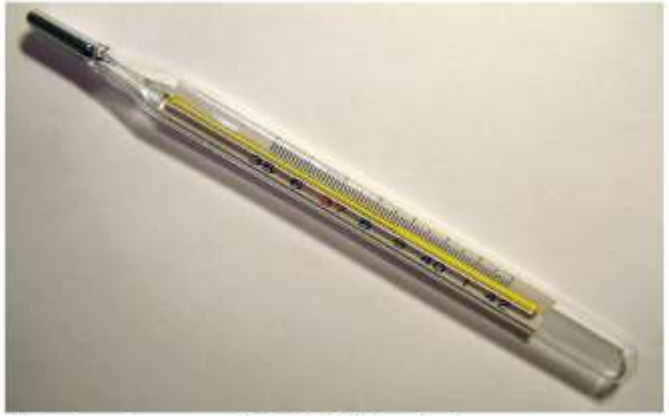
Mercury mine in Idrija, Slovenia, 1679, by Johann Weikhard von Valvasor (1641-1693). Wikimedia Commons. Public domain.

The Print sourced from:
Science for Environment Policy (2017) *Tackling mercury pollution in the EU and worldwide.* In-depth Report 15 produced for the European Commission, DG Environment by
the Science Communication Unit, UWE, Bristol.
Available at:

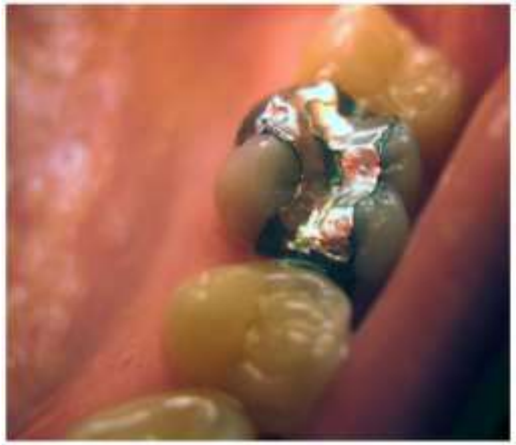
Mercury around us



Cinnabar on Dolomite. JJ Harrison, 2009. CC-BY-SA 3.0 Unported https://commons.wikimedia.org/wiki/File:Cinnabar_on_Dolomite.jpg



Clinical mecury thermometer. Menchi, 2005. Wikimedia Commons. CC-BY-SA 3.0 Unported.

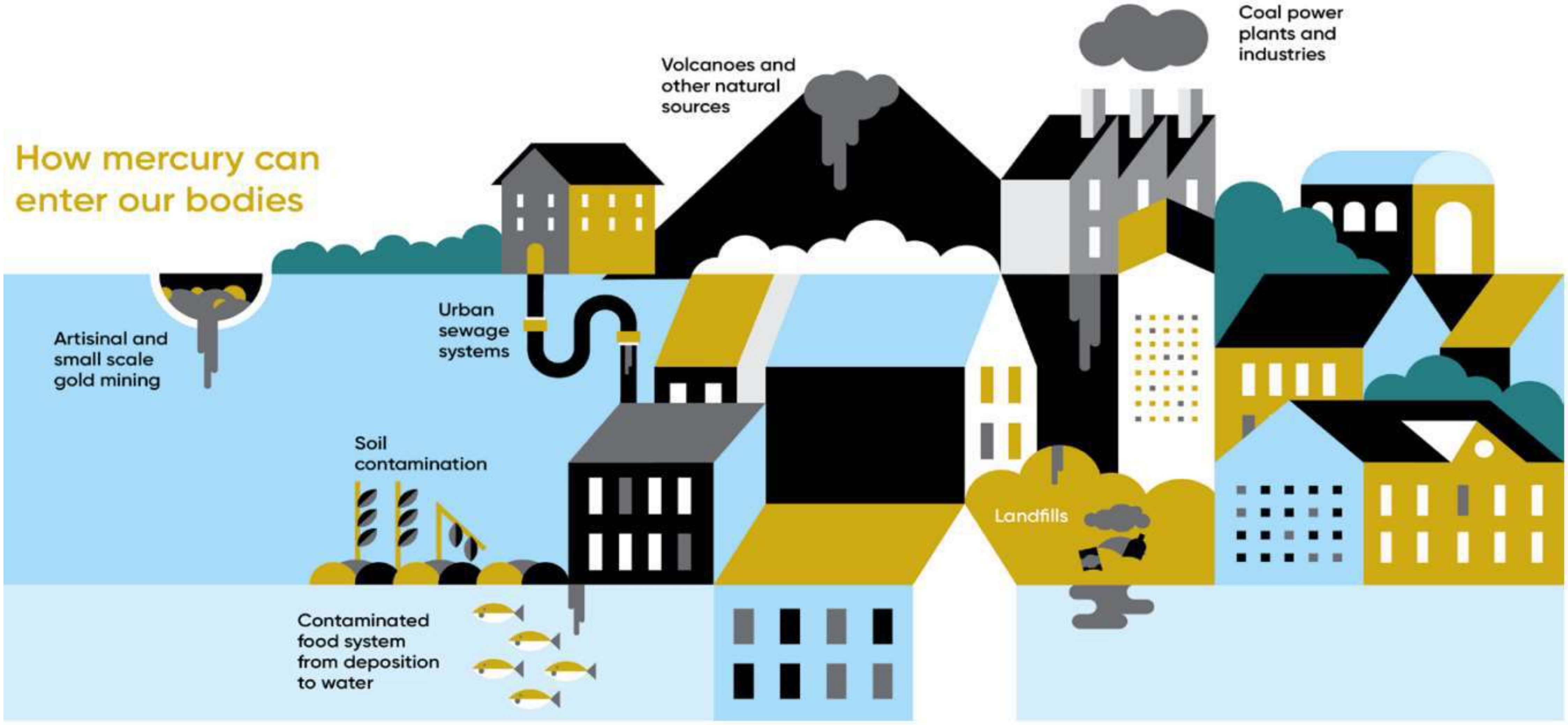


Mercury filling on first molar, shown upsidedown. Kauzio, 2009. Wikimedia Commons.

Li-ion battery from a laptop computer. Kristoferb, 2010. CC BY-SA 3.0 Wikimedia Commons.

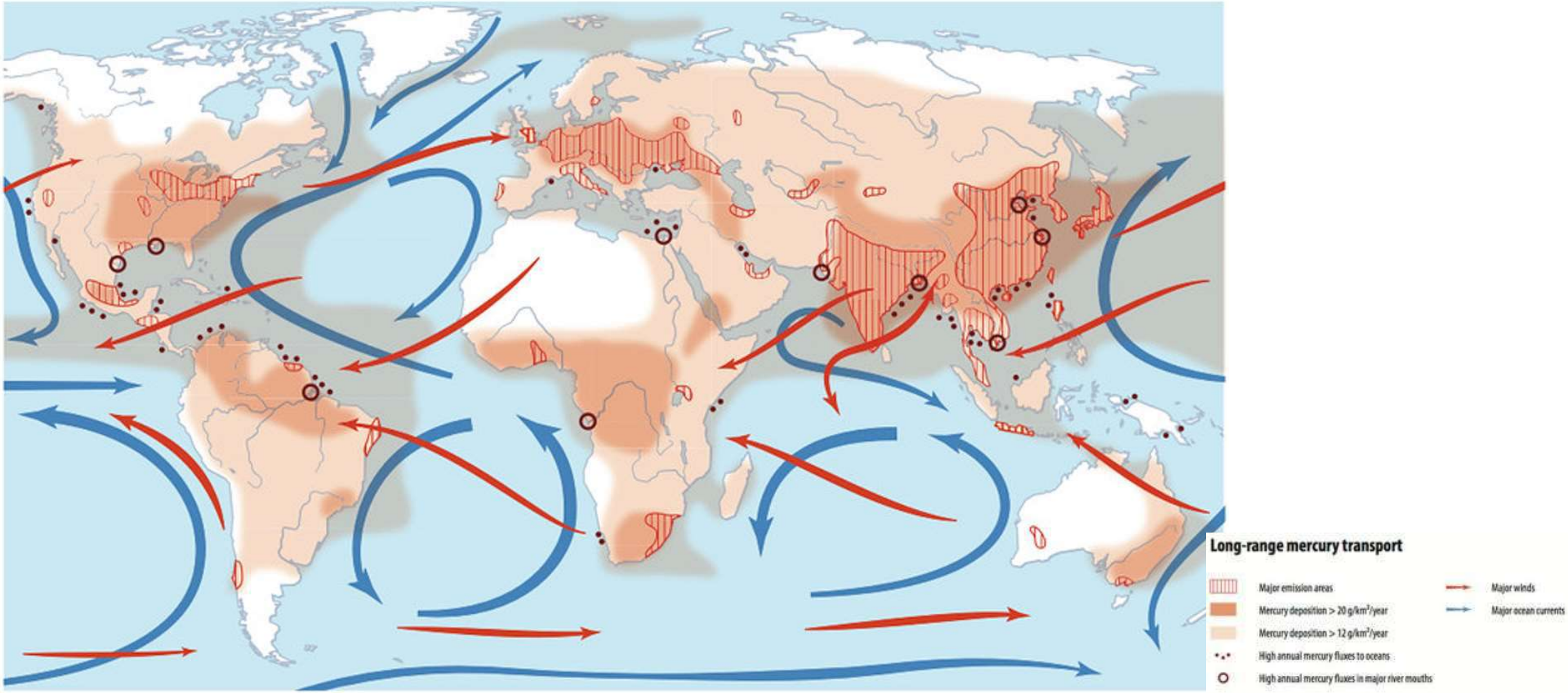
Science for Environment Policy (2017) *Tackling mercury pollution in the EU and worldwide.* In-depth Report 15 produced for the European Commission, DG Environment by the Science Communication Unit, UWE, Bristol.

Mercury around us



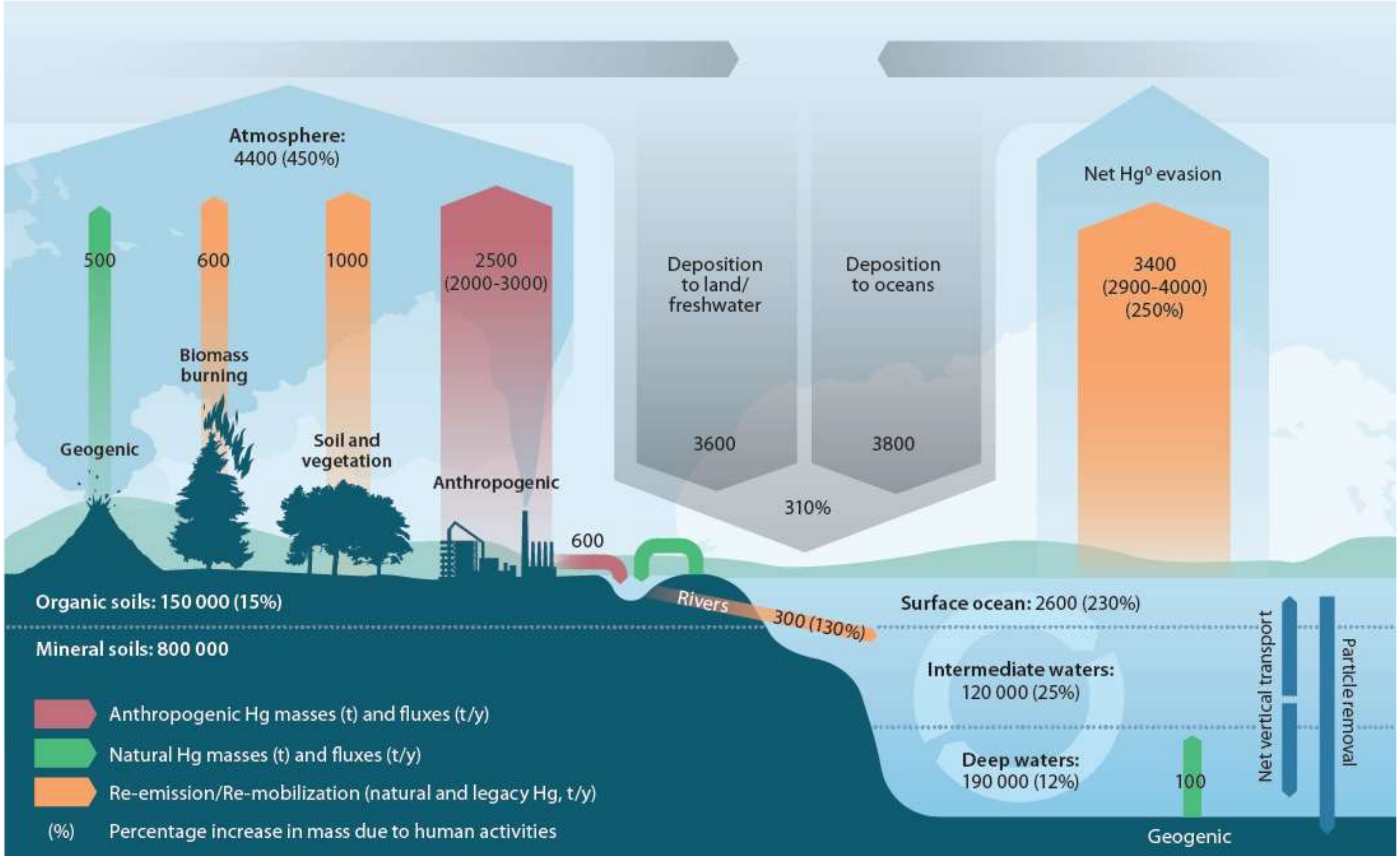
Mercury – pollutant of the global concern

MINAMATA CONVENTION ON MERCURY



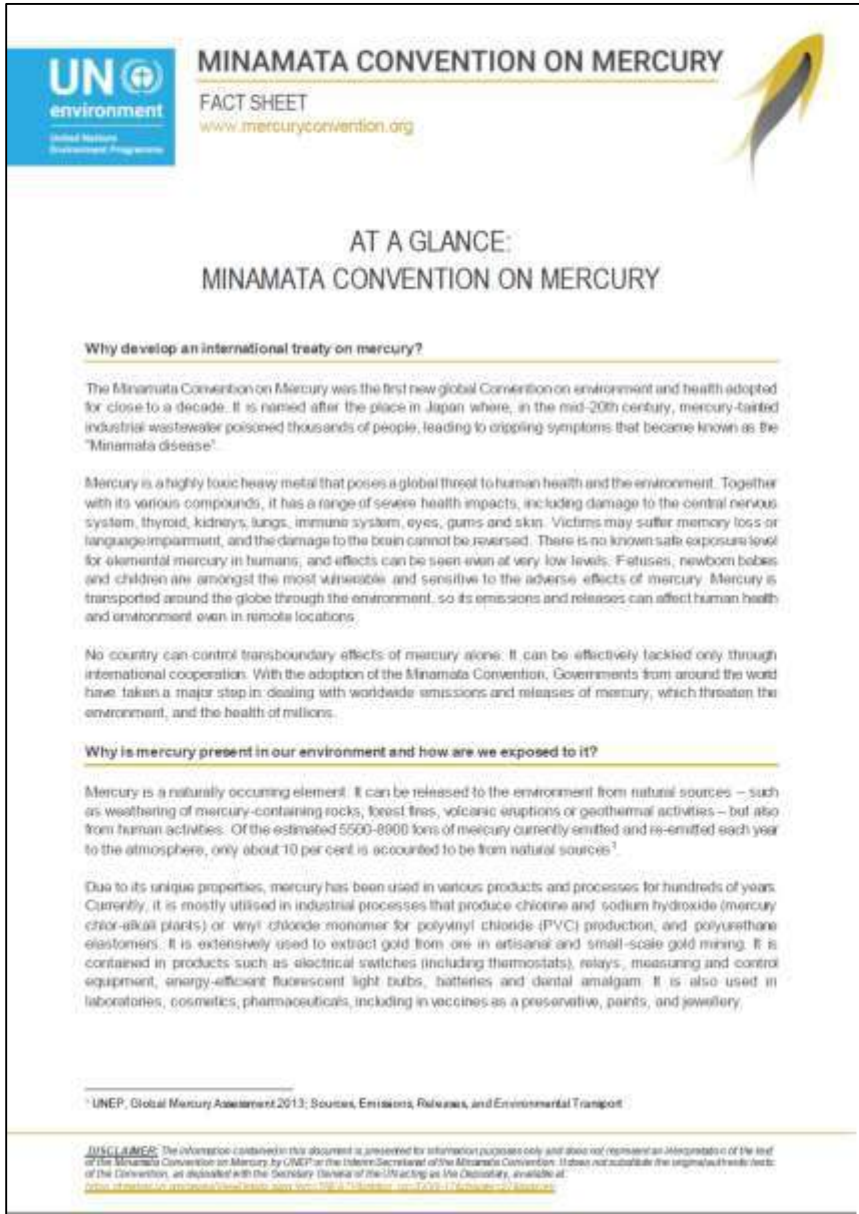
Source: Adapted from AMAP/UNEP 2008, Technical Background Report to the Global Atmospheric Mercury Assessment; UNEP, Global Mercury Assessment 2013: Sources, Emissions, Releases and Environmental Transport, 2013
Designed by Zoi Environment Network / GRID-Arendal, December 2012

GMA 2018 - Update on global Hg pools and cycles



Minamata Convention of Mercury

- Objective: to **protect the human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds**.
- Adopted in October 2013, entered into force in August 2017.
- Mercury is a chemical of global concern owing to its:
  - Long-range atmospheric transport,
  - Persistence in the environment once anthropogenically introduced,
  - Ability to bioaccumulate in ecosystems, and
  - Significant negative effects and human health and the environment.
- Recognizes the lessons of Minamata Disease, in particular the serious health and environmental effects from mercury pollution.


