NRDC SUBMISSION TO UNEP IN RESPONSE TO MARCH 2006 REQUEST FOR INFORMATION ON MERCURY SUPPLY, DEMAND, AND TRADE

The Natural Resources Defense Council (NRDC) provides this submission in response to the UNEP letter of March 24 requesting information on mercury supply, demand, and trade in preparation for the upcoming report requested by the Governing Council in Decision 23/9 IV on the mercury programme.[1]

Over the past 18 months, NRDC has collaborated with the Chemical Registration Center (CRC) of China's State Environmental Protection Administration (SEPA) to develop improved estimates of China's mercury supply and consumption. This collaboration has resulted in new consumption estimates for two of China's most significant mercury-consuming sectors: vinyl chloride and battery manufacturing. Additional data was also obtained on China mercury production and imports. This submission presents the methodology and results of the collaboration to date, and identifies remaining data gaps or inconsistencies warranting further investigation. In addition, NRDC provides information it has acquired on global mercury byproduct production.

Summary of Findings

China's total mercury supply from legal and illegal mining, imports, and recycling (of mercury catalysts) was estimated at approximately 1400 tons in 2004.[2] This quantity is well above one-third of the total estimated annual global mercury use, thereby signifying China's important role in achieving effective global mercury supply and demand reduction.

In 2004, China's battery manufacturing sector was responsible for approximately 153 tons of demand, and the vinyl chloride manufacturing sector accounted for 610 tons of mercury consumption. Thus, these two sectors now likely account for over one-half of the mercury use in China, with the vinyl chloride sector mercury consumption rising rapidly due to the explosive growth of PVC production in China.

Most global mercury byproduct production originates from gold production and zinc smelting operations. Byproduct production associated with zinc smelting is accomplished through use of the Boliden-Norzink and (and to a much lesser extent) Outokumpu mercury capture and recovery processes, both now

[1] The Natural Resources Defense Council is a private, U.S. not-for-profit environmental organization that uses science, law, and the support of more than 1 million members and activists nationwide to protect the planet's wildlife and wild places, and to ensure a safe and healthy environment for all living things.

[2] All tons in this report are metric tons, unless otherwise noted.

owned by Outokumpu. The company estimates global annual mercury byproduct production from zinc smelters at 284 tons, plus or minus 50%. Byproduct recovery of mercury from gold operations in the United States was about 97 tons in 2002, the last year for which precise data were available. Trade and other data suggest Peru and/or Chile may be recovering as much as 143 tons of mercury from gold production, but further investigation is required to estimate the actual amount of mercury recovered from gold mining in these two countries and other industrial gold production locations.

China Battery Manufacturing

Mercury is currently used in most batteries to inhibit corrosion and prolong battery life. It is also used in mercury oxide batteries to conduct an electric charge. Because of the tens of billions of batteries produced in China, the battery sector has the potential to consume significant quantities of mercury within the country. As described in detail below, CRC estimates that the battery sector in China used 153.5 tons of mercury in 2004, the latest reporting year available.

CRC investigated mercury use in the battery sector through collaboration with the China Battery Industry Association (CBIA). It relied upon a questionnaire completed by manufacturing companies as well as data provided from companies that manufacture mercury compounds for batteries, such as mercuric chloride and mercury-added zinc powder. Additional information was collected from China Customs, Hong Kong and COMTRADE databases.

Seven types of batteries manufactured in China contain mercury. Those seven categories are: paste-type zinc-manganese cylinder batteries, paperboard type zinc-manganese cylinder batteries, alkaline zinc-manganese cylinder batteries, silver oxide button cell batteries, zinc air button cell batteries, alkaline manganese button cell batteries, and mercury oxide batteries (typically button cells but could include larger batteries as well). Within these seven types of batteries, the paste-type cylinder batteries and the alkaline manganese button cells are manufactured in the largest quantities (each approximately nine billion units or more), and account for most of the mercury consumed by this sector, as indicated in Table 1 and Figure 1 below.

Paste and paperboard zinc manganese cylinder batteries are referred to in China as “ordinary” zinc manganese batteries. CBIA estimates about 274 facilities manufacture paperboard batteries, and approximately 60 of these factories make the paste batteries as well. The labels on these batteries generally contain the letter “S”, signifying their ordinary status.

In the paste-type zinc-manganese battery, mercury in the form of mercuric chloride is used as a corrosion inhibitor and to prolong battery life. Battery manufacturers purchase the mercuric chloride from an outside supplier and mix it with other materials (i.e., starch, water) at the plant to create the "paste". The paste is then inserted between the battery outside layer and the inner anode. Almost 98% of the paste batteries are "D" sized batteries. NRDC has observed the manufacturing of these batteries, and notes they can be distinguished by their soft outside shell, soft enough to squeeze with a hand, due to the consistency of the paste.

To determine mercury consumption in paste battery production, CRC relied upon mercuric chloride purchase and battery production data from questionnaires completed by 15 manufacturing companies (covering 2002-2004 and representing 17.5% of China paste battery output) to obtain a mean mercury chloride usage estimate for every 100 million paste batteries produced. By extrapolating this data to the known quantity of 9.349 billion paste batteries produced in 2004, CRC estimated mercury chloride consumption was 47.11 metric tons, and estimated mercury consumption was 34.91 tons for the paste battery manufacturing sector.

Paper zinc-manganese batteries rely upon laminated paper, to which the mercury-containing paste is adhered, for corrosion control. The mercury-containing laminated paper is purchased exclusively from outside paper suppliers.[3] The top two producers of laminated paper accounted for 85% of China production in 2004. To obtain mercury usage data for the paper batteries, CRC obtained mercury usage data from these top two companies and then extrapolated mercury usage upward to account for the remaining 15% of paper production. This approach produced a nationwide estimate of 10.35 tons for the paper battery manufacturing sector.

