Minamata Convention: Initial Assesment of Turkey

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Inventory Mercury Training Meeting

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Lecture 5

Toolkit for Identification and Quantification of Mercury Releases – Introduction to the Inventory Level 1 and 2 concept

Toolkit for Identification and Quantification of Mercury Releases

"Inventory Level 2" is the comprehensive version, including a detailed description of all mercury sources. It allows the development of a detailed mercury inventory by using specific input and output distribution factors.

"Inventory Level 1" provides a simplified version of the Toolkit, as well as calculation spreadsheets that allows the development of an overview mercury inventory, by using the defaulf factors.

Toolkit for Identification and Quantification of Mercury Releases

Guideline

for Inventory Level 1

Version 2.0

January 2017

Mercury Toolkit

The first Toolkit was published for the first time as a pilot draft in November 2005.

The revised Version 1.2 (January 2013) is the result of pilot testing and comments undertaken since the previous release.

The actual version 2.0 (January 2017) is nely developed and revised versions.

The most current version of the Toolkit will at any time be available on the UNEP Chemicals mercury web page at http://web.unep.org/chemicalsandwaste/chemicalsandwaste/node/419/

Mercury Toolkit

The newly revised Toolkit for identification and quantification of mercury releases - Inventory Level 1.

The Toolkit consists of 6 separate documents:

- This Guideline for Inventory Level 1;
- An electronic spreadsheets for calculation of estimates of mercury inputs and releases on Inventory Level 1;
- Two templates for data collection letters;
- An Inventory Reporting Template; and
- A Toolkit Reference Report.

Mercury Toolkit

The Toolkit Reference Report gives additional guidance on inventory development and describes the background inventory principles and the mercury source categories in more detail.

It also describes Inventory Level 2 which gives guidance to perform- ing more detailed and potentially more technically accurate mercury inventories

Mercury Toolkit

This guideline works closely together with the Toolkit electronic Inventory Level 1 spreadsheet for calculation of estimates of mercury inputs and releases.

The guideline and the calculation spreadsheet bring step by step through the development of national mercury inventory on Inventory Level 1.

The design of Inventory Level 1 makes it simple to organise and calculate the first national mercury inventory.

Mercury Toolkit

The Inventory Level 1 guideline and calculation spreadsheet is organised with the following steps:

Step 1: Getting started;
Step 2: Energy consumption and fuel production;
Step 3: Domestic production of metals and raw materials;
Step 4: Domestic production and processing with intentional mercury use; Step 5: Waste treatment and recycling;
Step 6: General consumption of mercury in products, as metal mercury and as mercury containing substances;
Step 7: Crematoria and cemeteries;
Step 8: Miscellaneous mercury sources not quantified on Inventory Level 1;
Step 9: Reporting your inventory and
Step 10: Refining your inventory (optional).

5.1 Extraction and use of fuels/energy sources

Coal combustion in large power plants

Other coal use

Mineral oils - extraction, refining and use

Natural gas - extraction, refining and use

Biomass fired power and heat production

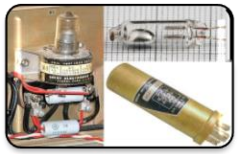
5.3 Production of other minerals and materials with mercury impurities

Cement production

Production of lime and light weight aggregates

5.5 Consumer products with intentional use of mercury

Thermometers with mercury



Electrical switches and relays with mercury

Light sources with mercury

Batteries with mercury

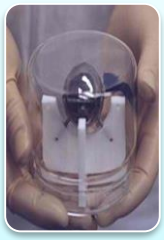
Paints

Polyurethane with mercury catalysts

5.6 Other intentional product/process uses

Manometers and gauges

Laboratory chemicals and equipment



Miscellaneous product uses, mercury metal uses, and other sources

5.7 Production of recycled metals ("secondary" metal production)

Production of recycled mercury ("secondary production")

Production of recycled ferrous metals (iron and steel)

Production of other recycled metals

5.8 Waste incineration

Incineration of municipal/ general waste

Incineration of hazardous waste

Incineration of medical waste

Informal waste incineration

5.9 Waste deposition/landfilling and waste water treatment

- Controlled landfills/deposits
- Diffuse deposition under some control
- Informal local disposal of industrial production waste
- Informal dumping of general waste
- Waste water system/treatment

Cemeteries

Potential hotspots

The mass balance principle, inputs and outputs

The mercury release calculations used in this Toolkit are based on the mass balance principle:

All the mercury fed into the system (e.g. an industrial sector) with materials and fuels will come out again, either as releases to the environment or in some kind of product stream.

In other words:

"Sum of inputs = sum of outputs".

The mass balance principle, inputs and outputs

Inputs: Therefore we quantify the mercury inputs from the amount of mercury containing material fed into the system (called "activity rate") and general data on the mercury concentration in the feed material (called "input factor").

Outputs: The mercury releases from the system are calculated by distributing this mercury amount on the relevant release pathways based on available data on how the releases (or "outputs") are generally distributed in this sector. For calculating this distribution, we use general "output distribution factors".

The mass balance principle, inputs and outputs

On Inventory Level 1, these calculations are automatic, and are based on default input factors and default output distribution factors, which are already entered in the electronic calculation spreadsheet.

So all you need to do is to enter the amount of material used or produced in each sector, as carefully described in the individual steps of this Guideline.

Basic quantification equation

Estimated mercury release to pathway Y

=

Activity rate * Input factor * Output distribution factor for pathway Y

The background for all default input factors and output distribution factors is also described in detail in the Toolkit Reference Report, in section 5.

Appendix 1 to this guideline provides background information on how the default factors were implemented in Inventory Level 1.

Remarks

These simplified results aim at providing a useful first insight into your country's situation on mercury inputs and releases. Generally, it may be useful to produce refined inventories at later stages, as the work with national management of mercury develops further.

Specifically, it is recommended to develop more detailed and refined inventories for targeted sectors or activities prior to launching any far reaching regulation or management procedures for these sectors or activities, preferably in cooperation with the relevant stakeholders.

For users who wish to reflect mercury management improvements in their inventory, which are not reflected on Inventory Level 1, the Toolkit Reference Report provides more detailed descriptions of the source categories, and release estimate calculations can be made in more detail in the Inventory Level 2 spreadsheet pages.

It should be noted that for some mercury source categories, the data available for developing the default factors have been very scarce, and some default factors are therefore associated with substantial uncertainty. In some cases where detailed mass balances have not been available, default output distribution factors were developed preliminarily based in expert assessment. In these cases the output distribution default factors are considered "signal values", which indicate a probable release distribution. As mentioned, the available data background for the default factors can be seen in the Toolkit Reference Report.

Each source-category section ("Step") in this guideline describes the limitations of Inventory Level 1 and lists the main factors which may influence the actual inputs and releases, including cases of more technically advanced source configurations, and cases with particularly uncertain default factors, including "signal

Step 1 – Getting started

Open spreadsheet page Step 1 and fill in the information requested, using the advice given in this guideline.

The coloured cells contain complex formulas without which the calculations will not work, and they are therefore protected and no changes can be made in them on Inventory Level 1.

In Inventory Level 1, only the white cells are open for entering data in the spreadsheet.

7	Source category	Source present?	Activity rate		Input, Kg Hg/y	Estimated Hg releases, standard estim						
8	**Production of recycled of metals**	Y/N/?	Annual production /waste disposal	Unit	Standard estimate	Air	Water	Land	By-products and impurities			
9	Production of recycled mercury ("secondary production")			Mercury produced, kg/y	Present?	Present?	Present?	Present?	Present?			
10	Production of recycled ferrous metals (iron and steel)			Number of vehicles recycled/y	Present?	Present?	Present?	Present?	Present?			
11												
12	**Waste incineration**											
13	Incineration of municipal/general waste			Waste incinerated, t/y	Present?	Present?	Present?	Present?	Present?			
14	Incineration of hazardous waste			Waste incinerated, t/y	Present?	Present?	Present?	Present?	Present?			
15	Incineration and open burning of medical waste			Waste incinerated, t/y	Present?	Present?	Present?	Present?	Present?			
16	Sewage sludge incineration			Waste incinerated, t/y	Present?	Present?	Present?	Present?	Present?			
17	Open fire waste burning (on landfills and informally)			Waste burned, t/y	Present?	Present?	Present?	Present?	Present?	Present?	Present?	5.8.5
18												
19	**Waste deposition/landfilling and waste water treatment**											
20	Controlled landfills/deposits			Waste landfilled, t/y	Present?	Present?	Present?	Present?	Present?	Present?	Present?	5.9.1

When you have established an overview of your work in Step 1, simply proceed to Step 2 of the guideline and the spreadsheet to proceed with the inventory work.