MINAMATA CONVENTION ON MERCURY

FACT SHEET

www.mercuryconvention.org

AT A GLANCE:

MINAMATA CONVENTION ON MERCURY

Why develop an international treaty on mercury?

The Minamata Convention on Mercury was the first new global Convention on environment and health adopted for close to a decade. It is named after the place in Japan where, in the mid-20th century, mercury-tainted industrial wastewater poisoned thousands of people, leading to crippling symptoms that became known as the "Minamata disease".

Mercury is a highly toxic heavy metal that poses a global threat to human health and the environment. Together with its various compounds, it has a range of severe health impacts, including damage to the central nervous system, thyroid, kidneys, lungs, immune system, eyes, gums and skin. Victims may suffer memory loss or language impairment, and the damage to the brain cannot be reversed. There is no known safe exposure level for elemental mercury in humans, and effects can be seen even at very low levels. Fetuses, newborn babies and children are amongst the most vulnerable and sensitive to the adverse effects of mercury. Mercury is transported around the globe through the environment, so its emissions and releases can affect human health and environment even in remote locations.

No country can control transboundary effects of mercury alone. It can be effectively tackled only through international cooperation. With the adoption of the Minamata Convention, Governments from around the world have taken a major step in dealing with worldwide emissions and releases of mercury, which threaten the environment, and the health of millions.

Why is mercury present in our environment and how are we exposed to it?

Mercury is a naturally occurring element. It can be released to the environment from natural sources – such as weathering of mercury-containing rocks, forest fires, volcanic eruptions or geothermal activities – but also from human activities. Of the estimated 5500-8900 tons of mercury currently emitted and re-emitted each year to the atmosphere, only about 10 per cent is accounted to be from natural sources[1].

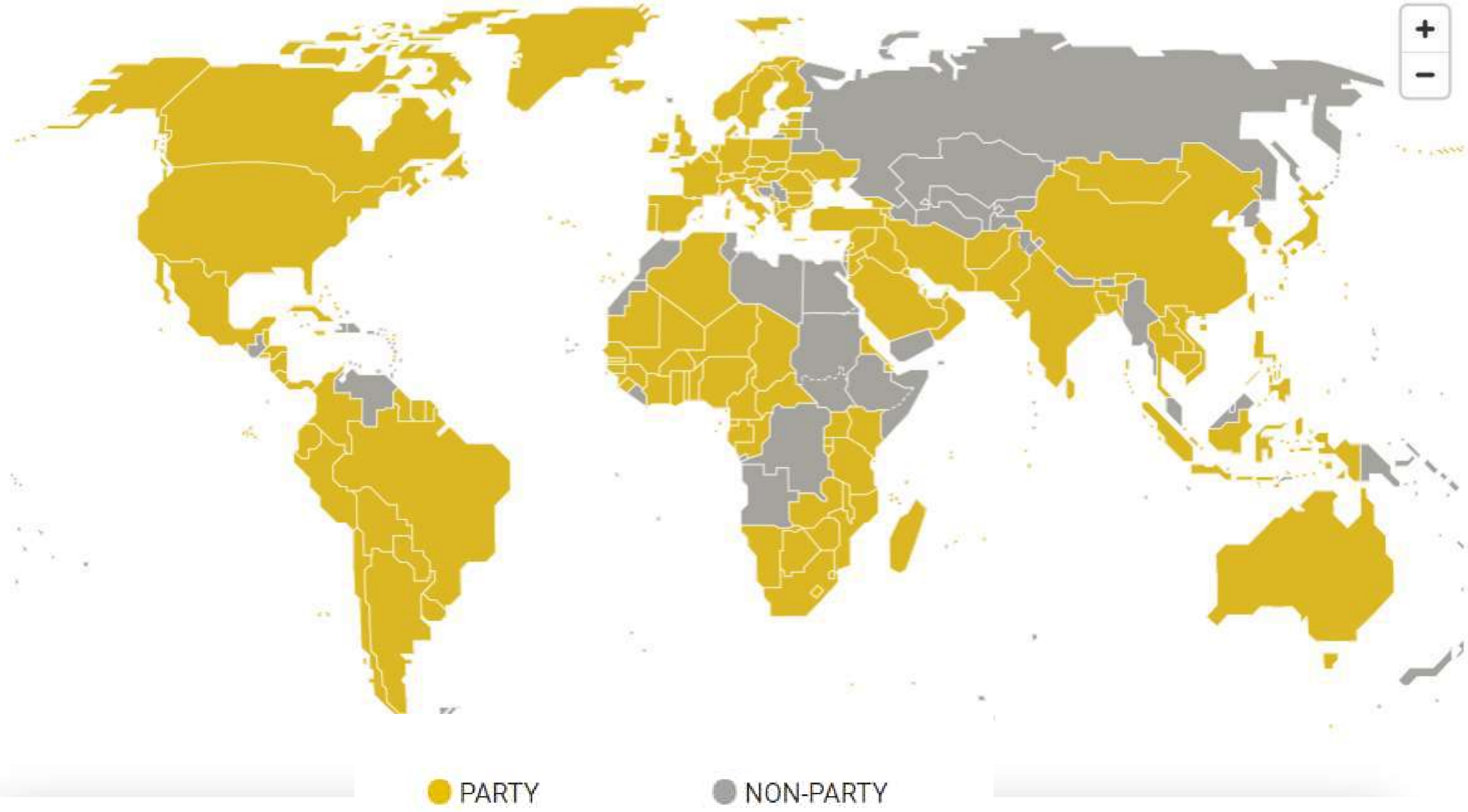
Due to its unique properties, mercury has been used in various products and processes for hundreds of years. Currently, it is mostly utilised in industrial processes that produce chlorine and sodium hydroxide (mercury chlor-alkali plants) or vinyl chloride monomer for polyvinyl chloride (PVC) production, and polyurethane elastomers. It is extensively used to extract gold from ore in artisanal and small-scale gold mining. It is contained in products such as electrical switches (including thermostats), relays, measuring and control equipment, energy-efficient fluorescent light bulbs, batteries and dental amalgam. It is also used in laboratories, cosmetics, pharmaceuticals, including in vaccines as a preservative, paints, and jewellery.

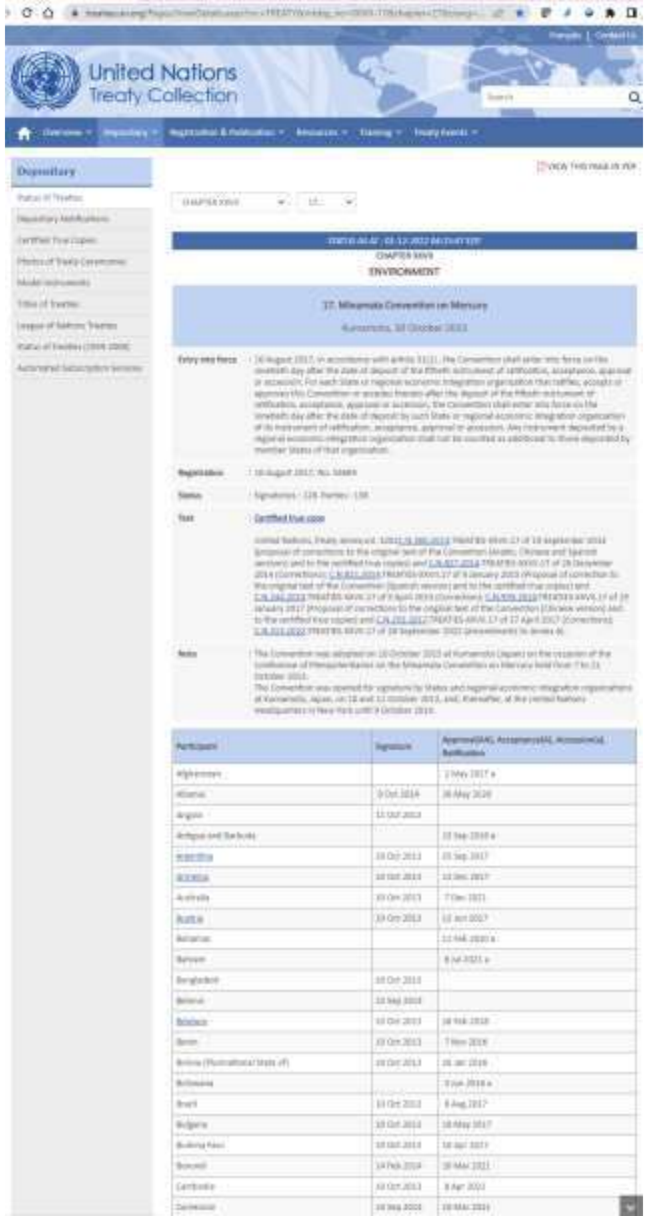
[1] UNEP, Global Mercury Assessment 2013: Sources, Emissions, Releases, and Environmental Transport

See Minamata Convention at a Glance

Parties to the Minamata Convention

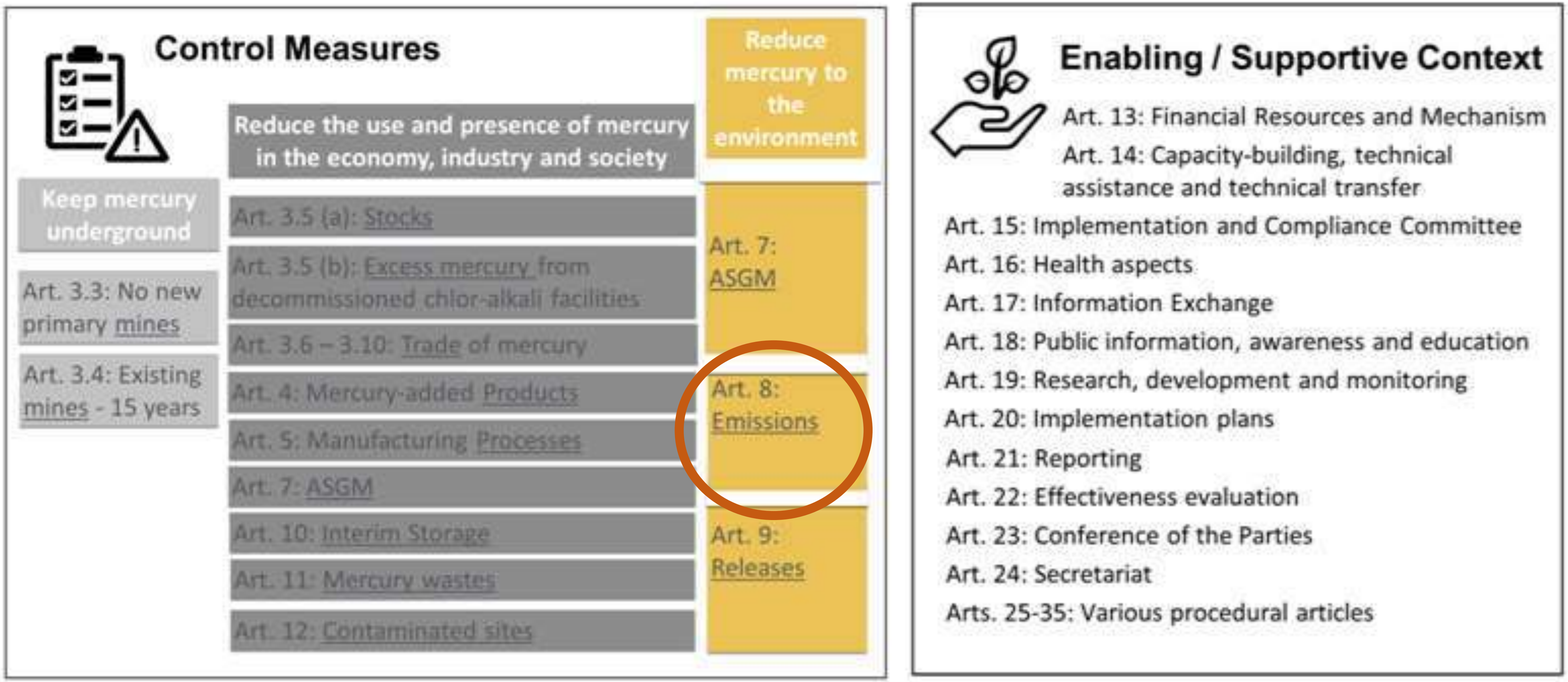
- ►148 parties as of May 2024





For most recent list of parties, see [UN Treaties Section website]

