INVENTORY OF MERCURY RELEASES IN INDONESIA

October 2012

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1. Executive Summary

1.1. Introduction

This mercury release inventory was conducted by BaliFokus in cooperation with the Ministry of Environment, the Indonesian Technical Working Group of mercury and key stakeholders in 2012 in Indonesia. This inventory was conducted by using data record in 2010, interpolation or extrapolation was also implemented to find the missing data from the same year.

The estimation of mercury release was carried out by the use of the "Toolkit for identification and quantification of mercury releases" made available by the United Nations Environment Programme's Chemicals division (UNEP Chemicals). The Toolkit is available at UNEP Chemicals' website:
http://www.unep.org/hazardoussubstances/Mercury/MercuryPublications/GuidanceTrainingMaterialToolkits/MercuryToolkit/tabid/4566/language/en-US/Default.aspx.

This inventory was developed based on the Toolkits Inventory Level-1. The Toolkit is based on mass balances for each mercury release source type. Inventory Level-1 works with **activity rate** which quantifies the mercury inputs from the amount of mercury containing material fed into the system, and pre-determined factors used in the calculation of mercury inputs to society and releases, the so-called the **default input factors**[1] and **default output distribution factors**[2]. These factors were derived from data on mercury inputs and releases from such mercury source types from available literature and other relevant data sources. All the mercury fed into the system with materials and fuels will come out again, either as releases to the environment or in some kind of product stream. The simple basic formula is used for estimating Hg release as follows:

Estimated Hg release (kg/year) = Activity rate x input factor x distribution factor

Using default output distsribution factors, part of mercury releases were calculated to the following five pathways: the air, the water, the land, by products and impurities, general waste, and sector specific waste treatment/disposal.

Due to the very limited data sources of activity rate, as well as the wide disparity from minimum to maximum value of default input factor within the toolkit, the inventory was made based on the following three steps:

- **Step one**: estimating mercury emission using minimum value of default input factor
- **Step two**: estimating mercury emission using maximum value of default input factor
- **Step three**: estimating mercury emission mainly using average value of default input factor, or based on certain value (minimum, maximum, or selected) of default input factor based on the condition in Indonesia.

[1] General data on the mercury concentration in the feed material

[2] Factors for calculation the distribution of this mercury amount on the relevant release pathways based on available data

The result of mercury estimation from Step three was chosen to describe the current mercury release in Indonesia. However, results from Step one and Step two may give a different perspective to the current estimation. This mercury inventory assessment for Indonesia has presented an indication of the pattern of emissions and sources of large generators of mercury which could be targeted for control measures.

1.2. Results and discussion

The results of mercury inventory utilizing different default input factors are presented in **Figure 1-1**. This figure shows that there is a major drawback in the toolkit, i.e. the wide range of input factors. The total mercury released was estimated to be 491,530 Kg Hg/y using the maximum values for the input factors, and if the minimum input factor were used, the estimate of 183,200 Kg Hg/yr was obtained. There is a discrepancy of about 300,000 kg Hg/y or 168% more between maximum and minimum estimation. Using the average default input factor and selected input factor for certain conditions, approximately 339,250 Kg Hg/y shall be emitted to the environment. Although there are still many uncertainties in defining the default input factors, the last estimation is considered to be the best value which is able to represent the Mercury release in Indonesia.

Source category	Estimated Mercury input to Pathway Kg Hg/y	Estimated Mercury releases, standard estimates, Kg Hg/y					
	Released Mercury	Air	Water	Land	By-products and impurities	General waste	Specific waste treatment/ disposal
Coal combustion and other coal use	33,600.0	30,240.0	0.0	0.0	0.0	3,360.0	0.0
Other fossil fuel and biomass combustion	4,441.9	4,441.9	0.0	0.0	0.0	0.0	0.0
Oil and gas production	36,482.7	4,782.9	4,772.6	0.0	2,923.7	5,403.6	0.0
Primary metal production (excl. gold prod. by amalgamation)	14,978.2	1,307.6	312.6	7,833.3	3,441.5	143.0	1,940.3
Gold extraction with mercury amalgamation	195,000.0	117,000.0	39,000.0	39,000.0	0.0	0.0	0.0
Other materials production	15,162.8	9,331.7	0.0	0.0	2,915.6	2,915.6	0.0
Chlor-alkali production with mercury-cells	-	-	-	-	-	-	-
Other production of chemicals and polymers	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Production of products with mercury content	2,779.8	26.3	13.9	278.0	0.0	278.0	27.8
Use and disposal of dental amalgam fillings	1,188.2	23.8	394.5	0.0	42.8	228.1	228.1
Use and disposal of other products	29,733.5	1,997.6	5,380.1	480.6	0.0	20,259.2	1,616.0
Production of recycled metals	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste incineration and open waste burning (*1)	31,565.2	29,391.8	0.0	0.0	0.0	0.0	2,173.4
Waste deposition (*1)	-	-	-	-	-	-	-
Informal dumping of general waste (*1)(*2)	26,992.3	2,699.2	2,699.2	21,593.8	-	-	-
Waste water system/treatment (*3)	1,944.6	0.0	1,750.1	0.0	0.0	194.5	0.0
Crematoria and cemeteries	22.5	1.1	0.0	21.3	0.0	0.0	0.0
TOTAL	**339,250.0**	**201,240.0**	**52,570.0**	**47,610.0**	**9,320.0**	**32,780.0**	**5,990.0**

Figure 1-1. Various estimation of mercury release using default input factors from UNEP Toolkit

Details of mercury release estimation is presented based on the value of mercury release of 339,250 Kg Hg/y. Presentation of the results for main groups of mercury release sources are shown in **Table 1-1**, **Figure 1-2** and **Figure 1-3** below.

The following top three source groups contribute with the major mercury inputs are:
1. Domestic production of metals and raw materials.
2. Energy consumption and fuel production.
3. Waste treatment and recycling.

As shown in **Table 1-1** and **Figure 1-1**, the individual mercury release sub-categories contributing with the highest mercury inputs were:

1. Gold extraction with mercury amalgamation.
2. Oil and gas production.
3. Coal combustion and other coal use.
4. Waste incineration and open waste burning.
5. Use and disposal of other products.
6. Informal dumping of general waste.

Figure 1-2 shows the gold extraction with mercury amalgamation as the individual mercury release sub-category contributing the highest mercury releases to the environment (57.5% of the total mercury emission from all contributors). The highest mercury releases were emitted to the atmosphere (59.32% of the total mercury emission to all pathways). Detailed presentation of mercury inputs and releases for all mercury release source types present in the country are shown in the following report sections.

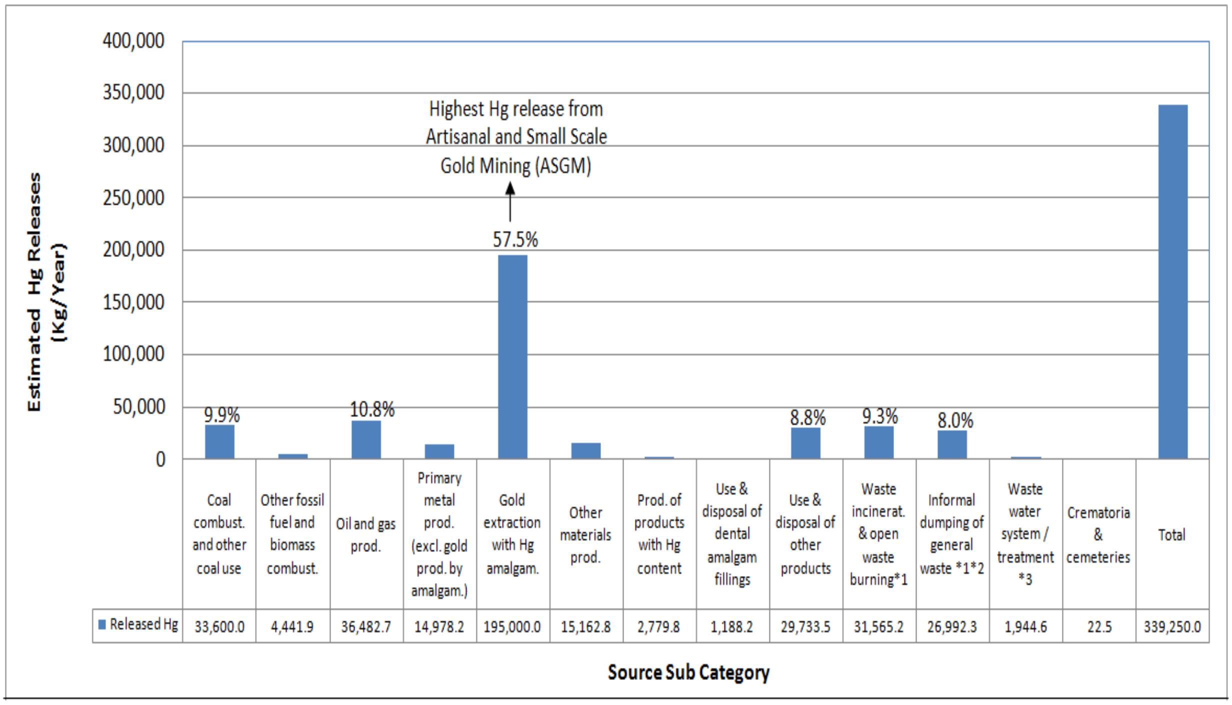
Table 1-1. Summary of mercury inventory results

Source category	Estimated Mercury input to Pathway Kg Hg/y	Estimated Mercury releases, standard estimates, Kg Hg/y					
	Released Mercury	Air	Water	Land	By-products and impurities	General waste	Specific waste treatment/ disposal
Coal combustion and other coal use	33,600.0	30,240.0	0.0	0.0	0.0	3,360.0	0.0
Other fossil fuel and biomass combustion	4,441.9	4,441.9	0.0	0.0	0.0	0.0	0.0
Oil and gas production	36,482.7	4,782.9	4,772.6	0.0	2,923.7	5,403.6	0.0
Primary metal production (excl. gold prod. by amalgamation)	14,978.2	1,307.6	312.6	7,833.3	3,441.5	143.0	1,940.3
Gold extraction with mercury amalgamation	195,000.0	117,000.0	39,000.0	39,000.0	0.0	0.0	0.0
Other materials production	15,162.8	9,331.7	0.0	0.0	2,915.6	2,915.6	0.0
Chlor-alkali production with mercury-cells	-	-	-	-	-	-	-
Other production of chemicals and polymers	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Production of products with mercury content	2,779.8	26.3	13.9	278.0	0.0	278.0	27.8
Use and disposal of dental amalgam fillings	1,188.2	23.8	394.5	0.0	42.8	228.1	228.1
Use and disposal of other products	29,733.5	1,997.6	5,380.1	480.6	0.0	20,259.2	1,616.0
Production of recycled metals	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Waste incineration and open waste burning (*1)	31,565.2	29,391.8	0.0	0.0	0.0	0.0	2,173.4
Waste deposition (*1)	-	-	-	-	-	-	-
Informal dumping of general waste (*1)(*2)	26,992.3	2,699.2	2,699.2	21,593.8	-	-	-
Waste water system/treatment (*3)	1,944.6	0.0	1,750.1	0.0	0.0	194.5	0.0
Crematoria and cemeteries	22.5	1.1	0.0	21.3	0.0	0.0	0.0
TOTAL	**339,250.0**	**201,240.0**	**52,570.0**	**47,610.0**	**9,320.0**	**32,780.0**	**5,990.0**

*1: To avoid double counting of mercury inputs from waste and products in the input TOTAL, only 10% of the mercury input to waste incineration, waste deposition and informal dumping is included in the total for mercury inputs. These 10% represent approximately the mercury input to waste from materials which were not quantified individually in Inventory Level 1 of this Toolkit.

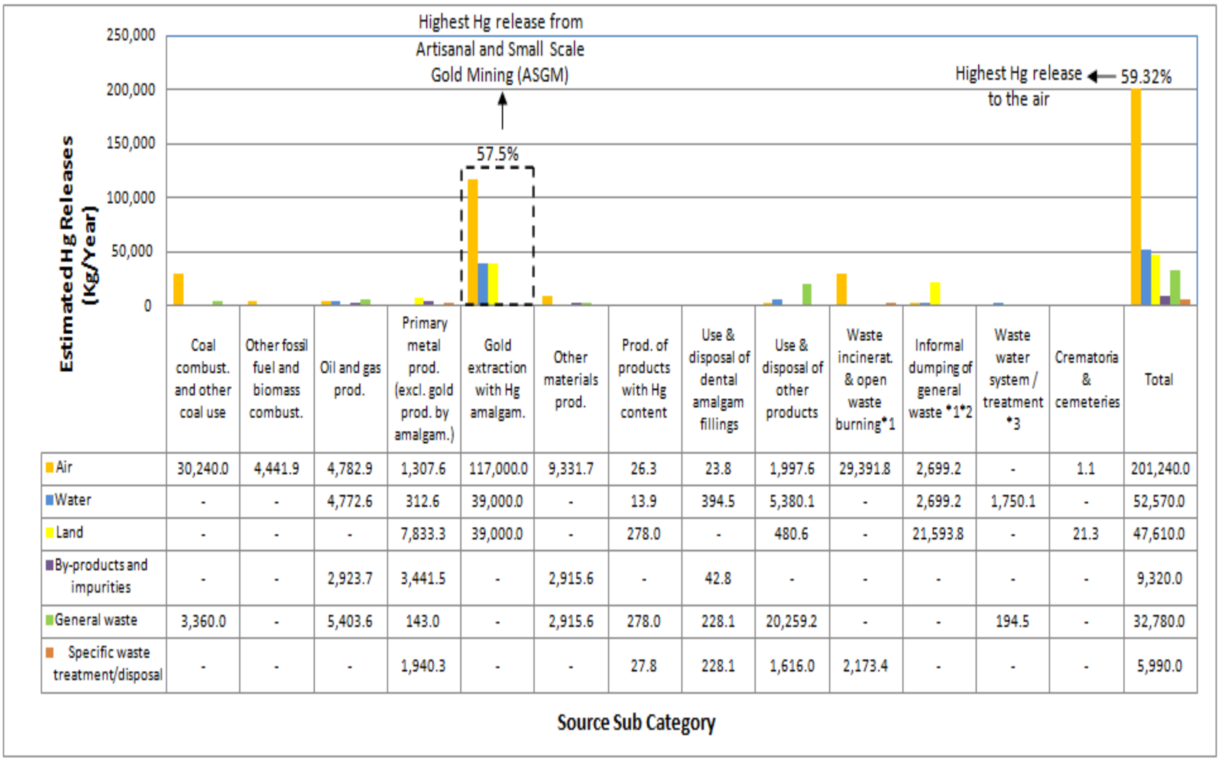
*2: The estimated quantities include mercury in products which has also been accounted for under each product category.
To avoid double counting, the release to land from informal dumping of general waste has been subtracted automatically in the TOTALS.

*3: The estimated input and release to water include mercury amounts which have also been accounted for under each source category.
To avoid double counting, input to, and release to water from, waste water system/treatment have been subtracted automatically in the TOTALS.



	Coal combust. and other coal use	Other fossil fuel and biomass combust.	Oil and gas prod.	Primary metal prod. (excl. gold prod. by amalgam.)	Gold extraction with Hg amalgam.	Other materials prod.	Prod. of products with Hg content	Use & disposal of dental amalgam fillings	Use & disposal of other products	Waste incinerat. & open waste burning*1	Informal dumping of general waste *1*2	Waste water system / treatment *3	Crematoria & cemeteries	Total
Released Hg	33,600.0	4,441.9	36,482.7	14,978.2	195,000.0	15,162.8	2,779.8	1,188.2	29,733.5	31,565.2	26,992.3	1,944.6	22.5	339,250.0

Figure 1-2. Summary of mercury inventory results for each source sub category



	Coal combust. and other coal use	Other fossil fuel and biomass combust.	Oil and gas prod.	Primary metal prod. (excl. gold prod. by amalgam.)	Gold extraction with Hg amalgam.	Other materials prod.	Prod. of products with Hg content	Use & disposal of dental amalgam fillings	Use & disposal of other products	Waste incinerat. & open waste burning*1	Informal dumping of general waste *1*2	Waste water system / treatment *3	Crematoria & cemeteries	Total
Air	30,240.0	4,441.9	4,782.9	1,307.6	117,000.0	9,331.7	26.3	23.8	1,997.6	29,391.8	2,699.2	-	1.1	201,240.0
Water	-	-	4,772.6	312.6	39,000.0	-	13.9	394.5	5,380.1	-	2,699.2	1,750.1	-	52,570.0
Land	-	-	-	7,833.3	39,000.0	-	278.0	-	480.6	-	21,593.8	-	21.3	47,610.0
By-products and impurities	-	-	2,923.7	3,441.5	-	2,915.6	-	42.8	-	-	-	-	-	9,320.0
General waste	3,360.0	-	5,403.6	143.0	-	2,915.6	278.0	228.1	20,259.2	-	-	194.5	-	32,780.0
Specific waste treatment/disposal	-	-	-	1,940.3	-	-	27.8	228.1	1,616.0	2,173.4	-	-	-	5,990.0

Figure 1-3. Summary of mercury release to the certain pathways

1.3. Data gaps

The major data gaps which influence the results of mercury releases quantification are:

- The lack of actual detail data source of activity rates for each source sub category
- The difficulties in selecting the suitable input factors due to the wide disparity between minimum and maximum value of default input factors
- No information available in Indonesia for site specific input factors and ouput distribution factors

2. Mercury release source types present

Table 2-1 shows which mercury release sources were identified as present and absent, respectively, in the country. Only source types positively identified as present are included in the quantitative assessment. It should be noted however, that the presumably minor mercury release source types shown in **Table 2-2** were not included in the detailed source identification and quantification work. These may however be present in Indonesia.

Table 2-1. Identification of mercury release sources in the country; sources present (Y), absent (N), and possible but not positively identified (?).