In alkaline manganese cylinder and button cell batteries, and in silver oxide, and zinc air button cells, mercury is used as a corrosion retardant in the zinc powder forming the battery anode. This zinc powder is obtained exclusively from outside sources, and is the only source of mercury in these batteries. The concentration of mercury in the zinc powder varies based upon battery type and the purity of manganese dioxide used at a particular facility.

CRC estimated mercury usage for alkaline manganese cylinder batteries by obtaining mercury usage data from the three outside suppliers which produced the mercury-containing zinc powder used to make these batteries in 2004. The mercury content of the powder was determined to be about 1%, and zinc powder output for 2004 was 535.8 tons, thus mercury usage was 5.358 tons for these cylinder batteries. Significantly, by law alkaline manganese cylinder batteries must be mercury-free beginning in 2005.[4]

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[3] These suppliers also make a mercury-free laminated paper, used to manufacture about 38% of the paper batteries in 2004.

[4] A substantial portion of the zinc powder produced for these batteries in 2004 was mercury free, in anticipation of the legal requirement becoming effective in 2005.

Alkaline manganese button cells were produced at 23 facilities, with an estimated output at between 8-10 billion units in 2004. Zinc powder usage for these facilities was 2,658 tons. Because the mercury content in the powder ranges from 3-6% at each facility, depending upon the quality of the manganese dioxide used, total mercury consumption in alkaline manganese button cell battery production was estimated at 98.65 tons, based upon an overall concentration of 4% mercury in the powder.

Few companies manufacture silver oxide batteries and output of this battery type in China is relatively small, as one company accounts for over 90% of national output of slightly above 81 million units. CRC obtained the zinc powder usage for this dominant company, and extrapolated total usage upward to account for the smaller producers. Mercury-containing zinc powder usage for this company was 0.2279 tons in 2004, and the powder contained 9% mercury. After extrapolation to account for the total China output, silver oxide battery production consumed an estimated 0.02278 tons of mercury in 2004.

There were only three large scale zinc air battery producers in China during 2004. The powder producers reported selling 144 tons of zinc powder containing 3% mercury to these companies. Thus, the production of zinc air button cells consumed about 4.32 tons of mercury in 2004.

Mercury oxide batteries consist of mercury-containing zinc powder as the anode and mercury oxide as the cathode. Therefore, these batteries have the highest mercury content. Most mercury oxide batteries are button cells, and are mainly used in cameras and hearing aids.

According to the China Battery Industry Association and CRC, China has listed mercury oxide batteries as a product for elimination, thus these batteries have virtually disappeared from the domestic market. Since no company would acknowledge currently manufacturing these batteries in questionnaires, interviews or other inquiries, Chinese Customs export data were used to estimate China's production output of mercury oxide batteries. According to the Customs data for 2004, only 244,700 mercury oxide batteries were exported. Assuming these batteries were the most typical model historically made in China, CBIA calculates each button cell would contain about 0.6 grams of mercury, and thus the total export quantity contained 0.147 tons of mercury.

Table 1 immediately below summarizes the mercury consumption data for China's battery manufacturing sector. Figure 1 illustrates the mercury consumption proportions by battery type. Following this table and figure, NRDC will discuss the most significant data uncertainty for this sector, and trends or actions that will influence future mercury use in this sector.

Table 1. Summary of China Battery Data

Battery Type	2004 Output	2004 Mercury Consumption Estimate (MT)	Estimation Methodology
Paste type zinc manganese cylinder batteries	9.349 billion units	34.65	Extrapolation from mercury chloride use at 15 battery production facilities
Paperboard zinc manganese cylinder batteries	5.742 billion units*	10.35	Extrapolation from mercury use at top two laminated paper producers
Alkaline manganese cylinder batteries	5 billion units**	5.358	Mercury used in zinc powder production from the 3 suppliers of this powder
Alkaline manganese button cell batteries	8-10 billion units	98.65	Mercury used in zinc powder production and supplied to the 23 battery manufacturers
Silver oxide button cell batteries	81.39 million units	0.02778	Extrapolation from mercury used in zinc powder production by leading company
Zinc air button cell batteries	Not Available	4.32	Mercury used in zinc powder production at 3 large battery manufacturers
Mercury oxide batteries	244,700 units	0.147	Chinese customs export data
Total		153.5	

* Of the 5.74 billion batteries produced, approximately 3.58 billion had mercury-containing paper
** Only an estimated 134 million of the 5 billion units produced had mercury-containing zinc powder

Summary of China Battery Data
2004 Mercury Consumption Estimate (Metric Tons)

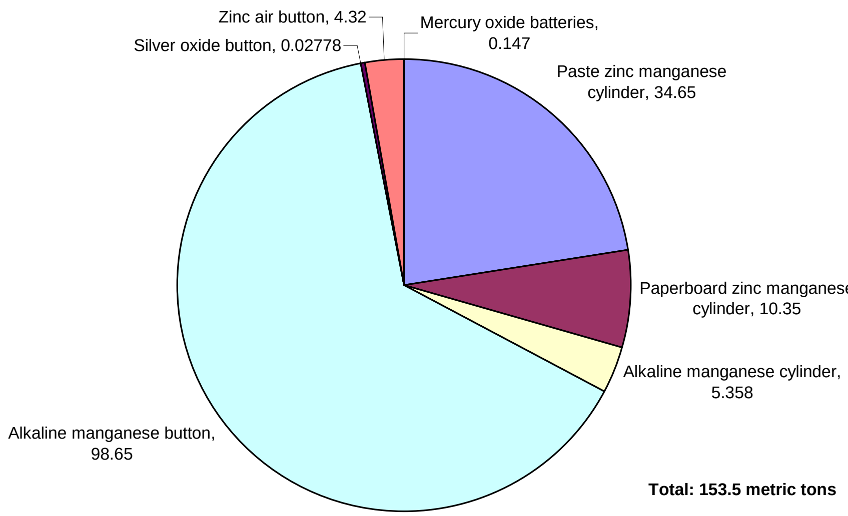

Figure 1

This 2004 estimate of 153.5 tons of mercury consumption for the battery sector represents a sharp decrease from earlier published estimates, and thus warrants careful scrutiny.[5] This decrease reflects several factors, such as the phase-in of stricter mercury content standards for some battery types both within China and in China's export markets over the past seven years, resulting in significantly lower mercury consumption despite overall increased production output.

