August 10, 2008

Gunnar Futsaeter
UNEP Mercury Programme, UNEP Chemicals
11-13, chemin des Anémones
CH-1219 Châtelaine
Geneva, Switzerland
By email: gfutsaeter@chemicals.unep.ch
cc:
hph@alaska.net
s.wilson@inter.nl.net

Dear Mr. Futsaeter,

The Zero Mercury Working Group (ZMWG) appreciates the opportunity to submit comments on the report entitled: UNEP Report on Atmospheric Emissions of Mercury: Inventory, Sources, and Transport, referred to hereafter as the main report, as well as the two supporting technical documents, the AMAP/UNEP Report on Sources of Mercury to the Atmosphere: Technical Background Document (referred to as the TBD), and Mercury Fate and Transport in the Global Atmosphere: Measurements, Models and Policy Implications produced by the Fate and Transport Partnership (referred to as the FTP report).

These documents will serve as important background to the upcoming UNEP Governing Council negotiations on mercury in February 2009, in Nairobi. As such, it is important that they provide a factually correct and transparent accounting of mercury emissions from the most important sources. Where there are data gaps or data inconsistencies, it is important that the authors explain clearly how they derived their estimates. Even better, the authors should provide a range of estimates where needed, to better show the impact of various assumptions on the final numbers. While the reports are commendable in their scope and objectives, we believe the final analysis falls short in its potential usefulness to stakeholders, for the reasons described in detail below.

Previously, NRDC consultant David Lennett provided comments on the products portion of the assessment (by email, 7/15/2008). The current comments supplement that submission and focus on the estimates derived for two other main sources of mercury emissions: coal combustion and nonferrous metals mining and processing (including gold mining). We also provide comments on the trends and future scenarios, as well as some minor comments on other aspects of the analysis.

General Comment

We would like to commend UNEP and the authors for putting together this wide-ranging and challenging set of analyses. This is extremely important work, and the documents represent a significant effort to give the UNEP Governing Council a sound basis for discussion as countries move forward to control mercury globally.

Nonetheless, ZMWG is concerned about several key components of the assessment: current emissions factors for key sources, including coal combustion and mining may result in an under-estimate of emissions; assumptions about the extent to which control devices are currently installed and operated are likely under-estimate emissions; and the positive impact of future control of sources is understated. These concerns are detailed below.

In addition, there are many places in the main report and associated documents where the basis for the estimate provided for a particular source is not well-explained. Because the data from which the assessment derives conclusions is in some cases quite limited, the rationale behind the data selected should be provided in substantial detail, and the influence of the assumptions on the resulting estimates explained clearly. Otherwise the credibility and usefulness of the report will be compromised.

Overall, the solution to these problems would be for the main report and associated documents to substitute ranges for point estimates. Specifically, we recommend that for each major source, the authors create both a best-case and reasonable worst-case estimate and present this range along with their selected working assumption.

1. Coal Combustion

Coal combustion is the largest source of mercury air emissions globally, by far. Estimates of annual mercury emissions from coal combustion are based on three primary data inputs: the amount of coal consumed per year, the mercury content of the coal, and the application of pollution control devices to limit mercury emissions to the air. Assumptions regarding two of these factors, mercury content of coal and the application of pollution control devices, require additional scrutiny.

The mercury content of coal is, of course, a significant driver in mercury emissions estimates. The mercury content of coal is highly variable, ranging from 0.01 and 1.5 g/tonne, as presented in Table 3.8 by the TBD (pg. 33). For countries and regions of the world where national-level expert estimates were lacking, the authors of TBD used values between 0.1 and 0.3 g/tonne for their own calculations. It is not clear how this range was derived. A better approach would be to derive best-case and worst-case calculations based on the full range of data, in order to see the effect that the variability of the data has on the estimates.

Further, the TBD (pg. 18) asserts that estimate of mercury emissions produced by Indian experts (Chapter 4 of the FTP report) was overestimated because they used a higher

concentration in coal (0.376) than is typical, and therefore re-calculated the Indian value using an assumed content of 0.3 g/tonne, which was termed "the reported geometric mean value of Hg content in coal." Please provide the citation where this value was reported. Further, because the value of 0.376 is based on actual samples from coal used at power plants in India (see Table 4.5), using a value of 0.3 instead of 0.376 would seem to underestimate possible emissions. What is the basis for dismissing the Indian coal plant data and using a value of 0.3 instead? Again, a better approach would be to present best-case and worst-case calculations, so that the influence of the assumption on the estimate would be transparent.

1.2 Prevalence and Efficiency of Pollution Control Devices

When estimating emissions, the assessment assumes that some mercury emissions are currently abated by the presence of pollution control devices on power plants and industrial sources. While these devices are generally not designed specifically for the removal of mercury, their presence results in mitigation of mercury emissions while controlling other pollutants, such as particulate matter, SO_2 and NO_X. Further, the TBD (pg. 33) asserts that these devices are "commonly used abatement measures in major electric power plants and central heating plants worldwide."