Data collection

Data collection may take time, and once specific data are requested from data owners it may take time before responses are received.

As the inventory should aim at describing the mercury situation in (or around) a given year, try to get data for that same year from the different data sources. If some data types are not available for that year, data from other adjacent years can be used, or averages over several adjacent years, if this describes the situation better.

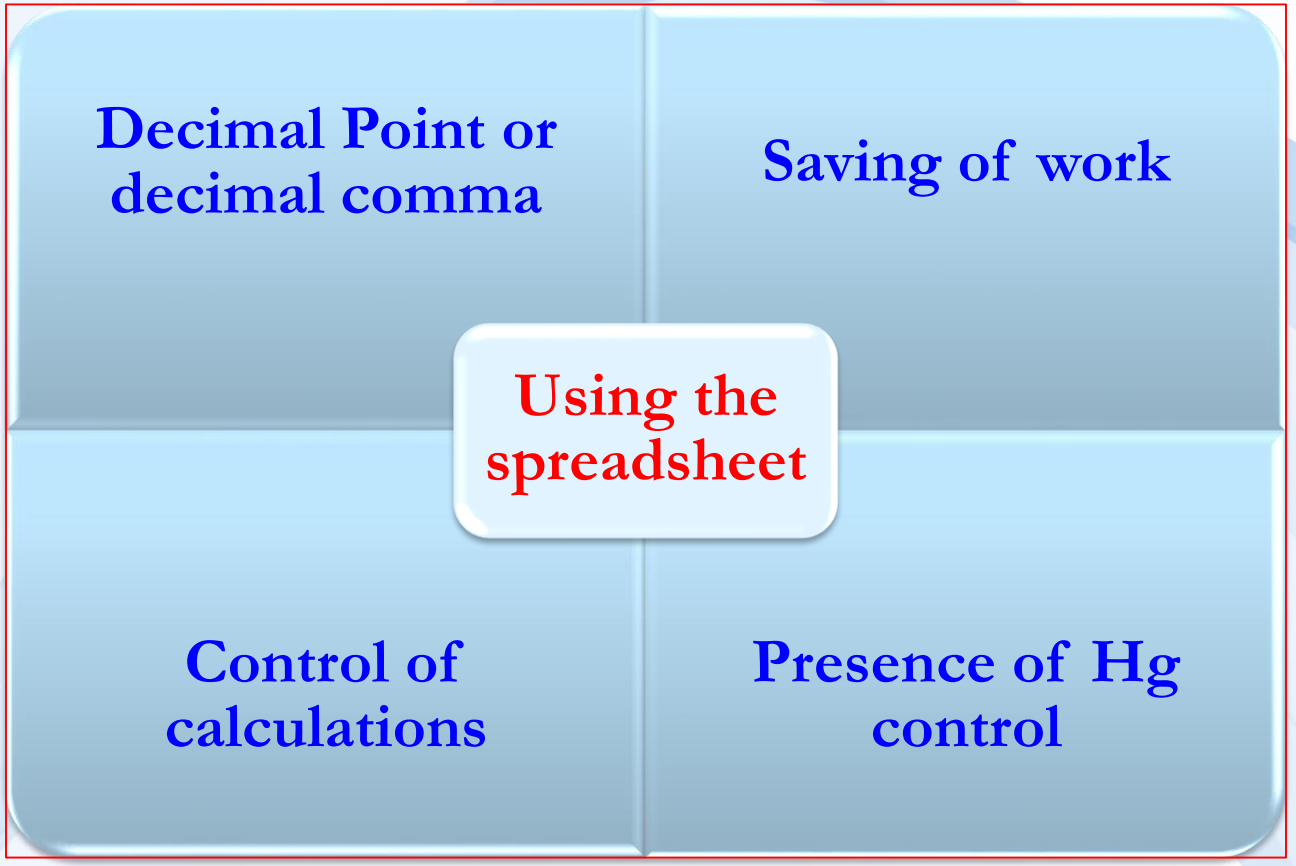
Data collection

Therefore, it is recommended to start data collection early for all inventory steps, and not wait for data for one step before proceeding to the next inventory step.

This also allows for coordination of data collection in cases where several data types are requested from the same sources of information (such as for example the national statistics bureau, or similar).

Data units !!!

Using the spreadsheet



Understanding the calculated results

Try opening the Inventory Level 1 calculation spreadsheet and open the page entitled "Step 2 Energy" by clicking on the page label with this title at the bottom of the screen window. You will first see a page as shown in Figure 1.

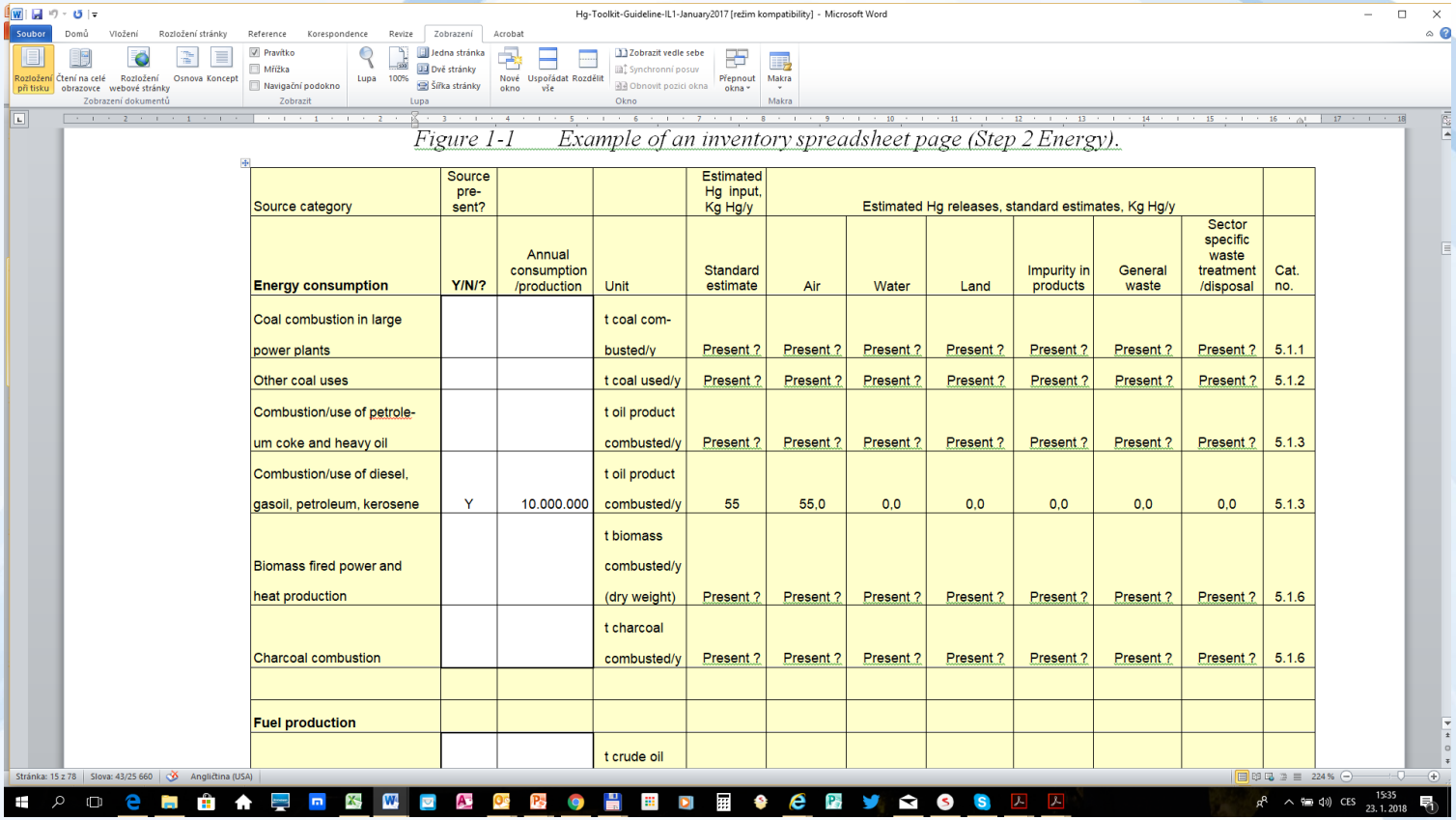


Figure 1-1 Example of an inventory spreadsheet page (Step 2 Energy).