Significantly, this 2004 estimate also is based upon a virtual elimination of mercury oxide battery production in China. It is certainly true, as Table 2 below reveals, mercury oxide battery production in China (and consequently its exports) has substantially decreased in recent years. However, China reportedly consumed 463.2 tons of mercury in mercury oxide battery production in 1999, just a few years ago.[6] Given the historical significance of mercury oxide battery production and the lack of direct information from China's battery manufacturers or mercury suppliers for this battery type, the most important uncertainty in the

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[5] The China battery sector reportedly used over 800 MT of mercury in 1999, the vast majority for alkaline manganese batteries (325.8 MT) and mercury oxide batteries (463.2 MT). Xinbin Feng, Mercury Pollution in China – An Overview, Table 3. In: Pirrone, N., Mahaffey, K. (Eds.), Dynamics of Mercury Pollution on Regional and Global Scales: Atmospheric Processes, Human Exposure Around the World. Springer Publishers, Norwell, MA, USA, pp. 657-678.
[6] Id.

current estimate for mercury use in China's battery manufacturing sector is the extent to which mercury oxide battery production has actually diminished in response to internal and external pressures for product elimination.

Table 2. China Mercury Oxide Battery Exports in Recent Years

Year	Quantity (10,000 sets)	Value ($10,000)
1997	123566.5244	2280.0600
1998	75197.3204	1184.9947
1999	11056.4884	185.6918
2000	333.1300	19.4182
2001	142.1508	7.6571
2002	320.9526	7.0077
2003	13.0576	1.0826
2004	24.4673	7.3342

To further probe this area of uncertainty, NRDC compared the China Customs export data for mercury oxide batteries with import data from countries which reported receiving these batteries from China (excluding Hong Kong), as provided in the COMTRADE data base.[7] The COMTRADE data indicate at least 35 countries reported importing mercury oxide batteries from China in 2004, as compared to the eight countries for which China Customs reports exports. Moreover, NRDC calculations indicate almost 146 tons of mercury was in the mercury oxide batteries reportedly imported from China according to the 2004 COMTRADE data, as compared to the 0.147 tons of mercury derived from the China Customs data.[8]

[7] This COMTRADE import data (using code 850630) for mercury oxide batteries are reported in either numbers of units, or by weight. Appendix 1 lists the countries reporting by weight, and the amounts reported. Appendix 2 lists the countries reporting by number of units, and the amounts reported. In total, 35 countries reported by weight or quantity receiving exports of mercury oxide batteries from China during 2004 (and at least three other countries reported a dollar value but no quantity or weight), as compared to the eight countries or regions identified by the China Customs data. If Mexico is included, the number is 36 (see Appendix 2).

[8] To estimate the total quantity and the amount of mercury potentially involved, NRDC converted the weights of imports reported into quantity figures (number of batteries). We assumed all the batteries were button cells averaging 2.34 grams, as estimated by CBIA. Using this methodology, the countries reporting by weight imported 222,871,367 units, which when added to the quantity imported by countries reporting in units, yields a sum of 243,422,850 units. This number is 1,000 times larger than the China Customs export quantity of 244,700 units. Using the 2.34 grams average weight, and the 25.6% mercury content estimate provided by CBIA, these batteries contain 145,820,024 grams of mercury, or almost 146 MT (as compared to the China Customs estimated quantity of 0.147 tons). Adding Mexico's units, based on the assumptions in Appendix 2, would result in an additional 2 tons.

Simply comparing the discrepancies just for the eight countries covered by the China Customs exported data is instructive:

	China Customs Exports	COMTRADE Imports from China
Hong Kong	61,432	5,579,896
Japan	10,700	56,342
Nepal	60,000	Not reported
Germany	2,000	0[9]
Russia	41,300	0
Czeck Republic	5,721	0
UK	5,650	135,898 **kg**
USA	67,500	3,398,896

These data indicate the discrepancies can occur in both directions, but the magnitude of the discrepancies is much greater where the Customs data are lower than the COMTRADE import data.

CRC and the Chinese Battery Industry Association are aware of these trade data discrepancies, and attribute them to the way China Customs records are kept for batteries (and other products) manufactured elsewhere but shipped through China. Goods shipped to China simply for re-export from bonded (or free trade) zones are not reflected in China Customs records, and thus would be recorded by importing countries but not China Customs. Accordingly, CRC and CBIA believe these mercury oxide batteries may be in-transit products, and produced outside of China.

Further research is required to determine in which country these mercury oxide batteries reported in the COMTRADE data base were manufactured. NRDC respectfully suggests UNEP make it a priority to determine the source of these batteries through additional data collection from the importing countries, if such data can be obtained. As a global matter, mercury oxide battery production still represents a significant (albeit declining) source of mercury demand on a per unit and aggregate basis that can and should be eliminated as soon as possible through the use of readily available non-mercury or low-mercury alternatives.

