ASSESSMENT OF EXCESS MERCURY IN ASIA, 2010-2050

MAY 2009

Sprl concorde

10 av. René Gobert 1180 Brussels ☎+32(2) 374 3647 concorde.ew@tele2allin.be

This paper has been researched and prepared by Peter Maxson, Director, Concorde East/West Sprl, with all reasonable care and due diligence. While the author has greatly benefited from valuable contributions from a number of colleagues, he accepts complete responsible for the accuracy of the paper and the stated conclusions. Nevertheless, third parties who rely on information contained in this document, or their own interpretation thereof, do so at their own risk.

Assessment of
Excess Mercury in Asia, 2010-2050

Executive summary

This document is a revised version of the original assessment dated November 2008. It has been revised, to the extent feasible, to take account of comments kindly provided by Japan, Nepal and China.

The overall aim of this analysis is to provide a framework for better understanding future mercury flows within Asia – a framework necessary to inform discussions about managing excess mercury in the region. This analysis provided background information for the "Inception Meeting of the Asian Mercury Storage Project" that took place on 4-5 March 2009, in Bangkok.

The reduction of mercury supplies, and long term management of mercury, have both been identified as priorities by the UNEP Governing Council. It is imperative, therefore, that Governments and other stakeholders consider how to deal with excess mercury, since we know that elemental mercury, apart from being toxic, cannot be destroyed or degraded, and hence must be managed over the long term in order to avoid its re-entry into the global marketplace.

Importantly, mercury flows in Asia need to be better understood before subsequent steps are taken – which may include planning for the necessary storage capacity, discussing regional coordination activities, securing financial and technical support, identifying technical criteria (including site assessments) that constitute environmentally sound long-term storage, and developing the basic design of such a facility or facilities.

Present information suggests that future sources of mercury in the Asian region will include primarily mercury recovered as a by-product from various mining and smelting activities, from the cleaning of natural gas, from the closure/conversion of mercury cell chlor-alkali plants, and from other significant sources such as end-of-life products. Regional sources of mercury are compared in this analysis with regional uses, such as lamps, measuring devices, dental amalgam, etc., over the same time period in order to estimate excess mercury that will be generated in the region.

This analysis demonstrates that the Asian region is a significant net importer of mercury at the present time. The vast majority of the imported mercury is used for small-scale gold mining, and lesser amounts for product manufacturing, while China consumes much of its own mined mercury in the production of VCM/PVC. Therefore, the timing of the generation of excess mercury in Asia depends to a large extent on the timing and magnitude of demand reduction in these key sectors.

UNIDO and other experts have determined that mercury supply restrictions can contribute to significant demand reductions in small-scale gold mining. Subsequently, measures to influence supply and demand can be mutually reinforcing, and to some extent supply restrictions must precede demand reductions to be effective. Therefore, for this region, planning for mercury storage may be especially important as an initiative to further encourage demand reduction.

According to the scenarios assessed in this report, mercury supply and demand in Asia are projected to reach a rough equilibrium beginning about 2014-2015. This time frame could be shorter if substantial additional by-product mercury is generated in response to stricter requirements imposed on the metal processing sector. On the other hand, this time frame could be longer if demand reduction in small-scale gold mining proves to be more difficult to achieve than the goals set out in the relevant UNEP partnership.

Furthermore, after 2017 the urgency of an Asian mercury storage capability is likely to depend on the rate of further demand reductions, the extent to which countries in the region wish to encourage these further demand reductions through supply restrictions, and the extent to which a regional solution is achieved (even though net supplies of excess mercury may occur in a relatively small number of countries).

In any case, substantial excess mercury can be expected in Asia after 2030. The quantity of excess mercury, mostly accumulated between 2030 and 2050, would likely amount to just over 5,500 tonnes. According to an alternative policy scenario, in which regional authorities may decide to move forward the storage of excess mercury, the quantity of mercury accumulated may be as high as 7,500 tonnes.

Contents

Tables

Figures

Assessment of Excess Mercury in Asia, 2010-2050

1 Background

1.1 Aims

The overall aim of this analysis is to provide a framework for better understanding future mercury flows within Asia – a framework necessary to feed discussions about managing excess mercury in the region. This analysis provided background information for the "Inception Meeting of the Asian Mercury Storage Project" that took place on 4-5 March 2009, in Bangkok. At that meeting, discussions focused on the possible need for a regional mercury storage facility or facilities, as the preferred – or most environmentally sound – option.

This research and analysis was carried out with the kind support of the Zero Mercury Working Group.[1] It is a revised version of the original assessment dated November 2008, and takes account of post-meeting comments kindly submitted by Japan, Nepal and China.

1.2 Context

The reduction of mercury supplies, as well as long-term management of mercury, have both been identified as priorities of the UNEP Governing Council. It is imperative, therefore, that Governments and other stakeholders consider how to deal with excess mercury, since we know that elemental mercury, apart from being toxic, cannot be destroyed or degraded, and hence must be managed over the long term in order to avoid its re-entry into the global marketplace.

Present trends suggest that as Asian mercury demand decreases with the gradual phase-out of mercury-containing products, there will be excess mercury generated in Asia from such sources as by-product mercury recovered from various metal mining and smelting activities, from the cleaning of natural gas, from the closure or conversion of mercury cell chlor-alkali plants, etc. Therefore, mercury flows need to be better understood before any subsequent steps are taken – such as planning for the necessary storage capacity, discussing regional coordination activities, securing financial and technical support, identifying technical criteria (including site assessments) that constitute environmentally sound long-term storage, and developing the basic design of such a facility or facilities.

---

1 The Zero Mercury Working group (www.zeromercury.org) is an international coalition of more than 55 public interest environmental and health non-governmental organizations from around the world, formed in 2005 by the European Environmental Bureau and the Mercury Policy Project/Ban Mercury Working Group. The aim of the group is to strive for 'zero' emissions, demand and supply of mercury, eventually eliminating the risks posed by mercury in the environment at EU level and globally.

1.3 Scope

The broader investigation into the feasibility of Asian regional capacity for the terminal storage of excess mercury has been structured in two initial phases. This assessment comprises the first phase; it responds to the need cited above by assessing the flows and quantities of mercury that may need to be stored. The second phase will focus on the location, design, financing and other practical requirements of an appropriate storage facility.

This assessment includes an analysis of the quantities of mercury arising over the next 40 years in the Asian region as a by-product from various mining and smelting activities, from the cleaning of natural gas, from the closure/conversion of mercury cell chlor-alkali plants, and from other significant sources such as end-of-life products. Regional sources of mercury are then compared in this analysis with regional uses, such as lamps, measuring devices, dental amalgam, etc., over the same time period in order to estimate excess mercury that will be generated in the region, and that could be stored at an appropriate facility or facilities.

2 The Asian region

In order to productively discuss mercury sources and uses in the region, it is necessary to first identify the countries that will be included in this analysis. While different groups of countries may be considered, this project will cover the subregions of East Asia and South Asia as indicated in Table 2-1. It should be noted that these are merely convenient geographical groupings and should not in any way be interpreted as regional groupings endorsed by the United Nations.

Table 2-1 Suggested Asian subregions and included countries

East and Southeast Asia	*South Asia*
Brunei Darussalam	Afghanistan
Cambodia	Bangladesh
China	Bhutan
Democratic People's Republic of Korea	India
Indonesia	Maldives
Japan	Nepal
Lao People's Democratic Republic	Pakistan
Malaysia	Sri Lanka
Mongolia	
Myanmar	
Papua New Guinea	
Philippines	
Republic of Korea	
Singapore	
Thailand	
Viet Nam	

It should be noted that the countries of the Middle East, Australia, New Zealand and Oceania are outside the scope of this assessment.

3 Methodology

As described in detail in the UNEP Global Mercury Assessment (UNEP 2002), mercury is intentionally added to a great number of products such as thermometers and dental amalgams, and processes such as the mercury-cell process for the production of chlorine. In the case of the products, many of these can be eventually collected and recycled to recover the mercury. Likewise, mercury can be recovered from various process uses. These and other typical sources and uses of mercury are discussed further in Sections 4 and 5 below.

The focus of this assessment is on a 40-year time frame, specifically 2010-2050. Clearly 40-year estimates are subject to significant uncertainties, and it is understood that precision is not realistic or possible for this exercise. The purpose is to develop an order-of-magnitude estimate of the quantity of elemental mercury that may need to be stored, and a rough idea of when that mercury may become available for storage.