The assumptions regarding current application of abatement technologies present several problems. First, assuming the presence of such devices at most power plants worldwide seems unduly optimistic, and biases the estimate of emissions downward. Further, it is not clear how this assumption was represented in the calculations of the emissions estimates. Did the authors assume the presence of pollution control at all power and central heating plants, or at only a certain fraction of plants, or at plants above a certain capacity? Which types of devices were assumed to be in place? For example, the FTP report states that while the installed capacity of electrostatic precipitators at power plants in China is now about 95% (FTP report, pg. 40), penetration of flue gas desulfurization is much lower, and expected to be only 58% by 2010 (FTP report, pg. 44).

More importantly, the mere presence of emissions-control technology does not ensure that such technology is being used routinely. For example, according to a 2006 report by the Organisation for Economic Co-Operation and Development (OECD) concerning environmental enforcement in China,

> *"In many cases, approved and installed air and water pollution control equipment is put in operation only at times when inspectors' visits are expected, as polluters are more interested in saving on operation costs..."*[1]

Thus, the assessment should not assume that devices are in continuous operation everywhere in the world that they are installed.

[1] Organisation for Economic Co-Operation and Development, 2006, *Environmental Compliance and Enforcement in China: An Assessment of Current Practices and Ways Forward*, http://www.oecd.org/dataoecd/33/5/37867511.pdf.

Second, we are concerned about the pollution control device efficiencies assumed in the assessment. For example, the assessment assumes that electrostatic precipitators (ESPs) and fabric filters (FF) remove 30 percent of mercury. Flue gas desulfurization (FGD), which is directed at controlling SO_2, is estimated to remove 30-50 percent of mercury, with higher removal rates when these devices are combined with other systems (TBD pg 33).

These removal efficiencies do not reflect the full range of efficiencies observed even in a developed country such as the U.S. Removal efficiency had been shown to vary significantly according to site specific conditions such as the configuration of control systems employed and the type of coal burned,[2] and thus the amount of reductions may vary significantly between plants. Current estimates suggest that the most commonly used pollution control technology currently in place in the United States, cold-side ESP, has an *average* removal efficiency of 29% but with a range of 0-63% for bituminous coal. When combined with FGD the removal efficiency increases to 69% with a range of 64-74%. The removal efficiencies for subbitum and lignite coal are significantly lower, 16% and 42% respectively. Notably, there is considerable research into the development of mercury specific control technology and current estimates by the US EPA project commercial application of technologies with 60-90% removal efficiencies for all coal types and configurations of control technologies by 2010. [3]

Further, the removal efficiencies used in the assessment are based on Western data, but the applicability of these figures to developing country technologies is not known. For example, as noted in the FTP report (pg 41), the removal efficiencies of the ESP, FF and other devices of Chinese design are not known due to lack of monitoring data.

For both of these reasons, the assessment should include worst-case mercury emissions estimates that assume the absence of air pollution control for mercury, except where **mercury-specific** controls are required by law (e.g., the EU), as well as best-case estimates. By comparing these values with the current estimates presented in the assessment, readers would be able to understand the influence of the assumptions regarding pollution control on the overall emissions estimates.

Finally, the TBD also asserts that solutions directed at controlling mercury specifically (such as activated carbon injection (ACI)) are expensive and used only on a few plants. Please provide the justification for the statement that ACI is expensive. While it is true that ACI is not widely employed worldwide, the marginal cost of ACI has been shown to be relatively small in the U.S., especially if the power plant already has existing pollution control installed. A study by the National Wildlife Federation in the U.S. found that retrofitting activated carbon injection on coal-fired power plants with existing ESPs would cost an average US household from about 70 cents to a little over $2.00 a month (http://www.nwf.org/wildlife/pdfs/GettingJobDone.pdf pg 19).

---

[2] Srivastava, Ravi K., Hutson, Nick, Martin, Blair, Princiotta, Frank, and Staudt, James. Control of Mercury Emissions from Coal-Fired Electric Utility Boilers. Environmental Science and Technology. March 1, 2006.

[3] Ibid

2. Non-ferrous Metals Mining/Smelting

Non-ferrous metals mining is the second largest source of mercury emissions globally. As with coal combustion, the major drivers of these estimates are the amount of metals processed globally each year, mercury emission factors and the prevalence and efficiency of pollution control devices. As is the case with the coal combustion emissions estimates, the mercury emissions factors from these important sources are based on limited and highly variable data, and assume the presence of pollution control devices. The assessment falls short by failing to adequately document the basis for these assumptions, and by failing to present both best- and worst-case estimates that show how the assumptions affect the outcome of the assessment.