Future mercury consumption elsewhere in the China battery sector will be largely determined by influences on paste battery and alkaline-manganese button cell production. For the button cells, the most important potential influence is whether China elects to issue more stringent standards requiring a

[9] Germany reported $3,000 import value, but no quantity or weight.

complete phase-out of mercury use, consistent with the recent commitment by USA manufacturers to eliminate mercury use in button cells by 2011.[10]

For the paste batteries, no additional standards limiting mercury content appear contemplated at the present time, therefore market forces may be most influential for this product type. The paste battery market is driven by price because this type of battery is cheaper to make and sell than comparable alkaline-manganese batteries. A paste battery sells for about one yuan in China, or about 13 cents in US dollars, about 1/5 the cost of an alkaline manganese battery. Moreover, about 80% of China's paste battery output is exported to the developing world because of the low battery price.

CBIA predicts the paste battery market will decline at a 5-8% annual rate because the batteries will become more expensive to manufacture, causing profit margins to shrink within the desired product price. The two principal causes of rising production costs will be dwindling supplies of inexpensive paste battery (low quality) manganese dioxide and zinc prices increases. Consequently, manufacturers will be left with the choice of raising the price or leaving the market. Given these batteries are manufactured mostly for export, the rate of market shrinkage may also depend upon standard-setting or other actions taken by importing countries to encourage use of mercury-free alkaline manganese cylinder batteries within their borders.

China Vinyl Chloride Manufacturing Sector

Mercury is used as a catalyst in the manufacture of vinyl chloride monomer (VCM) when the process uses an acetylene hydrocarbon feedstock. Purified dried acetylene is mixed with dried hydrogen chloride gas in approximately a one to one ratio within a shell-and-tube heat exchanger reactor. The tubes are filled with a catalyst comprised of mercuric chloride impregnated activated carbon. Mercuric chloride concentrations range from 8-12% on the carbon; when they drop to approximately 5% the catalyst must be refreshed. Temperature in the reactor is kept at 150-180 degrees C, and the gases are mixed. Gaseous vinyl chloride created under these conditions flows out of the reaction vessel into subsequent columns where it is further purified. Although theoretically no mercury catalyst is consumed during this process, mercuric chloride escapes from the activated carbon matrix under typical reaction conditions and becomes entrained in the reaction gases and may subsequently escape from the process. The extent to which this mercury is captured or lost is not well understood and likely varies substantially within the industry.

[10] The current USA legal limit is 25 mg/unit, and these batteries currently contain an average of 10.8 mg mercury/unit. Maine Department of Environmental Protection, Mercury Use in Button Cell Batteries, March 2005, Table 2, p. 8.

Most of the world manufactures vinyl chloride from ethylene instead of acetylene in a completely different process that does not rely on mercury at all. To our knowledge, only China and to a lesser extent Russia (as documented in the recent Russia mercury inventory prepared under the auspices of the Arctic Council), use mercury to produce VCM resin.[11]

The use of mercury in the vinyl chloride manufacturing sector in China has not been well documented to date. For example, a recent and otherwise comprehensive inventory of anthropogenic mercury emissions in China indicates "There are rumored to be factories in China using mercury as a catalyst in the production of polyvinyl chloride (PVC), but we have found no information on those sources."[12]

As discussed below, CRC estimates that 610 tons of mercury were used in the vinyl chloride manufacturing sector in 2004. CRC estimates almost 50% of this mercury was recycled and returned to mercury suppliers for further use in China. The fate of the remaining 50% (i.e., the non-recycled mercury) is not well understood.

Accordingly, CRC estimates net use of mercury in the sector was approximately 320 tons in 2004. This extent of mercury consumption likely represents the largest current mercury demand sector within China or within any individual nation globally,[13] and it is growing rapidly. CRC reports that from 2002-2004, PVC output in China rose from 1.9693 million tons to 3.0958 million tons, an annual increase of 25.6%. As seen further below, mercury catalyst usage grew by an annual rate of 31.4% during this period.

To research mercury use in the VCM sector, CRC, in conjunction with the China Chemical Information Center (CCIC), prepared and distributed a questionnaire requesting data on production output, and mercury catalyst usage and management for the 2002-2004 period. Significantly, all 62 facilities known to be using the mercury catalysts completed and returned the questionnaire. Phone surveys of some facilities were conducted to verify the data from various size plants, and one on-site inspection was conducted.

Table 3 summarizes the results obtained from the industry questionnaire. Since the purchased catalyst contains between 8-12% mercury, CRC assumed an average 10% mercury concentration (the range mid-point) in the catalyst purchased to construct the mercury consumption estimate.

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[11] Dr. Yuri Treger, Inventory of Mercury Releases from the Russian Federation – Chemical Industry (Draft Undated Working Paper), pp. 36-39.

[12] D.G. Streets et al., Anthropogenic Mercury Emissions in China, Atmospheric Environment 39 (2005) 7799.

[13] We use the language "likely represents" in the text to account for the remote possibility that mercury consumption in artisinal gold mining could exceed 320 tons annually in one country. Since these operations are often illegal, the actual quantity of mercury used in artisinal gold mining is not well documented.

Table 3. China VCM Sector Mercury Usage, 2002-2004

Year	2002	2003	2004
Mercury catalyst usage (ton)	3548	4151	6103
Total mercury usage (ton)	354.8	415.1	610.3

Significantly, the completed questionnaires indicate there is considerable variability in mercury catalyst consumption per unit of PVC output. For example, survey data indicate there is at least an 8 fold range in catalyst utilization efficiency across all facilities, and a 7 fold range just within the smallest facilities (less than 5,000 tons capacity). Furthermore, efficiency of catalyst use did not depend strictly upon the size of the facility. This range of variability strongly suggests opportunities for improved catalyst utilization efficiency in the VCM sector.