Due to the unique circumstances of China (and especially China's very large mercury supply and demand as described in various studies cited in this assessment) with regard to exports, imports, domestic mining and consumption of mercury, it is necessary to first have a good understanding of the Chinese situation, and to make certain assumptions about China for the purpose of this assessment. The following assumptions are made:

- assume that China will have no significant imports or exports of metallic mercury, unless there is a domestic excess, as described below;
- assume that the main Chinese "sources" of mercury include VCM catalyst recycling and mercury recovered as a by-product from zinc smelting and mercury mining;
- assume that domestic mercury production from primary (i.e. mercury) mining declines as domestic demand declines, as long as domestic demand is less than domestic sources of mercury;
- this implies that China will not generate excess mercury until domestic sources (without primary mining – see previous bullet) of mercury eventually exceed domestic demand;
- assume that when and if China generates excess mercury (without primary mining), it may be made available (exported) to other countries in Asia, as necessary to meet demand.

After the mercury flow situation of China has been considered, any excess mercury from China may be assumed to be an additional supply to the rest of Asia. The other countries in the region may then be analysed in one combined group or in two separate groups – the rest of East & Southeast Asia (i.e., without China), and South Asia – for which the following assumptions are made:

- assume that there may be transfers of mercury among these countries, as there are already (UNEP 2006);
- assume that there are no imports of metallic mercury except from China, should China have an excess supply;
- assume that there are no exports of metallic mercury or by-product mercury wastes outside the Asian region, although continued exports of mercury-containing products would be expected;
- assume that the main sources of mercury are imported products, chlor-alkali facilities, by-product mercury from non-ferrous metal smelting and natural gas cleaning, and some recycling of mercury-containing products;
- accept that if and when the region generates excess mercury, the mercury should go to terminal storage.

4 Regional mercury consumption for products/processes

Unless otherwise noted, the basic document sources for chapters 4 and 5 are the UNEP Trade Report (UNEP 2006), which presents an overview of global mercury uses and sources; an extensive analysis of mercury product life-cycles published in the US (Cain 2007); and a detailed analysis of mercury applications carried out recently for the European Commission (2008).

4.1 Present mercury consumption in the Asian region

The main groups of mercury-containing products and mercury processes assessed in this study are described below. The base year for “current” data is assumed to be 2005. It should be kept in mind that the determination of mercury consumption in different countries and regions, and for different applications, is difficult even in the best of cases. Therefore, the figures presented below are the best estimates that have been made based on information and research that may vary greatly in quality and depth, depending on the sources of the information and the resources devoted to the research.

4.1.1 Artisanal gold mining

With the possible exception of VCM production (see Section 4.1.2), artisanal and small-scale gold mining (ASM), an activity inextricably linked with issues of poverty and human health, remains the largest global user of mercury. The use of mercury in this sector reportedly continues to increase with the upward trend in the price of gold. Because nearly all of the mercury used in ASM is eventually released to the air, water and soil, ASM is also the largest source of releases from intentional use of mercury.

According to the UNIDO/UNDP/GEF Global Mercury Project, at least 100 million people in over 55 countries depend on ASM – directly or indirectly – for their livelihood, mainly in Africa, Asia and South America.[2] ASM is responsible for an estimated 20-30% of the world’s gold production, or approximately 500-800 tonnes per annum. It directly involves an estimated 10-15 million miners, including 4.5 million women and 1 million children. This type of mining relies on rudimentary methods and technologies, and is typically performed by miners with little or no economic capital, who operate in the informal economic sector, often illegally and with little organization. Due to inefficient mining practices, mercury amalgamation in ASM results in the consumption (and subsequent release) of an estimated 650 to 1000 tonnes of mercury per annum (Telmer 2008; UNEP 2008a).

In Section 4.1.10, regional estimates of mercury use in ASM have been derived from country estimates based on personal communications with a number of experts directly involved in the UNIDO/UNDP/GEF Global Mercury Project.[3]

---

[2] It should be noted that not all artisanal/small scale gold miners use mercury. Some use cyanide, permitting more gold to be recovered than when using mercury. Others use gravimetric methods without mercury or cyanide.

[3] It should be noted that in a more recent paper (Telmer and Veiga, 2008) attempting to improve past estimates of ASM activity worldwide, the authors have referred to ASM activity in as many as 70 countries, but have suggested even less certainty in estimates of global mercury consumption, for which they now claim the upper range may well exceed 1000 tonnes per year.

4.1.2 VCM production

The large and increasing use of mercuric chloride as a catalyst in the production of vinyl chloride monomer (VCM), mostly in China, is another area of major concern. Investigations in China estimated that 610 metric tonnes of mercury were used for this application in 2004. This use of mercury was estimated to increase 25-30% per year as the Chinese economy grew rapidly, and as Chinese demand for PVC end-products increased up to 2008. Two reports have confirmed that mercury consumption for VCM production in China would significantly surpass the estimated 700-800 metric tonnes consumed in 2005 (NRDC 2006; Tsinghua 2006).

Figure 4-1 A vinyl chloride monomer (VCM) production plant in China

However, it may be expected that the global economic slowdown has tempered the growth of this industry, and that increasing efforts will be undertaken to reduce mercury consumption in this industry, and to further increase mercury recovery. It has been reported in China that less than half of the mercury consumed for VCM is later recovered from the spent catalyst. The rest of the mercury goes mainly into the hydrochloric acid (HCl) by-product, from where mercury is not normally recovered as a standard practice at present (ACAP, 2005).

4.1.3 Chlor-alkali production

The chlor-alkali industry is the third major mercury user worldwide. Many plant operators have phased out this technology and converted to the more energy-efficient and mercury-free membrane process, others have plans to do so, and still others have not announced any such plans. In many cases governments have worked with industry representatives and/or provided financial incentives to facilitate the phase-out of mercury technology. Recently governments and international agencies have created partnerships with industry to encourage broader industry improvements with regard to the management and releases of mercury.

Table 4-1 Mercury cell chlor-alkali capacity in Asia, 2005

	Approx. chlorine production capacity (tonnes per annum)	Approx. cellroom mercury inventory (tonnes per annum)	Approx. mercury consumption* (tonnes per annum)
China	*none confirmed*	--	--
Other East & Southeast Asia			
Indonesia	24,000	48	incl. below
Myanmar	3,000	6	incl. below
Peoples' Dem. Rep. of Korea	25,000	50	incl. below
Philippines	14,000	28	incl. below
Subtotal	*66,000*	*132*	*4-8*
South Asia			
Bangladesh	5,000	10	incl. below
India	428,000**	856	incl. below
Pakistan	127,000	254	incl. below
Subtotal	*560,000*	*1,120*	*35-40*
Total Asian region	**626,000**	**1,252**	**40-50**

* The convention here is to calculate mercury "consumption" before any recycling of wastes. Some of the waste at some facilities may be recycled in order to recover the mercury, although most mercury waste is sent for disposal.
** As various Indian facilities have been closed in recent years, this paper considers a lower production capacity figure in the actual analysis.
Sources: UNEP 2006; EEB 2006; Euro Chlor 2007; WCC 2006; SRIC 2005

4.1.4 Batteries

The use of mercury in batteries, while still considerable, continues to decline as many nations have implemented policies to deal with the problems related to diffuse mercury releases related to batteries.

While mercury use in Chinese batteries was confirmed to have been high through 2000, most Chinese manufacturers have reportedly now shifted to lower mercury technologies, following international legislative trends and customer demand in other parts of the world. However, there are still vast quantities (tens of billions) of batteries with relatively low mercury content produced in China, and lesser quantities in other countries as well.[4]

[4] NRDC (2006) noted that for just one type of battery, the D-size "paste battery," the reported Chinese production in 2004 was 9.349 billion batteries. The authors estimated mercury chloride consumption

There also remain a large number of button cell batteries manufactured in many different countries, most containing up to 2% mercury, but some containing more. These will eventually be replaced by mercury-free button cells,[5] but for the moment these batteries, also produced in the tens of billions, consume significant amounts of mercury. Therefore, the global consumption of mercury in batteries still appears to number in the hundreds of metric tonnes annually. Asian regional demand presented in Section 4.1.10 has been estimated in UNEP (2008a).

4.1.5 Dental applications

In some countries and income groups (especially higher-income) the use of mercury in dental amalgams is now declining. The main alternatives are composites (most common), glass ionomers and compomers (modified composites). However, the speed of decline varies widely, so that dental amalgam use is still significant in most countries, while in some countries (e.g., Sweden, Norway) it has almost ceased. In many lower-income countries, changing diets and better access to dental care have actually led to an increase in dental mercury use.

Asian consumption of mercury for dental use is presented in Section 4.1.10, based on estimates provided to the author by EU manufacturers and exporters.

4.1.6 Measuring and control devices

There is a rather wide selection of mercury containing measuring and control devices, including thermometers, barometers, manometers, etc., still manufactured, although thermometers and sphygmomanometers dominate with regard to mercury use. As market awareness has improved, most international suppliers now offer mercury-free alternatives. European legislation, among others, is being implemented to phase out such equipment and to promote mercury-free alternatives since the latter are available for nearly all applications.

