Overview of Mercury Material Flow in Japan (FY2016)

1. Background and Objective

The Minamata Convention on Mercury (hereinafter referred to as the “Convention”) entered into effect on 16 August 2017. On the same day, the “Act on Preventing Environmental Pollution of Mercury (Act No.42 of 2015; hereinafter referred to as the “Act”) entered into force almost on a full scale.

The Convention requires to implement comprehensive mercury control measures throughout the lifecycle of mercury, including imports and exports, use in products, emissions and releases to the environment and disposal. In this regard, a mercury material flow could serve as a basic reference to develop and implement appropriate measures and to verify the effects thereof in the future. For this reason, the Ministry of the Environment, Japan (MOEJ) published “Mercury Material Flow in Japan (FY2010)”[1] in 2013 and the material flow[2] for FY2014 in FY2016.

The target year of this material flow is set to FY2016 so as to verify the progress of domestic measures before and after the enforcement of the Act, taking into account the availability of statistical and other information.

The methodology to develop a material flow will be further reviewed, as necessary, in line with the best available information for its improvement. It is expected that the knowledge and experience gained through the process of developing the material flow will be useful for other countries to develop their own material flows.

2. Executive Summary

The overview of the mercury material flow in Japan (FY2016) is shown in Figure 1 and Figure 2. The primary results of the flow are, (1) 79 tons of input came from raw minerals and fuels for domestic use (of which 73 tons is from imported raw minerals and fuels, 3.3 tons from domestically-produced raw minerals and fuels, 0.42 tons from imported mercury or mercury alloys, 0.88 tons from imported mercury-added products and 1.4 tons from imported waste containing mercury), (2) 102.1 tons exported (101 tons of mercury exported and 1.1 tons of mercury contained in exported products), (3) 16.78 tons emitted/released into the environment (16 tons of atmospheric emission, 0.20 tons of release to public waters and 0.58 tons of release to land), and (4) 7.8 tons landfilled for final disposal.

The input to each process and the output from the process are as follows[3].

- Mercury input to the processing/industrial use of raw minerals and fuels is 77 tons (mercury in imported raw minerals and fuels: 73 tons, mercury in domestically produced raw minerals and fuels: 3.3 tons, input

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[1] MOEJ press release (21st March, 2013): “Mercury Material Flow and Mercury Atmospheric Emission Inventory in Japan” http://www.env.go.jp/press/16475.html

[2] Results of Material Flow for mercury (FY2014) http://www.env.go.jp/chemi/tmms/materialflow/materialflow_2014.pdf

[3] All the totals have two significant figures and are rounded to the nearest whole number.

from the waste incineration process: 0.30 tons). Mercury output from the process is 60 tons (input to the mercury recovery process: 46 tons (input from waste generation side), atmospheric emissions: 11 tons, release to water: 0.060 tons, release to soil: 0.46 tons, final disposal: 2.9 tons).

- Mercury input to the mercury recovery process is 65 tons[4] (input from domestically produced raw minerals and fuels: 0.00023 tons, input from industrial use of raw minerals and fuels: 47 tons (recovery side), input from households and offices: 17 tons, input from waste incineration: 0.32 tons, mercury in imported wastes: 1.4 tons). Mercury output from the process is 101 tons (mercury exports: 101 tons, atmospheric emissions: 0.0052 tons, releases to water: 0.00029 tons, final disposal: 0.029 tons).
- Mercury input to mercury-using industries such as manufacturing of products in Japan is 0.42 tons (imported mercury or mercury alloys), mercury used for manufacturing of mercury-added products is 3.5 tons, and mercury output from those industries is 1.1 tons (mercury contained in exported products: 1.1 tons, atmospheric emissions: 0.0050 tons). Amount of mercury shipment has not been determined.
- Mercury input to households and offices is 0.88 tons (mercury contained in imported products), and mercury output from the process is 27 tons (input to the mercury recovery process: 17 tons, input to the waste incineration process is 9.6 tons, atmospheric emission: 0.070 tons). Amount of mercury in sold mercury-added products has not been determined.
- Mercury input to the waste incineration process is 9.6 tons (input from households and offices), and mercury output from the process is 11 tons (input to industrial use of raw minerals and fuels: 0.30 tons, input to the mercury recovery process: 0.32 tons, atmospheric emissions: 5.3 tons, release to water: 0.0050 tons, final disposal: 4.8 tons).

Prior to disclosure, the results of this material flow were authorized by related business organizations in FY2019. Some of the values, such as mercury content, are referenced to the results of past interview surveys, but the results of estimation using these values were also confirmed.

[4] Due to rounding, the value differs from the sum in parentheses.

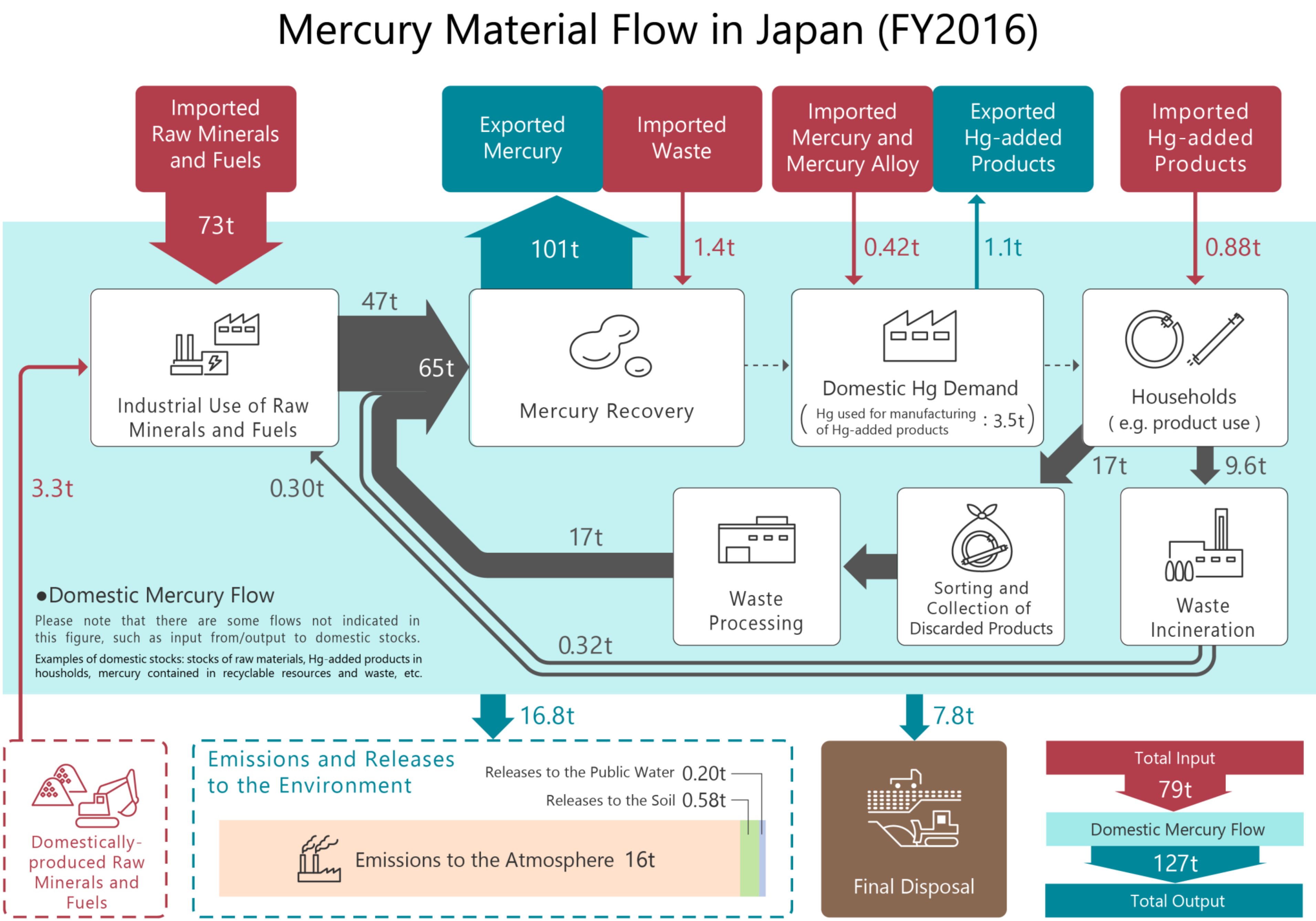
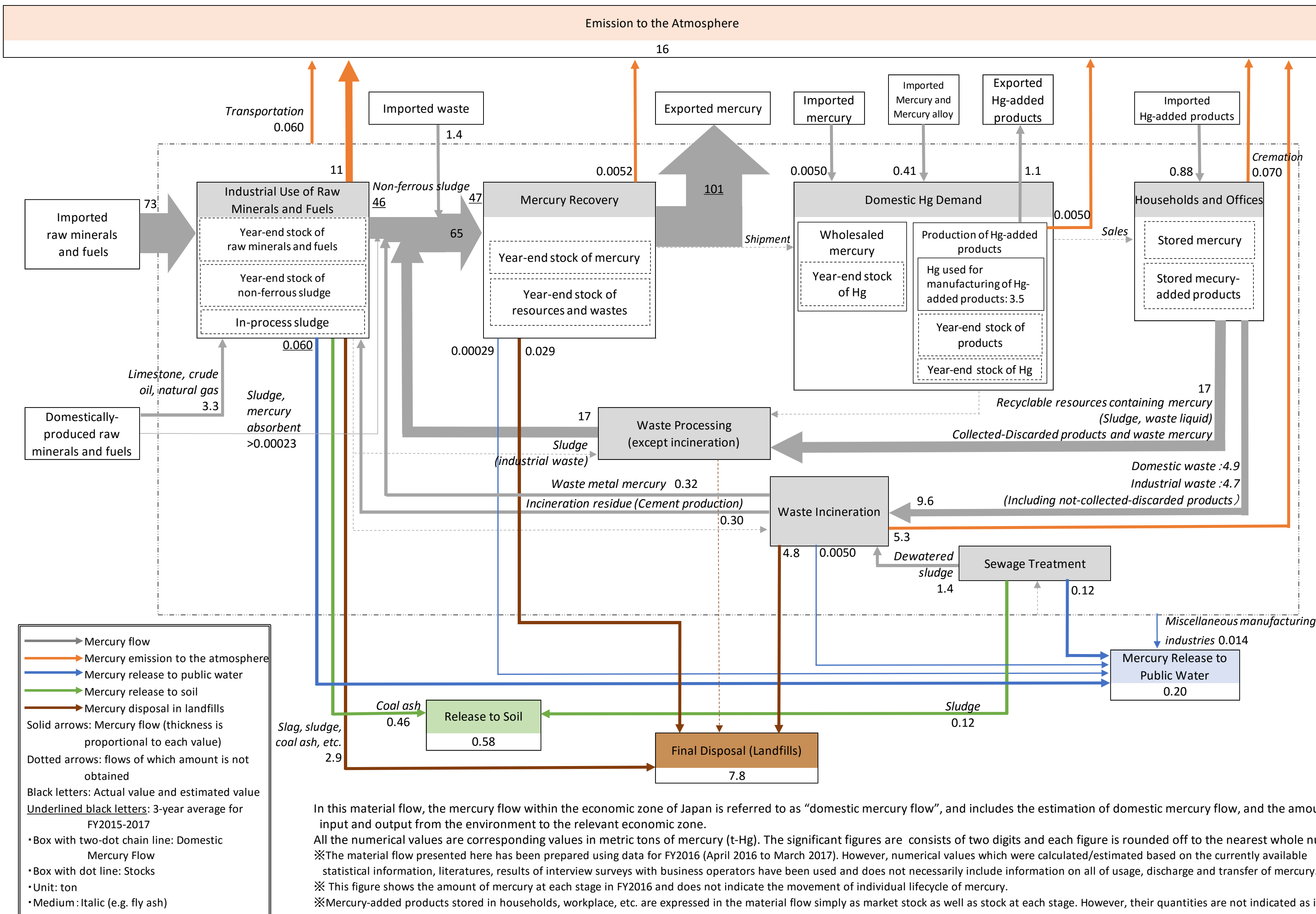


Figure 1 Simplified Mercury Material Flow in Japan (FY2016)

Mercury Material Flow in Japan (FY2016)



In this material flow, the mercury flow within the economic zone of Japan is referred to as "domestic mercury flow", and includes the estimation of domestic mercury flow, and the amount of input and output from the environment to the relevant economic zone.

All the numerical values are corresponding values in metric tons of mercury (t-Hg). The significant figures are consists of two digits and each figure is rounded off to the nearest whole number.

※The material flow presented here has been prepared using data for FY2016 (April 2016 to March 2017). However, numerical values which were calculated/estimated based on the currently available statistical information, literatures, results of interview surveys with business operators have been used and does not necessarily include information on all of usage, discharge and transfer of mercury.

※ This figure shows the amount of mercury at each stage in FY2016 and does not indicate the movement of individual lifecycle of mercury.

※Mercury-added products stored in households, workplace, etc. are expressed in the material flow simply as market stock as well as stock at each stage. However, their quantities are not indicated as it is difficult to obtain the relevant quantitative values.

※There are portions where the balance between the input amount and the discharge amount in each stage does not match. This part needs to be further reviewed for scrutiny.

Figure 2 Detailed Mercury Material Flow in Japan (FY2016)

3. Words of Caution when referring to the Mercury Material Flow

i. "Mercury Material Flow" and "Mercury Atmospheric Emission Inventory"

The material flow represents a flow of an object (material) within a certain period in a coherent system such as an economic zone (within “System boundary” in the conceptual diagram below). When observing the environmental impact of a specific substance in a certain system, an "inventory", which compiles the measurement results of the amount of the substance input from the environment ("Input" in the conceptual diagram below) and the amount released into the environment ("Output" in the conceptual diagram below), is utilized. On the other hand, the “material flow” captures the overall flow of the substance in the system by capturing the input to and output from the system to the environment, along with the flow of substance in each process and the flow of substance between the processes within the system.

In Japan, the “Mercury Atmospheric Emission Inventory[5]” has been developed focusing on atmospheric emissions of mercury in Japan. The material flow is intended to comprehensively capture domestic mercury flows, including emissions obtained in the inventory. In this material flow, the mercury flow within the economic zone of Japan is referred to as “domestic mercury flow”, and the estimation in the material flow covers domestic mercury flow, the amount of input from the environment, and output to the economic zone. Inputs for domestic mercury flow include mercury in imported and domestically produced raw minerals and fuels. Outputs from domestic mercury flow include emissions and releases to the environment and final disposal (landfill).

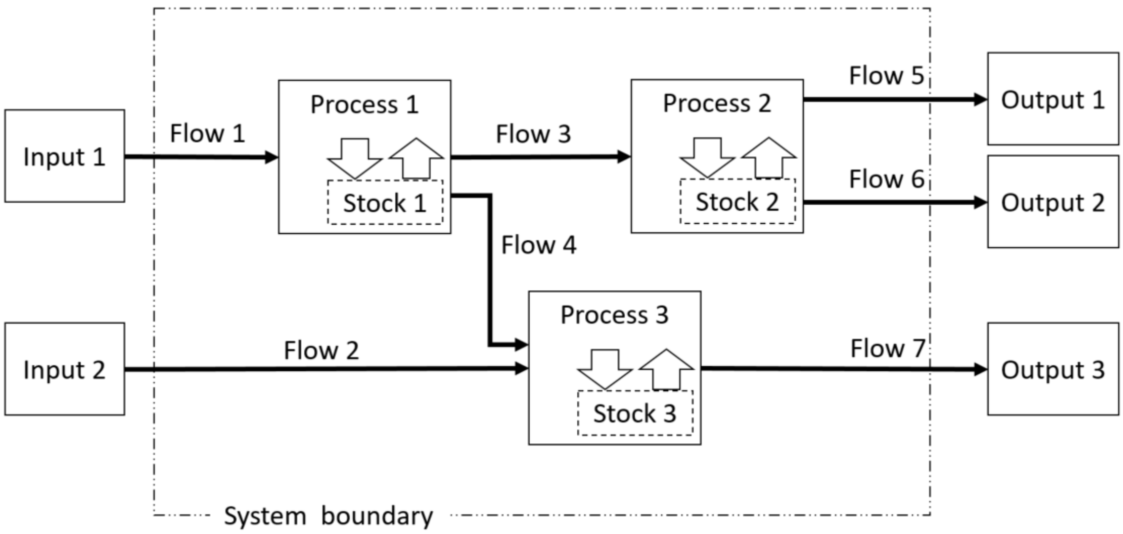


Figure 3 Conceptual diagram of material flow

[5] As of March, 2020, the estimation results for FY 2010, FY 2014, FY 2015, and FY 2016 have been published on the Ministry of the Environment website shown below. Details of the updated results are published in the Ministry of the Environment's “Survey Report on Measures to Control Mercury Atmospheric Emissions”.
http://www.env.go.jp/air/suigin/invertory.html

ii. Limitations of the Mercury Material Flow

1) The material flow has been developed using data from 2016 fiscal year (April 2016 to March 2017). However, calculated/estimated values based on the best available statistics, literatures and interview surveys with business operators do not necessarily cover all the usage, emission or transfer of mercury. Raw data in FY2016 are used whenever available, and if such data are not available or significantly fluctuate every year, numerical values of the nearest year to FY2016 or the average values over several years are used for the calculation/estimation (see attachment for details).
2) Mercury-added products stored in households and offices or waste/mercury-containing recyclable resources are expressed as “stocks” in the material flow. However, their quantities are not indicated as it is difficult to obtain.
3) There are some parts where the balance between input and output in each process does not match. This is possibly due to the fact that there are unknown values as described in 1) and 2). These parts need further elaboration.

iii. Entry Method of Numerical Values

All the numerical values are corresponding values in metric tons of mercury (t-Hg). The significant figures are two digits, and each figure is rounded off to the nearest whole number.

In each table, "0" is used when reported or estimated as "zero", and "unknown" is used when reported as "unknown". If the data is not reported or not available, it is marked as "-". “N.D.” means “Not Detected” (below the lower detection limit and hence not detected).

Attachment

Mercury Material Flow in Japan

(2016 Fiscal Year)

Estimation method

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1. RAW MINERALS AND FUELS

1.1 Mercury Content in Imported Raw Minerals and Fuels

According to trade statistics of the Ministry of Finance, resource and energy statistics, and interviews with the Japan Mining Association in FY2018, imports of raw minerals and fuels (coal, crude oil, naphtha, iron ore, non-ferrous metal ore, natural gas and limestone) are shown in Table 1.1.1. As imports of raw minerals and fuels other than non-ferrous metal ores have been almost stable from FY2015 to FY2017, the material flow uses the data for FY2016. For non-ferrous metal ores, a three-year average from FY2015 to FY2017 is adopted, considering that the amount of mercury recovered from non-ferrous metal smelting sludge varies widely between years.

The total amount of mercury in imported raw minerals and fuels is estimated as 73 t-Hg. For non-ferrous metal ores, the figures were obtained through interviews with the Japan Mining Association in FY2018. For other raw minerals and fuels, the amount of mercury is estimated by multiplying the amount of imports by the mercury concentration.