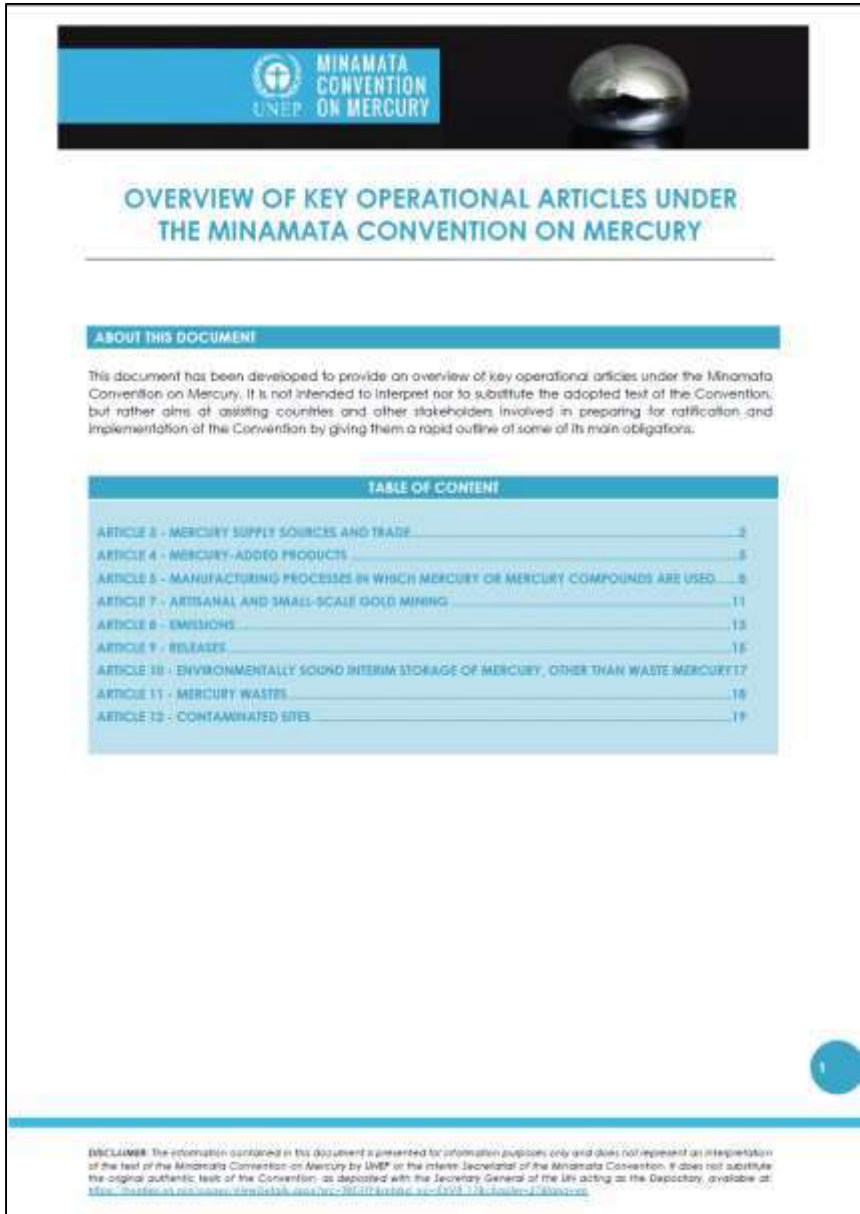
Control measures and support measures



Major obligations of the parties to the Minamata Convention

- Article 3: Not allow new mercury mines and close old ones in 15 years
- Article 3: Only export mercury with written consent of importing countries
- Article 4: Phase out listed mercury-added products by 2020 (2025 for newly-added product categories.
- Article 4: Take measures to phase down dental amalgam
- Article 5: Phase out listed mercury-using processes by 2018 or 2025, and take measures to restrict other listed processes
- Article 7: Develop and implement national action plans on artisanal and small-scale gold mining in 3 years
- Article 8: Take measures on new emission sources in 5 years and existing sources in 10 years. Establish emission inventory in 5 years
- Article 9: Identify relevant sources and take measures. Establish release inventory in 5 years
- Article 10: Take measures on interim storage
- Article 11: Manage mercury waste in an environmentally sound manner
- Article 12: Endeavour to develop strategies
- Article 21: Report on the implementation of the Convention

See Overview of Key Operational Articles


MINAMATA CONVENTION ON MERCURY
UNEP

OVERVIEW OF KEY OPERATIONAL ARTICLES UNDER THE MINAMATA CONVENTION ON MERCURY

ABOUT THIS DOCUMENT

This document has been developed to provide an overview of key operational articles under the Minamata Convention on Mercury. It is not intended to interpret nor to substitute the adopted text of the Convention, but rather aims at assisting countries and other stakeholders involved in preparing for ratification and implementation of the Convention by giving them a rapid outline of some of its main obligations.

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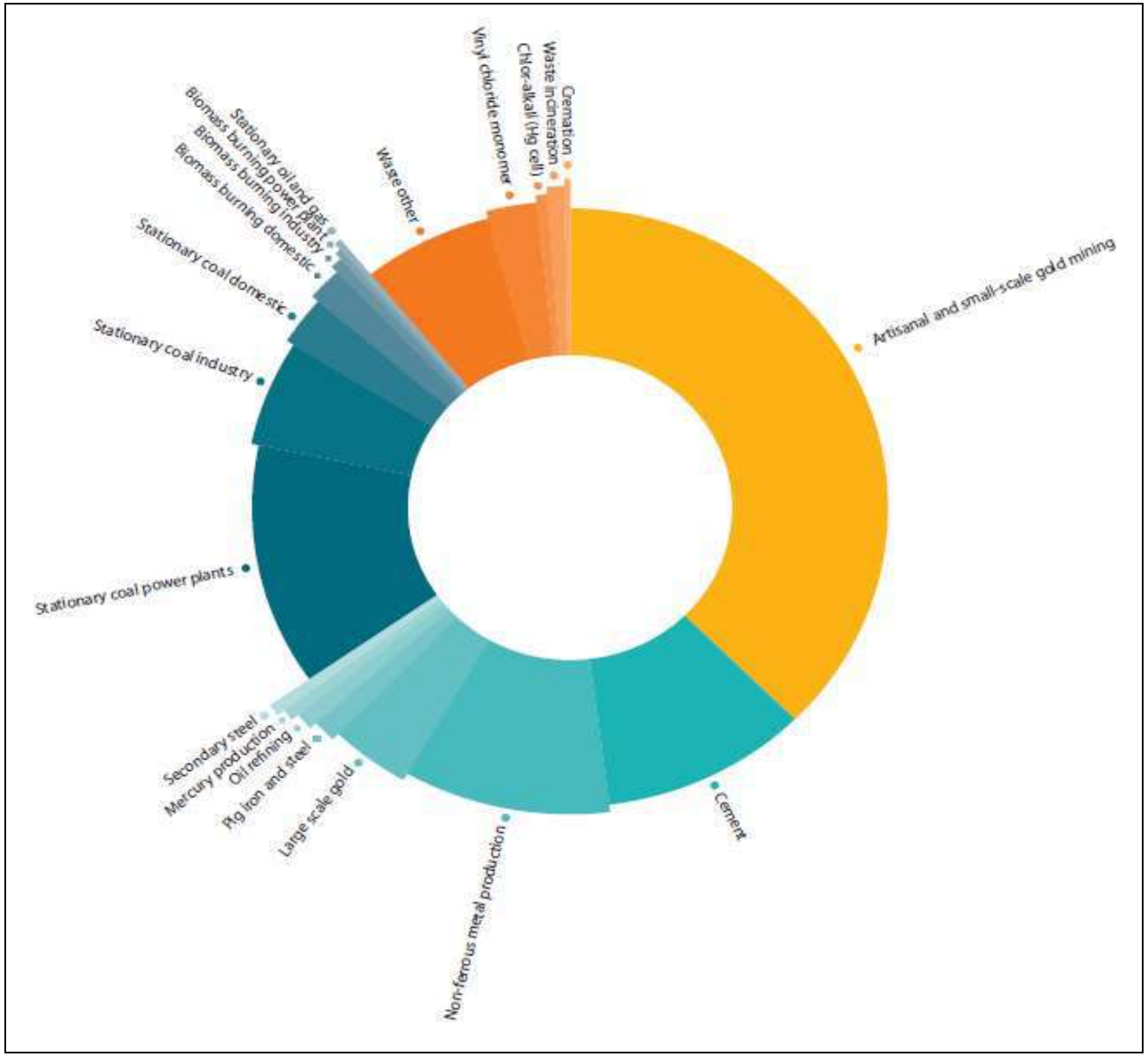
Global Mercury Assessment 2018

- The predominant source sector is artisanal and small-scale gold mining (about 38%).
- It is followed by stationary combustion of coal (about 21%), non-ferrous metal production (about 15%) and cement production (about 11%).



Article 8 of the Minamata Convention

- Controls the emissions of total mercury to air from the following sources listed in Annex D:
  - Coal-fired power plants
  - Coal-fired industrial boilers
  - Smelting and roasting processes used in the production of non-ferrous metals (lead, zinc, copper and industrial gold)
  - Waste incineration facilities
  - Cement clinker production facilities.
- Parties with relevant sources shall take measures to control emissions and may prepare a national plan, which is to be submitted **within 4 years after the entry into force** if prepared.
- For **new sources**, each Party shall require the use of BAT/BEP to control and reduce emissions, as soon as practicable but **no later than 5 years after the date of entry into force**.
- For **existing sources**, each Party shall include in any national plan, and shall implement, one or more of the following measures, as soon as practicable but **no more than 10 years after the date of entry into force**:
  - A quantified goal
  - Emission limit values
  - The use of BAT/BEP
  - A multi-pollutant control strategy that would deliver co-benefits
  - Alternative measures to reduce emissions from relevant sources
- Each Party shall establish, as soon as practicable and no later than **5 years after the date of entry into force** of the Convention for it, and maintain thereafter, an **inventory of emissions from relevant sources**.

Guidance under Article 8 of the Minamata Convention

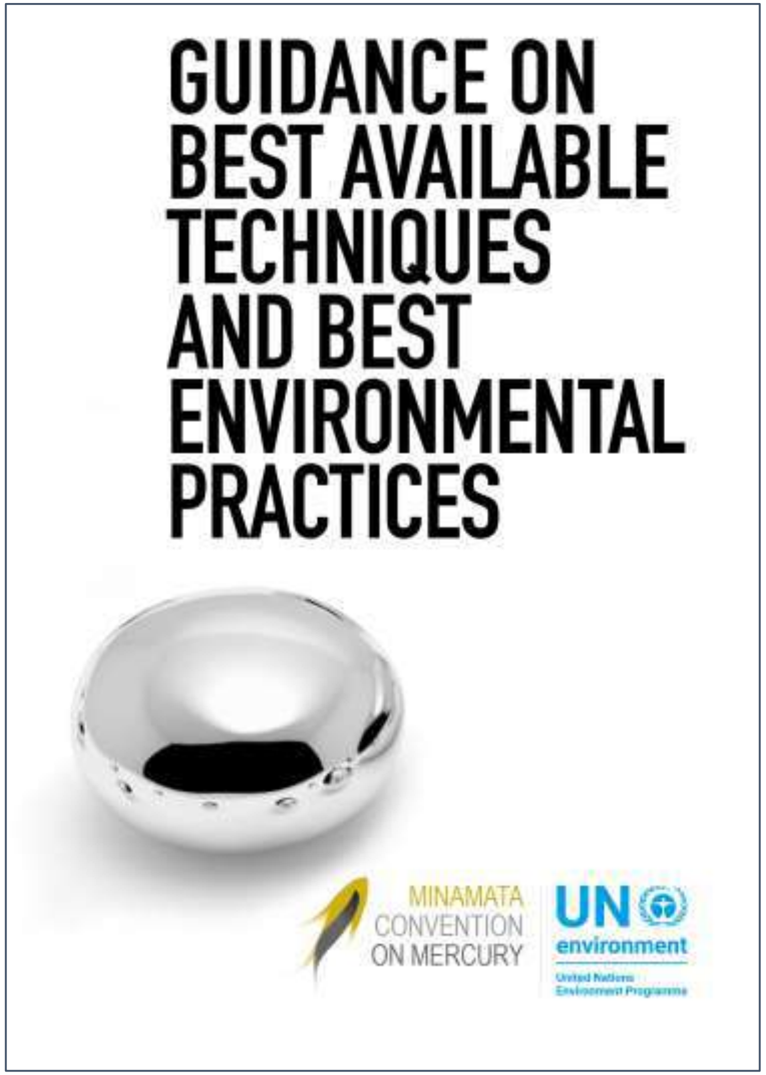
MINAMATA CONVENTION ON MERCURY

▶ Decision MC-1/4

- Adopted the guidance on BAT/BEP and on support for parties in implementing the measures
- Recognized that some of the measures described in the guidance may not be available to all parties for technical or economic reasons,
- Requested parties with experience in using such guidance to provide the secretariat with information on that experience, and the secretariat to compile such information and to update the guidance as necessary.

▶ Decision MC-1/16

- Adopted the guidance on criteria that parties may develop to identify emission sources, and on the methodology for emission inventories.



UNEP's Toolkit for identification and quantification of mercury releases

MINAMATA CONVENTION ON MERCURY

- UNEP's *Toolkit for identification and quantification of mercury releases* –aka UNEP Mercury *Toolkit* – is intended to assist countries to identify and quantify the sources of mercury emissions and releases, set priorities and reduction targets, enhance international co-operation, knowledge sharing, and **enable targeted technical assistance**.

- Inventories from countries contribute to the Global Mercury Assessment, the hub of the scientific knowledge of worldwide mercury emissions and releases.

- The Toolkit provides clear guidance on different stages of inventory development: identifying mercury sources, quantifying the consumption and calculating the final emissions and releases.

- The Toolkit includes detailed manual, calculation spreadsheet and a standard template for reporting.

- The Toolkit is one of the methods recommended in guidance from the Minamata Convention on preparing inventories of emissions pursuant to Article 8.

UNEP's Toolkit for identification and quantification of mercury releases

MINAMATA CONVENTION ON MERCURY

Inventory Level 1 (IL1) – simplified model based on default factors, requires national sectoral activity rate data; useful for first-time inventories, yet less accuracy of emission/release estimates should be expected

Inventory Level 2 (IL2) – detailed mercury inventory tool, all emission/release factors can be adjusted to national/local conditions (default factors are included), requires detailed national sectoral data to fully reflect mercury cycles

Inventory Level 3 (IL3) - integrates all mercury sources into their entire mass flow through and out of society to the environment linking different mercury sources and provides increased accuracy in estimations; most data- and expertise-intensive

+ Excel calculations sheets for Level 1, Level 2, and Level 3 inventories

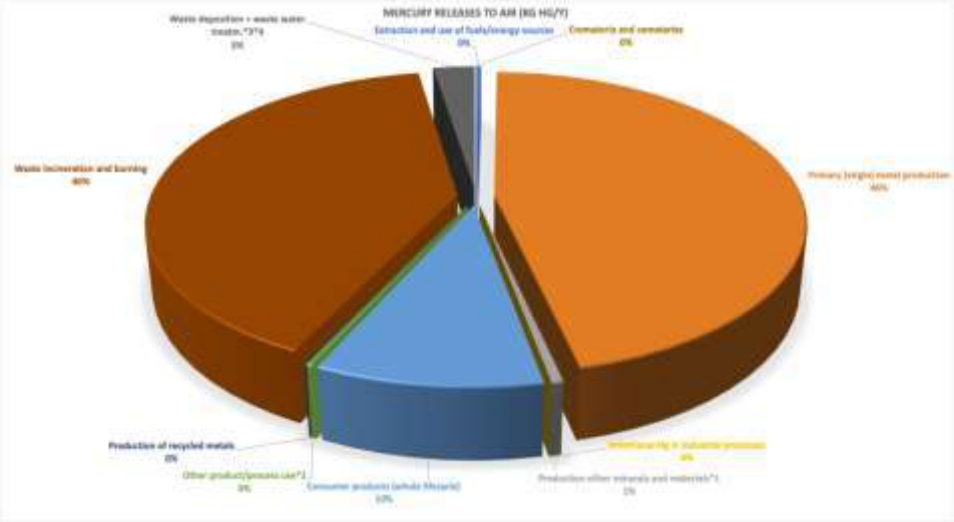
Source: https://www.unep.org/topics/chemicals-and-pollution-action/pollution-and-health/heavy-metals/mercury/mercury-inventory

UNEP's Toolkit for identification and quantification of mercury releases

MINAMATA CONVENTION ON MERCURY

Minamata Initial Assessment Report for Zambia (2017)