Source category	Source pre-sent?			Estimated Hg input, Kg Hg/y	Estimated Hg releases, standard estimates, Kg Hg/y						
Energy consumption	**Y/N/?**	Annual consumption /production	Unit	Standard estimate	Air	Water	Land	Impurity in products	General waste	Sector specific waste treatment /disposal	Cat. no.
Coal combustion in large power plants			t coal combusted/y	Present ?	Present ?	Present ?	Present ?	Present ?	Present ?	Present ?	5.1.1
Other coal uses			t coal used/y	Present ?	Present ?	Present ?	Present ?	Present ?	Present ?	Present ?	5.1.2
Combustion/use of petroleum coke and heavy oil			t oil product combusted/y	Present ?	Present ?	Present ?	Present ?	Present ?	Present ?	Present ?	5.1.3
Combustion/use of diesel, gasoil, petroleum, kerosene	Y	10.000.000	t oil product combusted/y	55	55,0	0,0	0,0	0,0	0,0	0,0	5.1.3
Biomass fired power and heat production			t biomass combusted/y (dry weight)	Present ?	Present ?	Present ?	Present ?	Present ?	Present ?	Present ?	5.1.6
Charcoal combustion			t charcoal combusted/y	Present ?	Present ?	Present ?	Present ?	Present ?	Present ?	Present ?	5.1.6
Fuel production											
			t crude oil								

Understanding the calculated results

Try opening the Inventory Level 1 calculation spreadsheet and open the page entitled "Step 2 Energy" by clicking on the page label with this title at the bottom of the screen window. You will first see a page as shown in Figure 1.

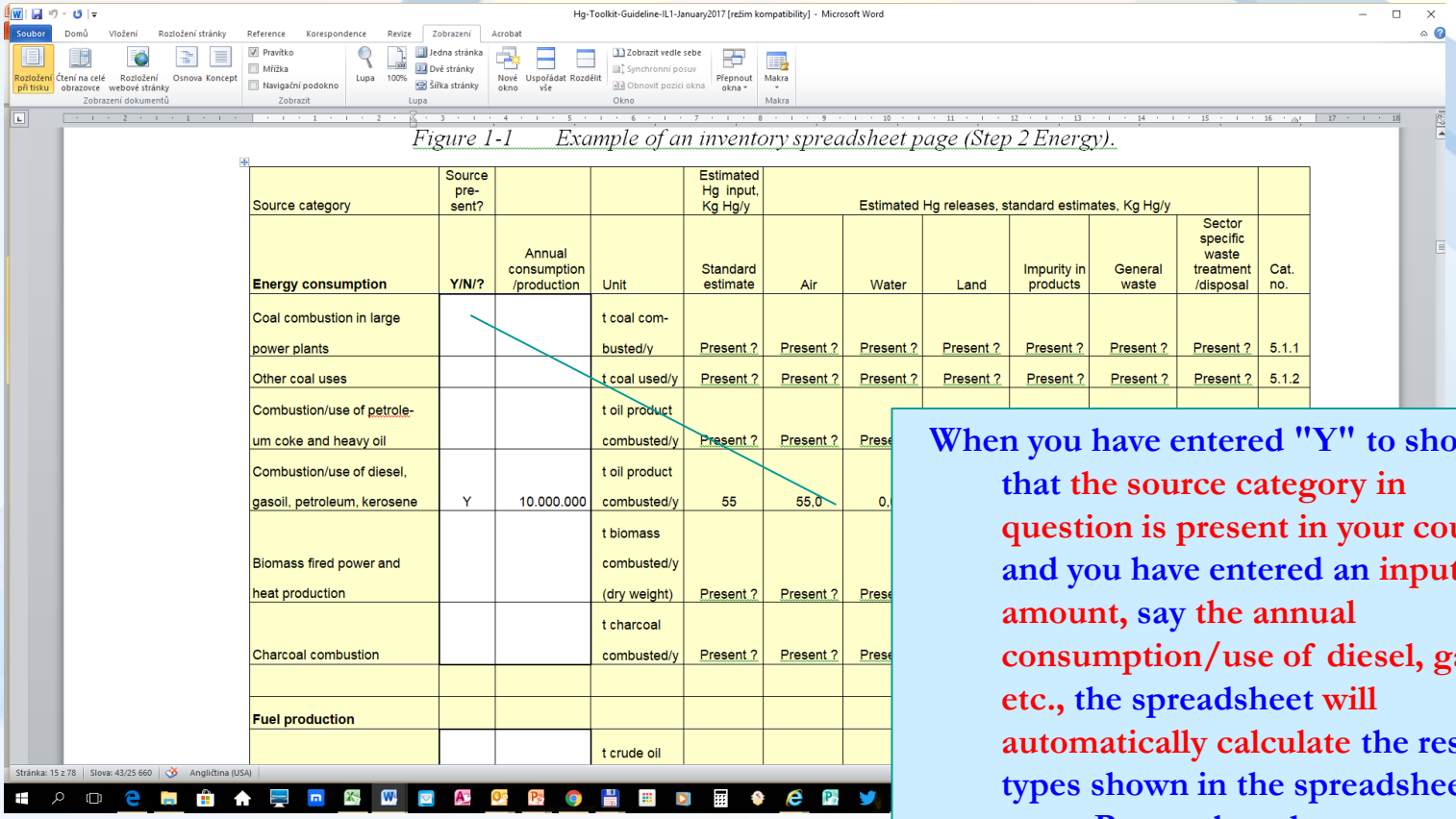


Figure 1-1 Example of an inventory spreadsheet page (Step 2 Energy).

Source category	Source pre-sent?			Estimated Hg input, Kg Hg/y	Estimated Hg releases, standard estimates, Kg Hg/y						
Energy consumption	**Y/N/?**	Annual consumption /production	Unit	Standard estimate	Air	Water	Land	Impurity in products	General waste	Sector specific waste treatment /disposal	Cat. no.
Coal combustion in large power plants			t coal combusted/y	Present ?	Present ?	Present ?	Present ?	Present ?	Present ?	Present ?	5.1.1
Other coal uses			t coal used/y	Present ?	Present ?	Present ?	Present ?	Present ?	Present ?	Present ?	5.1.2
Combustion/use of petroleum coke and heavy oil			t oil product combusted/y	Present ?	Present ?	Prese					
Combustion/use of diesel, gasoil, petroleum, kerosene	Y	10.000.000	t oil product combusted/y	55	55,0	0,					
Biomass fired power and heat production			t biomass combusted/y (dry weight)	Present ?	Present ?	Prese					
Charcoal combustion			t charcoal combusted/y	Present ?	Present ?	Prese					
Fuel production											
			t crude oil								

When you have entered "Y" to show that the source category in question is present in your country, and you have entered an input amount, say the annual consumption/use of diesel, gasoil, etc., the spreadsheet will automatically calculate the result types shown in the spreadsheet page. Remember, data can only be entered in the white cells.

