Mercury flows in Europe and the world:

The impact of decommissioned chlor-alkali plants

-- Draft final report 22 August 2003 --

Executive summary

Purpose of this report – impact of mercury from the chlorine industry

As stated in the project documents, the key objectives of this investigation were:

1. to get as good a picture as possible of the current mercury flows in Europe and the world; and

2. to get an idea of what impact the mercury obtained from decommissioned European mercury-based chlor-alkali plants might have on the world mercury market, and the resulting consequences in terms of mercury use patterns.

Mercury cell chlor-alkali plants and chlorine production capacities in Western Europe, 2001				
Country	Mercury-cell process		Total chlorine capacity ('000 tonnes)	Mercury cell process as a percent of total capacity
	Number of installations	Chlorine capacity ('000 tonnes)		
EU & EFTA countries				
Austria	0	0	55	0%
Belgium	3	550	752	74%
Finland	1	40	115	35%
France	7	874	1686	52%
Germany	10	1482	3972	37%
Greece	1	37	37	100%
Ireland	0	0	6	0%
Italy	9	812	982	83%
Netherlands	1	70	624	11%
Portugal	1	43	89	48%
Spain	9	762	802	95%
Sweden	2	220	310	71%
United Kingdom	3	856	1091	78%
EU total	**47**	**5746**	**10521**	**55%**
Norway	0	0	180	0%
Switzerland	3	104	104	100%
EU+EFTA total	**50**	**5850**	**10805**	**54%**
Accession countries				
Bulgaria	1	105	105	100%
Czech Republic	2	183	183	100%
Hungary	1	125	125	100%
Poland	3	230	460	50%
Romania	1	88	633	14%
Slovak Republic	1	76	76	100%
Turkey	0	0	168	0%
Accession countries total	**9**	**807**	**1750**	**46%**

This analysis is intended to support policy recommendations that will appear in the European Commission Mercury Strategy, which should also contain the main elements of a sustainability impact assessment (SIA), to be published in 2004 under the lead of the Commission's Directorate General for Environment, DG Environment. The SIA needs to consider, among other things, such questions as whether there appears to be any increased environmental, health or other social risk due to the diffusion of mercury from decommissioned mercury cell chlor-alkali plants.

Background – decommissioning of chlor-alkali plants

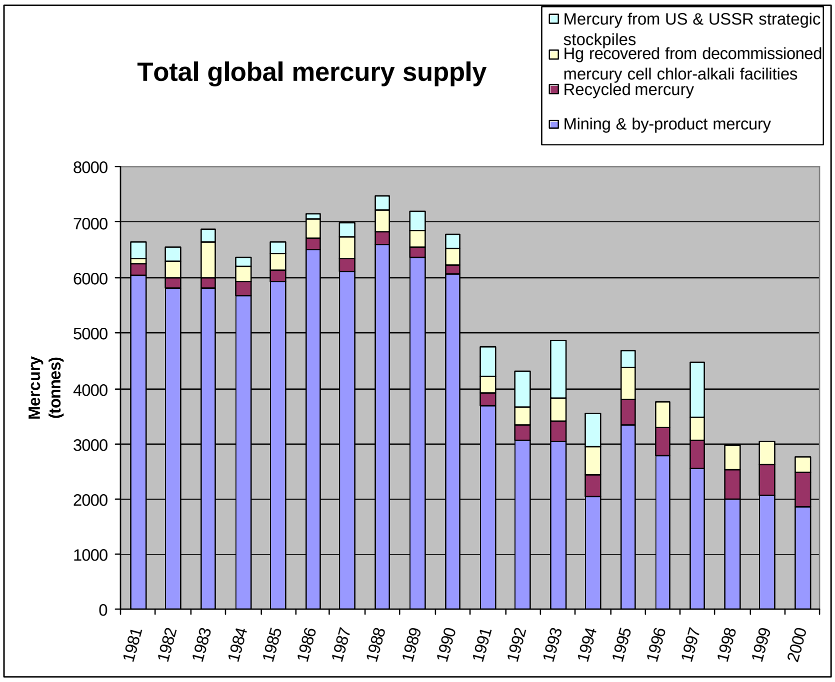
In the last 15 years at least 34 sites in the Netherlands, Germany, United Kingdom, Finland, France, Sweden, Norway, Italy, Portugal, Belgium, Spain, Austria and Denmark have shut down all or part of their mercury-cell production processes. These decommissioned installations have either re-used the residual mercury in other operating mercury-based chlor-alkali installations, in order to make up for mercury lost to air, water, products and waste during operation, or they have sold the residual mercury on the open market.

In the EU and EFTA there are presently about 50 operating mercury cell chlor-alkali plants, with a combined chlorine production capacity of 5.8 million tonnes per year. According to a Euro Chlor members' estimate (Euro Chlor, 2002c), they will all be decommissioned and/or converted to an alternative mercury-free process by 2020, along with a number of other mercury cell chlor-alkali plants in the US and elsewhere. Considering only the European mercury cell chlor-alkali plants, this decommissioning activity will release some 12 thousand tonnes of relatively pure process mercury, and nearly all of the mercury will end up on the international mercury market, since industry's only obligation about how to dispose of it is a Euro Chlor sponsored agreement that it should be purchased from industry by an "established mercury producer," i.e., for all intents and purposes, the Spanish mercury mining and trading company, MAYASA.

Euro Chlor's 2020 estimate for mercury cell chlor-alkali plant phase-out is not supported by all parties. The chlor-alkali industry is covered by the IPPC Directive, which requires installations to have permit conditions based on best available techniques (BAT). The mercury-cell process is not considered to be BAT for the chlor-alkali sector. The IPPC Directive states that existing installations should operate in accordance with the requirements of the Directive by 30 October 2007. Alternatively, a number of EU countries have announced that their mercury cell chlor-alkali plants will be decommissioned and/or converted to mercury-free technology by 2010, in line with a more flexible interpretation of the IPPC Directive, as well as a previous OSPAR Decision.

Context – mercury market structure

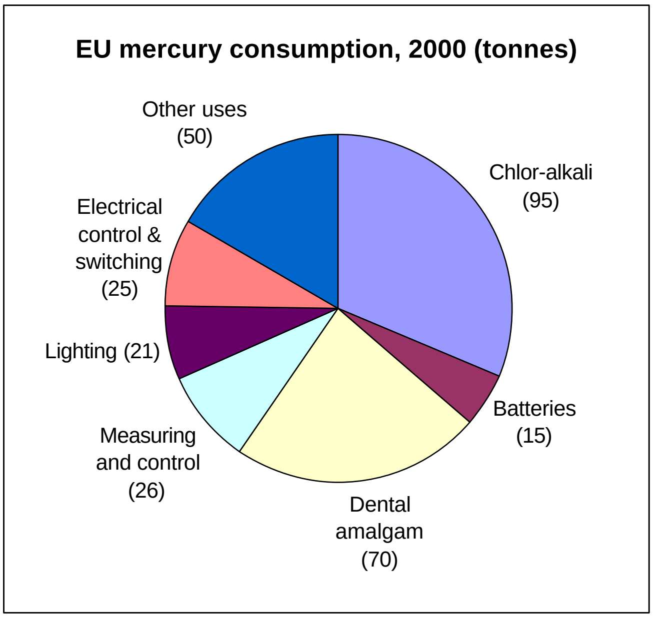
The approach taken in this analysis was to understand as well as possible the different facets of the EU and global mercury markets - imports, exports, supply , demand, key players, prices, etc. Then a "baseline" scenario was developed, along with two possible variations on that scenario, to suggest at what rate residual mercury from decommissioned mercury cell chlor-alkali plants might come onto the market. Finally, the impact of each of those scenarios on the international mercury market was assessed.



Global mercury **supply** to the markets is dominated by three main nations that mine mercury for export (Spain, Kyrgyzstan and Algeria), and China, which has long supplied its own robust home market. Both Spain and China may be in the process of closing their mines, especially as other sources seem to be growing, and mercury remains so inexpensive on the international market.

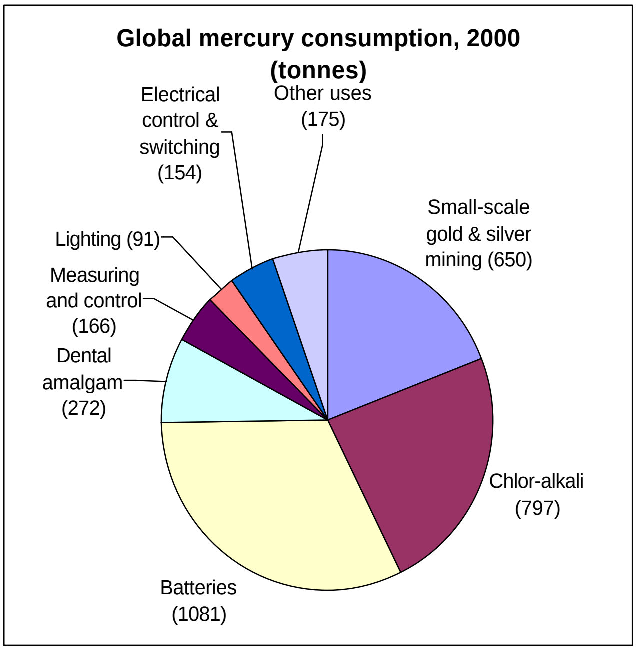
Due to an influx of stockpile mercury, first from the US, and then from the USSR in the early 1990s, and more frequent closure and release of mercury inventories from mercury cell chlor-alkali plants since the 1980s, combined with increasing recovery/recycling of secondary mercury, there has been a relative surplus of mercury on the market during the last ten years, holding prices down and fuelling speculation. This has led to declines in most mine output, and closure of any but the lowest cost (or State-owned) operations. As calculated for this paper, the mercury supply from 1994-2000 has averaged 3600 tonnes per year, and from 1996-2000 the average has been about 3400 tonnes per year, which one could take as a rough estimate of global mercury supply in 2000.

Demand for mercury has long been widespread but never completely understood. Just when analysts believe they have developed an understanding of the markets, another surprise seems to await them – increased use of mercury in artisanal gold mining (which mostly bypasses formal record keeping), mercury in toys, mercury in lighthouses, mercury in cosmetics or paints, uses that were thought to have been largely phased out, etc.

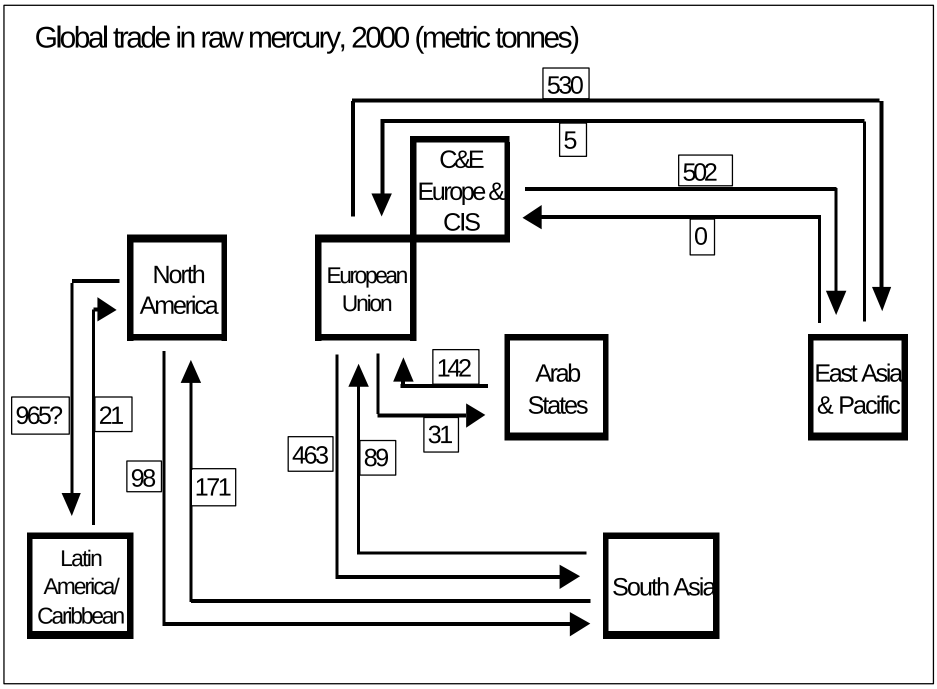


Mercury demand has been dominated by a range of products and processes over the years, but recently it is mostly used in the chlor-alkali industry, small-scale gold mining, dental amalgams, switches and relays, measuring equipment, lighting, etc., as well as a significant continued use in batteries. At the same time, it is found in a dizzying array of other uses, such as some 1000 homeopathic products identified by the US Food & Drug Administration, not to mention spiritual cleansing rituals, etc. Despite the wide range of applications, demand for mercury continues to decline overall, and the general market surplus persists.

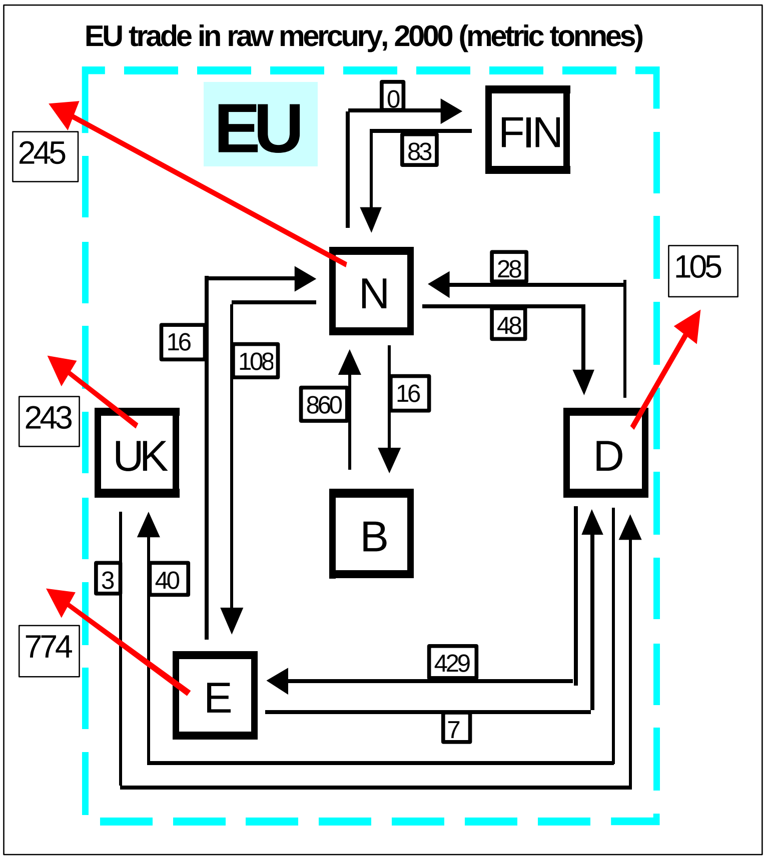
Through all of the above, especially in light of gradually increasing scrutiny and regulation, the global demand for mercury has declined from over nine thousand tonnes annual average in the 1960s, to over eight thousand tonnes in the 1970s, to just under seven thousand tonnes in the 1980s, down to an average of around four thousand tonnes in the 1990s, and well below that today.



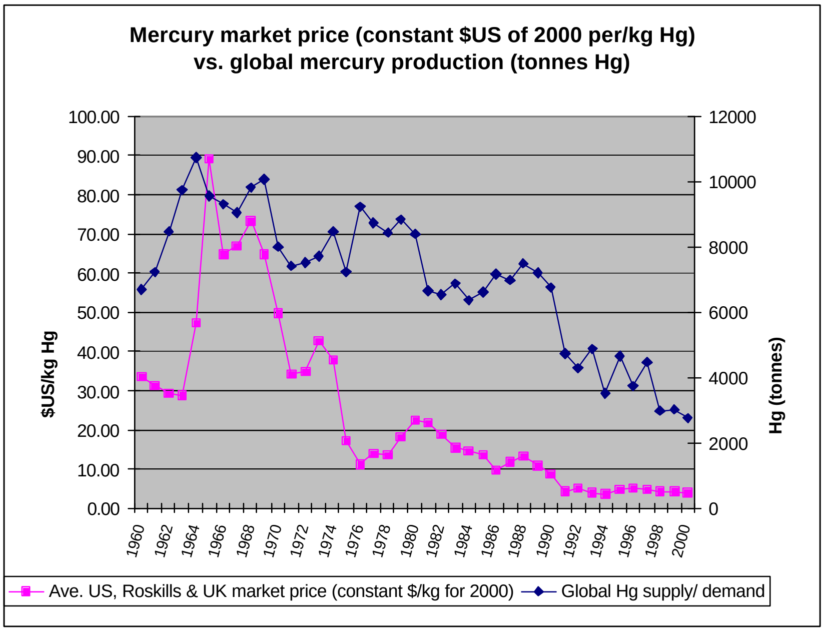
At the same time, while the last 15-20 years have shown a significant reduction of mercury use in the OECD countries, mercury consumption in many developing countries, especially South and East Asia (in the case of mercury use in products), and Central and South America (in the case of artisanal gold mining) has increased considerably. The main factors behind the shifts in mercury demand in the OECD are the reduction or substitution of mercury content in some products and processes in some regions (paints, batteries, chlor-alkali, etc.), a general shift of mercury product manufacturing operations from OECD countries to third countries (thermometers, batteries, etc.), and continuing robust supplies of mercury, combined with a long-term decline in mercury prices.



An analysis of mercury **trade** statistics confirms that regionally, North America and Europe have dominated mercury consumption in the past, but in recent years they have been overtaken by East Asia, especially China, and South Asia. However, the EU and the US retain general control over the majority of global trade in raw mercury. Four EU Member States shipped nearly 1400 tonnes of raw mercury out of the EU in 2000, while global movements of raw mercury amounted to more than 6000 tonnes – much of it changing hands repeatedly. In fact, on average, two tonnes of raw mercury appear in international trade statistics for each tonne of mercury consumed during the same year.



Trade statistics concerning mercury are far from perfect, but they frequently reveal surprises, such as the evidence that there remains a very active trade in mercuric oxide batteries, especially through China, but also through the EU and the US. Tracing the flows of mercury through the economy demonstrates how fluid and global mercury trade really is. It is not unlikely that residual mercury could be recovered from a Western European mercury cell chlor-alkali plant, sold to the world-renowned mercury mining/trading company in Spain, shipped to Germany for further purification and conversion into mercuric oxide, sold to mainland China for the manufacture of button-cell batteries, and the batteries sold to Hong Kong for incorporation into cheap watches for re-export to the European Union and the US.



Mercury **prices** have been on a downhill slide for most of the past 40 years. During the last 10 years they have stabilised at about their lowest levels ever, reflecting, in addition to a chronic supply surplus, the regulatory pressures on industry and others to responsibly dispose of mercury waste at hazardous waste sites, or alternatively, to send it to recyclers. However, for a long time mercury prices have been only a small fraction of the prices of goods they are used in, so it would be misleading to contend that low prices have spurred significant demand that would not have appeared otherwise.