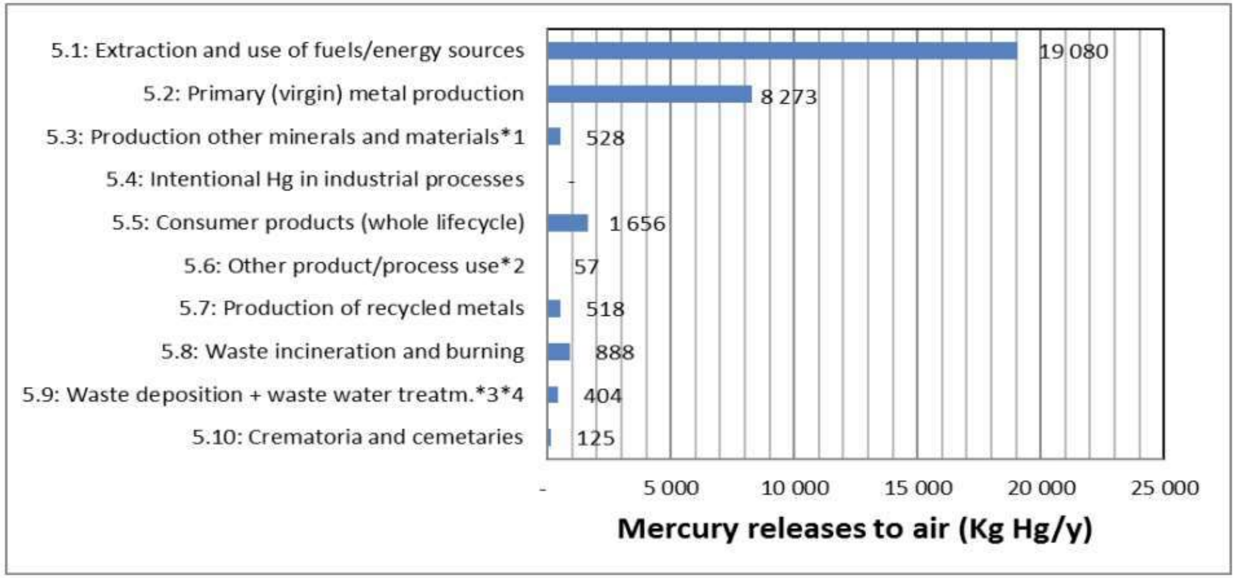
Source No.	Source category	Calculated Hg output, Kg/y						
		Air	Water	Land	By-products and impurities	General waste	Sector specific treatment/disposal	Total releases by source category
1	Extraction and use of fuels/energy sources	99	0	-	-	1	5	105
2	Primary (virgin) metal production	14,705	1,719	13,976	30,196	-	33,174	93,770
3	Production other minerals and materials*1	166	-	-	71	-	-	237
4	Intentional Hg in industrial processes	-	-	-	-	-	-	-
5	Consumer products (whole lifecycle)	3,164	288	3,219	-	6,190	0	12,861
6	Other product/process use*2	68	459	3	-	394	389	1,314
7	Production of recycled metals	36	-	37	-	36	-	109
8	Waste incineration and burning	12,815	-	-	-	-	-	12,815
9	Waste deposition + waste water treatm.*3*4	813	1,165	6,258	-	121	121	8,477
10	Crematoria and cemetaries	0	-	141	-	-	-	141
	SUM OF QUANTIFIED RELEASES*3*4	31,865	3,229	17,537	30,267	6,742	33,689	123,330



https://minamataconvention.org/sites/default/files/documents/minamata_initial_assessment/Zambia-MIA-2017.pdf

Minamata Initial Assessment Report for South Africa (2021)

Category	Source category	Calculated. Hg input to society(Kg/y)	Percentages of Total
5.1	Extraction and use of fuels/energy sources	38080	53.8
5.2	Primary (virgin) metal production	12894	18.2
5.3	Production of other minerals and materials with mercury impurities	803	1.1
5.4	Intentional use of mercury in industrial processes	0	0.0
5.5	Consumer products with intentional use of mercury	11726	16.6
5.6	Other intentional product/process use	4346	6.1
5.7	Production of recycled metals ("secondary" metal production)	1594	2.3
5.8	Waste incineration*3	905	1.3
5.9	Waste deposition/landfilling and wastewater treatment	408	0.6
5.10	Crematoria and cemeteries	1250	1.8



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UNEP's Toolkit for identification and quantification of mercury releases

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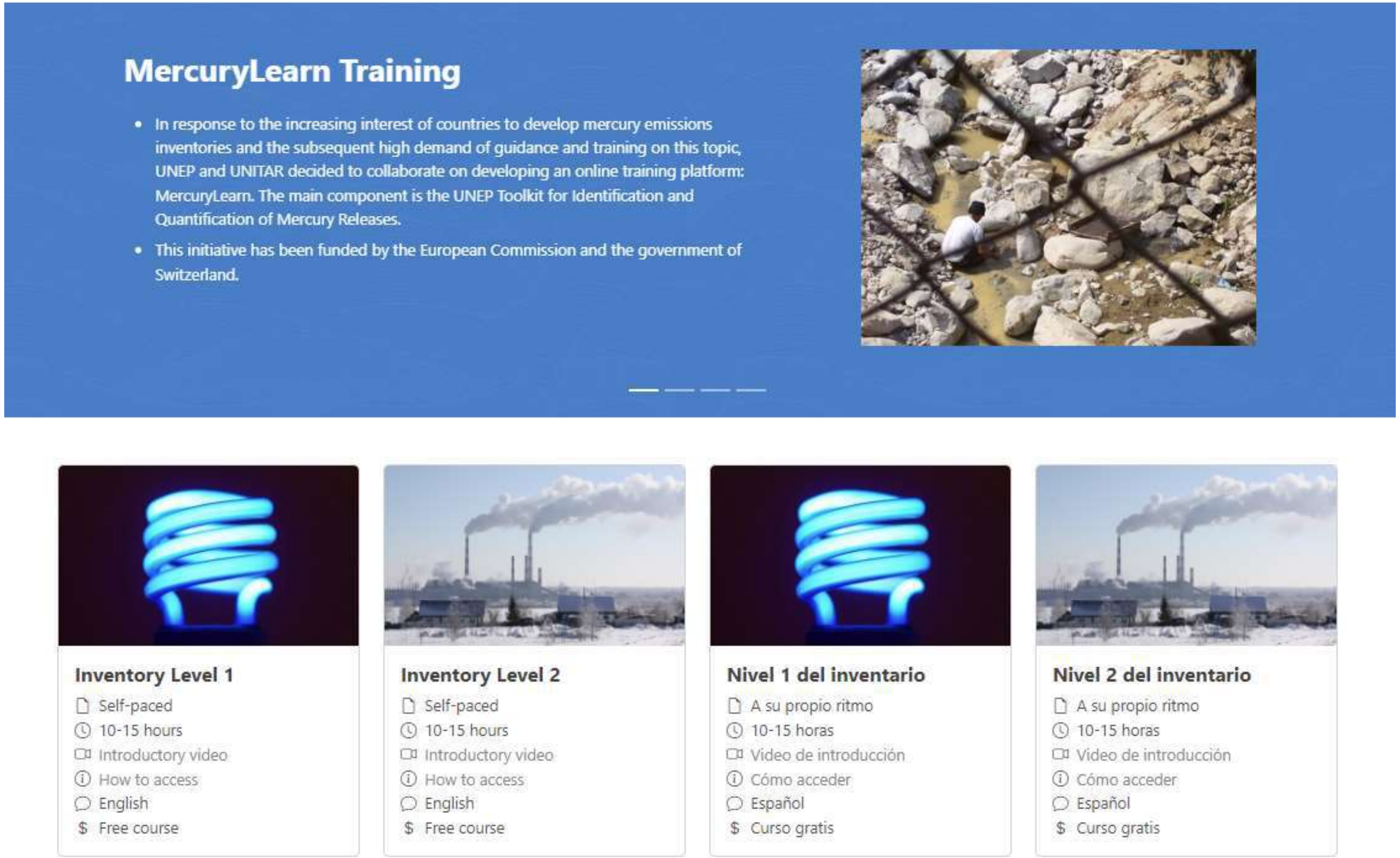
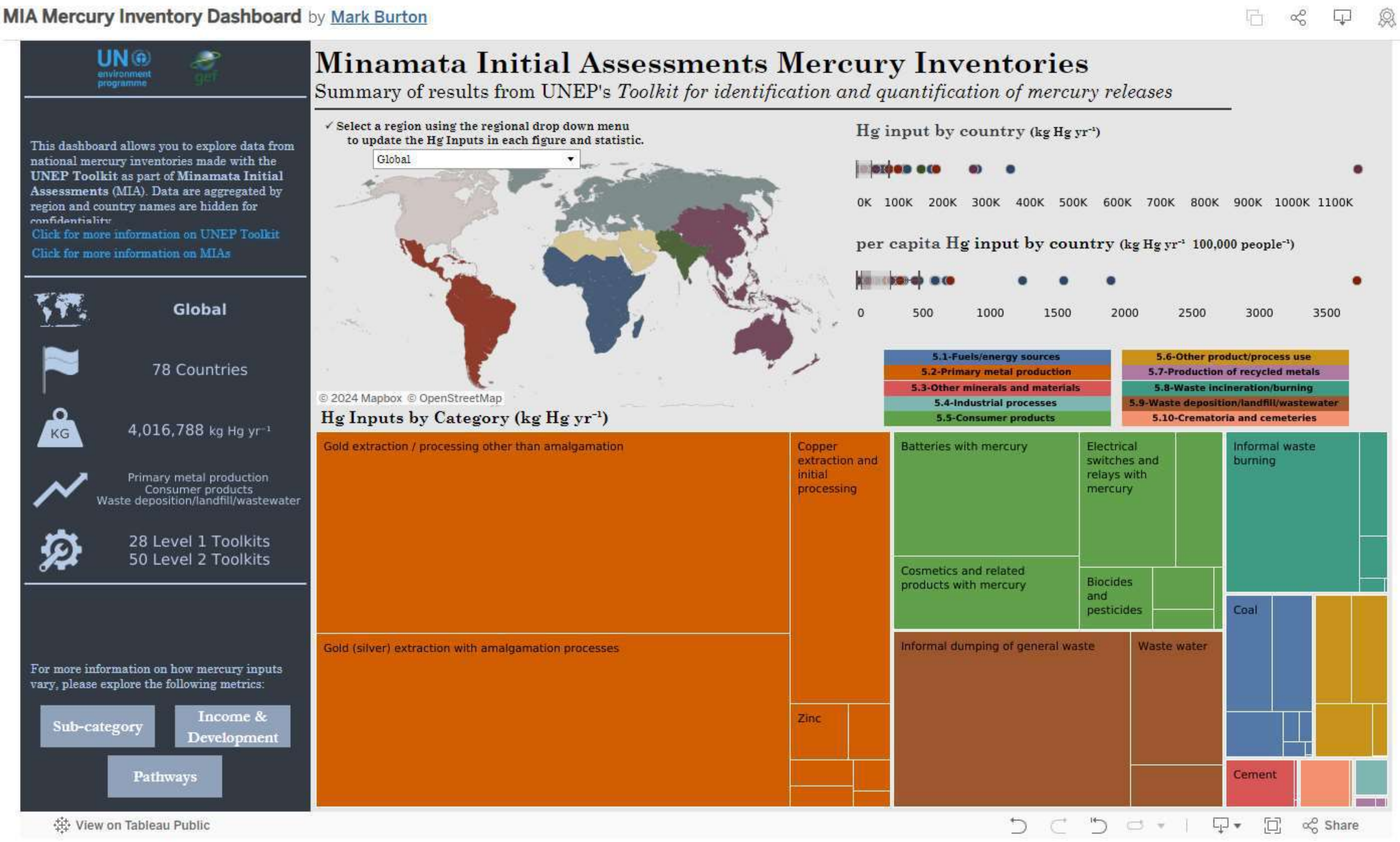


- https://mercurylearn.unitar.org/
- **Online training modules on the UNEP's Toolkit for identification and quantification of mercury releases Inventory Level 1 and 2**
- **Self-paced, available in English and Spanish**

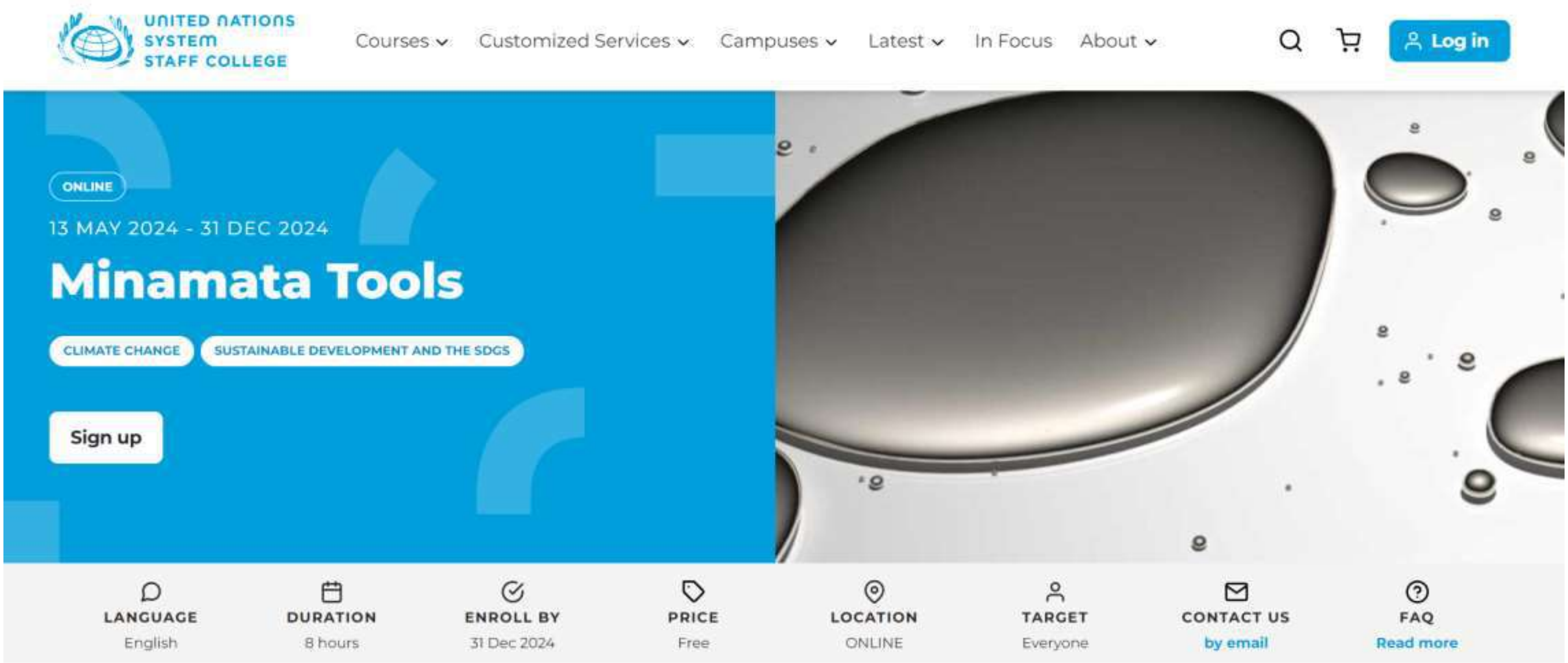
Minamata Convention Initial Assessments



https://public.tableau.com/app/profile/mark.burton.bri/viz/MIAMercuryInventoryDashboard/Main_Dashboard?publish=yes

Minamata (training) Tools

MINAMATA CONVENTION ON MERCURY



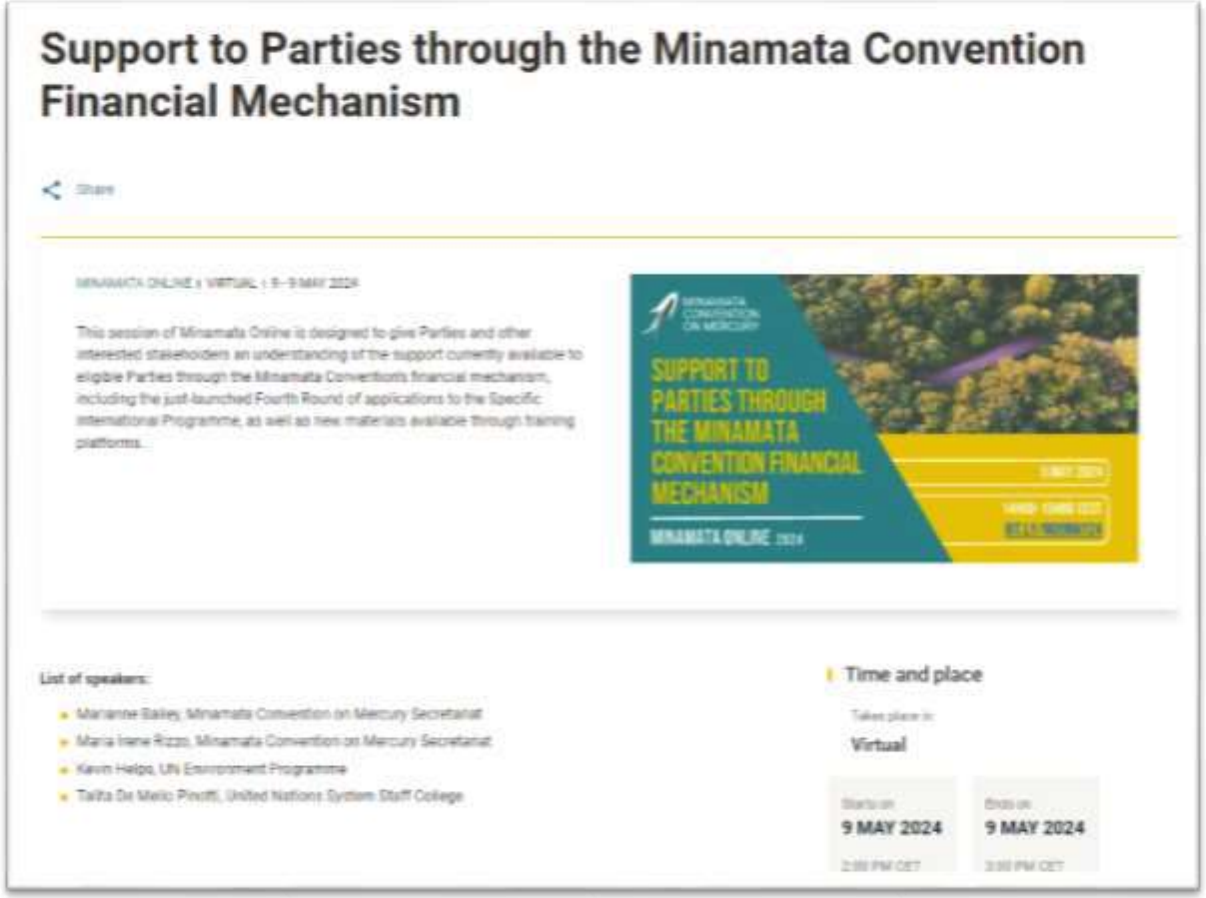
Funded by the European Union

Developed with the generous support of the European Union as part of project "Support to the capacity-building and technical assistance programme of the Secretariat of the Minamata Convention on Mercury"