Source category	Source present?
	Y/N/?
Energy consumption	
Coal combustion in large power plants	Y
Other coal uses	Y
Combustion/use of petroleum coke and heavy oil	Y
Combustion/use of diesel, gasoil, petroleum, kerosene	Y
Use of raw or pre-cleaned natural gas	Y
Use of pipeline gas (consumer quality)	N
Biomass fired power and heat production	Y
Charcoal combustion	Y
Fuel production	
Oil extraction	Y
Oil refining	Y
Extraction and processing of natural gas	Y
Primary metal production	
Mercury (primary) extraction and initial processing	N
Production of zinc from concentrates	N
Production of copper from concentrates	Y
Production of lead from concentrates	N
Gold extraction by methods other than mercury amalgamation	Y
Alumina production from bauxite (aluminum production)	Y
Primary ferrous metal production (iron, steel production)	Y
Gold extraction with mercury amalgamation - without use of retort	Y
Gold extraction with mercury amalgamation - with use of retorts	N
Other materials production	
Cement production	Y
Pulp and paper production	Y
Production of chemicals	
Chlor-alkali production with mercury-cells	N
VCM production with mercury catalyst	N
Acetaldehyde production with mercury catalyst	N
Production of products with mercury content	
Hg thermometers (medical, air, lab, industrial etc.)	Y
Electrical switches and relays with mercury	Y
Light sources with mercury (fluorescent, compact, others: see guideline)	Y
Batteries with mercury	Y
Manometers and gauges with mercury	Y

Source category	Source present?
	Y/N/?
Biocides and pesticides with mercury	Y
Paints with mercury	Y
Skin lightening creams and soaps with mercury chemicals	Y
Use and disposal of products with mercury content	
Dental amalgam fillings ("silver" fillings)	Y
Thermometers	Y
Electrical switches and relays with mercury	Y
Light sources with mercury	Y
Batteries with mercury	Y
Polyurethane (PU, PUR) produced with mercury catalyst	Y
Paints with mercury preservatives	Y
Skin lightening creams and soaps with mercury chemicals	Y
Medical blood pressure gauges (mercury sphygmomanometers)	Y
Other manometers and gauges with mercury	Y
Laboratory chemicals	Y
Other laboratory and medical equipment with mercury	Y
Production of recycled of metals	
Production of recycled mercury ("secondary production")	N
Production of recycled ferrous metals (iron and steel)	N
Waste incineration	
Incineration of municipal/general waste	Y
Incineration of hazardous waste	Y
Incineration of medical waste	Y
Sewage sludge incineration	Y
Open fire waste burning (on landfills and informally)	Y
Waste deposition/landfilling and waste water treatment	
Controlled landfills/deposits	N
Informal dumping of general waste *1	Y
Waste water system/treatment	Y
Crematoria and cemeteries	
Crematoria	Y
Cemeteries	Y

*1: To avoid double counting of mercury inputs from waste and products in the input TOTAL, only 10% of the mercury input to waste incineration, waste deposition and informal dumping is included in the total for mercury inputs. These 10% represent approximately the mercury input to waste from materials which were not quantified individually in Inventory Level 1 of this Toolkit.

Table 2-2. Miscellaneous potential mercury sources not included in the quantitative inventory; with preliminary indication of possible presence in the country.

Source category	Source present?
	Y/N/?
Combustion of oil shale	Y
Combustion of peat	Y
Geothermal power production	Y
Production of other recycled metals	Y
Production of lime	Y
Production of light weight aggregates (burnt clay nuts for building purposes)	Y
Chloride and sodium hydroxide produced from mercury-cell technology	N
Polyurethane production with mercury catalysts	Y
Seed dressing with mercury chemicals	N
Infra red detection semiconductors	Y
Bougie tubes and Cantor tubes (medical)	Y
Educational uses	Y
Gyroscopes with mercury	Y
Vacuum pumps with mercury	Y
Mercury used in religious rituals (amulets and other uses)	N
Mercury used in traditional medicines (ayurvedic and others) and homeopathic medicine	N
Use of mercury as a refrigerant in certain cooling systems	N
Light houses (leveling bearings in marine navigation lights)	Y
Mercury in large bearings of rotating mechanic parts in for example older waste water treatment plants	N
Tanning	Y
Pigments	Y
Products for browning and etching steel	Y
Certain color photograph paper types	Y
Recoil softeners in rifles	Y
Explosives (mercury-fulminate a.o.)	Y
Fireworks	Y
Executive toys	Y

3. Summary of mercury inputs to society

Mercury inputs to society should be understood here as the mercury amounts made available for potential releases through economic activity in the country. This includes mercury intentionally used in products such as thermometers, blood pressure gauges, fluorescent light bulbs, etc. It also includes mercury mobilized via extraction and use of raw materials which contains mercury in trace concentrations.

Table 3-1 presents the summary of mercury inputs to society. The source sub-categories made the largest contributions to mercury inputs to society are as follows:

- Gold extraction with Hg amalgamation
- Oil and gas production
- Coal combustion and other coal use
- Waste incineration & open waste burning
- Use & disposal of other products and
- Informal dumping of general waste

Table 3-1. Summary of mercury inputs to society

Source category	Source present?	Activity rate	Unit	Estimated Hg input, Kg Hg/y
	Y/N/?			Standard estimate
Energy consumption				
Coal combustion in large power plants	Y	67,000,000	t coal combusted/y	33,500
Other coal uses	Y	200,000	t coal used/y	100
Combustion/use of petroleum coke and heavy oil	Y	3,396,125	t oil product combusted/y	255
Combustion/use of diesel, gasoil, petroleum, kerosene	Y	45,987,875	t oil product combusted/y	253
Use of raw or pre-cleaned natural gas	Y	39,754,745,672	Nm^3 gas/y	9
Use of pipeline gas (consumer quality)	N		Nm^3 gas/y	
Biomass fired power and heat production	Y	119,247,139	t biomass combusted/y (dry weight)	3,577
Charcoal combustion	Y	2,901,052	t charcoal combusted/y	348
Fuel production				
Oil extraction	Y	48,919,607	t crude oil produced/y	13,453
Oil refining	Y	48,305,984	t oil refined/y	13,284
Extraction and processing of natural gas	Y	96,492,101,146	Nm^3 gas/y	9,746
Primary metal production				
Mercury (primary) extraction and initial processing	N	0	t mercury produced/y	
Production of zinc from concentrates	N	0	t concentrate used/y	
Production of copper from concentrates	Y	993,152	t concentrate used/y	7,945

Source category	Source present?	Activity rate	Unit	Estimated Hg input, Kg Hg/y
	Y/N/?			Standard estimate
Production of lead from concentrates	N	0	t concentrate used/y	
Gold extraction by methods other than mercury amalgamation	Y	119,726	t gold ore used/y	6,585
Alumina production from bauxite (aluminium production)	Y	440,000	t bauxit processed/y	220
Primary ferrous metal production (iron, steel production)	Y	4,561,065	t pig iron produced/y	228
Gold extraction with mercury amalgamation - without use of retort	Y	97,500	kg gold produced/y	195,000
Gold extraction with mercury amalgamation - with use of retorts	N		kg gold produced/y	
Other materials production				
Cement production	Y	53,010,000	t cement produced/y	14,578
Pulp and paper production	Y	19,500,000	t biomass used in production/y	585
Production of chemicals				
Chlor-alkali production with mercury-cells	N		t Cl_2 produced/y	
VCM production with mercury catalyst	N		t VCM produced/y	
Acetaldehyde production with mercury catalyst	N		t acetaldehyde produced/y	
Production of products with mercury content				
Mercury thermometers (medical, air, lab, industrial etc.)	Y	1,050	kg mercury used for production/y	788
Electrical switches and relays with mercury	Y	176	kg mercury used for production/y	176
Light sources with mercury (fluorescent, compact, others: see guideline)	Y	1,000	kg mercury used for production/y	1,000
Batteries with mercury	Y	300	kg mercury used for production/y	300
Manometers and gauges with mercury	Y	150	kg mercury used for production/y	150
Biocides and pesticides with mercury	Y	0	kg mercury used for production/y	0
Paints with mercury	Y	150	kg mercury used for production/y	150
Skin lightening creams and soaps with mercury chemicals	Y	216	kg mercury used for production/y	216
Use and disposal of products with mercury content				
Dental amalgam fillings ("silver" fillings)	Y	237,641,326	number of inhabitants	1,188
Thermometers	Y	164,257	items sold/y	284
Electrical switches and relays with mercury	Y	237,641,326	number of inhabitants	4,753
Light sources with mercury	Y	275,000,000	items sold/y	1,750
Batteries with mercury	Y	7,963	t batteries sold/y	4,023

Source category	Source present?	Activity rate	Unit	Estimated Hg input, Kg Hg/y
	Y/N/?			Standard estimate
Polyurethane (PU, PUR) produced with mercury catalyst	Y	237,641,326	number of inhabitants	2,376
Paints with mercury preservatives	Y		t paint sold/y	
Skin lightening creams and soaps with mercury chemicals	Y	4	t cream or soap sold/y	107
Medical blood pressure gauges (mercury sphygmomanometers)	Y	150,000	items sold/y	10,500
Other manometers and gauges with mercury	Y	237,641,326	number of inhabitants	1,188
Laboratory chemicals	Y	237,641,326	number of inhabitants	2,376
Other laboratory and medical equipment with mercury	Y	237,641,326	number of inhabitants	2,376
Production of recycled of metals				
Production of recycled mercury ("secondary production")	N		kg mercury produced/y	
Production of recycled ferrous metals (iron and steel)	N		number of vehicles recycled/y	
Waste incineration				
Incineration of municipal/general waste*1	Y	61,904	t waste incinerated/y	310
Incineration of hazardous waste*1	Y	786,499	t waste incinerated/y	18,876
Incineration of medical waste*1	Y	98,023	t waste incinerated/y	2,353
Sewage sludge incineration*1	Y	97,989	t waste incinerated/y	196
Open fire waste burning (on landfills and informally)*1	Y	1,966,247	t waste burned/y	9,831
Waste deposition/landfilling and waste water treatment				
Controlled landfils/deposits *1	N		t waste landfilled/y	
Informal dumping of general waste *1*2	Y	26,992,260	t waste dumped/y	26,992
Waste water system/treatment *3	Y	370,400,000	m3 waste water/y	1,945
Crematoria and cemeteries				
Crematoria	Y	749	corpses cremated/y	1
Cemeteries	Y	14,223	corpses buried/y	21
TOTAL of quantified inputs				**339,250**

Note:

*1: To avoid double counting of mercury inputs from waste and products in the input TOTAL, only 10% of the mercury input to waste incineration, waste deposition and informal dumping is included in the total for mercury inputs. These 10% represent approximately the mercury input to waste from materials which were not quantified individually in Inventory Level 1 of this Toolkit.

*2: The estimated quantities include mercury in products which has also been accounted for under each product category.
To avoid double counting, the release to land from informal dumping of general waste has been subtracted automatically in the TOTALS.

*3: The estimated input and release to water include mercury amounts which have also been accounted for under each source category.
To avoid double counting, input to, and release to water from, waste water system/treatment have been subtracted automatically in the TOTALS.

4. Summary of mercury releases

In the **Table 4-1** below, a summary of mercury releases from all source categories is given. The key mercury releases here are releases to air (the atmosphere), to water (marine and freshwater bodies, including via waste water systems), to land, to general waste, and to sectors specific waste. An additional output pathway is "by-products and impurities" which designate mercury flows back into the market with by-products and products where mercury does not play an intentional role. **Table 4-2** describes a more detailed description and definition of the output pathways.

Table 4-1. Summary of mercury releases

Source category	Estimated mercury releases, standard estimates, Kg Hg/y					
	Air	Water	Land	By-products and impurities	General waste	Sector specific waste treatment / disposal
Energy consumption						
Coal combustion in large power plants	30,150.0	0.0	0.0	0.0	3,350.0	0.0
Other coal uses	90.0	0.0	0.0	0.0	10.0	0.0
Combustion/use of petroleum coke and heavy oil	254.7	0.0	0.0	0.0	0.0	0.0
Combustion/use of diesel, gasoil, petroleum, kerosene	252.9	0.0	0.0	0.0	0.0	0.0
Use of raw or pre-cleaned natural gas	8.7	0.0	0.0	0.0	0.0	0.0
Use of pipeline gas (consumer quality)						
Biomass fired power and heat production	3,577.4	0.0	0.0	0.0	0.0	0.0
Charcoal combustion	348.1	0.0	0.0	0.0	0.0	0.0
Fuel production						
Oil extraction	0.0	2,690.6	0.0	0.0	0.0	0.0
Oil refining	3,321.0	132.8	0.0	0.0	1,992.6	0.0
Extraction and processing of natural gas	1,461.9	1,949.1	0.0	2,923.7	3,411.0	0.0
Primary metal production						
Mercury (primary) extraction and initial processing						
Production of zinc from concentrates						
Production of copper from concentrates	794.5	158.9	1,906.9	3,178.1	0.0	1,906.9
Production of lead from concentrates						
Gold extraction by methods other than mercury amalgamation	263.4	131.7	5,926.4	263.4	0.0	0.0
Alumina production from bauxite (aluminium production)	33.0	22.0	0.0	0.0	143.0	22.0
Primary ferrous metal production (iron, steel production)	216.7	0.0	0.0	0.0	0.0	11.4
Gold extraction with mercury amalgamation - without use of retort	117,000.0	39,000.0	39,000.0	0.0	0.0	0.0

Source category	Estimated mercury releases, standard estimates, Kg Hg/y					
	Air	Water	Land	By-products and impurities	General waste	Sector specific waste treatment / disposal
Gold extraction with mercury amalgamation - with use of retorts						
Other materials production						
Cement production	8,746.7	0.0	0.0	2,915.6	2,915.6	0.0
Pulp and paper production	585.0	0.0	0.0	0.0	0.0	0.0
Production of chemicals						
Chlor-alkali production with mercury-cells						
VCM production with mercury catalyst						
Acetaldehyde production with mercury catalyst						
Production of products with mercury content						
Mercury thermometers (medical, air, lab, industrial etc.)	7.9	3.9	78.8	0.0	78.8	7.9
Electrical switches and relays with mercury	1.8	0.9	17.6	0.0	17.6	1.8
Light sources with mercury (fluorescent, compact, others: see guideline)	10.0	5.0	100.0	0.0	100.0	10.0
Batteries with mercury	1.5	1.5	30.0	0.0	30.0	3.0
Manometers and gauges with mercury	1.5	0.8	15.0	0.0	15.0	1.5
Biocides and pesticides with mercury	0.0	0.0	0.0	0.0	0.0	0.0
Paints with mercury	1.5	0.8	15.0	0.0	15.0	1.5
Skin lightening creams and soaps with mercury chemicals	2.2	1.1	21.6	0.0	21.6	2.2
Use and disposal of products with mercury content						
Dental amalgam fillings ("silver" fillings)	23.8	394.5	0.0	42.8	228.1	228.1
Thermometers	28.4	85.1	0.0	0.0	170.2	0.0
Electrical switches and relays with mercury	475.3	0.0	475.3	0.0	3,802.3	0.0
Light sources with mercury	87.5	0.0	0.0	0.0	1,662.5	0.0
Batteries with mercury	0.0	0.0	0.0	0.0	4,023.0	0.0
Polyurethane (PU, PUR) produced with mercury catalyst	237.6	118.8	0.0	0.0	2,020.0	0.0
Paints with mercury preservatives	0.0	0.0	0.0	0.0	0.0	0.0
Skin lightening creams and soaps with mercury chemicals	0.0	101.3	5.3	0.0	0.0	0.0
Medical blood pressure gauges (mercury sphygmomanometers)	1,050.0	3,150.0	0.0	0.0	6,300.0	0.0
Other manometers and gauges with mercury	118.8	356.5	0.0	0.0	712.9	0.0
Laboratory chemicals	0.0	784.2	0.0	0.0	784.2	808.0
Other laboratory and medical equipment with mercury	0.0	784.2	0.0	0.0	784.2	808.0

Source category	Estimated mercury releases, standard estimates, Kg Hg/y					
	Air	Water	Land	By-products and impurities	General waste	Sector specific waste treatment / disposal
Production of recycled of metals						
Production of recycled mercury ("secondary production")						
Production of recycled ferrous metals (iron and steel)						
Waste incineration						
Incineration of municipal/ general waste	278.6	0.0	0.0	0.0	0.0	31.0
Incineration of hazardous waste	16,988.4	0.0	0.0	0.0	0.0	1,887.6
Incineration of medical waste	2,117.3	0.0	0.0	0.0	0.0	235.3
Sewage sludge incineration	176.4	0.0	0.0	0.0	0.0	19.6
Open fire waste burning (on landfills and informally)	9,831.2	0.0	0.0	0.0	0.0	0.0
Waste deposition/ landfilling and waste water treatment						
Controlled landfills/deposits						
Informal dumping of general waste *1	2,699.2	2,699.2	21,593.8			
Waste water system/ treatment *2	0.0	1,750.1	0.0	0.0	194.5	0.0
Crematoria and cemeteries						
Crematoria	1.1	0.0	0.0		0.0	0.0
Cemeteries	0.0	0.0	21.3		0.0	0.0
TOTAL of quantified releases	**201,240.0**	**52,570.0**	**47,610.0**	**9,320.0**	**32,780.0**	**5,990.0**

Note:
*1: The estimated quantities include mercury in products which has also been accounted for under each product category to avoid double counting; the release to land from informal dumping of general waste has been subtracted automatically in the TOTALS.

*2: The estimated release to water includes mercury amounts which have also been accounted for under each source category. To avoid double counting, input to, and release to water from, waste water system/treatment have been subtracted automatically in the TOTALS

Table 4-2. Description and definitions of the output pathways

Calculation result type	Description
Estimated mercury input, Kg Hg/y	The standard estimate of the amount of mercury entering this source category with input materials, for example calculated mercury amount in the amount of coal used annually in the country for combustion in large power plants
Air	Mercury emissions to the atmosphere from point sources and diffuse sources from which mercury may be spread locally or over long distances with air masses; for example from: • Point sources such as coal fired power plants, metal smelter, waste incineration; • Diffuse sources as small-scale gold mining, informally burned waste with fluorescent lamps, batteries, thermometers.
Water	Mercury releases to aquatic environments and to waste water systems: Point sources and diffuse sources from which mercury will be spread to marine environments (oceans), and freshwaters (rivers, lakes, etc.). for example releases from: • Wet flue cleaning systems from coal fired power plants; • Industry, households, etc. to aquatic environments; • Surface run-off and leachate from mercury contaminated soil and waste dumps
Land	Mercury releases to soil, the terrestrial environment: General soil and ground water. For example releases from: • Solid residues from flue gas cleaning on coal fired power plants used for gravel road construction; • Uncollected waste products dumped or buried informally • Local un-confined releases from industry such as on site hazardous waste storage/burial • Spreading of sewage sludge with mercury content on agricultural land (sludge used as fertilizer) • Application on land, seeds or seedlings of pesticides with mercury compounds
By-products and impurities	By-products that contain mercury, which are sent back into the market and cannot be directly allocated to environmental releases, for example: • Gypsum wallboard produced from solid residues from flue gas cleaning on coal fired power plants. • Sulphuric acid produced from desulphurization of flue gas (flue gas cleaning) in non-ferrous metal plants with mercury trace concentrations • Chlorine and sodium hydroxide produced with mercury-based chlor-alkali technology; with mercury trace concentrations • Metal mercury or calomel as by-product from non-ferrous metal mining (high mercury concentrations)
General waste	General waste: Also called municipal waste in some countries. Typically household and institution waste where the waste undergoes a general treatment, such as incineration, landfilling or informal dumping. The mercury sources to waste are consumer products with intentional mercury content (batteries, thermometers, fluorescent tubes, etc.) as well as high volume waste like printed paper, plastic, etc., with small trace concentrations of mercury.