Mercury releases and outputs

Calculation result type	Description
Estimated Hg input, kg Hg/y	The amount of mercury entering a source category with input materials, for example 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

Mercury releases and outputs

Calculation result type	Description
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.

Mercury releases and outputs

Calculation result type	Description
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 tech- nology; with mercury trace concentrations; - Metal mercury or calomel as by-product from non-ferrous metal mining (high mercury concentrations).

Mercury releases and outputs

Calculation result type	Description
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.

Mercury releases and outputs

Calculation result type	Description
Sector specific waste treat- ment /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.

Enter country data and contact details

Open the spreadsheet page entitled "Step 1 - Country data" by clicking on the page label with this title at the bottom of the screen window.

The first data you need to enter in step 1 of the Inventory Level 1 procedure are the general descriptive data listed in table 1-2 for your country, as well as the listed con- tact data types for your institution(s) responsible for inventory development.

Data types needed	Possible data sources and remarks
General population data Population Year and reference for population data	This number is needed for several of the calculations to function. The number appears automatically when you select your country from the drop-down list (see below). If not, enter your country's population number manually in this cell. Should you wish to use another population number (normally not needed), an alternative number can be entered in the cell. Population data are available for most (or all) countries and areas in several international statistics available via the Internet, for example at the United Nations Statistics Divisions homepage at http://unstats.un.org/unsd/demographic/products/dyb/dyb2.htm In the calculation spreadsheet, be careful to not overwrite the formula in this cell (population number), unless you are sure that you want to use an alternative population number.

Enter country data and contact details

Open the spreadsheet page entitled "Step 1 - Country data" by clicking on the page label with this title at the bottom of the screen window.

The first data you need to enter in step 1 of the Inventory Level 1 procedure are the general descriptive data listed in table 1-2 for your country, as well as the listed con- tact data types for your institution(s) responsible for inventory development.

Data types needed	Possible data sources and remarks
GDP (Gross Domestic product)	National Gross Domestic Product (GDP); a measure for the total national economic activity) can generally be found in national statistics. Otherwise, these data are available for most (or all) countries in several international statistics available via the Internet, for example the United Nations Statistics Divisions homepage at http://unstats.un.org/unsd/economic_main.htm
Year and reference for GDP data	
Main sectors in the economy of country (list)	Consult national country profiles, either from national sources or from international statistics available on the Internet.
Contact point responsible for inventory	Fill in relevant contact data.
Full name of institution	_
Contact person	_
E-mail address	_
Telephone number	_
Fax number	_
Website of institution	_

Toolkit for Idetification and Quantification of Mercury Releases Reference Report and

Guideline for Inventory Level 2

Version 1.4

January 2017

Introduction to the Inventory Level 2 concept

The Toolkit's Inventory Level 2 consists of a four-step standardized procedure to develop consistent and comparable source inventories.

The recommended four-step approach used to establish a national mercury release inventory using the Toolkit

ESTABLISHING A NATIONAL MERCURY RELEASE INVENTORY USING THIS TOOLKIT

STEP 1 - Apply screening matrix to identify main source categories present in the country or region investigated and identify existing descriptions of mercury sources in the country;

STEP 2 - Classify main source categories further into sub-categories and gather additional qualitative information to identify existing activities and sources of mercury releases in the country; and if feasible, the relative importance of each;

STEP 3 - Gather detailed quantitative information on the identified sources, and quantify releases with source specific data or default mercury input and output distribution factors from this Toolkit;

STEP 4 - Apply nation-wide to establish full inventory and report results using guidance given in the standard format.

Mercury Toolkit – level 2

In the first step, a coarse screening matrix is used to identify the main mercury source categories present in a country.

Also, any existing partial mercury inventories or descriptions of mercury sources in the country (or region) should be identified and collected.

If you have completed Inventory Level 1, this step in Inventory Level 2 need not be done again.

Step 1 – Screening matrix

Chapter	Main Source Category	Air	Water	Land	Products	Waste/ residue
5.1	Extraction and use of fuels/energy sources	X	X	x	x	X
5.2	Primary (virgin) metal production	X	X	X	X	X
5.3	Production of other minerals and materials with mercury impurities	X	x	x	x	x
5.4	Intentional use of mercury in industrial processes	X	X	X	X	X
5.5	Consumer products with intentional use of mercury	X	X	X	X	X
5.6	Other intentional products/process uses	X	X	X	X	X
5.7	Production of recycled metals ("secondary" metal production)	X	X	X	X	X
5.8	Waste incineration	X	X	X	x	X
5.9	Waste deposition/landfilling and waste water treatment	X	X	X		X
5.10	Crematoria and cemeteries	X		X		x
5.11	Identification of potential hot-spots	Probably registration only, to be followed by site-specific evaluation				

Mercury Toolkit – level 2

In the second step, these main source categories are further classified into sub-categories in order to identify the individual activities that potentially release mercury.

If only a qualitative identification of source types present in the country or region in question is desired, step three (quantification) can be omitted, and the qualitative findings can be reported as a commented list of main source categories and sub-categories identified in the country.

However, to give a better basis for preliminary evaluation and prioritization of further actions to address mercury releases, it is highly recommended to include, as a minimum, information that indicates the relative magnitude of the sub-category as a source of mercury releases, as described in step 3 below.

Sub-categories - example

Main category - Extraction and use of fuels/energy sources

This category covers the following main sub-categories:

- Coal combustion in large power plants, with thermal boiler capacity above 300MW;
- Other coal combustion, such as smaller combustion plants, domestic heating and other coal uses;
- Extraction, refining and use of mineral oil, i.e. all mercury releases in the life-cycle of mineral oil), such as heating, power production, use in transportation, synthesis of chemicals and polymers, carbon black production, etc.;
- Extraction, refining and use of natural gas, i.e. all mercury releases in the life-cycle of natural gas), such as heating, power production, use in transportation, synthesis of chemicals and polymers, carbon black production, etc.;
- Extraction and use of other fossil fuels, such as oil shale, peat, etc.;
- Biomass fired power and heat production, using wood, straw, etc.;
- Geothermal power production.

Sub-categories - example

Main category - Extraction and use of fuels/energy sources							
Chapter	Sub-category	Air	Water	Land	Product	Waste/ residue	Main inventory approach
5.1.1	Coal combustion in large power plants	X	x	x	x	X	PS
5.1.2	Other coal combustion	X		x	x	x	OW
5.1.3	Extraction, refining and use of mineral oil	X	X	x	x	x	OW/PS
5.1.4	Extraction, refining and use of natural gas	X	X	X	x	X	OW/PS
5.1.5	Extraction and use of other fossil fuels	X	x	x		x	OW
5.1.6	Biomass fired power and heat pro- duction	X	x	x		x	OW
5.1.7	Geothermal power production	X					PS

Notes: PS = Point source by point source approach; OW = National/overview approach;
X - Release pathway expected to be predominant for the sub-category;
x - Additional release pathways to be considered, depending on specific source and national situation.

Mercury Toolkit – level 2

If you have completed Inventory Level 1, step 2 in this Inventory Level 2 need not be done.

In the third step, a quantitative inventory is developed. At this step, it may be considered if a full quantitative inventory should be created from the start, or as an initial step, an interim inventory is desired to support the prioritization of the further work and initiate communication with inventory participants/ reviewers.

An interim inventory may present the identified source sub-categories along with indication of their relative importance.

Mercury Toolkit – level 2

A preliminary impression of the relative importance – magnitude of mercury releases - of the identified source sub-categories can be formed by gathering and applying activity volume data and/or other relevant information such as the approximate number of size of facilities in a particular industry, approximate number of people engaged in particulat activity, such as gold mining, or similar.

Obtaining some information on the principal intentional uses of mercury within the country will be particularly helpful as an important input to the interim inventory.

An interim report can be developed with outline as described in section 4.5.3.

Mercury Toolkit – level 2

For a full quantitative inventory, activity volume data ("activity rates") and process-specific information is gathered to be used to calculate estimated mercury releases from the identified mercury release sources in the country (or region) in question.

Releases are calculated via the equation and procedures given in section 4.4, and source type data described in chapter 5.