► https://www.unssc.org/courses/minamata-tools-0

Minamata Online

Minamata Online series of virtual webinars on various topics related to the Minamata Convention on mercury since 2020



https://minamataconvention.org/en/meetings/upcoming-list-view?field_event_type_target_id=287

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Thank you for your attention

Secretariat of the Minamata Convention on Mercury
United Nations Environment Programme
11-13, Chemin des Anémones - 1219 Châtelaine, Switzerland

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TWITTER: @minamataMEA
#MakeMercuryHistory

Using Inventory Data and Planned Policies to Inform Future Emission Scenarios in Pakistan

MACQUARIE University SYDNEY · AUSTRALIA

One-day working event on inventory production and compliance strategies for the South African Coal fleet under the Minamata Convention

6 June 2024

Project Outcomes

OUTCOME 1:

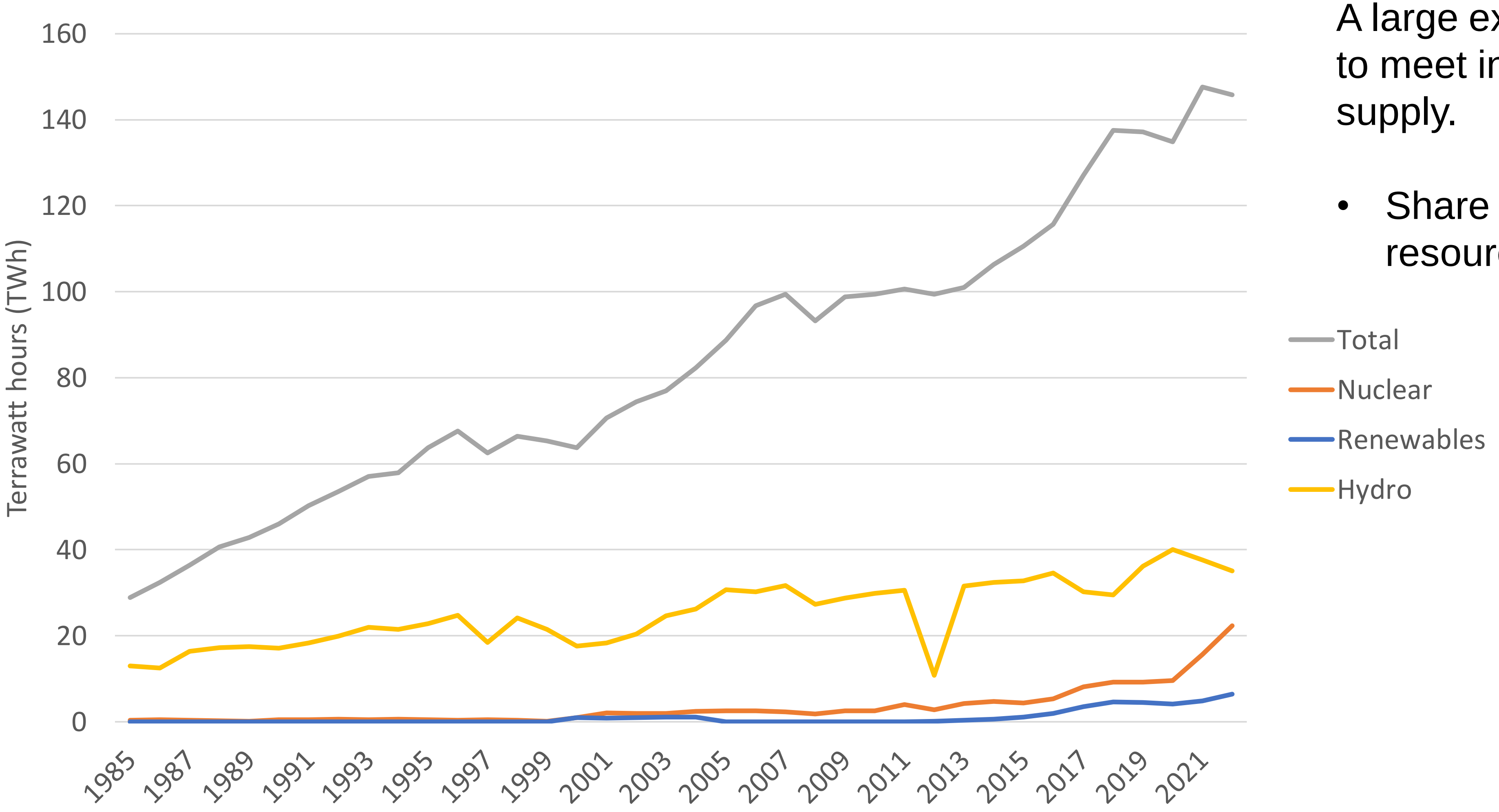
Comprehensive coal sectoral analysis

Activities

- Review scientific data on mercury emissions from CFPPs
- Evaluate the impact of commitments and targets by UN Conventions on Hg/GHG/POP emissions from the coal sector
- Potential mercury reduction figures & scenarios from CFPPs produced
  - Expand to Coal-Fired Industrial Boilers (CFIB)

Pakistan Energy Mix

ENERGY INSTITUTE – STATISTICAL REVIEW OF WORLD ENERGY



A large expectation of non-fossil fuels to meet increased power demand and supply.

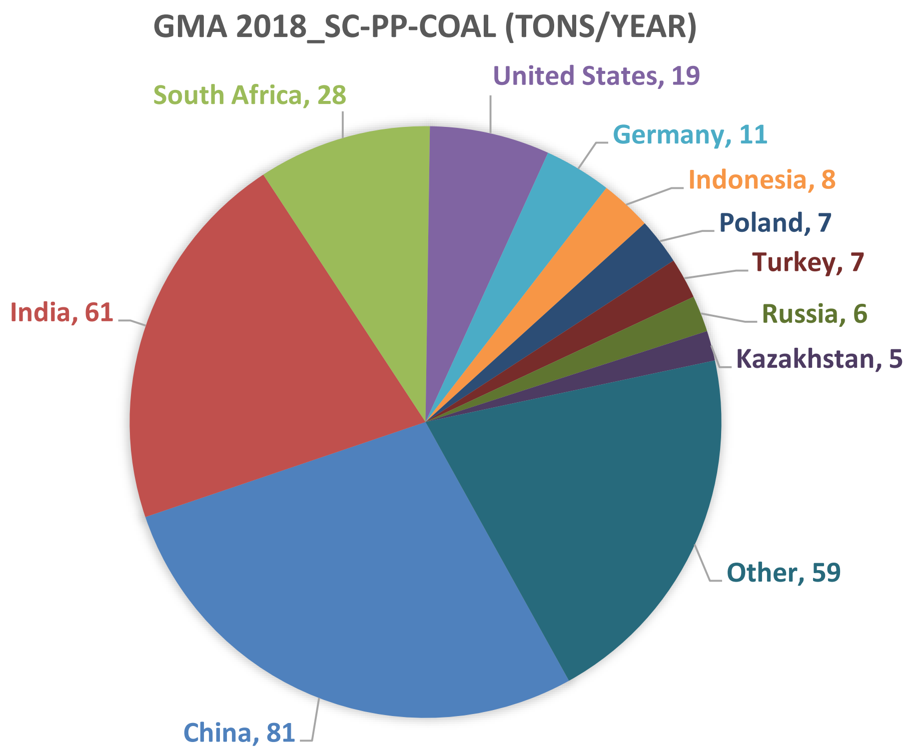
- Share of non-fossil energy resources still low

Global Mercury Assessment 2018

MACQUARIE University
SYDNEY·AUSTRALIA

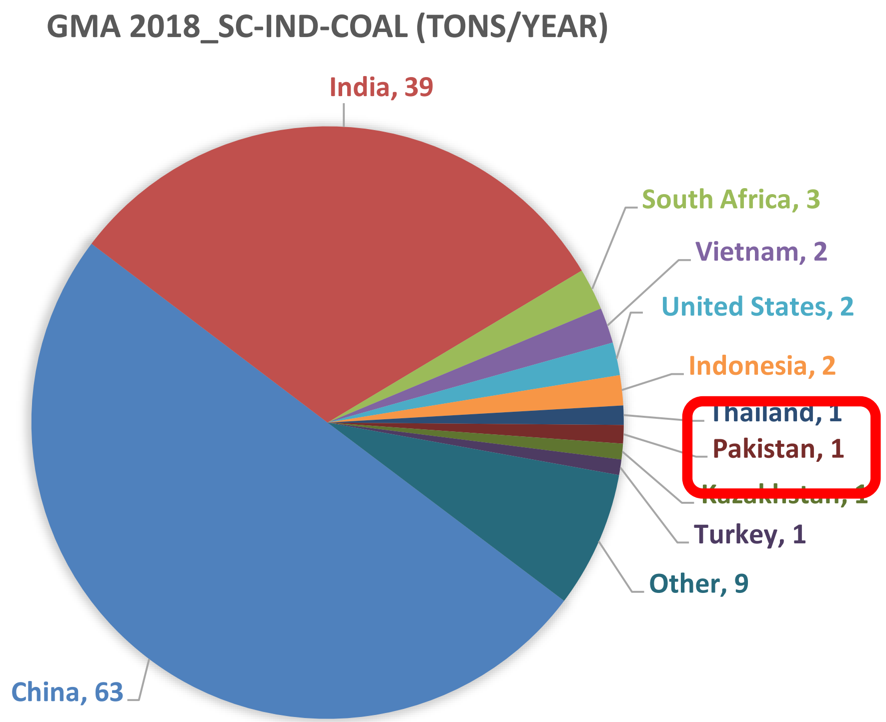
PAKISTAN IN THE GLOBAL CONTEXT

Stationary Combustion of Coal at Power Plants
292 tons/year



China, India & South Africa = 47% - 59% global coverage

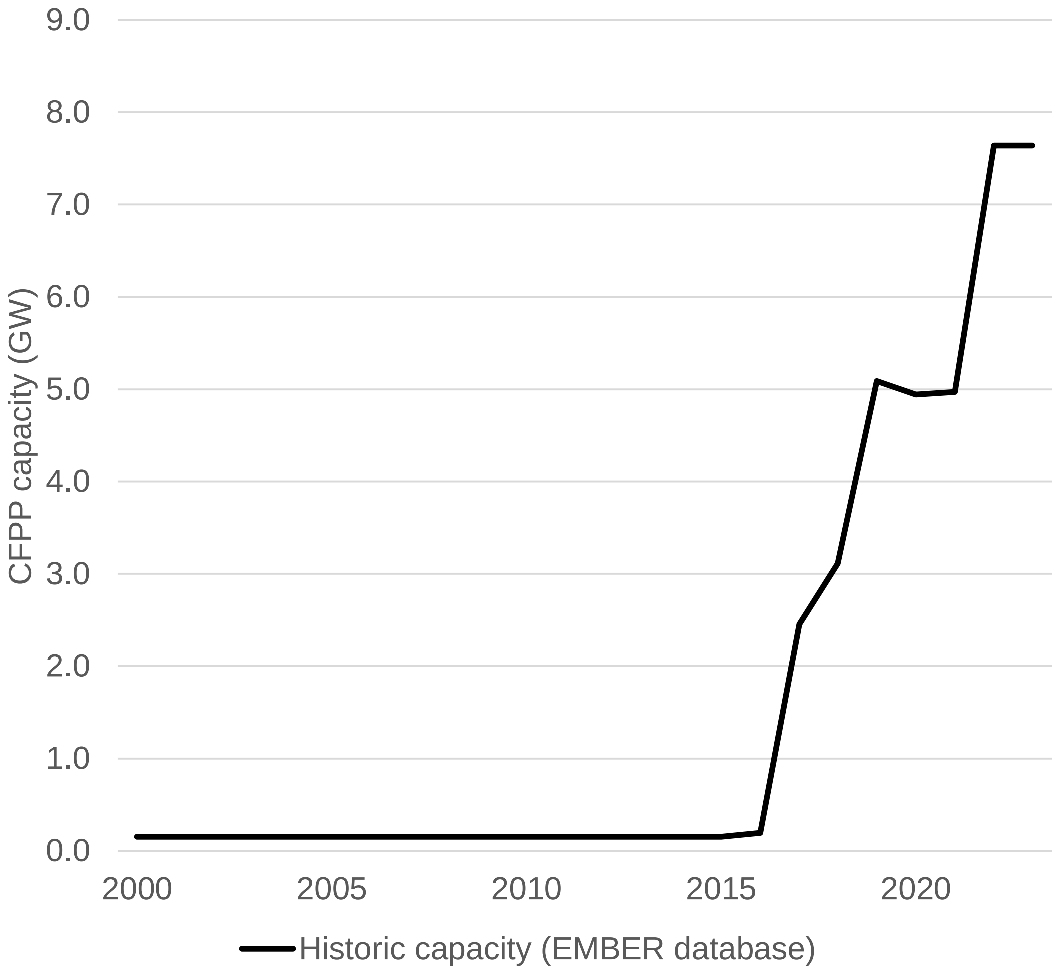
Stationary Combustion of Coal at Industrial Boilers
126 tons/year



China & India = 73% - 83% global coverage

Pakistan Coal-Fired Power Plants

LARGE INCREASE SINCE 2015 – EST. 7,6GW (2023)



<u>Coal consumption in power plants (MIA 2021):</u>

4,436,100 tonnes / year (Economic Survey of Pakistan - 2016-2017).