Total mercury consumption in these applications is based primarily on Chinese production of sphygmomanometers and thermometers. Chinese authorities calculated that over 270 tonnes of mercury were used in the production of these two types of devices in 2004, while Chinese production is estimated to represent 80-90% of world production of these two products (SEPA 2008). Likewise, thermometers and sphygmomanometers are considered to represent around 80% of total mercury consumption in the product category of "measuring and control devices." Asian regional demand presented in Section 4.1.10 has been drawn from UNEP (2008a).

4.1.7 Lamps

Mercury containing (fluorescent tubes, compact fluorescent, high-intensity discharge – HID, etc.) lamps remain the standard for energy-efficient lamps, where ongoing industry efforts to reduce the amount of mercury in each lamp are countered, to some extent, by the ever-increasing number of energy-efficient lamps purchased and installed in Asia. There is no doubt that mercury-free alternatives such as light-emitting diodes (LEDs) will increasingly become available, and technological developments point to the marketing of a comparable mercury-free alternative to the CFL in 2009 or 2010 (VU1 2008).

---

for these batteries at 47.11 tonnes, with an estimated mercury content of 34.91 tonnes. The battery label claims less than 250 ppm mercury content.

5 For example, the National Electrical Manufacturers' Association (NEMA) in the USA has called for a phase-out of all mercury in button cell batteries in the USA by 2011. In October 2008, Energizer announced sales of new zero-mercury hearing aid batteries – the first of their kind in the world.

Nevertheless, at present, for most lighting applications the mercury-free alternatives are very limited and/or more expensive, and separate collection and recycling of mercury-containing lamps in Asia are rare.

The ranges of mercury consumption presented in Section 4.1.10 include significant mercury use in backlighting (typically using small-diameter fluorescent tubes) of liquid crystal displays (LCDs) of all sizes – from electronic control panels to computer and television monitors. For China alone, mercury used in the production of fluorescent tubes and CFLs was estimated at 64 tonnes for 2005 (CRC 2007b). Chinese production has increased since then, but the average mercury content of lamps has likely declined during this period as well. Many of these lamps were exported outside the Asian region, but are clearly still relevant in the calculation of Asian regional demand for mercury.

4.1.8 Electrical and electronic equipment

Following the implementation of the European Union's Restriction on Hazardous Substances (RoHS) Directive, and similar initiatives in Japan, China and Korea, among others, mercury-free substitutes for mercury switches, relays, etc., are being encouraged, and overall mercury consumption for these applications appears to have declined in Asia in recent years.

In Section 4.1.10, the ranges of mercury consumption in electrical and electronic equipment are drawn from estimates by UNEP (2008a).

4.1.9 Other applications of mercury

This category has traditionally included the use of mercury and mercury compounds in such diverse applications as pesticides, fungicides, laboratory chemicals, pharmaceuticals, paints, applications in Chinese and Indian traditional medicine, cultural and ritual uses in India, cosmetics, etc. However, there are some further applications that have recently come to light in which the consumption of mercury is also especially significant.

In particular, the continued use of mercury in the production of artificial rubber is one such use that is rather widespread.[6] Likewise, the use of significant quantities of mercury in some research and testing devices has until recently escaped special notice. A recent study for the European Commission (2008) has also identified substantial mercury consumption in compounds used in a broad range of applications such as chemical intermediates. In Section 4.1.10, the ranges of mercury consumption in other applications of mercury are drawn from estimates by UNEP (2008a).

4.1.10 Summary of mercury consumption in Asia

Global mercury demand is strongly influenced by China's domestic consumption and production of mercury products, indicated in Table 4-2 below. However, because China's mercury supply is mostly sourced domestically, China's domestic mercury situation does not seriously affect the supply vs. demand equilibrium of the rest of the world. Likewise, just as domestic mercury mining has increased in response to Chinese demand in the past, it may be assumed that as China works to reduce its mercury consumption, then its domestic mercury supply will decline in parallel.

---

6 Mercury "catalysts" (basically hardening or curing agents) are sometimes used in the production of polyurethane elastomers, used as artificial "rubber" for roller blade wheels, etc., in which the catalysts remain in the final product.

For comparison, Japan claims to consume about 13 tonnes of mercury per year in batteries, lamps, measuring devices, electrical and electronic equipment, dental applications, etc. (Japan 2008)

Table 4-2 also summarises the key applications of elemental mercury in the Asian region as a whole for the reference year, 2005. It should be noted that this table indicates "gross" mercury consumption in Asia, i.e., before any recycling or recovery is counted, and including mercury used to manufacture goods that are later exported (especially batteries, measuring and control devices, lamps and electrical and electronic equipment). Largely for the convenience of this assessment, recycling and recovery are addressed as mercury "sources" in Section 5.1 below.

Table 4-2 Estimated mercury consumption in Asia, including products for export, 2005 (tonnes)

	China		East and South-east Asia, excl. China		South Asia	
	min.	*max.*	*min.*	*max.*	*min.*	*max.*
Small-scale gold mining	120	240	288	384	3	12
VCM/PVC production	700	800	0	0	0	0
Chlor-alkali production	--	--	4	8	35	40
Batteries	150	250	50	70	30	50
Dental applications	45	55	25	31	22	32
Measuring and control devices	280	310	20	30	40	50
Lamps	60	70	20	25	20	25
Electrical and electronic equipment	30	40	15	20	25	30
Other*	40	80	30	40	20	30
Totals	**1425**	**1845**	**452**	**608**	**195**	**269**

* "Other" applications include uses of mercury in pesticides, fungicides, catalysts, paints, chemical intermediates, laboratory and clinical applications, research and testing equipment, pharmaceuticals, cosmetics, traditional medicine, cultural and ritual uses, etc.

Sources: UNEP 2006; NRDC 2006; CRC 2007a; consultant estimates.

4.2 Future mercury consumption in Asia

The objective of this section is to describe the evolution of Asian mercury consumption between 2010 and 2050, reflecting existing and reasonably anticipated national and global initiatives, as specified in partnership business plans, and related UNEP and UNIDO global mercury activities, where available.

The concentration of mercury product manufacturing especially in China, India, Vietnam, Taiwan and Malaysia during the last 10-15 years (Lowell 2008) is already on the decline as countries and regions in many parts of the world implement increasingly strict and comprehensive legislation, in addition to many voluntary initiatives, to phase out various uses of mercury, and to restrict global supplies.

In the near to medium term, the rate of decline in mercury consumption will depend primarily upon reductions in the small-scale gold mining, battery, electrical equipment, and measuring device manufacturing sectors; dental use; and chlor-alkali facilities. These sectors represent the greatest potential for decreases in consumption during this time period because the alternative mercury-free technologies or products are readily available, they are of equal or better quality and prices are often competitive. For these sectors, the challenges are not technical, but are rather related to the extent of encouragement offered by countries or regions through awareness-raising, legal or voluntary mechanisms, etc.

For this analysis, the objectives for future reductions in mercury consumption are based on those agreed in the Mercury-Containing Products Partnership Area Business Plan (UNEP 2008b), which is also based on the “Focused Mercury Reduction Scenario” of UNEP’s *Summary of Supply, Trade, and Demand Information on Mercury* (UNEP 2006). These objectives are applied to Asian regional mercury consumption during the period 2010-2050, and are summarized in Table 4-3.

Table 4-3 Basic assumptions about future mercury consumption, 2010-2050

	China	**East & Southeast Asia, excl. China**	**South Asia**
Processes			
Small-scale gold mining	Reduce mercury consumption in small-scale gold mining globally by 50% over the next 10 years, with a subsequent decline after that of 5% per year. According to UNIDO, the 50% reduction can be met by eliminating whole ore amalgamation and encouraging greater mercury reuse (UNEP 2006). Supply restrictions are expected to help achieve this objective by raising mercury prices and otherwise encouraging greater efficiencies in mercury use.		
VCM/PVC production	An increase in mercury-free VCM production is problematic due to limited availability of ethylene supplies. It is assumed here that there is continued growth in mercury consumption to 1000t/y until 2010, stabilized consumption until 2015, and then a gradual phase-out of the mercury process from 2015-2030.	Not applicable	Not applicable
Chlor-alkali production	Assume no new mercury cell facilities will be constructed in any region.	Assume mercury cell capacity will be phased out by 2020, in line with voluntary EU industry objectives, which holds the majority of the world’s mercury cells.	Assume Indian mercury cell capacity will be phased out by 2012, and others by 2020.
Products			
Batteries	Assume a 75% decrease in mercury consumption by 2015, and the remaining demand phased out gradually thereafter until 2025.		
Dental uses	Assume a 15% reduction by 2015, and a gradual reduction thereafter to 2050.		
Measuring and control devices	Assume a 60% reduction of mercury consumption by 2015, the phase out of mercury fever thermometer and blood pressure cuff manufacturing by 2017, and the phase out of remaining demand by 2025.		
Lamps	Assume a 20% reduction by 2015 and a gradual reduction of 80% overall by 2050.		
Electrical and electronic equipment	Assume gradual 55% reduction of mercury consumption by 2015, and a gradual reduction thereafter to 2050.		
Other applications	Assume a gradual 25% reduction of mercury consumption by 2020, and another 50% by 2050.		