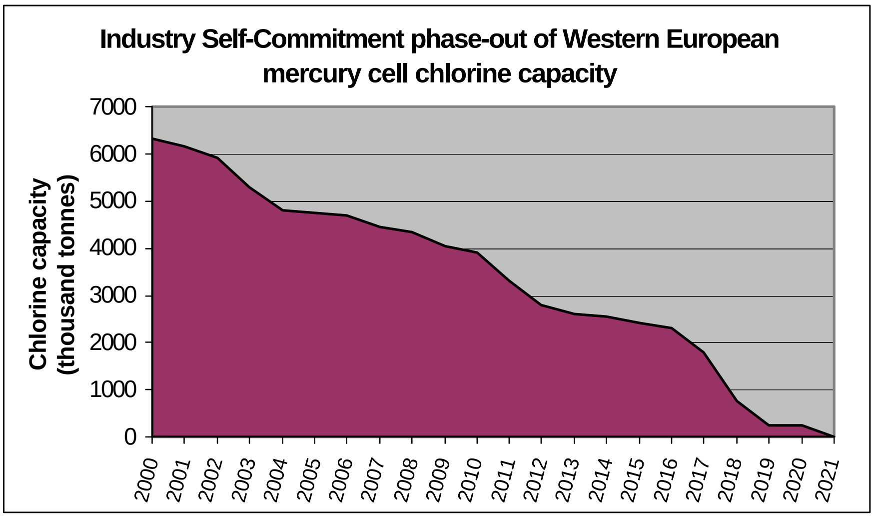
Regulatory measures influence mercury movements and markets by encouraging educational programs, collection and recycling programs, substitutes for mercury products, etc. In fact, it is argued that regulatory programs keep mercury prices low by putting an effective negative value on mercury wastes, so that recyclers could theoretically give recovered mercury away for free (no specific evidence has been seen of this extreme case) and still make a profit. One might ask whether, in such a regulatory environment, a free market in mercury still exists. But one could also ask whether a free market in a toxic substance is really in the best interest of society.

The market for elemental mercury is dominated by a limited number of virgin and secondary producers and mercury brokers. The same companies buy and control inventories, and trade mercury to influence the market and prices – in recent years less successfully. MAYASA, the Spanish mercury mining and trading company, purchased most or all of the USSR stockpile in the 1990s. In recent years MAYASA has also purchased residual mercury inventories from Western European chlor-alkali plants as they close or convert to mercury-free processes. Meanwhile the market surplus looks set to continue and perhaps even enlarge, potentially encouraging increased mercury uses and demand outside the OECD countries (European Commission, 2003).

Impact assessment – three decommissioning scenarios

Three scenarios were developed to describe a range of decommissioning alternatives. The main difference among these scenarios lies in the basic assumption of the decommissioning schedule, which affects the rate at which residual mercury from chlor-alkali plants comes onto the market.

Scenario 1 – Industry Self-Commitment

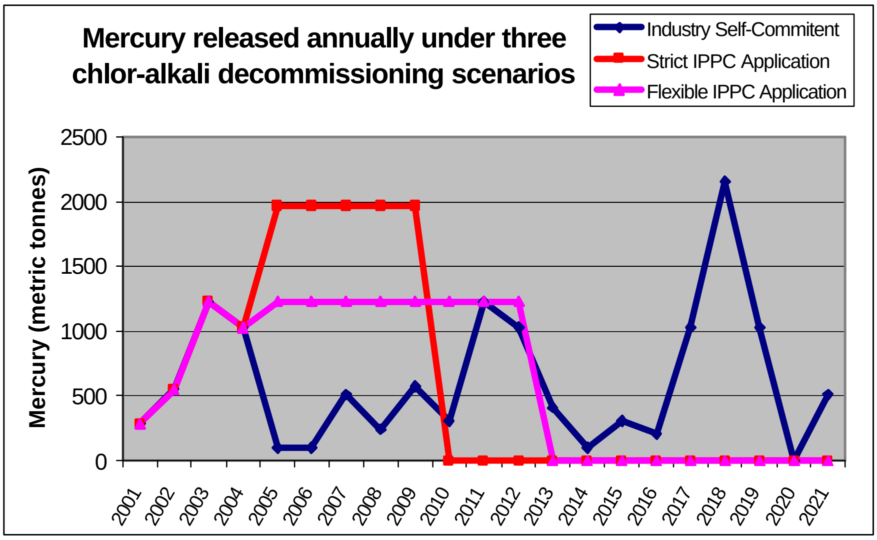


A logical baseline scenario has been developed around the Western European industry estimate for conversion of mercury cell chlor-alkali plants by 2020, which is roughly based on business-as-usual assumptions that take into account the economic lifetime of existing mercury cell chlor-alkali installations. This Industry Self-Commitment scenario assumes no major new legislative initiatives (that would significantly alter supply or demand) with regard to mercury, and a more or less "natural" or "economically realistic" phase-out of Western European mercury cell chlor-alkali production. This scenario reflects work done for Euro Chlor by Stanford Research Institute Consulting in a 1998 study, one objective of which was to describe in detail the normal economic lifetimes of the Western European mercury cell chlor-alkali plants. The figure at right shows the rate at which these plants' production capacity is expected to be phased out under the Industry Self-Commitment scenario. Appendix 4 of the main report provides a list of the remaining (in 2001) chlor-alkali plants in the EU and EFTA countries, totalling about 5.9 million tonnes of annual chlorine production capacity, and containing some 12 thousand tonnes of mercury relevant to this analysis.

Scenario 2 – Strict IPPC Application

In line with a strict reading of the Integrated Pollution Prevention and Control (IPPC) Directive (96/61/EC) requirements, existing chlor-alkali installations must be operated in full compliance with an integrated permit based on BAT by 30 October 2007, and it has been argued that this may be economically feasible as well. Therefore this second scenario, which may be referred to as the "Strict IPPC Application" scenario, assumes the more rapid phase-out of Western European mercury cell chlor-alkali plants by 2007. In this scenario, over 10 thousand tonnes of mercury from chlor-alkali plants mercury could deluge the international market between about 2005 and 2010.

Scenario 3 - Flexible IPPC Application



The third scenario, which may be referred to as the "Flexible IPPC Application" scenario, recognizes that in certain cases "flexibility" is required in the application of the Directive (see Directive Article 9, paragraph 4), which could permit some installations to delay the implementation of best available techniques (BAT) for a few years. The Flexible IPPC Application scenario therefore assumes a slightly less rapid phase-out of Western European mercury cell chlor-alkali plants by 2010, and a different schedule for mercury releases. The figure here summarises mercury releases for the three scenarios.

Findings – market impacts of the three scenarios

Scenario 1 - Industry Self-Commitment

The Industry Self-Commitment scenario is a reasonable baseline assessment of mercury supply and demand if current trends continue, and if no other special measures are taken. Briefly, mercury prices soften further as surpluses continue. Use patterns follow the trends suggested in the table at right. Mercury demand is cut in half by 2020, and the mercury supply shows a significant long-term surplus over demand. The surplus could reach a total of 13 to 14 thousand tonnes during the period 2005-2020, forcing more suppliers out of the market in response to steadily lower mercury prices.

Projected global mercury demand, 2020, by use category

Mercury use category	Prospects for mercury demand to 2020 (Industry Self-Commitment scenario)	Projected global demand for mercury, 2020 (metric tonnes)
Chlor-alkali industry	significant decline over next 10-20 years	280
Small-scale gold/ silver mining	unpredictable change, but present level of mining activity is not sustainable	400
Batteries	steep decline	100
Dental amalgam	some decline	250
Measuring & control	general decline	100
Lighting	gradual increase, at least in the foreseeable future	120
Electrical control & switching	general decline	100
Other uses	variable, especially mercury use in cosmetics	150
Total demand		**1500**

Scenario 2 - Strict IPPC Application

Under the Strict IPPC Application scenario, significant mercury supply surpluses appear immediately (see the following figure), whereas in the Industry Self-Commitment scenario, surpluses are not a serious issue until about 2009. The Strict IPPC Application scenario therefore severely disrupts the market equilibrium for about 10 years, from 2005 to 2015. During the period 2005-2010, mercury supply heavily outweighs mercury demand, and during the period 2010-2015, just the opposite occurs. Furthermore, the five years of exceptional mercury surpluses send a psychological message to the marketplace that international authorities do not put a high priority on restricting the marketing and use of mercury, which basically endorses business-as-usual, and undermines the range of mercury reduction efforts that are already in place in various parts of the world. Therefore, while the Strict IPPC Application scenario does not necessarily imply increased consumption of mercury through 2020, it certainly slows mercury reduction efforts, which effectively results in a relatively higher consumption compared to the Industry Self-Commitment scenario.

The Strict IPPC Application scenario results in a lower mercury price during the years of exceptional surplus 2005-2010, and a higher price during the subsequent years of relatively low supply 2010-2015. Furthermore, the early massive surplus of chlor-alkali mercury stunts many recycling efforts as well as primary mining activities, so that the total supply 2005-2020 is less overall for this scenario than it is for the two other scenarios. These supply sources would take some years to recover once the supply-demand imbalance shifts back in the other direction. In fact, due to its suppression of mercury supply sources, this scenario results in the closest long-term balance between estimated mercury supply and estimated mercury demand (both accumulated 2005 to 2020), although this comes at the expense of serious market shocks, and it also results in an increased overall demand (perhaps up to 10 percent increase) relative to the Industry Self-Commitment scenario.

Scenario 3 - Flexible IPPC Application

The Flexible IPPC Application scenario is something of a mix of the other two scenarios. It shows some mild disruption of the supply-demand market balance, but only for a few years (see figure at right). It does not much hinder other supply sources, nor does it significantly slow down existing mercury reduction efforts. It influences mercury market prices or use patterns relatively little. And while it leads to slightly higher long-term mercury demand than the Industry Self-Commitment scenario, its long-term (2005-2020) surplus supply over demand (less than 3,000 tonnes) is significantly smaller than that of the Industry Self-Commitment scenario, while somewhat larger than that of the Strict IPPC Application scenario.

Global mercury supply vs. demand (2001-2021), including percentage supply from decommissioned Western European chlor-alkali facilities

	Industry Self-Commitment			Strict IPPC Application			Flexible IPPC Application		
	Annual Hg supply (tonnes)	Western Europe chlor-alkali supply (%)	Hg market demand (tonnes)	Annual Hg supply (tonnes)	Western Europe chlor-alkali supply (%)	Hg market demand (tonnes)	Annual Hg supply (tonnes)	Western Europe chlor-alkali supply (%)	Hg market demand (tonnes)
2001	2907	10	3294	2907	10	3300	2907	10	3299
2002	3159	17	3201	3158	17	3214	3158	17	3212
2003	3827	32	3109	3827	32	3129	3827	32	3125
2004	3610	28	3016	3610	28	3043	3610	28	3038
2005	2676	4	2924	4168	47	2957	3430	36	2950
2006	2665	4	2831	3668	54	2871	3030	41	2863
2007	3063	17	2739	3368	58	2786	2930	42	2776
2008	2785	9	2646	3268	60	2716	2830	43	2689
2009	3101	19	2554	3268	60	2646	2830	43	2602
2010	2823	11	2461	1400	0	2576	2830	43	2520
2011	3734	33	2369	1500	0	2507	2830	43	2437
2012	3518	29	2276	1600	0	2437	2830	43	2355
2013	2891	14	2179	1700	0	2361	1700	0	2268
2014	2572	4	2082	1800	0	2285	1800	0	2180
2015	2765	11	1985	1900	0	2209	1900	0	2093
2016	2651	8	1888	1900	0	2134	2000	0	2005
2017	3460	30	1791	2000	0	2058	2100	0	1918
2018	4576	47	1694	2000	0	1982	2100	0	1830
2019	3437	30	1597	2100	0	1906	2200	0	1743
2020	2400	0	1500	2100	0	1830	2200	0	1655
2021	2912	18	1403	2200	0	1753	2300	0	1567
Total 2005-2020	49117	19	35514	37740	26	38261	39540	25	36884

Observations and conclusions

Mercury markets

To fully appreciate EU and global mercury markets, a number of observations should be brought together from the discussion and analysis presented in this paper:

- The markets for mercury are global, and the EU is a key player. The EU provides 20-30 percent of the global mercury supply, it is a partner in over 50 percent of global mercury trade, and it consumes some 10 percent of global demand;
- Raw mercury is extensively traded around the world, at the rate of at least three times the annual consumption;
- World mercury markets are dominated by a relatively few key players, whose dominance, however, is weakening as primary mine production decreases (primary mercury mining in Western Europe has now ended, private mines are closed), by-product and other secondary mercury recovery increases and a more diverse group of secondary suppliers and recyclers appears, who don't depend on mercury production costs to stay in business;
- Mercury prices are at a lower level in real terms than at any time in history, and there are no market reasons for any firming of prices in the foreseeable future;
- Mercury markets are bearing less and less resemblance to free markets. Depending on other developments, by 2020 there may be no more primary mercury mining whatsoever, and the "market" price of mercury will reflect only recycling and recovery costs, which are driven by regulation, and could therefore go much lower. In fact, regulations tend to give mercury a negative value. Whether it is raw mercury or mercury waste, holding mercury is a liability, and it costs money to dispose of it. The only way to add value to mercury is to put it in a product and sell it, or to use it in an industrial process, with the obvious risk of eventual emissions and exposures. Regulation is pushing these production processes out of the

OECD;
- Overall mercury supplies are slowly decreasing in response to low prices and diminishing demand, but not as rapidly as the low prices would suggest;
- Consumption of mercury has declined significantly in the EU and other OECD countries, but this decline is not so evident in the rest of the world, to which this low-value commodity is increasingly being shifted;
- Under any reasonable assumptions (i.e., declining global demand, gradually declining supply, increasingly from secondary sources, etc.), a net surplus of mercury supply over demand is expected to remain a hallmark of mercury markets into the foreseeable future. These surpluses could accumulate to 10-15,000 tonnes by 2020;
- Although mercury demand is rather slow to change, an extended period of low prices and surpluses may encourage uses (and eventual emissions) that would not otherwise have occurred, or at the least, they may discourage a number of other mercury reduction efforts;
- In general terms, the more mercury circulating in the economy and the environment, the more chance for emissions and exposure, misuse and abuse:

Mercury from chlor-alkali plants
Likewise, there are a number of key observations concerning residual mercury that becomes available from decommissioned chlor-alkali plants:
- The most easily recoverable mercury inventories of Western European mercury cell chlor-alkali plants amount to some 12,000 tonnes – approximately half of the global total held by chlor-alkali plants;
- Following industry estimates, these plants will close between now and 2020, and this mercury will come onto the international market - not to mention additional mercury from US and other decommissionings;
- Once the mercury from chlor-alkali plants is transferred to another party, the chlor-alkali industry - however responsible - loses control over its ultimate destination and use;
- Chlor-alkali mercury has become an increasingly important contributor to global mercury supplies, accounting for 10-20 percent of global supplies in recent years, and estimated to contribute 25-30 percent in the near future;
- The quantities of residual mercury that will be most easily recovered from Western European chlor-alkali plant closures up to 2020 are roughly equivalent to the expected mercury market surpluses during the same period.

Conclusions
This analysis was requested to specifically address the question of whether mercury coming from decommissioned mercury cell chlor-alkali plants might disrupt the functioning of the international mercury market.

Three scenarios for global supply and demand of mercury during 2000-2020 were identified and assessed, representing three alternative schedules for closing Western European chlor-alkali plants. With regard to the specific study objective of avoiding mercury market disruption, the Industry Self-Commitment scenario (plant closures by 2020) has the advantage of the least disruption of expected mercury markets. On the other hand, the Flexible IPPC Application scenario (plant closures by 2010) has the advantage of fixing a mercury cell decommissioning deadline that is flexibly consistent with the IPPC Directive, while at the same time causing relatively minor market disruption. While the Strict IPPC Application scenario (plant closures by 2007) would respect the formal IPPC decommissioning deadline of 2007, it would also bring the greatest shock to the mercury market.

However, it must be noted that none of these decommissioning scenarios – without substantial accompanying measures - is adequate to the challenge posed by mercury in the environment, nor consistent with the objectives of the European Union as laid out in the Amsterdam Treaty and confirmed in the Convention on the Future of Europe at Thessaloniki. The basic premise of these scenarios – that the transfer of mercury from decommissioned mercury cell plants should be permitted unrestricted access to the market - is entirely counter to the consensus of hundreds of stakeholders and experts who participated in the UNEP *Global Mercury Assessment* in 2002. Resulting from that series of meetings and consultations, and clearly presented in the report's conclusions, the basic consensus was that countries around the world should make every effort to **reduce – from the supply side as well as the demand side – the circulation of mercury in the economy and environment**. Unfortunately, these three scenarios do not embrace that most important overall objective of global mercury policy. On the contrary, it could be argued that since all of these three scenarios would contribute to an increase in the circulation of mercury in the economy and the environment, they are, by definition, unsustainable and would have to be identified as such in the sustainability impact assessment with regard to IPPC measures applicable to the chlor-alkali industry.

Mercury flows in Europe and the world:

The impact of decommissioned chlor-alkali plants

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Glossary

ABS	anti-lock (vehicle) braking system
Almadén	the name of the main mining district and geological formations exploited by the Spanish firm MAYASA (see below);
BREF	abbreviation for "best available techniques reference document," the series of guidelines being prepared by the European IPPC Bureau in Sevilla;
CFL	compact fluorescent lamp;
CIS	Commonwealth of Independent States, formed after the dissolution of the former USSR (see below);
DLA	US Defense Logistics Agency, responsible for the US Defense National Stockpile Center (DNSC);
DNSC	US Defense National Stockpile Center, part of the US Defense Logistics Agency (DLA);
EU	European Union, presently comprising 15 Member States - Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the United Kingdom;
EFTA	Iceland, Liechtenstein, Norway and Switzerland;
Euro Chlor	Euro Chlor is a federation that represents 85 companies in the chlorine industry across 21 European countries. It plays a key communications and representation role on behalf of its members;
FAO	United Nations Food and Agriculture Organization;
g	gram;
GDP	gross domestic product;
Hg	mercury;
IPPC	Integrated Pollution Prevention and Control, generally in reference to the IPPC Directive (Council Directive 96/61/EC);
KEMI	Swedish Chemicals Inspectorate;
kg	kilogram;
LCD	liquid crystal display;
m	meter;
MAYASA	abbreviation for the Spanish state-owned mercury mining and trading company Miñas de Almadén y Arrayanes, S.A., which holds rights to the best known and historically most important mercury deposits in the world; these deposits may have been mined as long as 6000 years ago, although the first recorded references date to the year 490 B.C. (see "Almadén" above);
metric ton	1000 kg;
mg	milligram (10^{-3} gram);
OECD	Organization for Economic Cooperation and Development;
ppm	parts per million;
ROW	rest-of-the-world;
SIA	sustainability impact assessment;
SSM	small-scale mine, used mostly in this text to refer to artisanal gold and silver mines;
Swedish EPA	Swedish Environmental Protection Agency;
t	metric tonne;
ton	US ton (2000 pounds, or about 908 kg);
tonne	metric ton (1000 kg);
UN	United Nations;
UNCED	United Nations Conference on Environment and Development;
UNEP	United Nations Environment Programme;
US EPA	United States Environmental Protection Agency;
US or **USA**	United States of America;
USSR	former Union of Soviet Socialist Republics, most of which joined to form the CIS (see above);
WEEE	waste electrical and electronic equipment
Western Europe	assumed in this report to comprise the EU and EFTA member states;
WFD	Water Framework Directive.
WHO	World Health Organization.