Table 1.1.1 Mercury content in imported raw minerals and fuels (FY2016)

<table>
<tr><th colspan="2" rowspan="2">Raw mineral and fuel</th><th colspan="2">Import</th><th rowspan="2">Hg concentration</th><th colspan="2">Hg content</th></tr>
<tr><th>Amount</th><th>Unit</th><th>(kg-Hg)</th><th>(t-Hg)</th></tr>
<tr><td rowspan="7">Coal</td><td>Anthracite</td><td>5,779</td><td rowspan="7">10^3 t</td><td rowspan="7">0.039 (g/t)</td><td rowspan="7">7,473</td><td rowspan="7">7.5</td></tr>
<tr><td>Bituminous coal</td><td>172,566</td></tr>
<tr><td>Other coals</td><td>11,070</td></tr>
<tr><td>Briquette, oval briquette, etc.</td><td>80</td></tr>
<tr><td>Lignite</td><td>19</td></tr>
<tr><td>Peat</td><td>114</td></tr>
<tr><td>Coke, etc.</td><td>1,988</td></tr>
<tr><td>Crude oil</td><td>Crude oil (refining use)</td><td>189,773</td><td>ML</td><td>2.6 (mg/kL)</td><td>493</td><td>0.49</td></tr>
<tr><td colspan="2">Naphtha</td><td>17,722</td><td>10^3 t</td><td>0.001 (g/t)</td><td>18</td><td>0.018</td></tr>
<tr><td rowspan="3">Iron ore (incl. concentrate)</td><td>Iron ore (uncondensed)</td><td>113,768</td><td rowspan="3">10^3 t</td><td rowspan="3">0.0329 (g/t)</td><td rowspan="3">4,221</td><td rowspan="3">4.2</td></tr>
<tr><td>Iron ore (condensed)</td><td>14,657</td></tr>
<tr><td>Burned iron sulphide</td><td>0.11</td></tr>
<tr><td>Non-ferrous metal ore Note</td><td>Copper, lead, zinc concentrate, gold ore</td><td>56.6</td><td>10^3 t</td><td>—</td><td>—</td><td>60.8</td></tr>
<tr><td>Natural gas</td><td>Liquified Natural Gas</td><td>84,749</td><td>10^3 t</td><td>—</td><td>—</td><td>—</td></tr>
<tr><td colspan="2">Limestone</td><td>547</td><td>10^3 t</td><td>0.022(ppm)</td><td>—</td><td>0.012</td></tr>
<tr><td colspan="5">Total</td><td>—</td><td>73</td></tr>
</table>

Note: The non-ferrous metal ore imports and the amount of mercury contained in the ores are averaged over three years from FY2015 to FY2017 in order to be consistent with the mercury flow at the non-ferrous metal smelting facilities.

[Source]
Amount of coal, iron ore, natural gas, limestone import: Trade Statistics of Japan (Ministry of Finance, Japan)
Crude oil and naphtha imports Source: Resource and Energy Statistics
Mercury concentration in coal: Interview with the Federation of Electric Power Companies of Japan (FY2018)
Mercury concentration in crude oil: Country-wise weighted average of crude oil import (Petroleum Association of Japan, 2009-2010)
Mercury concentration in naphtha: S&P Global Platts, "Methodology and specifications guide; Asia Pacific & Middle East Refined Oil Products (Last update: January 2020)"
Mercury concentration in iron ore: Arithmetic mean of ore lumps used in blast furnaces in Japan (National Institute for Environmental Studies Report, 2010)
Amount of import and Mercury concentration in non-ferrous metal ore: Interview with Japan Mining Industry Association (FY2018)
Mercury concentration in limestone: Implementation of measures to control the emission of mercury to the atmosphere based on the Minamata Convention on Mercury (First Report) Reference Material 2, "Results of Survey on Actual Conditions of Mercury Emission", page 92, http: //www.env.go. jp/press/102627.html

1.2 Mercury Content in Domestically Produced Raw Minerals and Fuels

According to the production dynamics statistics of the Ministry of Economy, Trade and Industry, domestic production of raw minerals and fuels (limestone, crude oil and natural gas) is as shown in Table 1.2.1. Since domestic production of raw materials and fuels has been stable in FY2015-2017, the material flows uses the data for FY2016.

The amount of mercury contained in domestically produced raw minerals and fuels is 3.3 t-Hg. The amount of mercury in limestone is estimated by multiplying the amount of production by the mercury concentration. The amount of mercury in crude oil and natural gas is obtained through interview survey conducted in FY2018. Since the actual value reported by the interviewed company is adopted and not all the businesses are covered, the value should be treated as the minimum value. It is also important to note that not all produced crude oil and natural gas contain mercury.

Table 1.2.1 Mercury content in domestically produced raw minerals and fuels (FY2016)

Raw mineral/fuel	Raw mineral/fuel production		Hg concentration	Hg content in product	
	Amount	Unit		(kg-Hg)	(t-Hg)
Limestone	139,129	10^3t	0.022 ppm	3,061	3.1
Crude oil	549	ML	N/A	143	0.14
Natural gas	2,797,235	10^3m^3S	N/A	136	0.14
			Total	3,340	3.3

Note: The individual sum does not exactly add up to the total due to rounding.
[Source]
Production volume: Ministry of Economy, Trade and Industry annual production dynamics statistics (resources, ceramics, building materials statistics)
Mercury concentration in limestone: Implementation of measures to control the emission of mercury into the atmosphere based on the Minamata Convention on Mercury (First Report) Reference Material 2, "Results of Survey on Actual Conditions of

Mercury Emission", page 92, http: //www.env.go. jp/press/102627.html

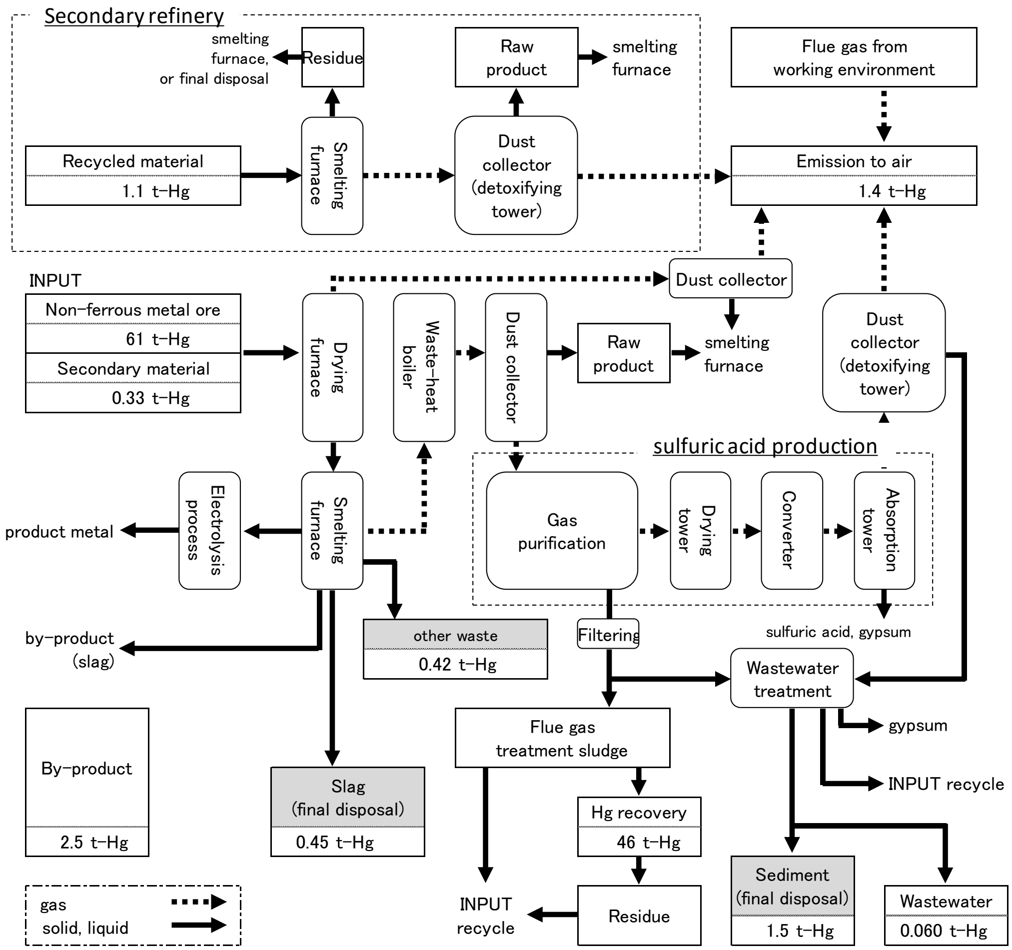
Mercury in crude oil and natural gas production: Interviews with domestic businesses in FY2018. Actual value reported by the interviewed company is adopted and not all companies are covered. Hence, the value should be treated as the minimum value in the material flow. It is also important to note that not all crude oil and natural gas produced contain mercury.

1.3 Processing/Industrial Use of Raw Materials and Waste Incineration

This section describes the mercury flow associated with processing/industrial use of raw minerals and waste incineration by each industry. The shaded items are to be subject to final disposal.

(1) Non-ferrous Metal Smelting Facility

Figure 1.3.1 shows the mercury flow for non-ferrous metal smelting facilities. Flue gas treatment sludge generated from the non-ferrous metal smelting process may be stored in the facility over multiple fiscal years, and therefore the year of generation and treatment may be different. Small amount of sludge may be stored for more than two years and discharged for mercury recovery altogether. Since the amount of mercury recovered from flue gas treatment sludge varies greatly between years, a three-year average from FY2015 to FY2017 is adopted for non-ferrous metal smelting facilities.



Flow: Based on interview with Japan Mining Industry Association
Values in the flow: Interview with Japan Mining Industry Association, FY2018

Figure 1.3.1 Mercury flow in non-ferrous metal smelting facilities (FY2016)

1) Atmospheric emission of mercury

Table 1.3.1 shows the estimated results of atmospheric mercury emission from non-ferrous metal smelting facilities in “Mercury Atmospheric Emission Inventory (FY2016)” (developed in FY2018. Updated results are published in the Ministry of the Environment's “Survey Report on Measures to Control Mercury Atmospheric Emissions in FY2018”).

Table 1.3.1 Mercury emission from non-ferrous metal smelting facilities (FY2016)

Non-ferrous metal	Producer [Note 1]	Estimation method [Note 2, Note 3]	Amount of Hg emission (t-Hg)
Electrolytic copper (primary + secondary)	Member	Σ (Average flue gas mercury concentration x average gas amount (Dry))	0.21
Electrolytic zinc or distilled zinc (primary)	Member		0.020
Electrolytic zinc or distilled zinc (secondary)	Member		0.49
Recycled zinc (secondary)	Non-member	Overall emission factor x production volume	0.000069
Emissions from roasting furnaces, sintering furnaces, blast furnaces and drying furnaces used for zinc recovery (Soot and dust from electric furnaces used for steelmaking, limited to the collection of zinc from dust collected by dust collectors)			0.30
Electrical lead (primary)	Member	Σ (Average flue gas mercury concentration x average gas amount (Dry))	0.030
Electrical lead (secondary)	Member		0.29
Recycled lead (secondary)	Non-member	Overall emission factor x production volume	0.0013
Gold (secondary)	Member	Σ (Average flue gas mercury concentration x average gas amount (Dry))	0.00011
		Total	1.4

Note 1: Producers are distinguished between members of the Japan Mining Association and non-members, and the overall emission factor is also separately calculated between members and non-members.

Note 2: The emission factor for production by the Japan Mining Association is calculated using the following formula with the results of measurements of 41 facilities of the Japan Mining Association's member companies (100% member coverage) in the 2015 Mercury Atmosphere Emissions Survey.

Mercury atmospheric emissions (ton-Hg/year) = Σ (mercury concentration in average flue gas (μg-Hg/Nm^3) x average gas amount (dry) (Nm^3/h) x annual operating time (h/year))

Note 3: As for production data of recycled zinc (secondary) and recycled lead (secondary), produced by non-members of the Japan Mining Association, production data for one facility for recycled zinc and two facilities for recycled lead were obtained and the overall emission factor is calculated individually. Since the sample size is small, the accuracy of the emission factor is poor and needs to be reviewed in the future.

[Recycled zinc (secondary)] Overall emission factor (0.0034 g-Hg/ton) x production volume (28,000 ton/year)

[Recycled lead (secondary)] Overall emission factor (0.033 g-Hg/ton) x Production volume (39,000 ton/year)

Quoted from "Mercury Atmospheric Emission Inventory (2016)" Table 4.12

2) Mercury content in non-ferrous metal ores and raw materials

According to the result of a survey conducted with the Japan Mining Association in FY2018, the amount of mercury contained in non-ferrous metal ores and raw materials that is input to the non-ferrous metal smelting process is as follows. A three-year average from FY2015 to FY2017 is adopted in the material flow.

Table 1.3.2 Non-ferrous metal smelting: Mercury content in material feed

Material	Hg content (t-Hg)			
	FY2015	FY2016	FY2017	Three-year Average
Non-ferrous metal ore	63	62.6	56.8	60.8
Recycled material	1.2	1.0	1.2	1.1
Secondary material	0.2	0.4	0.4	0.33

Note: According to Japan Mining Industry Association, several types (10 types at maximum) of raw material ore are purchased every year by each refinery, and the mercury content varies depending on the types of ore. The mercury content is calculated by multiplying the average of the value obtained from analysis for each ore type by the ore input amount.

Source: Interview with Japan Mining Industry Association in FY2018

Table 1.3.3 (Reference) Non-ferrous metal smelting: Import of non-ferrous metal ore

	FY2015	FY2016	FY2017	Three-year Average
Import of non-ferrous metal ore (10^3 t)	5,650	5,722	5,596	5,656

3) Mercury in waste

According to the result of a survey conducted with the Japan Mining Association in FY2018, the amount of mercury contained in emissions from non-ferrous metal smelting processes is as shown in Table 1.3.4. A three-year average from FY2015 to FY2017 is adopted in the material flow.

Table 1.3.4 Non-ferrous metal smelting: Mercury in waste

Medium	Hg content (t-Hg)			
	FY2015	FY2016	FY2017	Three-year average
Wastewater treatment sediment	0.27	2.38	1.92	1.52
Slag	0.26	0.50	0.58	0.45
Other waste	0.05	0.85	0.35	0.42
Wastewater	0.08	0.05	0.05	0.06

Source: Interview with Japan Mining Industry Association, FY2018. The amount of mercury is calculated by multiplying the measured value by the amount of emission.

4) Mercury in by-product

According to the result of a survey conducted with the Japan Mining Association in FY2018, mercury content in by-products (sulfuric acid/gypsum) generated from the non-ferrous metal smelting process is shown in Table 1.3.5. A three-year average from FY2015 to FY2017 is adopted in the material flow. Some of the desulfurized gypsum generated at non-ferrous metal smelting facilities is used in the finishing process of cement production, but the proportion is unknown. The mercury content in desulfurized gypsum utilized in cement manufacturing is identified as "less than 1.9 ton-Hg, noting that the maximum amount of 1.9 tons of mercury was transferred via by-products (sulfuric acid and gypsum) in FY2016(Refer to 1.3 (7)for details of cement production facilities).

Table 1.3.5 Mercury content in by-product

By-product	Hg content (t-Hg)			
	FY2015	FY2016	FY2017	Three-year Average
Sulfuric acid, gypsum	2.8	1.9	2.8	2.5

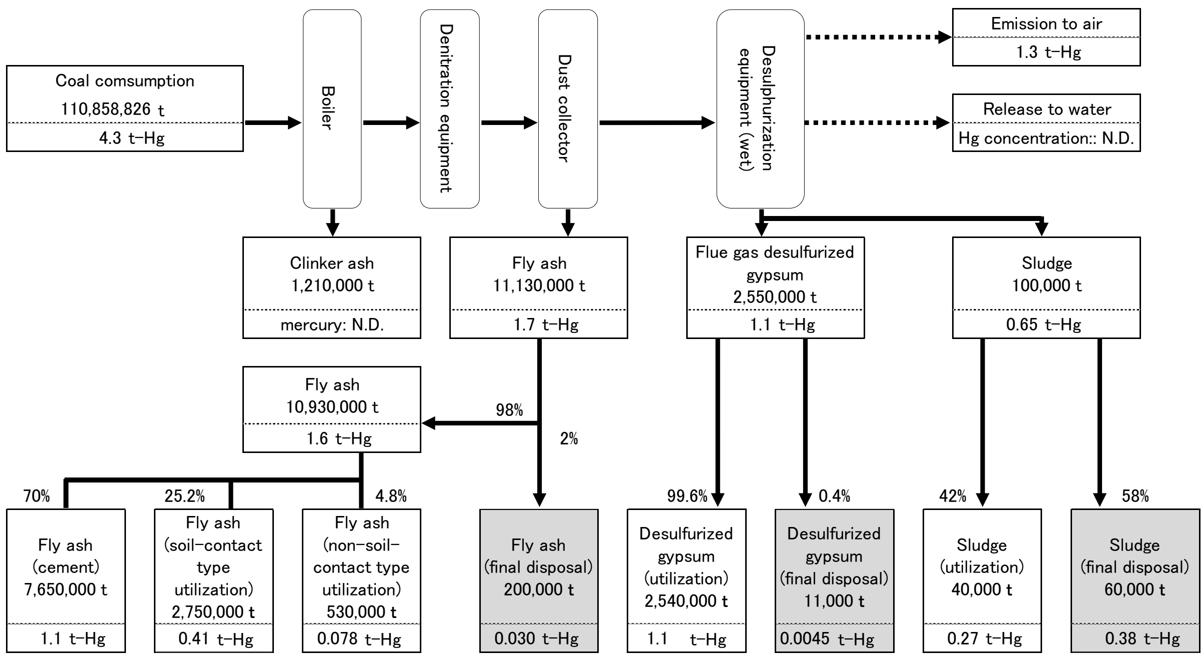
Source: Interview with Japan Mining Industry Association, FY2018

5) Mercury recovery from flue gas treatment sludge

Mercury in flue gas treatment sludge from non-ferrous metal smelting is recovered at outsourced waste treatment companies. In FY2016, 37 tons of mercury was recovered from the flue gas treatment sludge. Given that the amount of sludge varies greatly between years, a three-year average from FY2015 to FY2017 is adopted (46 t-Hg). Considering that the amount outsourced for treatment varies widely between years, the material flow adopted 47 t-Hg for mercury recovery, data obtained from waste treatment companies (For details on mercury recovery, see 4.1).

(2) Coal-Fired Power Plant

The mercury flow in coal-fired power plants is shown in Figure 1.3.2.



Flow: Based on interview with the Federation of Electric Power Companies

Values in the flow: Data extrapolated based on information obtained from interview with the Federation of Electric Power Companies in FY2018, using the results of the Survey of Electric Power Statistics conducted by the Agency of Natural Resources and Energy.

Figure 1.3.2 Mercury flow in coal-fired power plants (FY2016)

1) Atmospheric emission of mercury

Table 1.3.6 shows the result of estimated mercury emission to air from coal-fired power plants in "Mercury Atmospheric Emission Inventory (FY2016)".

Table 1.3.6 Mercury emission from coal-fired power plants (FY2016)

Energy generation (10^8 kWh)	Overall emission factor (μg/kWh)	Emission (t-Hg)
3,498	3.63	1.3

Note: Atmospheric emissions of mercury were estimated by multiplying the amount of domestic electricity generation by the overall emission factor calculated based on domestically measured data.

Source of energy generation: Electricity generation and access data for coal generation obtained from the "Annual Report on Energy in FY2019 (Energy White Paper 2018)" prepared by the Agency for Natural Resources and Energy

Overall emission factor: Data provided by the Federation of Electric Power Companies. Calculated from values measured at 28 units at 16 power plants from 2001 to 2014 (coverage rate: 51.6%. 10 member companies s of the Federation of Electric Power Companies of Japan + Ratio of 16 power plants to 31 power plants nationwide owned by Coal Power Development Co., Ltd. (excluding joint thermal power plants)).

Quoted from "Mercury Atmospheric Emission Inventory (2016)" Table 4.8

2) Mercury in coal consumption

According to the electricity survey statistics of the Agency for Natural Resources and Energy and interviews conducted with the Federation of Electric Power Companies in FY2018, domestic coal consumption in FY2016 is as shown in Table 1.3.7. Mercury contained in the coal consumption for thermal power generation is estimated by multiplying the coal consumption rate by the mercury concentration in coal (0.0390 g/ton) obtained from the interview survey with the Federation of Electric Power Companies of Japan. Material flow adopted the estimated value of 4.3 t-Hg, calculated based on the coal consumption rate in the power survey statistics, which covers a wider range of data than the interviews.