Calculation result type	Description
Sector specific waste treatment/ disposal	Waste from industry and consumers which is collected and treated in separate systems, and in some cases recycled; for example: • Confined deposition of solid residues from flue gas cleaning on coal fired power plants on dedicated sites. • Hazardous industrial waste with high mercury content which is deposited in dedicated, safe sites • Hazardous consumer waste with mercury content, mainly separately collected and safely treated batteries, thermometers, mercury switches, lost teeth with amalgam fillings etc. • Confined deposition of tailings and high volume rock/waste from extraction of non-ferrous metals

5. Data and inventory on energy consumption and fuel production

5.1. Data description

This inventory step covers the use of fossil fuels and plant matter (biomass) for production of electricity and heat. Fossil fuels and biomass naturally contain trace concentrations of mercury, and this mercury is released when the fuel is burned. Most of this mercury is released to the atmosphere, but some is captured by flue gas cleaning systems and ends up in residues from this system. Mercury concentrations in fuel vary depending on the fuel source and the fuel type. Large coal fired power plants are generally equipped with air pollution reduction equipment which retain parts of the mercury from flue gasses and transfer them to solid or wet residues. This is generally not the case for other coal uses. During extraction, refining and treatment of oil and natural gas, some of the mercury in the fuel may be released to the environment.

Table 5-1 shows each source sub category in this inventory with their origin of activity rate, conversion factor and data source. The activity rate of each source sub category of energy consumption and fuel production was calculated using data which were officially published by the Indonesian government through the Ministry of Energy and Mineral Resources and Directorate General of Oil and Gas.

The Handbook of Energy and Economic Statistics of Indonesia, published by Ministry of Energy and Mineral Resources provide accurate and reliable energy economic data and information consolidated in one book. This book simplifies the data search, because it presents data for the national level. The statistic data of oil, gas, coal, and electricity were also published by the Ministry of Energy and Mineral, with the original data from Directorate General of Oil and Gas.

Figure 5-1 shows the mercury releases from each source sub-category of energy consumption and fuel production as well as mercury releases to each pathway (air, water, land, by product impurities, general waste, and specific waste treatment/disposal). The sub-category of coal combustion in large power plants contributes the highest mercury releases (58.70%) to mercury emission from energy consumption and fuel production. Of all the released mercury to the environment, about 70.2% was emitted to the atmosphere.

Table 5-1. Source sub category, activity rate, conversion factor, and data sources for energy consumption and fuel production

(1)	(2)	(3)	(4)	(5)	(6)
Source Category	**Source Present?**	**Activity rate**		**Conversion factor or calculation**	**Data source**
		Annual consumption/ production	**Original data**		
Energy Consumption					
Coal combustion in large power plants	Y	67,000,000 t coal combusted/y	67,000,000 t coal combusted/y		Ministry of Energy and Mineral Resources, 2010*
Other coal uses	Y	200,000 t coal used/y	150,000 coke/ year	1 ton coal produces 750 kg coke	Center for Research and Development of Mineral and Coal Technology, 2009**
Combustion /use of petroleum coke and heavy oil	Y	3,396,125 t oil product combusted/y	4,245,156 m^3	Average density 800 kg/m^3	Directorate General of Oil and Gas, 2010***
Combustion/use of diesel, gasoil, petroleum, kerosene	Y	45,987,875 t oil product combusted/y	57,484,844 m^3	Average density 800 kg/m^3	Directorate General of Oil and Gas, 2010***
Use of raw or pre-cleaned natural gas	Y	39,754,745,672 Nm^3 gas/y	Domestic use: 41.2% of total production		Directorate General of Oil and Gas, 2010***
Use of pipeline gas (consumer quality)	N	Nm^3 gas/y			
Biomass fired power and heat production	Y	119,247,139 t biomass combusted/y (dry weight)	274.018 MBOE	1 ton = 2.2979 BOE (Barrel Oil Equivalent)	Ministry of Energy and Mineral Resources, 2010*
Charcoal combustion	Y	2,901,052 t charcoal combusted/y	14.42 MBOE	1 ton = 4.9713 BOE (Barrel Oil Equivalent)	Ministry of Energy and Mineral Resources, 2010*
Geothermal power production	Y	10,592,640 MWh	1226 MW	Operated 8640 hours/year	Directorate General of Oil and Gas, 2010***
Fuel Production					
Oil extraction	Y	48,919,607 t crude oil produced/y	344,800 Thousand Barrel/y 945 thousand BOPD	1 US Barrel = 0.17735 m^3 Density of oil: 800 kg/m^3	Directorate General of Oil and Gas, 2010***
Oil refining	Y	48,305,984 t oil refined/y	340,475 Thousand Barrel/y 933 Thousand BOPD	1 US Barrel = 0.17735 m^3	Directorate General of Oil and Gas, 2010***
Extraction and processing of natural gas	Y	96,492,101,146 Nm^3 gas/y	3,407,592 MMSCF /y 9,336 MMSCFD	1 ft^3 = 0.0283168 m^3	Directorate General of Oil and Gas, 2010***

Note:

* Handbook of Energy & Economic Statistic of Indonesia, Center for Data and Information on energy and Mineral, Ministry of Energy and Mineral Resources Republic Indonesia, 2010 can be accessed from the following website: http://prokum.esdm.go.id/Publikasi/Handbook%20of%20Energy%20&%20Economic%20Statistics%20of%20Indonesia%20/Handbook%202010.pdf.

** Can be accessed from the following website: http://isjd.pdii.lipi.go.id/index.php/Search.html?act=tampil&id=54784&idc=72.

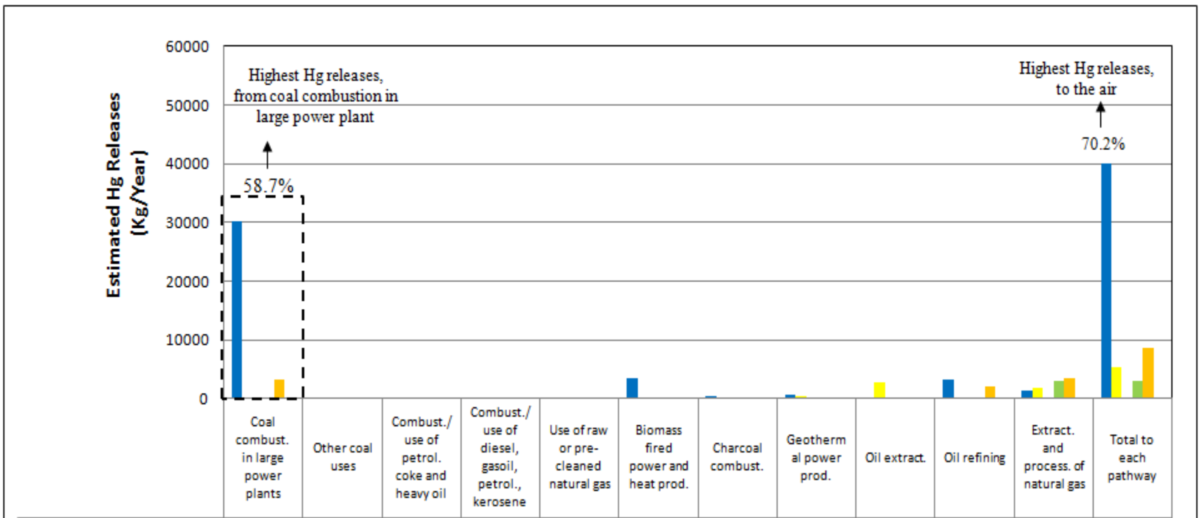
*** Can be accessed from the following website: http://www.esdm.go.id/publikasi/statistik.html.

Geothermal power production sub-category in Inventory Toolkit Level 1 is included in miscellaneous mercury sources.

In Inventory Level 1 (column 1, 2, 3), only the white cells are open for entering data in the spreadsheet.

Column 4, 5, and 6 were added to give information of the data origin of activity rate.

Mercury release estimation based on data of activity rate in 2010.



	Coal combust. in large power plants	Other coal uses	Combust./ use of petrol. coke and heavy oil	Combust./ use of diesel, gasoil, petrol., kerosene	Use of raw or pre-cleaned natural gas	Biomass fired power and heat prod.	Charcoal combust.	Geothermal power prod.	Oil extract.	Oil refining	Extract. and process. of natural gas	Total to each pathway
Air	30150.0	90.0	254.7	252.9	8.7	3577.4	348.1	606.4	0.0	3321.0	1461.9	40071.2
Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	529.6	2690.6	132.8	1949.1	5302.2
Land	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
By-products and impurities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2923.7	2923.7
General waste	3350.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1992.6	3411.0	8763.6
Specific waste treatment /disposal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 5-1. Estimated mercury releases from energy consumption and fuel production

Coal Combustion in Large Power Plant

The Ministry of Mineral Resources reported 8,361 MW coal fired power plants were installed in 2010, and projected to be increased up to 12,052.5 MW in 2011. The installed capacity is quickly growing since the government has announced to build 93 power plants under the second 10,000-megawatt (MW) power generation scheme (2010). **Table 5-2** shows the list of the major coal plants in the country with the latest installed capacity in 2012.

Table 5-2. Large coal fired power plant in Indonesia

No.	Power station	Operator	Location	District	Province	Region	Capacity per Unit (MW)	Installed Capacity (MVW)
1.	Bukit Asam	PT. PLN*	Tanjung Enim	Muara Enim	South Sumatra	Sumatra	4 x 65	260
2.	Paiton (PLN)	PT. PLN*	Paiton	Probo-linggo	East Java	Java-Bali	2 x 400	800
3.	Ombilin	PT. PLN*	Ombilin	Sawah lunto	West Sumatra	Sumatra	2 x 100	200
4.	Indramayu	PT. PLN*	Sumur Adem	Indramayu	West Java	Java-Bali	3 x 330	990
5.	Pacitan	PT. PLN*	Sukorejo	Pacitan	East Java	Java-Bali	2 x 315	630
6.	Tarahan	PT. PLN*	Tarahan	South Lampung	Lampung	Sumatra	2 x 100	200
7.	Labuan	PT. PLN*	Labuan	Pande-glang	Banten	Java-Bali	2 x 300	600
8.	Labuhan	PT. PLN*	Labuhan Angin	Central Tapanuli	North Sumatra	Sumatra	2 x 115	230
9.	Lontar	PT. PLN*	Lontar, Teluk Naga	Tangerang	Banten	Java-Bali	3 x 315	945
10.	Pelabuhan Ratu	PT. PLN*	Pelabuhan Ratu	Sukabumi	West Java	Java-Bali	3 x 330	990
11.	Rembang	PT. PLN*	Sluke	Rembang	Central Java	Java-Bali	2 x 315	630
12.	Suralaya	PT. Indonesia Power**	Suralaya	Cilegon	Banten	Java-Bali	4 x 40 3x600 1x625	4,025
13.	Paiton I	PT. Paiton Energy **	Paiton	Probo-linggo	East Java	Java-Bali	2 x 670	1,340
14.	Paiton II	PT. Jawa Power**	Paiton	Probo-linggo	East Java	Java-Bali	2 x 660	1,320
15.	Tanjung Jati-B	PT. Central Java Power**	Bangsri	Jepara	East Java	Java-Bali	2 x 662	1,320
16.	Tanjung Jati-B II	PT. Central Java Power**	Bangsri	Jepara	East Java	Java-Bali	2 x 662	1,320
17.	Cirebon	PT. Cirebon Electric Power**	Kanci Kulon	Cirebon	West Java	Java-Bali	1 x 660	660

No.	Power station	Operator	Location	District	Province	Region	Capacity per Unit (MW)	Installed Capacity (MVW)
18.	Cilacap	PT. Sumber Segara Primadaya**	Karang-kandri	Cilacap	Central Java	Java-Bali	2 x 300	600
19.	Bangka Belitung 3	PT. BMP**	Air Anyir	Bangka	Bangka Belitung	Sumatera	2 x 30	60
	Total							**17,020**

Source: *www.pln.co.id*

Note:
* State Own Utility (PLN)
**Private Independent Power Producer

Other Coal Use
Coke is the product of high temperature carbonization of steam coal. The product is used as reducing agent in steel plant. The Center for Research and Technological Development of Mineral and Coal (2009) predicted the need of coke as reducing agent was approximately 150,000 tons per year. This estimation was based on the need of coke in the metallurgy industry.

Combustion/Use of Petroleum Coke and Heavy Oil
The activity rate of combustion/use of petroleum coke and heavy oil was based on data from Directorate General Oil and Gas of energy which recorded about 3,396,125 ton oil product combusted in 2010.

Combustion/use of diesel, gasoil, petroleum, kerosene
Base on the statistic data published by Directorate General of Oil and Gas, the consumption of diesel, gasoil, petroleum and kerosene in 2010 was 45,987,875 ton oil product and majorly used by the transportation sectors.

Use of raw or pre-cleaned natural gas
According to data from Directorate General Oil and Gas, the amount of domestic consumption of natural gas is 41.2% of the total national production of gas, i.e. 39,754,745,672 Nm^3/y. Natural gas production has increased by more than a quarter since 2005. Indonesia exported about half of its natural gas consumption in 2009 – but the share of domestic consumption is expected to increase.

Biomass fired power and heat production, and charcoal combustion
Approximately 119,247,139 ton dry weight biomass was combusted in 2010 in the biomass fired power and heat production according to data from Ministry of Energy and Mineral Resources. For the country's long term energy policy, however, the Indonesian government has put forth the goals of reducing consumption of petroleum, while increasing consumption of natural gas, coal and biomass, nuclear, hydroelectric, solar, wind and other new energy sources and renewable energy. Use of biomass as an energy source would contribute to economic sustainability, which is in accordance with the policies of the country.

Geothermal Power Plant

Geothermal power in Indonesia is an increasingly significant source of renewable energy. As a result of its volcanic geology, Indonesia has 40% of the world's potential geothermal resources, estimated at 28,000 megawatts (MW). Although Indonesia generates 86 percent of its electricity from conventional thermal sources (coal, gas, and oil), it was the third-largest generator of geothermal power in 2009. Data from the Directorate General of Oil and Gas showed that the total power generated from geothermal power plant was 1,226 MW in 2010 as shown in **Table 5-3**.

Table 5-3. Geothermal power plant

No.	Location	Geothermal Power Plant	Installed Capacity (MW)
1	Java Island	Kamojang	200
2		Salak	377
3		Darajat	270
4		Wayang Windu	227
5		Dieng	60
6	Outside Java Island	Lahendong	80
7		Sibayak	12
	Total		**1,226**

***Source**: Directorate general of Renewable Energy and Energy Conversion*

Oil extraction and refining, and Extraction and processing of natural gas

Directorate General of Oil and Gas in 2010 through the annual report presented the fluctuation of oil extraction (production) in 2010 which can be seen in **Figure 5-2**. The average production throughout the year was 945 thousand barrel oil per day (BOPD), and 933 thousands BOPD was refined. Most of the national petroleum production generated by the old oil and gas fields have experienced natural production decline of about 7-12% per year. To push down the overall natural production decline rate, various efforts have been done such as through intensification initiatives (among others were to increase seismic and enhanced oil recovery activities) as well as business expansion efforts by proposing new blocks for exploration to the Directorate General of oil and gas.

The amount of natural gas which was extracted and processed in 2010 according to Directorate General of Oil and Gas was 3,407,592 MMSCF per year or 9,336 MMSCFD, with the monthly fluctuation shown in the **Figure 5-3.** During the past recent years, realization of natural gas production has been gradually increasing and in 2010 was realized at the highest level in the Indonesian oil and gas history. The increase in production was achieved after completion of several new projects of gas explorations.

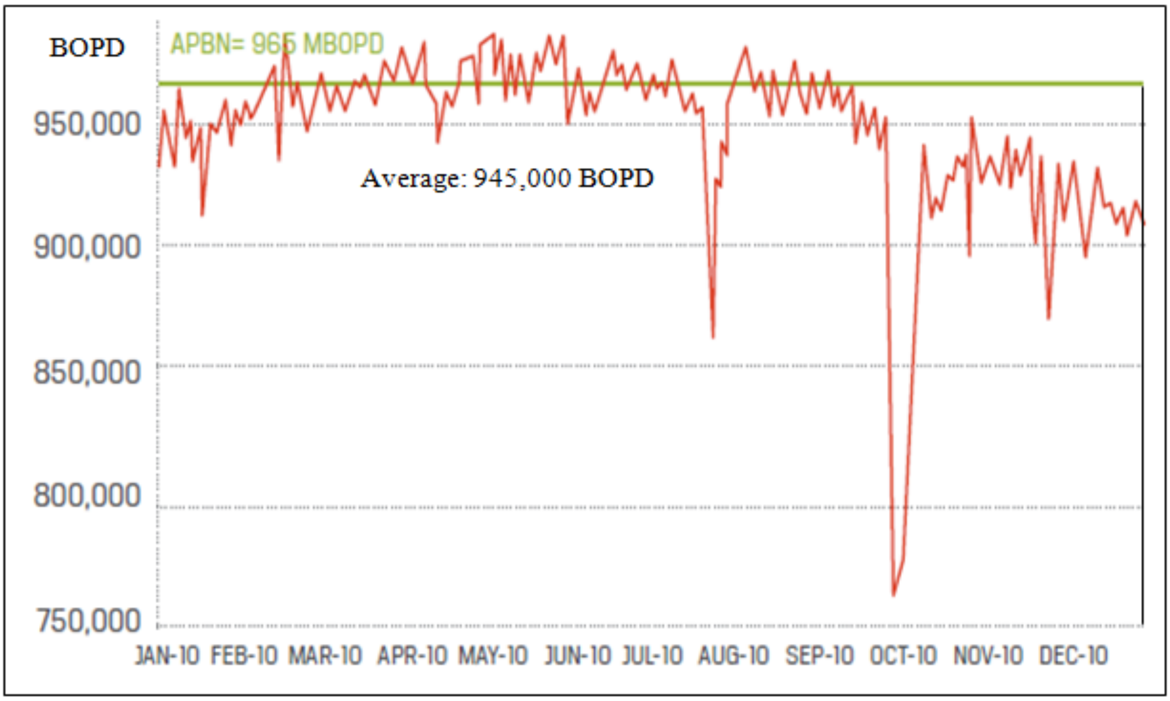


Figure 5-2. Production of oil in 2010
(Source: Directorate General of Oil and Gas, 2010)

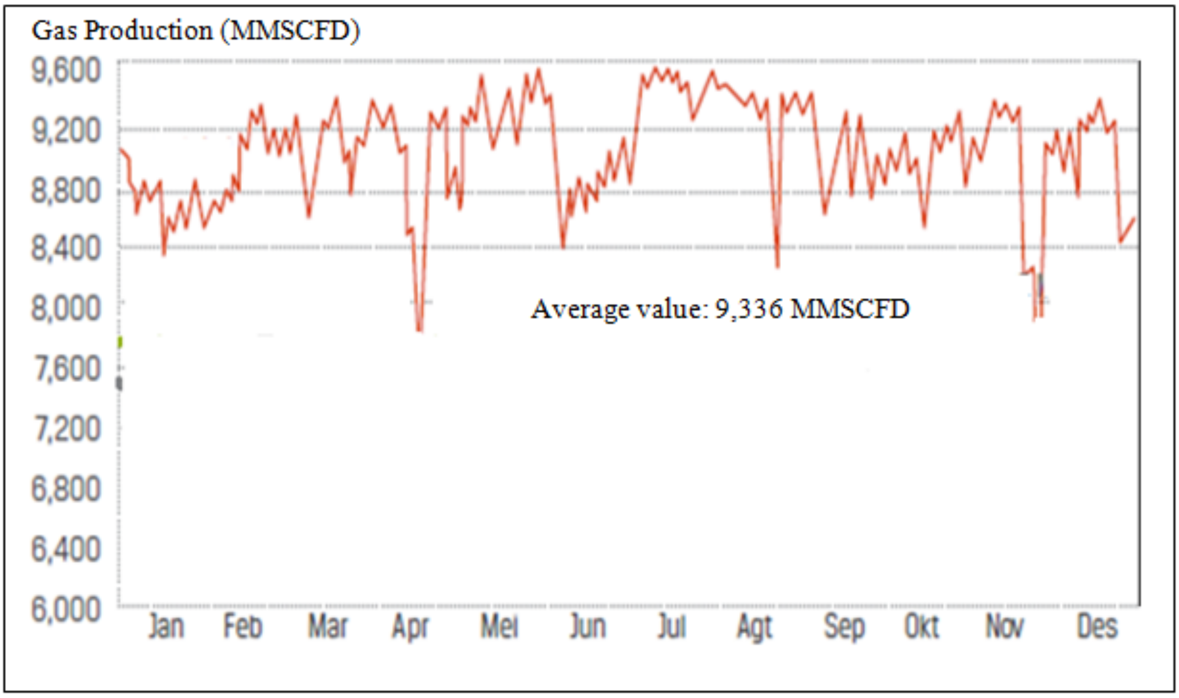


Figure 5-3. Production of gas in 2010 (MMSCFD)
(Source: Directorate General of Oil and Gas, 2010)

5.2 Background calculations and approximations

Fossil fuels and biomass naturally contain trace concentrations of mercury, and this mercury is released when the fuel is burned. Most of this mercury is released to the atmosphere, but some is captured by flue gas cleaning systems and ends up in residues from this system.