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-- Draft final report 22 August 2003 --

1 Background

Mandate
The following analysis was requested by the European Commission, DG Environment, in support of its mercury strategy to be published in 2004. The purpose of this report is to describe the work carried out and the results obtained during the study period from contract signing (8 November 2002) through the end of July 2003.

As stated in the project documents, the key objectives of this investigation were:

1. to get as good a picture as possible (within obvious resource constraints) of the current mercury flows in Europe and the world; and

2. to get an idea of what impact the mercury obtained from decommissioned European mercury-based chlor-alkali plants might have on the world mercury market, and the resulting consequences in terms of mercury use patterns.

Caveats
It is not the purpose of this analysis to present policy recommendations. Rather it is intended to provide data and analysis to support policy recommendations that will appear in the European Commission Mercury Strategy, currently under preparation under the lead of DG Environment.

The data on mercury flows generated in task 1 above have been developed specifically to respond to the needs of task 2 – to assess the impacts of mercury coming from European chlor-alkali plants. This needs to be mentioned because the development and/or reconciliation of a complete data base on mercury is not only far beyond the scope of this analysis, but virtually impossible given the present state of international mercury data collection and consistency.

Author
This report was prepared by Peter Maxson, Director, Concorde East/West Sprl, under the supervision of Michaela Braun, Administrative Officer, DG Environment. Since 1989 Mr. Maxson has been integrally involved in developing a better understanding of mercury and other heavy metals in the European Union and further afield, and has helped to develop mercury policy both for Member States and at the European level. Most recently he had an opportunity to influence mercury policies even more broadly as co-author of the Global Mercury Assessment sponsored by UNEP (see UNEP Chemicals, 2002a).

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2 Basic structure of global mercury markets

Global mercury **supply** to the markets is dominated by three main nations that mine mercury for export (Spain, Kyrgyzstan and Algeria), and China, which has long supplied its own robust domestic market. Both Spain and China may be in the process of closing their mines, especially as other sources seem to be growing, and mercury remains so inexpensive on the international market. Due to an influx of stockpile mercury, first from the US, and then from the USSR in the early 1990s, and more frequent closure and release of mercury inventories from mercury cell chlor-alkali plants since the 1980s, combined with increasing recovery/recycling of secondary mercury, there has been a relative surplus of mercury on the market during the last ten years, holding prices down and fuelling speculation. This has led to declines in most mine output, and closure of any but the lowest cost (or State-owned) operations. As calculated below, the mercury supply from 1994-2000 has averaged 3600 tonnes per year, and from 1996-2000 the average has been about 3400 tonnes per year, which one could take as a rough estimate of global mercury supply in 2000.

Demand for mercury has long been widespread but never completely understood. Just when analysts believe they have developed an understanding of the markets, another surprise seems to await them – increased use of mercury in artisanal gold mining (which mostly bypasses formal record keeping), mercury in toys, mercury in lighthouses, mercury in cosmetics or paints, uses that were thought to have been largely phased out, etc. Mercury demand has been dominated by a range of products and processes over the years, but recently it is mostly used in the chlor-alkali industry, small-scale gold mining, dental amalgams, switches and relays, measuring equipment, lighting, etc., as well as a significant continued use in batteries. At the same time, it is used in a dizzying array of other products, such as some 1000 homeopathic products identified by the US Food & Drug Administration, not to mention spiritual cleansing rituals, etc. Despite the wide range of applications, demand for mercury continues to decline overall, and the general market surplus persists.

Through all of the above, especially in light of gradually increasing scrutiny and regulation, the global demand for mercury has declined from over nine thousand tonnes annual average in the 1960s, to over eight thousand tonnes in the 1970s, to just under seven thousand tonnes in the 1980s, down to an average of around four thousand tonnes in the 1990s, and well below that today.

At the same time, while the last 15-20 years have shown a significant reduction of mercury use in the OECD countries, mercury consumption in many developing countries, especially South and East Asia (in the case of mercury use in products), and Central and South America (in the case of artisanal gold mining) has increased considerably. The main factors behind the shifts in mercury demand in the OECD are the reduction or substitution of mercury content in some products and processes in some regions (paints, batteries, chlor-alkali, etc.), a general shift of mercury product manufacturing operations from OECD countries to third countries (thermometers, batteries, etc.), and continuing robust supplies of mercury, combined with a long-term decline in mercury prices.

An analysis of mercury **trade** statistics confirms that regionally, North America and Europe have dominated mercury consumption in the past, but in recent years they have been overtaken by East Asia, especially China, and South Asia. However, the EU - a participant in at least 50 percent of mercury trades - and the US retain general control over the majority of global trade in raw mercury. Four EU Member States shipped nearly 1400 tonnes of raw mercury out of the EU in 2000, while global movements of raw mercury probably amounted to well over 8000 tonnes – much of it changing hands repeatedly. On average, three tonnes of raw mercury appear in international trade statistics for each tonne of mercury consumed during the same year.

Trade statistics concerning mercury are far from perfect, but they frequently reveal surprises, such as the evidence that there remains a very active trade in mercuric oxide batteries, especially through China, but also through the EU and the US. Tracing the flows of mercury through the economy demonstrates how fluid and global mercury trade really is. It is not unlikely that residual mercury could be recovered from a Western European mercury cell chlor-alkali plant, sold to the well-known mercury mining/trading company in Spain, shipped to Germany for further purification and conversion into mercuric oxide, sold to mainland China for the manufacture of button-cell batteries, and the batteries sold to Hong Kong for incorporation into cheap watches and toys for re-export to the European Union and the US.

Mercury **prices** have been on a downhill slide for most of the past 40 years. During the last 10 years they have stabilised at about their lowest levels ever, reflecting, in addition to a chronic supply surplus, the regulatory pressures for industry and others to responsibly dispose of mercury waste at hazardous waste sites, or alternatively, to send it to recyclers. However, for a long time mercury prices have been only a small fraction of the prices of goods they are used in, so it would be misleading to contend that low prices have spurred significant demand that would not have appeared otherwise.

Regulatory measures influence mercury movements and markets by encouraging educational programs, collection and recycling programs, substitutes for mercury products, etc. In fact, it is argued that regulatory programs keep mercury prices low by putting an effective negative value on mercury wastes, so that recyclers could theoretically give recovered mercury away for free (no specific evidence has been seen of this extreme case) and still make a profit. One might ask whether, under such regulatory pressures, a free market in mercury still exists. But one could also ask whether a free market in a toxic substance is really in the best interest of society.

The market for elemental mercury is dominated by a limited number of virgin and secondary producers and mercury brokers. The same companies buy and control inventories, and trade mercury to influence the market and prices – in recent years less successfully. MAYASA, the Spanish mercury mining and trading company, purchased most or all of the USSR stockpile in the 1990s. In recent years MAYASA has also purchased residual mercury inventories from Western European chlor-alkali plants as they close or convert to mercury-free processes. Meanwhile the market surplus looks set to continue and perhaps even enlarge, potentially encouraging increased mercury uses and demand outside the OECD countries (European Commission, 2003).

3 Mercury sources and supply

3.1 Key sources of supply

In this section we will summarise the four main source categories of mercury supplied to the market.

First, there is "virgin" or "prime" mercury, coming from both commercial and artisanal mines specifically established to produce mercury. (All other mercury (except mercury coming from existing inventories) is referred to as "secondary" mercury, including mercury produced as a by-product of other mining activities, recovered or recycled mercury, etc; see below.)

Second, there is "by-product" mercury, i.e., mercury that is recovered from mining or processing activities where the primary mineral is gold, silver, copper, zinc, etc. In this case, mercury comes along with the other metals and is removed only to keep in compliance with government regulations or to make the primary product more pure.

Third, there is “recovered” or “recycled” mercury, words often used interchangeably, but frequently the word “recycled” is used to denote a significant level of processing required to extract mercury. For example, the relatively pure mercury removed from the electrolytic cells of mercury cell chlor-alkali production plants is most commonly referred to as recovered mercury, while the mercury obtained from the processing of fluorescent tubes, batteries, thermometers or dental wastes via a smelting process is most commonly referred to as recycled mercury.

Fourth, a common “source” of mercury is from pre-existing inventories. Over a given period of time, a reduction of the quantity of mercury held in a specific inventory would imply a release of that quantity to the market. Inventories of mercury may be held by industry, such as chlor-alkali producers, manufacturers of products containing mercury, or mercury recyclers. They may be held by mercury mines, for example while waiting for demand and price to firm up. Or they may be held by educational institutions (commonly for lab work) or by government agencies, such as the US Defense National Stockpile Center (DNSC), part of the US Defense Logistics Agency. After World War II, the National Defense Stockpile was created so that in times of national emergency the United States would not have to depend on foreign sources for strategic and critical materials. Many of these materials are no longer needed for national defense and have been declared excess by Congress (DNSC, 2003).

3.2 Mercury produced from mining operations

A comprehensive summary of mercury mine operations is provided by Hylander and Meili (2003). This and the following four paragraphs are drawn largely from this source. These authors have confirmed that mine production of mercury in Europe and North America has substantially decreased during recent decades. The last primary mercury mine in the US - the McDermitt mine - closed in 1990 (USGS Mercury, 2002, as cited by Hylander and Meili, 2003), and the Idrija mine (in Yugoslavia) closed in 1995 (Cigale, 1997, as cited by Hylander and Meili, 2003).

The only primary mercury mine still operating in 2000 in western countries was the Almadén mine, operated by Miñas de Almadén y Arrayanes S.A. (MAYASA), a Spanish state-owned company. Almadén mine production was more than 1000 tonnes of mercury per year in 1995 and 1996 (see Table 2), but the substantial subsidies granted to the mining company in 1995 were linked already to a gradual phase-out of mercury mining (EIPPCB, 2003). Aided by its purchases of mercury from the Russian stockpile, as well as supplies of mercury from decommissioned chlor-alkali plants, Almadén was able to maintain its customer base while reducing mine output to approximately 400-500 tonnes of mercury per year during 1997-99, and only 236 tonnes in 2000. Underground mining of cinnabar at Almadén ended for good in June 2001. After that, mercury was recovered from the 80 thousand tonnes of cinnabar stockpiled from previous mining activity. All mineral processing activity at Almadén came to an end in October 2002. It is planned that the surrounding area will be converted into a “mineral cultural park,” for which purpose a cultural foundation has already been established (MAYASA, 2003).

Now that the Almadén mine is closed, the most important primary mercury mine remaining is in the Khaidarkan mining complex in Kyrgyzstan, which sells most of its output to Russia, CIS and China. The reported mercury production of Kyrgyzstan has been approximately 600 tonnes per year during the period 1996-1999, while Russia, Tajikistan and Ukraine produced approximately 50, 35 and 20 tonnes per year, respectively.

Quantities of mercury produced in the other two main producing countries, Algeria and China, are uncertain. Algeria produced approximately 200-500 tonnes per year for the latest decade. China produced a reported 835 tonnes of mercury in 1997, and the production for 1999 and 2000 was reported to be about 200 tonnes, which may be underestimates.[1] Hylander noted in Breaking the Mercury Cycle (2002) that China was still operating eight larger and 50 small-scale mercury mines in 2000, but announced plans to close them subsequently. There are also reports of small-scale, artisanal mining of mercury in Russia (Siberia), Outer Mongolia, Peru, and Mexico, but quantities have not been reported and are likely relatively minor (UNEP Chemicals, 2002a).

With regard to by-product mercury, Outokumpu Mining Oyj in Finland dominated production in central and northern Europe with 40-90 tonnes of mercury per year in 1994-2000 (Kuo, 2001, as cited by Hylander and Meili, 2003). Extraction of mercury as a by-product of gold production is estimated at 15 tonnes per year in the US during recent years (Metallgesellschaft, 1939-1998; Roskill's, 2000, as cited by Hylander and Meili, 2003). In a similar case, the Yanacocha Gold Mine in Peru produced 48 tonnes of mercury in 2000 and has reported gold reserves for two more decades of operation (UNEP Chemicals (2002b), as cited by Hylander and Meili, 2003).

Table 1 provides a snapshot view of the diverse global sources of mercury from mining operations in 2000. This table includes estimates of all primary (virgin) production, as well as by-product mercury from mining of other metals, for a conservative global total of about 1850 tonnes. This total excludes secondary mercury coming from other recovery and recycling processes, which are discussed in detail below.

[1] As noted by Hylander & Meili (2003), much information is missing in the historic databases, and official data often represent exported quantities, which do not include domestic consumption in China, Russia and neighbouring producer countries. Present estimates from China are also uncertain, partly because mercury is produced in various locations - some of them artisanal operations, which are technically illegal. Production estimates also vary considerably between different sources for certain years.

Table 1 - Mercury produced from mining operations (tonnes, 2000)

Country/-region	Source	Primary (virgin) Hg		Secondary Hg
		Commercial Hg mining	Artisanal Hg mining	By-product Hg
Algeria	Entreprise Nationale des Produits Miniers Non-Ferreux (ENOF)	240		
China	Danzhai Gold-Mercury Mine; and Guizhou, Wuchuan, and Tongren Mercury Mines, all within the Province of Guizhou (SW China).	200	?	
Czech Rep. & Slovakia	Rudnany (Slovakia) stocks (Czech Rep.)			?
Finland	Outokumpu Mining Oyj			45
Mexico			25	
Mongolia	Eco-Minex International Co., Ltd.		?	?
Peru	Yanacocha Gold Mine		?	48
Spain	Almadén mine	236		?
Russia/-Siberia	stocks		?	50
Kyrgyzstan	Khaidarkan Mercury State Joint Stock Co.	550		
Tadjikistan	Jijikrut antimony-mercury mine	40		
Ukraine	Nikitovka (produced about 20 tonnes/yr thru 1999)	?		
USA	by-product of gold production			15
Austria/-Slovenia/-Yugoslavia	Rudnik Zivega Srevbra (Idrija, Slovenia)			?
Other	Australia, New Zealand, Canada, Chile, Germany, Italy, Norway, etc.			400
Totals		**1270**	**25**	**560**

Sources:
Roskill Metals Databook, London: Roskill Information Services, Ltd., 2000.
USGS Mineral Commodity Summaries, Minerals Yearbook, Mercury. In: Minerals statistics and information 1994-2000 (annual volumes), US Geological Survey, 1995-2001, http://minerals.usgs.gov/minerals/pubs/commodity/mercury/.
MAYASA. Minas de Almadén y Arrayanes S.A., http://www.mayasa.es/.
Lawrence presentation at Breaking the Mercury Cycle (2002)

Table 2 provides a global historic perspective of primary and by-product mercury production over the last two decades. It should be noted that since mine production reached a recent peak (it was greater in the 1960s and 1970s) in 1988, it fell to about half that level by 1995, and virtually all mines have further reduced production since then.

Table 2 - Historical global mine production of mercury (tonnes), including by-product mercury, by major producer region

Year	Europe				America			Former USSR	Asia		Af-rica/Al geria	Other coun-tries	Total mined globally
	Spain	Slo-venia	Italy	Other	North	South & Cen-tral	Mexico		China	Other			
1981	1560	7	252	296	962	3	240	1700	800	204	30	0	6054
1982	1540	7	159	275	888	2	295	1200	800	246	386	0	5798
1983	1416	58	0	209	864	4	221	1200	850	162	828	0	5812
1984	1520	78	0	232	657	2	384	1220	800	182	586	0	5661
1985	1539	7	0	288	570	1	394	1200	800	226	801	80	5906
1986	1471	82	0	315	470	0	185	2250	700	262	764	0	6499
1987	1553	74	0	308	100	0	124	2300	700	211	756	0	6126
1988	1499	77	0	303	379	0	345	2300	940	97	662	0	6602
1989	967	57	0	291	428	0	651	2300	880	202	587	0	6363
1990	962	44	0	266	460	0	735	2100	800	60	639	0	6066
1991	52	16	0	149	58	0	340	1900	700	25	431	0	3671
1992	36	14	0	145	64	0	21	1900	392	5	476	0	3053
1993	636	7	0	148	70	0	12	1190	520	0	459	0	3042
1994	386	12	0	133	70	4	12	534	470	0	414	0	2035
1995	1497	11	0	140	70	13	15	520	780	0	292	0	3338
1996	1024	5	0	108	30	13	15	709	510	0	368	0	2782
1997	389	5	0	83	15	15	15	725	835	0	447	0	2529
1998	474	0	0	74	15	24	15	725	225	0	224	220	1996
1999	433	0	0	40	15	33	15	705	200	0	240	380	2061
2000	236	0	0	45	15	48	25	640	200	0	240	400	1849

Source: Hylander & Meili (2003).

3.3 Mercury recovery and recycling

The most important sources of mined mercury have been discussed above. This section will identify the key sources of recycled mercury, and the main recyclers and brokers active in the market.

3.3.1 Sources and market importance of recycled mercury

The principle sources for recycled and recovered mercury are mercury-containing products, decommissioned chlor-alkali plants, and various sorts of industrial wastes.

3.3.1.1 Mercury-containing products

The major products that are most commonly recycled for their mercury content are thermometers, barometers, manometers, dental amalgams, electrical switches and relays, thermostats, fluorescent (including compact fluorescent) tubes and lamps, high-intensity-discharge lamps, batteries, etc. The actual quantities of products actually sent for recycling vary greatly from one country or region to the next – depending to a large extent on the regulatory environment.

Another factor that may influence mercury supplies from one year to the next is the occasional recovery of mercury from waste inventories. For example, during the first quarter of 2003, recycling firms were invited to bid on reprocessing two thousand tonnes of used mercury-containing batteries accumulated in Sweden over sixteen years. The government estimates the mercury content at 20-35 tonnes. Generally in such a case, the recovered mercury would be sold on the international market. In this case, however, if a non-Swedish company wins the contract, the recovered mercury will be returned to Sweden for long-term disposal, according to the Swedish EPA. "We are pleased to have taken a further step towards getting mercury out of circulation," a spokesperson added.

3.3.1.2 Mercury product "reservoirs"

It should also be noted that a large "reservoir" of mercury is contained in products still in use, in storage and "on the users' shelves" in society. If responsibly collected, recycled and managed as these products are replaced or no longer used, this reservoir could be a much more significant source of society's real needs for mercury in future years. Attempts have been made to quantify these reservoirs of mercury in Sweden, the Netherlands, Denmark and the US, among others. Hylander (presentation at Breaking the Mercury Cycle, 2002) has estimated the quantity of mercury contained in goods and products (i.e., completely apart from mercury cell chlor-alkali plant inventories) in Western Europe at 2-5,000 tonnes, with another 4-8,000 tonnes in Central & Eastern Europe (excluding former Soviet states). A recent estimate for the US points to at least 3,000 tonnes in that economy (USEPA/NRMRL, 2002), not including mercury cell chlor-alkali plant inventories or government stockpiles, as summarised in Table 3.

Table 3 - US mercury use and reservoir in the economy, 2000
(US tons, where one US ton = 908 kg.)