According to the questionnaire data and the onsite interview, spent catalyst from VCM manufacture is replaced when the mercury content on the catalyst falls to about 5%. The questionnaire data indicated all 62 facilities ship the spent catalyst offsite for recycling. This practice of recycling of the catalyst is encouraged by the economics of managing spent catalysts since the VCM manufacturers are paid for their spent catalysts, and by the legal recycling requirement applicable to the catalysts as well.

CRC and CCIC identified five businesses recycling mercury catalysts in China. All five facilities reportedly recycle the mercury using a similar process. Calcium lime or caustic soda is added to the catalysts and then heated to form mercury oxide, which is then vaporized and separated into mercury and water vapors within a distillation furnace. The mercury is subsequently purified in a retort and sold to mercury suppliers.

The five catalyst recycling facilities are currently undergoing a review process in order to receive a permit from SEPA under the law governing dangerous waste recycling and disposal. Preliminary and unconfirmed data provided by the recyclers to SEPA thus far through the permitting process indicate the recyclers achieve a 95% recycling rate. Accordingly, CRC calculates the recyclers produced 289.9 tons of elemental mercury in 2004. This mercury is then sold to mercury suppliers for further use in China, including but not limited to the production of additional mercury catalyst.

Assuming the recycling figures are correct, *net mercury consumption* for the VCM sector in China (i.e., mercury in catalysts consumed less mercury recycled from the catalysts) was estimated as 320.4 tons in 2004.

Like all mercury inventories, this estimate is subject to uncertainties. Probably the largest area of uncertainty is the assumed 95% recycling efficiency of catalyst recycling. The actual recycling efficiency should become better known in the near future through the SEPA permitting process, as the companies are required to provide mercury mass balances before obtaining the permit. Soliciting information from catalyst suppliers for 2002-2004 about their annual sales of mercury catalysts would also serve as a cross-check of the catalyst consumption data obtained through the previously mentioned questionnaires.

Future mercury consumption in this sector will continue to rise dramatically without a substantial change in current practices. CRC estimates gross mercury usage (before consideration of recycling) will increase from the 610.3 tons in 2004 to over 1,000 tons by 2010 unless the industry changes in some meaningful way. Options for reducing mercury consumption include increased reliance on ethylene as a feedstock instead of acetylene, improved capture of mercury escaping during VCM manufacture, and substitution with a non-mercury catalyst if one is found to be available. Developing a method to use a coal-based feedstock to manufacture ethylene would enhance the country's ability to convert to the ethylene process in this sector.

China Domestic Mercury Production

China is one of the few countries in which primary (virgin) mercury mining is still conducted. Unlike the other mining nations, however, virtually all of China's mercury production is for domestic consumption, and thus not traded globally.

Figure 2 below provides the mercury production output from China's legal mines from 1995-2004. The sharp drop in production beginning in 1998 reflects the closure of China's largest mine at the time. During this drop in production, China relied more heavily on mercury imports, until 2002 when a 300 ton import limit was imposed (see Figure 3 below). Since 2002, domestic mercury production increased to meet China's internal demand, rising to an estimated 700 tons in 2004.[14]

[14] According to the Non-Ferrous Industry Yearbook, China's mercury production was 1140 tons in 2004, but CRC was unable to verify that number so it estimated production at 700 tons, a value more consistent with prior years.

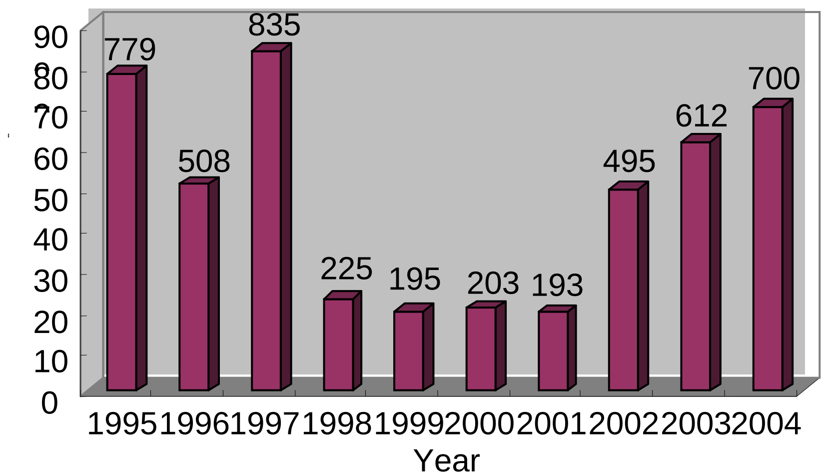

Fig.2 China's Mercury Mining Output (Legal), 1995-2004

Significantly, only one mercury mine in China currently produces more than 100 tons per year. In 2004, this mine produced 312.54 tons of mercury. This mine purportedly has an estimated remaining lifespan of only 5-6 years left, raising some question about whether China can maintain its current mercury output beyond 2010.

Figure 3 below provides the China mercury import data from 1995-2004. Mercury imports, legally capped at 300 tons annually as of 2002, was 180 tons in 2005 (all from Japan), and has averaged 233 tons/yr since the legal limit was imposed in 2002.[15] Figure 4 below represents the combined legal mining and import data, and illustrates a declining mercury supply until 2001, and then a steadily rising supply, likely reflecting decreasing consumption in the battery sector followed by rising demand in the VCM sector.

[15] The 354 MT value in 2004 appears to exceed the 300 MT legal limit, but may simply reflect delivery of mercury authorized for import in 2003.