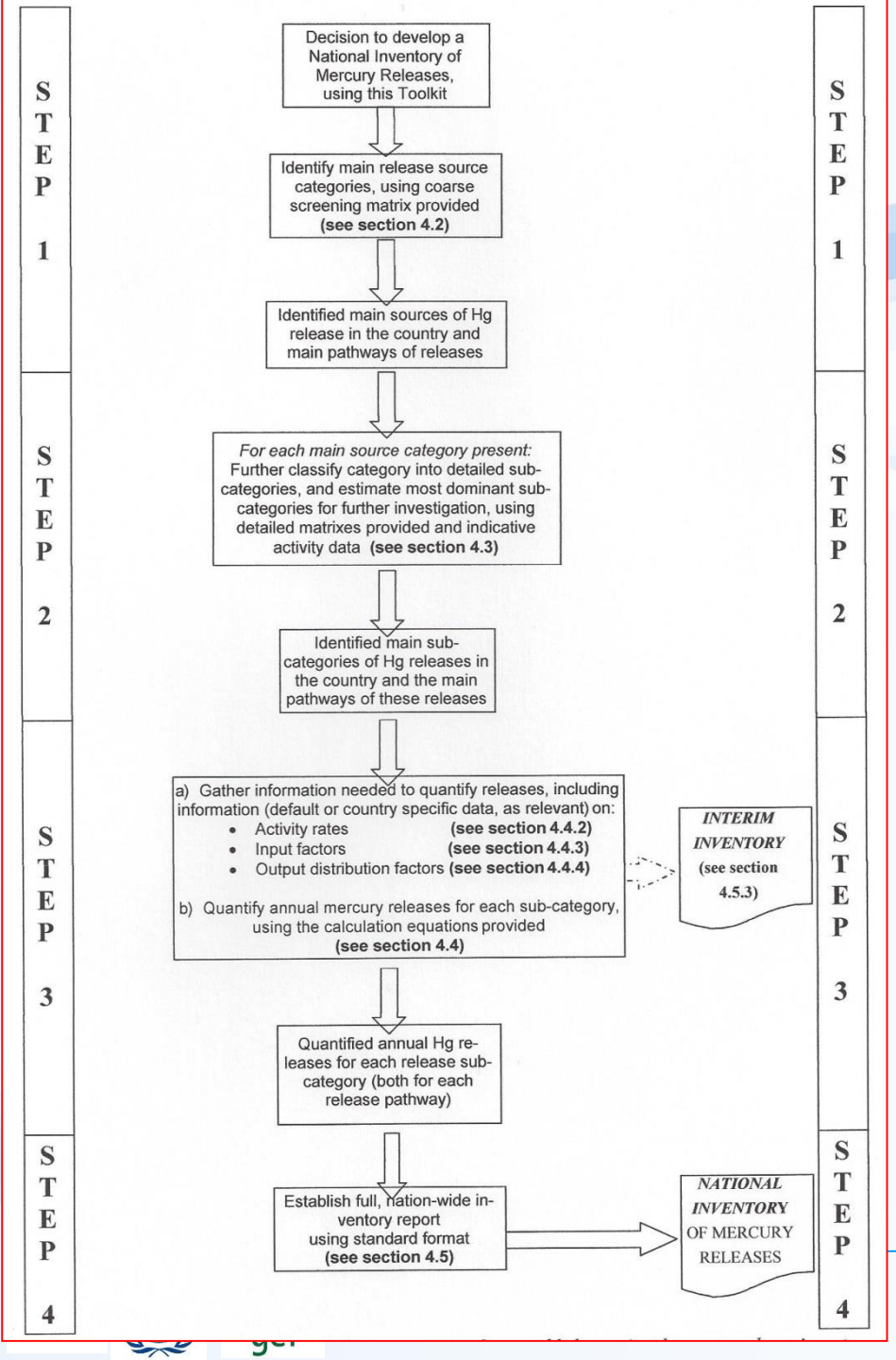
Mercury Toolkit – level 2

The fourth and final step is the compilation of the standardized mercury inventory using the results generated in steps 1 through 3.

A standardized presentation format is presented in section 4.5.2, in order to ensure that all known sources are considered (even if they cannot be quantified), data gaps are identified and inventories are comparable and transparent.

A flowchart, further illustrating the details of the process described above, is given in Figure 4-2 below.

Flowchart detailing the four-step approach to establish a national mercury release inventory using the Toolkit



Mercury Toolkit – level 2 – quantification principles

The basic aim of the Toolkit is to enable an estimation of the average annual release to each pathway or vector (air, water, land, products, general waste, sector-specific waste treatment) for each release process identified.

The estimate can be calculated using the following basic equation:

EQUATION 1:

Estimated mercury release to pathway X	=	activity rate * input factor * output distribution factor for pathway X

Mercury Toolkit – level 2 – quantification principles

EQUATION 1:

Estimated mercury release to pathway X	=	activity rate * input factor * output distribution factor for pathway X

In other words, the annual estimated mercury releases for each pathway is calculated by:

Multiplying the amount of feed material processed or product produced per unit of time (e.g. tons or pieces per year) – referred to as the activity rate - with

An "input factor". For sub-categories with only one life-cycle phase (such as coal combustion) the input factor is the mercury content (e.g,. in grams of Hg) per unit of feed material processed.

For sub-categories with more than one life cycle phase (such as battery production), the input factor is defined for each phase. For example, the input factor for the production phase is amount of mercury released per metric ton of batteries produced or product produced (e.g., metric ton or piece) – referred to as the input factor – and the fraction or part (unit-less) of the mercury input that is released through the particular pathway (air, water, land, product, general waste, or sector specific waste treatment) - referred to as the output distribution factors.

Mercury Toolkit – level 2 – quantification principles

Calculation of individual releases throughout the life-cycle

Within a specific sub-category, the releases from the relevant phases in the life-cycle are calculated individually, but described in the same section of the inventory report.

For each source sub-category described in chapter 5, an indication is given of the main release potentials for each phase throughout its life-cycle (production - use - disposal) and to which environmental media the releases are likely to happen. The information is given both in the text and in a table, as shown below.

Example of an overview table indicating main releases and receiving media in the life-cycle of a product or service (here for batteries with mercury)

Phase of life cycle	Air	Water	Land	Products	General waste	Sector specific treatment/ disposal
Production	X	x	x	X		**x**
Use						
Disposal	**X**		**X**		**X**	**X *1**

Notes: ***1**: Separately collected batteries containing mercury (or categorized under sorting as such) may be disposed of in specially secured landfills;

X - Release pathway expected to be predominant for the sub-category;

x - Additional release pathways to be considered, depending on specific source and national situation.

Mercury Toolkit – level 2 – quantification principles

It should be noted that within a specific sub-category, a point source approach may be best for estimating releases from the production phase, while the overview approach may be most suitable for the use and disposal phases.

This is, for example, the case for mercury thermometers, where a country may only have one or a few thermometer factories, but where mercury thermometers (including imported thermometers) are used for a variety of purposes spread on the whole geographical area of the country, and are broken or disposed of locally.

Mercury Toolkit – level 2 – quantification principles – Use of activity rates

The activity rate is a parameter describing the volume of the activity in the sub-category in question per unit of time (usually per year).

The choice of activity rate basis will vary between sub-categories, because in different sub-categories, different activity rates may best describe what the volume of the activity is, and certain data may be more easily available from public statistics or other sources.

Mercury Toolkit – level 2 – quantification principles – Use of activity rates

For example, the input of mercury with coal is most directly calculated by multiplying the concentration of mercury in the coal used (gram mercury per metric ton of coal), with the consumption of the same coal (metric ton coal per year). Remember here to observe if the weight basis is "dry matter" or other.

On the other hand, for mercury thermometers, the best-known data are mercury content per thermometer (gram mercury per piece) and the number of thermometers consumed or produced per unit of time (such as pieces per year).