Mercury Sector	Mercury Used in Raw Materials (tons/yr)	Mercury Reservoir (tons)
Mercury Supply		
Secondary Mercury Production	430	—
Imports and Exports	-83	—
U.S. Government Stockpiles	0	4,850
Total for Mercury Supply	347	4,850
Mercury Use in Manufacturing Processes		
Chlor-alkali Manufacturing	79	3,000*
Electrical Lights: Manufacturing	16	0
Electrical Lights: Use and Disposal	17	100*
Thermometers: Manufacturing	9 - 17	0
Thermometers: Use/ Disposal	9 - 17	90*
Thermostats: Manufacturing	15 - 21	0
Thermostats: Use and Disposal	13 - 20	230
Switches/Relays: Manufacturing	36 - 63	0
Switches/Relays: Use/Disposal	36 - 63	630[a]
Organic Chemical Production	??	??
Dental Preparations Manufact'g	34 - 54	0
Dental Office: Use	34 - 54	1,200
Mercury Compounds	??	??
Batteries manufacturing	negligible	0
Batteries: Use/disposal	25*	500*
Measuring & control equip.*	??	100*
Other: Use/disposal	50-100*	500*
Total mercury use in manufacturing	189 – 250	
Total mercury reservoir (excl. stockpile)		6,350*

[a] including 130 tons in US automobiles??
Sources: USEPA/NRMRL (2002); and author estimates marked with *.

If these figures are extrapolated, in line with "development" indicators, to other countries of the world, one arrives at a global inventory of some 20-30 thousand tonnes of mercury in existing products and processes, in addition to the 20-30 thousand tonnes held by the chlor-alkali sector (see below). Much of this inventory could eventually be made available for recycling and recovery, given the proper incentives.

3.3.1.3 Key industrial sources

The two main industrial sources of recycled or recovered mercury are decommissioned mercury cell chlor-alkali plants, and treatment of a variety of mercury wastes which, depending on the local regulatory environment, may be less costly to send to a recycler than to dispose of as hazardous waste.

Recovery of mercury from mercury cell chlor-alkali plants - Europe

Apart from the mercury wastes (contaminated old equipment, solids from water and brine purification, solids from caustic soda treatment, graphite and activated carbon from gas treatment, and other sludges, filters, residues, etc.) that are routinely recycled or disposed of by the chlor-alkali industry during normal operations, large quantities of mercury are recovered from these sites during decommissioning. Industry has substantial experience in decommissioning mercury cell chlor-alkali plants, including closing, dismantling, and converting plants, not to mention remediating soil, disposing of waste, etc., at more than 34 plants in the Netherlands, Germany, United Kingdom, Finland, France, Sweden, Norway, Italy, Portugal, Belgium, Spain, Austria and Denmark during the last 15 years. These mercury cell chlor-alkali plants were closed for many different reasons, including age of the plant and equipment, lack of proximity to downstream chlorine-based chemical processes, regulatory pressures, safety concerns, excessive production costs relative to competitors - which could be due to small size, electricity costs, etc. (European Commission, 2002; Maxson, 2000).

An incomplete list of mercury cell chlor-alkali plants decommissioned in Western Europe in recent years is presented in Table 4. As described later, the “natural economic” phase-out and decommissioning of Western European mercury cell chlor-alkali plants will continue through about 2020 if no further measures are taken to accelerate the process, although many have committed to close or convert by 2010.

Table 4 - Decommissioned Western European mercury cell chlor-alkali plants

-WESTERN EUROPE (1986-2002)- **DETAILS OF MERCURY CELL CHLOR-ALKALI PLANT CLOSURES OR CONVERSIONS (this list is incomplete)**				
Closure or conversion years	**Last owner**	**Est. chlorine production capacity (tonnes)**	**Country**	**Location**
1986	Akzo Nobel	85,000	Sweden	Skoghall
1990-92	Enichem	129,000	Italy	Montova
1991	Domsjø	35,000	Sweden	Domsjø
1992	Finnish Chem.	45,000	Finland	Aetsa
1993	ICI	90,000	UK	Fleetwood
1993	Soc. Elettrochim.	45,000	Italy	Tavazzano
1993	Elec. Andaluza	24,000	Spain	Ubeda
1994	Octel	75,000	UK	Ellesmere Port
1994	Nob Forss	13,000	Sweden	Koepmanholmen
1994	Enichem	115,000	Italy	Gela
1994	Akzo Nobel	58,000	Finland	Kuusankoski
1996??	Anaconda	20,000	Italy	Saline di Volterra
1996	Borregaard	40,000	Norway	Sarpsborg
1997	Caffaro	32,000	Italy	Brescia
1998	Micro-Bio Ltd.	6,000	Ireland	Fermoy
1998	Solvay	25,000	Portugal	Povoa di Santa Ir.
1998	Solvay	53,000	Austria	Hallein
1998	ECI	65,000	Germany	Bitterfeld
1998??	Vestolit	40,000	Germany	Luelsdorf
1999	Bayer	300,000	Germany	Dormagen
1999	Dow	200,000	Germany	Schkopau
1999	Clariant	60,000	Germany	Gersthofen
2000	Solvay	146,000	Netherlands	Linne Herten
2001	Bayer	130,000	Germany	Uerdingen
2002	Wacker	157,000	Germany	Burghausen
Note: Due to simultaneous modifications and expansions of other Western European operating mercury cell chlor-alkali plants (especially in 1994 and 1997), as well as transfers of mercury to other plants for consumption during routine operations, the quantities of mercury that reached the international market were considerably less than the full inventories represented by these closures.				
Source: Euro Chlor (1998, 2001a, 2001b, 2001c, 2002a); personal communication with A. Seys, Euro Chlor.				

According to Euro Chlor, between 1982 and 1995, while the differences in decommissionings from one year to the next were frequently large, a total of 1.95 million tonnes of Western European mercury cell chlorine capacity was closed or converted to alternative processes. In a later publication, Euro Chlor noted that between 1990 and 2000 an average of 100,000 tonnes per year of mercury cell capacity was closed or converted (Euro Chlor, 2002b).

Based on data collected by Maxson (2000) showing about 1,8 kg mercury (in cells) per metric tonne of chlorine capacity, and at least another 10-15 percent easily recoverable from other parts of the plant,[2] one can assume that at least two tonnes of mercury become available for each one thousand tonnes of annual chlorine production capacity closed down. This implies that nearly 6,000 tonnes of mercury were made available by Western European plant closures during the period 1980-2000, although a significant part of this went directly to other operating chlor-alkali

[2] This latter portion is not mentioned in the chlor-alkali BREF (EIPPCB, 2000), which considers only the reasonably pure, immediately marketable raw mercury contained in the electrolytic cells.

plants. It also implies that global mercury inventories associated with chlor-alkali plants that remain in operation may be estimated at some 25,000 tonnes, of which about half are in Western Europe.

Recovery of mercury from mercury cell chlor-alkali plants – United States

Mercury cell chlor-alkali plants decommissioned in the US in recent years are listed in Table 5 below, releasing nearly 2000 tonnes of residual mercury. The remaining US mercury cell chlor-alkali plants are intended to be decommissioned during the next 10-15 years.

Table 5 - Decommissioned United States mercury cell chlor-alkali plants

-UNITED STATES (1989-2002)- **DETAILS OF MERCURY CELL CHLOR-ALKALI PLANT CLOSURES OR CONVERSIONS**				
Closure or conversion years	**Last owner**	**Est. chlorine production capacity (tonnes)**	**City**	**State**
1980-1988	LCP	85,000	Linden	NJ
1984-1987	Olin	109,000	McIntosh	AL
1984-1988	Monsanto	36,500	East St. Louis	IL
1980-1988	Pennwalt	n.a.	Calvert City	KY
1988	OxyChem	51,000	Niagara Falls	NY
1988	LCP	n.a.	Syracuse	NY
1989-1994	LCP	96,200	Brunswick	GA
1991	Akzo	70,800	Lemoyne	AL
1991	LCP	78,900	Moundsville	WV
1992	Olin	81,600	Niagara Falls	NY
1994	OxyChem	33,600	Mobile	AL
1997-99	Georgia Pacific	81,600	Bellingham	WA
1998-99	Holtrachem	50,000	Acme	NC
2000	Holtrachem	76,000	S. Orrington	ME
2002	Westlake	120,000	Calvert City	KY

Note: Some plants have been listed as open in one year and closed in another non-consecutive year, leaving one to assume closure or conversion at some point during that time period.
Source: Anscombe (2002).

The figures reported in the US (Reece, 1991-99) for recycled mercury, shown in Table 6 below, provide some indications of when the residual mercury from decommissioned plants was placed on the market. There are no such consolidated recycling data for Western Europe. Rather than trying to guess when the residual mercury from Western European mercury cell chlor-alkali plants was returned to the market or to other operating plants, the relevant quantities are distributed evenly over the years in this table, while noting the particularly large closures reported in Germany for 1999, as shown inTable 4.

Table 6 -Releases of mercury due to closure and conversion of mercury cell chlor-alkali plants in the US and Europe

Year	Hg recovered from Western European mercury cell chlor-alkali plant decommissioning (tonnes)*	Hg recovered from US mercury cell chlor-alkali plant decommissioning (tonnes)**	Total Hg recovered from US & WE mercury cell chlor-alkali plant decommissioning (tonnes)
1981	100	0	100
1982	300	0	300
1983	300	320	620
1984	300	0	300
1985	300	0	300
1986	300	60	360
1987	300	100	400
1988	300	100	400
1989	300	0	300
1990	300	0	300
1991	300	0	300
1992	300	0	300
1993	300	125	425
1994	300	225	525
1995	300	275	575
1996	300	175	475
1997	300	100	400
1998	300	160	460
1999	300	100	400
2000	300	0	300
2001	300	152	452
Notes:	* Ref. Table 4 and consultant assumptions ** Ref. Table 5. This table does not include mercury cell chlor-alkali plant closures in other parts of the world during the same period, such as Canada, India, etc., which would count for at least another 5-10 percent in the amount of mercury recovered.		

3.3.1.4 Market impact of recycled mercury

Recycled mercury has played an increasingly important role on the global market in recent decades. The OECD estimated that secondary (non-mine) production of mercury could already in the early 1980s be as much as 40 percent of the level of primary production (OECD, 1985). Masters (1995-98) stated that 700 to 900 tonnes (20,000-25,000 "flasks"[3]) of mercury appeared to be recycled globally every year, of which he estimated that some 200-400 tonnes originated from spent mercury-containing products, and the rest came mainly from chlor-alkali plants. UNEP Chemicals (2002a) confirmed that large quantities of mercury continue to enter the market as a result of ongoing conversion and/or closure of mercury-based chlor-alkali production in Europe and other regions. Other recent estimates (Lawrence presentation at Breaking the Mercury Cycle, 2002) have

[3] Named for the leather container in which mercury was originally traded. Each flask (nowadays in fact a steel container) contains 34.5 kg of mercury.

maintained that some 50 percent of the global mercury supply now originates from sources other than mined prime or by-product mercury.

3.3.2 Principle mercury recyclers and brokers

According to the Lawrence presentation at Breaking the Mercury Cycle (2002), the US has 5 or 6 sophisticated retort recycling facilities, and perhaps as many as 50 less sophisticated mercury lamp recycling facilities. The rest of the world has another 5 or 6 retort mercury recycling facilities, most of them in Europe.

There are some recyclers who don't participate much in mercury trading, and some traders or brokers who don't have recycling facilities, but most of the major players are either involved in both pursuits, or they have extremely close contacts with other firms whose expertise complements their own, to the extent that four or five firms in the West, and about the same number in the East effectively control the mercury market. Statistical evidence of trade movements supports the contentions of those who know the mercury market well, that there is considerable market concentration, and the major players maintain an active network (Masters, 1995-98). The following sections will shed more light on the identities and activities of the key players in international mercury markets, and the general level of recycling activity in different regions.

3.3.2.1 European recyclers and brokers

The main mercury recyclers and traders operating in Europe are identified below. They span a broad range of capabilities from those who recycle only a single product or waste, to those who recycle nearly any materials that contain mercury. Typically, if the recyclers are not brokers themselves, they have close contacts with "specialty metals" brokers or traders who market the mercury for them, in which case it may go nearly anywhere in the world. In some cases the organisations that deliver the mercury waste to a recycler have a contract to repurchase the recovered mercury.

Spain

The Spanish company MAYASA has long been the most important player in the world mercury markets due to its considerable supply sources, low production costs, and its proximity to the European and American markets – historically the most important. MAYASA purchased and eventually traded most of the USSR stockpile that came onto the market during the 1990s. MAYASA also signed an agreement with Euro Chlor to purchase Western European mercury cell chlor-alkali plant mercury inventories as they become available following plant decommissioning. From these sources MAYASA has received between 400 and 900 tonnes of mercury annually since at least 1997. As market demand has shifted over the last 10-15 years, MAYASA has established sales offices in Spain, the UK, Peru, India, and the Philippines - clearly regions of significant trading activity (such as the UK) or market opportunities. In recent years 85% of MAYASA's mercury sales were exported outside the EU, mainly to China, countries of Southeast Asia and South America. Also in recent years the demand for "red oxide" (mercuric oxide) and calomel (mercury chloride), both mercury compounds produced and sold by MAYASA, has fallen off considerably.

Spanish battery recycler Recypilas SA opened in 1995-96, with a capacity to recover 170 tonnes of mercury per year. Recypilas, S.A., result of the collaboration of the local government Gobierno Vasco, Ihobe, and Indumetal Recycling, S.A., focuses on the recycling and treatment of batteries, accumulators and other products. Considering the present level of battery collection in Spain, it is estimated that Recypilas currently recovers no more than 20-25 tonnes of mercury per year.

Germany

German recycling of mercury has been quantified by Rauhaut (1996) for the period 1972-1993. In the years 1986-1993, the amounts of mercury recycled in Germany were equivalent to 3-53 percent of the domestic mercury consumption in that country. During this period, recycling increased slightly (from 7 tonnes in 1986 to 36 tonnes in 1993), while estimated German consumption decreased from 222 tonnes in 1986 to 67 tonnes in 1993 (Rauhaut, 1996).

In order to examine more closely recent recycling activities, one could look at the example of batteries. According to a recent press release by the Umweltbundesamt (http://www.umweltbundesamt.de/uba-info-presse-e/presse-informationen-e/p5602e.htm), in 2001 only 40 percent of the nearly one billion batteries sold annually in Germany were collected, implying that most batteries (i.e., some 18 thousand tonnes, excluding automotive batteries) are still being disposed of as household waste. This information was drawn from a study conducted for Gemeinsames Rücknahmesystem Batterien (GRS), an industry body established to ensure uniform and nationwide collection of spent batteries in Germany. In addition to other batteries containing lesser quantities of mercury, mercury oxide button cells (especially used in devices such as watches and pocket calculators) were identified as a particular problem. Mercury oxide button cells contain 20-40% mercury and, despite a ban on the sale of mercury oxide cells in force since mid-2001, twenty-one tonnes of these batteries were reported sold in Germany in 2001. Since the rate of collection for button cells is only around 10% of sales volume,[4] the whereabouts of some six tonnes of mercury remain unknown for this single product for 2001.

Permits for the transport (mostly within Germany, but also including significant waste imports and a few waste exports) of hazardous mercury wastes for 2001 – destined either for recycling or disposal – show, for three main categories of waste identified by the European Waste Catalogue:

- over 8000 tonnes of chlor-alkali wastes, approximately 15 percent imported mostly from the Netherlands, but also France and Switzerland;
- 34 tonnes of mercury-containing batteries, all domestic waste movements; and
- 5.5 tonnes of fluorescent lamps and household wastes (thermometers, etc.), nearly half of which are imported from Belgium, the Netherlands and Austria.

Two of the most important mercury recyclers in Germany are Rethmann Entsorgungs AG (Lünen) and GMR Gesellschaft für Metallrecycling mbH (Leipzig). It is estimated that they and other German recyclers recover 30-50 tonnes of mercury per year, not including the mercury recovered through on-site retorting of certain wastes by chlor-alkali plants.

Netherlands

In the Netherlands, 93 tonnes of mercury was recovered/recycled in 1995, including 2 tonnes of mercury from Dutch use of amalgam fillings, 6 tonnes from Dutch gas sludge/waste, and 85 tonnes of mercury from imported sludges and wastes (Maxson, 1996; Annema et al., 1995; DHV, 1996). The Dutch firm Claushuis-Metaal-Maatschappij reclaimed 70-90 tonnes mercury/year already before 1996. In May 1996 it added a new retorting process to permit it to reclaim mercury from a wider variety of wastes, and now typically recovers approximately 110 tonnes mercury/year from all sorts of products and wastes, much of it imported from neighbouring countries. Claushuis is far and away the largest mercury recycler in the Netherlands, and probably the largest in Europe apart from the firms that handle recovered mercury from chlor-alkali plants. Other specialised Dutch recyclers are listed in Appendix 2.

United Kingdom

[4] According to Environment Daily (no. 1307, 14 October 2002) and the European battery recycling association (EBRA), the battery recycling rate for all of Europe is less than 10 percent, although the collection rate is reportedly higher.

The London Metals Market has long been one of the world centres for trade in non-ferrous metals. Following are brief descriptions of the most significant (other than MAYASA's UK office) UK trader, and one of the more important UK mercury recyclers.

The original company Lambert Metals was formed in 1970 as a subsidiary of a large UK metals processing group; initially it traded secondary aluminium, non-ferrous scrap and residues, and minor metals. As Lambert Metals developed, it concentrated its activities on minor metals and ferro-alloys. In recent years, however, the company has reduced its activities to concentrate solely on its minor metals activities, for which it is rightly renowned worldwide. Today Lambert Metals remains a private independent company headquartered in London, UK, and continues to be owned by the management.

Wogen Resources Limited (WRL) is a leading dealer in minor metals (antimony, bismuth, cadmium, mercury, selenium, and silicon). WRL has in the past generally sourced raw materials from China and the Commonwealth of Independent States (CIS), and sold to clients in the European Union, North America, and the Far East. In 1989 Wogen's office in Moscow was opened to coincide with large quantities of strategic metals being supplied from the CIS, while contracts were negotiated in Moscow. According to the company's web-site, "many important deals were cemented in the office's dining room over dinner and Vodka." In the 1990s the break-up of the Soviet Union provided a massive source of mercury from previously strategic stockpiles. A lot of this material was "smuggled" out (see company web-site) through the ports of Estonia and Lithuania, providing "great trading opportunities," but also depressing the prices for these products worldwide. As China became an increasingly important factor in world mercury markets, in 1995 Wogen opened an office in Guangzhou.

The launch of the company Mercury Recycling Ltd (MRL) in September 1997 represented a major step for mercury recycling in the UK. It opened the UK's first fluorescent tube recycling plant in February 1998, which was honoured by the attendance of the Minister for the Environment, the Rt. Hon. Michael Meacher. Soon afterward the government awarded Biffa Waste Services, in collaboration with MRL, the contract to recycle the one million fluorescent lamps replaced in government buildings throughout the UK each year. MRL is rapidly expanding to handle all forms of mercury waste, and its Trafford Park site in Manchester, containing a Superior Distiller installation, can now distil mercury from wastes and contaminated equipment including barometers, dental amalgam, manometers, button cell batteries, thermometers, tilt switches, sphygmomanometers, arc rectifiers, etc. MRL can supply mercury to a purity of "two 9's" (i.e., 99.99%). It also offers a sieve and cleaning service, mercury spillage attendance, consultancy advice, decommissioning of contaminated plant and equipment, spillage kits for company safety purposes, etc.