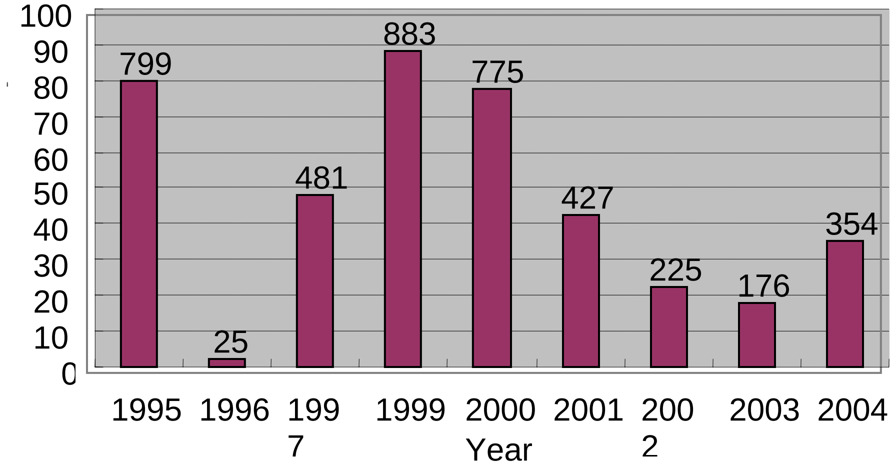

Fig. 3 China's Mercury Import Volume 1995-2004

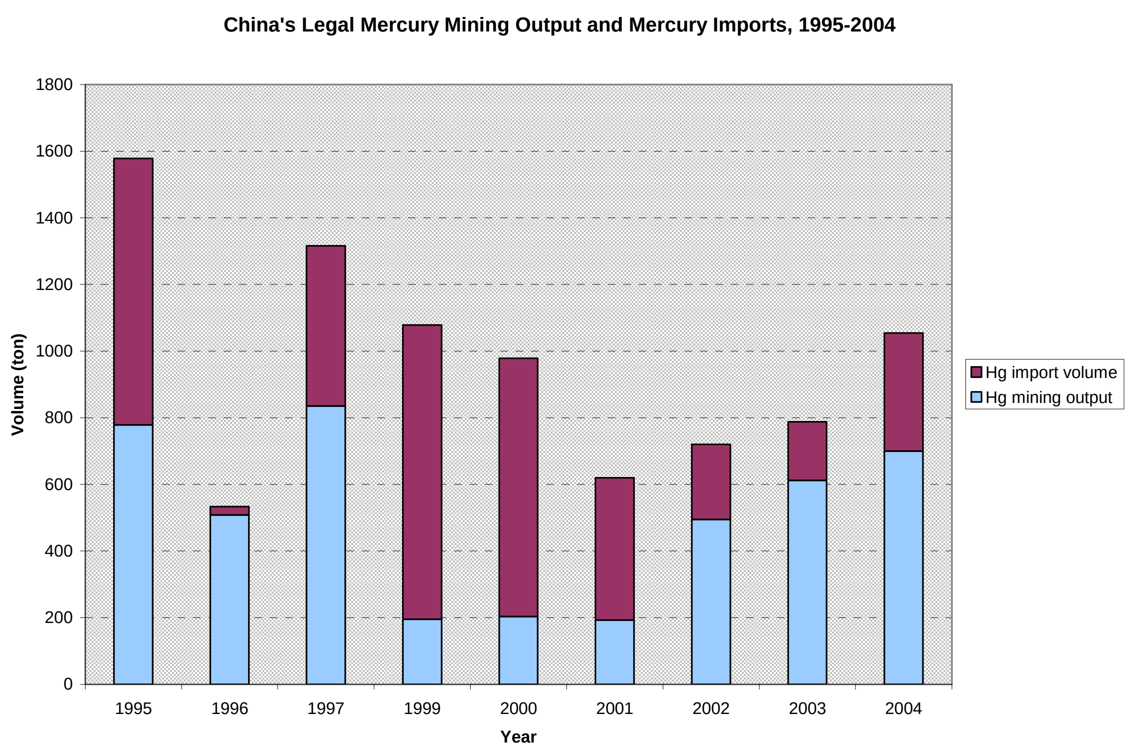

Figure 4

China's mercury supply is further augmented by illegal artisinal mercury mining, roughly estimated by CRC (based upon discussions with industry experts) to be a significant contributor at about 200 tons/yr. Finally, as noted above, mercury catalyst recyclers produced an estimated 289.9 tons of mercury in 2004. Accordingly, China's current mercury supply profile can be approximately estimated as follows:

Legal Mining	700
Imports	233
Catalyst Recycling	290
Illegal Mining	0-200
Total	1223-1423 tons

The largest areas of uncertainty in China's supply data are the legal and illegal mining outputs. There is a discrepancy of 400 tons for the legal mining 2004 output between the CRC estimate and the Industry Yearbook value. Here, the lower CRC estimate is used, because of its consistency with prior years. And the illegal mining estimate evades precision because of the nature of the activity.

Mercury Byproduct Production Worldwide

Global mercury supplies can come from four primary sources. These sources, in order of least to most environmentally problematic, are: byproduct mercury, mercury recovered/recycled from waste and products (such as those collected from pollution control devices and mercury switches in cars and appliances), mercury from decommissioned chlor-alkali plants, and primary virgin mined mercury. Byproduct mercury and mercury recovered from waste and products are preferred sources because they are, at least for the moment, inadvertent outputs that are impossible to avoid. Without collection, much of this mercury would be immediately released into the environment. Furthermore, the emissions reductions are extremely cost effective, given the US Government cost estimates of $30,000/pound of mercury emissions reduced from pollution controls at coal combustion facilities.[16] With the apparent closure of the Algerian mine, the pending EU mercury export ban and associated closure of the Almaden mine, and increasing pressures on the remaining mining nations to curb primary production, byproduct production can become an ever increasingly important source of global mercury, until demand is decreased to the point where it is no longer required.