Mercury Toolkit – level 2 – quantification principles – Use of activity rates

In order to assist users of the Toolkit to estimate the releases from individual sub-categories, the activity rate data types needed for the quantitative inventory calculations are listed in the individual sub-category descriptions in chapter 5, along with the type of mercury input factors.

The information is structured in overview tables like the example given below.

Life-cycle phase	Activity rate data needed	Mercury input factor
Production	Metric tons of batteries produced per year (in the country)	**Kg of mercury released per metric ton of batteries produced *2**
Use	Not needed (Releases negligible)	**Not needed (Releases negligible)**
Disposal	**Metric tons of batteries consumed (or disposed) per year *1**	**Kg of mercury disposed or released per metric ton of batteries consumed *3**

Notes: ***1*** As a substitute for metric tons disposed of per year. If good estimates of amounts of batteries disposed of exist, these should preferably be used. In times of changing consumption, the two numbers differ from each other;

2 Kg of mercury released per metric ton of batteries produced = amount of mercury input (kg mercury) used to produce each metric ton of batteries multiplied by the percent of input mercury that is released during this phase of the life cycle";

3 This input factor can also be defined as kg of mercury in each metric ton of batteries multiplied by the percent of this mercury that is released from disposal phase of the life cycle. If one assumes that eventually all the mercury in the batteries is eventually released to some media, than the "percent of mercury released" can be assumed to 100%.

Mercury Toolkit – level 2 – quantification principles – Definition of consumption

„Consumption" of a product or material per year in a country or region is defined as given in equation (2), where yearly production, imports and exports refer to the same country or region:

EQUATION 2:

Consumption per year = Production + Imports – Exports (per year)

Disposal may reflect consumption from earlier years.

The calculation of mercury outputs from disposal should ideally be based on total product amounts being disposed of in the year in question, but often such data are not readily available, and consumption numbers are therefore used instead as best estimates.

As a default, current consumption can be used.

In cases where the consumption pattern is changing rapidly, consumption numbers from previous years (an average product life-time earlier) may be preferred, if available.

For a number of products, disposal takes place some (or many) years after it was purchased (consumed).

Mercury Toolkit – level 2 – quantification principles – Definition of content

For sub-categories where mercury compounds are applied, calculations should be based on activity rates and input factors converted to elemental mercury content.

For this conversion, data on atomic weights for the compound(s) in question versus atomic weight for elemental mercury should be applied, as shown in equation 3:

EQUATION 3:

Content of Hg	=	Weight of Hg-compound	*	# of Hg atoms in compound molecule * atomic weight of Hg (atomic weight of compound molecule)

Notes: "#" means number.

Mercury Toolkit – level 2 – quantification principles – Definition of content

EQUATION 3:

Content of Hg	=	Weight of Hg-compound	*	# of Hg atoms in compound molecule * atomic weight of Hg (atomic weight of compound molecule)

Notes: "#" means number.

As an example, the content of elemental mercury in 1 kg of the compound diphenylmercury (molecular formula $C_{12}H_{10}Hg$) can be calculated as follows:

$$\text{Content of Hg} = 1\ \text{kg } C_{12}H_{10}Hg * \frac{1 * 201\ \text{g Hg/mol}}{(12 * 12.0 + 10 * 1.01 + 1 * 201)\ \text{g compound/mol}} = \sim 0.566\ \text{kg Hg}$$

Mercury Toolkit – level 2 - Choice of Hg input factors

The mercury input factor is simply defined as the mercury content (for example in gram Hg) per unit of feed material processed or product produced (for example metric ton or piece) as relevant for the individual source type.

The input factors for sub-categories with more than one life cycle phase are a bit more complicated.

Nonetheless, examples of mercury inputs to each release source type are - to the extent data has been available - presented in the source description sections in chapter 5.

The examples are derived from easily available literature, and reflect conditions prevailing at the place and the time they were observed.

In chapter 5, time and origin of the data is generally described along with the data given.

Mercury Toolkit – level 2 - Choice of Hg input factors

It is important to note that:

- For certain source sub-categories, the mercury input factors change over time. Significant examples of this are consumer products that over recent years have been subject to a regulatory pressure towards reduction - or elimination - of mercury content, such as batteries and light sources.

- The mercury input factors vary with geography. Changes in mercury content in products have not happened at the same speed in all regions of the world.

- Also, for natural raw materials - including fuels - mercury concentrations vary considerably with geographical location due to differences in geology and, for some sources, also due to previous anthropogenic mercury deposition loads.

Mercury Toolkit – level 2 - Choice of Hg input factors

Thus, the choice of mercury input factors may have significant effects on the release estimates calculated.

For quick, rough first estimates of mercury releases for a sub-category, the default input factors as presented in chapter 5 may be used; unless the default input factors clearly do not reflect the prevailing conditions. It should be noted that, as described in section 4.1.1, the default factors defined in this draft Toolkit are preliminary and subject to future revisions.

Whatever input factors (as well as other data) are chosen, it may be appropriate to review and/or confirm these factors/data for local/national conditions before major decisions are taken on implementation of mitigation initiatives.

Mercury Toolkit – level 2 - Choice of output distribution factors

The output pathways include:

- Direct releases to the atmosphere (air);
- Direct releases to aquatic environments (water);
- Direct releases to land (terrestrial environment, including ground water);
- Flows of mercury as an impurity in marketed products (for example gypsum wallboard produced from solid residues from flue gas cleaning on coal fired power plants);
- Flows of mercury to the public waste water treatment system;
- Flows of mercury to the general waste treatment system;
- Flows of mercury to sectors specific waste treatment or disposal systems.

Hg Toolkit – Output distribution factors

For each mercury release source type, outputs are - to the extent data has been obtained – presented in the source description sections in chapter 5 as the relative share of the inputs that follow each specific output pathway (or release pathway) - designated here as output distribution factors.

Hg Toolkit – Output distribution factors

The principles applied in this "output path" vary between the sectors; it may for example involve special separate collection and recycling, special safe deposition for high concentration mercury waste, or use of low concentration residues in road construction or other similar activities.

To distinguish such disposal activities from uncontrolled "direct releases to land", the first mentioned should be characterized by an element of evaluation by risk assessments or informed acceptance from the authorities.

Knowledge of the actual treatment or disposal taking place should always be noted in the developed inventory reports.

Mercury Toolkit – level 2 – General key factors for the distribution of mercury outputs

- Point sources
- Manufacturing facilities
- Good workplace procedure
- Reduction of emissions and releases
- Consumer products with intentional use of Hg – disposal phase is the most important – depends on the waste management system in country
- Output distribution factors may vary very extensively between countries and between localities and point sources.

Mercury Toolkit – level 2 – Gathering of data

- Existing description of mercury release sources
- Activity rate data
- Mercury input factors
- Output distribution data
- Incomplete data
- Report data uncertainty
- Report data origin
- Confidential data

Activity rate

Cat. no.	Source category	2010	2011	2012	2013	2014	Unit
		Annual consumption / production					
	Energy consumption						
5.1.1	Coal combustion in large power plants	201,106	161,641	159,996	183,806	178,306	Coal combusted, t/y
5.1.2	Other coal uses	190,120	197,824	192,758	247,721	180,491	Coal used, t/y
5.1.3	Combustion/use of petroleum coke and heavy oil	44,904	35,542	27,139	27,643	27,493	Oil product combusted, t/y
5.1.3	Combustion/use of diesel, gasoil, petroleum, kerosene, LPG and other light to medium distillates	725,184	763,686	682,973	716,001	722,459	Oil product combusted, t/y
5.1.4	Use of raw or pre-cleaned natural gas	0	0	0	0	0	Gas used, Nm^3/y
5.1.4	Use of pipeline gas (consumer quality)	2,970,900,000	3,099,500,000	3,078,100,000	2,386,000,000	2,823,500,000	Gas used, Nm^3/y
5.1.6	Biomass fired power and heat production	501,521	613,298	624,416	730,245	778,488	Biomass combusted, t/y
5.1.6	Charcoal combustion	0	0	576	475	712	Charcoal combusted, t/y
	Fuel production						
5.1.3	Oil extraction	11,000	13,000	11,000	10,000	8,000	Crude oil produced, t/y
5.1.3	Oil refining	21,000	19,000	18,000	19,000	18,000	Crude oil refined, t/y
5.1.4	Extraction and processing of natural gas	89,000	59,000	118,000	118,000	89,000	Gas produced, Nm^3/y
	Other materials production						
5.3.1	Cement production	861,357	1,018,024	1,051,413	1,095,262	1,086,152	Cement produced, t/y
5.3.2	Pulp and paper production	0	0	0	0	0	Biomass used for production, t/y
5.3.3	Lime production	3,180	7,615	6,971	5,569	8,378	Lime produced, t/y
	Production of chemicals						
	Chlor-alkali production with mercury-						