2.1 Emissions Factors

2.1.1 Gold Mining Emission Factor

As noted in the main report, both large scale industrial and small scale gold mining can result in mercury emissions. In typical large-scale gold mining, various thermal methods used to pre-process gold ore (e.g., ore roasting, autoclaves, etc) and post-process gold cyanide into dore (e.g., regeneration of carbon units, electro-winning and refining) can release mercury into the atmosphere unless it is captured[4] . These releases can be substantial, absent controls. For example, in 1998, the first year that gold mining companies were required to report their mercury emissions to the national US Toxics Release Inventory, the Jerritt Canyon gold mine in the US state of Nevada (which **does not** use Hg amalgamation to extract gold) reported releasing released 9,400 lbs (about 4 metric tons) of mercury in stack emissions, compared to average annual stack emissions of 200-400 lbs (about 0.1 to 0.2 metric tons) for coal-fired power plants in the U.S.[5] (Subsequent voluntary controls and state-level regulations have led to reduced emissions of mercury from U.S. gold mines.) Gold mines that still use Hg amalgamation for gold extraction, such as some mines in China, may have even higher emissions (see FTP, pg 51).

Unfortunately, there is insufficient information presented in the main report or associated documents to understand how emissions from this important source were derived. For example, Table 3.2 of the TBD does not present an emission factor for large scale gold mining.

ZMWG estimates that the emission factor could be as high as 16,276 g Hg per tonne of gold produced. This figure is derived by dividing total Hg air emissions from gold mining facilities reported to the Toxics Release Inventory (TRI) by U.S. gold production for the corresponding year. Gold production data are published in the U.S. Geological Survey (USGS) *Minerals Yearbook*.

---

[4] Jones, G., Miller, G., 2005. Mercury and modern gold mining in Nevada. Dept of Natural Resources and Environmental Sciences, University of Nevada, pg 13-14.
[5] Ibid, pg. 16.

Atmospheric Hg emissions reported to TRI ÷ US gold production = Hg emissions factor

The average emissions factor for the 2000 – 2005 period is 11,889 g Hg/tonne Au. The average for the 2000 – 2001 period (before pollution controls were implemented) is 16,276 g Hg/tonne Au. Controls began to be implemented in 2002. The average for the 2003 – 2005 period (after controls) is 8492 g Hg/tonne Au.

Hg air emissions factors: Applying USGS production data from 2000-2005 to TRI data for the corresponding year

Year	Hg emissions (grams)	Au production (tonnes)	Hg emissions factor (g Hg/tonne Au)
2000	5 664 879	353	16 048
2001	5 528 774	335	16 504
2002	3 964 796	298	13 305
2003	2 282 046	277	8 238
2004	2 234 954	258	8 663
2005	2 194 942	256	8 574
Average 2000 – 2005:			**11 889**
Average 2000 – 2001 (pre-control):			**16 276**
Average 2003 – 2005 (post-control):			**8 492**

The assessment must make clear what factors were used in the gold mining emissions calculations, and should explicitly present both best-case and worst-case estimates, assuming control and no-control scenarios.

From information presented in the FTP report, it appears that some emission factors used for the current emissions estimates are much lower than those calculated based on U.S. data. For example, the apparent mercury emissions factors used for South Africa gold mining are relatively low compared to the U.S. values (see FTP report, section 5.2.2.7)[6]. The South African assessment estimated a range of 0.10 - 0.93 Mg of Hg emitted from 255 Mg Au production in 2004, which gives an average emission factor of 392 to 3647 g Hg per tonne of gold produced, much lower than the US values.

Because South Africa is one of the largest producers of gold in the world, representing 11% of global production in 2006[7], it is important to ensure that the emissions from this source are not under-estimated. Unfortunately the information presented in the FTP report does not allow readers to determine if the estimate from this important source is underestimated. The South Africa estimate is based on the analysis of 459 gold particles from two sites in South Africa (Frimmel and Gartz (1991)), which found the average Hg

[6] The same section states that an average of 0.32 Mg Hg is released from Au production in that year based on the same data. In the next paragraph, the average emissions from smelting of other primary metals is given as 0.32 mg Hg a year, suggesting that the average given for gold is in error.

[7] USGS Mineral Yearbook: Gold, 2006. http://minerals.usgs.gov/minerals/pubs/commodity/gold/myb1-2006-gold.pdf

concentration to be in the range of 0.6 to 5.8 wt. %[8]. Although the authors of this study gave sufficient evidence to show that their samples were representative of gold extracted from the Witwatersrand Basin, it remains a question as to whether this deposit is also representative of the Hg concentration of all South African gold deposits. South Africa produces gold from a number of other Achaean greenstone belts that not only lie outside of the Witwatersrand Basin, but are an entirely different type of deposit[9]. The South Africa gold emissions estimate further assumes that 4 to 6% of the mercury contained in gold ore is lost to the atmosphere during gold production. The basis for this value is not at all clear. Jones and Miller (2005) is cited as one reference for the 6%, however the reference does not actually cite this number[10].

Actual measurements from thermal processes used at major gold mines in South Africa would form the best basis to confirm the emissions estimates. Absent measured emissions data, and absent a wider variety of samples from a range of gold deposits in the country combined with an accurate estimate of mercury lost to the atmosphere, the TBD should at a minimum comment on how representative the data is likely to be. For example, the document should discuss: what fraction of all gold mined in South Africa does this deposit represent? How might this deposit differ from others in terms of mercury content, based on the geology? What are the thermal processes at South African goldmines that could release mercury? What do data from measured emissions at other gold mines suggest about the amount of mercury lost during these thermal processes?