[16] www.epa.gov/clearskies/03technical_package_sectionc.pdf.

Comprehensive and accurate estimates of global mercury byproduct production have been unavailable in the public domain to date. At best, it is possible to piece together reasonably accurate national, regional, or process information, and hope enough pieces of the puzzle can be fit together to produce a thoughtful and well-reasoned global estimate. With this challenge in mind, NRDC submits the information it has gathered on global mercury byproduct production and identifies the most significant data gaps UNEP should investigate further pursuant to preparation of the upcoming trade report.

The bulk of mercury byproduct production derives from either industrial gold production, or industrial non-ferrous metal production.

1. Industrial Gold Mining Mercury Byproduct Production

In the case of gold production, mercury is recovered prior to leaching as part of a pre-treatment step in autoclaves or roasters where the ore is oxidized at high temperatures, and the mercury is captured in air emission control devices. In addition, mercury recovery occurs after the leaching process, where the silver-gold-mercury complexes are separated from the cyanide leaching medium, either using zinc or activated carbon (and then captured in air emission mercury removal systems on carbon regeneration units). After initial capture, the mercury can be purified using retort processes.

The United Stated reported six gold mines performing mercury product recovery in 1996 (4 in NV, 1 in Utah, 1 in CA), but no quantities were provided.[17] More recent data covers six mines operated by four companies, all in the State of Nevada. For 2000-2002, the quantity of mercury produced by these four Nevada companies for resale is 35, 70, and 96.7 tons respectively (see attached).[18] One company, Barrick, accounted for about 85% of the 2002 quantity recovered for resale, and the majority of the Barrick mercury was recovered from the roasters at the site (with the mercury retort the second largest recovery source).[19]

The six Nevada mines reporting byproduct recovery likely account for the vast majority of such US production; Nevada accounts for 82% of gold produced in the USA, and this geographic area is known for significant mercury concentrations in the ore compared to other gold producing areas in the country.

[17] United States Environmental Protection Agency, Mercury Study Report to Congress, 1996, p. 4-68.

[18] Given reported Nevada byproduct production in 2000 was 35 tons, the United States Geologic Survey estimate of 120 tons of mercury byproduct production nationwide in the USA for 2000 appears too high for that year, although it may be more accurate as a current estimate. See Brooks and Matos, Mercury Recycling in the United States in 2000, USGS Circular 1198-U, 2005, Figure 1.

[19] Barrick uses the Boliden-Norzink mercury removal process on its roasters, a technology most often associated with byproduct recovery at zinc smelters, as discussed below. To NRDC's knowledge, Barrick and one other Nevada facility are the only gold mining operations worldwide where the Boliden-Norzink process has been installed.

The four companies account for 80% of Nevada gold production (2003) and 98% of this region's mercury Toxic Release Inventory (TRI) emissions (2001).

The more than doubling of Nevada mercury byproduct production between 2000-2002 reflects participation in a voluntary mercury emissions reduction program by these companies. There is no federal law or regulation requiring mercury emissions control at these gold mining sites in the United States. Instead, an expanded reporting TRI obligation for the mining industry resulted in a public admission about the amounts of mercury emitted from these facilities. The widespread concern following release of these TRI data triggered a "voluntary" program, which has reportedly reduced emissions by 82% (17,343 lbs of mercury) since the 2001 baseline year.

To ensure these mercury emission reductions remain or improve, and to extend these controls to other facilities, the State of Nevada promulgated in March 2006 a set of state regulations for precious metal mining facilities. Some key aspects of these regulations are:

1. Mercury byproduct reporting will be required under this program, so annual data from Nevada should be easier to obtain in the future.
2. The program will be implemented in phases. The first phase involves facility descriptions, monitoring and data collection. The second phase involves air pollution control selection for process units (known as Maximum Allowable Control Technology or MACT) at the facilities. MACT controls must be installed within two years from permit issuance that includes selection of the MACT technology.
3. The facilities in the voluntary program are considered Tier 1 facilities. Their phase 1 permit applications are due soon (within 90 days of the regulation effective date). MACT determinations (phase 2) are not anticipated until between 38 and 55 months of regulation effectiveness.
4. Other facilities with process units emitting mercury in significant quantities are Tier 2 facilities. Their phase 1 permit applications are due within 180 days of the regulation effective date. MACT determinations for these facilities are anticipated within the same time frame.

The link to the Nevada program is http://ndep.nv.gov/mercury/index.htm.

Byproduct recovery from industrial gold mining is also reported for Peru. The United States Geologic Survey (USGS) notes in its 2004 Mercury Commodity Report that gold mines in Peru exported mercury to the United States for processing that year.[20] According to USGS officials contacted by NRDC, at least two Peru gold mines use zinc to precipitate mercury, silver, and gold from the cyanide solution after leaching, and then recover the mercury onsite in a

[20] See http://minerals.usgs.gov/minerals/pubs/commodity/mercury/index.html#myb for access to the 2004 report.

retorting process.[21] The mercury produced onsite is 99% pure, and is sent offsite for further refinement to achieve 99.9% purity. COMTRADE data indicates Peru exports even larger quantities of mercury to Spain (but the source of this mercury is not publicly available), and mercury exports reported by Chile suggest gold mines in Chile may be similarly recovering mercury.[22] Peru and Chile together exported globally 142.56 tons of mercury in 2004.

The extent to which mercury byproduct recovery is occurring at industrial gold mines outside of the United States is the most important data gap on mercury byproduct recovery that UNEP should investigate further. NRDC suggests UNEP overlay COMTRADE mercury export data with known industrial gold mining countries and ascertain the source of the exported mercury from these countries. In addition, UNEP should obtain the cooperation of international gold mining trade associations and suggest they survey their industrial gold mining member companies to estimate global mercury byproduct production from this source. By cross-checking the two data sources, and factoring in the information above, deriving a reasonable estimate should become achievable.