- Sub-bituminous (brown) coal (2,825,000 t/y)
- Lignite (brown) coal (1,611,100 t/y)

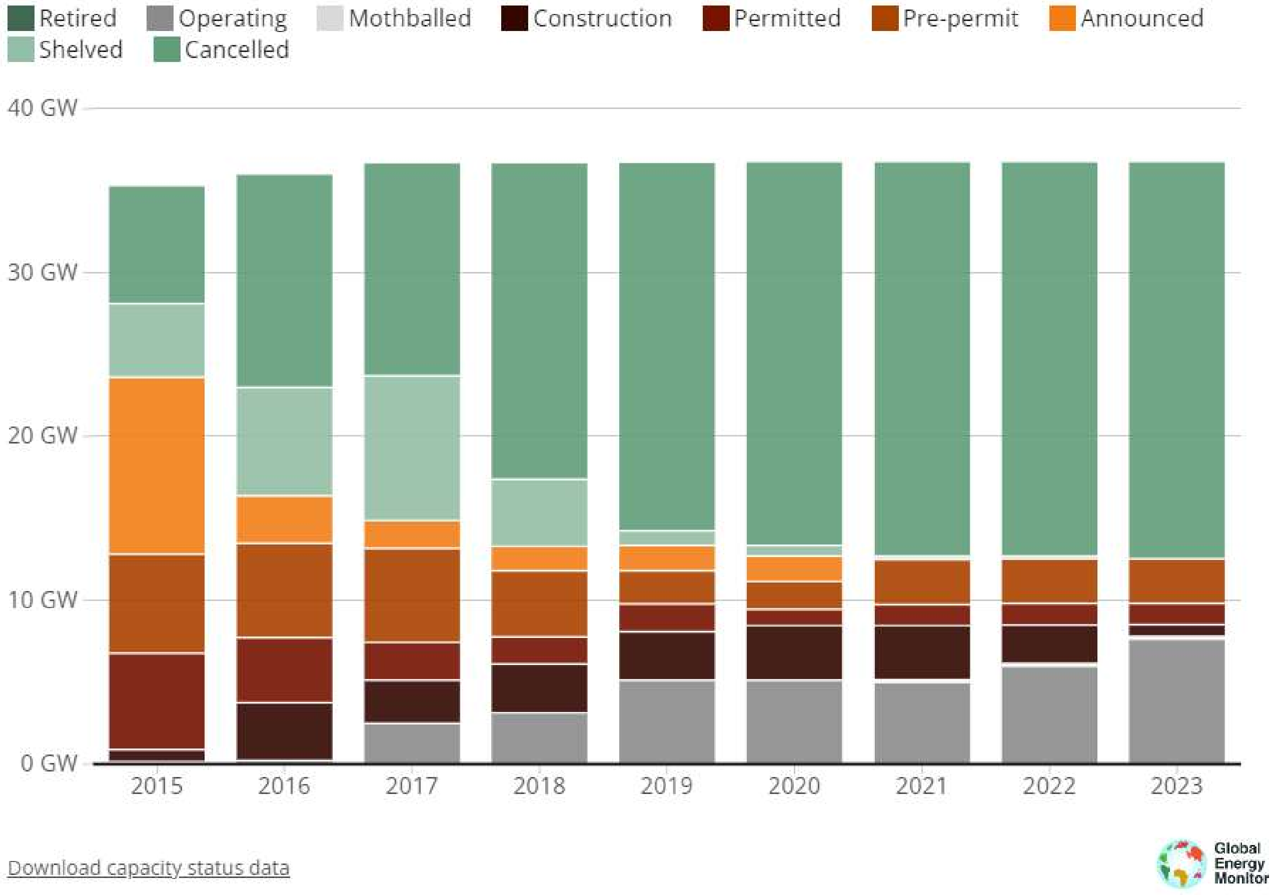
* Coal type influence mercury removal efficiency as mentioned in Minamata toolkit & POG

Global Energy Monitor – Global Coal Plant Tracker database

HTTPS://GLOBALENERGYMONITOR.ORG/PROJECTS/GLOBAL-COAL-PLANT-TRACKER/

How does coal capacity break down by status?

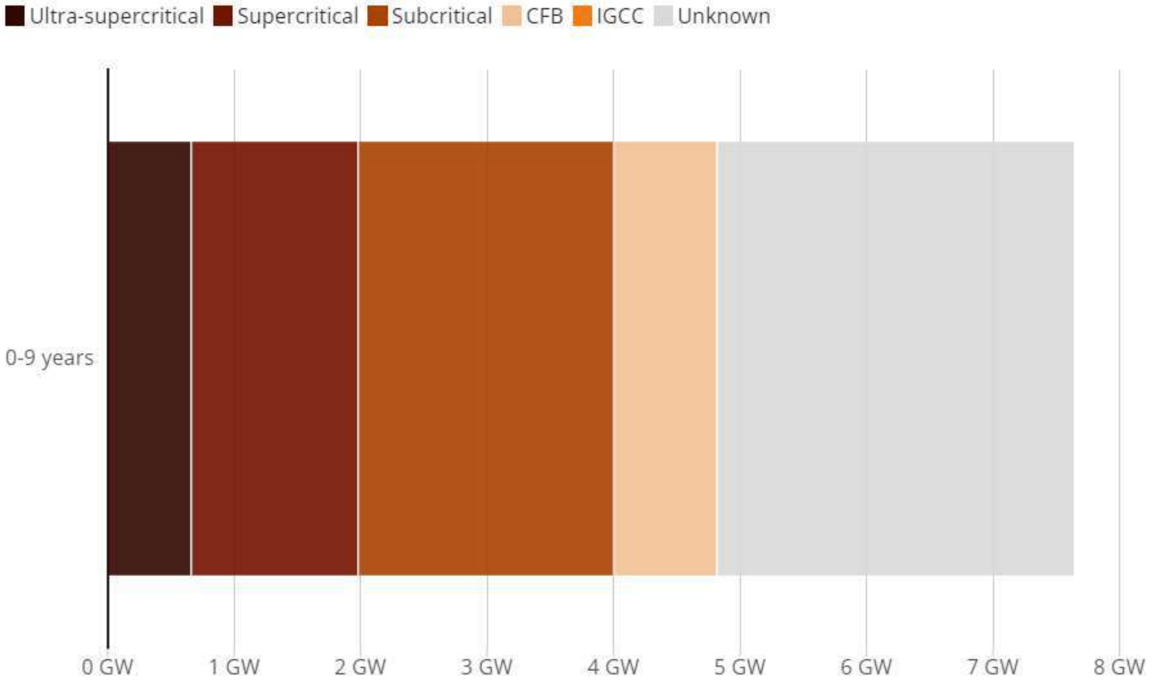
Coal-fired power capacity by status, each year since 2015



Download capacity status data

What is the age and technology of operating coal capacity?

Operating coal-fired power capacity, by unit age group and technology type



Download age and technology type data •

GEM wiki link for full definitions of coal plant technology type

Pakistan Minamata Initial Assessment 2021

MCM RATIFICATION – DECEMBER 2020

MACQUARIE University SYDNEY·AUSTRALIA

Table3.4:- Summary of calculated Hg output in different environmental compartments

Toolkit Chapter		Source category	Exists (Y/N/?)	Calculated Hg output, Kg/y					
				Air	Water	Land	By-products and impurities	General waste	Sector specific treatment /disposal
5.1	Source category: Extraction and use of fuels/energy sources								
	5.1.1	Coal combustion in power plants	Y	167	0	0	0	0.0	500
	5.1.2.1	Coal combustion in coal fired industrial boilers	Y	0	0	0	0	0	0
	5.1.2.2	Other coal use	Y	1121	0	0	0	0	0
	5.1.3	Mineral oils - extraction, refining and use	Y	336	4	0	0	0	14
	5.1.4	Natural gas - extraction, refining and use	Y	822	814	0	2,035	0	407
	5.1.5	Other fossil fuels - extraction and use	N	0	0	0	0	0	0
	5.1.6	Biomass fired power and heat production	Y	2,273	0	0	0	0	0
	5.1.7	Geothermal power production	N	0	0	0	0	0	0
5.2	Source category: Primary (virgin) metal production								

Mercury input factor (mg Hg/ kg coal)

0.15

CFPPs:

Emission to air:

- 0.167 tonnes / year

CFIBs:

Emission to air:

- 0 tonnes / year – contrasting result from GMA 2018

GMA 2018

Row Labels	Sum of Emission estimate, kg	Sum of Low range estimate, kg	Sum of High range estimate, kg
CEM	3488	1232	18387.2
SC-IND-coal	1270.8	686.232	3028.74
SC-PP-coal	17.775	9.5985	42.36375
Grand Total	4776.575	1927.8305	21458.30375

Methodology – CFPP emissions

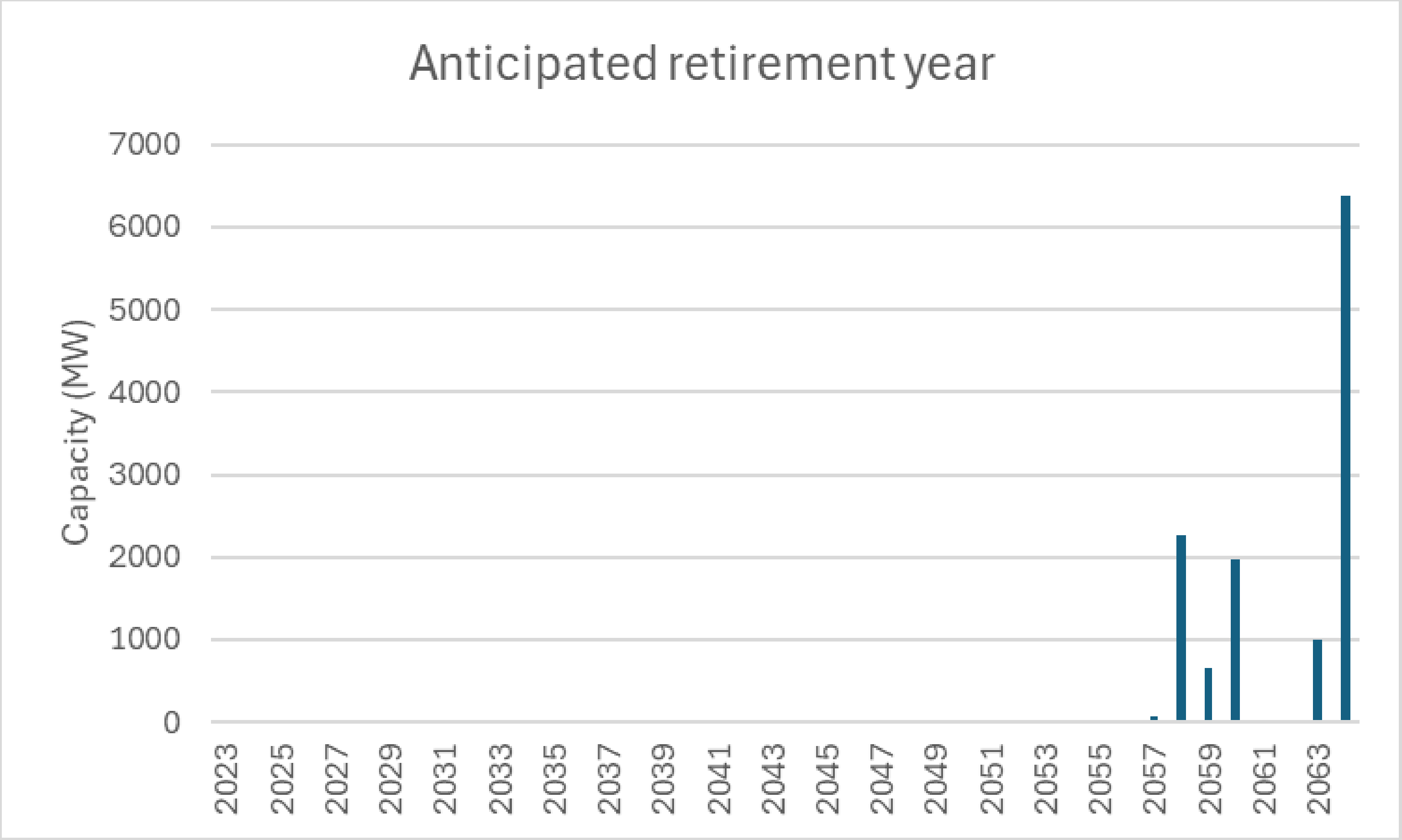
BASELINE DATA FROM THE GLOBAL ENERGY MONITOR

https://globalenergymonitor.org/projects/global-coal-plant-tracker/
https://globalenergymonitor.org/projects/global-coal-plant-tracker/methodology/

Country- & Unit-level information
- Capacity (MW)
- Start/Planned retirement year
- Combustion technology
- Coal type
- Heat rate (Btu/kWh) - https://www.gem.w
- Capacity factor - Global average from Inte
- Remaining plant lifetime

E.g., Heat Rate
– Pakistan CFPP units

Low – 8,272 Btu / kWh
High – 10,326 Btu / kWh



Methodology – CFPP emissions

BASELINE DATA FROM THE GLOBAL ENERGY MONITOR

Assumptions/uncertainties

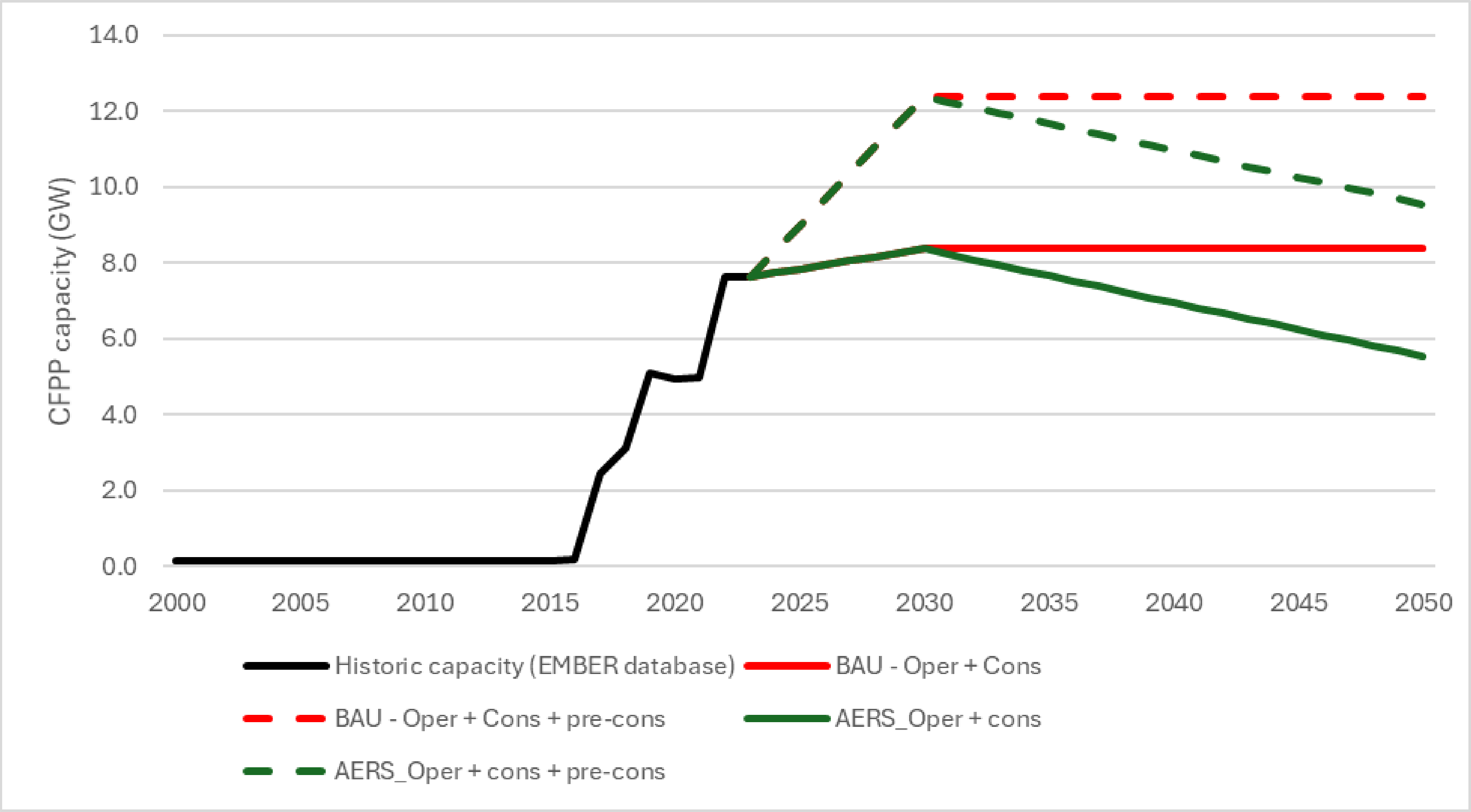
- Default 40-year plant life expectancy
- New project start year (where not indicated) – operational by 2030
- Mercury emissions
  - Defined APCD configurations on unit level limited
    - Assumption – **ESP** only for existing units, **ESP + FGD** for all new builds (construction/pre-construction)
  - Unit-level capacity factors
  - Unit-level GCV (kJ/kg coal) – average levels per coal type based on Annex 28 of the Stockholm Convention Toolkit