Table 1.3.7 Coal-fired power generation: Mercury in coal consumption in electric power industries (FY2016)

Source	Coal consumption amount Note (10^4 t)	Hg concentration in coal (g/ton)	Hg content in coal consumed (t-Hg)
Electricity Survey Statistics	11,086	0.0390	4.3
Federation of Electric Power Companies	7,310		2.9

Note: The ratio of coal consumption for the Federation of Electric Power Companies data (7,310x10^4) and the electricity survey statistics data (11,086x10^4) is 100 to 152. This ratio is used to extrapolate amount of generation of coal ash, flue gas desulfurized gypsum, and sludge obtained through interview with Federation of Electric Power Companies in FY2018.

[Source]

Amount of coal consumption: electricity survey statistics of the Agency for Natural Resources and Energy and interview with the Federation of Electric Power Companies in FY2018

Mercury concentration in coal: interview with the Federation of Electric Power Companies in FY2018

3) Mercury in utilized or disposed coal ash

Table 1.3.8 and Table 1.3.9 summarize the amount of generation, utilization and final disposal of coal ash (fly ash, clinker) in coal-fired power plants based on the data obtained from interviews with the Federation of Electric Power Companies in FY2018. The amount of coal ash generated from businesses covered by the electricity survey statistics is extrapolated using the ratio of 100:152 (ratio of coal consumption from data obtained from the Federation of Electric Power Companies and the electricity survey statistics data as shown in 2) above).

Mercury in fly ash is estimated as 1.7 t-Hg by multiplying the extrapolated amount of coal ash generation by the mercury concentration obtained from the interview with the Federation of Electric Power Companies in FY2018. Clinker is set to 0 t-Hg since the mercury concentration is below the lower limit of detection (N.D.).

Table 1.3.8 Coal-fired power generation: Mercury amount in generation, utilization and final disposal of fly ash (FY2016)

Fly ash		Federation of Electric Power Companies data (10^4 t)	Extrapolated value (10^4 t)	Hg concentration in fly ash (mg/kg)	Hg content in fly ash (t-Hg)
Generation		733.6	1,113	0.149	1.7
	Utilization	720.4	1,093		1.6
	Final disposal	13.2	20		0.030

[Source]

Amount of generation, utilization and disposal of fly ash: Interview with the Federation of Electric Power Companies in FY2018. Note that the ratio of coal consumption (Federation of Electric Power Companies data: the electricity survey statistics data=7,310:11,086=100:152) is used for extrapolation.

Mercury concentration in precipitator ash (fly ash): Interview with the Federation of Electric Power Companies in FY2018.

Table 1.3.9 Coal-fired power generation: Mercury in generation, utilization and final disposal of clinker (FY2016)

Clinker		Federation of Electric Power Companies data (10^4 t)	Extrapolated value (10^4 t)	Hg concentration in clinker	Hg content in clinker (t-Hg)
Generation		79.5	121	N.D.	0
	Utilization	78.6	119		0
	Final disposal	0.90	1.4		0

Note: The sum of extrapolated amount does not match the total due to rounding

[Source]

Amount of generation, utilization and final disposal of clinker: Interview with the Federation of Electric Power Companies in FY2018. Note that the ratio of coal consumption (Federation of Electric Power Companies data: the electricity survey statistics data=7,310:11,086=100:152) is used for extrapolation.

Mercury content in clinker: Interview with the Federation of Electric Power Companies in FY2018

The "Coal Ash Nationwide Fact-finding Report (Results for FY2016)" summarizes the amount of coal ash generated from the “electricity business” and “general industry (manufacturing industry, etc.)” and its status of utilization. According to this report, the amount of utilized coal ash generated from the electricity business and its breakdown is as shown in Table 1.3.10 (unit of amount is shown as thousand tons based on the report). Table 1.3.11 shows the amount of mercury that transfers from the utilized coal ash when it is mixed with the soil or spread directly on the soil (Shaded items in the table. In the material flow, shown as “soil-contact type utilization”). Fly ash used as a raw material in cement manufacturing facilities is separately estimated in 1.3 (7). Hence among “cement production” category, “cement materials” and “cement admixture” excluding “concrete admixture” are regarded as “cement use”. Items other than “soil contact-type utilization” and “cement use” are regarded as “non-soil-contact type utilization”. The composition ratio for each type of utilization is; 70.0% for “cement use”, 25.2% for “soil-contact type utilization” and 4.8% for “non-soil-contact type utilization”.

In Table 1.3.11, mercury contained in fly ash is estimated by multiplying the amount of utilized fly ash of

1,092.5 thousand tons obtained through extrapolation as shown in Table 1.3.8 by respective utilizations ratio, and then multiplying it by the mercury content. Since the utilization ratio of fly ash and clinker ash differs for each purpose of use, no distinction is made between fly ash and clinker ash in the "Coal Ash Nationwide Fact-finding Report (Results for FY2016)". Since the composition ratio in Table 1.3.10 is not exclusive to fly ash, the amount of mercury allocated to each purpose of utilization in Table 1.3.11 may be either underestimated or overestimated. However, the total value of 1.6 t-Hg of mercury in fly ash destined to be utilized is the result of estimation through extrapolation as shown in Table 1.3.8, and therefore it is not affected by errors in the composition ratio.

Table 1.3.10 Amount of utilization and composition ratio of coal ash generated from electricity business (FY2016)

Category	Purpose of use Note1	Amount of utilization (10^3 t)	Ratio (%)
Cement production	Cement material	6,200	69.17
	Cement admixture	72	0.80
	Concrete admixture	73	0.81
	Subtotal	6,345	70.78
Engineering	Soil improvement material	105	1.17
	Construction material	340	3.79
	Electric construction material	20	0.22
	Soil stabilizer	280	3.12
	Asphalt filler	3	0.03
	Coal mine filling	387	4.32
	Subtotal	1,135	12.65
Architecture	Building interior board	232	2.59
	Artificial lightweight aggregate	91	1.02
	Concrete secondary product	33	0.37
	Subtotal	356	3.98
Agriculture, forestry and fisheries	Fertilizer (incl. snow melting agent)	29	0.32
	Fish reef	0	0
	Soil improvement material	34	0.38
	Subtotal	63	0.70
Others	Sewage treatment agent	1	0.01
	Iron and steel production	1	0.01
	Others Note2	1,063	11.86

Category	Purpose of use Note1	Amount of utilization (10^3 t)	Ratio (%)
Subtotal		1,065	11.88
Total		8,964	100

Note 1: The shaded items (either mixing with soil or direct spreading over soil) is categorized into "soil-contact type utilization". Other purposes except for "soil-contact type utilization" are categorized into "non-soil-contact type utilization". "Cement material" and "cement admixture" used as raw materials in cement manufacturing facilities are regarded as "cement use" and are not included in "non-soil-contact type utilization".

Note 2: Almost all of the "Others" in the table refers to "land reclamation" (sea reclamation, etc.) and hence are classified as "soil-contact type utilization".

Note 3: In regard to the utilized coal ash, no distinction is made between fly ash and clinker ash in the "Coal Ash Nationwide Fact-finding Report (Results for FY2016)".

Source: "Coal Ash Nationwide Fact-finding Report (Results for FY2016)", February 2018, Japan Coal Energy Center

http://www.jcoal.or.jp/ashdb/ashstatistics/upload/H28_ashstatistics.pdf

Table 1.3.11 Coal-fired power generation: Mercury content in utilized fly ash (FY2016)

Purpose	Composition rate (%)	Amount of utilized fly ash (10^4 t)	Hg concentration in fly ash (mg/kg)	Hg content in fly ash (t-Hg)
Cement use	70.0	765	0.149	1.1
Soil-contact type	25.2	275		0.41
Non-soil-contact type	4.8	53		0.078
Total	100	1,093		1.6

Note: The "Coal Ash Nationwide Fact-finding Report" does not distinguish between fly ash and clinker ash, and the breakdown of fly ash and clinker ash in the composition ratio of each purpose of use is unknown. The amount of mercury allocation to each recycling application based on the composition ratio may be underestimated or overestimated. However, the total value of 1.6 t-Hg is the result of extrapolation as shown in Table 1.3.8, and hence the result is not affected by errors in the composition ratio.

Source of composition rates by purpose: "Coal Ash Nationwide Fact-finding Report (Results for FY2016)" (February 2018, Japan Coal Energy Center) http://www.jcoal.or.jp/ashdb/ashstatistics/upload/H28_ashstatistics.pdf

Source of mercury content in fly ash: interview survey with the Federation of Electric Power Companies of Japan in FY2018

4) Mercury in utilized or disposed flue gas desulfurized gypsum

Table 1.3.12 shows the amount of generation, utilization and final disposal of flue gas desulfurized gypsum in coal-fired power plants according to the interview with the Federation of Electric Power Companies in FY2018. It needs to be noted that the amount of desulfurized gypsum generated from businesses covered by the electricity survey statistics is extrapolated using the ratio of 100:152 (ratio of coal consumption from data obtained from the Federation of Electric Power Companies and the electricity survey statistics data as shown in 2) above).

The amount of mercury contained in flue gas desulfurized gypsum is estimated by multiplying the mercury concentration (0.428 mg/kg) obtained from interview with the Federation of Electric Power Companies by the extrapolated amount of generation, utilization and final disposal.

Table 1.3.12 Coal-fired power generation: Mercury from the generation, utilization and final disposal of flue gas desulfurized gypsum (FY2016)

Flue gas desulfurized gypsum		Federation of Electric Power Companies data (10^4 t)	Extrapolated value (10^4 t)	Hg concentration in flue gas desulfurized gypsum (mg/kg)	Hg content in flue gas desulfurized gypsum (t-Hg)
Generation		168.2	255	0.428	1.1
	Utilization	167.5	254		1.1
	Final disposal	0.70	1.1		0.0045

[Source]

Amount of generation, utilization and final disposal of flue gas desulfurized gypsum: Interview with the Federation of Electric Power Companies in FY2018. Note that the ratio of coal consumption (Federation of Electric Power Companies data: the electricity survey statistics data=7,310:11,086=100:152) is used for extrapolation.

Mercury content in flue gas desulfurized gypsum: Interview with the Federation of Electric Power Companies in FY2018.

5) Mercury in utilized or disposed sludge

Table 1.3.13 shows the amount of generation, utilization and final disposal of sludge from coal-fired power plants according to the interview with the Federation of Electric Power Companies in FY2018. It needs to be noted that that the amount of sludge generated from businesses covered by the electricity survey statistics is extrapolated using the ratio of 100:152 (see 2) above).

The amount of mercury contained in the sludge is estimated by multiplying the mercury concentration (6.60 mg/kg) obtained from interview with the Federation of Electric Power Companies by the extrapolated amount of generation, utilization and final disposal.

Table 1.3.13 Coal-fired power generation: Generation, utilization and final disposal of sludge (FY2016)

Sludge		Federation of Electric Power Companies data (10^4 t)	Extrapolated value (10^4 t)	Hg concentration in sludge (mg/kg)	Hg content in sludge (t-Hg)
Generation		6.5	10	6.60	0.65
	Utilization	2.7	4		0.27
	Final disposal	3.8	6		0.38

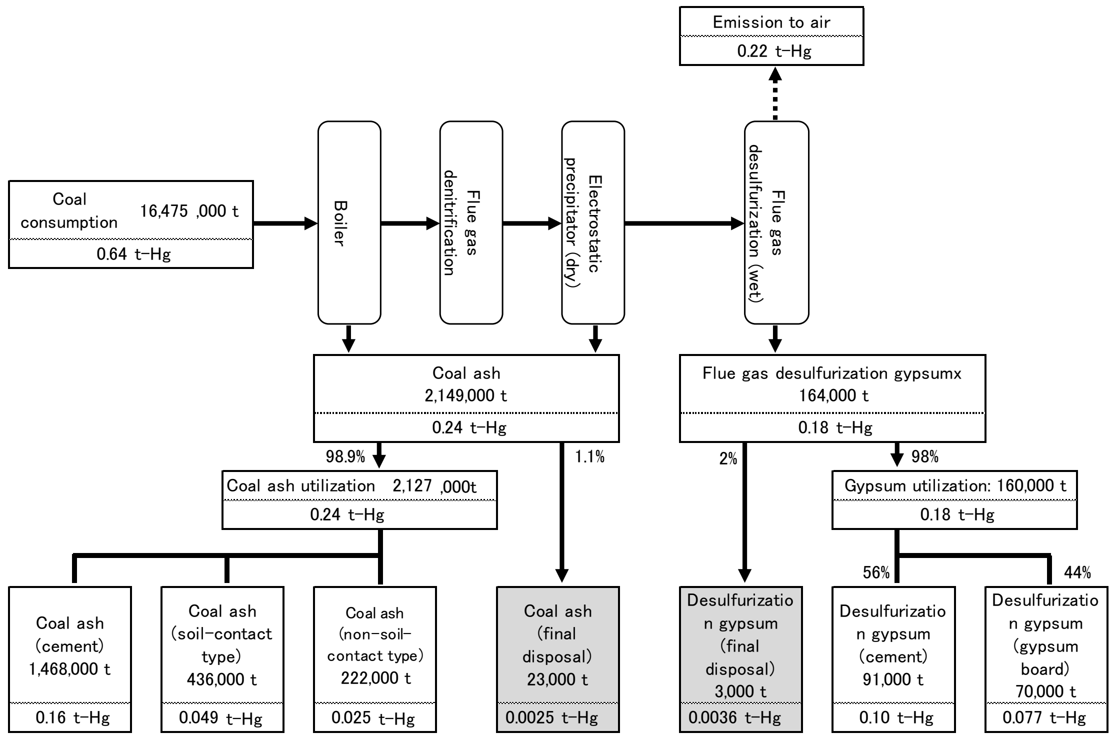
[Source]

Amount of generation, utilization and final disposal of sludge: Interview with the Federation of Electric Power Companies in FY2018. Note that the ratio of coal consumption (Federation of Electric Power Companies data: the electricity survey statistics data=7,310:11,086=100:152) is used for extrapolation.

Mercury content in sludge: Interview with the Federation of Electric Power Companies in FY2018.

(3) Coal-Fired Industrial Boiler

The mercury flow in coal-fired industrial boilers is as shown in Figure 1.3.3.



Flow: Based on interview with Japan Boiler Association

Values in the flow: The estimated results of "Mercury Atmospheric Emission Inventory (FY2016)" and "Coal Ash Nationwide Fact-finding Report (Results for FY2016)" (February 2018, Japan Coal Energy Center) are used but values are updated.

Figure 1.3.3 Mercury flow in coal-fired industrial boilers (FY2016)

1) Atmospheric emission of mercury

Table 1.3.14 shows the estimated result of the mercury emission from coal-fired industrial boilers in "Mercury Atmospheric Emission Inventory (FY2016)".

Table 1.3.14 Atmospheric emission of mercury from coal-fired industrial boilers (FY2016)

Coal consumption (10^3 t)	Emission factor (coal consumption-base) Note (mg-Hg/t)	Emission (t-Hg)
16,475	13.425	0.24

Note: The emission factor is calculated using the following formula with the measurement results in 69 facilities (coverage is about 35%) obtained from the survey on the actual situation of mercury emission in FY2015:

(1) Σ (average concentration of mercury in flue gas x average gas flow (dry)) = 552,458,664 (μg-Hg/d)

(2) Σ (coal consumption) = 41,151 (t/d)

Emission factor = (1) / (2) = 13.425 mg-Hg/t (from Mercury Atmospheric Emission Inventory (FY2014))

Source of coal consumption data: Values of “Coal energy from private power generation, private steam generation and district heat supply” obtained from General Energy Statistics (FY 2016) issued by the Agency of Natural Resources and Energy.

Quoted from "Mercury Atmospheric Emission Inventory (2016)" Table 4.10

2) Mercury in residue

Mercury transferred from coal-fired industrial boilers to residue is calculated with the assumption that all the mercury not being emitted to air is transferred to residue (coal ash, flue gas desulfurized gypsum).

Table 1.3.15 Coal-fired boiler: Mercury contained in residue (FY2016)

Coal consumption (10^3 t)	Hg concentration in coal (g/t)	Amount of Hg in coal consumed (t-Hg)	Atmospheric emission (t-Hg)	Hg in residue (t-Hg)
16,475	0.0390	0.64	0.22	0.42

Source of coal consumption: "Mercury Atmospheric Emission Inventory (FY2016)"
Source of mercury content in coal: Interview with the Federation of Electric Power Companies in FY2018.

The distribution of mercury in coal ash and desulfurized gypsum is shown in Table 1.3.16. Mercury transfer ratio (4:3) is calculated by using mercury content ratio in residue (coal ash: desulfurized gypsum = 1:3) obtained from the interview with the Federation of Electric Power Companies in FY2018 and multiplying it by generation ratio (coal ash: desulfurized gypsum = 4:1) obtained from the “FY 2013 Report on Analysis for the Environmentally Sound Management of Mercury Waste”. This is further multiplied by the amount of mercury in residue (0.42 t-Hg) from Table 1.3.15 to identify the mercury content in coal ash and desulfurized gypsum.

Table 1.3.16 Coal-fired boilers: Mercury in coal ash and desulfurized gypsum

	Hg concentration (ppm) Note 1	Generation ratio Note 2	Mercury transfer ratio Note 2	Hg content (t-Hg)
Coal ash	0.149	4	4	0.24
Desulfurized gypsum	0.428	1	3	0.18

Note 1: Mercury concentration in the residue obtained from interview with the Federation of Electric Power Companies in FY2018. Concentration of fly ash used for coal ash.
Note 2: Generation ratio of residue, based on FY2013 Report on Analysis of Environmentally Sound Management of Mercury Waste, is coal ash: desulfurized gypsum = 4:1
Note 3: Mercury transfer ration is mercury content ratio of residue (1:3) x generation ratio (4:1) = 4:3

3) Mercury in utilized or disposed coal ash

The amount of coal ash generated, utilized and disposed from “general industry” are obtained from the "Coal Ash Nationwide Fact-finding Report (Results for FY2016)". The amount of coal ash generation from coal-fired industrial boilers is calculated by using the ratio between the coal consumption in industrial coal-fired boilers identified in the “Mercury Atmospheric Emission Inventory (FY2016)” and “general industry (manufacturers, etc.)” (Businesses other than electricity businesses that use coal-fired industrial boilers for their own power generation) obtained from the "Coal Ash Nationwide Fact-finding Report (Results for FY2016)". In addition, the amount of coal ash utilized and disposed of are estimated by multiplying the amount of coal ash generation by its utilization rate (98.9%), and the disposal rate (1.1%) obtained from "Coal Ash Nationwide Fact-finding

Report (Results for FY2016)". The amount of generation, utilization and final disposal of coal ash generated from coal-fired industrial boilers is shown in Table 1.3.17.

Table 1.3.17 Coal-fired boilers: Generation, utilization and final disposal of coal ash (FY2016)

	Coal consumption (10^3 t)	Amount of generation (10^3 t)	Amount of utilization (10^3 t)	Amount of final disposal (10^3 t)
General industries	25,457	3,321	3,286	35
Coal-fired industrial boilers	16,475	2,149	2,127	23

[Source]

General industries: Coal Ash Nationwide Fact-finding Report (Results for FY2016) (February 2018, Japan Coal Energy Center), http://www.jcoal.or.jp/ashdb/ashstatistics/upload/H28_ashstatistics.pdf

Coal-fired industrial boilers: Amount of coal ash generation is estimated using the ratio of coal ash consumption retrieved from the aforementioned report and coal ash consumption obtained from “Mercury Atmospheric Emission Inventory (FY2016)”. Amount of utilization and final disposal are estimated by multiplying the amount of coal ash generation by the rate of utilization (98.9%) and the rate of final disposal (1.1%) obtained from the "Coal Ash Nationwide Fact-finding Report (Results for FY2016)".

According to the “Coal Ash Nationwide Fact-finding Report (Results for FY2016)", the amount of coal ash utilized that are generated from “general industry” and the breakdown of its use are shown in Table 1.3.18. Similar to coal ash generated from coal-fired power plants, the ratio of each purpose of utilization is summarized as follows: "cement use” at 69.0%, "soil-contact type utilization” at 20.5%, "non-soil-contact type utilization" at 10.4 %.