2. Mercury Recovery from Non-Ferrous Metal Production

According to an EU IPPC BAT Reference Document, eight methods or processes are available in the non-ferrous metal production industry for mercury recovery in the gaseous stream. Two of these processes – the Boliden-Norzink and Outokumpu processes - lead to mercury byproduct recovery.[23]

Both processes are associated with sulfuric acid cleaning plants as part of the gaseous mercury controls for these facilities (In other words, if there is no sulfuric acid air emission controls by conversion of SO2 to sulfuric acid, there is no Hg byproduct recovery). In the Boliden-Norzink process, the gas is scrubbed after SO2 removal with a mercury chloride solution to form mercurous chloride (calomel), which is removed and ultimately sent for further processing into elemental mercury. In the Outokumpu process, the gas is washed with 85-90% sulfuric acid, which eventually precipitates a mercury-selenium sulfate sludge that is washed/filtered and sent offsite for processing into elemental mercury (selenium is separately recovered as well). Finland reports this process has a 99.5% Hg removal efficiency.

The Boliden-Norzink is by far the more important of the two systems insofar as it has been installed at about 35 facilities worldwide, while the

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[21] Personal communication between Earl Brooks, USGS and Susan Keane, NRDC, May 8, 2006.

[22] Chile has two copper smelters where the Boliden-Norzink mercury recovery systems were installed, but the company reports to NRDC that these systems are not operational at the present time. E-mail from Klas G. Hultbom, Outokumpu Technology AB, to David Lennett, NRDC, dated May 9, 2006. Therefore, the sources of the Chilean mercury exports are not known.

[23] See Reference Document on Best Available Techniques in the Non-Ferrous Metals Industries, 2001, pp. 134-135, 190. This BAT Reference Document can be found at http://eippcb.jrc.es/pages/FActivities.htm.

Outokumpu process may be limited to one smelter in Finland. However, both processes are now owned by Outokumpu.

According to company officials, even though the Boliden-Norzink process has been installed on zinc, copper, lead, and pyrite smelters around the world to reduce mercury emissions, only the zinc smelters typically encounter mercury at sufficient quantities to warrant byproduct recovery (aside from the Nevada gold production facilities as discussed above). Accordingly, discounting the non-zinc smelters, and assuming those facilities using the Imperial Smelting process for zinc and lead production have closed for economic reasons, Outokumpu officials can calculate a mercury byproduct production estimate based upon the design capacity of the units, the associated amount of gas managed in the units, and the typical mercury content of the gas. They estimate about 260 tons of mercury produced globally through the Boliden-Norzink process at zinc smelters annually, plus or minus 50% given uncertainties about individual plant operations, unit operating status, etc.[24] The 24 tons of mercury produced at the Finland smelter using the Outokumpu process in 2004 should be added to the estimate to produce an aggregate global zinc smelting mercury byproduct recovery estimate.

It is important that UNEP make the effort in the upcoming trade report to both achieve a credible estimate of current byproduct recovery and determine the extent to which such byproduct recovery can be increased globally. Byproduct mercury production can be used for any remaining critical mercury uses following anticipated EU export restrictions and other initiatives to terminate primary mercury mining and otherwise curtail the global mercury supply.

[24] E-mail from Klas G. Hultbom, Outokumpu Technology AB, to David Lennett, NRDC, dated May 3, 2006.

APPENDIX 1

2004 IMPORTS OF MERCURY OXIDE BATTERIES FROM CHINA
COMTRADE DATA – REPORTED BY WEIGHT

Country	Amount (kg)	Value
Albania	2,187	$2,990
Australia	65	$1,178
Austria	97	$1,658
Bulgaria	105,882	$348,397
Chile	2,187	$647
Macao	300	$1,801
Columbia	123,121	$64,690
Denmark	4,187	$14,498
Estonia	40	$606
Finland	3,562	$6,293
France	16,898	$50,621
Greece	57,289	$98,961
Guyana	2,375	$973
Indonesia	6,562	$6,988
Italy	1,312	$89,426
Norway	332	$7,541
Paraguay	54,093	$62,054
Poland	7	$1,345
Portugal	687	$854
S. Korea	2,687	$4,916
Slovakia	14	$646
Spain	1,687	$12,229
Switzerland	50	$9,085
UK	135,898	$211,480
Total	521,519	$999,877

APPENDIX 2

2004 IMPORTS OF MERCURY OXIDE BATTERIES FROM CHINA
COMTRADE DATA – REPORTED BY QUANTITY

Country	Amount (# batteries)	Value
Canada	7,752,924	$1,752,816
Hong Kong	5,759,896	$318,333
Japan	56,342	$12,006
Malta	20,473	$5,667
Mauritius	1,147	$2,597
Netherlands	787,778	$43,553
Pakistan	5,100	$917
S. Africa	2,460,226	$278,388
Uganda	58,600	$65,472
USA	3,398,197	$541,274
Yemen	250,800	$14,284
Total	20,551,483	$3,035,307
Mexico[25]	3,400,000	$550,927

[25] Mexico reported importing 1,203,914,101 kg of mercury oxide batteries from China in 2004. Since this weight is so extraordinary, and is likely an error, NRDC chose not to count it among the weights reported in Appendix 1. However, the value of the batteries reported, $550,927, is only slightly higher than the value of the batteries imported into the USA, $541,274. Therefore, rather than eliminating the Mexico imports entirely, it may be reasonable to assign a value of 3.4 million units imported into Mexico during 2004.