2.1.2 Zinc Smelting and Other Nonferrous Metals Smelting Emission Factors

There are substantial differences between the current and previous estimates of mercury emissions from zinc smelting in China. The FTP report uses emissions factors from Feng et al (2004)[11] and Li (2007)[12] to calculate mercury emissions from zinc smelters, while previous estimates had used values from Streets et al (2005)[13]. Table 3.2 summarizes the factors used from Feng et al. (2004) and Li (2007); the table shows mercury emissions for zinc processing ranging from 5.7 to 155, depending on the process. It is notable that the range of emission factors reported by Streets et al. (2005), from 13.8 to 156.4, is not substantially different from the Feng et al (2004) and Li (2007) values. Rather, the difference in the resulting mercury emissions estimates appears to stem from assumptions

[8]Frimmel, H.E. and Gartz, V.H. (1997). Witwatersrand gold particle chemistry matches model of metamorphosed, hydrothermally altered placer deposits. *Mineralium Deposita*, 32: 523-530.
[9] "South Africa – Mining: Gold Mining", http://www.mbendi.co.za/indy/ming/gold/af/sa/p0005.htm
[10] This was confirmed through personal communication with Dr. Miller 8/07/08.
[11] Feng, X., Li, G., Qiu, G., 2004. A preliminary study on mercury contaminations to the environment from artisanal zinc smelting using indigenous method in Hezhang county, Guizhou, China. Part I mercury emissions from zinc smelting and its influences on the surface water. Atmospheric Environment 38: 6223-6230.
[12] Li, G, 2007. Mercury emissions from zinc smelting in China and environmental impacts, PhD thesis, Institute of Geochemistry, Chinese Academy of Sciences, pp1-110.
[13] Streets D.G., J. Haob, Y. Wuc , J. Jiangb, M. Chand, H. Tianb, and X. Feng (2005) Anthropogenic mercury emissions in China, *Atmospheric Environment* 39 (2005) 7789–7806.

regarding (a) the distribution of zinc production across the different types of smelting, and (b) the presence and efficiency of a "mercury removal device."[14]

Similar to coal combustion, page 8 of the main report states: "Today, most major non-ferrous metal smelters use pollution control mechanisms similar to those in power plants, with similar rates of mercury removal. Smaller operations, particularly in the developing world, are unlikely to use any emissions-control technology." Furthermore, according to the TBD, "…all major thermal non-ferrous metal smelters employ ESPs and FGDs, working with efficiencies comparable with those for noted for [*sic*] energy production."[15] There appears to be no basis for this assumption. The assessment should instead present an estimate of what emissions would be absent such devices, as well as with such devices, in order to bound the potential emissions.

It is also notable that the mercury emission factor for zinc production in India was assumed to be 8 g/tonne (see FTP, pg 63). This value is on the lowest end of the range of values reported for China, and is consistent with the use of a mercury removal device. Again, an upper-bound estimate should be calculated assuming no removal device, unless it is known with certainty that the smelter(s) in India routinely use such devices.

2.2 Overall Emissions Estimates from Non-ferrous Metals Mining and Smelting

The table on page 9 of the main report ("*Proportion of global anthropomorphic emissions of mercury to air in 2005 from various sectors"*) gives an estimate of mercury emissions from non-ferrous metals production in 2005 of 140.0 tonnes (or 7 percent of world emissions). This figure may underestimate emissions from this sector.

According to the TBD the mercury emissions factors used for copper, lead and zinc smelters were 5.0, 3.0 and 7.0 g Hg/tonne metal produced, respectively.[16] These are roughly consistent with those estimated by Pacyna and Pacyna (2002) for the countries of Europe, North America and Australia (industrial countries): 5.6, 3.0 and 7.6 g Hg/tonne metal produced for copper, lead and zinc.[17] However, the TBD has applied these factors to all countries – industrial and developing – where national-level estimates were not prepared.

---

[14] It is not stated what happens to the mercury that is collected using these devices.

[15] Arctic Monitoring and Assessment Programme, and United Nations Environment Programme, 2008, *AMAP/UNEP Report on Sources of Mercury to the Atmosphere, Technical Background Document, Draft for Review* [20 June 2008 draft], http://www.chem.unep.ch/MERCURY/Atmospheric%20Emissions/UNEP%20Technical%20background%20document%20REVIEW%20Draft%20-%2020%20June%202008.pdf.

[16] Arctic Monitoring and Assessment Programme, and United Nations Environment Programme, 2008, *AMAP/UNEP Report on Sources of Mercury to the Atmosphere, Technical Background Document, Draft for Review* [20 June 2008 draft], http://www.chem.unep.ch/MERCURY/Atmospheric%20Emissions/UNEP%20Technical%20background%20document%20REVIEW%20Draft%20-%2020%20June%202008.pdf.

[17] Pacyna, E.G., and J.M. Pacyna, Global Emission of Mercury from Anthropogenic Sources in 1995, *Water, Air, and Soil Pollution* 137: 149–165, 2002.