5 Key regional sources of metallic mercury

5.1 Major sources of mercury supply

If recycled or recovered mercury is considered a "source," there are typically five main regional sources of mercury supply:

1. Mining and processing of primary mercury ores;
2. Collection of process mercury from decommissioned mercury cell chlor-alkali plants (MCCAPs);
3. By-product mercury from the refining or processing of some ferrous and most non-ferrous metals; and from the cleaning of natural gas;
4. Stocks of mercury accumulated from previous years (typically the original source would have been from mercury mining or a by-product of other mining, chlor-alkali decommissioning, or other large sources).
5. Mercury recovered or recycled from products containing mercury and from processes using mercury.

In this sense, mercury imported from outside the region (as metallic mercury or in products) would not be considered a regional source.

5.1.1 Mercury mining and external trade

Mercury mining refers to the extraction of mercury from ores typically containing between 0.1 and 3% mercury. There is no significant mercury mining in Asia except in mainland China, primarily in the region of Guizhou.

Chinese mercury imports in 2004 were reported as 354 tonnes, with no exports registered in that year or in later years. In line with increased mercury consumption in China in recent years, domestic production has increased. According to the Non-Ferrous Industry Yearbook, China's mercury mine production was 1140 tonnes in 2004, the highest since 1990.

In 2005, Chinese mine production was reported at 1094 tonnes and imports at 180 tonnes. In 2006 no imports were formally registered, consistent with increased government restrictions on import permits for mercury imports (SEPA 2008; CRC 2007a). Nevertheless, there have been possible informal imports of mercury in recent years from neighbouring countries such as Viet Nam (CRC 2006).

Table 5-1 Estimated mercury mine production in China

Mercury mine production (metric tonnes)	2000	2001	2002	2003	2004	2005
China	203	193	495	612	1,140	1,094

Sources: CRC (2006) data, not including a modest amount of mercury reported to come from "informal" mining operations, i.e., small groups of miners not necessarily respecting the regulations on protecting the health of workers.

It should also be mentioned that only one mercury mine in China currently produces more than 100 tonnes per year. In 2004, this mine produced 312.54 tonnes of mercury. Due to limited reserves, it has been suggested that this mine may have an estimated remaining lifespan of only 5-6 years. Furthermore, if the total output of Chinese mercury mines remains in the range of 1000 tonnes per year, it has been estimated that China's mercury mines may be able to maintain that level of production for only about 10 more years (CRC 2007a; SEPA 2008).

Forecasting future mine output is difficult, and may be expected to fluctuate to some extent with domestic demand. It is assumed here that output of not more than 1000-1100 tonnes/year is possible until 2015, after which output may be expected to decline to not more than about 300 tonnes/year between 2015 and 2025. During this period, if the domestic demand for mercury significantly exceeds supply, this could put pressure on the authorities to relax import restrictions, and the imbalance may also encourage possible informal imports.

Alternatively, the authorities could encourage the exploitation of other sources of mercury such as by-product sources from zinc smelting, as discussed further below.

5.1.2 Mercury cell chlor-alkali facilities

There is a large quantity of process mercury at the bottom of the electrolytic "cells" that is necessary for the chlor-alkali production process to function properly. When a mercury cell facility is closed or converted (also called "decommissioning") to the membrane process, the mercury may be removed. In the past this mercury has typically been reused within the industry, or it has been sold outside the industry on the international market.

The mercury process is considered to be old technology (not BAT) with a variety of mercury releases and losses, some of which have proven impossible to control. No new mercury cell facilities have been constructed in Asia for at least 20 years. The Indian chlor-alkali producers have announced plans to phase out their remaining mercury facilities by 2012.

Table 5-2 Mercury cell chlor-alkali capacity in Asia, 2005

	Approx. chlorine production capacity (tonnes/yr.)	Approx. cellroom mercury inventory (tonnes)	Assumed phase-out period	Mercury consumption (tonnes/yr.)	Mercury in wastes (tonnes/yr.)
China	*none confirmed*				
Other East and Southeast Asia	66,000	132	2015-2020	4-8	3-5
South Asia	560,000	1,120	800 tonnes Hg by 2012 320 tonnes Hg 2015-2020	35-40	20-30
Total Asian region	626,000	1,252		40-50	25-35

* The convention here is to calculate mercury "consumption" before any recycling of wastes, with the knowledge that, as in many industries, some waste is recycled in order to recover the mercury, while most mercury waste is sent for disposal.

Sources: UNEP 2006; EEB 2006; Euro Chlor 2007; WCC 2006; SRIC 2005

Since there is no indication when other facilities will close or convert to a mercury-free process, it is assumed that general international pressure will encourage them to phase out more or less as indicated in Table 5-2 above. At that time the mercury inventory held in the electrolytic cells will be recovered, and for the purpose of this analysis, the recovered mercury is allocated over the indicated years.

Apart from the metallic mercury in the electrolytic cells, mercury waste is also generated by chlor-alkali facilities, which may account for 50-75% of the mercury consumed (see Table 5-2). It is possible to retort and recover most of the mercury from the waste, but until now this is not common practice in Asia.

5.1.3 By-product mercury

Zinc ores may contain significant trace quantities of mercury, especially in those regions of the world, such as parts of China, where the appropriate geological conditions exist. World zinc production grew by 4% to 10.7 million tonnes in 2006. A 6% rise in total output to 11.3 million tonnes has been estimated for 2007, with a further increase of 6.4% to over 12 million tonnes estimated for 2008, driven by strong growth in Asia. Among other countries, new capacity is coming on line in China, India (Hindustan Zinc's second 170,000 tonnes/year refinery at Chanderiya was commissioned in December 2007), Japan, the Republic of Korea, and Indonesia (Herald Resources' 220,000 tonnes/year Dairi mine) (IMSG 2008).

Gold, copper and lead ores also contain trace mercury, though typically in lower quantities than zinc ores (NRDC 2007). While the mercury content may vary greatly from one region or mine to another, it is often significant enough that it should be removed from the flue gases or wastewater during the processing of the ores.

Several technologies are available to control and capture mercury emissions from thermal processes at ore processing facilities. The Boliden-Norzink process uses mercuric chloride to precipitate metallic mercury as calomel (mercurous chloride). In the Outokumpu process, mercury is removed with sulphuric acid and then precipitated with selenium to produce mercury-selenium sulphate sludge. Importantly, the products of these two processes can be reprocessed to recover metallic mercury.

Other processes for mercury removal from ore processing gases include the Bolchem process (which uses thiosulfate to precipitate mercury), the sodium thiocyanate process, activated carbon filters, selenium scrubbers, selenium filters and lead sulphide filters.

At present, the only significant recovery of by-product mercury in the Asian region appears to be from zinc smelting in Japan, amounting to some 67 tonnes of mercury per year.[7] In other countries in Asia most mercury appears to be released to the environment, or disposed of with the processing waste.

In an effort to estimate the mercury potentially recoverable worldwide from primary zinc ores (UNEP 2006), Boliden company officials calculated the waste generated by their own mercury removal equipment <u>already installed</u>, based upon the design capacity of the units, the amount of gas managed in the units, and the typical mercury content of the gas. Globally, they estimated about 260 tonnes of mercury in calomel produced at zinc smelters in 2004 (with a margin of error of 50%, in light of uncertainties about individual plant operations, unit operating status, etc.). It should be noted that in 2004, China alone accounted for over one-quarter of world primary zinc production. While two Chinese smelters have installed equipment to control mercury emissions, according to Boliden, no by-product mercury production has yet been documented there.

---

7 Average 70-74 tonnes mercury content, of which about 67 tonnes was recovered (Japan 2008).

In 1996 the Newmont Mining Corporation opened the Minahasa Raya (NMR) gold mine at Buyat Bay on the northern Indonesian island of Sulawesi. Several years later an audit determined that the mine was annually emitting about 17 tonnes of mercury into the air and 16 more tonnes into the bay. The company installed a scrubber but it did not operate as planned. In 2004 the mine began closing down its operations in North Sulawesi, but a Newmont-operated gold and copper mine, Batu Hijau, located close to Senunu Bay on the remote island of Sumbawa in the south-central portion of the Indonesian archipelago, is expected to remain operational until at least 2025. Meanwhile, the company has plans to develop a copper deposit at Elang, 60 kilometres from Batu Hijau, that is expected to "add to the life of Batu Hijau."

Newmont Indonesia's Minahasa Raya and Batu Hijau gold mines.

Minahasa Raya mine with Buyat Bay in the distance (2004).

Source: Map and photo courtesy Newmont Mining Corporation.