The amount of utilized coal ash in Table 1.3.19 is calculated by multiplying the estimated amount of utilized coal ash generated from coal-fired industrial boilers (2,127,000 tons) in Table 1.3.17 by the ratio of each purpose of utilization. Further, the amount of mercury contained in utilized coal ash is calculated by multiplying the estimated amount of mercury in coal ash (0.24 t-Hg) in Table 1.3.16 by the ratio of each purpose of utilization.

Table 1.3.18 Amount of utilization and composition ratio of coal ash generated from general industry (FY2016)

Category	Purpose of use Note 1	Amount of utilization (10^3 t)	Ratio (%)
Cement production	Cement material	2,227	67.78
	Cement admixture	42	1.26
	Concrete admixture	9	0.28
	Subtotal	2,278	69.32
Engineering	Soil improvement material	324	9.85
	Construction material	43	1.3
	Electric construction material	0	0

Category	Purpose of use Note 1	Amount of utilization (10^3 t)	Ratio (%)
	Soil stabilizer	218	6.64
	Asphalt filler	0	0
	Coal mine filling	16	0.49
	Subtotal	601	18.28
Architecture	Building interior board	280	8.52
	Artificial lightweight aggregate	0	0
	Concrete secondary product	1	0.03
	Subtotal	281	8.55
Agriculture, forestry and fisheries	Fertilizer (incl. snow melting agent)	4	0.12
	Fish reef	0	0
	Soil improvement material	70	2.12
	Subtotal	74	2.24
Others	Sewage treatment agent	0	0
	Iron and steel production	7	0.2
	Others	46	1.4
	Subtotal	53	1.60
Total		3,286	100

Note: The shaded items (either mixture with soil or direct spreading over soil) are categorized into “soil-contact type utilization”. Other purposes except for “soil-contact type utilization” are categorized into "non-soil-contact type utilization". “Cement material” and “cement admixture” used as raw materials in cement manufacturing facilities are regarded as “cement use” and are not included in “non-soil-contact type utilization”.

Source: "Coal Ash Nationwide Fact-finding Report (Results for FY2016)", February 2018, Japan Coal Energy Center http://www.jcoal.or.jp/ashdb/ashstatistics/upload/H28_ashstatistics.pdf

Table 1.3.19 Coal-fired boilers: Mercury in utilized coal ash (FY2016)

Purpose of use	Composition rate (%)	Amount of utilized coal ash (10^3 t)	Mercury in coal ash	
			(kg-Hg)	(t-Hg)
Cement-related	69.0	1,468	164	0.16
Soil-contact type	20.5	436	49	0.049
Soil non-contact type	10.4	222	25	0.025
Total	100.0	2,127	238	0.24

Note: Total and the sum of each entity of composition rate does not match due to rounding off.

Source of composition rate: "Coal Ash Nationwide Fact-finding Report (Results for FY2016)" (February 2018, Japan coal energy center), http://www.jcoal.or.jp/ashdb/ashstatistics/upload/H28_ashstatistics.pdf

4) Mercury in utilized or disposed flue gas desulfurized gypsum

Amount of generation, utilization and final disposal of flue gas desulfurized gypsum from “general industries” are obtained from the "Coal Ash Nationwide Fact-finding Report (Results for FY2016)". The amount of generation of flue gas desulfurized gypsum from coal-fired industrial boilers is calculated by using the ratio between the coal consumption in coal-fired industrial boilers in the “Mercury Atmospheric Emission Inventory (FY2016)” and “general industry” obtained from the "Coal Ash Nationwide Fact-finding Report (Results for FY2016)". Amount of flue gas desulfurized gypsum utilized and disposed are estimated by multiplying the amount of flue gas desulfurized gypsum generated by its utilization rate (98%), and the disposal rate (2%) obtained from "Coal Ash Nationwide Fact-finding Report (Results for FY2016)". Results are as shown in Table 1.3.20.

Table 1.3.20 Coal-fired boilers: Generation, utilization and final disposal of flue gas desulfurized gypsum (FY2016)

	Coal consumption (10^3 t)	Generation of FGD gypsum (10^3 t)	Utilization of FGD gypsum (10^3 t)	Final disposal of FGD gypsum (10^3 t)
General industries	25,457	253	248	5.0
Coal-fired industrial boilers	16,475	164	160	3.2

[Source]

General industries: "Coal Ash Nationwide Fact-finding Report (Results for FY2016)" (February 2018, Japan Coal Energy Center) http://www.jcoal.or.jp/ashdb/ashstatistics/upload/H28_ashstatistics.pdf

Coal-fired industrial boilers: Amount of FGD gypsum generation in coal-fired industrial boilers is estimated using the ratio of coal consumption retrieved from the aforementioned report and coal consumption in “Mercury Atmospheric Emission Inventory (FY2016)”. Amount of utilization and final disposal are estimated by multiplying the amount of FGD gypsum generation by its utilization rate (98%) and the disposal rate (2%) obtained from the "Coal Ash Nationwide Fact-finding Report (Results for FY2016)".

According to the report above, 56% of utilized flue gas desulfurized gypsum is used as cement materials and the rest (44%) is used for gypsum boards. Amount of mercury in utilized and disposed FGD gypsum is estimated as shown in Table 1.3.21 calculated by multiplying the amount of mercury in FGD gypsum (0.18t-Hg) as estimated in Table 1.3.16 by the utilization rate (98%), disposal rate (2%) and ratio of each purpose of utilization (cement raw material: 56%, gypsum: 44%).

Table 1.3.21 Coal-fired boilers: Mercury in utilized or disposed flue gas desulfurized gypsum (FY2016)

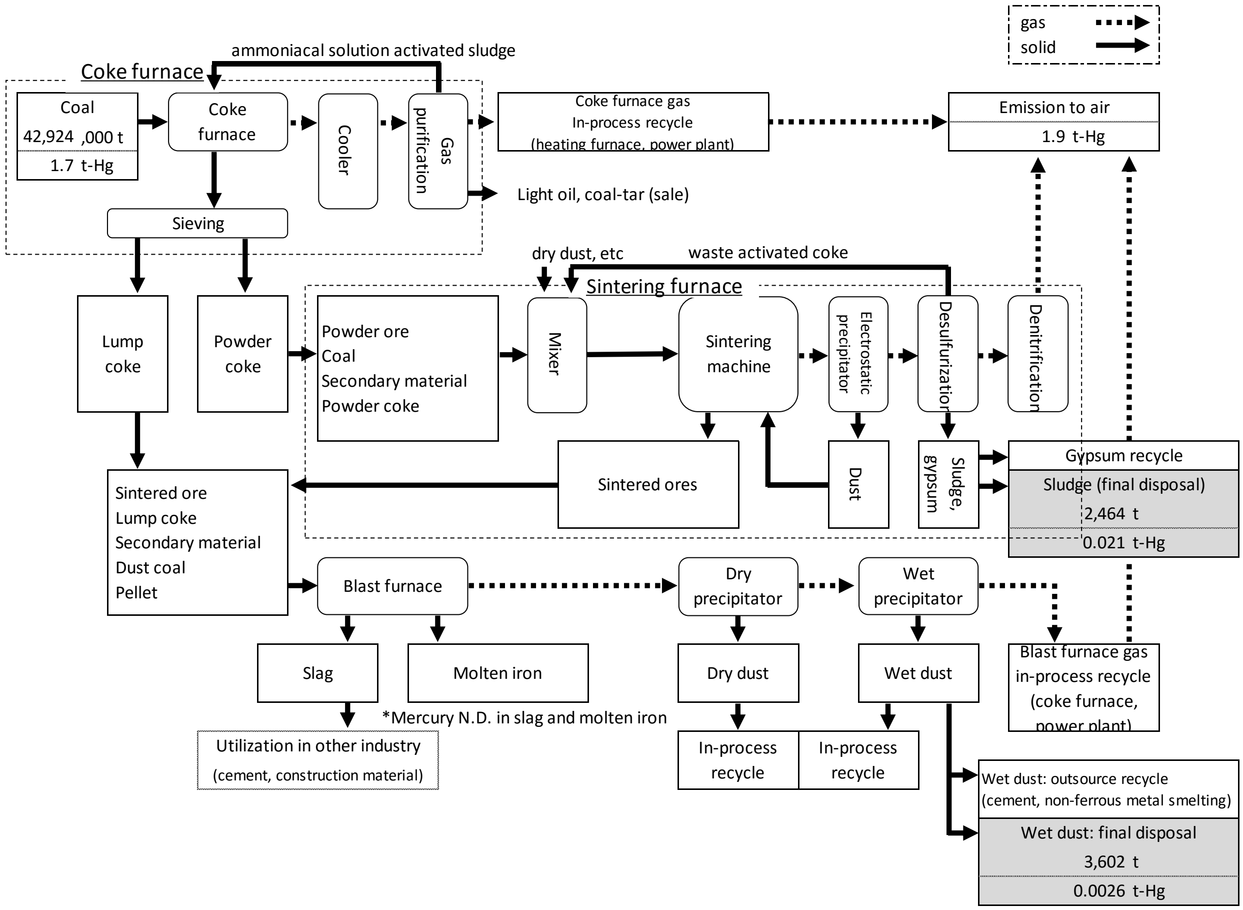
		Amount of generation (10^3 t)	Hg content	
			(kg-Hg)	(t-Hg)
Utilization	Cement material	91(56%)	100	0.10
	Gypsum board	70(44%)	77	0.077
	Subtotal	160	177	0.18
Final disposal (landfill)		3.2	3.6	0.0036
Total		164	181	0.18

Note: Total and the sum of each entity of generation amount does not match due to rounding off

Source utilization rate: "Coal Ash Nationwide Fact-finding Report (Results for FY2016)" (February 2018, Japan Coal Energy Center), http://www.jcoal.or.jp/ashdb/ashstatistics/upload/H28_ashstatistics.pdf

(4) Primary iron production facility

Mercury flow in primary iron production facilities is shown in Figure 1.3.4.



Flow: Based on interview with Japan Iron and Steel Federation

Amount of final disposal: Interview with the Japan Iron and Steel Federation in FY2018

Amount of mercury: Estimated by Ministry of the Environment, Japan based on the amount of final disposal above and the concentration of mercury in residue ("Mercury Emission Behavior in the Iron and Steel Industry", Masaki Takaoka, Kazuyuki Oshita, 2007). It needs to be noted that only a limited number of data samples were available (n=1 or 3).

Figure 1.3.4 Mercury flow in primary iron production facilities (FY2016)

1) Atmospheric emission of mercury

Table 1.3.22 shows the estimated results of mercury emission from primary iron production facilities in "Mercury Atmospheric Emission Inventory (FY2016)".

Table 1.3.22 Mercury emission from primary iron production facilities (FY2016)

Item	Emission factor (mg-Hg/t-product)	Annual production (10^3 t)	Mercury Emission (t-Hg)
Sintering furnace (including pelletizing furnace)	16.2	103,468	1.7
By-product gas from blast furnace	1.6	79,829	0.13
By-product gases from coke oven	0.89	25,371	0.023
		Total	1.9

*Mercury emission from sintering furnaces is estimated by multiplying the emission factor, based on an independent survey (25 sintering furnaces, 1 pelletizing furnace. 26 facilities in total. Cover rate 100%) conducted by the Japan Iron and Steel Federation (FY2008 - FY2015), by the annual production.

※Atmospheric emission from by-product gas from blast furnaces and by-product gases from coke oven are estimated by multiplying emission factor obtained from「Mercury emission and behavior in primary ferrous metal production」(Fukuda et al : 2011) by the annual production volume of pig iron and coke.

Quoted from "Mercury Atmospheric Emission Inventory (2016)" Table 4.24

2) Mercury in raw materials

Table 1.3.23 shows the amount of coal put into coke ovens and the corresponding mercury content in FY2016. The amount of mercury in coal consumption is calculated by multiplying the amount of coal input (based on FY2018 interview with the Japan Iron and Steel Federation) by mercury concentration (0.0390 g/ton) obtained from the FY2018 interview with the Federation of Electric Power Companies of Japan. Regarding the amount of coal input at the primary iron production facilities and the corresponding mercury content, as the amount of coal input to sintering furnace is not available, the amount of coal input to the coke oven and the amount of mercury in the input to the coke oven are regarded as the minimum values.

Table 1.3.23 Primary iron production: Mercury in coal consumption in coke oven (FY2016)

Coal consumption (10^3 t)	Hg concentration in coal (g/t)	Hg content (t-Hg)
42,924	0.0390	1.7

[Source]
Coal input: Interview with the Japan Iron and Steel Federation in FY2018.
Mercury concentration in coal: Interview with the Federation of Electric Power Companies in FY2018.

Iron ore, limestone and other materials are put into the sintering furnace, but the concrete amount of input is unknown. The amount of mercury, as shown in Table 1.3.24, is estimated assuming that all of the imported iron ore would be put into the sintering furnace for primary iron production (steelmaking). Values for limestone are estimated by referring to the statistics of the Limestone Association of Japan. However, as no distinction is made between primary and secondary steelmaking in the statistical data, Table 1.3.24 is treated as a reference.

Table 1.3.24 (Reference) Primary iron production: Mercury content in raw materials input to sintering furnace (FY2016)

Input feed	Input amount (10^3 t)	Hg concentration (g/t)	Hg content (t-Hg)
Coal	Unknown	0.0390	-
Iron Ore	128,425	0.0329	4.2
Limestone	19,404 Note	0.022	0.43

Note: The "steel" category in Limestone Production and Shipment Trends (Limestone Association of Japan) has been referenced to where there are no separate categories for primary and secondary steel. In the material flow, the total amount is assumed to be the input to the primary, and the limestone input to the secondary is set as N/A to avoid duplication.

[Source]

Coal and iron ore input: interview with the Japan Iron and Steel Federation in FY2019 (Value for iron ore is the same as import amount)

Input of limestone: Limestone Association of Japan "Limestone Production and Shipment Trends" (May 27, 2019) http://www.limestone.gr.jp/doc/toukei/pdf/toukei2019.pdf

Mercury concentration in coal: 2018 Interview with the Federation of Electric Power Companies of Japan

Mercury concentration in iron ore: National Institute for Environmental Studies (2010), " FY2009 Ministry of Environment project : Investigation and research work on long-term transport characteristics of persistent substances such as mercury," page 70, Table 3.34

Mercury concentration in limestone: Implementation of measures to control the emission of mercury into the atmosphere based on the Minamata Convention on Mercury (First Report) Reference Material 2 "Results of Survey on Actual Status of Mercury Emissions", Page 92, http://www.env.go.jp/press/

3) Mercury in waste disposed of

The amount of final disposal of waste from primary iron production facilities obtained from the interview with the Japan Iron and Steel Federation in FY2018 is multiplied by the mercury concentration in waste obtained from the literature, and the amount of mercury in waste is estimated as shown in Table 1.3.25. It should be noted that the number of data samples in this study is limited (n=1 or 3).

Table 1.3.25 Primary iron production: Mercury in Final disposal of waste (FY2016)

Waste	Amount of final disposal Note (t)	Hg concentration in waste (g/t)	Hg content (t-Hg)
Desulfurization sludge	2,464	8.340	0.021
Wet dust	3,602	0.716	0.0026

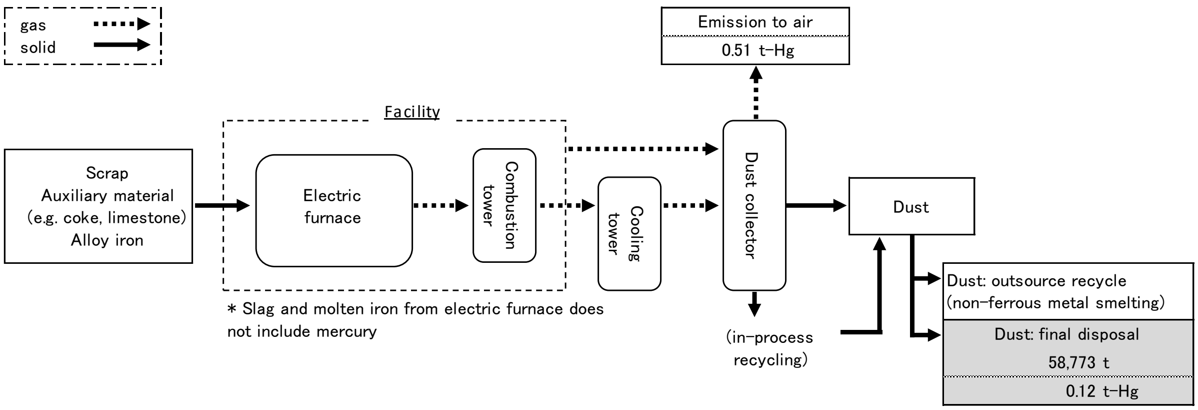
Note: Both types of waste are disposed of in leachate-control type landfills

Source of final disposal amount: FY2018 interview with the Japan Iron and Steel Federation

Mercury concentration in waste: "Mercury Emission Behavior in the Iron and Steel Industry" (Masaki Takaoka, Kazuyuki Oshita, 2007). It needs to be noted that only a limited number of data samples were available (n= 1 or 3).

(5) Secondary iron production facility

Mercury flow in secondary iron production facilities is shown in Figure 1.3.5.



Flow: Based on interview with the Japan Iron and Steel Federation.

Amount of final disposal: Interview with the Japan Iron and Steel Federation in FY2018.

Amount of mercury in the flow: Estimated by Ministry of the Environment, Japan based on the amount of final disposal above and the mercury concentration in waste (result of an independent survey conducted by the Japan Iron and Steel Federation obtained from Interview with the federation in FY2013). It needs to be noted that only a limited number of mercury concentration data samples (n=19) are used because the independent survey was conducted at limited number of manufacturers.

Figure 1.3.5 Mercury flow in secondary iron production facilities (FY2016)

1) Atmospheric Emission of Mercury

Table 1.3.26 shows mercury emission from secondary iron production facilities summarized in "Mercury Atmospheric Emission Inventory (FY2016)".

Table 1.3.26 Mercury emission from secondary iron production facilities (FY2016)

Target facility	Emission factor Note (mg-Hg/t-product)	Annual production of electric steel (10^3 t)	Emission (t-Hg)
Electric furnace for steel production (excluding waste treatment facility)	25.8	19,811	0.51

Note: Atmospheric emission factor is calculated using data obtained in 60 of the 64 steelmaking furnaces operating nationwide (94% of coverage).

*Emission from electric furnace for steel production (excluding waste treatment facility) is estimated by multiplying the emission factor, based on an independent survey conducted by the Japan Iron and Steel Federation (FY2008-FY2015), by the annual production. It needs to be noted that the emission from waste treatment facilities is estimated as a part of the emission from waste incineration facilities.

Quoted from "Mercury Atmospheric Emission Inventory (2016)" Table 4.28

2) Mercury in disposed waste

Table 1.3.27 shows the amount of final disposal of waste generated from secondary iron production facilities and the mercury content therein. The amount of mercury contained in precipitator dust that underwent final disposal is calculated by multiplying the total amount of disposal of precipitator dust obtained from the interview of Japan Iron and Steel Federation in FY2018 by mercury concentration obtained from literature. It needs to be noted that the data sample size in this literature is limited (n=19).

Table 1.3.27 Secondary iron production: Mercury in disposed waste (FY2016)

Waste	Final disposal Note (t)	Hg concentration of waste (g/t)	Hg content (t-Hg)
Precipitator dust	58,773	2.0	0.12

Note: The waste was disposed of in leachate-control type landfills.