Considering the UK and Ireland together, and the fact that mercury recycling is not generally well developed, it is estimated that recycled mercury (not including on-site recycling of chlor-alkali waste) presently amounts to no more than 20 tonnes annually.

Switzerland

The major Swiss recycler of mercury containing products and waste is Batrec Industrie. According to Mr. Andreas Krebs (personal communication 31 March 2003), this company's resulting output of mercury in recent years has been:

13.7 tonnes in 1999
12.5 tonnes in 2000
13.3 tonnes in 2001
8.7 tonnes in 2002

In 2002, Switzerland collected 2500 tonnes of batteries, which is approximately two-thirds of the quantity sold (Krebs, ibid). Switzerland reports a very significant use of energy-efficient fluorescent lamps, of which more and more are being recycled. Between 1999 and mid-2001, Swiss recycling organizations took in a yearly average of 154 tonnes of mercury-containing waste, including about 32 tonnes of fluorescent lamps (UNEP Chemicals, 2002a). Overall, Switzerland recovers about 15 tonnes of recycled mercury/year (UNEP Chemicals, 2002c).

France

In a fairly recent assessment of mercury in wastes in France, it was estimated that recycling of mercury in France produced only about 2.8 tonnes of mercury per year. However, significant mercury wastes from chlor-alkali production, electrical contacts and laboratories, among others, were not included in the assessment (Groupe de travail de l'AGHTM, 1999). Since that time, a number of recycling activities have been established around France to deal mostly with lamps, batteries and accumulators, and WEEE, and it is likely that recycled mercury (apart from chlor-alkali activities) now amounts to at least 10 tonnes per year.

Appendix 2 provides a general overview of mercury recycling services and mercury traders in Europe, by country, name of firm and services provided, as available.

3.3.2.2 United States recyclers and brokers

In 1996 the production of secondary mercury in the USA was already greater than reported industrial usage (372 tonnes), and almost in the same range as the estimated amount consumed in all applications (417 tonnes; source: Sznopek and Goonan, 2000). Mostly in response to Federal and State regulations to reduce the discharge and disposal of mercury-containing products and wastes, the sources of this secondary mercury included not only by-product mercury from other mining and refining operations, but also all mercury recovered or recycled from the chlor-alkali industry (both on-site and off-site), spent batteries, HID and fluorescent lamps, switches, dental amalgams, measuring devices, control instruments, and laboratory wastes, most of which were processed using high-temperature retorting. Reported recycling rates increased in general from about 100 tonnes in 1990 to an estimated 400 tonnes in 1998 (US EPA, 1997; USGS, 1991-98).

A specific example of relevant legislation is the RCRA regulation that requires certain mercury-bearing hazardous wastes (i.e., wastes with greater than 260 mg/kg mercury content) to be retorted (i.e., thermally treated) to recover the mercury. Other legislation/local ordinances impose recycling, reductions in mercury use/sale, and/or disposal restrictions. Some States require the separate collection of fluorescent lamps and other products, while others have implemented laws that phase out or ban the manufacture of certain mercury-containing products. Labelling, disclosure of mercury content, and limits on the use of mercury in manufacturing have also been used by States in various policy initiatives.

According to Reese (2001a, 2001b), three companies produce the bulk of secondary mercury in the United States:

- Bethlehem Apparatus Co. Inc.,
- D. F. Goldsmith Chemical and Metal Corp., and
- Mercury Waste Solutions, Inc.

Bethlehem Apparatus Company is one of the world leaders in the recycling of a wide variety of solid and liquid mercury-bearing wastes (see Appendix 3). It operates the world's largest commercial mercury recycling facility (over 10,000 sq. meters) including 29 advanced high-vacuum mercury waste retorts able to process 200 different types of mercury wastes, two continuous-feed fluorescent lamp glass retorts, eight quadruple distillation systems and a 550-tonne calomel processing plant. BA is also a global supplier of prime virgin and high purity mercury.

Another major US mercury recycler and broker is D.F. Goldsmith Chemical & Metal Corporation (DFG). According to the company web-site, this business opened in Chicago in 1960 with facilities to produce gold salts and to refine and bottle mercury. The company now has its own 500-square-meter headquarters in Illinois. In addition to distilling and packaging mercury, DFG markets a wide range of precious metal products, exotic metals and inorganic chemicals. Currently, mercury accounts for approximately one-third of sales volume. Both scrap and virgin mercury are chemically treated and vacuum distilled at precisely regulated temperatures to obtain the purity of mercury necessary – their sophisticated equipment can provide better than "five 9's" (99.999+% purity) when needed. This ultra-pure mercury is packaged in a variety of glass or plastic containers for numerous applications - mercury batteries, electronic and electrical devices, dentistry, general laboratory use, etc.

Appendix 2 provides a general overview of mercury recycling services and mercury traders in North America, by name of firm and address, types of wastes accepted and services provided, as available.

3.3.2.3 Recyclers and brokers in the Far East

While there are not yet major mercury recycling operations in South and East Asia, a number of important traders and brokers are active, especially as the People's Republic of China has become the dominant consumer of mercury during the last 10 years. Initially most of this trade passed via Hong Kong. Now brokers outside China are more frequently dealing directly with their mainland China counterparts.

Appendix 2 provides a general overview of the chief brokers and traders in East and South Asia, by name of firm and address, with some description of the firm and services provided, as available.

3.3.2.4 Global mercury recycling and recovery activity

Based on the above discussion, and considering that there are significant variations from one year to the next, on a global scale recovery and recycling of mercury may be estimated as in Table 7 for the year 2000.

Table 7 - Other secondary sources - recovered & recycled mercury (tonnes, 2000

Country/region	Secondary mercury		
	Mercury recovered from decommissioned chlor-alkali cells	Hg recycled from wastes of operating chlor-alkali plants, both on-site and off-site	Other recycled mercury
European Union (15)	1100	30	150
North America	0	10	270
Other OECD	?	5	50
Central & Eastern Europe and CIS	?	0	15
Arab States	0	0	0
East Asia and Pacific	0	15	40
Latin America & Caribbean	0	0	10
South Asia	70	0	10
Sub-Saharan Africa	0	0	5
Total	**1170**	**60**	**550**
Comments	assume mercury recov-	estimated recycling of	Not including any

	ered in 2000 from plants decommissioned in 1999, which were far larger than the average EU decom-missioning	0.0-0.5% of the mercury reservoirs in these plants, consistent with reported figures for OSPAR sites.	chlor-alkali Hg, by-product Hg from other mining operations, nor Hg that may be recycled during ar-tisanal gold mining.

Table 8 summarises estimated mercury recycling in the US and the European Union during the past two decades. While recovery of mercury from decommissioned mercury cell chlor-alkali plants may also be referred to as recycling, for purposes of this paper it is preferred to treat these two "sources" separately, as above. The US has traditionally recycled more of the other chlor-alkali mercury wastes than other countries, but in recent years the EU has been rapidly catching up.

Table 8 - Production of recycled mercury (not including mercury recovered from mercury cell chlor-alkali plant decommissioning) in the US, Europe and Rest-of-the-world

Year	(A) US Secondary production of mercury, incl. decom-missioning (tonnes)	(B) US Hg recov-ered from mer-cury cell chlor-alkali plant decom-missioning (tonnes)	(A-B=C) US production of mercury via re-cycling (tonnes)	(D) EU production of mercury via recycling (tonnes)	(E) Rest-of-the-world produc-tion of mercury via recycling (tonnes)	(C+D+E) Total mercury recycling worldwide (tonnes)
1981	146	0	146	30	20	196
1982	154	0	154	30	20	204
1983	474	320	154	30	20	204
1984	196	0	196	30	20	246
1985	185	0	185	30	20	235
1986	219	60	159	30	20	209
1987	265	100	165	30	20	215
1988	278	100	178	30	20	228
1989	137	0	137	30	20	187
1990	108	0	108	40	20	168
1991	165	0	165	50	30	245
1992	176	0	176	60	50	286
1993	350	125	225	70	60	355
1994	466	225	241	80	70	391
1995	534	275	259	110	90	459
1996	446	175	271	130	100	501
1997	389	100	289	140	110	539
1998	400	160	240	150	120	510
1999	375	100	275	160	140	575
2000	280	0	280	180	150	610
Sources:	Reese (1991-99); Reese (2001); Sznopek & Goonan (2000); consultant est. 1999-2000	Ref. Table 5	Difference between column A and col-umn B	consultant esti-mates	consultant esti-mates	

3.4 Strategic stockpiles and other inventories

The disposition of mercury inventories held by governments, mines or other industries may have a very significant effect on yearly mercury supplies, although over the short to medium term these inventory increases and decreases may be expected to balance out so that trends in annual supplies may be more clearly seen. The main exception to this observation is government stockpiles, which may be held for many years, and then disposed of in a relatively short time period.

The objectives of various organisations in holding and selling mercury from inventories may vary considerably.

> Governments have held strategic inventories for security of supply, and when they decide to sell, their chief objective is to avoid a major disruption of the market. Maximising the sale price is a secondary consideration.
>
> Private mines and mercury brokers have held inventories only to influence market stability and to respond to sudden demands – both with the overall objective of maximising revenues. State-owned mines have the additional (if not overriding) objective of maintaining employment and social cohesion in regions where the mines may be critical in supporting the local economy.
>
> Other private industries have kept raw mercury inventories in the past to ensure availability of supply, and secondarily in an attempt to manage raw material costs.

For purposes of comparison, when disposing of residual mercury from decommissioned mercury cell chlor-alkali plants (the major inventory of "used" mercury), industry used to look only for a reasonable price on the open market. In recent years, however, during a time of closer scrutiny of mercury in general, industry has become less concerned with the price received for residual mercury, and more concerned that the mercury is dealt with responsibly. This is evident, for example, from the 2001 industry agreement with MAYASA that residual mercury purchased by MAYASA from the Euro Chlor members should displace new production of virgin mercury.

3.4.1 Strategic stocks

There have been during the past 20 years significant contributions to the mercury supply from strategic stockpiles, chiefly from the US and USSR, the latter bringing nearly 3000 tonnes of mercury to market since 1990. The approximate quantities of mercury sold on the market from these inventories are summarised in Table 9 below.

Table 9 - Major mercury sales from government strategic stocks, 1981-2000

Year	Sales from US strategic stocks (tonnes)	Sales from USSR strategic stocks (tonnes)	Total stockpile sales US + USSR (tonnes)
1980	335	0	335
1981	300	0	300
1982	250	0	250
1983	225	0	225
1984	150	0	150
1985	190	0	190
1986	100	0	100
1987	250	0	250
1988	265	0	265
1989	349	0	349
1990	245?	0	245
1991	336	200	536
1992	371	300	671

1993	543	500	1043
1994	86	500	586
1995	sales discontinued pending review	300	300
1996	0	0	0
1997	0	1000	1000
1998	0	stockpile reportedly exhausted	0
1999	0	0	0
2000	0	0	0

Sources: USSR data from Masters (1995-98), who gives USSR stockpile sales as 1000 tonnes in 1997, none in 1996, 300t in 1995, 500t in 1994, and about 1000t between 1990-1993;
US data from Sznopek & Goonan (2000), USGS Mercury (2002) including annual USGS reports.

3.4.2 Other inventories

In estimating total sources of mercury in 2000, it is important not to be misled by other changes in inventories. Because mine inventories are used, as in other commercial operations, to anticipate demand and to influence prices, the mine production in a given year does not necessarily bear any direct relation to that year's sales of mercury. For example, while MAYASA produced 236 tonnes of mercury in 2000, it sold about 800 tonnes. For this reason this paper reports annual mine production rather than mine sales, knowing that any inventory changes will gradually appear over time.

Likewise, the various industrial inventories tend to increase and decrease from one year to the next, but these also eventually appear over time in figures for industry purchases and/or consumption of mercury.

Finally, mercury waste inventories, especially those held by mercury cell chlor-alkali plants (or the 2000 tonnes of waste batteries collected in Sweden over 16 years), are often stockpiled or stored on site for several years before final recycling or disposal. While quantities sent for recycling may sometimes be significant, they are not large enough to disrupt the market, and are in any case considered in this paper as recycling rather than inventory changes.

3.5 Total European and world mercury supply

Based upon the previous analysis, one can calculate the overall mercury supply for Western Europe and the rest of the world.

3.5.1 Total Western European mercury supply

Table 10 shows total Western European and world mercury supply from 1981-2000, where mined mercury includes all primary mined mercury as well as mercury produced as a by-product of other mining operations, mercury recovered from decommissioned mercury cell chlor-alkali plants, and other recycled and recovered mercury.

Table 10 - Total Western European mercury supply - primary and secondary mercury production, including mining, recycled mercury and mercury recovered from decommissioned mercury cell chlor-alkali plants (tonnes)

Year	Mining & by-product mercury	Hg recovered from decommissioned mercury cell chlor-alkali plants	Recycled mercury	Total Western European mercury production (tonnes)
1961-70	ave. 4519/yr.	min.	min.	est. 4550/yr.
1971-80	ave. 2834/yr.	min.	min.	est. 2900/yr.
1981	2115	100	30	2245
1982	1981	300	30	2311
1983	1683	300	30	2013
1984	1830	300	30	2160
1985	1834	300	30	2164
1986	1868	300	30	2198
1987	1935	300	30	2265
1988	1879	300	30	2209
1989	1315	300	30	1645
1990	1272	300	40	1612
1991	217	300	50	567
1992	195	300	60	555
1993	791	300	70	1161
1994	531	300	80	911
1995	1648	300	110	2058
1996	1137	300	130	1567
1997	477	300	140	917
1998	548	300	150	998
1999	473	300	160	933
2000	281	300	180	761

Table 10 shows mercury mining in Europe declining dramatically over the years, not only due to declining demand, but also due to supplies coming to Europe from other sources. For example, from 1991 to 1994, and again in 1997, MAYASA received large shipments of mercury from USSR stockpiles, and reduced its mine output accordingly. From 1998 MAYASA began to receive mercury from decommissioned chlor-alkali plants, and kept its mine output at a lower level. Especially the figures in this table for mercury received from decommissioning (which have been averaged out over time due to lack of precise data) are misleading for 1999 and 2000 since substantially larger quantities of mercury were actually released from this source during those years.

At the same time, European recycling of mercury has gradually increased, as more and more mercury wastes are segregated, the range of mercury wastes that are considered hazardous increases, and recycling is seen as a viable alternative (in some cases) to landfilling.

3.5.2 Total global mercury supply

Table 11 summarises global mercury supply, including all of the elements in Table 10 above, as well as the contributions of mercury from strategic stockpiles in the 1980s and 1990s.

Table 11 - Total global mercury supply - primary and secondary mercury production, including mining, recycled mercury, mercury recovered from decommissioned mercury cell chlor-alkali plants, and mercury from strategic stockpiles (tonnes)

Year	Mining & by-product mercury	Hg recovered from decommissioned mercury cell chlor-alkali plants	Recycled mercury	Mercury from US & USSR strategic stockpiles	Total global mercury production (tonnes)
1961-70	ave. 9200/yr.	n.a.	n.a.	n.a.	est. 9300/yr.
1971-80	ave. 8200/yr.	n.a.	n.a.	n.a.	est. 8400/yr.
1981	6054	100	196	300	6650
1982	5798	300	204	250	6552
1983	5812	620	204	225	6861
1984	5661	300	246	150	6357
1985	5906	300	235	190	6631
1986	6499	360	209	100	7168
1987	6126	400	215	250	6991
1988	6602	400	228	250	7480
1989	6363	300	187	350	7200
1990	6066	300	168	245	6779
1991	3671	300	245	518	4734
1992	3053	300	286	670	4309
1993	3042	425	355	1043	4865
1994	2035	525	391	586	3537
1995	3338	575	459	300	4672
1996	2782	475	501	0	3758
1997	2529	400	539	1000	4468
1998	1996	460	510	0	2966
1999	2061	400	575	0	3036
2000	1849	300	610	0	2759

Similar to the European case, global mining has decreased dramatically, and has been replaced to some extent by secondary sources. This will add to the difficulties in further controlling mercury flows, since many more “suppliers” of mercury exist as the major mines have reduced their activities or have closed.

Figure 1 - Total global mercury supply

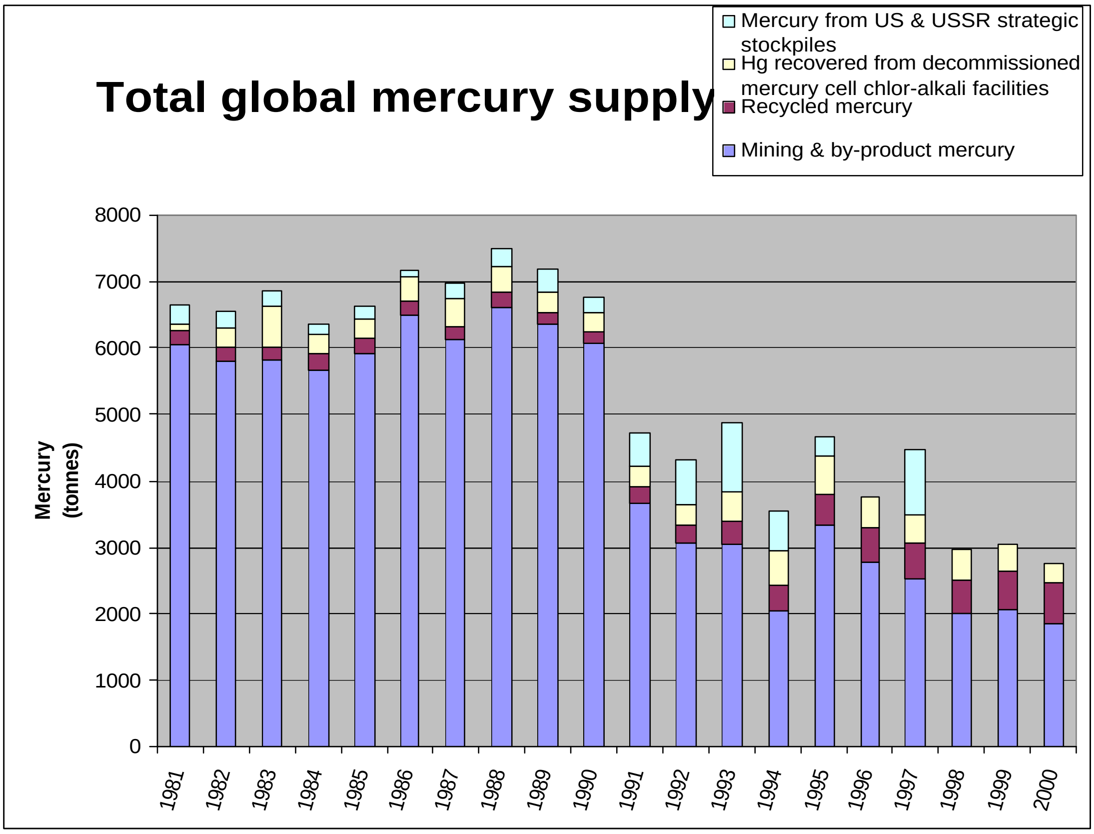
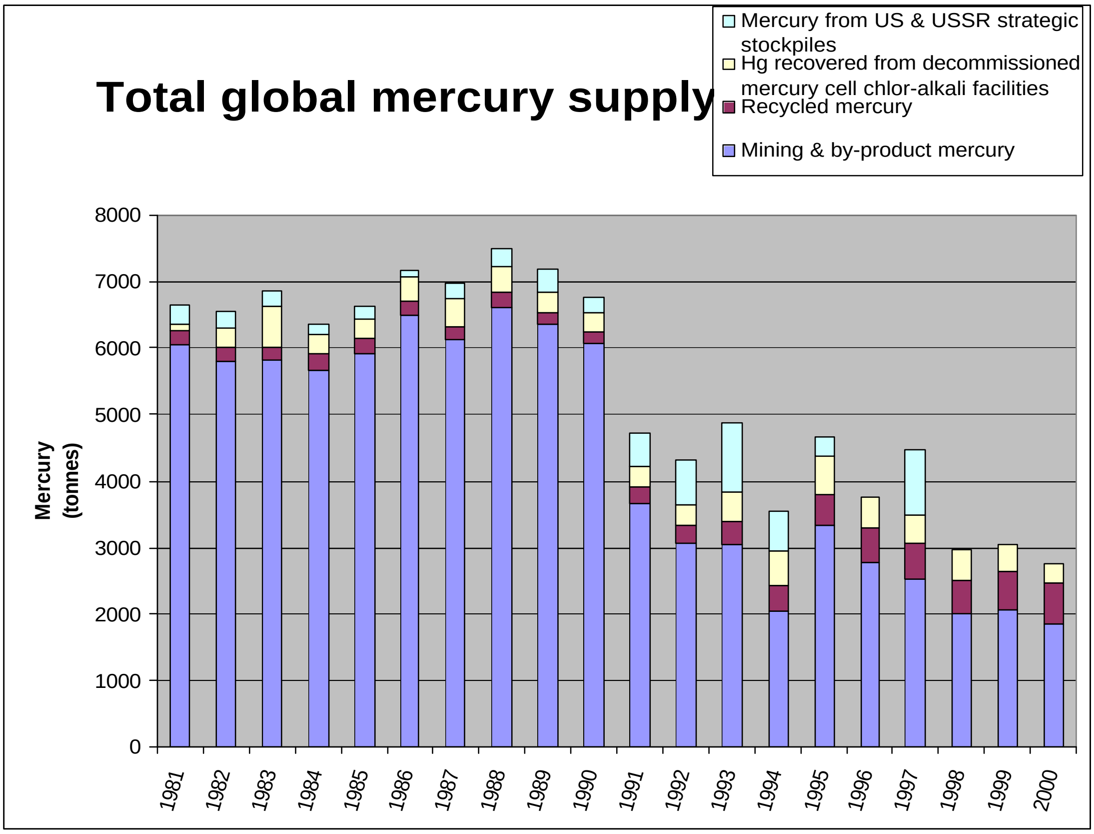


Figure 1 demonstrates clearly to what extent overall mercury demand has fallen off as well, showing mercury supply in 2000 at less than half of its level in 1990.