Understanding that mercury removal technology is most cost-effective (and most likely to be installed in the future) on the largest smelters, which carry out some 50% of Chinese primary zinc smelting, Table 5-3 identifies the larger zinc smelters (those with production capacity >100,000 tonnes per year) in Asia and their capacities in 2003.

Table 5-3 Selected Asian zinc smelters greater than 100,000 metric tonnes capacity (2003)

	Company	Location	Construction	Capacity (tonnes)
China	Baiyin Zinc	Baiyan, Gansu	1991	200,000
	Huludao Lianshanqu Zinc	Huludao, Liaoning (vertical retorts)	1978	200,000
	Huludao Lianshanqu Zinc	Huludao, Liaoning (electrolytic)	1995	165,000
	Zhuzhou Lead/Zinc	Zhuzhou, Hunan	1959	350,000
Japan	Akita Zinc Co.	Iijima, Akita	1972	200,000
	Hachinohe Smelting Co	Hachinohe, Aomori	1969	118,000
	Toho Zinc Co.	Annaka, Gunma	1937	139,000
India	Hindustan Zinc	Chanderiya	2007	340,000
Korea	Korea Zinc Co.	Onsan, Kyoungnam	1978	420,000
	Youngpoong Corp.	Sukpo, Kyoung Buk	1970	270,000
Thailand	Padaeng Industry Public Co	Tak	1984	105,000

Source: ILZRO 2004.

Recalling that the Boliden-Norzink mercury removal equipment generates calomel as the waste product, with a mercury export ban in place, one may expect mercury to be recovered from the calomel only if there is an appropriate financial incentive, i.e., if the domestic mercury market price is sufficiently high to justify recycling and sale of the mercury, or if there is a legal requirement to do so.

Considering the rapid economic growth in the region, along with rising commodity prices, it may be assumed that the capacity of large zinc smelters will increase over the medium term as suggested in Table 5-4, although the specifics of such increases are impossible to predict.

Table 5-4 Large primary zinc smelters in Asia, and recoverable mercury

	Est. capacity of large primary zinc smelters (thousand tonnes)		Mercury content of ores processed (grams/tonne)	Quantity of mercury that could be recovered if appropriate mercury control technology were installed (tonnes)	
	2005 est.	2030 est.		2005 est.	2030 est.
China	1000	3600	86.6*	83	312
Japan (all smelters)	540	700		72**	92
Other Asia excl. China & Japan	1000	2100	20.0***	20	42

* Streets (2005).
** Average 70-74 tonnes recoverable mercury, of which about 67 tonnes was actually recovered (Japan 2008).
*** Pacyna (2002).

Following the global trend, it is likely that in the future mercury will be recovered from all of the larger Asian zinc smelters, as they have been implicated in major mercury emissions to the environment. For this assessment, it is assumed that appropriate control equipment will be installed on these smelters during 2010-2015 in China, and during 2010-2020 for other Asian countries. It is also assumed – in order to have an outside estimate of the mercury supply available – that all of the calomel waste will then be processed to recover mercury.

As mentioned above, in addition to zinc ores Asian countries mine and/or process gold, lead and copper ores that also contain varying trace amounts of mercury. Based on the Indonesian example, it may be reasonably assumed that, whatever mercury is recovered from zinc smelting in Asia, at least 25% more mercury may also be recovered from other non-ferrous metal (especially gold, lead, copper) processing activities in Asia.

5.1.4 Mercury stocks

In the past, reserve stocks of mercury held by governments or their proxies have been traded on the world market. While this no longer seems to be the case, and the recent US mercury export ban specifically forbids the government from selling its stocks, there remain various mercury inventories that may be available to the market.

Other than some stocks held on-site in storage rooms by chlor-alkali producers, it is likely there are other commercial stocks remaining as well, especially in light of increased speculation by brokers, fuelled by the volatility of mercury prices since 2004. It is estimated that most commercial mercury users maintain inventories of two to six months' expected consumption.

The global metals trader Lambert Metals, based in the UK, has long maintained mercury storage facilities at the ports of Antwerp and Rotterdam (WSJ 2006), from where shipments frequently go to Asia, although storage by Lambert Metals in Asia has not been confirmed. The largest Indian mercury broker, Beri Mercurio Limited, has been especially active in the market in recent years, and logically maintains stocks in Mumbai and elsewhere in Asia, although there is no precise information regarding quantities.

It is likely that the Chinese government may also be in the process of accumulating a stockpile of mercury to guard against eventual shortages. While the stockpiling of mercury has not been confirmed by Chinese authorities in the case of mercury, it is not an unusual practice. The Chinese government manages stocks of other commodities, and regularly buys and sells inventories in order to prevent prices from rising too high or falling too low. Recently, for example, Chinese zinc smelters called on the central government to launch a similar national policy with regard to zinc stocks, or reserves.

In any case, for this analysis mercury stocks may not be considered in the same manner as other mercury supplies that are generated every year. Rather, stocks should be considered as inventories held in reserve, and brought out only as needed under special circumstances – to dampen or to take advantage of price fluctuations, to meet sudden surges in demand, etc.

While it may be assumed that various Asian mercury stocks will be made available to meet modest shortfalls in supply, there are no reliable regional data on the quantities involved. Therefore, merely for the purposes of this analysis, it is assumed that the region presently maintains mercury stocks of some 1,000-2,000 tonnes.

5.1.5 Recycling

In order to facilitate this analysis, recycling is considered as a "source" of mercury that may be exploited or managed through a variety of policies that deal with mercury-containing products as they enter the waste stream, and/or residual mercury and wastes from industrial processes.

With regard to the use of mercury in artisanal gold mining, since this is a rather special and diverse area of mercury use, we will not estimate how much mercury used in the process may be subsequently retorted or otherwise recovered. Instead, such instances are included in this analysis as merely a decrease in the consumption of mercury in ASM, which is already accounted for in the projections presented in Table 4-3.

With regard to VCM, we note that the quantity of mercury remaining in the spent catalyst is slightly less than half of the total mercury consumed in the production process. As concerns the recycling of the spent catalyst at present and into the future, it is simply estimated that nearly all of the mercury remaining in the spent catalyst is recycled.

In the chlor-alkali industry, very little of the mercury in the waste stream is presently recycled in Asia. Due to the time frame during which most of the mercury cell facilities will probably be phased out (see Table 4-3), and the limited amount of waste that may be recycled until the phase-out dates, it is suggested to ignore this relatively small source of mercury.

Various mercury products are collected for recycling in different parts of the world, especially measuring devices (mainly thermometers and sphygmomanometers), batteries, lamps, dental amalgam, etc. Japan has reported that it recovers an average of 15 tonnes of mercury annually from recycled products. For all of Asia it is estimated that about 3% of the mercury consumed in products is presently recycled, particularly some sphygmomanometers used in health clinics, some dental wastes and some button cell batteries.

Estimating how the recycling rate for products will evolve in the future is highly dependent on government policies not only for dealing with end-of-life products, but also concerning the disposal of hazardous wastes. It has been observed that as hazardous waste disposal becomes more costly, more mercury waste is diverted to recycling and less to other forms of disposal. Of course, this shift assumes that there remains a viable demand for mercury. At such point as the supply of mercury exceeds the demand, the financial incentive for recycling becomes much less compelling.

With the knowledge that the EU and US have reportedly achieved an overall 15% mercury product recycling rate, it is here assumed that Asia could achieve at least 10% by 2020 and 25% by 2040. We note that collection, recycling, and recovery of mercury from products may continue for several years after phase-out of a mercury containing product. However, such details have little influence on the outcome of this analysis.

Combining all recycling efforts, the baseline recycling data for 2005 and basic assumptions regarding future mercury recycling in Asia during the period 2010-2050 are summarized in Table 5-5 below.

Table 5-5 Basic assumptions regarding Asian mercury recycling 2010-2050 (tonnes)

	Consumption 2005	**Recycling 2005**	**Forecast 2010-2050**
Processes			
Artisanal and small-scale gold mining	410-530	Included simply as reduced consumption.	Included simply as reduced consumption
VCM/PVC production	700-800	~47% of consumption	~47% of consumption
Chlor-alkali production	40-50	Minimal	Too small to influence the analysis
Products			
All products combined	920-1240	3% of consumption	10% of consumption by 2020, and 25% by 2040

5.2 Asian mercury supply

Overall, the main Asian regional sources of mercury are summarised in Table 5-6 below. These are purely domestic sources, i.e., generated within the region. The evolution of these sources during the period 2010-2050 has been discussed in the previous Sections 5.1.1 through 5.1.5.

Table 5-6 Asian "sources" of elemental mercury, 2005 (tonnes)

	China	**East & Southeast Asia, excl. China**	**South Asia**
Mercury mining (formal)	1094	0	0
Mercury mining (informal)*	0-200	0	0
Decommissioned chlor-alkali	See Table 5-2		
By-product mercury	0	67	0
Recycled Hg from VCM	350	0	0
Recycled Hg from products	18-24	10-15	
Inventory (not a "source"):			
Mercury stocks	**500-1000**	500-1000	
* Informal or artisanal mining is typically carried out by individuals or small groups outside the normal commercial and legal system; as such, it is very difficult to obtain good information on the extent of these activities.			