Coal Combustion in Large Power Plant
Large power plants presented in **Table 5-2** have actually various air pollution controls, but none are actually intended to capture Mercury. As shown in **Figure 5-4**, at least a large power plant must install the electrostatic precipitators (ESP) for controlling the fly ash emission to the air. Some power plants, especially the independent power producer also install the Flue Gas Desulphurization (FGD), for controlling the SO_2 emission, as well as the Low NO_x burner type boiler for reducing the NO_x emission. Some mercury attached to the particles could also be captured within the ESP, while oxidized Hg^{2+} could react with S^{2-} in the FGD system.

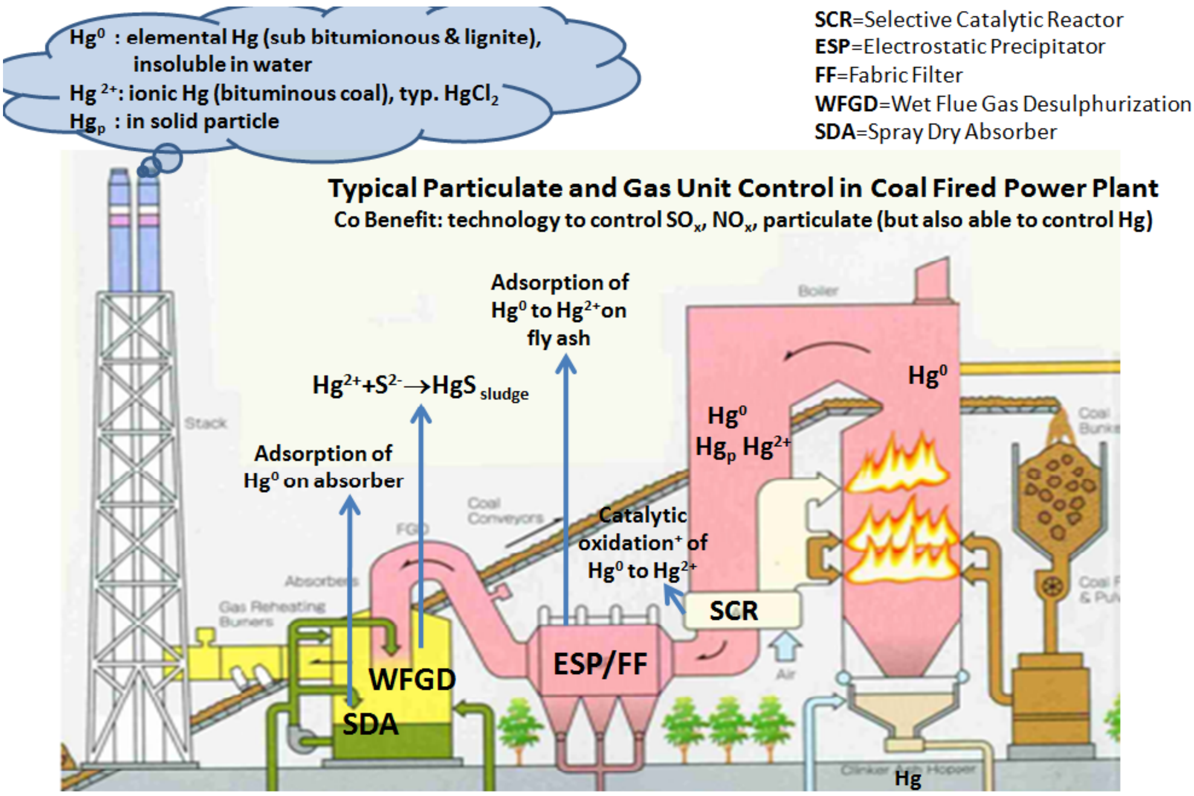


Figure 5-4. Mercury emission from Large Coal Power Plant
Source of Mercury Data: The Department of Energy/National Energy Technology Laboratory (DOE/NETL) &the Electric Power Research Institute (EPRI)

Based on the 2010 Indonesian Energy Statistic Data, the total coal consumption of the country was **67 million tons per year**, or only 24.35% from the total coal production (275 million tons). About 75.61% Indonesian coal were exported, and only 0.045% (111 thousand tons) was imported from other country.

The default input factors in the UNEP Toolkit are between 0.05 and 0.5 g Hg/ton coal, which are the minimum and maximum value respectively. Using these values, there was a wide range of estimation of mercury releases, i.e. a total of 3,350 Kg to 33,500 Kg mercury emitted per year.

In the calculation of the mercury emissions from this sub category, it was assumed that all the consumption of coal in Indonesia was used by the large power plant. But in the actual condition, not all coal is combusted in the large power plant. Therefore it was chosen the maximum value of input factor 0.5 g Hg/ton coal, to take into account mercury which could be emitted from small scale power plant (hence the emission estimated to be 33,500 Kg/year). From this value, the output distribution was allocated mostly in the air, comprising 90%, and general waste for the remaining 10%.

Other Coal Uses
Approximately 150,000 tons coke was used in 2010, and if one ton coal produces 750 kg coke according to Center for Research and Development of Mineral and Coal Technology, the coal used for coke production was about 200,000 tons per year. The default input factors in the UNEP Toolkit were 0.05 - 0.5 g Hg/ton coke production, which are the minimum and maximum value respectively, and about 10 Kg/year to 100kg/year mercury were predicted to be released. In estimating the amount of mercury releases from other coal uses, the maximum default input factor was used, i.e. 0.5 g Hg/ton coke production, because no data available for the use of air pollution control during coke production. The output distribution was allocated mostly in the air, comprising 90%, and general waste for the remaining 10%.

Combustion/use of petroleum coke and heavy oil
Data from Directorate General of Oil and Gas recorded 4,245,156 m^3 petroleum coke and heavy oil were combusted per year. Assuming the average density of 800 Kg/m^3, the activity rate for petroleum coke and heavy oil combution became 3,396,125 ton oil product combusted/year. The default input factors in the UNEP Toolkit are between 10 - 100 mg Hg/ton heavy oil and petroleum coke combustion, which are the minimum and maximum value respectively, yielding mercury releases 34 kg/year to 340 kg/year. In estimating mercury releases from combustion of petroleum coke and heavy oil, it was chosen the default factor of 75 mg/Hg/ton, approximately 255 Kg Hg/y, and all of mercury was assumed to be emitted to the air.

Combustion/use of diesel, gasoil, petroleum, kerosene
In 2010, the total amount of diesel, gasoline, petroleum, and kerosene consumption was about 57,484,844 m^3. Assuming the average density of the oil to be 800 kg/m^3, about 45,987,875 tons oil product was combusted. The minimum and maximum default input factors for combustion of diesel, gasoil, petroleum and kerosene are 1 – 10 mg Hg/t respectively, and about 46 to 460 ton mercury per year was released from this sub category. For current calculating mercury releases, default input factor of 4.4 mg Hg/t was used, resulting about 252.9 Kg Hg/y, and emitted 100% to the air.

Use of raw or pre-cleaned natural gas
The UNEP toolkit stated that if no details are available on the quality of the gas, considered it as cleaned pipeline quality. For activity rate of 39,754,745,672 Nm^3 gas use in 2010, and the default value of input factors of 0.03-0.4 μg Hg/Nm^3 gas used, yielded mercury releases of 1.19-15.9 Kg Hg/y, as maximum and minimum estimation respectively. In the calculation of use of pre cleaned natural gas, the input factor was

assumed to be 0.22 μg Hg/Nm^3 with the average mercury emission of 8.7 Kg Hg/y, and emitted 100 % to the air.

Biomass fired power and heat production, and charcoal combustion

Data of Energy Statistics showed that 288.44 MBOE of biomass was used for combustion. This biomass included the firewood and charcoal. It was assumed that 95% of the biomass was firewood (274.018 MBOE), and the rest was charcoal (14.42 MBOE). If 1 ton firewood is equal to 2.2979 BOE and 1 ton of charcoal is equal to 4.9713 BOE, the amount of combusted firewood would be 119,247,139 ton per year, while the amount of combusted charcoal would be 2,901,052 ton per year. The biomass value here was only for the biomass fired power and heat production, and did not take into account the wood used for domestic consumption.

The default input factors for firewood for minimum-maximum value are between 0.007 and 0.07 g Hg/t (dry weight), therefore the total of mercury releases were 835 to 8,347 Kg mercury per year. While the default input factor for charcoal combustion is four times of firewood combustion input factor, i.e. 0.028-0.28, and by using these values mercury releases were estimated to be 81 – 812 Kg per year. In the calculation for current condition, the selected input factor was 0.03 for firewood combustion and 0.12 for charcoal combustion. Therefore, Hg emission from this sub category was estimated to be 3,577.4 Kg and 348.1 Kg per year, and the emission was assumed to be totally emitted to the air.

Geothermal power production

The lists of the geothermal power plants in the country are shown in **Table 5-3**. If the operating hour is assumed to be 8640 hours per year, the total energy consumed is about 10,592,640 MWh. There is no default input factor in the UNEP Toolkit for geothermal power (UNEP 2005). Various emission factors had been found in the literature as shown in the **Table 5-4**.

Table 5-4. Various emission factors for geothermal power plant

No.	Geothermal Power Plant	Emission factor	Unit	Source
1	Off gas ejectors	0.00075-0.02	g/MWh	EPA 1997 based on Robertson et al 1977
	Cooling tower exhaust	0.026-0.072	g/MW	
2	Not specified	0.091	g/MWH	Bloomfield et al., 2003 in Clark et.al 201
3	Not specified	0.26-1.3	g/MWh	EMEP/EEA emission inventory guidebook 2009

Using these emission factors, mercury releases could be estimated as follows:

- 275 to 975 kg Hg/y, with average 606 kg Hg/y, using emission factor from EPA 1997 (from US geothermal power plant)
- 964 kg Hg/y, using Bloomfield 2001 (from US geothermal power plant)
- 2,754 to 13,770 Kg Hg/y, using EEA guidebook 2009 (from European geothermal power plant)

According to the above calculation, the mercury releases from geothermal power plant could be between 275 up to 13,770 Kg Hg/y, which is a very wide range of estimation. However, the amount of mercury released from this sub category classified as miscellaneous mercury release sources and not quantified on Inventory Toolkit Level 1.

Oil extraction
Directorate General of Oil and Gas published that 344,800 Thousand Barrel or 945 thousand BOPD was produced in 2010. Since, 1 US Barrel is equal to 0.17735 m^3, the volume of oil produced would be 61,149,509 m^3. Assuming the oil density to be 800 kg/ m^3, the total weight of oil produced in 2010 was 48,919,607 ton. For oil and gas extraction, two mercury inputs may be present, i.e. mercury naturally present in trace concentrations in the oil and gas, and a specific type of drilling mud with a mercury-containing mineral (barite) which is only used in some cases. On Inventory Level 1, only the trace concentrations in fuel are included in the inventory. Using default input factors of 5-300 mg Hg/t and activity rate of 48,919,607 t crude oil produced/y, the minimum maximum values of Hg release would be 245-14,676 Kg Hg/y. The selected input factor for this sub category was selected to be 275 mg Hg/t, which released 13,453 Kg Hg per year.

Oil refining
The original data was in the value of 326,986 Thousand Barrel/y. One US Barrel is equal to 0.17735 m^3, therefore the total volume of refined oil would be 60,382,480 Nm^3/y. Using the average oil density of 800 Kg/m^3, the weight of oil would be 48,305,984/y. Using the default input factors of 5-300 mg Hg/t, the minimum-maximum estimation would be 242-14,492 Kg Hg/y. For current condition, the selected default input factor was 275 mg Hg/t, resulted in 13,284 Kg Hg emission.

Extraction and processing of natural gas
Natural gas may be processed with or without dedicated mercury removal (retention) systems. On Inventory Level 1, default output factors for extraction are estimated by assuming that 50% of the gas is processed without mercury removal and 50% with mercury removal. The amount of natural gas which was extracted and processed in 2010 according to the Directorate General of Oil and Gas was 3,407,592 MMSCF per year or 9,336 MMSCFD. If one ft^3 equal to 0.0283168 $m^{3,}$ the total volume of natural gas would be 96,492,101,146 Nm^3 gas/y. The default input factors are 2-200 μg Hg/Nm^3 gas, therefore the minimum and maximum values of estimation would be 192.98 -19,298.42 Kg Hg/y. For current estimation, the selected default factor was 101 μg Hg/Nm3 gas, yielding 9,746 Kg mercury releases per year.

5.2. Data gaps and priorities for potential follow up

For this sub category, there are several data gaps and priorities for potential follow up which could be identified as follows:

- The UNEP toolkit only taking into account the combustion of coal in large power plant which already installed the air pollution control devices, whereas the combustion in small power plants without air pollution control devices are not taken into account. The electricity generated per ton of coal is approximately **2,460** kWh with 50% efficiency of energy conversion from coal to electricity**.** For the installed large power plant capacity in 2010 (8,361 MW or 60,199,200,000 KWh for one year) the required coal in large power plant would approximately be 49 million tons of coal. This is 70%

from the total domestic use according to the statistical data. About 18 millions of ton coal was actually combusted in small power plants. There is no default input factor available in the toolkit for small power plants, therefore the emission from this sub category is expected to be higher than the calculated one, since the air pollution control in small power plants are usually much simpler than large power plants. However in Indonesia, there is no recorded data available related to the use of coal in small power plants.

- For oil and gas extraction and refining are actually can be refined, since most of the oil and gas companies have the data record of Hg removal from their process flow. However, these data are not published and become the company confidential data.
- The use of biomass as a source of heat production like in cooking foods is widely used in rural areas but these were not accounted for because of the unavailability of data and the assumption that the contribution of this subcategory is negligible to the total emissions
- There is a huge disparity between minimum and maximum value of default input factors (the highest are the default input factors for oil and gas extraction and refining, i.e. 5 to 300 mg Hg/t), which denotes that the individual characterics of the fuel which is consumed or produced are determined the real value of default input factors.

6. Data and inventory on domestic production of metals and raw materials

6.1. Data description

This step covers three groups of activities: 1) Industrial mining and primary processing of metals where the mercury source is trace concentrations in the ore material - also in ore for extraction of other metals than mercury, 2) small scale gold mining with mercury amalgamation, where mercury is added to extract the gold, and 3) industrial production of the large volume materials cement and paper.

Table 6-1 shows each source sub category in this inventory with their origin of activity rate, conversion factor and data source. The activity rate of each source sub category of production of metals and raw materials was calculated using data which were officially published by the Indonesian government through the Statistical Central Agency, global mercury monitoring project conducted by BaliFokus, Ministry of Public Works, and Indonesian Pulp and Paper Association.