Figure 1 - Total global mercury supply



The explanation for the dramatic fall-off in supply between 1990 and 1991 is unclear. Mine output across the board was sharply down in 1991, while some influx of mercury from the USSR stockpile appeared that year. However, as there is no evidence that mercury demand fell off so rapidly during that brief period of 1990-91, it is likely that other mercury inventories may also have been released during that period - quantities that are not visible in these data. In any case, since 1991 the apparent global mercury supply has only once risen above the level of 1991, and has generally continued to show a decline.

Based on the relatively conservative data of Table 11 above, the mercury supply from 1994-2000 has averaged 3600 tonnes per year, and from 1996-2000 the average has been 3300-3400 tonnes per year, which one could take as a reasonable time-weighted estimate of global mercury supply in 2000.

4 Mercury demand

4.1 Equivalence between mercury supply and demand

As noted in UNEP Chemicals (2002a), the global demand for mercury, over time (i.e., balancing out intermediate stock changes), is equivalent to the amount of mercury flowing to final global users/consumers from the supply sources listed in the previous section of this paper. In the preceding analysis, one of the reasons that such a significant effort has been devoted to details of the global mercury supply is that it may be used as a proxy for demand, especially as mercury demand data are so incomplete and imprecise.

A range of efforts have been made during the last 10-12 years to estimate EU mercury demand, but the motivations behind such efforts have been so varied, and the demand picture has changed so much during this period, that many of these results are scarcely comparable. Moreover, as mercury demand in Western Europe has shrunk under legislation and increasing public scrutiny, even some of this data - while diminishing in relative importance - is becoming less readily available and less reliable.

With regard to global mercury demand, no precise data have been generated on the specific elements of global consumption of mercury, its distribution among countries, or its distribution among applications. There are a number of reasons why the details of global demand are highly elusive, despite a number of efforts over the years to improve them:

- there are a multitude of uses, most of them incorporated in another product;
- the trade statistics for raw mercury are barely adequate for a soft analysis; but there are no statistics at all for mercury when it is incorporated in a product;
- mercury is treated as a commodity, and the same mercury may change hands several times; as is evident from trade statistics, it is frequently bought, sold and stored depending on general market opportunities (and sometimes political opportunities), rather than in response to specific demand;
- there are a number of illegal or extra-legal uses of mercury that discourage record-keeping; a great deal of mercury use in developing countries takes place beyond mainstream society, and therefore beyond the realm of the normal compilation of economic statistics - especially its use in small-scale, artisanal mining of gold and silver - yet this use may be among the largest on a global basis.

Thus, estimates of global demand for mercury must rely in part on uncertain estimates from very incomplete data. To the extent possible, the task of this section of the paper is to compile what we know about overall mercury demand, and to then examine to what extent it corresponds to what we know about mercury supply.

4.2 Overview of mercury demand in products and processes

Mercury is consumed in a broad range of products and processes around the world. The major categories of mercury demand in Western Europe include:[5]

- chlor-alkali production
- dental amalgams
- fever and other thermometers
- mercury oxide and other batteries
- neon, compact fluorescent, HID and other lamps
- measuring and control equipment
- electrical switches, contacts and relays
- laboratory and educational uses
- other industrial processes requiring catalysts, etc.
- pharmaceutical processes, products and preservatives
- other product uses, such as cosmetics, fungicides, toys, etc.

Additional categories of mercury consumption more prevalent in, but not exclusive to, less developed countries include:

- artisanal gold and silver mining
- cosmetics
- cultural uses and traditional medicine
- paints and agricultural chemicals.

[5] A more exhaustive list may be found in Gilkeson (1996).

In the analysis below, mercury consumption in the EU, the US and globally will be estimated for the more important of these categories, listed in Table 12 below.

Table 12 - Six of the most important mercury demand categories, and indications of key organisations or regions involved in each sector

Major mercury demand category	Key organisations or regions
Chlor-alkali	World Chlorine Council Chlorine Institute Euro Chlor
Artisanal gold/silver mining	United Nations Industrial Development Office (UNIDO) Brazil's National Department of Mines and Prospecting Center for Minerals Technology of the Brazilian Research Council (CETEM)
Batteries	European Portable Battery Association (EPBA) Gemeinsames Rücknahmesystem Batterien, Hamburg International manufacturers: Duracell, Energizer, Rayovac, Philips, Sony, Varta, Panasonic Regional manufacturers: Gold Peak (Hong Kong), etc.
Dental amalgam	World Dentist Federation (FDI) Typically, triple-distilled mercury is placed in capsules or other small containers by companies in Germany and the Netherlands; these capsules are then packaged with alloys, which are distributed to EU dentists primarily by two non-EU dental supply companies
Measuring and control equipment	Major EU manufacturers in the UK and Germany, although many thermometers and other measuring equipment are imported, primarily from China, India and Japan.
Lighting	International Association for Energy Efficient Lighting (IAEEL) European Lighting Companies Federation (ELC) Manufacturers: Philips, Osram (Siemens) and GE Lighting

4.3 Data anomalies

When dealing with data concerning demand for mercury containing products, there may be significant confusion in differentiating between “manufacturing” demand (demand for mercury by manufacturers) and “final” product demand (demand by the greater public for products containing mercury). For example, Ireland imported 17 tonnes of mercury in 1999 for use in soaps, which were subsequently exported from the EU. The import of mercury was thus an EU “manufacturing” demand, but the manufacturing demand did not translate into an EU “final” demand since the soaps were not consumed in the EU. There is, of course, a trend to reduce the amount of mercury in most products consumed in the EU. But at the same time, there is also less and less manufacturing of mercury products within the EU, and an increase in the net imports to the EU of finished products containing mercury.

Depending upon the objectives of any given analysis, other authors have focused on manufacturing demand for mercury, final demand for mercury containing products, or the issue may not have been clarified at all. In this analysis, both types of data will be considered “EU demand” as long as they do not involve double counting. In other words, the Irish import of mercury will be counted as an EU demand for mercury. The EU consumption of mercury thermometers manufactured in India will be considered an EU demand for mercury. And the EU consumption of compact fluorescent lamps (CFLs) will be considered an EU demand for mercury, regardless of whether they were manufactured in the EU or in third countries. Therefore, EU mercury demand will be based on final EU consumption of mercury containing products, consumption of mercury in EU manufacturing processes, and any other consumption of mercury that takes place within the EU, such as the insertion of amalgam dental fillings.

4.4 Mercury consumption by product/process category

In this section, the descriptions of the use of mercury in these products and processes are taken from COWI (2002), as noted, with relatively minor additions or modifications. The calculations of European Union mercury consumption for each of these product categories are largely based on the range of sources provided in Royal Haskoning (2002) and RPA (2002), the latter of which is one of the more diligent efforts to provide serious mercury consumption estimates for the EU. In the several cases where these sources do not fully consider the relevant facts or documentation, or fail to respond to the needs of this analysis, revisions are proposed.

4.4.1 Chlor-alkali production with mercury-technology

Mercury is used as a fluid cathode in one of the three main types of electrolytic process used for production of chlorine and sodium hydroxide (NaOH) from salt brine. The process is sometimes referred to as the "mercury cell" process. A single mercury cell chlor-alkali plant may have many tonnes of mercury in use (COWI, 2002). Other well known mercury-free processes are widely used, and it is generally accepted that these alternative processes will gradually replace the mercury process over time.

Worldwide mercury cell chlorine production capacity for 2000 exceeded 12 million tonnes, as summarised in Table 13. Based upon the Chinese, Mexican (UNEP Chemicals, 2002a) and Indian (Narain, 2002) information and other indications in the literature, it is most likely that the Indian situation is roughly representative of the 35 percent of world mercury-cell chlorine production capacity (4.2 million tonnes/yr.) located outside the US and Western Europe, i.e., consuming mercury at about three times the average level in the US for 2000. Some of the plants in this group have lower consumption of mercury, while others are known to have far higher. Given world mercury-cell chlorine production capacity of 12 million tonnes, mercury consumption outside the US and Western Europe would be about 630 tonnes annually – about 80 tonnes for India (with 500 thousand tonnes mercury-cell chlorine production capacity) and 550 tonnes for the others. OSPAR and US consumption of mercury in 2000 have been reported by Euro Chlor (2002a) and the Chlorine Institute (2002). If one assumes that the weighted average mercury consumption reported by OSPAR and US firms is representative of the remaining Western European plants, then the Western European plants all together may be calculated to consume about 95 tonnes of mercury annually. As shown in Table 13, this gives a combined estimate of about 800 tonnes of mercury consumed in 2000 by the global chlor-alkali industry (note that chlor-alkali "consumption" of mercury should not be taken as equivalent to "emissions").

Table 13 –Global mercury cell chlorine production capacity and mercury consumption (2000)

Region	Mercury cell chlorine production capacity ('000 tonnes)	Mercury consumption (tonnes)
Western Europe	6,592	95
United States	1,409	72
Rest of world	4,200	630
Totals	12,201	797

Sources: Euro Chlor (2001a, 2001b, 2002a); Chlorine Institute (2002); UNEP Chemicals (2002a).

4.4.2 Gold extraction with the mercury-amalgamation process

Mercury is consumed during gold extraction with the amalgamation process - typically applied in small scale mining (SSM) or so-called artisanal gold mining. The main steps of this extraction process are:

- Ore concentrated by sedimentation is mixed with metallic (liquid) mercury, during which the most easily extractable gold is dissolved in the mercury ("amalgamation").
- The mercury-gold amalgam is separated from the solids and heated until most of the mercury has evaporated, and the gold can be collected and sold/processed in further steps. This process is often done with no effort to capture the volatilised mercury, which is consequently emitted to the atmosphere, although semi-closed "retorts" are sometimes used to capture some of the mercury (COWI, 2002).

The same process is known to be used for small-scale silver mining as well, but the extent of this practice is not as well studied as gold mining. Substitution or modification of this artisanal process is not simple, mainly due to socio-economical factors.

Greenpeace (1994) estimated the total world-wide consumption of mercury for gold mining at 400-500 tonnes/year in 1993-94, while others suggested that the figure had declined by 1996 to 350-450 tonnes/year. The most comprehensive recent analysis of this practice (MMSD, 2002), noting that typically at least one kilogram of mercury is lost for each kilogram of gold recovered (Veiga, 2002), and estimating that SSMs produced an estimated 500 tonnes of gold in 2000, suggested that 500 to 1000 tonnes of mercury annually may be consumed by artisanal gold and silver miners. Considering the various uncertainties, a conservative estimate of mercury consumed in 2000 in SSMs for gold and silver would be 650 tonnes, as in Table 14 below.

Table 14 - Mercury consumed in small-scale mining (2000)

Region	Gold produced by SSM in 2000 (tonnes)	Hg consumed in small-scale mining (tonnes)
European Union	min.	min.
United States	min.	min.
Rest of world	500	650
Totals	500	650

Sources: MMSD (2002); UNEP Chemicals (2002a).

4.4.3 Batteries containing mercury

The use of mercury in various types of batteries has been among the largest product uses of mercury. Mercury is present in high concentrations (about 30% by weight) in mercury oxide batteries (mainly sold as button cells, but also with a number of military and other applications). Marketing of mercury oxide batteries is now severely restricted in several OECD countries, although specific uses (especially military) may still be exempted (COWI, 2002). This is putting pressure on producers to gradually replace these batteries with mercury-free alternatives, but mercury oxide batteries have such a significant price advantage, and the production infrastructure is in place, that substitution is slow, despite Commission Directive 98/101/EC requiring Member States to prohibit, from 1 January 2000, the marketing of button cells (and batteries made up of button cells) containing more than 2% mercury by weight. This explains why 37 tonnes of mercury from batteries were recently reported to still enter the EU waste stream annually (European Commission, 2001), and why there remains a continued high output of mercury oxide batteries from East and South Asia, as well as significant trade through the EU and the US.

Until recently, alkaline cylindrical cells on the European market had mercury concentrations of up to 1%. Due to environmental restrictions on large Western markets, the presence of mercury in many cylindrical alkaline batteries was reduced, and many or most are now produced virtually mercury-free. However, some nationally or regionally traded brands of alkaline batteries containing mercury surely remain. Button cell batteries of alkaline, silver oxide and zinc/air types may still contain mercury at concentrations up to 1%. Other battery types are no longer believed to contain significant amounts of mercury. It should be noted that besides normal battery sales, batteries are imported and exported in massive quantities in other products such as electronics, toys, greeting cards with sounds, articles of clothing, hats and shoes, etc. (COWI, 2002).

In calculating EU mercury consumption in batteries, one would like to be able to rely on industry data. However, EU industry representatives have a strong vested interest in claiming that mercury in batteries is no longer an issue, and their data are appropriately biased. As noted by RPA (2002), the most comprehensive data on current mercury usage in batteries is found with the German submission to UNEP Chemicals (2002d), and puts German consumption of mercury in batteries in 2000 at 3.1 tonnes/year, although it is not clear if this figure includes batteries imported in other products. One should note that the mercury oxide button cells banned in the EU from January 2000 still accounted for 70% of Germany's estimated consumption of mercury in batteries in 2000. This is consistent with trade statistics for other EU Member States as well. As Germany accounts for about 20% of the button cell market, if one extrapolates the German figures to the EU as a whole, these data suggest that some 15 tonnes of mercury per year (RPA, 2002) may have been consumed by the EU in batteries in 2000. This figure should be compared to around 2 tonnes/year suggested by industry, which reports only sales by the European Battery Producers Association (EPBA) members, who no longer sell mercury oxide button cells in the EU.

In the case of the US, since batteries containing mercury are not supposed to be any longer widely produced in the US, USEPA/NRMRL (2002) suggests that the manufacturing consumption and the level of mercury in batteries going to disposal is "negligible." But this is entirely inconsistent not only with European Commission (2001), but also with 2000 trade statistics (see the following section) that report extensive worldwide (including the EU and US) trade in mercury oxide batteries. Therefore, until a better explanation is provided, one must assume a similar mercury consumption from batteries as in the EU, adjusted for population and GDP/capita, as in Table 15.

Considering the lack of statistics concerning production levels and mercury content, a calculation of battery consumption for the rest of the world (ROW) is quite a challenge, and happily not a key focus of this paper. Briefly, it is useful to recall that the US itself consumed at least 700 tonnes of mercury per year in batteries from about 1975 through the late 1980s (Sznopek & Goonan, 2000), although many were for export. It is also evident that outside the US and EU there is little pressure to reduce the mercury content of batteries, although that will come. It is also astounding to see the reported level of current trade in mercury oxide batteries, especially through East and South Asia (see following section). A simplistic estimate of mercury consumption could be based on the fact that the ROW GDP is about three times that of the US, and the assumptions that Asia is producing about the same number of batteries as the US did in the 1980s, but at a level of mercury use per battery that may be 50% lower than it was in the US during the 1980s, due to some technological improvements. This would give an estimate, while highly uncertain, of (700 tonnes Hg/yr.) * (ROW GDP/US GDP) * (50% less Hg) ˜ 1050 tonnes Hg/yr. The various estimates of mercury use in batteries are summarised in Table 15.

Table 15 – Mercury consumed in batteries (2000)

Region	**Population (millions, 2000)**	**GDP/capita (US dollars, 2000)**	**GDP (billion US dollars, 2000)**	**mercury consumed in batteries (tonnes)**
European Union	376.3	23,645	8,898	15
United States	283.2	34,142	9,669	16
Rest of world	5357.5	4,904	26,274	1050
Totals	6017.0			1081

Sources: UNDP (2002); UNEP Chemicals (2002a); RPA (2002); consultant estimates.

4.4.4 Dental mercury amalgam fillings

Dental amalgam fillings consist of an alloy of mercury (typically 44-51% mercury by weight), silver, copper and tin. It is typically supplied to dentists 1) as pure mercury and, separately, a powder mix of the other metals, which are weighed out and mixed when needed at the dental clinic, or 2) as small capsules or sachets in which mercury and the metal powder are provided in the necessary proportions, and only need to be mixed (in the capsule before opening) in the clinic. Depending on the size and type of filling, something between 0.4 g and 1.0 g of mercury is normally consumed per filling (including excess amalgam), according to Danish practice (COWI, 2002). RPA (2002) has reported 0.350 g of mercury per filling, but this does not include the 40% of the total that goes to waste, suggesting that the quantity of mercury actually consumed for one filling is just under 0.6 g.