Sources: Derived from NRDC (2006), CRC (2006) and personal communications.

6 Results regarding excess Asian mercury

6.1 China

Based only on domestic sources and uses of mercury, assuming that China's mercury mines continue working at full capacity, and assuming recovery of mercury from the major metal smelters, this analysis indicates that China will have a "formal" mercury supply shortage only until around 2013 The word "formal" is used to suggest that informal sources of mercury, such as informal imports and illegal mercury mining, may serve to fill some of this supply deficit. Alternatively, formal imports and/or stocks of mercury could also serve to fill this gap.

The anticipated near-term gap between domestic mercury supply and demand may be addressed through demand-side policies as well, of which the most effective would be further restrictions on the soaring consumption of mercury for VCM/PVC production, which could also include further measures to recycle mercury from this process. Over the longer term, however, China could expect to see a considerable excess of domestic mercury supply over demand.

6.2 Other Asian countries

With regard to the other countries of East Asia, Southeast Asia and South Asia, this analysis shows a much longer period during which domestic demand may be expected to exceed the domestic supply of mercury. This is not surprising because these countries are not endowed with the significant mineral mercury reserves China is able to exploit. They have mostly had to rely on mercury imports. Nevertheless, the demand for mercury is expected to decrease over time, while more by-product mercury becomes available, so that by about 2030 these other Asian countries could expect to generate an excess of mercury.

6.3 All Asian countries combined – main scenarios

For all of Asia together, Figure 6-1 demonstrates to what extent the rest of Asia could benefit from transfers of excess mercury from China, still assuming that China's mercury mines continue working at full capacity. In this "All-Asia Maximum Mining" scenario, Asia would probably see mercury supply roughly equal to demand beginning in 2014, and a substantial excess of mercury emerging soon after 2025.

However, it is reasonable to assume that China would have no desire to continue operating its mercury mines at full capacity if there is no corresponding Asian demand for mercury, and especially if China would be obliged to store any excess mercury. Therefore, Figure 6-2 presents the case in which Chinese mercury mine production is reduced as much as possible during each year in which the overall Asian mercury supply would otherwise exceed demand.

According to this "All-Asia Reduced Mining" scenario, as Figure 6-2 indicates, regional demand and supply would be roughly equal from about 2014, and continue that way for some years until excess supplies are projected to become significant around 2030. Based on the preceding assumptions and analysis, this "All-Asia Reduced Mining" scenario is considered the most likely basis for more detailed discussions of an Asian mercury storage strategy.

Since this is the most likely scenario for mercury excesses generated in the Asian region during the period 2010-2050, the detailed calculations supporting Figure 6-2 are included in the Appendix – "Most likely scenario for excess mercury in Asia."

Figure 6-1 Asian excess mercury (assuming maximum Chinese mercury mining)

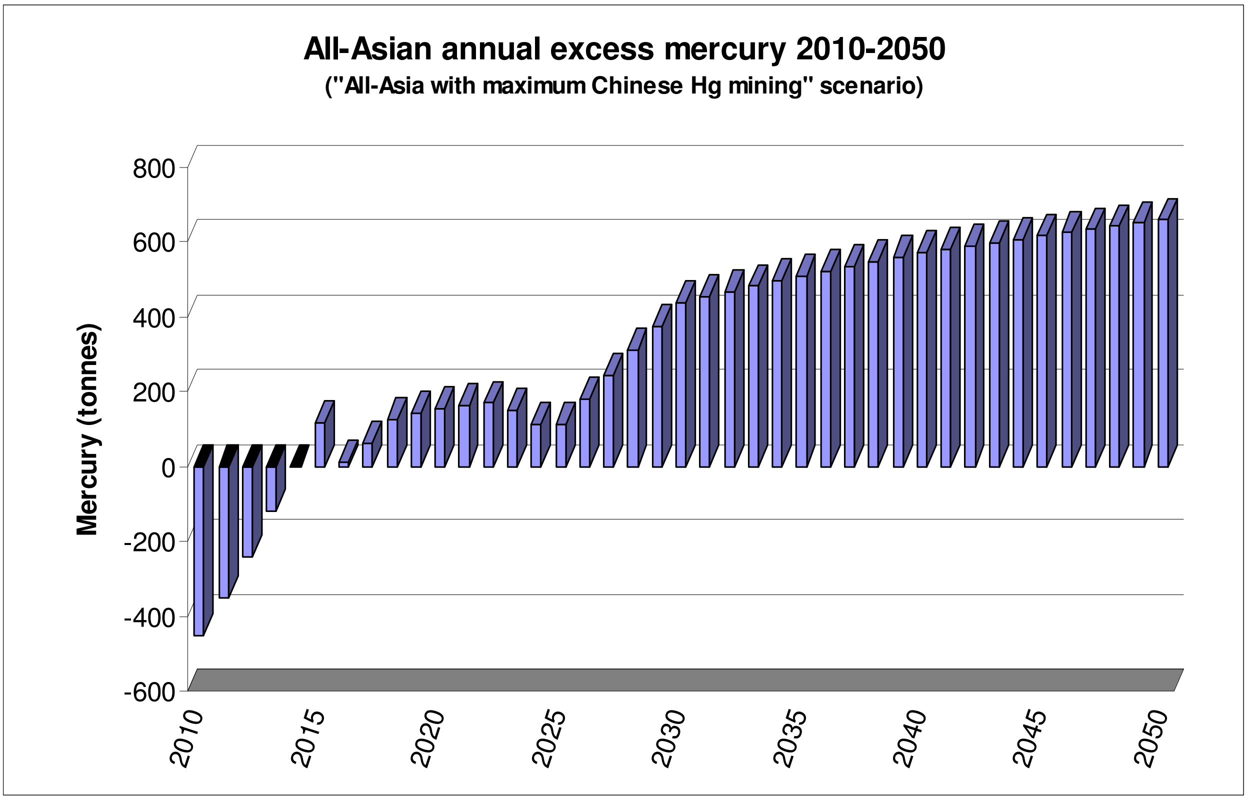
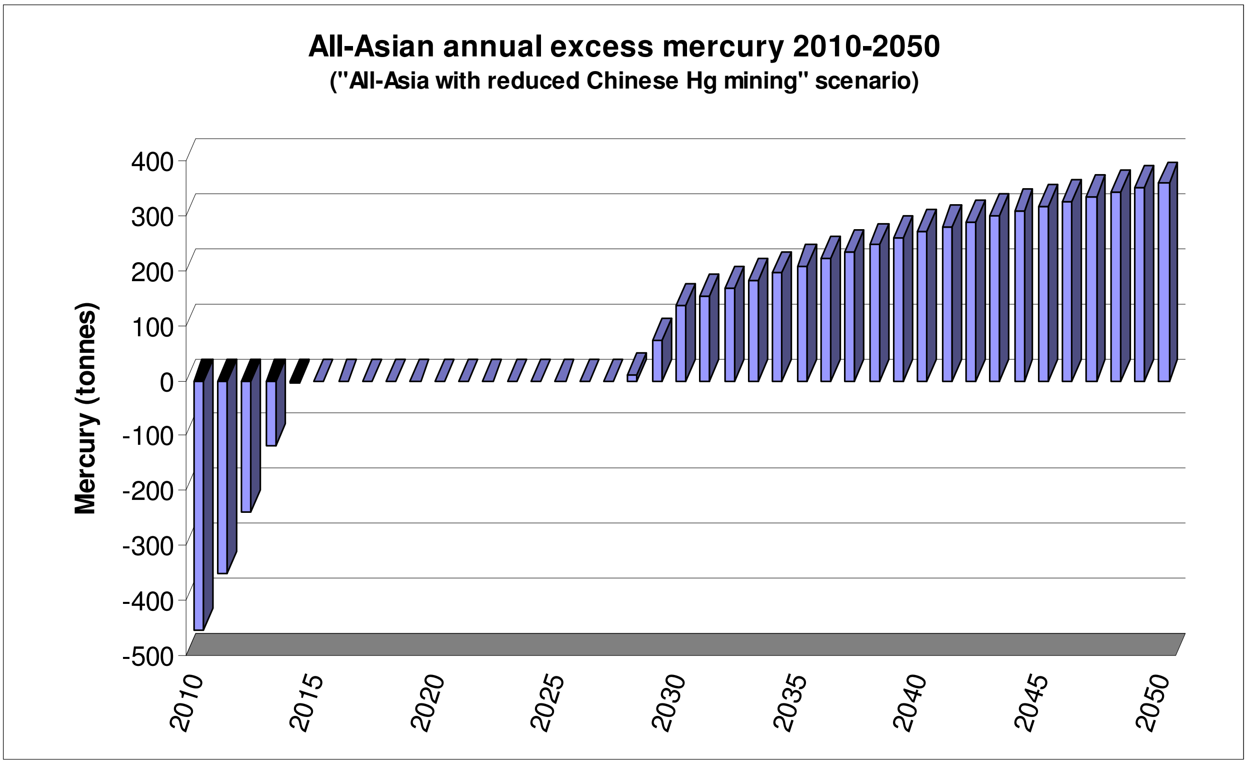