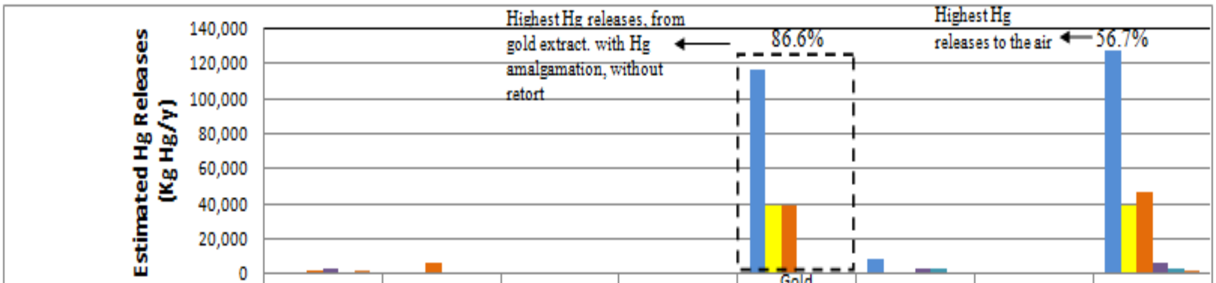
Figure 6-1 shows the Hg released from each source sub category of production of metals and raw materials as well as Hg released to each pathway (air, water, land, by product impurities, general waste, and specific waste treatment/disposal). The sub category of gold extraction with Hg amalgamation without use retort contributes the highest mercury releases (86,6%) to the total release from domestic production of metals and raw material. Of all the released Hg to the environment, about 56.7% entered the atmosphere

Table 6-1. Source sub category, activity rate, conversion factor, and data sources for domestic production of metals and raw materials

(1)	(2)	(3)	(4)	(5)	(6)
Source category	Source present (?)	Activity rate		Conversion factor or calculation	Data Source
	Y/N/?	Annual consumption/ production	Original data		
Primary metal production					
Mercury (primary) extraction and initial processing	N	t mercury produced/y			
Production of zinc from concentrates	N	t concentrate used/y			
Production of copper from concentrates	Y	993,152 t concentrate used/y	993,152 t concentrate used/y		Statistics Central Agency, 2010*
Production of lead from concentrates	N	t concentrate used/y			
Gold extraction by methods other than mercury amalgamation	Y	119,726 t gold ore used/y	119,726 t gold ore used/y		Statistics Central Agency, 2010*
Alumina production from bauxite (aluminum production)	Y	440,000 t bauxite processed/y	440,000 t bauxite processed/y		Statistics Central Agency, 2010*
Primary ferrous metal production (iron, steel production)	Y	4,561,065 t pig iron produced/y	4,561,065 t pig iron produced/y		Statistics Central Agency, 2010*
Gold extraction with mercury amalgamation - without use of retort	Y	97,500 kg gold produced/y	97,500 kg gold produced/y		Statistics Central Agency, 2010*
Gold extraction with mercury amalgamation - with use of retorts	N	kg gold produced/y			
Other materials production					
Cement production	Y	53,010,000 t cement produced/y	53,010,000 t cement produced/y		Ministry of Public Works, 2010**
Pulp and paper production	Y	19,500,000 t biomass used in production/y	6,500,000 pulp and paper production	To produce 1 ton pulp and paper, requires 3 ton of biomass	Indonesian Pulp and Paper Association (APKI, Asosiasi Pulp dan Kertas Indonesia), 2010

Note:

* Accessed from the following website: http://www.bps.go.id/
**Can be accessed from the following website: http://pusbinsdi.net/semen.php?page=produksi
On Inventory Level 1 (column 1, 2, 3), only the white cells are open for entering data in the spreadsheet.
Column 4, 5, and 6 were added to give information of the data origin of activity rate.
Mercury release estimation is done based on data of activity rate in 2010.



	Prod. of copper from concent.	Gold extract. by methods other than Hg amalgam.	Alumina prod. from bauxite	Primary ferrous metal prod.	Gold extract. with Hg amalgam. - without use of retort	Cement prod.	Pulp and paper prod.	Total to each pathway
Air	795	263	33	217	117,000	8,747	585	127,639
Water	159	132	22	-	39,000	-	-	39,313
Land	1,907	5,926	-	-	39,000	-	-	46,833
By-products and impurities	3,178	263	-	-	-	2,916	-	6,357
General waste	-	-	143	-	-	2,916	-	3,059
Specific waste treatment /disp.	1,907	-	22	11	-	-	-	1,940

Source Sub Category

Figure 6-1. Estimated mercury releases from domestic production of metals and raw materials

Production of copper, lead from concentrate, alumina from bauxite, and primary ferrous metal

Data of copper, gold extraction by methods other than mercury amalgamation, alumina production from bauxite, and primary ferrous metal production in 2010 were derived from Statistics Central Agency. Not only primary mercury extraction, but also extraction and processing of other non-ferrous and ferrous metals may be potent sources of mercury releases. Non-ferrous metal extraction ranks as the second largest emitter of mercury to the atmosphere globally only surpassed by coal fired power plants.

Gold Extraction

Production of gold in Indonesia can be found in the national production statistics published by Statistics Central Agency. The production of gold from the large scale industry of gold mining uses gold extraction and initial processing by methods other than mercury amalgamation. The national production in 2010 was approximately 119,726 ton of gold.

Production of gold from artisanal and small-scale gold mining (ASGM) which use mercury for amalgamation in ball-mills are easily found all over Indonesia. Research conducted by BaliFokus in 2009 until 2010, through media clippings, interviews, data from the field and various studies, identified about 900 hotspots, produced minimum 5-10 gram of gold in a week. It means, in a year, the gold produced from ASGM sector was approximately 65-130 ton, almost equal with the large scale gold mining sector, about 127 ton in 2011. Almost in every ASGM sites, mercury was used to extract gold and burned in open spaces. Large scale gold mining does not use mercury in their process but might co-mined mercury together with other minerals. Depending on the type of ore in the region, in ASGM hotspots, mercury was added in the pan, sluice boxes, and ball-mills even combine with cyanide. From these processes, at least 10 gram of mercury per gram gold will be released to the environment. Mercury vapor will stay in the atmosphere for 1.5 years and will then be deposited in a place far from its source. Mercury released to water and soil accumulated in fish and plants consumed by people (Ismawati, 2011).

Cement production

Indonesia was the second largest consumer amongst the Southeast Asian countries, however, per-capita consumption was only 195 kg, which was quite low compared to global and even regional standards. **Figure 6-2** shows the annual cement production and prediction from 2010 to 2015. Installed capacacy by 2010 reached 53 millions tons. Around 98% of cement produced in Indonesia was consumed by the domestic market itself during the year and the rest was exported.

Annual cement consumption recorded a growth of 17.7% in year 2011 backed by strong demand from the housing and construction sectors. To cash in on this rising demand, leading cement companies have charted out aggressive expansion plans. Semen Gresik has planned to invest IDR 6.96 trillion to develop cement plants in Java and Sumatra while Indocement has planned to invest IDR 1 trillion to develop two cement plants in Java. The third biggest producer, Holcim Indonesia has also planned to invest USD 200 million to develop a cement plant in Tuban, East Java. As a result of these expansions, the total designed capacity in the country is expected to touch 64 million tons by the end of year 2013. The outlook for the Indonesian cement industry is positive. Backed by strong domestic demand and government support for housing and infrastructure development, the annual cement consumption is expected to cross 55 million tons by end of 2012 itself. The major challenges facing it are raising prices of fuel, coal, and transportation costs. The industry will also have to meet global pollution and emission standards which will take another considerable amount of investment.

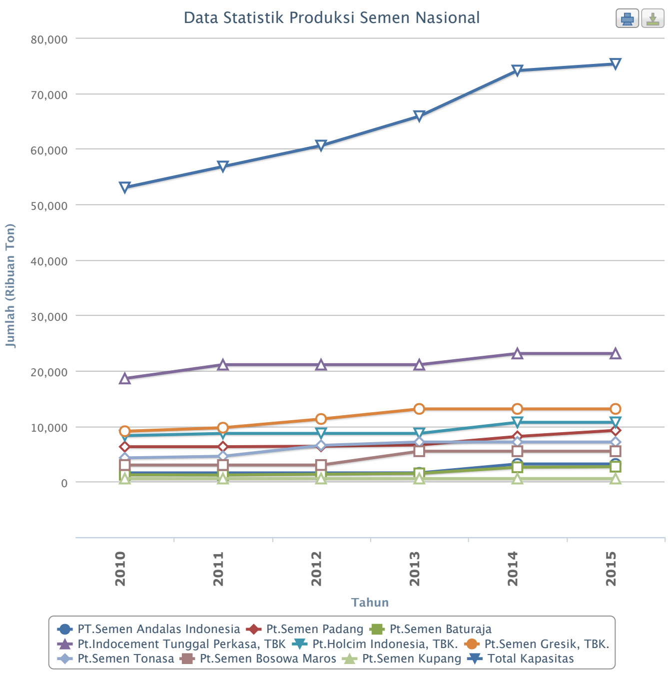


Figure 6-2. Estimation of Cement Production in Indonesia
Source: Resource Development Center, Ministry of Public Works
http://pusbinsdi.net/semen.php?page=produksi

Pulp and paper production
The ability of pulp and paper production Indonesia in 2010 reached 6.35 million tonnes with an installed capacity of 7.9 million tonnes. Pulp and paper production capacity of 6.35 million tons, generated by mainly PT Toba Pulp Lestari, PT Indah Kiat Pulp and Paper, PT Riau Andalan Pulp and Paper, PT Lontar Papyrus, PT Tanjung Enim Lestari. It requires ± 3 ton of biomass to produce 1 ton pulp and paper, therefore approximatle 19,5 million tons of biomass had been consumed in 2010.

Despite the economic potential, literature sources indicate some long standing structural problems in the pulp and paper sector. Since its establishment in the late 1980s, the pulp and paper industry has been heavily reliant on the natural forest for timber (Barr 2001). The high growth of the pulp and paper industry has proceeded far more rapidly than efforts to secure a sustainable supply of raw materials through the development of pulpwood plantations (Cossalter 1998). To date, Indonesia's pulp mills have relied heavily on unsustainable and much of which is obtained through the clear-cutting of natural forests. As of 2010, key pulp and paper producers in Riau, Sumatra, sourced more than half of their raw material from the conversion of natural forest (IWGFF 2011). Although extensive timber plantation development programs have been implemented over the years, the supply of timber available from these plantations remains to be insufficient.

6.2. Background calculations and approximations

Production of copper, lead from concentrate, alumina from bauxite, and primary ferrous metal
Ore for extraction of copper, lead, and other metals (mainly sulphide ore) contain trace amounts of mercury. In the process of extracting the desired metal from the ore, processes are used which release this mercury from the rock material. This mercury may evaporate and follow the gaseous streams in the extraction processes (in most cases) or follow wet (liquid) process streams, depending on the extraction technology used. Although there are technically advanced release reduction devices on smelter facilities, which may retain in filter residues (wastes), some of the mercury otherwise emitted to the atmosphere. Metal mercury is sometimes recovered from filter residues and sold on the market. The use of wet extraction processes instead of pyrometallic (heating) processes may have much lower air emissions, yet more of the mercury follows wastes, sludges and waste water discharges.

According to national statistics data, the production of copper from concentrate in 2010 used 993,152 ton concentrate, and by using default input factors from UNEP Toolkit 1-15 g Hg/t, the amount of mercury releases were estimated to be 993 – 14,897 Kg Hg/y. For current estimation, 8 g Hg/t input factor as the average value was chosen, resulted in mercury estimation of 7,945 Kg Hg/y. Out of the total mercury released, 10% enters to the air, 2% to water, 24% to land, 40% by product and impurities, and 24% to specific treatment disposal.

It was recorded that 440,000 ton of bauxite had been processed in 2010 to produce alumina. Using default input factors of 0.07-1 g Hg/t bauxite processed, there would be about 31 Kg Hg/y for minimum estimation and 440 Kg Hg/y for maximum estimation of mercury releases to the environment. For current calculation, the value of 0.5 g Hg/t was used, therefore the amount of mercury release from bauxite processed was predicted to be

220 Kg Hg/y. Out of this number, 15% emitted to the air, 10% to waste, 65% in general waste, and 10% to specific treatment disposal.

For the primary ferrous metal production, about 4,561,065 t pig iron was produced in 2010. There is only one input factor available for this activity, i.e. 0.05 g Hg/pig iron produced, therefore about 228 Kg mercury was estimated to be released 95% to the air, and the rest 5% to the specific treatment disposal.

Gold Extraction

For sub category of gold extraction and initial processing by methods other than mercury amalgamation, it was recorded that about 119,726 ton gold ore used for production in 2010. By implementing default input factors of 10-100 g Hg/t ore extracted, there should be around 1,197 Kg mercury up to 11,973 Kg mercury emitted to the environment. Using average value of this input factor, i.e. 55 g Hg/t ore used (extracted), mercury release was estimated to be 6,585 Kg mercury in 2010. Out this value, 4% emitted to the air, 2 % to the water, 90% to the land, 4% to the by product.

Artisanal and Small-scale Gold Mining with mercury amalgamation gives rise to substantial mercury releases on a global scale. Here, liquid metal mercury is added intentionally because it can dissolve gold present in the ore or concentrate, and the mix ("amalgam") can hereafter be separated from the rock material (called "tailings"), and the mercury can finally be heated off to produce the pure gold. Today, this ancient method is mainly used by "artisanal" small scale gold mining (ASGM). When only the concentrate is amalgamated, the mercury consumption and releases are somewhat lower compared to whole ore amalgamation. In some cases so-called retorts are used to recover some of the mercury from the heating process for re-use. This reduces the mercury consumption and releases further.

Using data fieldwork by BaliFokus in 2009 until 2010, approximately 65-130 ton gold produced in one year. According to UNEP toolkit, mercury releases from ASGM may vary significantly depending on local ore type and processing techniques. On Inventory Level 1, it is assumed that amalgamation is conducted without retorts, about 50% of the gold is produced from whole ore amalgamation process, and the rest are from amalgamation of concentrate only (using less mercury).

Using the minimum-maximum value of gold production from ASGM, i.e. 64-130 ton gold produced in one year, and default input factor of 3 kg Hg/kg gold produced from whole ore (assumption: 50% from total production) and 1 kg Hg/kg gold produced from concentrate (assumption: 50% from total production). **The minimum and maximum mercury releases were 128,000 Kg Hg/year and 260,000 Kg Hg/year respectively.**

The current estimation used average value of gold production from ASGM sector of 97.5 ton per year, about 48.75 ton gold produced from amalgamated of whole ore, and 48.75 ton gold produced from amalgamation of concentrate only. Implementing default input factor from the toolkit, i.e. 3 kg Hg/kg gold produced from whole ore and 1 kg Hg/kg gold produced from concentrate, there would be about 146,250 Kg Hg/y and 48,750 Kg Hg/y released to the environment. Therefore total amount of emitted mercury from ASGM was approximately **195,000 Kg mercury per year**, with the distribution as follows: **60% emitted to the air, 20% to water, and the rest 20% to the land.**

Cement production
The raw materials used for the production of cement contain trace concentrations of mercury. The origin of this mercury is mercury naturally present in virgin raw materials and fuels used (lime, coal, oil etc.), mercury content in used solid residues from other sectors (e.g. fly-ashes and gypsum from combustion of coal) in which mercury content may be elevated compared to virgin materials, and in wastes sometimes used as fuels in cement manufacturing. The use of waste products as feed materials may significantly increase the total input of mercury to the cement production. The primary output pathways of mercury fed in with raw materials are releases to the atmosphere and through trace mercury levels in the produced cement. Mercury contributions from fossil fuels are deducted in the calculations here, because they are accounted for under the fossil fuel sub-categories if waste or chemical waste is combusted/used as fuel in cement kilns, the amount and type of waste may have significant influence on the mercury releases. Dust filters may be used, but generally they do not retain much mercury as the collected dust is often fed back into the process, and mercury, being on gas form at these temperatures, may not be held back effectively.

In the Inventory Toolkit Level-1, 50% of the cement produced is assumed produced through the co-incineration of hazardous waste and the remaining without co-incineration of hazardous waste. Basic particle filters are assumed used. Mercury contributions from fossil fuels are deducted in the calculations here, because they are accounted for under the fossil fuel sub-categories.

Data from the Ministry of Public Works recorded that the cement production in 2010 reached 53,010,000 ton. The default input factors for cement production with co-incineration of hazardous waste is 0.08 – 0.8 g Hg/ton cement produced, and input factor for cement production without co-incineration of hazardous waste are 0.02-0.2 g Hg/ton cement produced. Using these values, the minimum and maximum estimations for mercury releases from the cement production sector were estimated to be 2,651 Kg Hg/y and 26,505 Kg Hg/y.

For current estimation, it was selected the average value of input factor, i.e. 0.44 g Hg/ton cement produced (with co-incineration of hazardous wastes) and 0.11 g Hg/ton cement produced (without co-incineration of hazardous wastes), resulted in 14,578 Kg Hg/y releases, with the following breakdown:

- 11,662 Kg Hg/y (from cement production with co-incineration of hazardous wastes); out of this value, about 80% entered the air and the rest remained in the by-product.
- 2,916 Kg Hg/y (from cement production without co-incineration of hazardous wastes); out of this value, about 60% went to the air, 20% to the by product, and 20% to the general waste.

Pulp and Paper
The original mercury sources in pulp and paper production is the mercury present in trace concentrations in wood, as well as trace concentrations in fuels and chemicals (NaOH, H_2SO_4, Cl_2) used in the process. Data from the Indonesian Pulp and Paper Association showed that 19,500,000 ton biomass were used in the production of pulp and paper in 2010. Implementing default input factors of 0.007-0.7 g Hg/t biomass used in production, approximately 136.5 – 1,365 Kg Hg/y were emitted to the environment. For current estimation, the average input factor of 0.03 g Hg/t biomass (dry weight) was used, which resulted mercury emission of 585 Kg Hg/y, and 100% enters the atmosphere.

6.3. Data gaps and priorities for potential follow up

For this sub category, there are data gaps and priorities for potential follow up which could be identified as follows:

- The mercury releases from ASGM source sub category is the largest contributor to the whole Hg emission to the country. On Inventory Level 1, the toolkit uses the assumption for amalgamation without retorts that 50% of the gold is produced from amalgamated of whole ore (default input factor: 3 kg Hg/kg gold produced), and the rest from amalgamation of concentrate only using less mercury (default input factor: 1 kg Hg/ kg gold produced). Using these input factors, the mercury releases were calculated to be 195 ton per year.
- Based on the researches conducted by BaliFokus in several hotspots of ASGM in Indonesia 2006-2010, it was estimated that the production of gold from this sub-category were between 65 up to 130 ton per year, with estimation of input factors based on the literature study between 5 to 10 Hg per kg gold produced. Unfortunately, due to its illegal form nature of business, there was no actual measurement of Hg emission which characterises the individual site specific default input factor. Using the estimation based on the study by BaliFokus, the emission of Hg might be much higher than UNEP toolkit estimation, i.e. 325-650 ton per year mercury releases if uses 5 Hg/kg gold produced, and 650 to 1300 ton per year mercury releases if uses 10 Hg/kg gold produced.
- However, although there are many differences between estimation by the UNEP toolkit and the study by local researches, it is very potential to increase the level of estimation for ASGM sector from Inventory Level-1 to Inventory Level-2.
- For this category, there is also a disparity between minimum and maximum value of default input factors (e.g. the highest are the default input factors for production of copper from concentrates, i.e. 1 to 15 g Hg/t), which denotes that the individual characteristics of the activity determine the real value of default input factors.

7. Data and inventory on domestic production and processing with intentional mercury use

7.1. Data description

This step covers two groups of activities:

1) Industrial production of chemicals, and
2) Industrial production of mercury containing products.

The source sub-categories included in this inventory step are shown in **Table 7-1** below along with their origin of activity rate, conversion factor and data source. The estimation of activity rate was calculated based on the original data of mercury import from the Ministry of Trade.