Another approach would be to calculate emissions from developing countries using the emissions factors calculated by Pacyna and Pacyna (2002) for countries in Africa, Asia and South America (developing countries): 10.0 and 20.0 g Hg/tonne of metal produced for copper and zinc. Pacyna and Pacyna (2002) give an emissions factor of 3.0 g Hg/tonne lead produced for all countries; however the FTP report estimates for China and India both use 43.5 g/tonne, based on Jiang (2004). Furthermore, Streets et al. (2005) calculated an emissions factor for zinc production in China of 86.6 g Hg/tonne zinc.[18] Applying these emissions factors to copper, lead and zinc production in developing countries may produce a more realistic upper-bound estimate of mercury emissions from the non-ferrous metals smelting sector. The ZMWG has previously estimated these values, as noted in Table 1.7 of the FTP document; details on updated calculations, assuming a developing country lead smelting emissions factor of 43.5 g/tonne, are given in Appendix A. Our calculations show a range from 156 to 611 tonnes per year.

The main report (page 9) and TBD (page 40) give a total of 111.7 tonnes for emissions from industrial scale gold production. The source of this estimate is not clear based on information presented in either of these documents. Multiplying world production of gold for 2005 (2,470 tonnes Au) by the average emissions factor of 8492 g Hg/tonne Au obtained under the U.S. emissions control scenario results in an estimate of global mercury emissions from gold mining of 21 tonnes Hg. Applying the emissions factor obtained under the no-control scenario (16276 g Hg/tonne Au) to world gold production would result in total mercury emissions of 40 tonnes. Thus the fact that the assessment estimates 111.7 tonnes is puzzling, especially in light of the fact that the assessment uses a lower emissions factor for South African gold than the US values. Some industrial scale gold mining may still be done using Hg amalgamation for gold extraction, a process which has much higher emissions factors, but it is not clear what fraction of the total emissions are contributed by this type of mining. As with other sources, the authors should present a transparent set of calculations with a best- and worst-case estimate for these emissions.

For emissions from artisanal and small scale gold mining (ASGM), the table on page 9 of the main report shows a total of 330 tons Hg air emissions per year; however, Chapter 6 of the FTP report, from which the figure is derived, estimates around 400 tons of mercury per year from this source, because of latent air emissions of mercury from ASGM releases to water and land. The main report should be changed to reflect the 400 tonne figure. Chapter 3 of the FTP report notes that China has an official ban on artisanal gold mining, and that emissions from this practice have thus declined. This statement is contradicted by data presented in Chapter 6 of the same document, which cites the work of Gunson (2004)[19] who estimated between 237 and 652 tons released from this practice in China, despite the ban.

[18] Streets D.G., J. Haob, Y. Wuc , J. Jiangb, M. Chand, H. Tianb, and X. Feng (2005) Anthropogenic mercury emissions in China, *Atmospheric Environment* 39 (2005) 7789–7806.

[19] Gunson, A.J., 2004. Mercury and Artisanal and Small Scale Gold Miners in China. MASC Thesis. Dept.Mining Engineering, University of British Columbia, Vancouver, Canada, 154 pp.

3. Trends in Mercury Emissions

The main report presents a discussion of trends in mercury emissions during two historical periods: prior to 2000, and 2000-2005 and, quite surprisingly, concludes that trends are downward since 2000. While the main report notes that meaningful comparisons between 2000 and 2005 emissions figures are difficult, because of changes in the way that the emissions were calculated, nonetheless, the main report asserts that part of the changes may actually reflect an apparent decline in emissions, due to emissions controls put into place for some sources for some regions, such as the EU.

ZMWG does not find this conclusion credible. It defies belief that reductions in emissions from a handful of countries responsible for a small percentage of coal combustion could possibly offset the dramatic worldwide growth in major industrial activities that emit mercury, such as coal combustion, cement production, and metal smelting in China and India and elsewhere in the world (see Tables 1-3).

Table 1.[20] Trends in global coal production between 2000 and 2005.

Source	2000	2005	Delta	% change
U.S.	569	574.2	5.2	0.9
India	144.2	184.4	40.2	21.8
China	667.4	1088.8	421.4	38.7
EU	316.2	311.3	-4.9	-1.6
World	2340.4	2892.4	552	19.1

Values are given as millions of tons oil equivalent.

Table 2.[21] Trends in global cement production between 2000 and 2005.

Source	2000	2005	Delta	% change
U.S.	89,510	100,903	11,393	11.3
India	95,000	145,000	50,000	34.5
China	583,190	1,038,300	455,110	43.8
World	1,643,000	2,310,000	667,000	28.9

Values are given as millions of tons oil equivalent.

Table 3.[22] Trends in global zinc production between 2000 and 2005.

Source	2000	2005	Delta	% change
U.S.	371,000	309,000	-62,000	-20.1
India	201,000	293,000	92,000	31.4
China	1,920,000	2,800,000	880,000	31.4
World	9,050,000	10,700,000	1,650,000	15.4

Values are given as millions of tons oil equivalent.