GCV (kJ kg coal)	Av
Bituminous	29300
Subbituminous	14500
Anthracite	30667
Lignite	8583
Unknown	25000
Waste coal	25000

Stockholm Convention Annex 28 averages

  - Mercury coal input factor – 0.15 mg/kg – Default input factor & also used in Pakistan's MIA
  - Limitations: Additions of mercury-specific controls, Br additions, coal washing, Hg speciation, Cl content, coal blending/co-firing

CFPP capacity outlook - Pakistan



Business-as-usual (BAU)

2024: 7.6GW
2030: 8.4 - 12.4GW
2050: 8.4 -12.4GW

10-year early retirement (AERS)

2030: 8.4 - 12.4GW
2050: 5.5 - 9.5GW

Methodology – Mercury Emissions Estimate (UNEP toolkit)

Mercury emission (kg/year) = Coal consumption * IF * ((100-RF)/100)

HRV / GCV * CAP * CF * 9.24E03

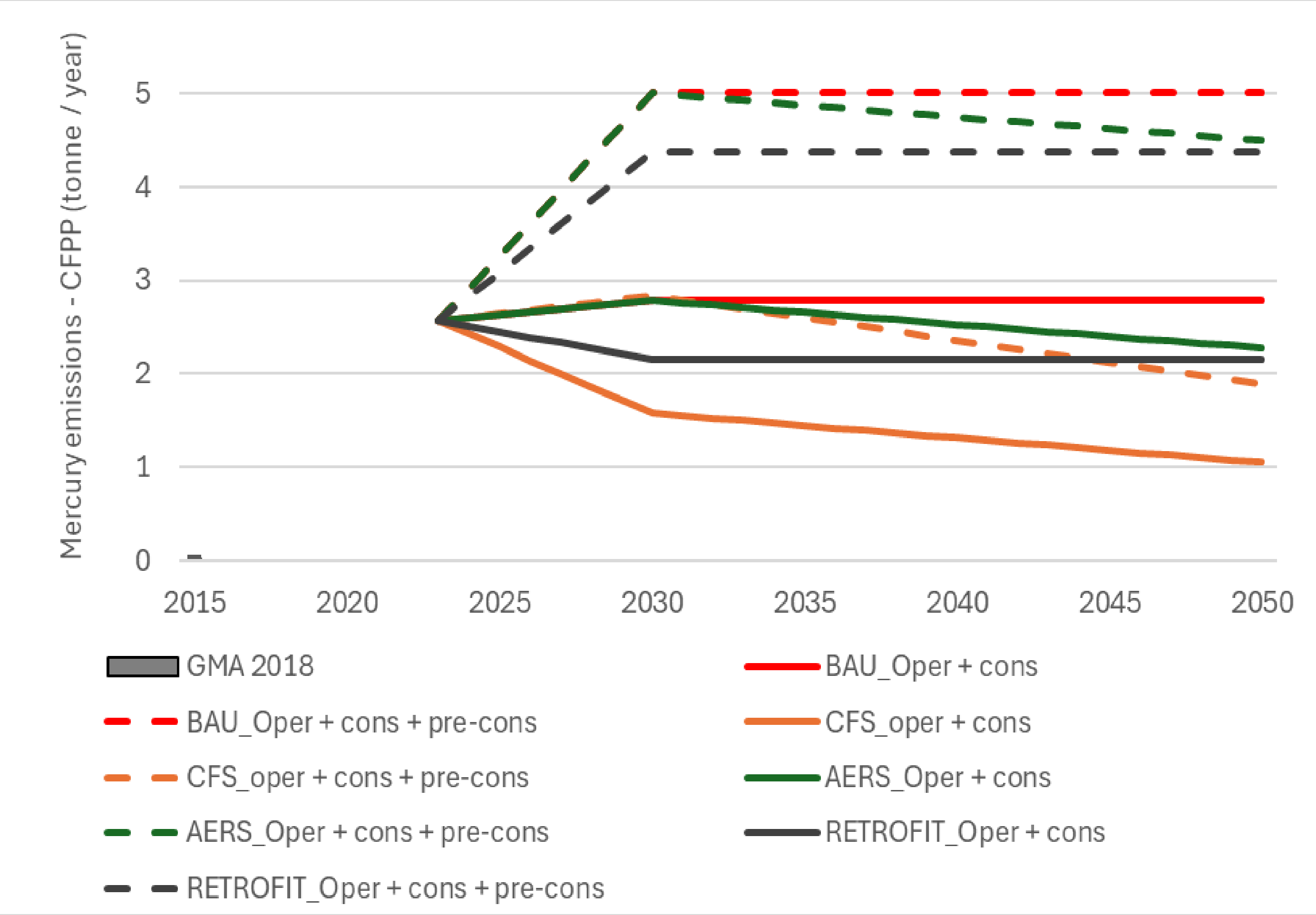
Pakistan CFPPs (2023) = 21.7 million tonnes / year

Mercury input factor by country (mg/kg) - USGS default		
China	0,17	Liu et al., 2019
India	0,22	India country profile
Indonesia	0,06	BCRC-SEA, 2017
Vietnam	0,28	UNEP, 2017
Philippines	0,08	USGS
Thailand	0,14	USGS
Malaysia	0,08	USGS
South Africa	0,21	https://link.springer.c
REMAINING WORLD	0,15	USGS
Australia	0,08	USGS
United States	0,13	https://pubs.usgs.gov

Table 5-11 Mercury retention rates and application profile developed by UNEP/AMAP (2012).

	Intermediate mercury retention rates, %, by coal type		Degree of application (%) by country group *1				
Air pollution controls	Hard coal (anthracite, bituminous)	Brown coal (sub-bituminous, lignite)	1	2	3	4	5
Industrial use (combustion):							
Level 0: None	0.0	0.0			25	50	75
Level 1: Particulate matter simple APC: ESP/PS/CYC	25.0	5.0	25	25	50	50	25
Level 2: Particulate matter (FF)	50.0	50.0	25	50	25		
Level 3: Efficient APC: PM+SDA/wFGD	50.0	30.0	25	25			
Level 4: Very efficient APC: PM+FGD+SCR	90.0	20.0	25				
Level 5: Mercury specific	97.0	75.0					
Other coal combustion:							
Level 0: None	0.0	0.0	50	50	100	100	100
Level 1: Particulate matter simple APC: ESP/PS/CYC	25.0	5.0	50	50			

CFPP Mercury Emissions



BAU – Business as Usual

AERS – Early Retirement

- All subcritical CFPPs retire 10 years earlier

CFS (Capacity factor scenario)

- 2024 – 0.53 (default global average)
- 2030 – 0.3
- 2050 – 0.2

More alternative energy resources (e.g., RE, nuclear, etc)

RETROFIT scenario

RETROFIT scenario criteria	
Remaining lifetime	20
Original APCD configuration	ESP
New APCD configuration	ESP + FGD
Unit status to retrofit	Operating
Retrofit by	2030

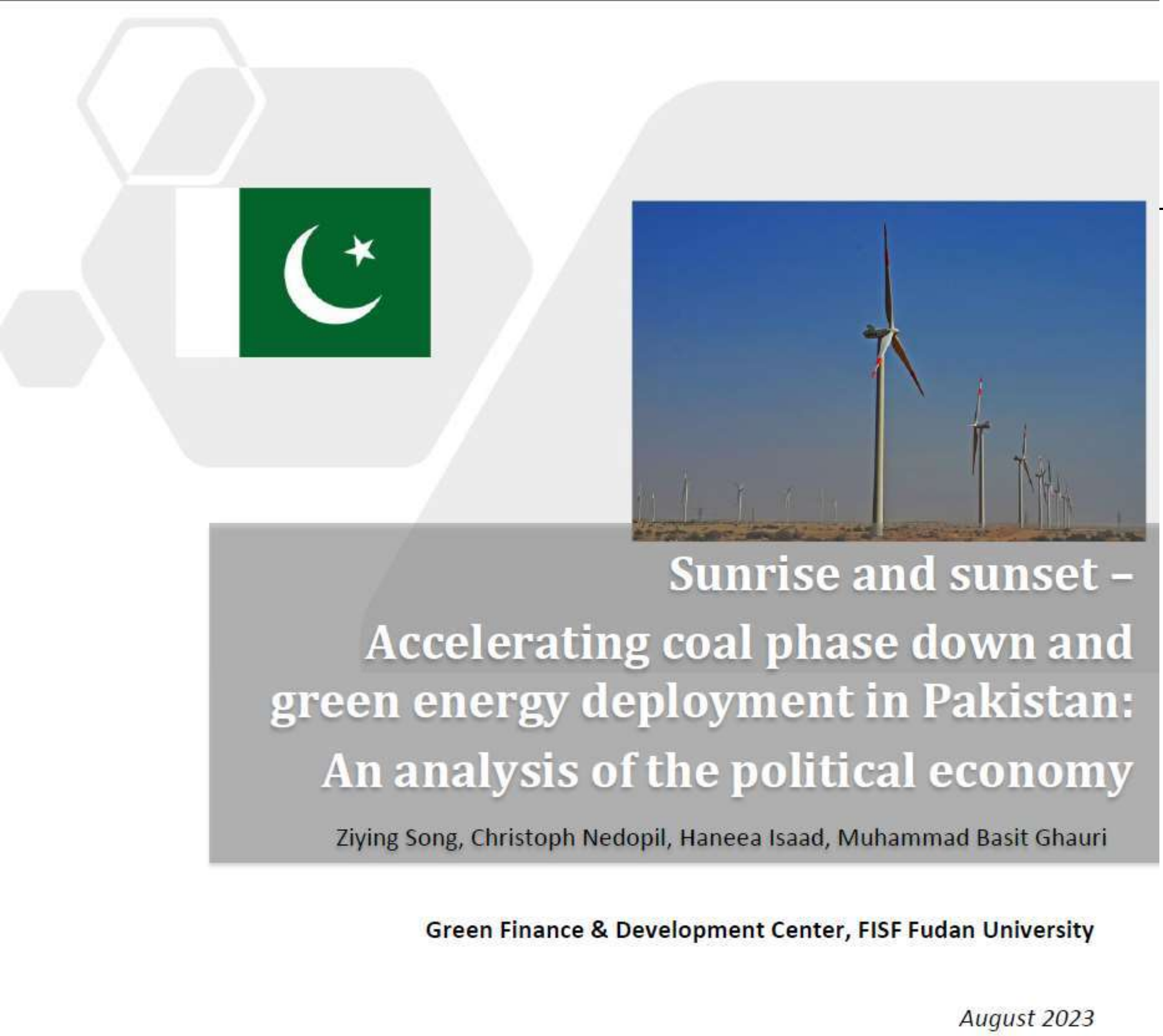
Project Outcomes

Activities

- Synthesis of results from completed & ongoing CFPP projects
- Selection criteria: Future projects based on highest impact potential
  - Guidance on where to support large scale projects – Training/Capacity-Building
- Assist public and private sectors in their decision-making processes

OUTCOME 2:

STRATEGY FOR THE COAL SECTOR'S EMISSIONS REDUCTION CONTRIBUTION TO STOCKHOLM AND MINAMATA CONVENTIONS



Sunrise and sunset –
Accelerating coal phase down and green energy deployment in Pakistan: An analysis of the political economy

Ziying Song, Christoph Nedopil, Haneea Isaad, Muhammad Basit Ghauri

Green Finance & Development Center, FISF Fudan University

August 2023

Coal-phase out & renewable energy development:

Limitation – "…***long-term green benefits have been superseded by Pakistan's short-term concerns regarding energy security***…"

"…***Achieving transformative change and diminishing the role of coal in the medium to long term requires a deep understanding of the local political economy***…"

Pakistan's continued reliance on China for future renewable energy growth

Thank you

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Inventory enhancement for coal using the iPOG

Workshop to enhance inventories and strategies under Article 8 of the Minamata Convention in Pakistan

Virtual Event

Thursday 6th June 2024

Wojciech Jozewicz, PhD

Background

- iPOG is an interactive application for UNEP's POG
- Developed for UNEP Coal Partnership by Niksa Associates
- Tool to help determine approaches to Hg emission control and rank them for individual coal-fired units
- Tradeoffs were made to only include basic inputs at the expense of quantitative accuracy
- Allows for addition of flue gas cleaning approaches and systems according to BAT/BEP
  - Improved fuel quality and blending
  - PM, SO_2, and NO_X control systems for co-benefit
  - Dedicated Hg control technology
- Follows "Decision Tree" logic from the POG

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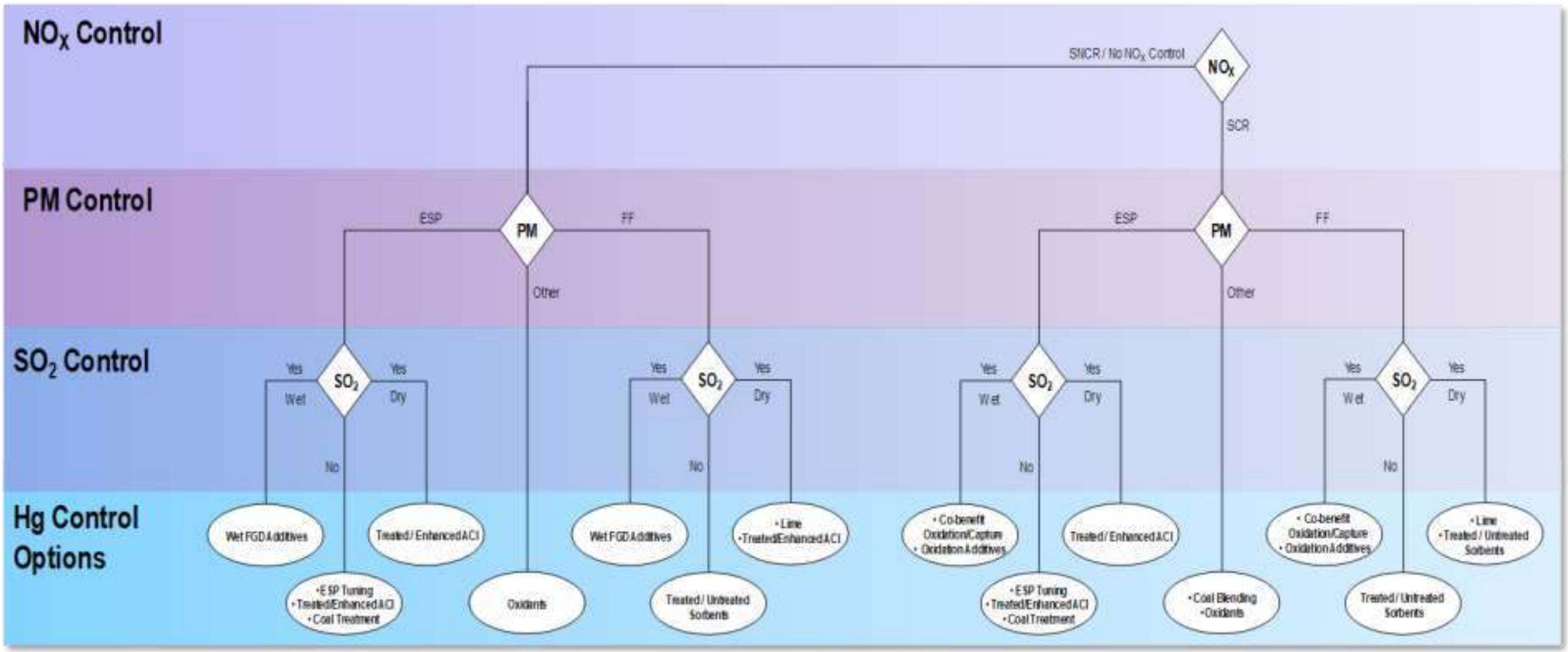
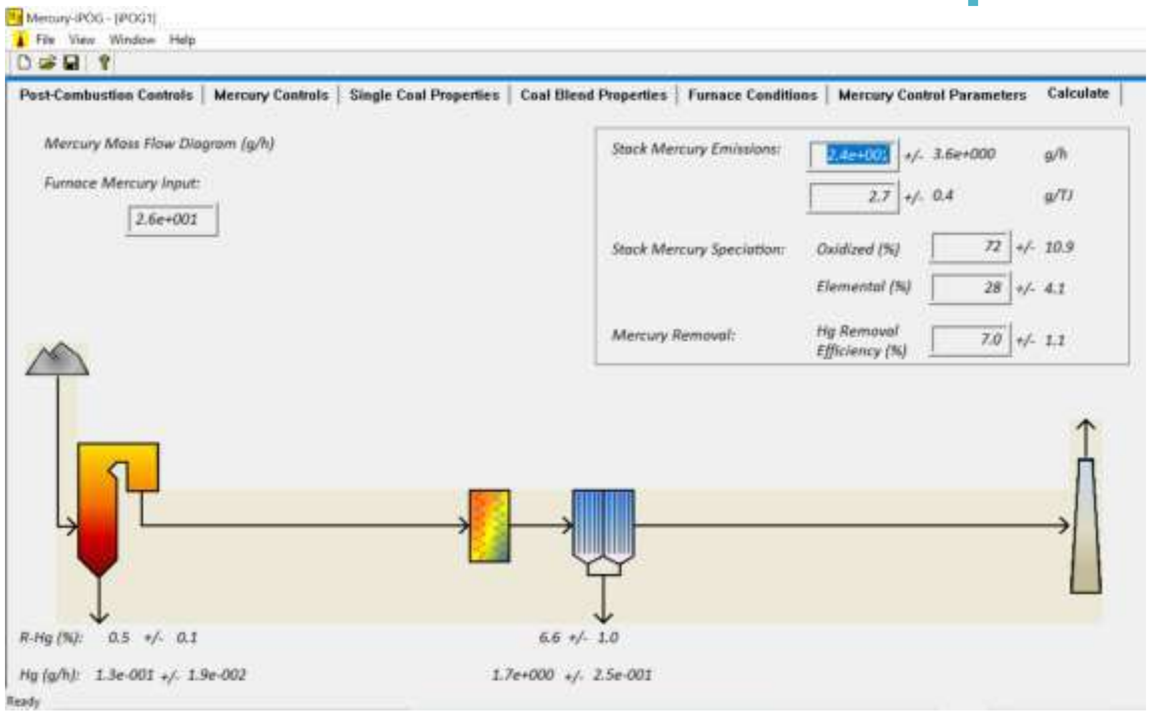
iPOG "Decision Tree" Structure