Figure 6-2 Asian excess mercury – most likely scenario (reduced Chinese mining)

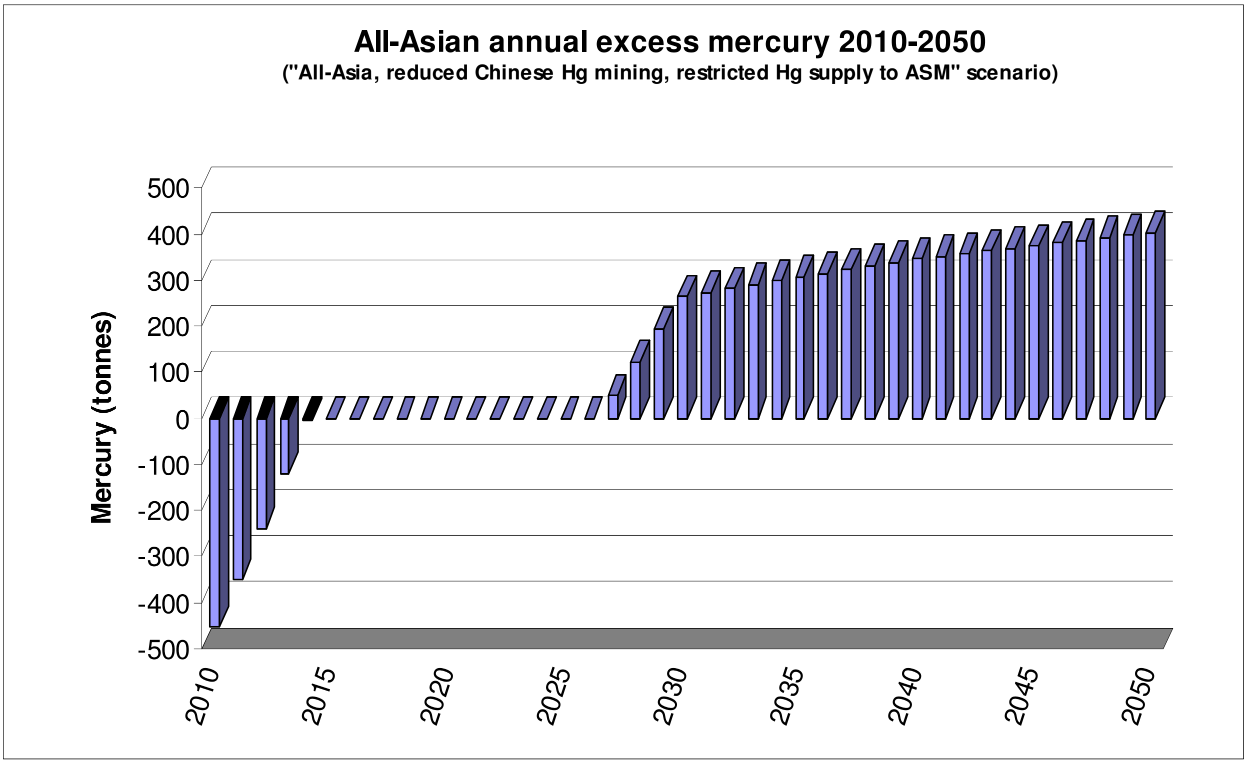


The quantity of excess mercury requiring storage, as accumulated between 2029 and 2050 in the most likely “reduced Chinese mining” scenario, amounts to just over 5,500 tonnes.

Finally, to test the sensitivity of the overall Asian analysis to a change in one of the important assumptions, the category of mercury consumption in ASM was selected. The original assumption was that the considerable use of mercury in ASM would be cut by 50% over the next 10 years, and after that it would be further reduced by 5% per year until 2050.

The alternative policy option considered here is that, following the initial 50% reduction in mercury consumption, mercury supplies are further restricted so that ASM consumption of mercury will be nearly completely phased out between 2020 and 2030. The impact of this ”ASM supply restriction” scenario, shown in Figure 6-3, is that excess mercury in Asia would appear a few years earlier than demonstrated in Figure 6-2, and lead to a somewhat greater accumulation of mercury up to 2050.

Figure 6-3 Asian excess mercury (assuming special restrictions on mercury supply to ASM)



The quantity of excess mercury requiring storage, as accumulated between 2027 and 2050 in this “ASM supply restriction” scenario, amounts to around 7,500 tonnes. Moreover, since this scenario assumes that a policy of enhanced mercury storage is implemented expressly to reduce regional supplies, development of some limited storage capability would be required by 2017, or shortly thereafter.

It is obvious that many other assumptions integral to this assessment may be modified in various ways. However, due to the many elements that are already included in this analysis, it is evident that such alternative assumptions would have relatively little impact on the basic observations and conclusions of this assessment.

7 Conclusions

With the possible exception of China and Japan, the Asian region is a significant net importer of mercury at the present time. The vast majority of the imported mercury is used for small-scale gold mining, and lesser amounts for product manufacturing. China, on the other hand, consumes much of its mercury in the production of VCM/PVC, and provides for a large part of its mercury requirements from domestic mercury mining. Therefore, the timing of an anticipated mercury excess in Asia depends greatly on the timing and magnitude of demand reduction in these key sectors.

Since UNIDO and other experts have determined that mercury supply reductions can contribute to significant demand reductions in small-scale gold mining, supply and demand reductions for this sector are mutually reinforcing, and to some extent supply reduction must precede demand reduction to be effective. Therefore, for this region, planning for mercury storage may be especially important as an initiative to further encourage demand reduction.

According to the scenarios assessed in this report, mercury supply and demand in Asia are projected to reach a rough equilibrium beginning about 2014-2015. This time frame could be shorter if substantial additional by-product mercury is generated in response to stricter requirements imposed on the metal processing sector. On the other hand, this time frame could be longer if the reduction in mercury demand in small-scale gold mining proves to be more difficult to achieve than the goals set out in the UNEP partnership.

The scenarios assessed in this report generally assume gradual reductions in mercury demand post-2017. For example, reduced mercury demand for small-scale gold mining, especially as a result of intentionally restricting the mercury supply, would bring forward the date at which a mercury storage capability is needed. Furthermore, after 2017 the urgency of an Asian mercury storage capability is likely to depend on the rate of further demand reductions, the extent to which countries in the region wish to encourage these further demand reductions through supply restrictions, and the extent to which a regional solution is achieved (even though net supplies of excess mercury may occur in a relatively small number of countries).

In any case, substantial excess mercury may be expected in Asia as a whole post-2030. The quantity of mercury requiring storage, as accumulated between 2029 and 2050 in the most likely “All-Asia Reduced Mining” scenario, amounts to just over 5,500 tonnes.

As mentioned, in order to help reduce mercury consumption, regional authorities may decide to accelerate the storage of excess mercury. In this case they would likely follow the hierarchy established by the European Union, whereby any mercury recovered from decommissioned chlor-alkali facilities would be stored first, and then by-product mercury recovered from metal ore processing and the cleaning of natural gas would be stored as a second priority. This option would result in the generation of excess mercury while restricting the supply of mercury that now goes to less acceptable uses, as shown in the more aggressive ”ASM supply restriction” scenario (Figure 6-3) above. In this case, the quantity of excess mercury that may be accumulated between 2027 and 2050 is estimated at nearly 7,500 tonnes.

Appendix – "Most likely scenario for excess mercury in Asia"

The table in this appendix provides 5-year snapshots of the calculations behind the most likely scenario (see Figure 6-2) for future mercury sources and uses in Asia, showing the excess mercury that would likely be generated in the region during the period 2010-2050.