Figure 7-1 shows the estimated mercury releases from production and processing with intentional mercury use. The largest contributor to this category was the light sources with mercury (fluorescent, compact, others) with almost 36% contribution to the total emission from domestic production and processing with intentional mercury use. About 44.6% of the total emitted mercury entered the land and the general waste.

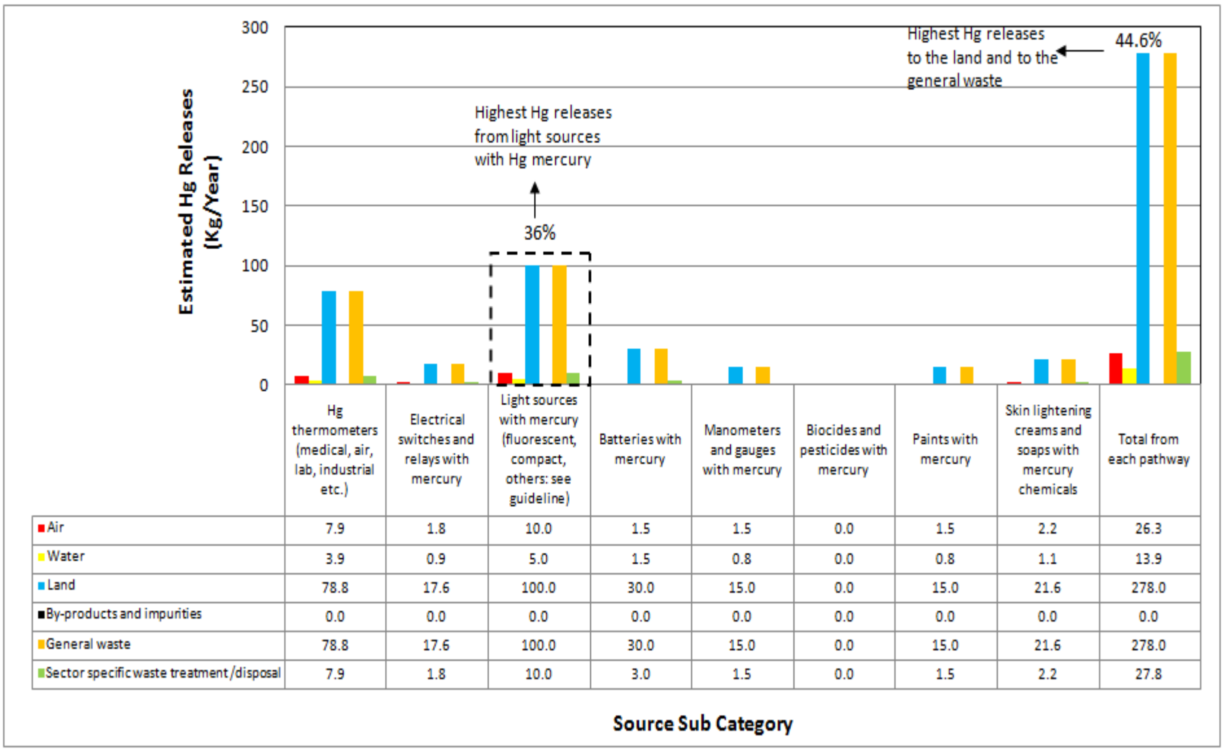
Table 7-1. Source sub-category, activity rate, conversion factor, and data sources for domestic production and processing with intentional mercury use

(1)	(2)	(3)	(4)	(5)	(6)
Source category	**Source present ?**	**Activity rate**	**Original data**	**Conver-sion factor or calculation**	**Data source**
	Y/N/?	**Annual consumption/ production**			
Production of chemicals					
Chlor-alkali production with mercury-cells	N	t Cl_2 produced/y			
VCM production with mercury catalyst	N	t VCM produced/y			
Acetaldehyde production with mercury catalyst	N	t acetaldehyde produced/y			
Production of products with mercury content					
Hg thermometers (medical, air, lab, industrial etc.)	Y	1,050 kg mercury used for production/y	1,050 kg mercury used for production/y		Ministry of Trade, 2010*
Electrical switches and relays with mercury	Y	176 kg mercury used for production/y	176 kg mercury used for production/y		Ministry of Trade, 2010*
Light sources with mercury (fluorescent, compact, others: see guideline)	Y	1,000 kg mercury used for production/y	1,000 kg mercury used for production/y		Ministry of Trade, 2010*
Batteries with mercury	Y	300 kg mercury used for production/y	300 kg mercury used for production/y		Ministry of Trade, 2010*

(1)	(2)	(3)	(4)	(5)	(6)
Source category	**Source present ?**	**Activity rate**	**Original data**	**Conver-sion factor or calculation**	**Data source**
	Y/N/?	**Annual consumption/ production**			
Manometers and gauges with mercury	Y	150 kg mercury used for production/y	150 kg mercury used for production/y		Ministry of Trade, 2010*
Biocides and pesticides with mercury	Y	0.25 kg mercury used for production/y	0.25 kg mercury used for production/y		Ministry of Trade, 2010*
Paints with mercury	Y	150 kg mercury used for production/y	150 kg mercury used for production/y		Ministry of Trade, 2010*
Skin lightening creams and soaps with mercury chemicals	Y	216 kg mercury used for production/y	216 kg mercury used for production/y		

Note:

- *Directorate of Imports, Directorate General of Foreign Trade, Ministry of Trade, 2010.
- On Inventory Level 1 (column 1, 2, 3), only the white cells are open for entering data in the spreadsheet.
- Column 4, 5, and 6 were added to give information of the data origin of activity rate.
- Mercury release estimation is based on data of activity rate in 2010.



	Hg thermometers (medical, air, lab, industrial etc.)	Electrical switches and relays with mercury	Light sources with mercury (fluorescent, compact, others: see guideline)	Batteries with mercury	Manometers and gauges with mercury	Biocides and pesticides with mercury	Paints with mercury	Skin lightening creams and soaps with mercury chemicals	Total from each pathway
Air	7.9	1.8	10.0	1.5	1.5	0.0	1.5	2.2	26.3
Water	3.9	0.9	5.0	1.5	0.8	0.0	0.8	1.1	13.9
Land	78.8	17.6	100.0	30.0	15.0	0.0	15.0	21.6	278.0
By-products and impurities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
General waste	78.8	17.6	100.0	30.0	15.0	0.0	15.0	21.6	278.0
Sector specific waste treatment/disposal	7.9	1.8	10.0	3.0	1.5	0.0	1.5	2.2	27.8

Figure 7-1. Estimated mercury releases from domestic production and processing with intentional mercury use

7.2. Background calculations and approximations

A large number of traditional products make use of mercury's characteristics in their function. The major products groups in which mercury is added intentionally are thermometers, fluorescent light bulbs, some battery types, some traditional types of electrical switches, and traditional manometers and pressure gauges. The consumption of these products is declining in many countries because of mercury's adverse effects on health and the environment, and because electronic equipment for the same purposes but with smart features has gained increasing shares of the market. The manufacture of mercury containing products may give rise to mercury releases to air, waste water and production wastes. Publicly available mercury release data on such manufacture are scarce, and the estimation calculations here are based on a limited data base.

Mercury-containing lamp (fluorescent and other discharge lamp types) is an exception, as their sales are in the rise due to their lower energy demand and the lack of sufficiently matured mercury-free low-energy alternatives. In some countries mercury containing latex paints (where mercury is a preservative), biocides/pesticides and skin lightening creams and soaps are also manufactured and used.

Many glass thermometers are produced with alcohol liquid instead of mercury. A decline in consumption is not necessarily seen in all regions of the world, as the mercury containing products are still in the low end as regards costs, when waste and health expenses are not included. The activity rate for mercury-based thermometer production (for medical, air, lab, industrial etc.), was derived from the amount of imported mercury according to the Ministry of Trade, i.e. 1,050 Kg Hg/y, and it was assumed that all of this imported mercury was used for production. The default input factor for this sub-category is 0.75, therefore it was estimated approximately 788 Kg Hg/y from this sub category may be emitted. Out of this value, 77.5% remained within the product, and the rest was estimated to enter the environment through air, water, land, general waste, and specific treatment.

For other sub categories, data were also derived from the Ministry of Trade. The default activity rate for all sub-categories were 1, which means, all the mercury used in production shall enter the environment. The sub-category and its mercury usage for production are resptectively as follows: electrical switches and relays with mercury (176 Kg Hg/y), light sources with mercury (1,000 Kg Hg/y), batteries with mercury (300 Kg Hg/y), manometers and gauges with mercury (150 Kg/y), biocides and pesticides with mercury (0.25 Kg Hg/y), paints with mercury (150 Kg Hg/y), and skin lightening creams and soaps with mercury compound (216 Kg Hg/y). Using the default input factor of 1, it was assumed that the amount of mercury used is the same as the amount enters the environment. However, out of this value, 77.5% remained within the product, and the rest was etimated to be emitted to the environment through air, water, land, general waste, and specific treatment.

7.3. Data gaps and priorities for potential follow up

For this source category, there are data gaps which could be identified as follows:

- Only very limited data available for this source category, i.e. data of imported mercury from the Ministry of Trade and their intentional use, and other published data resources can not be found.

- There is also no recorded data at the Ministry of Industry concerning the use of mercury in the domestic production. Therefore further refining data of activity rate is required for this category.

8. Data and inventory on waste handling and recycling

8.1. Data description

This step includes all types of waste treatment, landfilling, incineration, dumping, open burning and recycling activities. The source sub-categories included in this inventory step are shown in the **Table 8-1** below along with its activity rate, their origin of activity rate, conversion factor and data source. The estimation of activity rate was calculated based on data from the Ministry of Health, Ministry of Environment, and the National Economic Social Survey (by Central Agency of Statistics).

Figure 8-1 present the estimated mercury releases from waste handling and recycle. The highest contributor to this category was the informal dumping of general waste (44.6%), and approximately 53% of the released Hg entered the atmosphere.

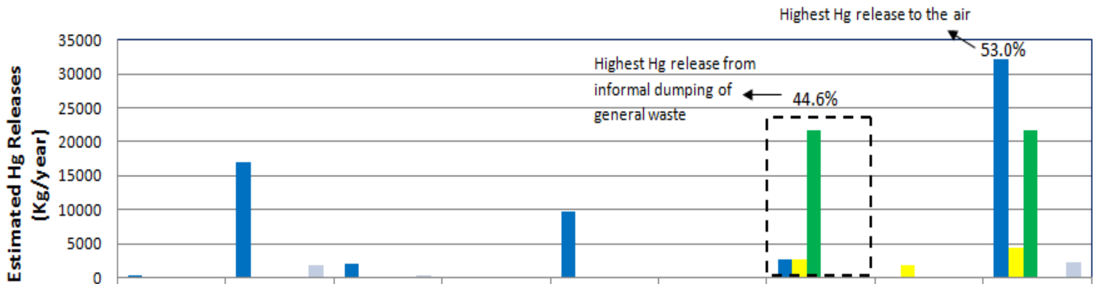
Table 8-1. Source sub-category, activity rate, conversion factor, and data sources for waste handling and recycling

(1)	(2)	(3)	(4)	(5)	(6)
Source category	**Source present?**	**Activity rate**		**Conversion factor or calculation**	**Data source**
	Y/N/?	**Annual production/ waste disposal**	**Original data**		
Production of recycled of metals					
Production of recycled mercury ("secondary production")	N	kg mercury produced/y			
Production of recycled ferrous metals (iron and steel)	N	number of vehicles recycled/ y			
Waste incineration					
Incineration of municipal/general waste	Y	61,904 t waste incinerated/y	2 waste to energy plants (Sumur Batu and Bantar Gebang Bekasi)		Ministry of Environment, 2008***
Incineration of hazardous waste	Y	786,499 t waste incinerated/ y	39,324,931 ton waste produced/ year in 2010	Approx. 2% of solid waste is hazardous waste	Damanhuri, 2008*
Incineration of medical waste	Y	98,023 t waste incinerated/ y	166,288 Hospital bed (assumed full occupancy)	Production of solid waste: 1.6 kg/bed/day	Ministry of Health, 2010**
Sewage sludge incineration	Y	97,989 t waste incinerated/y	370,400,000 m^3 waste water/y	sludge: 1.0 t/MGallon	

(1)	(2)	(3)	(4)	(5)	(6)
Source category	Source present? Y/N/?	Activity rate: Annual production/ waste disposal	Activity rate: Original data	Conversion factor or calculation	Data source
Open fire waste burning (on landfills and informally)	Y	1,966,247 t waste burned/y	38,500,000 t waste produced/year (2008)	39,324,931 t waste produced/year in 2010 5% open burned	Ministry of Environment, 2008*** Ministry of Environment, 2009****
Waste deposition/landfilling and waste water treatment					
Controlled landfills/ deposits	N	t waste landfilled/ y			
Informal dumping of general waste *1	Y	26,992,260 t waste dumped/y	38,500,000 t waste produced/ year (2008) 69% taken to landfill	39,324,931 t waste produced/year in 2010	Ministry of Environment, 2008*** Ministry of Environment, 2009****
Waste water system/treatment	Y	370,400,000 m^3 waste water/y	9.26×10^9 m^3/y 2.55% of waste treated in waste water system	Extrapolate to 5% for the year of 2010	Ministry of Environment, 2010***** Survey Sosial Ekonomi Nasional (Susenas), 2007******

Note:

- *Damanhuri, Lecture Note of Solid Waste Management, Study Program of Environmental Engineering, Institut Teknologi Bandung, 2008
- * * Ministry of Environment, Survey of National Economy and Social, 2010
- ***Indonesian Solid Waste Statistics, Ministry of Environment, 2008
- ****Indonesian Environmental Status, Ministry of Environment, 2009
- *****Indonesian Environmental Status, Ministry of Environment, 2010
- ******Survey of National Economic and Social, Central Statistics Agency Republic of Indonesia, 2007
- On Inventory Level 1 (Column 1, 2, 3), only the white cells are open for entering data in the spreadsheet
- Column 4, 5, and 6 were added to give information of the data origin of activity rate
- Hg release estimation based on data of activity rate in 2010



	Incineration of municipal / general waste	Incineration of hazardous waste	Incineration of medical waste	Sewage sludge incineration	Open fire waste burning (on landfills and informally)	Controlled landfills / deposits	Informal dumping of general waste *1	Waste water system/treatment	Total from each pathway
Air	278.6	16,988.4	2,117.3	176.4	9,831.2	0.0	2,699.2	0.0	32,091.1
Water	0.0	0.0	0.0	0.0	0.0	0.0	2,699.2	1,750.1	4,449.4
Land	0.0	0.0	0.0	0.0	0.0	0.0	21,593.8	0.0	21,593.8
By-products and impurities	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
General waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0	194.5	194.5
Specific waste treatment	31.0	1,887.6	235.3	19.6	0.0	0.0	0.0	0.0	2,173.4

Source Sub Category

Figure 8-1. Estimated mercury releases from waste handling and recycling

Incineration of municipal/general waste

Data of incinerated municipal waste was derived from the book of Indonesian Environmental Status, published by the Ministry of Environment in 2008. There were two waste-to-energy plants, which both exist in Bekasi, West Java, i.e. in Sumur Batu (0.12 MW) incinerate 3,504 t waste/y, and Bantar Gebang (initially 2 MW incinerates 58,400 t /y, and upgraded to 26 MW in the future). The overall incinerated general waste in 2010 was approximately 61,904 t waste/y.

Incineration of hazardous waste

In 2010, the amount of waste generated was 39,324,931 ton. Approximately 2% of this waste was hazardous waste, therefore the amount of hazardous waste was estimated to be 786,499 ton/y.

Incineration of medical waste

The amount of medical waste calculated from the number of hospital beds in all over indonesia. According to data from Ministry of Health in 2010, there were about 166,288 beds in hospitals all over indonesia. With the asumption of full occupancy and waste generation of 1.6 kg/bed, and 50% of generated waste was medical waste, the total weight of medical waste was about 98,023 ton per year.

Sewage sludge incineration

The amount of waste water production which can be treated through the waste treatment facilities was only 5% of total generated wastewater (370,400,000 m³), i.e. 97,989 ton per year. Using the assumption that for municipal wastewater plants sludge production will typically be 0.8-1.2 dry tons per million gallons of wastewater treated (in this case the value of 1 dry tons sludge per million gallons of wastewater treated was selected), the amount of sewage sludge production in 2010 was approximately 97,989 ton, and it was assumed that all sludge was incinerated.

Open fire waste burning (in the landfills and informally or illegal dump sites)
The Ministry of Environment provided data of solid waste generation about 38,500,000 in 2008. Using the extrapolation method, the amount of generated solid waste was expected to be 39,324,931 ton production in 2010. According to the Indonesian Environmental Status in 2009, 5% of generated waste was incinerated. Therefore, the amount of waste which was burnt on landfills and informally was about 1,966,247 ton. From the total solid waste generation, data from Ministry of Environment in 2009 showed that 69% of generated waste (or 26,992,260 t /y) was taken to the landfill. Unfortunately, most of landfills in Indonesia do not apply the sanitary landfill technique; therefore the prediction shall assume that all landfills are operating as open dumping site.

Waste water system/treatment
In 2010, the Ministry of Environment through the Indonesian Environmental Status, stated that the clean water consumption reached the value of 9.26 x 10^9 m^3. About 80% of this amount was disposed to the environment as wastewater. According to the National Economic and Social Survey in 2007, only 2.55% (extrapolated to 5% for the year of 2010) of the generated waste water was treated in waste water treatment facilities, which was about 370,400,000 m^3.

8.2. Background calculations and approximations

Further calculation of mercury releases in this sub-category on waste and recycling depends on the amount of waste which has been treated under public control. In Indonesia more than 2/3 (two thirds or 67%) of the waste collected and treated under public control.

Incineration of municipal/general wastes
According to the Indonesian Environmental Status, there is only two waste-to-energy plants which incinerate the municipal wastes, i.e. located in Sumur Batu (120 KW) and Bantar Gebang Bekasi (2 MW, which will be upgraded to 26 MW) with total ton of waste incinerated approximately 61,904 t/y. Using default input factors of 1-10 g Hg/t waste incinerated, the emission of Hg was estimated to be 62 to 619 Kg Hg /year. For current estimation, using the selected input factor was 5 g Hg/t waste incinerated, this sector generated 310 Kg Hg/year to the atmosphere.

Incineration of hazardous wastes
The default input factor for incineration of hazardous wastes as well as for medical wastes are between 8 and 40 g Hg/t waste, using these values, for 786,499 ton of incinerated hazardous waste, the amount of released mercury is varied between 6,292 to 31,460 Kg Hg/y and all was emitted to the air. For the selected input factor, in this case 24 g Hg/ton waste, the released mercury from hazardous wastes incineration to the air was predicted to be 18,876 Kg Hg/y. Similar to hazardous waste, the incinerated medical waste were emitted between 788 and 3,940 Kg Hg/y. For current estimation of the released mercury from medical waste incineration to the air, the middle value input factor of 24 g Hg/ton waste was used. Based on this calculation, the incineration of hazardous wastes was predicted to release 2,364 Kg Hg/y to the atmosphere.