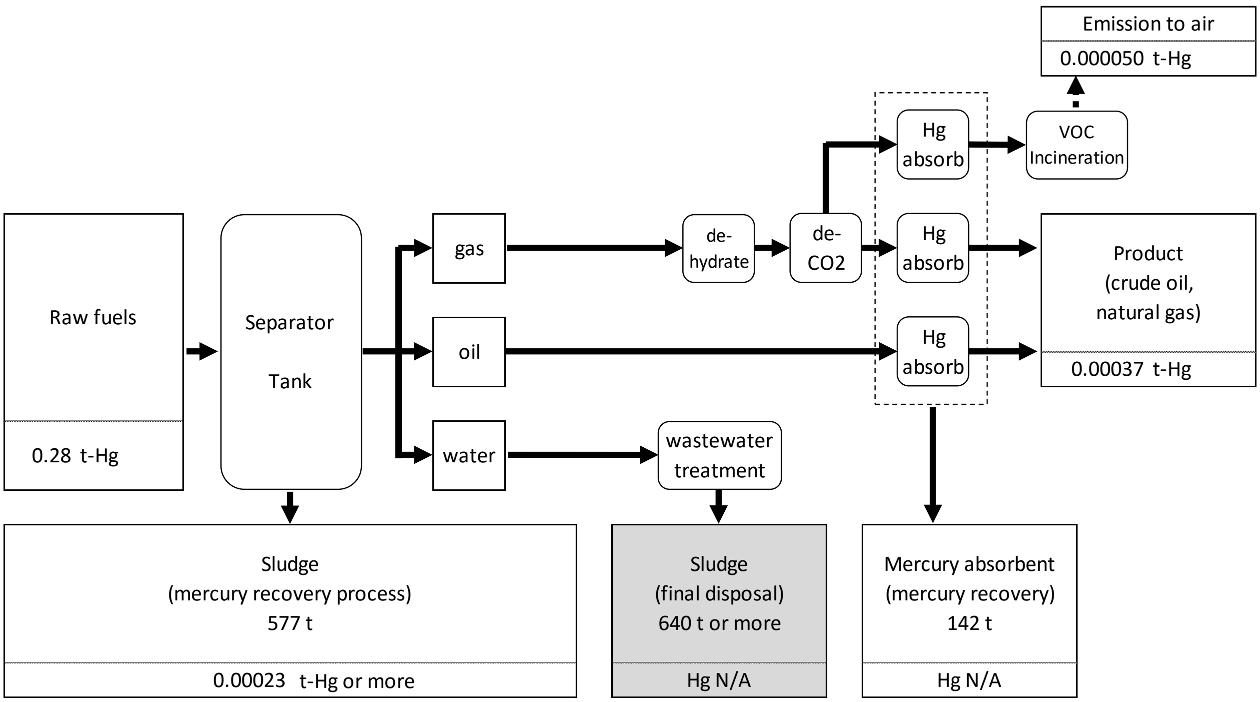
[Source]

Amount of final disposal: Interview with the Japan Iron and Steel Federation in FY2018

Concentration of mercury in waste: the result of the survey conducted by the Japan Iron and Steel Federation, which was obtained during the interview in FY 2013. It should be noted that the survey was conducted with some of the Federation members, thus the number of sample was limited (n=19).

(6) Oil and gas production facility

The mercury flow in oil and gas processing facilities is shown in Figure 1.3.6. It needs to be noted that this figure is only an example and not all facilities employ the same equipment.



Flow: Based on interview with Japan Petroleum Development Association.
Values in the flow: Interview with domestic companies in FY2018.

Figure 1.3.6 Mercury flow in oil and natural gas production facilities (FY2016)

1) Atmospheric emission of mercury

According to "Mercury Atmospheric Emission Inventory (FY2016)", mercury emission from oil and gas production facilities is 50 g-Hg (0.000050 t-Hg).

2) Mercury in raw fuels

According to the interviews with domestic companies in FY2018, the amount of mercury in crude oil and natural gas produced in FY2016 is 0.28 t-Hg.

3) Mercury in residue

Table 1.3.28 shows the amount of residue at oil and gas production facilities and mercury concentration therein obtained from interviews with domestic companies in FY2018.

Table 1.3.28 Oil and gas production: Residue generation amount and mercury content (FY2016)

Residue	Generation (t)	Hg concentration (g/t)	Hg content (t-Hg)	Treatment method
Separator tank sludge	577.1	N/A	0.00023 or more	Mercury recovery
Mercury adsorbent	142	N/A	N/A	Mercury recovery
Wastewater treatment sludge	640 or more	N/A	N/A	Final disposal

Source: Interview with domestic companies in FY2018

4) Mercury transferred to products

Table 1.3.29 shows the mercury transfer to products (crude oil and natural gas) obtained from interviews with domestic companies in FY2018.

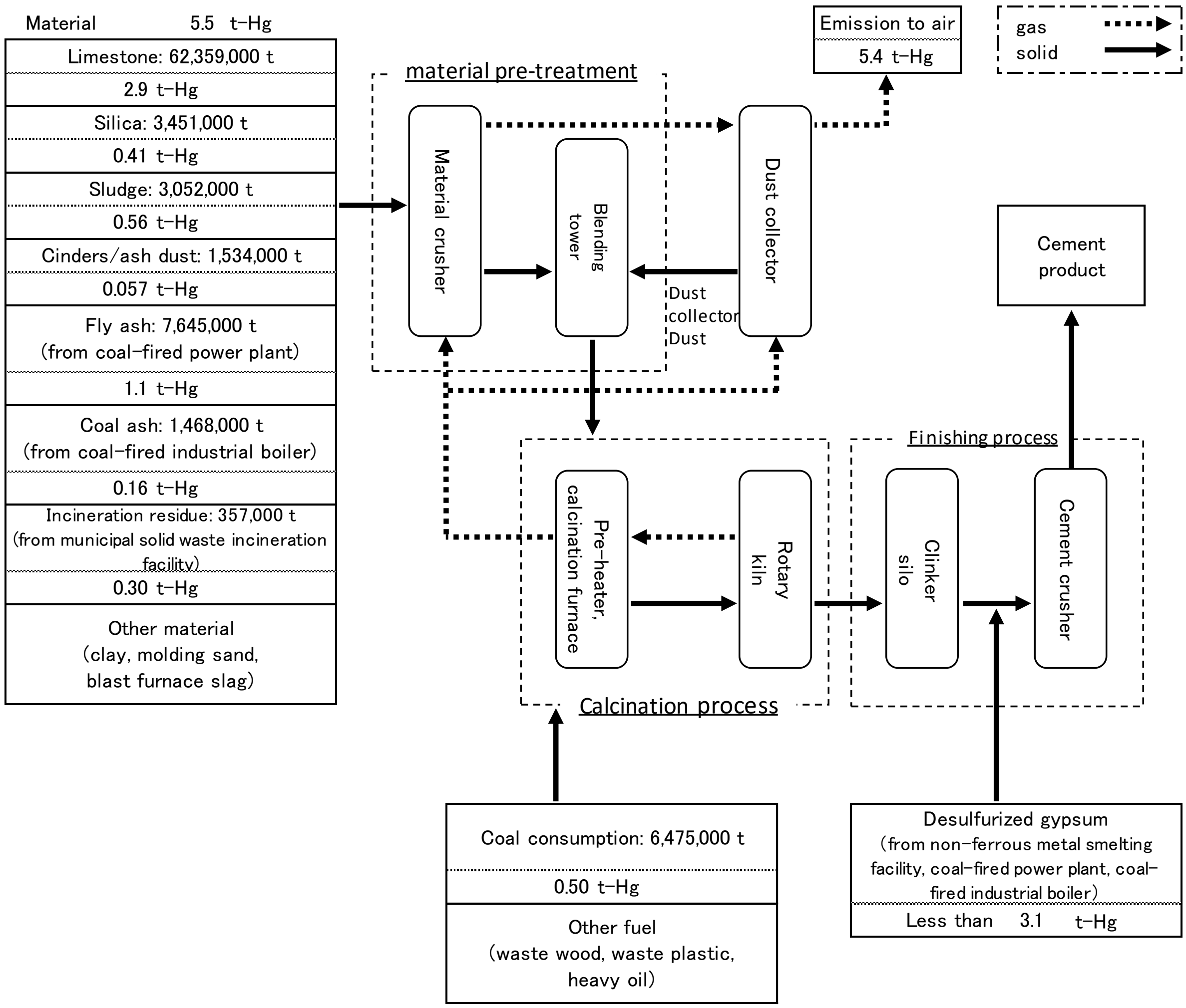
Table 1.3.29 Oil and natural gas production: Mercury transfer to products (FY2016)

Product	Mercury transfer to product (t-Hg)
Crude oil	0.00032
Natural gas	0.000054
Total	0.00037

Source: Interview with domestic companies in FY2018

(7) Cement production facility

The mercury flow in cement production facilities is shown in Figure 1.3.7.



Flow: Based on interview with Japan Cement Association.
Values in the flow: Interview with Japan Cement Association in FY2018, and estimated mercury flow of other industries.

Figure 1.3.7 Mercury flow in cement production facilities (FY2016)

1) Atmospheric emission of mercury

According to "Mercury Atmospheric Emission Inventory (FY2016)", mercury emission from cement production facilities is 5.4 t-Hg. Amount of atmospheric emission of mercury from cement manufacturing plants is estimated by multiplying the overall emission factor obtained from the FY2014 inventory by the amount of production of clinkers. The overall emission factor is calculated by multiplying the average mercury concentration and average volume of flue gas per unit (arithmetic mean of all data from the Mercury Atmospheric Emissions Survey in FY2015 and the voluntary measurements conducted by the Japan Cement

Association from CY2007 to CY2015) by the amount of atmospheric mercury emission of 5.5 t-Hg (calculated by multiplying the annual operating hours), and dividing it by the amount of clinker production (5.5×10^9 / 51,573).

2) Mercury in raw/recovered material

Table 1.3.30 shows the input of raw/recovered material in the process of cement production obtained from interview with Japan Cement Association in FY2018 and estimated mercury flow in other industries shown in section 1.3. Amount of mercury is estimated using the input and mercury concentration in the respective raw materials obtained from literature, interview with the association and interview with other industries as mentioned in section 1.3.

Table 1.3.30 Cement production: Mercury in raw/recovered material input (FY2016)

Input material	Source	Input (10^3 t)	Hg concentration (mg/kg)	Hg content (t-Hg)
Limestone	-	62,359	0.046	2.9
Silica	-	3,451	0.119	0.41
Sludge	-	3,052	0.183	0.56
Cinders/soot and dust	-	1,534	0.037	0.057
Fly ash	Coal-fired power plant	7,645	0.149	1.1
Coal ash	Coal-fired industrial boiler	1,468	-	0.16
Incineration residue	Municipal solid waste incineration facility	357	0.03/5.4	0.30
			Total	5.5

Note: Total amount of mercury and the individual numbers do not match due to rounding.

[Source]

Amount of input: Interview with Japan Cement Association in FY2018 and the mercury flow in other industries as estimated in section 1.3.

Mercury concentration in limestone, silica, sludge, cinders, soot and dust: Interview with Japan Cement Association of in FY2018

Mercury concentration in fly ash: Interview with the Federation of Electric Power Companies in FY2018

Mercury in coal ash: Estimated result from section 1.3 (3)

Mercury concentration in incineration residue: Bottom ash 0.03ppm, Fly ash 5.4ppm (2011 Mercury Emissions Investigation Report from Waste Disposal Facilities (March 2012, Towa Technology)). Breakdown of bottom ash and fly ash are unknown, but based on an existing report (Report on the Environmentally Sound Management of Mercury Waste, March 2014, Ministry of the Environment), estimation was carried out based on assumption that bottom ash accounts for 85% and fly ash for 15%

3) Mercury in coal consumed in the burning process

Table 1.3.31 shows the coal consumption and mercury content therein in the process of cement production obtained from interview with Japan Cement Association in FY2018. The amount of mercury contained in the coal consumed in the firing process is estimated as 0.50 t-Hg by multiplying the coal consumption by the mercury concentration.

Table 1.3.31 Cement production: Mercury in coal consumption (FY2016)

Coal consumption (10^3 t)	Hg concentration (mg/kg)	Hg content (t-Hg)
6,475	0.077	0.50

Source of coal consumption and mercury concentration in coal: Interview with Japan Cement Association in FY2018.

4) Mercury in flue gas desulfurized gypsum used in the finishing process

Table 1.3.32 shows the input of flue gas desulfurized gypsum in the finishing process of the cement production obtained from mercury flow in other industries estimated in section 1.3. Mercury content in desulfurized gypsum from non-ferrous metal smelting facilities and coal-fired power plants are unknown since their breakdown are not available. It is assumed that the maximum amount of mercury transferred to by-products (sulfuric acid and gypsum) in non-ferrous metal smelting process is 1.1t-Hg and the maximum amount of mercury in utilized desulfurized gypsum from coal-fired power plants is 1.1 ton. Hence the values for these two sources are set to be less than 1.9 ton-Hg and 1.1 ton-Hg respectively.

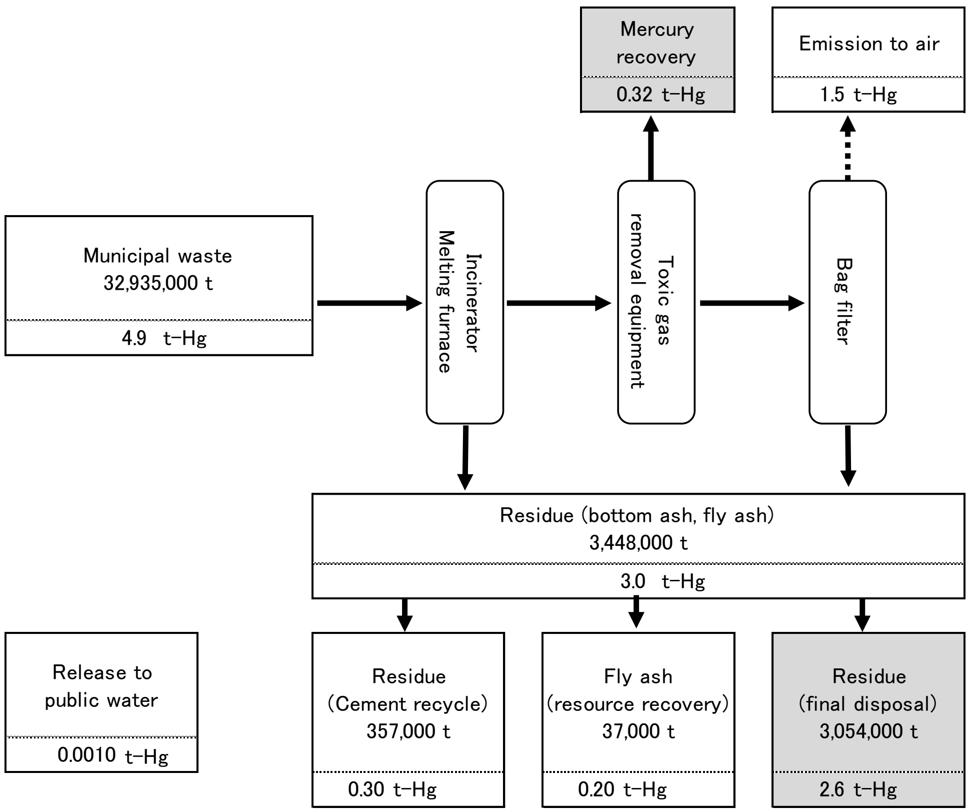
Table 1.3.32 Cement production: Mercury in flue gas desulfurized gypsum input (FY2016)

Input	Source	Input (10^3 t)	Hg concentration (mg/kg)	Hg content (t-Hg)
Flue gas desulfurized gypsum	Non-ferrous metal smelting	N/A	N/A	Less than 1.9
	Coal-fired power plant	Less than 2,540	0.428	Less than 1.1
	Coal-fired industrial boiler	91	-	0.10
			Total	Less than 3.1

Source: Mercury flow in other industries estimated in section 1.3

(8) Municipal solid waste incineration facility

The mercury flow in municipal solid waste incineration facilities is shown in Figure 1.3.8.



Flow: Based on the interview with municipal waste treatment companies.

Values in the flow: Estimated result based on on-site measurement of municipal waste treatment (FY2016), and interview with waste treatment companies in FY2018.

Figure 1.3.8 Mercury flow in municipal solid waste incineration facilities (FY2016)

1) Atmospheric emission of mercury

Table 1.3.33 shows the result of mercury emission from municipal solid waste incineration facilities as estimated in "Mercury Atmospheric Emission Inventory (FY2016)".

Table 1.3.33 Mercury emission from municipal solid waste incineration facilities (FY2016)

Type of municipal solid waste incineration facility	Municipal waste incineration (10^3 t)	Overall emission factor Note 1 (mg-Hg/t)	Mercury emission Note 2 (t-Hg)
Incineration facility (excluding facilities with ash melting furnace)	28,084	43	1.2
Facilities with ash melting furnace	5,824	43	0.25
Total	33,908		1.5

Note 1: The overall emission factor is the median of the data in 17 domestic furnaces (0.8% of coverage) obtained through the on-site measurement of mercury emission conducted in FY2015 (Since facilities with relatively high mercury concentration were focused on in the investigation, the median was applied).

Note 2: The total of mercury atmospheric emission does not match with the sum of components due to rounding

Source of amount of incineration: Ministry of Environment, “Results of Survey on Municipal Waste Treatment" (FY2016) (http://www.env.go.jp/recycle/waste_tech/ippan/)

Quoted from "Mercury Atmospheric Emission Inventory (2016)" Table 4.15

2) Mercury in utilized or disposed incineration residue

Table 1.3.34 shows the concentration of mercury in residue generated at municipal solid waste incineration facilities.

Table 1.3.34 Municipal solid waste incineration: Mercury concentration in incineration residue (bottom ash, fly ash)

Medium	Hg concentration (g/t)
Bottom ash	0.03
Fly ash	5.4
Residue (bottom ash 85%, fly ash 15%) Note	0.84

Note: Although the breakdown for bottom ash and fly ash are unclear, estimation was carried out under the assumption that the composition of 85% for bottom ash and 15% for fly ash, as obtained from the "Report on the environmentally sound management of mercury wastes" (Ministry of the Environment, Japan, March 2012).

Source of mercury concentration in fly ash and bottom ash: "Report on the investigation on mercury emissions from waste treatment facilities in FY2011" (Ministry of the Environment, Japan, March 2012)

Table 1.3.35 shows the amount of utilized and disposed incineration residue generated at municipal solid waste incineration facilities. The amount of mercury in incineration residue is calculated by using mercury concentration shown in Table 1.3.34.

Table 1.3.35 Municipal solid waste incineration: Mercury in utilized and disposed incineration residue (FY2016)

Medium	Destination	Amount of utilization/disposal (t)	Hg content (t-Hg)
Incineration residue	Conversion to cement material	356,881	0.30
	Final disposal	3,054,279	2.6
Fly ash	Resource recovery Note1	36,981	0.20
	Total	3,448,141	3.0

Note 1: Resource recovery refers to input to non-ferrous metal smelting for recovery.
Note 2: The total amount of mercury does not match with sum due to rounding
Source of amount of utilization and disposal: Ministry of the Environment "Results of Survey on Municipal Waste Treatment" (FY2016) http://www.env.go.jp/recycle/waste_tech/ippan/h28/index.html

Molten slag derived from municipal waste is not included in the material flow since the mercury content is very small.

[Reference] Mercury content in molten slag (FY2010 estimation)

National Federation of Industrial Waste Management[6] investigated the amount of molten slag generation from municipal waste in FY2006. About 90% has been utilized as alternate materials such as aggregate of concrete products or asphalt mixture[7]. The amount of utilization (recycling) in FY2010 is identified through the investigation on municipal waste treatment[8] conducted by Ministry of the Environment, Japan. The concentration of mercury in molten slag was measured by Ministry of the Environment, Japan[9] in FY2011[10]. According to the data above, the mercury content in utilized molten slag generated from municipal waste is shown below:

Table 1.3.36 (Reference) Mercury in utilized molten slag generated from municipal waste

Molten slag production (FY2006)	Amount of molten slag utilization (FY2010)	Hg concentration	Hg content in utilized slag
770,000 t	557,000 t	Less than 0.01 mg/kg-dry	Less than 5.6 kg-Hg

6 "Investigation Report on JIS Compliance of Molten Slag Derived from Industrial Waste (2008 FY)" (March, 2009)
7 In July 2006, JIS for molten slag as road building material and aggregate for the concrete was developed.
JIS A 5032: Molten slag for roads is made by melt-solidification of municipal waste, sewage sludge, or their bottom ash
JIS A 5031: Molten slag aggregate for concrete is made by melt-solidification of municipal waste, sewage sludge or their bottom ash
8 "Municipal waste treatment investigation in 2010 FY" http://www.env.go.jp/recycle/waste_tech/ippan/h22/index.html
9 "Report for investigation on emission status of mercury and others from waste treatment facilities and others in 2011 FY" (March in 2012)
10 Although JIS A 5032 and JIS A 5031 define the content standard for mercury related with molten slag as "total mercury 15mg/kg or less", mercury is scarcely detected because heating up to the temperature of 1200°C or higher is conducted in the process.