All-Asia elemental mercury excess and accumulation, 2010-2050 (tonnes)

Zinc and other smelting - mercury source	2010	2015	2020	2025	2030	2035	2040	2045	2050
Hg available large zinc smelters (LZS) (China)	129	175	220	266	312	312	312	312	312
% LZS w/ Hg controls	0%	100%	100%	100%	100%	100%	100%	100%	100%
Hg captured LZS w/ controls (93% eff.)	0	162	205	248	290	290	290	290	290
Hg recovered from calomel (max.) - China	0	162	205	248	290	290	290	290	290
Hg available LZS (Japan)	76	80	84	88	92	92	92	92	92
% LZS w/ Hg controls	100%	100%	100%	100%	100%	100%	100%	100%	100%
Hg captured at LZS w/ controls (93% eff.)	71	74	78	82	86	86	86	86	86
Hg recovered from calomel (max.) - Japan	71	74	78	82	86	86	86	86	86
Hg available LZS (other Asian countries)	24	29	33	38	42	42	42	42	42
% LZS w/ Hg controls	0%	50%	100%	100%	100%	100%	100%	100%	100%
Hg captured at LZS w/ controls (93% eff.)	0	13	31	35	39	39	39	39	39
Hg recovered from calomel (max.) – other Asia	0	13	31	35	39	39	39	39	39
Total Hg recovered by all Asian LZS (max)	71	250	314	364	415	415	415	415	415
Other smelting adds +25%	18	63	78	91	104	104	104	104	104
Total Hg recovered by Asian smelting (max)	88	313	392	455	518	518	518	518	518
Uses of mercury including product exports									
Batteries (excluding China)	63	25	13	0	0	0	0	0	0
Dental applications (excluding China)	51	47	44	40	37	34	31	28	25
Measuring and control devices (excluding China)	49	28	11	0	0	0	0	0	0
Lamps (excluding China)	41	36	32	28	24	21	17	13	9
Electrical & electronic equipment (excl. China)	33	20	19	18	16	15	14	13	11
Other* (excluding China)	55	50	45	40	35	30	25	20	15
Products and "other" (China)	546	387	307	238	213	188	163	138	113
VCM	1000	1000	667	333	0	0	0	0	0
ASM	380	290	213	164	127	98	76	59	46
Chlor-alkali	26	15	4	0	0	0	0	0	0
Total uses	**2243**	**1898**	**1354**	**862**	**453**	**386**	**326**	**270**	**218**
Sources of mercury including smelting									
Product recycling - Japan (tonnes Hg)	15	15	15	15	15	15	15	15	15
Product recycling - China (tonnes Hg)	29	30	31	33	37	40	41	34	28
Product recycling - others (tonnes Hg)	15	16	16	17	20	21	22	18	15
VCM recycling	467	467	311	156	0	0	0	0	0
Chlor-alkali decommissioning	125	125	67	0	0	0	0	0	0
Total Hg recovered from zinc & other smelting - see above	88	313	392	455	518	518	518	518	518
Formal Hg mining (maximum)	1050	1050	675	300	300	300	300	300	300
Mercury stocks 1000-2000t?	?	?	?	?	?	?	?	?	?
Total sources	**1789**	**2015**	**1508**	**976**	**890**	**895**	**896**	**886**	**877**
All-Asia annual excess (-deficit) mercury - max. Chinese Hg mining	-453	117	154	114	437	509	570	616	658
IMPACT - reduced Chinese Hg mining	0	-117	-154	-114	-300	-300	-300	-300	-300
All-Asia annual excess (-deficit) mercury - reduced Chinese Hg mining	**-453**	**0**	**0**	**0**	**137**	**209**	**270**	**316**	**358**
Cumulative excess mercury (tonnes Hg)	0	0	0	0	221	1125	2357	3848	5556

References

ACAP (2005) – "Assessment of Mercury Releases from the Russian Federation." Arctic Council Action Plan to Eliminate Pollution of the Arctic (ACAP), Russian Federal Service for Environmental, Technological and Atomic Supervision & Danish Environmental Protection Agency. Danish EPA, Copenhagen. See http://www.mst.dk/udgiv/Publications/2005/87-7614-539-5/html/helepubl_eng.htm

Cain (2007) – A Cain, S Disch, C Twaroski, J Reindl and CR Case, "Substance Flow Analysis of Mercury Intentionally Used in Products in the United States," *Journal of Industrial Ecology*, Volume 11, Number 3, copyright Massachusetts Institute of Technology and Yale University.

CRC (2006) – "Research Report on Mercury Production and Use in China," Chemical Registration Center (CRC) of State Environmental Protection Administration of China (SEPA) and Natural Resources Defense Council (NRDC), 2006.

CRC (2007a) – "Research Analysis Report on Mercury Use in China 2003 – 2005 - The Measuring Devices Industry of China," Chemical Registration Center (CRC) of State Environmental Protection Administration of China (SEPA) and Natural Resources Defense Council (NRDC), May 2007.

CRC (2007b) – "Survey and Research Report on the Status of Use of Mercury in China's Electric Light Source Industry," Chemical Registration Center (CRC) of State Environmental Protection Administration of China (SEPA) and Natural Resources Defense Council (NRDC), 2007.

EEB (2006) – "Status report: Mercury cell chlor-alkali plants in Europe," Concorde East/West Sprl for the European Environmental Bureau, Brussels, October 2006.

Euro Chlor (2007) – "Chlorine Industry Review 2006-2007," Euro Chlor, Brussels, August 2007. See www.eurochlor.org.

European Commission (2008) – "Options for reducing mercury use in products and applications, and the fate of mercury already circulating in society," COWI A/S and Concorde East/West Sprl for the Commission of the European Communities, September 2008, Brussels.

ILZRO (2004) – "World Directory 2003: Primary and Secondary Zinc Plants," International Lead and Zinc Research Organization (ILZRO).

IMSG (2008) – "Metals Despatch," Newsletter of the International Metals Study Groups, Issue No. 5, June 2008.

Japan (2008) – Result of research on material flow of Hg in Japan. Ministry of the Environment. Available at http://www.env.go.jp/chemi/tmms/2001/mat04_2.pdf (only in Japanese).

Lowell (2008) – "Report on the major mercury-containing products and processes, their substitutes and experience in switching to mercury-free products and processes," Lowell Center for Sustainable Production for the United Nations Environment Programme, Chemicals Branch, Geneva, October 2008.

NRDC (2006) – "NRDC submission to UNEP in response to March 2006 request for information on mercury supply, demand, and trade," Natural Resources Defense Council, Washington, DC, May 2006; and Comments submitted by NRDC to the 1 September 2006 draft report, "Summarizing Supply, Trade and Demand Information on Mercury." Both available at http://www.chem.unep.ch/mercury/Trade-information.htm

NRDC (2007) – "Mercury Releases from Industrial Ore Processing," Natural Resources Defense Council, Washington, DC, June 2007.

Pacyna (2002) – Pacyna, EG and JM Pacyna, "Global Emissions of Mercury from Anthropogenic Sources in 1995," *Water, Air, and Soil Pollution 137:* 149–165, 2002.

SEPA (2008) – "Strategy Proposal for International Actions to Address Mercury Problem - Mercury Situation in China," State Environmental Protection Administration of China (SEPA), submitted to UNEP 28 January 2008.

SRIC (2005) – E Linak, S Schlag and K Yokose, "Chlorine/Sodium Hydroxide," CEH Marketing Research Report, SRI Consulting, Zurich, August 2005.

Streets (2005) – Streets DG, J Hao, Y Wu, J Jiang, M Chan, H Tian, and X Feng (2005), "Anthropogenic mercury emissions in China," *Atmospheric Environment 39* (2005) 7789–7806.

Telmer (2008) – Personal communications with experts Telmer (School of Earth and Ocean Sciences, University of Victoria, Canada), Veiga and Spiegel (both with the Norman B. Keevil Institute of Mining Engineering, University of British Columbia, Canada) – all involved in the UNIDO/UNDP/GEF Global Mercury Project.

Telmer and Veiga (2008) – K Telmer and M Veiga, "World emissions of mercury from artisanal and small scale gold mining and the knowledge gaps about them," Final draft, paper prepared for UNEP FT, Rome, 23 May 2008.

Tsinghua (2006) – "Improve the Estimates of Anthropogenic Mercury Emissions in China," Tsinghua University, October 2006.

UNEP (2002) – "Global Mercury Assessment." United Nations Environment Programme, Chemicals Branch, Geneva, December 2002. Available in English, French and Spanish at http://www.chem.unep.ch/mercury/.

UNEP (2006) – "Summary of supply, trade and demand information on mercury." Report prepared by Concorde East/West Sprl in response to UNEP Governing Council decision 23/9 IV, United Nations Environment Programme – Chemicals. Geneva, November 2006.

UNEP (2008a) – The challenge of meeting mercury demand without mercury mining: An assessment requested by the Ad Hoc Open-Ended Working Group on Mercury, report prepared by Concorde East/West Sprl for the United Nations Environment Programme – Chemicals. Geneva, November 2008.

UNEP (2008b) – "Mercury-Containing Products Partnership Area Business Plan," US Environmental Protection Agency in coordination with UNEP, Washington DC, 1 July 2008.

VU1 (2008) – See http://www.vu1.com/technology/technology.htm

WCC (2006) – "Submission [to UNEP] on Global Mercury Partnership for the Reduction of Mercury in the Chlor-alkali Sector," World Chlorine Council, undated, no address, see http://www.worldchlorine.com

WSJ (2006) – J Fialka, "Backfire: How Mercury Rules Designed for Safety End Up Polluting," *Wall Street Journal*, New York, NY, 20 April 2006.