Sewage sludge incineration
For sewage sludge incineration, the value of 2 g Hg/t proposed in the toolkit to predict the mercury release. It is predicted that sewage incineration process produced 196 Kg Hg/y, with 90 percent emitted to the air, and the rest remained in the specific treatment/disposal.

Open fire waste burning (in the landfills and informally or illegal dump sites)
The informal waste burning default input factors are 1-10 g Hg/t waste, therefore the minimum and maximum value of mercury emission were 1,966 and 19,662 Kg Hg/y. Using the middle value of 5 g Hg/t, mercury released from this sub-category was calculated to be 9,831, and 100% emitted to the air.

Similar to the informal waste burning, the informal waste dumping has the same default input factors 1 – 10 g Hg/t, and for 26,992,260 ton waste dumped/year, the released mercury was predicted to be 26,992 – 269,923 Kg Hg/y. For current estimation, the selected default input factor was chosen to be the minimum one, since it was assumed that informal dumping of general waste was the same as the open dumping which was easily found in Indonesia, and no waste went to the controlled landfills. Actually, there are also some landfills in Indonesia which were operated using sanitary landfill technique, but the amount of waste treated using this technique was hard to find. From the open fire waste burning activities, mercury released to the environment approximately 10% evaporated to the air, 10% enters the water, and 80% deposited on the land.

Waste water system/treatment
The default input factors for this sub category are between 0.5 -10 mg Hg/m^3 treated waste water, for activity rate of 370,400,000 m^3 waste water/y, It was calculated about 185 to 3,704 Kg Hg/y as minimum and maximum value respectively could be emitted to the environment. Using the middle value of input factor of 5.25 mg Hg/m^3 waste water, tihs activity would release about 1,946 Kg Hg/y to the environment, and out of this value, about 90% emitted to the water, and 10% to the general waste.

8.3. Data gaps and priorities for potential follow up

For waste handling and recycling, there are data gaps and priorities for potential follow up which could be identified as follows:

- As stated in UNEP toolkit guideline, open waste burning will generally be hard to quantify precisely, but as the mercury releases directly to the environment may be substantial, it is important to try and make a rough estimate for mercury release quantification. In Indonesia, open fire waste burning becomes one of the major source of mercury emission, and the results may be higher than predicted by the UNEP toolkit. One of the reason is beside the open fire waste burning in landfills and informally, there are also open fire in the forests, especially for land clearing for oil palm field, and unintentional forest fire during certain period.
- There is a disparity between minimum and maximum value of default input factors (e.g. the highest are the default input for waste water system/treatment is between 0.5 to 10 mg Hg/m^3 waste water, which denotes that the individual characteristics of the activity determine the real value of default input factors. There should be detail on the type of waste treatment set up, the type of implemented technology, as well as the fate of sludge.

9. Data and inventory on general consumption of mercury in products, as metal mercury and as mercury containing substances

9.1. Data description

This step includes national consumption of a wide variety of consumer products (such as thermometers and fluorescent light bulbs), and product where mercury must be added for its function (such as dental amalgam and manometers). The included products may be produced domestically, but may also be imported, and therefore needs to be quantified separately.

The national annual consumption is defined as:

Consumption = production + import - export (in the same year)

The source sub-categories included in this inventory step are shown in **Table 9-1** along with activity rate, conversion factor and data source. Many of these products and mercury uses are used by private consumers and in large numbers, and are therefore spread diffusely all over the country and may break during use or be lost with informal waste disposal. Activity rate for this sub categories were derived from the Statistics Central Agency, Indonesian Association of Electrical Lighting Industry, and other research conducted by NGOs such as BaliFokus.

Figure 9-1 shows the estimated mercury release from general consumption of mercury in products, as metal mercury and as mercury-containing substances. The medical blood pressure gauges (sphygmomanometers) was the highest contributor, and contributed about 34.26% of the total emission from this category, and more than 66.84% of released mercury was disposed in the general waste.

Table 9-1. Source sub categories, activity rates, conversion factors, and data sources for general consumption of mercury in products, as metal mercury and as mercury containing substances

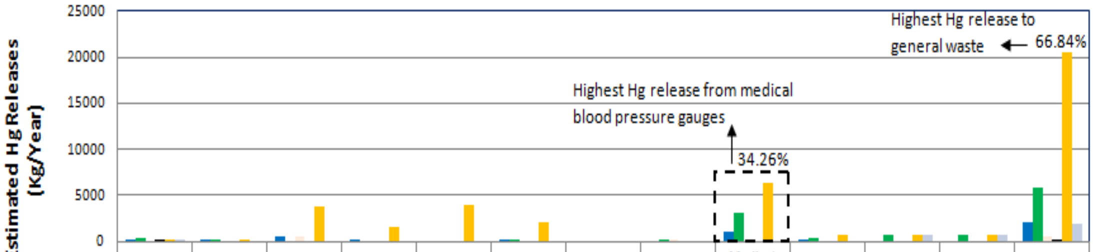
(1)	(2)	(3)	(4)	(5)	(6)
Source category	Source present?	Activity rate		Conversion factor or calculation	Data source
	Y/N/?	Annual consumption/ population	Original data		
Use and disposal of products with mercury content					
Dental amalgam fillings ("silver" fillings)	Y				
Preparations of fillings at dentist clinics		237,641,326 number of inhabitants	237,641,326 number of inhabitants		Statistics Central Agency, 2010*
Use - from fillings already in the mouth					Statistics Central Agency, 2010*
Disposal (lost and extracted teeth)					Statistics Central Agency, 2010*
Thermometers	Y	157,129			
Medical Hg thermometers	Y	150,000 items sold/y			BaliFokus, 2010
Other glass Hg thermometers (air, laboratory, dairy, etc.)	Y	14,257 items sold/y	7129 Number of laboratories **	2 Assumption of Thermometer each lab	Statistics Central Agency, 2008*
Engine control Hg thermometers and other large industrial/speciality Hg thermometers	Y	items sold/y			No data available
Electrical switches and relays with mercury	Y	237,641,326 number of inhabitants	237,641,326 number of inhabitants		Statistics Central Agency, 2010*
Light sources with mercury	Y	275,000,000 items sold/y			
Fluorescent tubes (double end)	Y	75,000,000 items sold/y	75,000,000 items sold/y		Indonesian Association of Electrical Lamp Industry, 2010***
Compact fluorescent lamp (CFL single end)	Y	200,000,000 items sold/y	200,000,000 items sold/y		
Other Hg containing light sources (see guideline)	N	items sold/y			
Batteries with mercury	Y	7,963 t batteries sold/y			

(1)	(2)	(3)	(4)	(5)	(6)
Source category	Source present? Y/N/?	Activity rate: Annual consumption/ population	Activity rate: Original data	Conversion factor or calculation	Data source
Mercury oxide (button cells and other sizes); also called mercury-zinc cells	Y	3.4 t batteries sold/y	237,641,326 number of inhabitants	2.9 gram weight of each battery 0.5% Inhabitants use this batteries (number of inhabitants x weight of each button battery x 0.5%)/10^6	Statistics Central Agency, 2010*
Other button cells (zinc-air, alkaline button cells, silver-oxide)	Y	138 t batteries sold/y	237,641,326 number of inhabitants	2.9 gram weight of each tube alkaline battery 20% inhabitants use this batteries (number of inhabitants x weight of each button battery x 20%)/10^6	Statistics Central Agency, 2010*
Other batteries with mercury (plain cylindrical alkaline, permanganate, etc., see guideline)	Y	7,822t batteries sold/ y	521,470,407 number of alkaline batteries sold	15 gram weight of each tube alkaline battery (number of alkaline batteries sold x weight of each tube alkaline battery)/10^6	http:// id.acnielsen.com, 2008
Polyurethane (PU, PUR) produced with mercury catalyst	Y	237,641,326 number of inhabitants			Statistics Central Agency, 2010*
Paints with mercury preservatives	Y	t paint sold/y			No data available

(1)	(2)	(3)	(4)	(5)	(6)
Source category	Source present?	Activity rate		Conversion factor or calculation	Data source
	Y/N/?	Annual consumption/ population	Original data		
Skin lightening creams and soaps with mercury chemicals	Y	3.56 t cream or soap sold/y			No data available
Medical blood pressure gauges (mercury sphygmomanometers)	Y	150,000 items sold/y			BaliFokus, 2010
Other manometers and gauges with mercury	Y	237,641,326 number of inhabitants			Statistics Central Agency, 2010*
Laboratory chemicals	Y	237,641,326 number of inhabitants			Statistics Central Agency, 2010*
Other laboratory and medical equipment with mercury	Y	237,641,326 number of inhabitants			Statistics Central Agency, 2010*

Note:

- * Can be accessed from the following website: http://www.bps.go.id/
- ** Based on number of testing lab., calibration lab., clinical lab., industrial lab., and university lab.
- *** Accessed from the following website: www.aperlindo.com
- On Inventory Level 1 (column 1, 2, 3), only the white cells are open for entering data in the spreadsheet
- Column 4, 5, and 6 were added to give information of the data origin of activity rate
- Hg release estimation based on data of activity rate in 2010



	Dental amalgam fillings	Thermo-meters	Electrical switches and relays with mercury	Light sources with Hg	Batteries with Hg	Polyure-thane produced with Hg catalyst	Paints with Hg preserv.	Skin lightening creams and soaps with Hg chems.	Medical blood pressure gauges (Hg sphygmo manomet ers)	Other manome-ters and gauges with mercury	Lab. chemicals	Other lab. and medical equip. with Hg	Total to each pathway
Air	23.8	28.4	475.3	87.5	0.0	237.6	0.0	0.0	1,050.0	118.8	0.0	0.0	2,021.4
Water	394.5	85.1	0.0	0.0	0.0	118.8	0.0	101.3	3,150.0	356.5	784.2	784.2	5,774.6
Land	0.0	0.0	475.3	0.0	0.0	0.0	0.0	5.3	0.0	0.0	0.0	0.0	480.6
By-products and impurities	42.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.8
General waste	228.1	170.2	3,802.3	1,662.5	4,023.0	2,020.0	0.0	0.0	6,300.0	712.9	784.2	784.2	20,487.4
Specific waste treatment /disp.	228.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	808.0	808.0	1,844.1

Source Sub Cateogry

Figure 9-1. Estimated mercury releases from general consumption of mercury in products, as metal mercury and as containing substances

9.2. Background calculations and approximations

For estimating the mercury released from dental amalgam fillings, use from fillings already in the mouth, disposal (lost and extracted teeth), electrical switches and relays with mercury, polyurethane produced with mercury catalyst, other manometer and gauges with mercury, laboratory chemicals, and other laboratory and medical equipment with mercury, mercury releases estimation were calculated based on number of inhabitants.

Preparation of fillings at dentist clinics
For preparations of fillings at dentist clinics, the default input factors were 0.05-0.2 g Hg/(y*inhabitant), therefore the minimum-maximum value of estimation were 11,882 Kg Hg/y to 47,528 Kg Hg/y. Since this estimation based on the condition in the United States, the estimation for mercury releases from this source of sub-category for Indonesia was corrected by ten percent of minimum value. In this case, the estimation of mercury emission was only 1,188 Kg Hg/y. For the use from fillings in the mouth (releases from mercury supply for fillings 5-15 years ago) and disposal (releases from mercury supply from fillings 10-20 years ago), the default input factor are not available in the toolkit.

Electrical switches and relays with mercury
Electrical switches and relays with mercury and Polyurethane (PU, PUR) produced with mercury catalyst have the same default factors, i.e. 0.02-0.25 g Hg/(y*inhabitant). The activity rate is the number of inhabitans, and using the minimum-maximum input factors, the emission from this sub categories were estimated to be 4,753 to 59,410 Kg Hg/y. For current estimation, the lowest value of 4,753 Kg Hg/y was selected as the predicted mercury released from this category.

Laboratory chemicals and other laboratory and medical equipment with mercury
For laboratory chemicals and other laboratory and medical equipment with mercury, only one default input factor available, i.e. 0.01 g Hg/(y*inhabitant), for acitivity rate of 237,641,326 number of inhabitants, hence approximately 2,376 Kg Hg per year was produced by each sub category.

Medical blood gauges with mercury
For manometers and gauges with mercury, the default input factors were 70-85 g Hg/item. Using the activity rate of 150,000 items sold/year, the mercury released from this measuring devices would be 10,500 to 12,750 Kg Hg/y as minimum-maximum values. From thes values, about 10% was released to the air, 30% to the water, and the rest was disposed into the general waste. The minimum value of estimation was selected to be the value for current condition in Indonesia.

Thermometers
The number of medical mercury thermometers sold was 150,000 items in 2010. With default input factors of 0.5 - 1.5 g Hg/item, the minimum-maximum value of mercury release should be 75 – 225 Kg Hg/y. For current estimation, the selected input factor was 0.75 g Hg/item, hence 113 Kg Hg/y was produced from this sub-category.

For ambient air thermometers, approximately 7,129 items were sold per year. Using default input factors of 2-5 g Hg/item, estimation of mercury releases were about 14 to 36 Kg Hg/y. The selected default input factor was 3.5 g Hg/item, therefore the emission was predicted to be 25 Kg Hg/y. For other glass mercury-based thermometer, the default input factors were of 1-40 g Hg/item, with activity rate of 7,129 items sold per year, the minimum-maximum value of of mercury releases were estimated between 7 to 285 Kg Hg/y. The selected input factor was 20.5 g Hg/item, producing 146 Kg mercury emisson per year.

Lights with mercury
Fluorescent tubes (double end) light were sold 75,000,000 items in 2010, with default input factors of 10-40 mg Hg/item, the minimum-maximum value would be 750 to 3000 Kg Hg/y. For compact fluorescent lamp (CFL single end), the default input factors are 5-15 mg Hg/item. For 200,000,000 items sold in one year, the minimum-maximum value of Hg release were estimated to be 1,000 to 3,000 Kg mercury to the environment. For this sub-category, the minimum value had been chosen for the prediction.

Batteries with mercury
About 7,963 ton batteries with mercury were sold in 2010, consisted of button cells and non-button cell batteries. Out of this number, the mercury oxide (button cells) were predicted to be 3.4 ton. This value was derived from the assumption that 0.5% of the total number of inhabitants used this batteries (weight of each of 2.9 gram). Only one default input factor is available in the toolkit, i.e. 320 kg Hg/ton batteries. Using this value, the amount of mercury released was approximately 1,103 Kg Hg/y.

Other button cells such as zinc air button cells (45.9 ton batteries sold/y and input factor of 12 kg Hg/t batteries), alkaline button cells (45.9 ton batteries sold/y and input factor of 5 kg Hg/t batteries), and silver oxide button cells (45.9 ton batteries sold/y and input factor of 4 kg Hg/t batteries), emitted Hg 551 Kg/y, 230 Kg/y, and 184 Kg/y respectively. The last type of batteries are those with mercuy other than button cells, which predicted to be sold up to 7,822 ton batteries per year. By using default input factor of 0.25 Kg Hg/t batteries sold, it was estimated that the mercury releases should not be less than 1,956 Kg Hg/y.

Paints with mercury preservatives, skin lightening creams and soap with mercury chemicals
The paints with mercury preservatives were really hard to predict, therefore no data can be assumed. For the skin lightening creams and soaps with mercury chemicals, it was estimated that about 3.56 ton of skin and soap were sold per year based on number of cosmetics brands which were identified by BPOM as mercury containing product (*Badan Pengawas Obat dan Makanan*, agency which responsible for supervising drug and food and drink in Indonesia). Using the default input factors of 10 and 50 Kg Hg/t, the maximum minimum value of Hg release were predicted to be 36 to 178 Kg Hg/y. The selected input factor was 30 Kg Hg/t, thereofore approximately 107 Kg Hg/y might be emitted to the environment.

9.3. Data gaps and priorities for potential follow up

Data gaps and priorities for potential follow up from this category are as follows:

- There are many activity rates in these sub categories that are predicted from the number of inhabitants (i.e., Hg from dental amalgam fillings, use from fillings already in the mouth, teeth disposal, electrical switches and relays with mercury, polyurethane produced with mercury catalyst, other manometer and gauges with mercury, laboratory chemicals, and other laboratory and medical equipment with mercury). Predicting the activity rates through the number of inhabitant could deviate from the actual value, since many technical and non technical factors might influence the predication. For instance, the habitual behavior of certain society for visiting or not visiting dentist, people live in remote places or villages use fewer number of electrical switches and relays with mercury, or number of medical laboratories within a country, and etc. Therefore prediction of mercury releases based on number of inhabitants within a country, should be refined, e.g. by differentiating the default input factors for developed and developing country.

- The actual number of button cell batteries (either mercury oxide, alkaline button cells, silver oxide) was hard to find as no record had been openly published. Therefore the activity rates were quantified very roughly from the number of inhabitants who are expected to use these kinds of batteries.

10. Data and inventory on crematoria and cemeteries

10.1. Data description

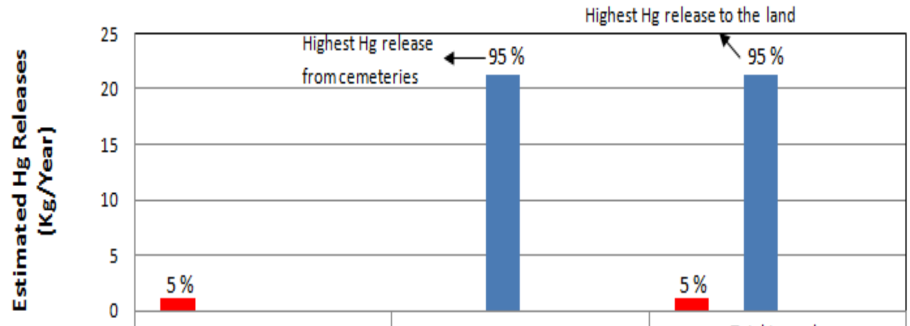
This step includes mercury releases from the cremation and burial of human corpses. The source sub-categories included in this inventory step are shown in **Table 10-1** below along with the activity rate, conversion factor and data source. The highest mercury releases (95%) from this category originated from cemeteries as shown in **Figure 10-1**, and was mostly remained on the land.