Note: The average concentration of mercury in soil sampled from 3,020 measuring points was 0.1 ppm according to data[11] published by National Institute of Advanced Industrial Science and Technology (in 2007 at 3,024 measurement points, (excluding 4 points whose mercury concentration is more than 10 ppm)). The concentration of mercury in molten slag is less than 0.01 ppm (mg/kg-dry), which is less than the concentration in soil.

Source: Ministry of the Environment, Japan, "FY2013 Mercury Waste Treatment Survey Report" (March 2014)

3) Mercury recovery

According to the interviews with waste treatment companies in FY2018, the amount of mercury recovered from municipal solid waste incineration facilities in FY2016 is 0.32 t-Hg. However, the breakdown of municipal and industrial waste is unknown. In order to avoid duplication in the material flow, the entire amount is attributed to municipal solid waste incineration facilities.

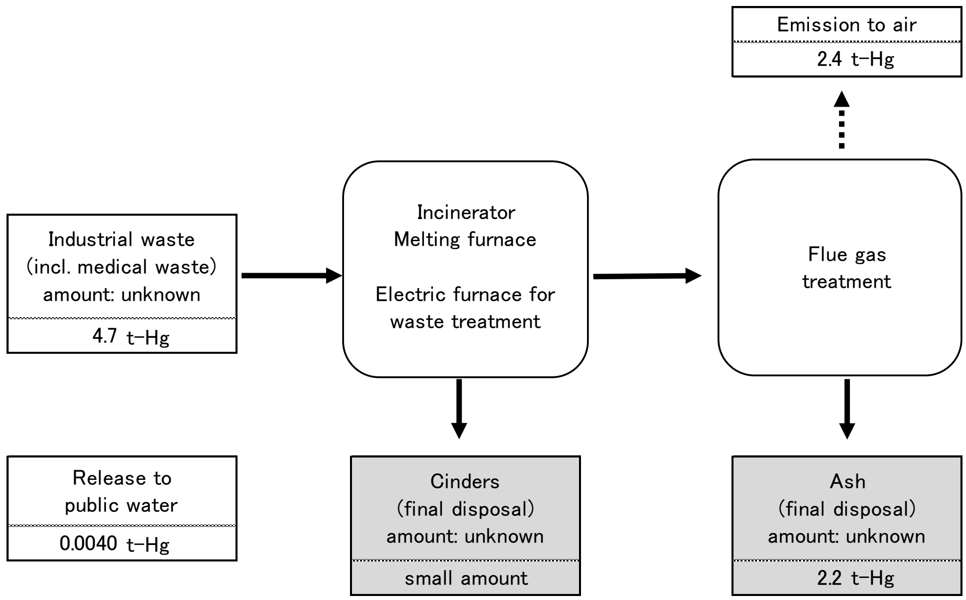
4) Mercury release to public waters

According to the PRTR data of FY2016, the amount of mercury and its compounds reported to be released to public water from municipal solid waste incineration business is 1 kg-Hg (= 0.0010 t-Hg).

[11] http://riodb02.ibase.aist.go.jp/geochemmap/data/download.htm

(9) Industrial waste incineration facility

The mercury flow in industrial waste incineration facilities is shown in Figure 1.3.9.



Values in the flow: Estimated by Ministry of the Environment, Japan based on "Mercury Atmospheric Emission Inventory (FY2016)"

Figure 1.3.9 Mercury flow in industrial waste incineration facilities (FY2016)

1) Atmospheric emission of mercury

Table 1.3.37 shows mercury emission from industrial waste incineration facilities in "Mercury Atmospheric Emission Inventory (FY2016)". Table 1.3.38 shows mercury emission from electric furnaces for steel production that treat waste. The sum of these values, 2.4 t-Hg, is considered as emission from industrial waste incineration facilities in the inventory.

Table 1.3.37 Mercury emission from industrial waste incineration facilities (FY2016)

Mercury concentration in flue gas Note1 (μg-Hg/Nm^3)	Nationwide flue gas emission Note2 (Nm^3)	Mercury emission (t-Hg)
15	1.5 x 10^{11}	2.3

Note 1: Based on the on-site measurement data (2013 to 2015, 177 facilities, coverage rates 14%) obtained through the on-site measurement of mercury emission in FY2015, the weighted average efficiency (Σ (Mercury concentration in flue gas x flue gas flow) / Σ (Flue gas flow)) is calculated.

Note 2: The estimated value of nationwide flue gas emission from industrial waste incineration facilities by Ministry of the Environment, Japan, "Investigation on the emission status of dioxin and the like from industrial waste incineration facilities " is used.

Quoted from "Mercury Atmospheric Emission Inventory (2016)" Table 4.16

Table 1.3.38 Mercury emission from electric furnaces for steel production (waste treatment process) (FY2016)

Electric furnace for steel production (treated waste)	Emission factor Note 1 (mg-Hg/product t)	Electric steel annual production (10^3 t)	Mercury emission Note 2 (t-Hg)
Waste other than dry-cell batteries	33.4	1,264	0.042
Dry-cell battery	41.8	2,402	0.10
		Total	0.14

Note 1: Measurement target facilities: Among electric furnaces for steel making in Japan, facilities treating waste other than discarded dry-cell batteries (four facilities out of seven (coverage rates 57.1%)) and facilities treating discarded dry-cell batteries (seven facilities out of seven (coverage rates 100%)).

Note 2: Mercury atmospheric emissions are calculated by multiplying emission factor based on voluntary measurements made by the Japan Iron and Steel Federation from 2008 to 2015 by the annual production.

Quoted from "Mercury Atmospheric Emission Inventory (2016)" Table 4.17

2) Mercury in dust

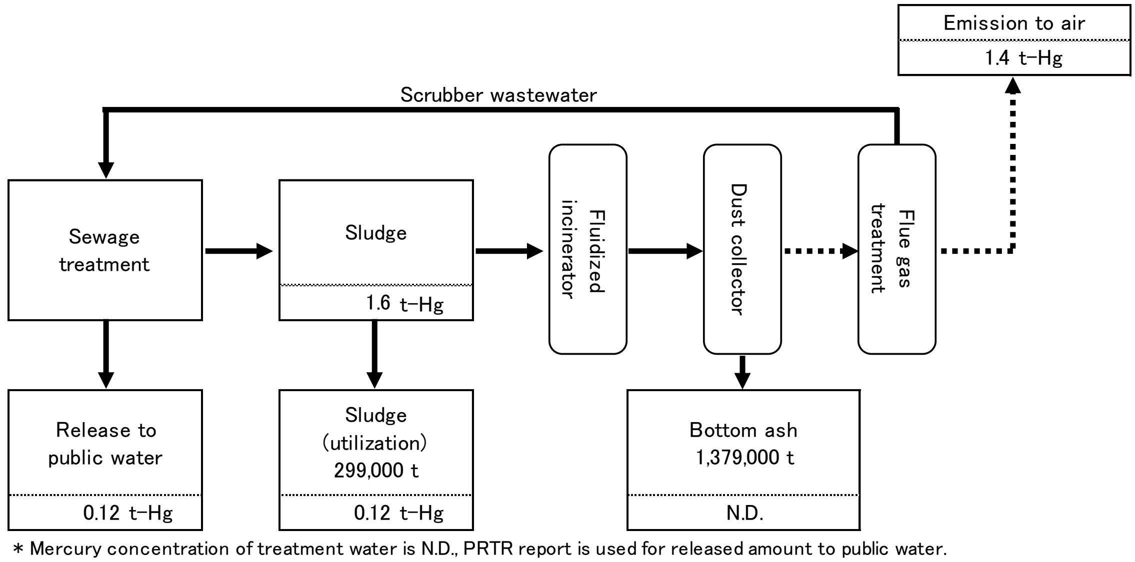
Emission reduction efficiency in industrial waste incineration facilities is 47.9% according to Kida (2007). Assuming that mercury not emitted to the atmosphere is transferred to water or dust, the amount of mercury in dust is estimated as shown in Table 1.3.39. Since the amount of mercury release to water, based on PRTR notification, is 0.0040 t-Hg, the amount of mercury in dust is estimated to be 2.2 t-Hg.

Table 1.3.39 Industrial waste incineration: Mercury in residue (FY 2016)

Mercury emission (t-Hg)	Emission Reduction Efficiency*	Mercury emission to public water bodies (t-Hg)	Mercury transfer to incinerator ash (t-Hg)
2.4	0.479	0.0040	2.2

*Source of emission reduction efficiency: Akiko Kida, Shinichi Sakai, Yasuhiro Hirai, Hiroshi Moritomi, Masaki Takaoka, Kenji Yasuda (2007), "Study on the emission inventory of mercury including waste management processes and emission reduction measures". Chapter 2 Study on mercury emission sources, emission factors and emission inventory. 47.9% of the amount of mercury is transferred to dust.

(10) Sewage sludge incineration facilities



Mercury flow in sewage sludge incineration facilities is shown in Figure 1.3.10.

Flow: Data provided by Ministry of Land, Infrastructure and Transport, Japan
Values in the flow: Data provided by Ministry of Land, Infrastructure and Transport, Japan (actual amount in FY2018)

Figure 1.3.10 Mercury flow in sewage sludge incineration facilities (FY2016)

1) Atmospheric emission of mercury

Table 1.3.40 shows the estimated result of mercury emission from sewage sludge incineration facilities in "Mercury Atmospheric Emission Inventory (FY2016)".

Table 1.3.40 Atmospheric Mercury emission from sewage sludge incineration facilities (FY2016)

Sewage sludge incineration Note1		Overall emission factor Note2 (mg-Hg/t-dry)	Mercury emission Note3 (t-Hg)
Wet weight (10^3 t-wet)	Dry weight (10^3 t-dry)		
4,598	1,012	1.36	1.4

Note 1: The amount of sewage sludge incineration (dry-weight base) is calculated by the "amount of incineration (weight-base (wet)) x (1 - 0.78)". 0.78 is retrieved from the arithmetic mean (78%) of "average water content (%) in dewatered sludge being brought into sludge incineration facilities" (Source: Sewage statistics).
Note 2: The overall emission factor is calculated based on 30 samples (six domestic facilities x five times for each) obtained through the investigation of the actual situation on mercury emission conducted in FY2015.
Note 3: Mercury emission = Sewage sludge incineration (dry) x Overall emission factor

Quoted from "Mercury Atmospheric Emission Inventory (2016)" Table 4.20

2) Mercury in residue

If the emission reduction efficiency of 47.9% at industrial waste incineration facilities estimated by Kida

(2007) could also be applied to emission reduction efficiency at sewage sludge incineration facilities, mercury not being emitted to the atmosphere and transferred to residue is estimated to be 1.3 t-Hg. However, since the concentrations of mercury in both treated sewage water and bottom ash are N.D.[12] and since there is no data on the amount of mercury transfer, this estimated value is treated as a reference value in the material flow.
The amount of mercury in effluent to public water is obtained from PRTR data (0.12 t-Hg).

Table 1.3.41 (Reference) Sewage sludge incineration: Mercury flow to residue

Mercury emission (t-Hg)	Emission Reduction Efficiency	Mercury transfer to residue (t-Hg)
1.4	0.479	1.3

Source of emission reduction efficiency: Akiko Kida, Shinichi Sakai, Yasuhiro Hirai, Hiroshi Moritomi, Masaki Takaoka, Kenji Yasuda (2007), 2006 Research Report on Scientific Research Grants for Waste Management: "Study on the emission inventory of mercury including waste management processes and emission reduction measures" Chapter 2 Study on mercury emission sources, emission factors and emission inventory. The emission reduction efficiency at industrial waste incineration facilities in this study is alternatively applied.

3) Mercury in utilized of sewage sludge (green farmland)

The amount of mercury in sewage sludge is estimated as shown in Table 1.3.42 by multiplying the amount of sewage sludge used at green farmlands (Data from Ministry of Land, Infrastructure, Transport and Tourism) by mercury concentration of sludge fertilizer obtained from existing literatures. It needs to be noted that mercury transfer associated with the utilization of sewage sludge for green farmlands is considered as a release to soil in the material flow.

Table 1.3.42 Mercury flow associated with the utilization of sewage sludge (FY2016)

Item	Utilization for green farm (t-dry)	Mercury concentration (ppm-dry)	Mercury transfer (t-Hg)
Compost	250,478	0.4	0.10
Mechanically dried sludge	24,122	0.3	0.0072
Carbonized sludge	3,719		0.0011
Dewatered sludge	19,445	0.4	0.0078
Others	1,031		0.00041
Total	298,795		0.12

Source of amount of utilization for green farmland: Data provided by Ministry of Land, Infrastructure and Transport, Japan, "National disposal and utilization" (Amount of generated solid-base, the actual amount in FY2016)

Source of mercury concentration in each item: Ministry of Agriculture, Forestry and Fisheries, Japan, Manual on Heavy Metal Management in Sludge Fertilizer (August, 2010), Weighted average of mercury concentration based on on-site inspection conducted from FY2003 to FY2009 (Compost: Concentration in fermented sludge fertilizer is used, Mechanically dried sludge/carbonized sludge: Concentration in burned sludge fertilizer is used, Dewatered sludge and others: Concentration in sewage sludge fertilizer is used)

[12] Data provided by the Ministry of Land, Infrastructure, Transport and Tourism

2. FLOW OF MERCURY AND MERCURY ALLOY

2.1 Import of Mercury and Mercury Alloy

Mercury import in FY2016 is 0.0050 t-Hg according to the supply and demand dynamics statistics for non-ferrous metals. The same data does not show the breakdown of mercury compounds and hence the compounds are not included in the material flow. According to the interview conducted with the Japan Lighting Manufacturers Association in FY2018, the amount of mercury contained in imported mercury alloys is 0.41 t-Hg.

Table 2.1.1 Import of mercury and mercury alloy (FY2016)

Item	Data used (t-Hg)	Miscellaneous
Mercury import	0.0050	FY 2016 figures
Import of mercury alloy (mercury equivalent)	0.41	FY 2016 figures
Total	0.42	

Source of mercury import: Ministry of Economy, Trade and Industry, Agency for Natural Resources and Energy, Statistics on supply and demand of non-ferrous metals CY2018 edition (annual report)
Source of mercury alloy import: Interview with Japan Lighting Manufacturers Association in FY2018

(1) Import of mercury

According to the statistics on supply and demand of non-ferrous metals, mercury import in FY2015-2017 is shown in Table 2.1.2. In the material flow, 5 kg-Hg (= 0.0050 t-Hg), which is the actual value for FY2016, is adopted.

Table 2.1.2 Mercury import (FY2015 to FY2017)

Item	FY 2015	FY 2016	FY 2017	Three-year average
Mercury import amount (kg-Hg)	5	5	4	5

Source: Ministry of Economy, Trade and Industry, Agency for Natural Resources and Energy, Statistics on supply and demand of non-ferrous metals CY2018 edition (annual report)

(2) Import of mercury alloys

According to the interview conducted with the Japan Lighting Manufacturers Association in FY2018, the import of mercury alloys used for manufacturing lamps (FY2015-FY2017, mercury equivalent) is shown in Table 2.1.3. For material flow, 405 kg-Hg (≒ 0.41 t-Hg), which is the actual value for FY2016, is adopted.

Table 2.1.3 Import of mercury alloys (Mercury equivalent) (FY2015 to FY2017）

Item	FY2015	FY2016	FY2017	Three-year average
Mercury alloys import (kg-Hg) (mercury equivalent)	402	405	282	363

Source: Interview with Japan Lighting Manufacturers Association in FY2018

2.2 Export of Mercury

According to the supply and demand statistics of non-ferrous metals, etc., the export amount of mercury from Japan (FY2015-FY2017) is as shown in Table 2.2.1. Considering that the export volume varies widely between years, a three-year average of 101,229 kg-Hg (≒ 101 t-Hg) is adopted in the material flow.

Table 2.2.1 Export of mercury (FY2015 - FY2017)

Item	FY2015	FY2016	FY2017	Three year average
Mercury export amount (kg-Hg)	115,015	145,074	43,597	101,229

Source: Ministry of Economy, Trade and Industry, Agency for Natural Resources and Energy, Statistics on supply and demand of non-ferrous metals, etc. 2018 edition (annual report)

2.3 Year-End Stock of Mercury (reference)

According to statistics on supply and demand of non-ferrous metals, the year-end stock of mercury in the consumer sector at the end of FY2015-2017 is shown in Table 2.3.1. In addition, as the "Report on the Storage of Mercury or Mercury Compounds According to the Mercury Pollution Prevention Act" has commenced since FY2018, it has become possible to consider using this data in the future.

Table 2.3.1 Year-end stock of mercury in the consumer sector (FY2015-FY2017)

Year	End of FY2015 (March 2016)	End of FY2016 (March 2017)	End of FY2017 (March 2018)
Year-end stock of mercury in the consumer sector (kg-Hg)	10,130	2,993	1,276

Source: Ministry of Economy, Trade and Industry, Agency for Natural Resources and Energy, Statistics on supply and demand of non-ferrous metals, etc. 2018 edition (annual report)

2.4 Domestic Shipment of Mercury (reference)

According to statistics on supply and demand for non-ferrous metals, the amount of metal mercury shipped (domestic sales) in FY2016 was 21,450 kg-Hg (≒ 22 t-Hg). However, this value is treated as a reference value in the material flow since the amount passing through the intermediary business may be double counted.

2.5 Mercury Storage and Carryover of Stock (mercury recovery company)

According to the interviews with mercury recovery companies in FY2019, the amount of mercury stock carried over between FY2015 and FY2016 (the amount of mercury stock at the end of FY2015) is approximately 80 t-Hg. Since these companies had 4 t-Hg of stock at the end of FY2016, about 76 t-Hg seems supplied from stock during FY2016.

3. MERCURY-ADDED PRODUCTS

3.1 Production, Import and Export of Mercury-Added Products

Table 3.1.1 shows the amount of mercury used for the domestic production of mercury-added products, and mercury content in imported/exported products, obtained through interviews with industry organizations and business entities in FY2018. Total amount of mercury used in domestically manufactured products is estimated as 3.5 t-Hg, mercury content in imported products is estimated as 0.88 t-Hg and mercury content in exported products is estimated as 1.1 t-Hg. The data in the table below is obtained through interviews with the business entities and does not cover the entire domestic market.

Table 3.1.1 Mercury in domestically produced, imported and exported products (FY2016)

Product		Hg used for domestic production (t-Hg)	Year Note1	Hg in imported products (t-Hg)	Hg in exported products (t-Hg)	Year Note1
Button batteries	Alkaline button batteries	0	2016CY	N/A	0	2016FY
	silver-oxide batteries	0.12	2016CY	0	0.11	2016FY
	Zinc-air batteries	0.010	2016CY	0.61	0.025	2016FY
Mercury-added dry-cell batteries		0	201CFY	N/A	0	2016FY
Switches and relays		0.44	2016FY	N/A	0.33	2016FY
Lamps	Fluorescent lamps Note2	0.81	2016FY	0.13	0.017	2016FY
	HID lamps	0.31	2016FY	0.074	0.15	2016FY
	Neon lamps	0.017	2016FY	N/A	N/A	2016FY
Measuring devices	Glass Hg thermometers	0.21	2016FY	0.0050	0.019	2016FY
	Hg-filled thermometers	0.011	2016FY	N/A	N/A	
	Diaphragm manometers for high temperature	0.021	2016FY	N/A	N/A	
	Liquid manometers	0.0030	2016FY	0	0	2016FY
	Liquid column barometers	0	2016FY	N/A	0	2016FY
	Vacuum gauges	0.049	2016FY	N/A	N/A	
Medical measuring devices	Mercury thermometers	0	2016FY	0.062	0	2016FY
	Sphygmomanometers	0.56	2016CY	0	0.48	2016CY
Mercury for dental use		0	2016FY	0	0	2016FY
Pharmaceuticals	Vaccine preservative	0.00016	2016FY	0.00013	0	2016FY
	Merbromin solution	0.010	2016FY	0	0	2016FY
	Merbromin products	0.00077	2016FY	0	0	2016FY
Inorganic chemicals	Mercuric sulphide	0.91	2016FY	N/A	N/A	
	Mercury compounds	0.044	2016FY	N/A	N/A	
Total		3.5		0.88	1.1	

Note 1: 2016FY denotes Fiscal year 2016 and 2016CY denotes Calendar year 2016
Note 2: Fluorescent lamps include cold cathode fluorescent lamps (CCFL)

Note 3: The figures in the table show the amount obtained from interviews conducted with manufacturers and importers/exporters of mercury-added products and business associations in FY2018, and do not necessarily reflect the amount in the entire market.