RPA (2002) has suggested a large decrease in mercury use for fillings in the EU, from 110 tonnes in 1990 to about 70 tonnes in 2000. This is based on consultations with dental practitioners, many of whom reported that they increasingly use alternative materials in their work. Yet the specific studies cited of recent consumption (France, the UK) show increases in mercury consumption for fillings (except in Scandinavia), and there is corresponding evidence of better coverage of dental visits by EU health plans, better awareness of the benefits of periodic dental care, more dentists and more visits to dentists than 10 years ago - all of which suggest a continued rather high level of mercury consumption.

USEPA/NRMRL (2002) estimates US mercury use in dentistry in 2000 at 34-54 US tons (approximately 30-50 tonnes), compared to 44 tonnes in 1990 and 31 tonnes in 1996 (UNEP Chemicals, 2002a). The 2000 mid-range, 40 tonnes, would be a significant decrease (especially considering the simultaneous population increase) from the level of dental mercury consumption estimated 10 years previously for the US. However, such a decrease is not supported by evidence of such a significant increase in the use of alternative materials in fillings, i.e., a decrease in the average quantity of mercury per filling, nor of such a significant decrease in the total number of fillings inserted due to such measures as better preventive care.

For other regions of the world, once again, a reasoned estimate must be made. Considering that a number of these countries are OECD members, dental practices and availability vary widely, etc., one could assume a level of mercury consumption per capita about one-tenth the EU and US levels, as summarised in Table 16.

Table 16 –Mercury consumed in dental amalgams (2000)

Region	Population (millions, 2000)	GDP (billion US dollars, 2000)	Grams of mercury per million $US of GDP	Hg consumed in dental amalgams (tonnes)
European Union	376.3	8,898	7.87	70
United States	283.2	9,669	4.55	44
Rest of world	5357.5	26,274	6.00	158
Totals	6017.0			272

Sources: UNDP (2002); UNEP Chemicals (2002a); RPA (2002); consultant estimates.

4.4.5 Measuring & control devices

Mercury thermometers have traditionally been used for most medium temperature range measurements. Today they are increasingly substituted by electronic and other thermometer types, but the degree of substitution varies greatly among countries. Major remaining uses include medical thermometers (body temperature measurements), in chemical laboratories, and in controls of some machines (diesel engines in large ships, etc.) and industrial equipment. Mercury thermometers may contain between about 1 (medical) and several hundred grams per unit, depending on the use (COWI, 2002).

Medical blood pressure gauges (**sphygmomanometers**) are used widely in hospitals, in private medical practices, etc. They normally contain about 70g mercury per unit.

Barometers are commonly used for meteorological purposes (professional and private). The quantities of mercury per unit are generally similar to U-shaped manometers (see below).

Pressure valves are found in district heating and elsewhere. They contain 100-600 kg mercury per unit, sometimes more.

U-shaped classical **manometers** are mostly for educational purposes. The mercury content varies, but is typically on the order of 70-140 g mercury per item.

This is a difficult category to estimate mercury consumption due to the range of items included, the varying amounts of mercury contained, the gradual phase-out of a number of these items in some countries, etc. KEMI (1997) estimated mercury consumption in the EU at 70 tonnes. WS Atkins (1998) estimated mercury consumption at 55 tonnes. RPA (2002) has made a case for a substantial reduction to 26 tonnes in 2000, which is within range of the USEPA/NRMRL (2002) estimate of about 35 US tons (about 32 tonnes), but the latter applies only to thermostats and thermometers. While the RPA estimate of 26 tonnes seems low for the EU, there is no more precise current data with which to improve it.

For the rest of the world, most of the industrial and private sectors have not upgraded this sort of equipment to mercury-free alternatives, so one could expect a slightly higher level of mercury consumption per unit of GDP than observed in the EU and US, as summarised in Table 17.

Table 17 - Mercury consumed in measuring and control devices (2000)

Region	Population (millions, 2000)	GDP (billion US dollars, 2000)	Grams of mercury per million $US of GDP	Hg consumed in measuring & control devices (tonnes)
European Union	376.3	8,898	2.92	26
United States	283.2	9,669	3.62	35
Rest of world	5357.5	26,274	4.00	105
Totals	6017.0			166

Sources: RPA (2002), USEPA/NRMRL (2002), consultant estimates.

4.4.6 Light sources with mercury

Mercury is used in small amounts per lamp in a number of different types of discharge lamps, with fluorescent tubes and compact fluorescent lamps as the most common examples. Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment limits the mercury content of standard fluorescent tubes to no more than 10 mg, and of CFLs to no more than 5 mg from 2006 for the EU. Ongoing efforts have been made by some producers to reduce the amount of mercury per lamp, and significant reductions have been achieved in some newer lamps. The older types with a higher mercury content are, however, still on the market, and continue to be sold in large volume as they are generally cheaper than low-mercury lamps. Examples of mercury content in lamps include (Maag et al., 1996; COWI, 2002):

- best available fluorescent tubes (as regards mercury): About 3-4 mg Hg/lamp.
- “low end” fluorescent lamps: 10-40 mg Hg/lamp.
- "neon lights" for street signs ("argon" tube type, usually custom made): 500-2500 mg Hg/lamp, depending on design and manufacturing process.
- UV lamps for sun-tanning: 15-40 mg Hg/lamp.
- mercury vapour lamps and other high-intensity discharge (HID) lamps (for outdoor lighting and commercial buildings): 20-70 mg Hg/lamp.
- high pressure sodium lamps (for outdoor lighting and commercial buildings): 9-20 mg Hg/lamp.
- other light sources reported to contain mercury include special lamps for photographic purposes, chemical analyses (atomic absorption spectrometry lamps), and UV-sterilisation, back-lighting for flat LCD-screens, etc.

RPA (2002) has estimated mercury consumption in lighting in the EU at 5.2 tonnes. A review of their methodology reveals that they have not considered all of the types of lights mentioned above, they have focused on manufacturing demand at the expense of final product demand, and they have not carefully considered the number of lights that are still manufactured in the EU and in third countries using “older” (higher mercury content) technology, and subsequently sold in the EU.[6] Therefore, it is preferred to retain the WS Atkins (1998) estimate of 21 tonnes per year, especially as it is more consistent with the USEPA/NRMRL (2002) estimate of 17 US tons (about 15 tonnes) for the US, which is based upon a more restricted range of light sources.

[6] Fluorescent lamps and other products may represent similar cases where massive imports from East Asia to the West contain far higher levels of mercury than similar products presently produced in Western countries, according to Sznopek & Goonan (2000).

Considering that, in the rest of the world, high-efficiency lighting is widespread, and that most of the lamps are still made with older technology, one could assume a similar level of mercury consumption in lamps per unit of GDP as in the EU and US, as indicated in Table 18.

Table 18 - Mercury consumed in lighting (2000)

Region	Population (millions, 2000)	GDP (billion US dollars, 2000)	Grams of mercury per million $US of GDP	Hg consumed in lighting (tonnes)
European Union	376.3	8,898	2.36	21
United States	283.2	9,669	1.76	17
Rest of world	5357.5	26,274	2.00	53
Totals	6017.0			91

Sources: WS Atkins (1998), RPA (2002), USEPA/NRMRL (2002), consultant estimates

4.4.7 Electrical control and switching equipment

Mercury has been, and still is, used in a great variety of electrical and electronic switches and relays, although most standard uses in electrical and electronic equipment in the EU are to be substituted after 2006 (Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment). At present, the most important use of mercury in this category may be in "level" switches used to switch an electrical current on/off in response to mechanical movement (traditionally a glass tube with solid contacts in one end that may be shorted by floating mercury in the tube). Such switches have particularly been used in sewer and drinking water pumps (detects water level), railway control lights, car boot and bonnet lights, freezers and refrigerators, telephones, theft alarms on boats, etc. Other switches and relays possibly containing mercury are listed below (COWI, 2002):

- level switches: for sewer pumps, 7-14 g Hg/switch, in sport shoes with blinking lights, 1-2 g/switch.
- thermal switches/thermostats: mercury content varied, used in some household appliances (3-6 g Hg/thermostat), in laboratory equipment, etc.
- mercury-wetted contacts in electronics (used instead of gold contacts): mercury content probably small, but may be in use widely.
- Reed relays for data transmission (computers/modems): mercury content and use status unknown.
- ABS break activators in cars: typically contains about 3 g mercury.

Mercury is also present in mercury vapour tubes and arc-rectifiers. The former are commonly used as sources of electromagnetic radiation, especially X-rays, microwaves and radio waves. Arc-rectifiers are most commonly used in industrial control and welding equipment.

RPA (2002) suggests a figure of 8 tonnes of mercury consumption for the EU, based on limited documentation, which seems unrealistic especially in light of the USEPA/NRMRL (2002) estimate of 36-63 US tons (32-57 tonnes) for the US. While recognizing that many of these uses are gradually being replaced with mercury-free substitutes, it remains true that most of the mercury switches and relays are still available on the market, they are inexpensive and reliable, and they are quite familiar to most electricians. It seems more realistic to assume something like 25 tonnes, more in line with the estimates of WS Atkins (1998) of 29 tonnes of mercury (including 13 tonnes only for mercury vapour tubes and arc-rectifiers), and ERM (1998) of 24 tonnes.

For the rest of the world, the level of mercury consumption per unit of GDP estimated for the US is unrealistic, as it assumes an extensive industrial network at the same time as a sophisticated supply network for these "old technology" items. Therefore an estimate of mercury consumption per unit of GDP more in line with the EU experience has been proposed, as seen in Table 19.

Table 19 – Mercury consumed in electrical control and switching equipment (2000)

Region	Population (millions, 2000)	GDP (billion US dollars, 2000)	Grams of mercury per million $US of GDP	Hg consumed in electrical control & switching (tonnes)
European Union	376.3	8,898	2.81	25
United States	283.2	9,669	5.17	50
Rest of world	5357.5	26,274	3.00	79
Totals	6017.0			154

Sources: WS Atkins (1998), ERM (1998), USEPA/NRMRL (2002), consultant estimates.

4.4.8 Other products and processes containing mercury

Mercury is present in a large number of other products and processes both within the EU and in third countries, including pesticides and fungicides (seed dressing, sugarcane bedding plant treatment, etc.), paints (mercury preservatives in latex and marine paints, and possibly other types), laboratory use (chemicals, electrodes and specialised equipment in limited numbers), pharmaceuticals (vaccines, eye drops, some herbal medicines), catalysts (for production of PUR elastomers and other chemicals and polymers), cosmetics (skin lightening cream, preservatives in some eye cosmetics), gyroscopes for marine and aviation use, lighthouses (lens/light source unit rests on mercury in a common design), pigments, cultural/religious rituals, explosives, etc. (COWI, 2002).

Within the EU, regulation limits or bans the use of mercury in fungicides and pesticides (Directive 79/117/EEU and its amendments), cosmetics (Directive 76/768/EEU and its amendments 2000/6/EC and 2000/11/EC), marine anti-fouling paints and wood preservatives (Directive 76/769/EEU), etc. However, RPA (2002) identified some 50 tonnes of mercury among "other" use categories in the EU, particularly substantial mercury use in soaps and cosmetics (produced in the EU for sale in third countries), and secondarily in pharmaceutical and medical applications.

The US has similar uses, and has also documented cultural practices in various cities (E, 2002) that consume several tonnes of mercury annually.

In other parts of the world, in addition to cosmetics,[7] mercury remains a common element in paints and agricultural fungicides – uses that have mostly disappeared in the West. As suggested in Table 20, the level of mercury consumption in such uses can only be guessed at, but is certainly larger than "other uses" in the EU and US.

[7] In Cameroon, an Inter-Ministerial Order was implemented that banned the importation, marketing and use of cosmetic products containing more than two percent mercury. Under this order, twelve soaps and thirteen creams were subsequently removed from the marketplace (UNEP Chemicals, 2002a).

Table 20 - Uses of mercury in other products and processes (2000)

Region	Population (millions, 2000)	GDP (billion US dollars, 2000)	Grams of mercury per million $US of GDP	Hg consumed in other products & processes (tonnes)
European Union	376.3	8,898	5.62	50
United States	283.2	9,669	5.17	50
Rest of world	5357.5	26,274	2.85	75
Totals	6017.0			175

Sources: RPA (2002), consultant estimates.

4.5 EU and global demand for mercury

Table 21 below summarises all of the previous categories of mercury use in 2000, for the EU, the US and the rest of the world. Considering the uncertainties in many of the numbers, it would probably be safe to say that the category data for the EU and the US are accurate to no more than about plus-or-minus 20 percent, and the totals to perhaps plus-or-minus 10 percent. The figures for the rest of the world are considerably less confident.

Table 21 - European Union, US & global mercury demand (2000)

Mercury use category	EU-15 consumption (tonnes)	US consumption (tonnes)	Rest-of-the-world consumption (tonnes)	Global consumption (tonnes)
Chlor-alkali industry	95	72	630	797
Small-scale gold/ silver mining	0	0	650	650
Batteries	15	16	1050	1081
Dental	70	44	158	272
Measuring & control	26	35	105	166
Lighting	21	17	53	91
Electrical control & switching	25	50	79	154
Other uses	50	50	75	175
Totals	**302**	**284**	**2800**	**3386**

Table 22 summarises global mercury demand by region, according to the regional groupings detailed in Appendix 1. Apart from the figures derived previously for the European Union and the US, the other figures in this table have been estimated based on a vast range of international information submitted in support of UNEP Chemicals (2002a), as well as a variety of trade statistics (Eurostat, Europroms, Comtrade and the US International Trade Commission) including those analysed in detail in the following chapter, UN economic development data, etc.

Table 22 - Global manufacturing demand for mercury, by region, 2000

Region	Mercury consumption (tonnes)
European Union (15)	**302**
North America	314
Other OECD	100
Central & Eastern Europe/CIS	530
Arab States	100
East Asia and Pacific	1100
Latin America & Caribbean	450
South Asia	400
Sub-Saharan Africa	90
TOTAL	**3386**

4.6 Observations concerning European and global mercury demand

During the last several decades, mercury use has been remarkable for the variety of applications that start modestly, grow to consume sometimes thousands of tonnes of mercury annually, and then, often as the health or environmental effects become too widespread to ignore, drop back over time to a lower but relatively stable level of consumption. This has been the case for mercury uses in agriculture, in paints, in various industrial processes (acetaldehyde, etc.) including the chlor-alkali industry, in batteries, in pharmaceutical uses, and most recently in thermometers, switches, etc. It will also certainly be the case for mercury use in dental amalgams and lighting applications, although the peak mercury use in these cases will not come anywhere close to that seen in such cases as batteries and chlor-alkali. Mercury has also been consumed in vast quantities over the millennia for small-scale gold and silver mining, but the main options for reining in that demand significantly are all problematic:

- the increase in the mercury price that would be needed is highly improbable;
- a range of efforts have been made to encourage more efficient use and recovery of mercury (also helped somewhat by higher mercury prices) – so far with not much success;
- alternatively, one must wait until the more accessible ore deposits are exhausted, which has already occurred in a number of previously active small-scale mining regions.

Through all of the above, especially in light of increased scrutiny and substantial new research carried out over the last 10-15 years, the global demand for mercury has declined from over nine thousand tonnes annual average in the 1960s, to over eight thousand tonnes in the 1970s, to just under seven thousand tonnes in the 1980s, down to an average of around four thousand tonnes in the 1990s, and somewhat below that today.

At the same time, while the last 15-20 years have shown an even greater reduction of mercury use in the OECD countries, mercury consumption in many developing countries, especially South and East Asia (in the case of mercury use in products), and Central and South America (in the case of artisanal gold mining) has increased considerably. The main factors behind these important shifts in mercury demand are the reduction or substitution of mercury content in some products and processes in some regions (paints, batteries, chlor-alkali, etc.), a general shift of mercury product manufacturing operations from OECD countries to third countries (thermometers, batteries, etc.), and continuing robust supplies of mercury, combined with a long-term decline in mercury prices.

Despite these experiences, despite the recognized toxicity of mercury, and despite the general consensus that mercury has become a global problem (UNEP Chemicals, 2002a), there are relatively few restrictions on mercury marketing and use in most countries around the world. It has taken many years to build general awareness of mercury issues among OECD countries (WHO/IPCS, 1976), and this awareness has been gradually pushed out to third countries primarily by the enforcement of OECD (especially EU) marketing and use restrictions.

5 Mercury trade flows

5.1 Purpose of trade flow analysis

The mercury supply and demand factors discussed above have led to diverse and ever-changing trade flows, not to mention considerable challenges for those researchers trying to get a handle on them. As a check on overall levels of mercury supply and demand cited in the previous chapters, and to bring some transparency to mercury flows around the world, this chapter analyses EU and world trade flows of raw mercury and mercury oxide batteries. It takes a “snapshot” picture of world trade in the year 2000, which should not be assumed to represent trade flows in other years (no two years are alike in the mercury business), but at least provides an idea of trading partners, volumes and general market structure. This analysis also permits a better informed assessment of the eventual European and global impact of the supplies of mercury that are being brought onto world markets as chlor-alkali plants continue to close and/or convert to other processes.

5.2 Limitations of trade data

There are several factors that make mercury trade data less transparent than most other trade data. The international commodity characteristics of mercury mean that is frequently sold for speculative reasons rather than to satisfy immediate demand, resulting in the same mercury sometimes being traded several times. Also, as suggested previously, the regional locations of product manufacturers are often not the same as the regions of final product consumption – or at least not in the same volumes. Therefore one cannot assume that a shipment of mercury sent to India, for example, will end its life-cycle in India. One needs to further understand how the mercury is used in India, and whether/where the products are eventually exported, which goes significantly beyond the scope of this analysis. Nevertheless, the geographic locations of major mercury dealers are generally evident from the trade data – unless they convert the mercury to a compound (such as mercuric chloride) to better disguise the movement of raw mercury.

Trade data, whether from Eurostat, the International Trade Commission, Comtrade or others are routinely criticised by analysts, and are well known to be incomplete, frequently inaccurate, and seem to routinely lack just those details one would most like to explore. For a relatively small overall market, such as that for mercury, any inaccuracies or omissions take on an even greater importance. Furthermore, the more interest researchers demonstrate in mercury data, the less willing many providers of the data eventually seem to become, as the US Geological Survey (Reese, 1991-99) has discovered over many years of collecting mercury data. Nevertheless, a careful analysis of the data can produce some very useful findings, as will be seen below.

5.3 Trade in raw mercury

For the purposes of this analysis, and based on the consultant’s previous experience with Eurostat statistics on mercury, Comtrade statistics have been used. They are collected and presented under the responsibility of the United Nations Department of Economic and Social Affairs – Statistics Division), accessible via the website: http://unstats.un.org/unsd/comtrade/. Statistics for the year 2000 were selected, since that is the base year for this analysis, largely because most information and data that will ultimately be gathered for 2000 has already been gathered, which is not necessarily the case for 2001 data.

A search for “raw mercury” (no mercury compounds) trade movements was carried out for HS1996 code 280540, SITC rev. 2 code 52216, and SITC rev. 3 code 52227. In order to reduce the database to a more or less manageable size, the database was requested to overlook any trade movements valued at less than $10,000US, which means that movements of several tonnes, of which there are surely many, have not been included in this analysis.