Table 10-1. Sub categories, activity rates, conversion factors, and data sources for crematoria and cemeteries

(1)	(2)	(3)	(4)	(5)	(6)
Source category	**Source present?**	**Activity rate**		**Conversion factor or calculation**	**Data source**
	Y/N/?	**Annual numbers dead**	**Original data**		
Crematoria and cemeteries					
Crematoria	Y	749 corpses cremated/y	237,641,326 number of inhabitants	6.3 Crude death rate in 2010 5% dead corpses cremated/y (crude death rate x number of inhabitants)/100,000	Statistics Central Agency , 2010*
Cemeteries	Y	14,223 corpses buried/	237,641,326 number of inhabitants	6.3 Crude death rate in 2010 95% corpses buried (crude death rate x number of inhabitant)/100,000	Statistics Central Agency, 2010*

Note:

- *Accessed from the following website: http://www.bps.go.id/
- On Inventory Level 1 (Column 1, 2, 3), only the white cells are open for entering data in the spreadsheet
- Column 4, 5, and 6 were added to give information of the data origin of activity rate
- Mercury release estimation is done based on data of activity rate in 2010



	Crematoria	Cemeteries	Total to each pathway
Air	1.1	0.0	1.1
Water	0.0	0.0	0.0
Land	0.0	21.3	21.3
By-products and impurities	0.0	0.0	0.0
General waste	0.0	0.0	0.0
Sector specific waste treatment /disposal	0.0	0.0	0.0

Source Sub Category

Figure 10-1. Estimated mercury released from crematoria and cemeteries

10.2. Background calculations and approximations

The main original mercury source is dental amalgam fillings, and mercury is present as fillings in remaining teeth and also in the body tissue at minor concentrations. At cremation, the mercury is released through the flue gas. At burial the mercury is released to the cemetery soil or immediate surroundings.

Data on annual mortality are available in national population statistics, reported by the Statistics Central Agency Republic of Indonesia. In Indonesia, almost all dead corpses are buried and only in small part of them being cremated. The cremation takes place in certain places, e.g. in Bali island, where most of the people are Hindus, and when somebody died, their crops must be cremated in certain ceremony called *Ngaben*.

The crude death rate in 2010 is 6.3, therefore 14,971 people might die in a year. It was assumed that only 5% from these number 749 dead corpses were cremated and the rest, 14,223 dead corpses were buried in the cemeteries. The default input factors for crematoria and cemeteries were 1-5 g Hg/corpse, therefore mercury releases from crematoria and cemeteries were 1.12 Kg Hg/y and 21.3 Kg Hg /y respectively.

10.3. Data gaps and priorities for potential follow up

The data gaps for this category is related to the default input factor. The default input factors for this category are between 1 – 4 Hg/corpses, and this value is based on the mercury in dental amalgam fillings and in body tissue at minor concentration. Using input factor, it is assumed that all corpses had dental amalgam fillings, which is actually not true. There should certain correction factor covering this issue.

11. List of major data gaps

The important types of data gaps across all source categories are presented as follows:

- **Actual data of activity rates are hard to find**

  The actual data of activity rates are hard to find, either they are not openly published, or not available at all.

- **The wide disparity between minimum and maximum value of default input factors for inventory level 1, and difficulties in determining the suitable input factors for Indonesia**

  This wide disparity may influence the magnitude of estimation. The maximum input factor may up to 60 times higher than minimum input factor. Overall, the prediction using the maximum default input factor may produce 2.68 times higher result than using the minimum default input factor.

- **There is no information available in Indonesia for site specific input factors and output distribution factors for mercury emission**

  Research determined the site specific input factors as well as output distribution factors for mercury emission are not available in Indonesia.

- **May exist source that are not accounted for**

  The sources which are not accounted for in Indonesia include, but not limited to:

  - Biomass as a source of heat production like in cooking foods is widely used in rural areas but these were not accounted for because of the unavailability of data and the assumption that the contribution of this subcategory is negligible to the total emissions;
  - Land clearing for oil palm plantation and other intentional forest fire.

- **Hg balance can not be quantified, therefore Hg phase out from Indonesia can not be identified**

  The amount of calculated mercury only originate from the domestic consumption, therefore the amount of imported and exported mercury are not quantified and integrated into the source of mercury. The form of mercury which are imported and exported (either in the elemental form or in the product containing mercury substances) is also unknown.

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Appendix 1 - Inventory Level 1 calculation spreadsheets

STEP 1 : Country Data

MERCURY INVENTORY FOR (COUNTRY NAME):	
General population data	
Population (number of inhabitants)	237,641,326
Year and reference for population data	2,010
GDP (Gross Domestic product)	**6,436,270.8**
Year and reference for GDP data	2010
Main sectors in the economy of country (list)	Mining, Oil and Gas
Contact point responsible for inventory	
Full name of institution	BaliFokus
Contact person	
E-mail address	
Telephone number	
Fax number	
Website of institution	
PASSWORD PROTECTION: Worksheets and workbook are protected with the password "password" to avoid un-intentional damages to calculations.	
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Version:	
3; April 2011	

STEP 2: **ENERGY CONSUMPTION AND FUEL PRODUCTION**

Source category	Source present?	Activity rate		Estimated Hg input, Kg Hg/y	Estimated Mercury Releases, standard estimates, Kg Hg/y						
Energy consumption	**Y/N/?**	Annual consumption/ production	Unit	Standard estimate	Air	Water	Land	By-products and impurities	General waste	Sector specific waste treatment / disposal	Cat. no.
Coal combustion in large power plants	Y	67,000,000	t coal combusted/ y	33,500	30,150.0	0.0	0.0	0.0	3,350.0	0.0	5.1.1
Other coal uses	Y	200,000	t coal used/ y	100	90.0	0.0	0.0	0.0	10.0	0.0	5.1.2
Combustion/use of petroleum coke and heavy oil	Y	3,396,125	t oil product combusted/ y	255	254.7	0.0	0.0	0.0	0.0	0.0	5.1.3
Combustion/use of diesel, gasoil, petroleum, kerosene	Y	45,987,875	t oil product combusted/ y	253	252.9	0.0	0.0	0.0	0.0	0.0	5.1.3
Use of raw or pre-cleaned natural gas	Y	39,754,745,672	Nm3 gas/y	9	8.7	0.0	0.0	0.0	0.0	0.0	5.1.4
Use of pipeline gas (consumer quality)	N		Nm3 gas/y	-	-	-	-	-	-	-	5.1.4
Biomass fired power and heat production	Y	119,247,139	t biomass combusted/ y (dry weight)	3,577	3,577.4	0.0	0.0	0.0	0.0	0.0	5.1.6
Charcoal combustion	Y	2,901,052	t charcoal combusted/ y	348	348.1	0.0	0.0	0.0	0.0	0.0	5.1.6
Geothermal power production	Y	10,592,640	MWh	606	529.6	0.0	0.0	0.0	0.0	0.0	
Fuel production											
Oil extraction	Y	48,919,607	t crude oil produced/y	13,453	0.0	2,690.6	0.0	0.0	0.0	0.0	5.1.3
Oil refining	Y	48,305,984	t oil refined/ y	13,284	3,321.0	132.8	0.0	0.0	1,992.6	0.0	5.1.3
Extraction and processing of natural gas	Y	96,492,101,146	Nm3 gas/y	9,746	1,461.9	1,949.1	0.0	2,923.7	3,411.0	0.0	5.1.4

STEP 3: DOMESTIC PRODUCTION OF METALS AND RAW MATERIALS											
Source category	Source present?	Activity rate		Estimated Hg input, Kg Hg/y	Estimated Mercury Releases, standard estimates, Kg Hg/y						Cat. no.
	Y/N/?	Annual consumption/ production	Unit	Standard estimate	Air	Water	Land	By-products and impurities	General waste	Sector specific waste treatment / disposal	
Primary metal production											
Mercury (primary) extraction and initial processing	N		t mercury produced/y	-	-	-	-	-	-	-	5.2.1
Production of zinc from concentrates	N		t concentrate used/y	-	-	-	-	-	-	-	5.2.3
Production of copper from concentrates	Y	993,152	t concentrate used/y	7,945	794.5	158.9	1,906.9	3,178.1	0.0	1,906.9	5.2.4
Production of lead from concentrates	N		t concentrate used/y	-	-	-	-	-	-	-	5.2.5
Gold extraction by methods other than mercury amalgamation	Y	119,726	t gold ore used/y	6,585	263.4	131.7	5,926.4	263.4	0.0	0.0	5.2.6
Alumina production from bauxite (aluminium production)	Y	440,000	t bauxit processed/y	220	33.0	22.0	0.0	0.0	143.0	22.0	5.2.7
Primary ferrous metal production (iron, steel production)	Y	4,561,065	t pig iron produced/y	228	216.7	0.0	0.0	0.0	0.0	11.4	5.2.9
Gold extraction with mercury amalgamation - without use of retort	Y	97,500	kg gold produced/y	195,000	117,000.0	39,000.0	39,000.0	0.0	0.0	0.0	5.2.2
Gold extraction with mercury amalgamation - with use of retorts	N		kg gold produced/y	-	-	-	-	-	-	-	5.2.2
Other materials production											
Cement production	Y	53,010,000	t cement produced/y	14,578	8,746.7	0.0	0.0	2,915.6	2,915.6	0.0	5.3.1
Pulp and paper production	Y	19,500,000	t biomass used in production/y	585	585.0	0.0	0.0	0.0	0.0	0.0	5.3.2

STEP 4: DOMESTIC PRODUCTION AND PROCESSING WITH INTENTIONAL MERCURY USE											
Source category	**Source present ?**	**Activity rate**		**Estimated Hg input, Kg Hg/y**	**Estimated Mercury Releases, standard estimates, Kg Hg/y**						
Production of chemicals	**Y/N/?**	**Annual consumption/ production**	**Unit**	**Standard estimate**	**Air**	**Water**	**Land**	**By-products and impurities**	**General waste**	**Sector specific waste treatment / disposal**	**Cat. no.**
Chlor-alkali production with mercury-cells	N		t Cl2 produced/y	-	-	-	-	-	-	-	5.4.1
VCM production with mercury catalyst	N		t VCM produced/y	-	-	-	-	-	-	-	5.4.2
Acetaldehyde production with mercury catalyst	N		t acetaldehyde produced/y	-	-	-	-	-	-	-	5.4.3
Production of products with mercury content											
Hg thermometers (medical, air, lab, industrial etc.)	Y	1,050	kg mercury used for production/y	788	7.9	3.9	78.8	0.0	78.8	7.9	5.5.1
Electrical switches and relays with mercury	Y	176	kg mercury used for production/y	176	1.8	0.9	17.6	0.0	17.6	1.8	5.5.2
Light sources with mercury (fluorescent, compact, others: see guideline)	Y	1,000	kg mercury used for production/y	1,000	10.0	5.0	100.0	0.0	100.0	10.0	5.5.3
Batteries with mercury	Y	300	kg mercury used for production/y	300	1.5	1.5	30.0	0.0	30.0	3.0	5.5.4
Manometers and gauges with mercury	Y	150	kg mercury used for production/y	150	1.5	0.8	15.0	0.0	15.0	1.5	5.6.2
Biocides and pesticides with mercury	Y	0.25	kg mercury used for production/y	0.25	0.003	0.001	0.025	0.000	0.025	0.0	5.5.5
Paints with mercury	Y	150	kg mercury used for production/y	150	1.5	0.8	15.0	0.0	15.0	1.5	5.5.6
Skin lightening creams and soaps with mercury chemicals	Y	216	kg mercury used for production/y	216	2.2	1.1	21.6	0.0	21.6	2.2	5.5.7

STEP 5: GENERAL WASTE MANAGEMENT SET-UP IN THE COUNTRY		
How much of the waste is collected and treated under public control?	**Y/N**	Answer according to your best estimate (you may revise once you have more specific data)
Is more than 2/3 (two thirds; 67%) of the waste collected and treated under public control?	Y	

WASTE HANDLING AND RECYCLING											
Source category	**Source present?**	**Activity rate**		**Estimated Hg input, Kg Hg/y**	**Estimated Mercury Releases, standard estimates, Kg Hg/y**						
Production of recycled of metals	**Y/N/?**	**Annual production/ waste disposal**	**Unit**	**Standard estimate**	**Air**	**Water**	**Land**	**By-products and impurities**	**General waste**	**Sector specific waste treatment / disposal**	**Cat. no.**
Production of recycled mercury ("secondary production")	N		kg mercury produced/y	-	-	-	-	-	-	-	5.7.1
Production of recycled ferrous metals (iron and steel)	N		number of vehicles recycled/y	-	-	-	-	-	-	-	5.7.2
Waste incineration											
Incineration of municipal/general waste	Y	61,904	t waste incinerated/y	310	278.6	0.0	0.0	0.0	0.0	31.0	5.8.1
Incineration of hazardous waste	Y	786,499	t waste incinerated/y	18,876	16,988.4	0.0	0.0	0.0	0.0	1,887.6	5.8.2
Incineration of medical waste	Y	98,023	t waste incinerated/y	2,353	2,117.3	0.0	0.0	0.0	0.0	235.3	5.8.3
Sewage sludge incineration	Y	97,989	t waste incinerated/y	196	176.4	0.0	0.0	0.0	0.0	19.6	5.8.4
Open fire waste burning (on landfills and informally)	Y	1,966,247	t waste burned/y	9,831	9,831.2	0.0	0.0	0.0	0.0	0.0	5.8.5
Waste deposition/ landfilling and waste water treatment											
Controlled landfills/ deposits	N		t waste landfilled/y	-	-	-	-	-	-	-	5.9.1
Informal dumping of general waste *1	Y	26,992,260	t waste dumped/y	26,992	2,699.2	2,699.2	21,593.8	-	-	-	5.9.4
Waste water system/ treatment	Y	370,400,000	m3 waste water/y	1,945	0.0	1,750.1	0.0	0.0	194.5	0.0	5.9.5

STEP 6: GENERAL CONSUMPTION OF MERCURY IN PRODUCTS, AS METAL MERCURY AND AS MERCURY CONTAINING SUBSTANCES											
Source category	**Source present ?**	**Activity rate**		**Estimated Hg input, Kg Hg/y**	**Estimated Mercury Releases, standard estimates, Kg Hg/y**						
	Y/N/?	**Annual consumption/ population**	**Unit**	**Standard estimate**	**Air**	**Water**	**Land**	**By-products and impurities**	**General waste**	**Sector specific waste treatment /disposal**	**Cat. no.**
			NOTE: Selection regarding waste management:		**More than 2/3 of the waste is collected and treated under public control**						
Use and disposal of products with mercury content											
Dental amalgam fillings ("silver" fillings)	***Y***			***1,188***	***23.8***	***394.5***	***0.0***	***42.8***	***228.1***	***228.1***	5.6.1
Preparations of fillings at dentist clinics		237,641,326	number of inhabitants		23.8	166.3	0.0	0.0	142.6	142.6	
Use - from fillings already in the mouth		237,641,326	number of inhabitants		0.0	14.3	0.0	0.0	0.0	0.0	
Disposal (lost and extracted teeth)		237,641,326	number of inhabitants		0.0	213.9	0.0	42.8	85.6	85.6	
Thermometers	***Y***	***164,257***		***284***	***28.4***	***85.1***	***0.0***	***0.0***	***170.2***	***0.0***	5.5.1
Medical Hg thermometers	Y	150,000	items sold/y	113							
Other glass Hg thermometers (air, laboratory, dairy, etc.)	Y	14,257	items sold/y	171							
Engine control Hg thermometers and other large industrial/speciality Hg thermometers	Y		items sold/y	0							5.5.1
Electrical switches and relays with mercury	Y	237,641,326	number of inhabitants	4,753	475.3	0.0	475.3	0.0	3,802.3	0.0	5.5.2
Light sources with mercury	***Y***	***275,000,000***	items sold/y	***1,750***	***87.5***	***0.0***	***0.0***	***0.0***	***1,662.5***	***0.0***	5.5.3
Fluorescent tubes (double end)	Y	75,000,000	items sold/y	750							
Compact fluorescent lamp (CFL single end)	Y	200,000,000	items sold/y	1,000							
Other Hg containing light sources (see guideline)	N		items sold/y	-							
Batteries with mercury	***Y***	***7,963***	***t batteries sold/y***	***4,023***	***0.0***	***0.0***	***0.0***	***0.0***	***4,023.0***	***0.0***	5.5.4
Mercury oxide (button cells and other sizes); also called mercury-zinc cells	Y	3.4	t batteries sold/y	1,103							

STEP 6: GENERAL CONSUMPTION OF MERCURY IN PRODUCTS, AS METAL MERCURY AND AS MERCURY CONTAINING SUBSTANCES

Source category	Source present?	Activity rate		Estimated Hg input, Kg Hg/y	Estimated Mercury Releases, standard estimates, Kg Hg/y						
	Y/N/?	Annual consumption/ population	Unit	Standard estimate	Air	Water	Land	By-products and impurities	General waste	Sector specific waste treatment /disposal	Cat. no.
			NOTE: Selection regarding waste management:		More than 2/3 of the waste is collected and treated under public control						
Other button cells (zinc-air, alkaline button cells, silver-oxide)	Y	138	t batteries sold/y	965							
Other batteries with mercury (plain cylindrical alkaline, permanganate, etc., see guideline)	Y	7,822	t batteries sold/y	1,956							
Polyurethane (PU, PUR) produced with mercury catalyst	Y	237,641,326	number of inhabitants	2,376	237.6	118.8	0.0	0.0	2,020.0	0.0	5.5.5.
Paints with mercury preservatives	Y		t paint sold/y	0	0.0	0.0	0.0	0.0	0.0	0.0	5.5.7
Skin lightening creams and soaps with mercury chemicals	Y	3.56	t cream or soap sold/y	107	0.0	101.3	5.3	0.0	0.0	0.0	5.5.8
Medical blood pressure gauges (mercury sphygmomanometers)	Y	150,000	items sold/y	10,500	1,050.0	3,150.0	0.0	0.0	6,300.0	0.0	5.6.2
Other manometers and gauges with mercury	Y	237,641,326	number of inhabitants	1,188	118.8	356.5	0.0	0.0	712.9	0.0	5.6.2
Laboratory chemicals	Y	237,641,326	number of inhabitants	2,376	0.0	784.2	0.0	0.0	784.2	808.0	5.6.3
Other laboratory and medical equipment with mercury	Y	237,641,326	number of inhabitants	2,376	0.0	784.2	0.0	0.0	784.2	808.0	5.6.3, 5.6.5

STEP 7: CREMATORIA AND CEMETERIES												
Source category	**Source present?**	**Activity rate**	**Unit**	**Estimated Hg input, Kg Hg/y**	**Estimated Mercury Releases, standard estimates, Kg Hg/y**							
Crematoria and cemeteries	**Y/N/?**	**Annual numbers dead**		**Standard estimate**	**Air**	**Water**	**Land**	**By-products and impurities**	**General waste**	**Sector specific waste treatment /disposal**	**Cat. no.**
Crematoria	Y	749	corpses cremated/y	1	1.1	0.0	0.0	-	0.0	0.0	5.10.1
Cemeteries	Y	14,223	corpses buried/y	21	0.0	0.0	21.3	-	0.0	0.0	5.10.2