Source: Information obtained through interview with manufacturers/importers and other business entities, 2018.

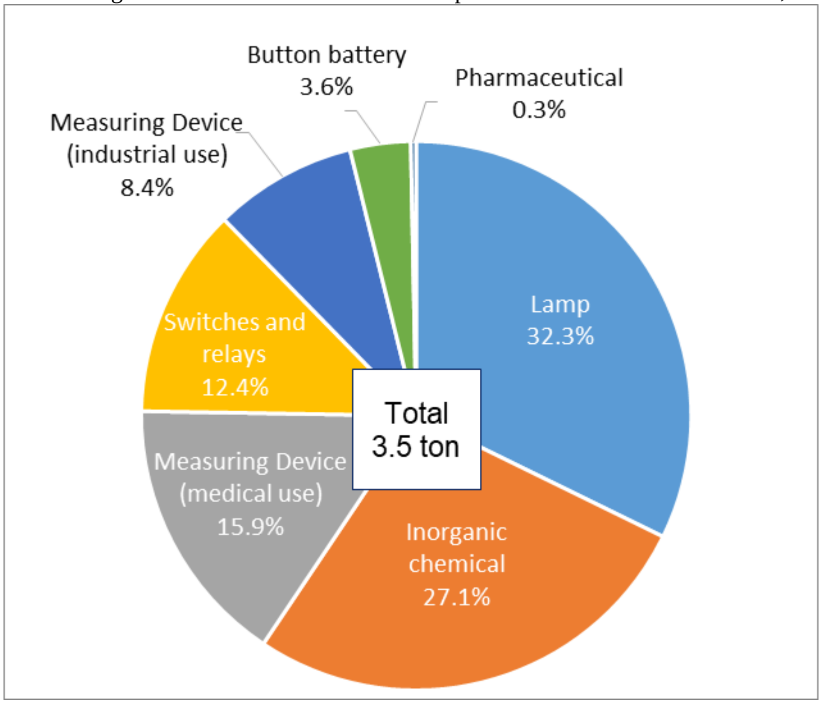


Figure 3.1.1 Mercury used for the domestic production of mercury-added products (FY2016)

(1) Button batteries

Table 3.1.2 shows the amount of mercury used for the domestic production of button batteries by Battery Association of Japan (BAJ) member companies and mercury contained in import/export of button batteries obtained through interview with BAJ in FY2018.

It is estimated that 0.0060 tons of mercury was contained in alkaline manganese batteries imported by BAJ member companies. Besides this amount, it is assumed that there are certain amounts of mercury-added batteries imported by non-BAJ member companies and some mercury-added batteries are incorporated in and imported with assembled products. Hence, the total picture is unknown. Therefore, the amount of mercury in the imported alkaline button batteries is determined to be "unknown" in Table 3.1.1.

Table 3.1.2 Mercury in domestically manufactured and imported/exported button batteries (CY2016, BAJ member companies)

Product	Hg in manufactured amount (t-Hg)	Hg in import (t-Hg)	Hg in export (t-Hg)
Alkaline manganese	0	0.0060	0
Silver oxide	0.12	0	0.11
Air zinc	0.010	0.61	0.025

Product	Hg in manufactured amount (t-Hg)	Hg in import (t-Hg)	Hg in export (t-Hg)
Total	0.13	0.62	0.14

Source: Interview with Battery Association of Japan (BAJ) in FY2018

(2) Dry-cell batteries

Domestically manufactured dry-cell batteries are all mercury free. Hence, amount of mercury in dry-cell batteries that are domestically manufactured and exported is 0. The amount of mercury-added dry-cell batteries import remains unknown. Further, it has been known, through “FY2018 Survey of merchandise using mercury (Ministry of the Environment)”, that some mercury-added dry-cell batteries are incorporated in and imported with assembled products, but this amount remains unknown. Hence it has been indicated as N/A in Table 3.1.1.

(3) Switches and relays

Table 3.1.3 shows mercury used for the production (contained within the products) and contained in exports of switches and relays, as obtained through interview with domestic manufacturer of switches and relays in FY2018. There are some possibilities that switches and relays are incorporated in and imported with large assembled products, but as the volume of distribution in unknown, it has been deemed to be N/A in Table 3.1.1.

Table 3.1.3 Mercury in domestically manufactured and exported switches and relays (FY2016)

Product	Manufacture amount (units)	Hg in manufactured amount (t-Hg)	Export (units)	Hg in exported product (t-Hg)
Over current relays [Note1]	9,002	0.14	3,910	0.059
Seismoscopes [Note2]	1,008,893	0.30	888,605	0.27
Total		0.44		0.33

Note 1: 15g of mercury is used in one “over current relay”

Note 2: 0.3g of mercury is used in one seismoscope

Source: Interview with manufacturers of switches and relays in FY2018

(4) Lamps

Table 3.1.4 shows mercury content in domestically manufactured lamps and Table 3.1.5 shows mercury content in imported and exported mercury-added lamps, according to the interview with Japan Lighting Manufacturer’s association and Japan Sign Association in FY2018.

Table 3.1.4 Mercury content in domestically manufactured lamps (FY2016)

Product	Average Hg concentration (mg-Hg/unit)	Lamp manufacture (1,000 units)	Hg in manufactured lamps (t-Hg)
Fluorescent lamps*	5.9	137,507	0.81
HID lamps	57.2	5,426	0.31
Neon lamps	227	73	0.017
Total			1.1

*Category "Fluorescent lamps" includes cold cathode fluorescent lamps (back light)
Source of fluorescent lamps, HID lamps: Interview with JLMA in FY2018
Source of neon lamps: Interview with Japan Sign Association in FY2018

Table 3.1.5 Mercury in imported and exported lamps (FY2016)

Product	Imported lamp (1,000 units)	Hg in imported lamp (t-Hg)	Exported lamp (1,000 units)	Hg in exported lamp (t-Hg)
Fluorescent lamps*	21,859	0.13	2,827	0.017
HID lamps	1,293	0.07	2,620	0.15
Neon lamps	N/A	N/A	N/A	N/A
Total		0.20		0.17

*Category "Fluorescent lamps" includes cold cathode fluorescent lamps (back light)
Source of fluorescent lamps, HID lamps: Interview with JLMA in FY2018
Source of neon lamps: Interview with Japan Sign Association in FY2018

(5) Industrial measuring devices

Table 3.1.6 shows the amount of mercury used for the manufacture of industrial measuring devices (mercury contained in devices) obtained through interviews with manufacturers thereof conducted in FY2018. Table 3.1.7 shows the amount of mercury contained in import and export of these measuring devices.

Table 3.1.6 Mercury in domestically manufactured industrial measuring devices (FY2016)

Product	Mercury content (g-Hg/unit)	Number of manufactured device (units)	Hg in manufactured device (t-Hg)
Glass mercury thermometers Note1	3.7	57,887	0.21
Mercury filled thermometers	100	110	0.011
Diaphragm manometers for high temperature Note2	40	516	0.021
Liquid manometers	1,500	2	0.0030
Liquid column barometers	N/A	0	0
Macleod vacuum gauges	135	36	0.0049

Product	Mercury content (g-Hg/unit)	Number of manufactured device (units)	Hg in manufactured device (t-Hg)
U-shape vacuum gauge	125	356	0.045
Total			0.30

Note 1: "Glass mercury thermometers" includes devices assembled in float-type hydrometers
Note 2: "Diaphragm-seal manometer for high temperature" includes high pressure diaphragm-seal pressure transmitter
Note 3: The sum of numbers does not exactly match the total due to rounding
Sources: Interviews with entities shown below conducted in FY2018

Glass mercury thermometers: Japanese Cooperative Kumiai for Glass Measuring Instruments Industry

Mercury filled thermometers, diaphragm manometers for high-temperature, liquid manometers: Japan Pressure Gauges and Thermometers Manufacturers' Association

Liquid column barometers: Japan Association of Meteorological Instrument Engineering

Vacuum gauges: Japan Scientific Instruments Association

Table 3.1.7 Mercury in imported and exported industrial measuring device (FY2016)

Product	Number of imported device (units)	Hg in imported device (t-Hg)	Number of exported device (units)	Hg in exported device (t-Hg)
Glass mercury thermometers [Note]	1,268	0.005	5,026	0.019
Mercury filled thermometers	N/A	N/A	N/A	N/A
Diaphragm manometers for high temperature	N/A	N/A	N/A	N/A
Liquid manometers	0	0	0	0
Fortin barometers	N/A	N/A	0	0
Vacuum gauges	N/A	N/A	N/A	N/A
Total		0.005		0.019

Note: As float-type is not imported/exported, the values only include glass mercury thermometers
Sources: Interviews with entities shown below conducted in FY2018

Glass mercury thermometers: Japanese Cooperative Kumiai for Glass Measuring Instruments Industry

Mercury filled thermometer, diaphragm manometers for high temperature, liquid column manometers: Japan Pressure Gauges and Thermometers Manufacturers' Association

Fortin barometers: Japan Association of Meteorological Instrument Engineering

Vacuum gauges: Japan Scientific Instruments Association

(6) Medical measuring devices

The amount of mercury in medical measuring instruments is estimated using mercury concentration in devices (obtained from interviews with domestic manufacturers and importers and the Japan Federation of Medical Devices Associations in FY2016) with the manufacture amount (shown in the Pharmaceutical industry production dynamic statistics) (see Table 3.1.8). The amount of mercury in imported and exported products (see Table 3.1.9) are estimated similarly.

Table 3.1.8 Mercury in domestically manufactured medical measuring devices (FY2016)

Product	Mercury concentration (g-Hg/unit)	Number of devices manufactured (unit)	Mercury in manufactured device (t-Hg)
Sphygmomanometers	47.6	11,770	0.56
Mercury thermometers	1.2	0	0
		Total	0.56

[Source]
Mercury content in sphygmomanometers: Interview with Japan Federation of Medical Devices Associations in FY2016.
Mercury content in mercury thermometers: Interview with importers in FY2016
Number of manufacture of mercury sphygmomanometers devices: Statistical Survey on Trends in Pharmaceutical Production
Number of manufacture of mercury thermometers: Statistical Survey on Trends in Pharmaceutical Production

Table 3.1.9 Mercury in imported and exported medical measuring devices (FY2016)

Product	Number of imported devices (units)	Hg in imported devices (t-Hg)	Number of exported devices (units)	Hg in exported devices (t-Hg)
Sphygmomanometers	0	0	9,982	0.48
Mercury thermometers	51,254	0.062	0	0
Total		0.062		0.48

[Source]
Import/export amount of mercury sphygmomanometers: Statistical Survey on Trends in Pharmaceutical Production
Export of amount of mercury thermometers: Statistical Survey on Trends in Pharmaceutical Production
Import of mercury thermometers: Interview with Japanese Cooperative Kumiai for Glass Measuring Instruments Industry in FY2018

(7) Dental mercury

According to the interview with Japan Dental Materials Manufacturers Association in FY2013, the manufacture and import of dental mercury in Japan have ceased since February 2014. Hence, the manufacture/import amount of dental mercury in FY2016 is set to be 0.

(8) Pharmaceuticals

1) Vaccine containing thimerosal

Table 3.1.10 shows the amount of mercury used for the domestic production of vaccine containing thimerosal and import/export amount of vaccine, obtained through an interview with Japan Vaccine Industry Association in 2018.

Table 3.1.10 Mercury in vaccine containing thimerosal (FY2016)

Product	Mercury in domestically produced vaccine (g-Hg)	Mercury in imported vaccine Note (g-Hg)	Mercury in exported vaccine (g-Hg)
Vaccine containing thimerosal	161.261	125.503	0

Note: Imported vaccine is used only for animals.
Source: Interview with Japan Vaccine Industry Association, 2018

2) Merbromin solution

Table 3.1.11 shows the amount of mercury used for the production of merbromin solution obtained through interviews with the manufacturers in 2018. Merbromin solution itself is no longer being imported or exported and manufacturers use stocks of merbromin concentrate (raw material for merbromin) that was previously imported.

Table 3.1.11 Mercury used in the production of merbromin solution (FY2016)

Product	Merbromin concentrate use (t)	Hg in merbromin concentrate Note	Hg in produced solution (t-Hg)
Merbromin solution	0.040	25%	0.010

Note: Mercury concentration in merbromin concentrate is to be22.4~26.7% in the Japanese Pharmacopoeia. Taking into account the information obtained through interviews with manufacturers, 25% is applied in this estimation.
Source: Interview with manufacturers of merbromin solution, 2018

3) Merbromin products (adhesive plaster containing merbromin)

Table 3.1.12 shows the estimation of mercury use for domestically manufactured products containing merbromin (adhesive plaster) in reference to interviews with manufacturer in 2018. These products are not currently imported or exported.

Table 3.1.12 Mercury in domestically manufactured adhesive plaster containing merbromin (FY2016)

Product	Amount produced (1,000 units)	Average mercury concentration Note (mg-Hg/unit)	Total Hg (t-Hg)
Adhesive plaster containing merbromin	3,312,507	0.231	0.00077

Note: There are several types of adhesive plasters with different sizes. Average mercury concentration in different types of plaster is applied in this estimation.
Source: Interview with manufacturers of adhesive plaster containing merbromin, 2018

(9) Inorganic chemicals

1) Mercuric sulfide

Table 3.1.13 shows the amount of mercury used for domestic production of mercuric sulfide for pigment use obtained from interviews with manufacturers in FY2018. Imported/exported amount of mercuric sulfide remains unknown and is excluded from the material flow.

Table 3.1.13 Mercury used for the manufacture of mercuric sulfide (FY2016)

Product	Mercury content	
	(kg-Hg)	(t-Hg)
Mercuric sulfide (pigment use)	913	0.91

Source: Interview with manufacturer of mercuric sulfide, 2018

2) Mercury compounds

Table 3.1.14 shows mercury used for the domestic production of mercury compounds obtained from interview with domestic producers in FY2018. The amount of import/export of mercury compounds are unknown.

Table 3.1.14 Mercury in domestically produced mercury compounds (FY2016)

Product	Mercury use	
	(kg-Hg)	(t-Hg)
Mercury compounds [Note]	44	0.044

Note: Mercury compounds include mercuric sulfide (II), mercury acetate (II), mercury nitrate (I), and others. Mercuric sulfide produced for use as reagents is used.

Source: Interview with domestic producer of mercury compounds in FY2018

3.2 Mercury-added products in households and offices

In the material flow, mercury-added products shipped to the market have been categorized as “mercury-added products in households and offices” and include stocks of products at retailers, products being used, used product before being discarded as waste (products being hoarded) etc. Further consideration is needed to understand the amount of “mercury-added products in households and offices”.

4. MERCURY WASTE AND MERCURY-CONTAINING RECYCLABLE RESOURCES

4.1 Mercury Recovery from Waste and Mercury-Containing Recyclable Resources

Table 4.1.1 shows the amount of mercury recovery from waste and mercury-containing recyclable resources obtained from a survey conducted in FY2018 with business entities involved in mercury recovery. The total amount of mercury recovered is estimated as 65,047 kg-Hg (≒65 t-Hg).

Table 4.1.1 Mercury recovery from waste and recyclable resources (FY2016)

Type of medium		Mercury recovery (kg-Hg)	Source
(1) Discarded product	Industrial waste	6,744	FY2016 results
	Municipal waste	851	FY2016 results
(2) Waste mercury		8,161	FY2016 results
(3) Sludge, waste liquid		2,379	FY2016 results
(4) Non-ferrous metal smelting sludge		46,584	Three-year average (FY2015-FY2017)
(5) Others	Dental amalgam	324	Waste and mercury-containing recyclable resources
	Silver oxide battery	4	mercury-containing recyclable resources
Total (kg-Hg)		65,047	
Total (t-Hg)		65	

(1) Discarded products (industrial waste and municipal waste)

According to the interview with mercury recovery companies in FY2018, amounts of discarded products treated for the purpose of mercury recovery and the amount of mercury recovered are as shown in Table 4.1.2. The total amount of mercury recovered from discarded products is 7,595 kg-Hg (≒ 7.6 t-Hg).

Table 4.1.2 Treatment and mercury recovery from discarded mercury-added products (FY2016)

Product	Industrial waste		Municipal waste	
	Amount of waste (kg)	Amount of recovered Hg (kg-Hg)	Amount of waste (kg)	Amount of recovered Hg (kg-Hg)
Dry cell	1,584,810	32	12,140,462	240
Button batteries	8,556	17	352	1
Fluorescent lamps (including shredded portions)	3,252,448	130	4,461,802	170

Product	Industrial waste		Municipal waste	
	Amount of waste (kg)	Amount of recovered Hg (kg-Hg)	Amount of waste (kg)	Amount of recovered Hg (kg-Hg)
Backlight (cold cathode fluorescent lamp and external electrode fluorescent lamp)	65,428	3	0	0
HID lamps	50,347	2	180	0
Medical mercury thermometers / industrial mercury thermometers	5,664	560	1,806	180
Medical mercury sphygmomanometers	116,554	5,800	5,296	260
Industrial mercury thermometers, mercury manometers, mercury barometers, mercury hygrometers	0	0	0	0
Switches and relays, manometers	20,489	200	6	0
Total (kg-Hg)	5,103,296	6,744	16,609,904	851
Total (t-Hg)	5,103	6.7	16,610	0.85

Note: Mercury recovery treatment includes roasting, heat treatment, distillation and extraction of metal mercury.
Source: Interview with mercury recovery companies in FY2018

(2) Waste metal mercury

Table 4.1.3 shows the amount of recovered mercury from waste metal mercury and the emission sources thereof obtained from interview with mercury recovery companies in FY2018.

Table 4.1.3 Mercury recovery from waste metallic mercury (FY2016)

Medium	Emission sources of waste mercury	Recovery Hg (kg-Hg)
Waste mercury	Business	4,483
	University/school	1,068
	Lighthouse	106
	Hospital	869
	Municipal solid waste incineration facility	324
	Others	407
	Imported waste	904
Total (kg-Hg)		8,161
Total (t-Hg)		8.2

Source: Interview with mercury recovery companies in FY2018

(3) Sludge, waste liquid

According to the interview with mercury recovery companies in FY2018, for industrial waste other than products, mercury is recovered from sludge and waste liquid. Table 4.1.4 shows the amount of sludge and waste liquid treated and the amount of mercury recovered.

Table 4.1.4 Amount of mercury recovered from sludge and waste liquid (FY2016)

Medium	Amount of treatment (t)	Recovered Hg (t-Hg)
Sludge, waste liquid	2,063	2.4
(Sludge and waste liquid- imported portion)	(301)	(0.51)

Source: Interview with mercury recovery companies in FY2018

(4) Non-ferrous metal smelting sludge

Table 4.1.5 shows the amount of mercury recovered from sludge generated in the process of non-ferrous metal smelting. The data is obtained from interview with mercury recovery companies in FY2018 and from Japan Mining Industry Association (sludge generator). Since the amount of mercury recovered from the sludge varies greatly between years, a three-year average of 47t-Hg is adopted in the material flow.