[20] BP Coal Consumption
http://www.bp.com/sectiongenericarticle.do?categoryId=9023786&contentId=7044482
[21] USGS Mineral Yearbooks, Cement: 2000, 2005.
http://minerals.usgs.gov/minerals/pubs/commodity/cement/index.html#myb
[22] USGS Mineral Yearbooks, Zinc: 2000, 2005.
http://minerals.usgs.gov/minerals/pubs/commodity/zinc/index.html#myb

Furthermore, the Energy Information Administration projects that global coal consumption will continue to increase at an annual rate of 2.5% through 2030.[23] This includes a positive rate of growth for every region, lead by the 4.2% annual rate predicted for China, which is already the leading consumer of coal in the world. We urge the authors to review of the basis for this conclusion, and provide documentation for any assertion that there has been any true reduction in global emissions not attributable to simple changes in calculation methodologies.

4. Future Scenarios

An important aspect of this assessment is the prediction of mercury emissions under future no-control and control scenarios for mercury. The assessment predicts that under the status quo scenario, in 2020 mercury emissions will be 1900 tonnes; under an "extended control" scenario, emissions will drop to 970 tonnes, and under a "maximum control" scenario, emissions will drop to 750 tonnes. The predicted declines in emissions are due primarily to assumed reductions in coal burning and more required control technology, especially in China[24].

The main report underplays the significance of reductions achieved in the control scenarios, because the declines are compared to 2005 levels of mercury emissions. When compared to 2005, the emissions levels in 2020 represent declines of one-third to one-half in global emissions. However, the more relevant comparison is to mercury emissions under the status quo scenario in 2020 – in other words, what will happen to mercury emissions if the global community works intentionally to control mercury emissions, compared to taking no action? When compared to predicted 2020 emissions under the status quo, the "extended control" scenario reduces emissions by one-half, and the "maximum control" scenario reduces emissions by two-thirds.

A notable missing element from the estimate of future scenarios is artisanal and small scale gold mining (TBD pg 15). This is a serious omission, because this sector is growing rapidly, and inaction on reducing mercury use in this sector is likely to result in significantly higher emissions in the future. Because the price of gold is now hovering around $1000 per ounce, the number of ASGM gold miners worldwide has increased dramatically.[25] Note that ASGM already accounted for about 400 tons of mercury emissions in 2005, when the price of gold was around $450 per ounce.[26] Without action to prevent the further spread of the use of mercury in this practice, in particular, absent restrictions on the trade of excess mercury that keeps mercury cheap and available, the world is likely to see continued substantial, unabated emissions from this sector.

---

[23] "World coal consumption by region, reference case, 2003-2030." http://www.eia.doe.gov/oiaf/ieo/pdf/ieoreftab_6.pdf

[24] We note that, given the existing data from US coal plants, there is reason to believe that the assumption of a mercury removal efficiency of 74% for a combined ESP and FGD,[24] without mercury-specific controls, used to project future mercury emissions in China may be an over-estimate. This number represents the high end of what has been measured in US plants for bituminous coals. Lower rank coals and site-specific variations have resulted in significantly lower removal efficiencies.

[25] Stalbum, A., 2008. "Big increase in illegal gold mining as price rockets." Thomson Reuters

[26] "Gold price news: 2005 gold price", http://goldprice.org/news/2006/01/2005-gold-price.html

Finally, the assessment notes that "even if mercury supply is decreased, illegal trade may replace this mercury and new or previously active mines may resume." (TBD pg. 60). This assertion ignores the fact that the restrictions on global mercury supply can be complemented by an active global campaign to disseminate non-mercury gold recovery techniques among small scale mining communities. These non-mercury techniques can not only enhance gold recovery, but also directly benefit the health of miners and their families.

In summary, the failure to address ASGM in the future scenarios means that the assessment ignores the significant contribution this sector left unabated could have to future emissions. At the same time, the assessment is overly pessimistic about the potential influence that restrictions on trade, coupled with a meaningful worldwide technical assistance campaign, could have on curtailing these emissions. The main report should reflect the conclusions of Chapter 6 of the FTP report, namely that a 50-60 percent reduction in mercury use in the ASGM sector could be achieved through realistic intervention efforts within 10 years (pg 97).

5. Other Emission Sources

5.1 Vinyl Chloride Monomer and Other Coal-to-Chemicals Processes

One potentially important source of mercury emissions is not estimated in the document: emissions from the production of vinyl chloride monomer (VCM). While the document notes that VCM is a one of the largest consumers of mercury because of its use of a mercury catalyst, it does not provide any quantitative estimate of emissions from this practice. NRDC has reported that as much as half the mercury used annually in this sector is lost, and a reasonable worst case assumption would be that it is lost as air emissions, because the process runs so hot that escape through volatilization is quite likely. The NRDC estimate for this sector for 2004 was about 320 tons per year and is expected to grow[27].

Further, the same process that produces VCM using a mercury catalyst also uses coal as a feedstock to create acetylene from which the VCM is derived. (Elsewhere in the world polyvinyl chloride (PVC) is derived from ethylene that is based on petroleum feedstocks rather than coal.)