Activity rate

Cat.	Source		2010	2011	2012	2013	2014	Unit
			Annual conspumtion					
5.5.1	**Thermometers**							
	Clinical		293628	130400	185903	82040	201303	Items/y
	Laboratory		77	77	77	212	212	Items/y
5.5.2	**Electrical switches and relays with mercury**	Level 1	3563695	3560430	3559541	3559497	3557634	Inhabitants
		Level 2	1425478	1424172	1423816,4	1423798,8	1423053,6	40 % of inhabitants
5.5.3	**Light sources with mercury**							
	Fluorescent tubes (double end)		786625	688730	1248720	1037708	568813	Items/y
	Compact fluorescent lamp		384433	242260	85017	196466	753712	Items/y
	UV light		69793	22343	5686	12005	5147	Items/y
	Metal halide lamps		33305	15857	17221	8679	3576	Items/y
	Mercury vapors		57388	61836	80055	24353	37106	Items/y
	High-pressure sodium lamps		3860	9830	8803	13931	1955	Items/y
5.5.4	**Batteries with mercury**							
	Mercury oxide (all sizes)		0,001	0,001	0,001	0,001	0,001	Batteries, t/y (estimatted from the quanity of hearing aids)
	Cilindric cells		24,92	53,93	37,22	24,71	31,23	Batteries, t/y
	Alkaline button cells		0,00148	0,06	0,0226	0,126	0,00344	Batteries, t/y
	Silver oxide button cells		0,00858	0,0626	0,10741	0,132	0,0606	Batteries, t/y
	Zinc-air button cells		0,11528	0,00732	0,00828	0,09	0,063	Batteries, t/y
5.6.2	**Polyurethane with**	Level 1	3563695	3560430	3559541	3559497	3557634	Inhabitants

Activity rate

Cat. no.	Source category		2010	2011	2012	2013	2014	Unit
			Annual consumption / production					
	Use and disposal of products with Hg content							
5.6.2	Medical blood pressure gauges (medical sphygmomanometers)	Level 1	103	44	67	79	56	Items sold/y
		Level 2	0	0	0	0	0	Items disposed/y
5.6.2	Other manometers and gauges with mercury	Level 1	3,562,045	3,562,045	3,562,045	3,562,045	3,562,045	Number of inhabitants
		Level 2	0	0	0	0	0	Items disposed/y
5.6.3	Laboratory chemicals	Level 1	3,562,045	3,562,045	3,562,045	3,562,045	3,562,045	Number of inhabitants
		Level 2	0	1	1	1	4	Chemicals with mercury, kg/y
5.6.3	Other laboratory and medical equipment with mercury	Level 1	3,562,045	3,562,045	3,562,045	3,562,045	3,562,045	Number of inhabitants
		Level 2	0	0	0	0	0	Items disposed/y
	Production of recycled metals							
5.7.1	Production of recycled mercury		0.00096	0.00052	0.00023	0.00026	0.00025	Mercury recycled, kg/y
5.7.2	Production of recycled ferrous metals: iron and steel		275	275	275	275	210	Number of vehicles recycled/y
	Waste incineration							
5.8.2	Incineration of hazardous waste		19.4	16.7	19	16.7	17.4	Waste incinerated, t/y
5.8.3	Incineration and open burning of medical waste		442	669	679	671	632	Waste incinerated, t/y
5.8.5	Open fire waste burning (on landfills and informally)		88266	88199	88188	88232	88204	Waste burned, t/y
	Waste deposition/ landfilling and waste water treatment							
5.9.1	Controlled landfills/deposits		921040	940000	968440	1058960	1164880	Waste landfilled, t/y

Default mercury input fators

Cat. No.	Source Category	Level 2	Units of the default input factors
5.1.1	Coal combustion in large power plants	0.07	g Hg/t coal combusted
5.1.2	Other coal use	0.07	g Hg/t coal combusted
5.1.3	Combustion/use of heavy oil	20	mg Hg/ton heavy petroleum product
5.1.3	Combustion/use of diesel, gasoil, petroleum, kerosene	2.0	mg Hg/ton light distillate petroleum product
5.1.4	Use of natural gas	0.22	µg Hg/Nm^3 pipeline natural gas
5.1.6	Biomass fired power and heat production	0.03	g Hg/t biomass burned (dry weight basis)
5.1.6	Charcoal production	0.12	g Hg/t produced charcoal
5.1.3	Extraction and refining of oil	3.4	mg Hg/ton crude oil
5.1.4	Extraction and processing of natural gas	100	µg Hg/Nm^3 unprocessed gas
5.3.1	Cement production	0.118	g Hg/ t cement produced
5.3.3	Lime production	7.4	mg Hg/ t lime produced

Default mercury input fators

Cat.	Source		Unit
5.5.1	**Thermometers**		
	Clinical	1	gram of Hg per item
	Laboratory	20,5	gram of Hg per item
5.5.2	**Electrical switches and relays with mercury**	0,02	gram of Hg/inhabitant
5.5.3	**Light sources with mercury**		
	Fluorescent tubes (double end)	25	mg of Hg per item
	Compact fluorescent lamp	10	mg of Hg per item
	UV light	15	mg of Hg per item
	Metal halide lamps	25	mg of Hg per item
	Mercury vapor	30	mg of Hg per item
	High-pressure sodium lamps	20	mg of Hg per item
5.5.4	**Batteries with mercury**		
	Mercury oxide (all sizes)	320	Kg of Hg per ton of batteries
	Cilindric cells	0,25	Kg of Hg per ton of batteries
	Alkaline button cells	5	Kg of Hg per ton of batteries
	Silver oxide button cells	4	Kg of Hg per ton of batteries
	Zinc-air button cells	12	Kg of Hg per ton of batteries

Default mercury input fators

Cat. No.	Source Category	Level 2	Units of the input factors used
5.6.2	Medical blood pressure gauges (medical sphygmomanometers)	80	g Hg/item
5.7.1	Production of recycled mercury	1.00452	kg Hg/kg Hg released totally
5.7.2	Production of recycled ferrous metals (iron and steel)	0.2	g Hg/vehicle
5.8.2	Incineration of hazardous waste	0.02	g Hg/t waste incinerated
5.8.3	Incineration and open burning of medical waste	8	g Hg/t waste incinerated
5.8.5	Open fire waste burning (on landfills and informally)	1	g Hg/t waste incinerated
5.9.1	Controlled landfills/deposits	1	g Hg/t waste
5.9.4	Informal dumping of general waste *1	1	g Hg/t waste
5.9.5	Waste water system/treatment	0.5	mg Hg/m3 waste water
5.10.2	Cemeteries	1	g Hg/corpse

Comparative results of the level 1 and level 2, Energy and Industry sector, 2014

Inventory Level 1 Results, kg Hg	2010	2011	2012	2013	2014
Coal combustion and other coal use	55.5152	50.6226	49.7005	60.6003	50.8114
Other fossil fuel and biomass combustion	22.1575	25.2359	24.7278	27.9476	29.5469
Oil and gas production	0.1177	0.1147	0.1104	0.1104	0.0973
Other materials production	111.9764	132.3431	136.6837	142.3841	141.1998
SUM OF QUANTIFIED RELEASES	**189.7667**	**208.3163**	**211.2224**	**231.0424**	**221.6553**