iPOG Calculations Tab - Example



- Final tab to initiate calculations sequence
- In this example: older but well-controlled 500 MW, wall-fired boiler, burning low-S coal, cold-side ESP
- Essentially no Hg removal predicted (<10%)
- Estimated Hg emissions of 24 g/h or up to about 0.2 ton Hg/year

Data Quality Very Important

- Stakeholders should ensure that any missing data are obtained directly from the plant considered for the project rather than by the proxy calculations
- Unit details: generating capacity, commissioning date, planned retirement
- Unit performance: operational load, utilization, gross efficiency, coal consumption, LOI
- Coal quality: calorific value, ash-S-Hg-Cl content
- Emissions controls: PM, FGD, Hg controls
- Quality data in – Quality results out!

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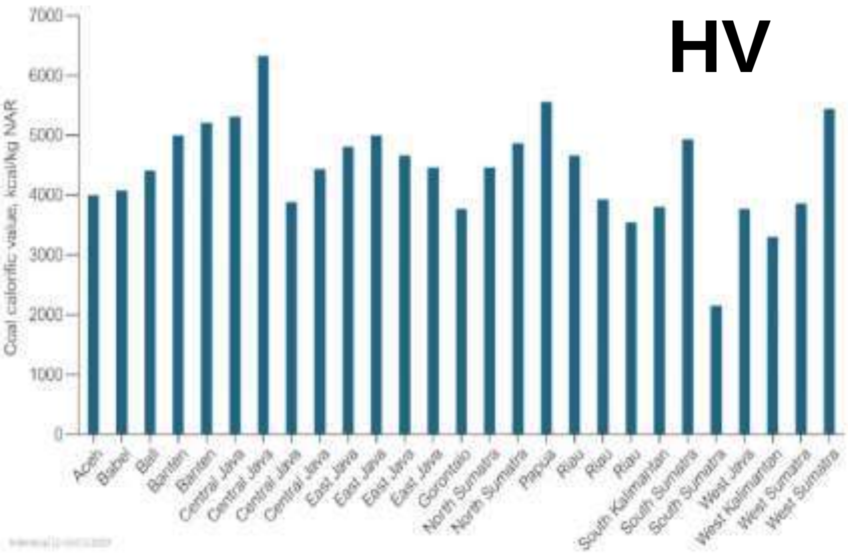
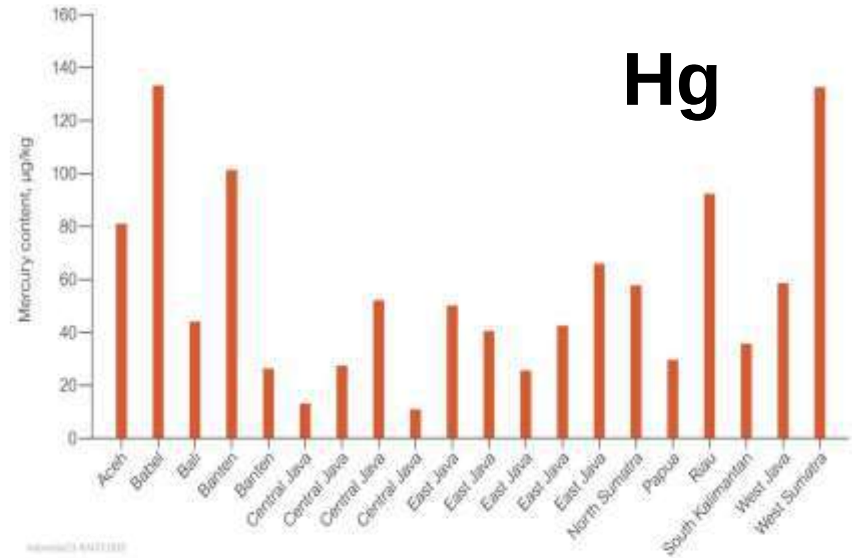
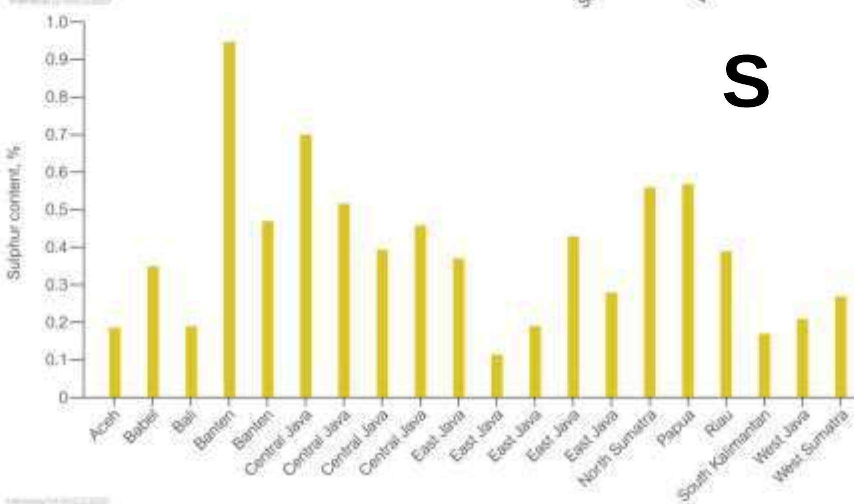
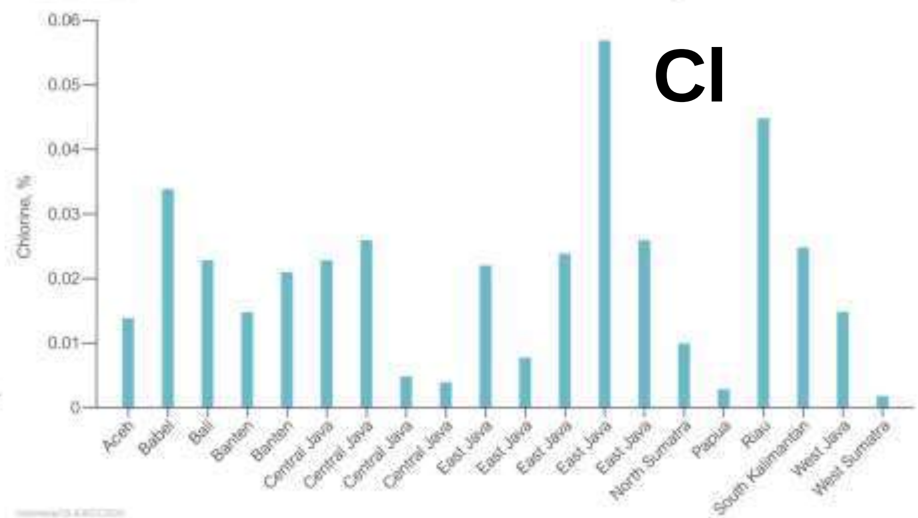
Variability Examples









Bituminous Coal Fired Unit

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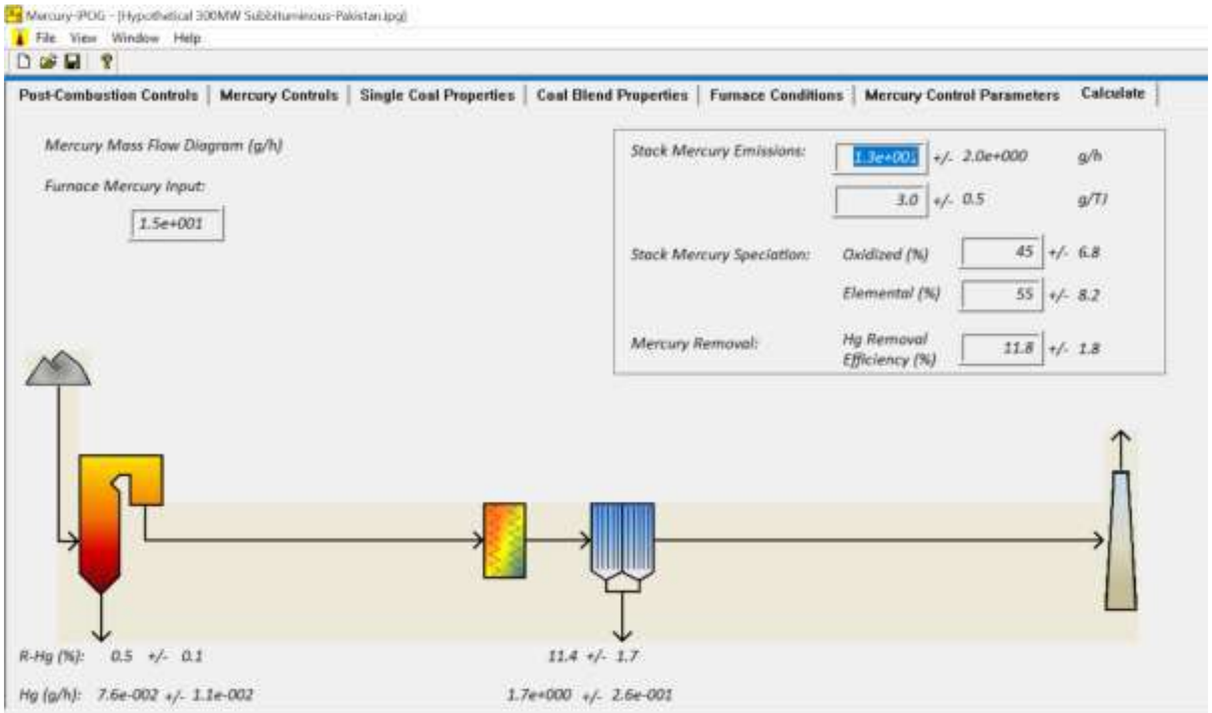
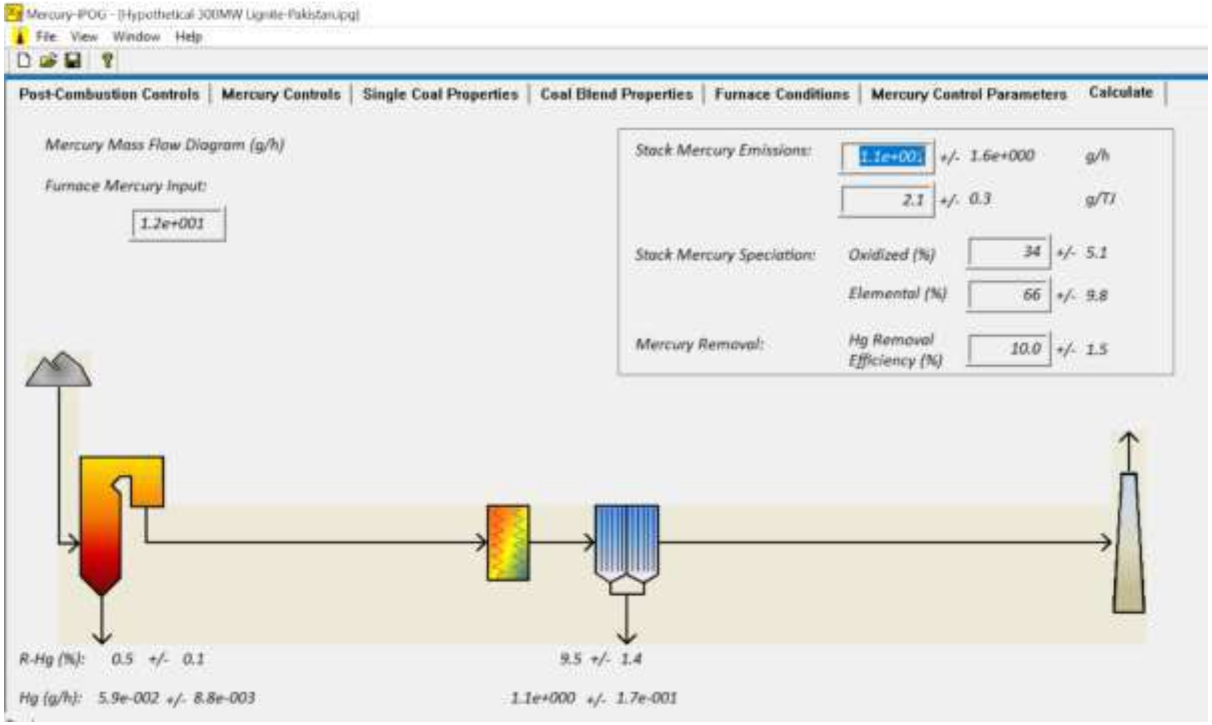


- 300 MW unit with ESP
- Only about 12% Hg removal; emissions 55% of Hg^0 and 45% of Hg^{++}

Lignite Coal Fired Unit



- 300 MW unit with ESP
- Only about 10% Hg removal; emissions 66% of Hg^0 and 34% of Hg^{++}
- Emission control of Hg from lignite is generally the most demanding

Improvement Strategies

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- Various techniques and technologies can be considered to improve Hg capture by the coal-fired power plant's system. For example,
  - Replacement of ESP with an FF - Hg removal increased to 49 and to 17% for lignite and subbituminous coals, respectively.
  - Plus: ACI immediately upstream of FF- Hg removal increased to over 80% for both coals.
- Wet FGD addition for SO_2 - co-benefit Hg removal of 49% for ESP and wet FGD system.
  - Improvement possible with addition of oxidising agent to coal (to augment oxidised Hg fraction), or
  - ACI immediately upstream of the ESP (to adsorb Hg vapour)
  - 60-85% Hg removal, depending on the amount of chemical added.

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Summary

- Limited information on FGD installation and performance throughout the country
- iPOG can be used to predict Hg removal
- Data of good quality is needed for accurate predictions
- Improvement strategies possible for units of varying size and age

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Thank you!