The production of VCM using coal feedstock is only one example of the burgeoning coal-to-chemical sector in China, where coal is used as a basic feedstock for organic chemicals manufacturing, especially as basis of methanol-to-olefins (MTO) technology.

It is unclear if the current mercury emissions estimates from coal combustion include consideration of coal as feedstock, rather than only the use of coal as fuel. The proportion of coal used for the feedstock can be substantial in a coal-to-chemicals

[27] http://www.chem.unep.ch/MERCURY/Trade%20information/NRDC-UNEPTRADESUBMISSIONMAY2006.doc, pg 11.

process. In South Africa, where the use of coal as a chemical feedstock is common, 70% of coal used to make liquid fuel is gasified to create syngas; only 30% is consumed as fuel (FTP report, pg 88).

Because of the growing importance of the coal-to-chemicals sector, the assessment should include an estimate of mercury emissions associated with coal gasification and other processes used in that industry.

5.2 Primary Mining

The FTP report (pg 20) incorrectly states that Algeria and Spain are engaged in primary mining of mercury. Neither of these countries is currently producing virgin mercury. The world's biggest mercury mine, in Almadén, Spain, stopped all mining and processing of primary mercury ores in 2003, and is not expected to restart in large part due to the anticipated EU mercury export ban. Algeria apparently closed its mercury mine at the end of 2004, in light of continuing technical problems, notwithstanding increased mercury prices.[28]

6. Conclusion

The control of global mercury pollution has been part of deliberations of the UNEP Governing Council since the early part of this decade. The time is now ripe for decisive action on mercury, and this emissions report will form an important basis for choosing the most appropriate actions. Because of its key role in the debate, it is vital that this work provide a rich description of the possible magnitude current emissions of mercury globally, including presentation of emissions estimates under the best and worst case for all important sources, so that decision makers can understand the full range of potential impacts of controls on various sources. Further, the assumption of widely used, fully functioning mercury abatement devices should be tempered by the reality of uneven application and enforcement of these requirements across the globe. Finally, the future scenarios analysis should present the most relevant information for decision makers, that is, an estimate of the potential magnitude of future mercury emissions absent concerted global action, compared to the reductions that could be achieved through coordinated, aggressive measures by all countries worldwide, to reduce health and environmental threats from this dangerous pollutant.

Appendix A

ZMWG calculated a best estimate of world mercury emissions for primary production of the non-ferrous metals zinc, copper and lead of 532 tonnes for the year 2004 (low- and high-end estimates were 156 tonnes and 611 tonnes, respectively). Emissions from secondary production were not calculated. This estimate was calculated by obtaining production figures for zinc, copper and lead for 2004 from the U.S. Geological Survey *Minerals Yearbook*. Published emissions factors were obtained from the scientific literature and applied as detailed below for each metal. Low-end and high-end emissions

[28] Summary of Supply, Trade and Demand information on mercury, requested by UNEP GC Decision 23/9, November 2006, p.26

estimates were calculated for zinc and copper by applying lower and higher published emissions factors in Pacyna and Pacyna (2002). Low and best/high end estimates were calculated for lead based on a low lead smelting emissions factor from Pacyna and Pacyna (2002) and on a higher lead smelting emissions factor from Jiang (2004)[29]. Countries were considered "developed" (industrial) for the purpose of applying emissions factors in these calculations based on country classifications in the CIA *The World Factbook*.[30]

Estimates of world mercury emissions from zinc, copper and lead production, 2004				
Type of estimate	**Mercury emissions (tonnes)**			**Total mercury emissions (tonnes)**
	Zinc	**Copper**	**Lead**	
Best estimate	274*	116	142	**532***
Low-end estimate	68.5	78	9.8	**156.3**
High-end estimate	330	139	142	**611**

*Applying the same emissions factor to Chinese zinc production that was applied to all other developing countries (instead of the country-specific emissions factor estimated by Streets et al. (2005)) would produce an estimate of world mercury emissions from zinc production of 124 tonnes. In this scenario, total mercury emissions from zinc, copper and lead production would be approximately 250 tonnes.

A. 1. Copper

Best estimate
The best estimate of mercury emissions from primary copper production was calculated by multiplying 2004 production figures obtained from the U.S. Geological Survey (USGS) *Minerals Yearbook*[31] for each country by the following emissions factors:

- 10 g Hg/tonne Cu for developing countries[32]
- 5.6 g Hg/tonne Cu for industrial countries[33]

The best estimate for mercury emissions from copper production is **116 tonnes.**

Low-end estimate
The low-end estimate was calculated by applying the industrial country emissions factor of 5.6 g Hg/tonne Cu *to all countries*. The low-end estimate for mercury emissions from copper production is **78 tonnes.**

High-end estimate
The high-end estimate was calculated by applying the developing country emissions factor of 10 g Hg/tonne Cu *to all countries*. The resulting high-end estimate is **139 tonnes** of mercury emissions.

[29] Cited as Jiang 2004 in Chapter 3 of the FTP report. However, the bibliography does not contain a reference for this citation.