Table 4.1.5 Mercury recovery from non-ferrous metal smelting sludge

Source	Amount of recovered Hg (t-Hg) Note1			
	FY2015	FY2016	FY2017	Three-year average
FY2018 interview with mercury recovery companies (Recovery side. Only members of Japan Mining Industry Association) Note2	57.0	44.0	38.7	46.6
Japan Mining Industry Association Note 3 (Generation side. Only members of Japan Mining Industry Association)	71.6	36.9	28.8	45.8

Note 1: Regarding the difference on the amount of mercury recovered between generation side and recovery side, in addition to the differences in the survey targets, there may be a time lag between the discharge and treatment or counting thereof.
Note 2: Non-member companies made no treatment contracts between FY2015-2017
Note 3: The data provided by Japan Mining Industry Association are estimated values of the amount of mercury included in those contracted-out and carried out from offices of non-ferrous metal smelting companies.

(5) Others

1) Dental amalgam

Table 4.1.6 shows the amount of dental amalgam treatment and mercury recovery obtained from interview with mercury recovery operators conducted in FY2018. It needs to be noted that there are two types of dental amalgam; those treated as industrial waste or valuable resources (contract smelting). Mercury is recovered in both cases.

Table 4.1.6 Mercury recovery from dental amalgam (FY2016)

Medium	Classification	Amount of treatment (kg)	Hg recovery	
			(kg-Hg)	(t-Hg)
Dental amalgam	Industrial waste	171	80	0.080
	Valuables (recyclable resources)	512	244	0.24
	Total	683	324	0.32

Source: Survey with mercury recovery operators in FY2018

2) Silver oxide batteries

Table 4.1.7 shows the amount of silver oxide batteries treated and mercury recovered thereof obtained from interview with mercury recovery operators conducted in FY2018. Amount of silver oxide batteries treated as industrial waste and mercury recovery from this operation is included in Table 4.1.2 (Button batteries).

Table 4.1.7 Treatment and mercury recovery from silver oxide batteries treated as recyclable resources (FY2016)

Medium	Classification	Amount of treatment (kg)	Hg recovery	
			(kg-Hg)	(t-Hg)
Silver oxide battery	Valuables (recyclable resources)	1,886	4	0.004

Source: Interview survey with mercury recovery operators (2018)

4.2 Final disposal

(1) Final disposal from processing/industrial use of raw materials

According to section 1.3, the amount of final disposal of waste and residue generated from processing/industrial use of raw materials and waste incineration, and mercury therein, are shown in Table 4.2.1. A total of 7.8 t-Hg was disposed of from eight industry sectors.

Table 4.2.1 Final disposal derived from processing/industrial use of raw minerals and residue from incinerators (FY2016)

Emission source	Medium	Final disposal (t)	Hg contained in final disposal (t-Hg)
Non-ferrous metal smelting facility Note	Wastewater treatment sludge	N/A	1.5
	Slag, etc.	N/A	0.45
	Other waste	N/A	0.42
Coal-fired power plant	Fly ash	200,000	0.030
	Flue gas desulfurized gypsum	11,000	0.0045
	Sludge	60,000	0.38
Coal-fired industrial boiler	Coal ash	23,000	0.0025
	Flue gas desulfurized gypsum	3,200	0.0036
Primary iron-manufacturing plant	Desulfurization sludge	2,464	0.021
	Wet dust	3,602	0.0026
Secondary iron-manufacturing plant	Precipitator dust	58,773	0.12
Oil and natural gas processing facility	Wastewater treatment sludge	640 or more	N/A
Municipal solid waste incineration facility	Incineration residue	3,054,279	2.6
Industrial waste incineration facility	Ash dust	N/A	2.2
	Cinders	N/A	Small amount
		Total	7.8

Note: Data from non-ferrous metal smelting facilities are based on a three-year average from FY2015 to FY2017, taking into account the fact that there is considerable year-to-year variation.

(2) Final disposal of municipal waste (direct landfilling)

Direct landfilling of municipal waste is not included in the material flow since the amount of discarded mercury-added products to be landfilled as non-combustible is not available. For reference, in the report on "Investigation on the situation of mercury waste disposal in FY2013", the amount of mercury to be landfilled contained in mercury-added products in FY2010 is estimated to be 16 kg-Hg.

Table 4.2.2 (Reference) Mercury contained in direct landfilling of discarded products (FY2010)

Product	Number of responding municipalities	Treated (t)	Hg content (kg-Hg)
Fluorescent lamps	17	297	12
Dry-cell batteries, other batteries (excluding button batteries)	14	213	3.6
Mercury thermometers	0	N/A	-
Mercury manometers	0	N/A	-
Total			16

Note: The amount of mercury to be contained in discarded mercury-added products is calculated using the actual treatment data provided by mercury recovery companies in reference to the survey conducted on companies treating industrial waste in 2012.

Source: Ministry of the Environment, Japan, Report on "Investigation on the situation of mercury waste disposal in 2013" (March 2014)

Table 4.2.3 (Reference) Mercury content per discarded mercury-added products

Product	Discarded product treatment (t) (FY2010)	Hg recovery (kg) (FY2010)	Hg content(kg-Hg/t)
Fluorescent tubes	8,185	325	0.040
Dry-cell batteries, other batteries (excluding button batteries)	12,159	209	0.017

Source: Ministry of the Environment, Japan, Report on "Investigation on the situation of mercury waste disposal in 2013" (March 2014)

(3) Mercury in waste generated from the mercury recovery process

According to the interviews conducted with mercury recovery companies in FY2018, the amount of mercury in waste generated in the process of mercury recovery is 28.5 ㎏ (≒0.029 t-Hg).

(4) Final disposal of waste

Based on the subsection (1) - (3), the amount of final disposal derived from processing/industrial use of raw material is estimated to be 7.8 t-Hg, and the final disposal of mercury from mercury recovery process is estimated to be 0.029 t-Hg. In the material flow, sum of these values is used (7.8 t-Hg) for final disposal of waste.

4.3 Import of specified hazardous waste (reference)

Table 4.3.1 shows the specified hazardous wastes imported to Japan classified as Y29 (containing mercury or mercury compound) obtained from the aggregated data on the enforcement status of "Law for the Control of Export, Import and Others of Specified Hazardous Wastes and Other Wastes". The amount of mercury recovered from imported waste metal mercury and from sludge and waste liquid is shown to be 1.4 t-Hg in section 4.1. The mercury contents of other specified hazardous wastes are not included in the material flow since their mercury contents are unknown.

Table 4.3.1 Import of specified hazardous wastes (CY2013-CY2016)

Year	Waste Note1	Partner country	Weight transferred (t)
2013	Waste fluorescent lamps Waste HID lamps	Philippines	5
2014	Waste button batteries	Taiwan Note 2	13
	Waste HID lamps	Taiwan	6
2015	-	-	0
2016	Waste mercury	Indonesia	1
	Mercury-containing waste liquid	Indonesia	10
	Mercury-containing solid wastes	Indonesia	7
	Mercury-containing waste catalyzers	Indonesia	28
	Mercury-containing filters	Indonesia	7
	Mercury-containing sludge	Indonesia	50
	Mercury-containing sludge	Indonesia	272
	Waste mercury	Indonesia	0.05

Note 1: The purpose of the import is "metal recovery".

Note 2: Since documents for import/move are not issued for the import from Taiwan, the value of weight transferred is data obtained by the Ministry of the Environment, Japan.

Source: Status of import/export of waste, etc. (1) Enforcement status of Basel Law can be referenced at http://www.env.go.jp/recycle/yugai/index4.html

5. EMISSIONS AND RELEASES OF MERCURY

5.1 Atmospheric emission of mercury

Table 5.1.1 shows the estimated results of atmospheric mercury emissions in “Mercury Atmospheric Emission Inventory (FY2016)” (developed in FY2018). Total amount of anthropogenic atmospheric emission of mercury is 16 t-Hg. Atmospheric emission from the mercury recovery process is determined to be 0.0052 t-Hg, based on the interviews with mercury recovery companies in FY2018.

Table 5.1.1 Mercury Atmospheric Emission Inventory (FY2016)

Source category	Emission source			Emission (ton-Hg/year)[1] FY2016	Subtotal
Sources listed in Annex D of Minamata Convention	Coal-fired power plants			1.3	14
	Coal-fired industrial boilers			0.22	
	Non-ferrous metals production			1.4	
	Waste incineration	Municipal solid waste		1.5	
		Industrial waste		2.4	
		Sewage sludge[2]		1.4	
		A facility that recovers mercury from mercury-containing recyclable resources and industrial waste that is obligated to undergo recovery (limited to facilities that include a heating process at the time of recovery) [2]		0.005	
	Cement clinker production			5.4	
Other sources	Iron and steel production	Primary iron production	Sintering furnace (including pellet firing furnace)	1.7	2.5
			Others (from blast furnace by-product gas, coke oven by-product gas)	0.15	
		Secondary iron production	Electric furnace	0.51	
	Oil refining			0.12	
	Oil and gas production			0.00005	
	Combustion of oil and others	Oil-fired power plants		0.007	
		LNG-fired power plants		0.002	
		Oil-fired industrial boilers		0.002	
		Gas-fired industrial boilers		0.0004	
	Facilities that use mercury or mercury compounds in production processes[3]			N.O.	
	Manufacturing facility for products that use mercury[4]	Facilities that do not include a heating process [Includes fluorescent lamp collection and crushing facility]		< 0.00001 [0.000005]	

Source category	Emission source		Emission (ton-Hg/year)[1] FY2016	Subtotal
		Facilities that include a heating process during mercury recovery	0.00003	
	Hg-containing products manufacturing	Battery[5]	N.E.	
		Mercury switch and relay	< 0.000001	
		Lamp[6]	0.005	
		Soaps and cosmetics[7]	N.O.	
		Pesticides and biocides[7] (agricultural chemicals)	N.O.	
		Sphygmomanometer[8]	N.E.	
		Hg thermometer[7]	N.O.	
		Dental amalgam[7]	N.O.	
		Thimerosal production facility[7]	N.O.	
		Vermillion production facility	0.000005	
	Others[9]	Limestone production	0.10	0.35
		Pulp and paper manufacturing (black liquor)	< 0.04	
		Carbon black manufacturing	0.08	
		Cremation	0.07	
		Transportation[10]	0.06	
Natural sources	Volcano		> 1.4	> 1.4
Total (excluding natural sources)			18(16)	

Note 1: For information on the amount of activities, data from FY2016 (April 2016 to March 2017) is used.

Note 2: For atmospheric emissions of 0.1 ton-Hg/year or more, significant figure of two, and for values less than 0.1 ton-Hg / year, significant figure of one is used.

1. "N.E." stands for "Not Estimated" (Existence of the emission source is unknown, or emission sources exist but no estimation has been done). "N.O." stands for "Not Occurring" (emission sources do not exist or there is an emission source, but no mercury is emitted to the atmosphere due to the manufacturing process and the structure of the manufacturing facility).
2. Although some facilities do not fall within waste incineration facilities under domestic laws of Japan, they are categorized as waste incineration facilities in the inventory.
3. Mercury is not used in all of the relevant facilities in Japan (the following six types of facilities) (confirmed in FY2012).
   Chlor-alkali production facility, vinyl chloride monomer production facility, polyurethane production facility, sodium methylade production facility, acetaldehyde production facility, vinyl acetate production facility
4. Excludes facilities subject to Annex D of the Convention from intermediate waste treatment facilities.
5. In Japan, mercury is used for the production of button-type batteries only. It has been reported that equipment used in the production process does not allow the emission of mercury to the atmosphere. However, as the detailed flow of the process is not available, it has been treated as N.E.
6. “Lamp” includes fluorescent lamps for general use, cold cathode fluorescent lamps and HID lamps.
7. It has been confirmed that there are no sources of emission for the manufacture of soap and cosmetics and manufacture of pesticides and biocides (FY2012), manufacture of mercury thermometer and manufacture of mercury amalgam for dental use (FY2013), and manufacture of thimerosal (FY2016).
8. It was confirmed in FY2016 that it was difficult to measure the mercury concentration from the outlet due to the structure of the facility, and it was impossible to estimate the amount of discharge.
9. Sources that have not been addressed in past government negotiations but are likely to have mercury emissions into the atmosphere
10. The target is fuel consumption of gasoline and diesel (for business use)

Source: "Mercury Atmospheric Emission Inventory (FY2016)" http://www.env.go.jp/air/suigin/2016inventry.pdf

5.2 Mercury releases to water

Table 5.2.1 shows mercury releases to water obtained from interviews with business organizations in charge of processing/industrial use of raw minerals and manufacturers of mercury-added products, and data obtained from Japanese PRTR.

Table 5.2.1 Mercury releases to water (FY2016)

Release source	Mercury release (t-Hg)
Processing/industrial use of raw minerals	0.060
Production process of mercury-added products	0
Mercury recovery process Note1	0.00029
PRTR (Notification amount + Estimation of amount not subject to notification due to threshold) Note2	0.14
Total	0.20

Note 1: Emissions from the mercury recovery process also include mercury emissions from the treatment of wastewater from mines

Note 2: In order to avoid double-counting of the release from processing/industrial usage of raw fuel (non-ferrous metal smelting process), the value of "non-ferrous metal production" is excluded from the PRTR data.

(1) Mercury releases to water from processing/industrial use of raw minerals

Table 5.2.2 shows mercury releases to water from processing/industrial use of raw minerals, as demonstrated in section 1.3. The total amount of release to water is 0.060 t-Hg.

Table 5.2.2 Mercury releases to water from processing/industrial use of raw minerals (FY2016)

Release source	Mercury content in wastewater (t-Hg)	Source (remarks)
Non-ferrous metal smelting	0.060	Interview with Japan Mining Industry Association (Three-year average of data from FY2015 to FY2017)
Coal-fired power plants	0	Interview with the Federation of Electric Power Companies (Wastewater from stack gas desulfurization facility: Mercury concentration N.D.)
Coal-fired industrial boilers	0	-
Primary iron-manufacturing	N/A	Interview with Japan Iron and Steel Federation (Process managed based on the effluent standard in the Water Pollution Control Law)
Secondary iron-manufacturing	0	Interview with the Japan Iron and Steel Federation (Wastewater does not occur due to dry-type flue gas treatment)
Oil and natural gas processing	0	Interview with domestic companies

Release source	Mercury content in wastewater (t-Hg)	Source (remarks)
Cement clinker production	0	Interview with Cement Association of Japan
Total	0.060	

(2) Mercury releases to water from manufacturing processes of mercury-added products

Table 5.2.3 shows mercury releases to water in manufacturing processes of mercury-added products. According to the interviews with business organizations and others in FY2018 and FY2019, the amount of release is “0” for all the manufacturing processes.

Table 5.2.3 Mercury releases to water from manufacturing processes of mercury-added products (FY2016)

Product	Mercury release (kg-Hg)	Interviewee
Button batteries	0	Battery Association of Japan
Switches and relays	0	Manufacturer
Lamps [Note]	—	Japan Lighting Manufacturers Association
Neon Lamps	0	Japan sign Association
Industrial measuring devices	0	Japanese Cooperative Kumiai for Glass Measuring Instruments Industry, Japan Pressure Gauge and Thermometer Manufacturers' Association, Japan Association of Meteorological Instrument Engineering, Japan Scientific Instrument Association
Medical measuring devices	0	The Japan Federation of Medical Devices Association
Medicines	0	Japanese Association of Vaccine Industries, Manufacturers
Inorganic chemicals	0	Manufacturer
Total	0	

Note: The actual status of mercury release into water from the lamp manufacturing process has not been investigated.
Source: Interview with organizations/companies shown in the column of "Interviewee" in FY2018 and FY2019.

(3) Mercury release from the mercury recovery process to public water bodies

According to the FY2018 interview survey with mercury recovery companies, the amount of mercury released from the mercury recovery process into public water bodies is 0.29 kg-Hg (= 0.00029 t-Hg).

(4) Mercury releases to public water (PRTR data)

Table 5.2.4 shows the reported data on mercury releases to public water and the estimated releases outside notification in reference to the PRTR data in FY2016. In the material flow, in order to avoid double-counting with “(1) Mercury releases to water from processing/industrial use of raw minerals”, the total amount under the PRTR notification excluding "non-ferrous metal production" with estimated amount (for estimation for portion under the cutoff amount for notification), which amounts to 0.14 t-Hg, is adopted.

Table 5.2.4 Mercury releases to public waters (FY2016, PRTR data)

Industry code	Industry type	Reported data of releases to water (kg/year)	Estimated releases outside notification (release below cutoff threshold requiring notification) (kg/year)	Industrial category in the material flow
500	Metal mining	0	Not estimated	-
700	Crude oil and natural gas mining	0	Not estimated	Crude oil and natural gas production
1200	Manufacture of food	No notification	0	-
1300	Manufacture of beverages, tobacco and feed	No notification	0	-
1800	Manufacture of pulp, paper and paper products	11	0	-
1900	Publishing, printing and allied industries	No notification	0	-
2000	Manufacture of chemical and allied products	0	0.6	-
2100	Manufacture of petroleum and coal products	0	0	-
2200	Manufacture of plastic products	0	0	-
2300	Manufacture of rubber products	No notification	0	-
2500	Manufacture of ceramic, stone and clay products	0	0	Cement manufacturing
2600	Steel industry	0	0	Primary/Secondary iron production
2700	Manufacture of non-ferrous metals and products [Note2]	~~16~~	0	Non-ferrous metal smelting
2800	Manufacture of fabricated metal products	No notification	0	-
2900	Manufacture of general-purpose machinery	No notification	0	Manufacture of mercury using products (batteries, lamps
3000	Manufacture of electrical machinery, equipment and supplies	No notification	0	-
3200	Manufacture of precision instruments and machinery	No notification	0	Manufacture of mercury using products (industrial

Industry code	Industry type	Reported data of releases to water (kg/year)	Estimated releases outside notification (release below cutoff threshold requiring notification) (kg/year)	Industrial category in the material flow
				measuring instruments, medical measuring instruments)
3400	Miscellaneous manufacturing industries	No notification	0	Manufacture of mercury using products (Pharmaceuticals, inorganic chemicals)
3500	Electric industry	0	0	Coal thermal power station
3700	Heat supply industry	No notification	0	-
3830	Sewage industry	118	0	Sewage sludge incineration (Refer to PRTR for water release from sewage treatment)
4400	Warehousing business	No notification	0	-
7210	Laundry industry	No notification	0	-
7810	Machine repair industry	No notification	0	-
8620	Product inspection industry	No notification	0	-
8630	Measurement certification industry	0	0	-
8716	Municipal solid waste treatment service	1	Not estimated	Municipal solid waste incineration
8722	Industrial waste disposal business (including special controlled industrial waste disposal business)	4	0	Industrial waste incineration
8800	Medical and other health services	No notification	1.9	-
9140	Higher education institution	No notification	0	-
9210	Natural science research institution	0	0	-
	Subtotal	134	2.5	
	Total	136.5		

Note 1: “0 kg/year” indicates a value of less than 0.5 kg.

Note 2: In order to avoid double counting of the released amount from processing/industrial usage of raw material (non-ferrous metal smelting process), the value of "non-ferrous metal production" is excluded when aggregating the material flow.
Source: PRTR Information Square, FY2016 data (published on March 2, 2018), http://www.env.go.jp/chemi/prtr/result/gaiyo.html

5.3 Mercury releases to land

For residue generated from the processing/industrial use of raw minerals, “mercury releases to land” refers to the amount of mercury released to soil from the portion that either comes in direct contact with soil or gets mixed, or is utilized by directly spreading over the soil.

Table 5.3.1 shows the amount of residue utilization that falls within the definition mentioned above and mercury content therein. The total amount of mercury released to land is estimated as 0.58 t-Hg.

Table 5.3.1 Mercury releases to land from processing/industrial use of raw materials (FY2016)

Release source	Medium	Utilization purpose	Amount (10^3 t)	Hg content (t-Hg)
Coal-fired power plants	Fly ash	Soil-contact type	2,754	0.41
Coal-fired industrial boilers	Coal ash	Soil-contact type	436	0.049
Others	Sewage sludge	Compost use at green farms	299	0.12
			Total	0.58