Inventory Level 2 Results, kg Hg	2010	2011	2012	2013	2014
5.1: Extraction and use of fuels/energy sources	45.4791	46.5228	46.0556	54.6691	74,6
5.3: Production of other minerals and materials with mercury impurities	101.6637	120.1832	124.1183	129.2821	128.2279
5.4: Intentional use of mercury in industrial processes	0.0000	0.0000	0.0000	0.0000	0.0000
SUM OF QUANTIFIED RELEASES	**147.1428**	**166.7060**	**170.1739**	**183.9512**	**202.82**

Inventory Level 1 Results vs Level 2 Results, kg Hg	2010	2011	2012	2013	2014
INVENTORY LEVEL 1	189.8	208.3	211.2	231.0	221.7
INVENTORY LEVEL 2	147.1	166.7	170.2	184.0	179.4
Difference, %	**-22.5**	**-20.0**	**-19.4**	**-20.4**	**-19.1**

Comparative results of the level 1 and level 2 Consumer products sector, 2014

LEVEL 1, kg Hg/y	2010	2011	2012	2013	2014
5.5.1:Thermometers	89	39	56	26	61
5.5.2:Electrical switches and relays with mercury	492	491	491	491	491
5.5.3: Light sources with mercury	27	22	34	30	23
5.5.4: Batteries with mercury	8	15	10	10	9
5.5.5:Polyurethane with mercury catalysts	105	105	105	105	105
SUM OF QUANTIFIED EMISSIONS	**721**	**672**	**696**	**662**	**689**

LEVEL 2, kg Hg/y	2010	2011	2012	2013	2014
5.5.1:Thermometers	89	39	56	26	61
5.5.2:Electrical switches and relays with mercury	54	28	28	28	29
5.5.3: Light sources with mercury	28	22	35	29	23
5.5.4: Batteries with mercury	8	14	9	8	9
5.5.5:Polyurethane with mercury catalysts	0,00002295	0,00002835	0,00001795	0,00001065	0,0000108
SUM OF QUANTIFIED EMISSIONS	**179**	**103**	**128**	**91**	**122**

Inventory Level 1 Results vs Level 2 Results, kg Hg	2010	2011	2012	2013	2014
Nivelul 1	**721**	**672**	**696**	**662**	**689**
Nivelul 2	**179**	**103**	**128**	**91,000011**	**122**
Diferența, %	-75,2	-84,7	-81,6	-86,3	-82,3

Comparative results of the level 1 and level 2 Other products, waste, recycling category , 2014

Inventory Level 1 Results, kg Hg	2010	2011	2012	2013	2014
Use and disposal of products with mercury content	202	197	199	200	198
Production of recycled metals	0	0	0	0	0
Waste incineration and open waste burning	452	457	458	458	457
Waste deposition/landfilling and waste water treatment	318	316	317	321	320
Crematoria and cemeteries	102	92	93	90	93
SUM OF QUANTIFIED RELEASES	**1074**	**1062**	**1067**	**1069**	**1068**

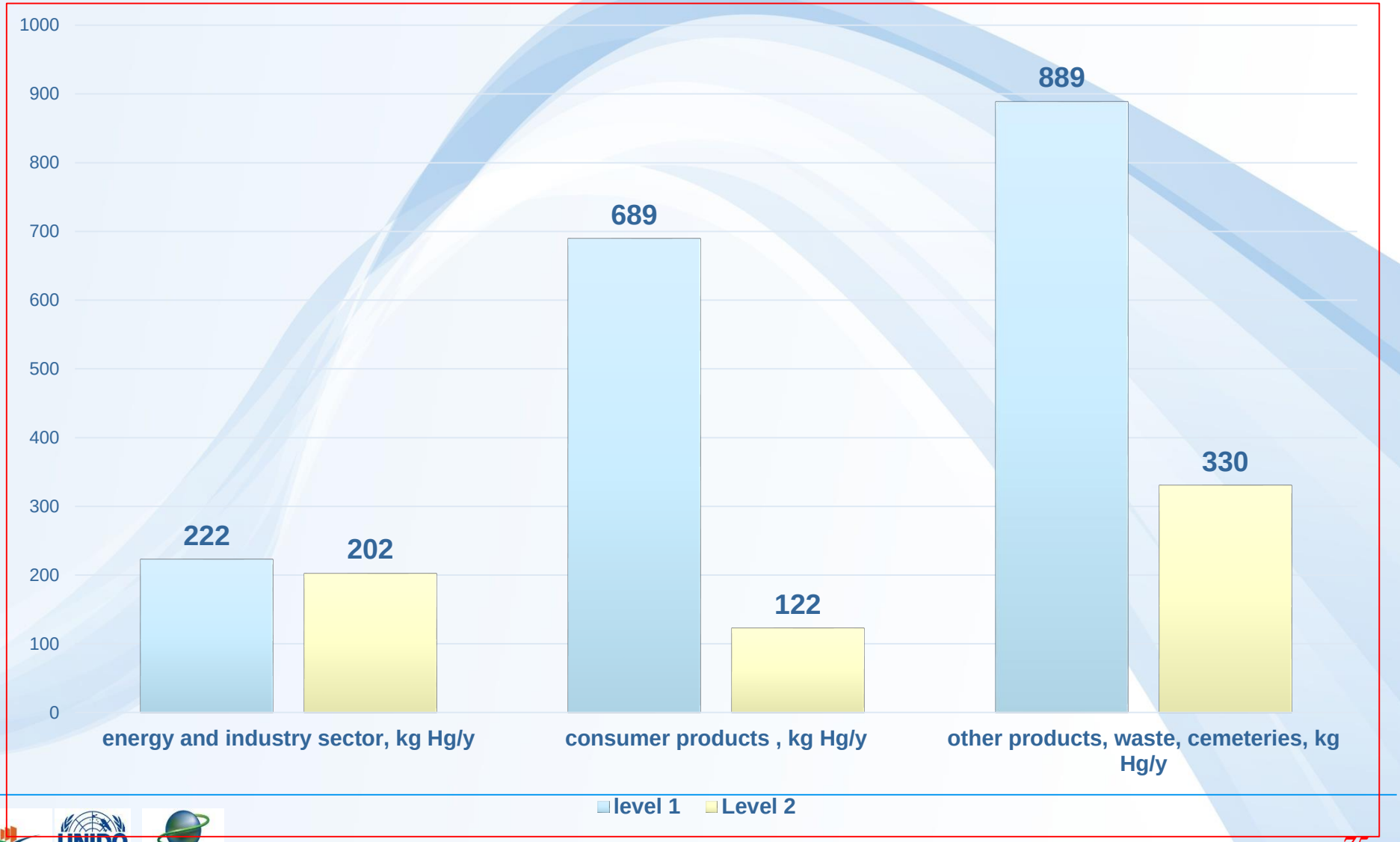
Inventory Level 2 Results, kg Hg	2010	2011	2012	2013	2014
5.6 Other intentional product/process use	0	1	1	1	4
5.7 Production of recycled metals	0	0	0	0	0
5.8 Waste incineration and burning	92	94	94	94	93
5.9 Waste deposition/landfilling and waste water treatment	277	275	275	276	280
5.10 Crematoria and cemeteries	41	37	37	36	37
SUM OF QUANTIFIED RELEASES	**326**	**324**	**325**	**324**	**330**

Inventory Level 1 Results vs Level 2 Results, kg Hg	2010	2011	2012	2013	2014
INVENTORY LEVEL 1	1074	1062	1067	1069	1068
INVENTORY LEVEL 2	326	324	325	324	330
Difference, %	**-69.6**	**-69.5**	**-69.5**	**-69.7**	**-69.1**

Comparative results of the level 1 and level 2 – total

Inventory Level 1 Results vs Level 2 Results, kg Hg	2010	2011	2012	2013	2014
INVENTORY LEVEL 1	1985	1942	1974	1962	1959
INVENTORY LEVEL 2	652	593	623	599	631
Difference, %	-67,2	-69,5	-68,4	-69,5	-67,8

Comparative results of the level 1 and level 2 approach for 2014 year per sector



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