[30] CIA, *The World Factbook*, 2006, Appendix B, https://www.cia.gov/cia/publications/factbook/

[31] U.S. Geological Survey, *Minerals Yearbook*, http://minerals.usgs.gov/minerals/pubs/myb.html.

[32] Pacyna, E.G., and J.M. Pacyna, Global Emission of Mercury from Anthropogenic Sources in 1995, *Water, Air, and Soil Pollution* 137: 149–165, 2002.

[33] *Id.*

Estimates of world mercury emissions from primary copper production, 2004			
Estimate type	**Emissions factor (g Hg/tonne Zn)**		**Mercury emissions (tonnes)**
	Developing countries	**Industrial countries**	
Best estimate	10	5.6	116
Low-end estimate	5.6	5.6	78
High-end estimate	10	10	139

A. 2 Lead

Low-end estimate
A low-end estimate of mercury emissions from primary lead production was calculated based on the 2004 lead production figures reported in the USGS *Minerals Yearbook* and by applying the emissions factor of 3.0 g Hg/tonne Pb in Pacyna and Pacyna (2002) *to all countries*. Note that only total lead production figures were available for Bolivia, Kazakhstan, North Korea, and Russia. Primary lead production for these countries was estimated by multiplying their total production by a factor of 0.5, based on the ratio of primary to total production in other countries. The low-end estimate of mercury emissions from lead production in 2004 is **9.8 tonnes.**

Best to high-end estimate
The best to high-end estimate was calculated by applying a lead smelting emissions factor of 43.6 g Hg/tonne Pb derived for China by Jiang (2004), to *all developing* countries, and a factor of 3.0 g Hg/tonne Pb for industrial countries. The resulting best to high-end estimate is **142 tonnes** of mercury emissions.

Estimates of world mercury emissions from primary lead production, 2004			
Estimate type	**Emissions factor (g Hg/tonne Pb)**		**Mercury emissions (tonnes)**
	Developing countries	**Industrial countries**	
Low-end estimate	3.0	3.0	9.8
Best to high-end estimate	43.6	3.0	142

Zinc

Best estimate
Calculations of a best estimate of mercury emissions from worldwide primary zinc production were made by multiplying 2004 primary production obtained from the USGS *Minerals Yearbook* for each country by the following emissions factors:

- 20 g Hg/tonne Zn for developing countries (Pacyna and Pacyna, 2002)[34]
- 7.6 g Hg/tonne Zn for industrial countries (Pacyna and Pacyna, 2002)[35]

[34] Pacyna, E.G., and J.M. Pacyna, Global Emission of Mercury from Anthropogenic Sources in 1995, *Water, Air, and Soil Pollution* 137: 149–165, 2002.

- 86.6 g Hg/tonne Zn for China (Streets et al., 2005)[36]

For those developing countries for which only total zinc production figures were available, primary production was estimated by multiplying total production by 0.9 based on the fraction of primary to total production observed for other countries in the USGS data. Primary production for industrialized countries for which only total production was reported was estimated by multiplying total production by a factor of 0.75 based on the average of the fractions of primary to total production observed in the United States and Japan. Primary zinc production in 2004 was estimated to be 9,013,139 tonnes. The resulting best estimate of mercury emissions from primary zinc production was **274 tonnes.**

Low-end estimate

A low-end estimate was calculated by applying the industrial country emissions factor of 7.6 g Hg/tonne Zn *to all countries*. The result is a low-end estimate of **68.5 tonnes** of mercury.

High-end estimate

The high-end estimate was calculated by applying the developing country emissions factor of 20 g Hg/tonne Zn obtained from Pacyna and Pacyna (2002) *to all countries except China*. The country-specific emissions factor of 86.6 g Hg/tonne Zn obtained from Streets et al. (2005) was applied to Chinese zinc production. Based on these factors, the high-end estimate of mercury emissions from worldwide primary production of zinc is **330 tonnes**.

Estimates of world mercury emissions from primary zinc production, 2004

Estimate type	Factor used to estimate primary production*		Emissions factor (g Hg/tonne Zn)			Mercury emissions (tonnes)
	Developing countries	Industrial countries	Developing countries	Industrial countries	China	
Best estimate	0.9	0.75	20	7.6	86.6	274**
Low-end estimate	0.9	0.75	7.6	7.6	7.6	68.5
High-end estimate	0.9	0.75	20	20	86.6	330

*When only total production data were available for a country, a factor of primary-to-total production was applied to estimate primary production. The factor for developing countries without primary production figures was 0.9 based on the fraction of primary to total production observed for other countries in the USGS data. The factor for industrialized countries was 0.75 based on the average of the fractions of primary to total production observed in the United States and Japan.

**Applying a 20 g Hg/tonne zinc to Chinese zinc production, as to other developing countries, would produce an estimate of world mercury emissions of 124 tonnes.

[35] *Id*.

[36] Streets D.G., J. Haob, Y. Wuc , J. Jiangb, M. Chand, H. Tianb, and X. Feng (2005) Anthropogenic mercury emissions in China, *Atmospheric Environment* 39 (2005) 7789–7806.