The raw mercury trade data for imports and exports among the EU-15 are summarised in the figures below. As seems to be common with trade data, the figures submitted by country A for mercury imports from trade partners B and C were often not consistent with the figures submitted by countries B and C as mercury exports to trade partner A. Such discrepancies have "reconciled" by filling in the missing data, or revising the existing data to reflect all reported movements, whether they were reported by one country as exports, or by a trade partner as imports.

5.3.1 EU trade in raw mercury

Figure 2 shows total transfers of raw mercury between EU Member States in 2000 as 1930 tonnes, not including any trading that may have taken place within individual Member States. Considering that the EU consumes only 300 tonnes of mercury per year, this is proof that mercury is treated as a commodity, with a number of players trading it in an attempt to maximise their benefit.

During the year 2000, Belgium reportedly shipped more mercury (860 tonnes to the Netherlands) than any other Member State. This is easier to see in Figure 3. Since Belgium itself closed no chlor-alkali plants in recent years (although Solvay closed plants in other countries), it is not clear where this mercury originated. Belgium imported 138 tonnes from Algeria in 2000, but this amount falls far short of the Belgian export. If the mercury had been imported into Antwerp for transhipment to Rotterdam, there would generally have been some record of the import in 2000, unless perhaps it was imported before 2000. Another possibility is that Solvay had a large inventory of mercury in Belgium as a central supply source for its other chlor-alkali plants around Europe. It is also possible that the data could contain a mistake, perhaps a misplaced decimal, especially since the declared transaction price per kilogram was significantly lower than most others. In any case, barring faulty data, it is not surprising that such a large quantity of mercury would be shipped to the Netherlands or to Spain, both of which have the most sophisticated network of contacts for mercury sales outside the EU.

Germany also shipped a large quantity of mercury in 2000, sending 429 tonnes to Spain, which is a clear indication that the origin was a mercury cell chlor-alkali plant, of which Germany closed several in 1999 and 2000. MAYASA has signed an agreement to buy up residual mercury from chlor-alkali plants, which are subsequently sold on the international market (see global mercury movements below). In 2000 Spain also shipped a large amount (169 tonnes) of raw mercury to the Netherlands, but the purpose was not clear.

The quantities of mercury destined for the Netherlands and Spain invited further analysis of the data in order to determine the ultimate destination if the mercury. Such an analysis produced several interesting findings that are not evident from Figure 2 and Figure 3:

1. In 2000 the Netherlands shipped 245 tonnes of raw mercury to at least 18 countries outside the EU – about half of that amount to countries in the Latin America/Caribbean region. Most of this mercury was low-priced, i.e., low purity, suitable for small-scale gold mining, among other things.
2. In 2000 Spain shipped 774 tonnes of raw mercury to at least 20 countries outside the EU – about two-thirds of it to the East Asia/Pacific region. Virtually all of this mercury was low purity, including 50 tonnes exported to Latin America.
3. In 2000 Germany shipped 105 tonnes of raw mercury to at least 10 countries outside the EU – most of this was better refined, and therefore appears in the data at a higher value.
4. In 2000 the UK shipped over 220 tonnes of raw mercury to three countries in South Asia which, along with the nearly 200 tonnes shipped by Spain, made South Asia one of the key destinations for mercury that year. Interestingly, the mercury shipped from the UK was not

formally recorded in the Comtrade statistics as a UK export, but it was formally recorded by each trade partner as having been imported from the UK.

Several final points should be kept in mind:

- These trade figures show only discrete freight movements – the origin and destination of a shipment, and the quantity transported. There is no indication whether the source of the shipment is the real origin of the material, or whether the destination of the shipment is the final destination.
- The trade statistics for raw mercury do not include trade in mercury compounds, which would certainly increase the mercury flows described here.
- Likewise, if one were to assume a certain number of unreported trade movements, or trade within large countries such as China, Spain, the US, etc., that does not appear in these statistics, or even the instances of trade under $US 10,000 that have been excluded from this analysis, one would see an even more substantial trade picture – perhaps at least a ten percent increase in the mercury flows described here, when taking all of these factors into account.

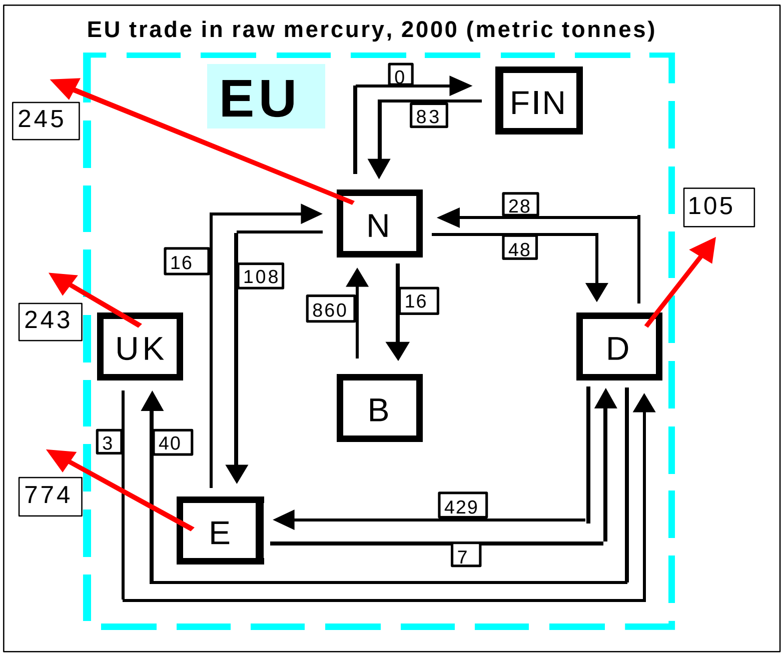
*Figure 2 - Reconciled **raw mercury** movements (tonnes) **in the EU** for 2000*
(for reported transactions greater than or equal to euro 10,000)
Source: COMTRADE statistics, United Nations Department of Economic and Social Affairs – Statistics Division, as interpreted by the consultant..

Hg transferred to:

Hg transferred from:	**A**	**B**	**DK**	**FIN**	**F**	**D**	**EL**	**I**	**IRL**	**L**	**NL**	**P**	**E**	**S**	**UK**	**TOTAL EU**
Austria																0
Belgium										0.1	859.6					860
Denmark																0
Finland											82.8					83
France	1.0							1.5			2.0	3.0				8
Germany		0.2			7.6		0.2	2.0			27.9		429.4	3.9	39.9	511
Greece																0
Italy																0
Ireland															12.0	12
Luxembourg																0
Netherlands		15.8			8.9	48.1	20.6	25.0					107.8		4.7	231
Portugal																0
Spain					6.8	7.0		4.4			169.1					187
Sweden						0.1										0
United Kingdom					0.7	3.1		8.5	1.3		25.0					39
Total EU transfers within EU	1	16	0	0	24	58	21	41	1	0	1166	3	537	4	57	1930

Legend: > 400 | 30-200 | 6-30 | < 5

*Figure 3 - Major **EU** movers of **raw mercury** (tonnes) in 2000, and their principle EU trading partners, drawn from Figure 2 above*



5.3.2 Global trade in raw mercury

The same analytical approach has been applied using data for inter-regional global trade in raw mercury. This trade is summarised in Figure 4. One should ignore the data in Figure 4 on the diagonal (shaded in grey), that appear to represent trade within a region, because these data are not comparable. For example, the figure of 1930 tonnes for EU-EU represents reported trade between EU countries, while the figure of 15.6 tonnes for North America-North America represents only the reported trade between the US and Canada, and therefore overlooks all trade between states (within the US) and provinces (within Canada). For the same reason, these data are not included in the inter-regional or global trade totals – the last column and bottom row of Figure 4.

The three regions that imported the most raw mercury in 2000, as seen in below, were Latin America/Caribbean with 1197 tonnes, East Asia with 1100 tonnes, and South Asia with 628 tonnes. Of those amounts, as seen in Figure 5, the EU supplied about half of the mercury needs of East Asia, and virtually all of the mercury needs of South Asia. Furthermore, as mentioned above, Spain, the Netherlands and the UK (followed some distance behind by Germany) were the main suppliers from within the EU, especially for low-priced, low-grade mercury.

Further analysis of the Latin American/Caribbean transfers of mercury shows that 965 tonnes of the total 1197 tonnes was reported by Mexico to be imported from the US. However, the reported value of this shipment was so low, compared to all others, that one must wonder if the import was properly reported, or if it was exported from the US virtually for free in order to transfer potential liability for the inventory. Without further information on this large shipment, one is obliged to question this particular data until it is better explained.

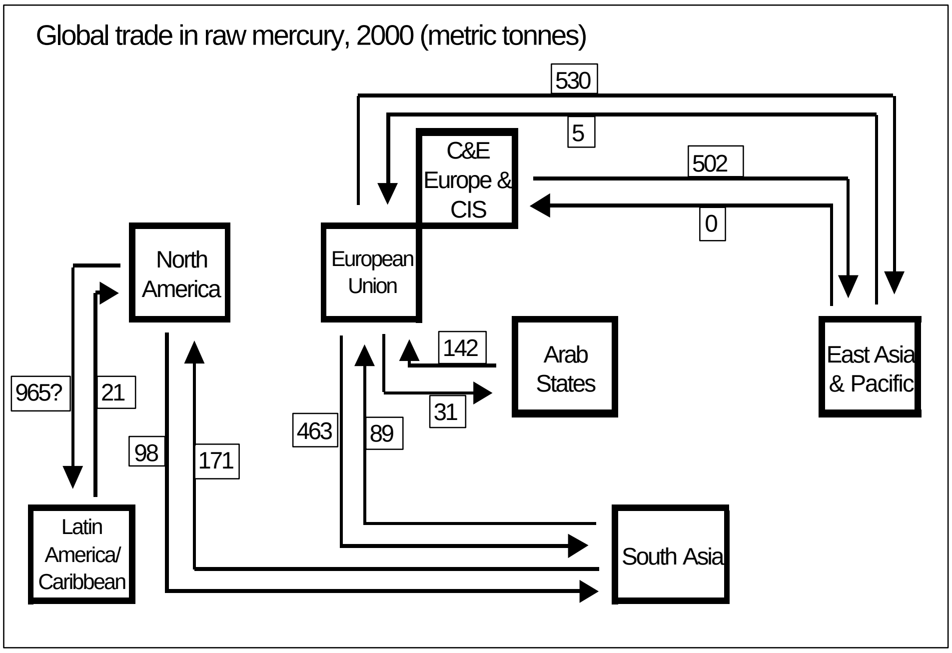
*Figure 4 - Reconciled **global raw mercury** movements for 2000 (tonnes)*
(for reported transactions greater than or equal to $US 10,000)
Source: COMTRADE statistics, United Nations Department of Economic and Social Affairs – Statistics Division, as interpreted by the consultant.

Hg TRANSFERRED TO:

Hg TRANSFERRED FROM:	European Union (15)	North America	Other OECD	Central & Eastern Europe and CIS	Arab States	East Asia and Pacific	Latin America & Caribbean	South Asia	Sub-Saharan Africa	Not specified	Total regional transfers
European Union (15)	1930.0	43.1	74.7	27.2	30.9	529.8	164.0	463.2	24.1	49.3	1406
North America	67.2	15.6	16.9	1.2	1.9	17.4	964.6	97.7		1.5	1168
Other OECD	29.4	62.9				7.1		18.0		33.0	150
Central & Eastern Europe and CIS	27.0	20.6	7.0	144.4		501.9	61.7	15.9	3.6	1.5	639
Arab States	142.2		4.1			17.3		10.0			174
East Asia and Pacific	4.7					20.6		5.2			10
Latin America & Caribbean		21.2					60.7				21
South Asia	89.4	171.0	85.0			10.0		4.1			355
Sub-Saharan Africa								17.0		1.4	18
Not specified	17.2		4.0	15.2	1.2	16.8	6.7	1.1	5.9		68
Total global transfers	**377**	**319**	**192**	**44**	**34**	**1100**	**1197**	**628**	**34**	**87**	**4011**

Legend: > 400 | 80-200 | 20-80 | < 20

*Figure 5 - Major **global** transfers **of raw mercury** (tonnes) in 2000, drawn from Figure 4 above*



5.4 Trade in mercury oxide batteries

Due to periodic reports that the battery sector remains a significant consumer of mercury, the trade data for mercury oxide batteries were also scrutinized. Specifically, the relevant Comtrade data[8] cover world trade (2000) in mercuric oxide primary cell batteries (volume < 300 cc), including both HS1996 code 850630, and HS1992 code 850612. In order to limit the quantity of data, a search was carried out only for reported trade movements of a value equal to or greater than $US 50,000.

5.4.1 EU trade in mercuric oxide batteries

The analysis of EU trade in primary cell (non-rechargeable) mercury-oxide batteries revealed over 500 tonnes of batteries transferred among EU countries in 2000 (see Figure 6), representing at least 100 tonnes of mercury. Belgium and Spain were the primary net exporters to other Member States in 2000. While this does not necessarily represent demand for raw mercury in addition to what has already been presented, it is an interesting statistic in a use category where the battery industry dismisses concerns about mercury because they have reportedly phased out mercury use in their European production facilities. Now it remains to be confirmed that there is not some mistake in the statistics or their coding, to determine what precisely this battery trade represents, to what extent it may reflect military demand (which is unlikely, since most of the trade is high volume, low value per item), whether the demand is persistent, etc., all of which are beyond the present scope. In any case, it is not an issue that has been highlighted in recent years, and requires further investigation.

Figure 6 - Reconciled ***EU*** *trade (tonnes) in* ***mercuric oxide primary cell batteries****, 2000, for which the volume < 300 cc (for reported trade movements valued at equal to or greater than $US 50,000)*
Source: COMTRADE statistics, United Nations Department of Economic and Social Affairs – Statistics Division, as interpreted by the consultant.

Hg transferred from:	Hg transferred to: A	B	DK	FIN	F	D	EL	I	IRL	L	NL	P	E	S	UK	TOTAL EU
Austria																0
Belgium											8.8		152.1			161
Denmark																0
Finland																0
France			50.0													50
Germany			4.1					1.6			11.7				0.4	18
Greece																0
Italy					13.6	88.3										102
Ireland																0
Luxembourg																0
Netherlands		80.3				5.9										86
Portugal																0
Spain												130.1				130
Sweden																0
United Kingdom					7.1			1.4			11.8					20
Total EU transfers within EU	0	80	54	0	21	94	0	3	0	0	32	130	152	0	0	567

Legend: >100 | 50-90 | 10-15 | <10

[8] As previously noted, accessible via the United Nations Department of Economic and Social Affairs - Statistics Division, http://unstats.un.org/unsd/comtrade/.

5.4.2 Global trade in mercuric oxide batteries

Global trade statistics for mercuric oxide batteries were also analysed for the year 2000. These statistics (summarised in Figure 7) report a remarkable 2000 tonnes of mercuric oxide batteries imported by the EU, and over 1000 tonnes of mercuric oxide batteries imported by the US (400 tonnes coming from the EU). With regard to exports, the statistics claim that in 2000 both the US and East Asia exported over 2000 tonnes each of mercuric oxide batteries, and the EU exported nearly 1000 tonnes. Is it conceivable that such levels of trade in mercury-containing batteries really continue, and they are not widely reported or scrutinised? Supporting this view is the statement by Sznopek & Goonan (2000) that the People's Republic of China had legislation on the books that intended to eliminate mercury-oxide battery production by 2002. Could Chinese producers have been madly producing and stockpiling batteries in 2000, that would help to explain the high levels of reported trade?

Since the major international battery producers claim to be no longer using much mercury in batteries produced in the EU, it is surprising that they would not complain more loudly about such low-cost competition from overseas producers. Is it possible that many transporters and customs officials have no idea whether the button cells they handle contain mercuric oxide or some alternative technology? Could the statistics be so wildly inaccurate? Further investigation is necessary. In the meantime, it appears that a large amount of the mercury going to the East Asia/Pacific region is being put into the manufacturing of mercuric oxide batteries.

It is expected, of course, that production of mercury oxide batteries will gradually decrease in the coming years, and be eventually replaced by less hazardous alternatives. But the level of production in 2000 remained apparently so massive, and the quantities of mercury involved so great (and so inexpensive), it is impossible to imagine a phase-out worldwide in just a few years.

*Figure 7 - Reconciled **global** trade (tonnes) in **mercuric oxide primary cell batteries**, 2000, for which the volume < 300 cc (for reported trade movements valued at equal to or greater than $US 50,000)*
Source: COMTRADE statistics, United Nations Department of Economic and Social Affairs – Statistics Division, as interpreted by the consultant.

BATTERIES TRANSFERRED TO:

BATTERIES TRANSFERRED FROM:	European Union (15)	North America	Other OECD	Central & Eastern Europe and CIS	Arab States	East Asia and Pacific	Latin America & Caribbean	South Asia	Sub-Saharan Africa	Not specified	Total regional transfers
European Union (15)	567	406	13	300	147	38			50	32	986
North America	1713	30		9	7	76	191			41	2037
Other OECD	24	120	19	330	13	1084	38			14	1623
Central & Eastern Europe and CIS	44	59		2	1	302	189				595
Arab States				33							33
East Asia and Pacific	402	254	333	48	255	2385	980		366	80	2718
Latin America & Caribbean		260					122				260
South Asia	24						172				196
Sub-Saharan Africa									32	22	22
Not specified	151	19	87	1	46	15	200		132		651
Total global transfers	2358	1118	433	721	469	1515	1770	0	548	189	9121

Legend: >900 | 300-600 | 100-260 | <100

5.5 Trade in mercury compounds

Mercury compounds are still commonly used in many countries in cosmetics, batteries, pharmaceuticals, paints and biocides, according to CADTSC (2001). The compounds in most frequent use include mercury oxide, mercury chloride, and phenylmercuric acetate. In fact, the use of certain compounds, which MAYASA no longer produces in much volume, has long been promoted by a range of trade names and other descriptions that pretend to have no relation to mercury. Appendix 4 shows such an example. In general, the consumption of mercury in mercury compounds has already been accounted for in the previous discussion of mercury content in products.

According to EPA (1999), the only major mercury compounds still imported by the US for use in products are organo-mercury compounds. In a recent year, U.S. imports of organo-mercury compounds were said to be 37 tonnes.

5.6 Observations concerning mercury trade flows

Analysis of trade flows over the years shows a clear pattern of mercury used as a commodity - to be routinely bought and sold according to market opportunities rather than purchased to respond directly to a specific demand. This greatly complicates any understanding of, and eventual political influence over, the international mercury market.

Despite reduced EU demand for mercury over the years, the EU is integrally tied into global mercury markets, playing a part in supplying a substantial part of global demand, mainly through companies in Spain, the Netherlands, the UK and Germany. Other key transhipment points around the world include Hong Kong.

Even though primary mercury production has fallen off at the Spanish mine Almadén, the EU remains a major mercury supplier to the rest of the world, mainly through the large quantities of mercury routinely being recovered from chlor-alkali production plants as they periodically close down and sometimes convert to alternative production processes.

6 Mercury economics

This section will review historic world mercury prices, compare them with typical mercury production costs, and then discuss trends in prices, mercury supply and mercury demand.

6.1 Historic world mercury prices

Assuming that global mercury supply is a reasonable proxy for global demand over time, Figure 8 shows the evolution of world mercury market prices and supply/demand over time. There are no historical records of European demand that are reliable enough to support a similar European graph, and one cannot use European production as a proxy for European demand because it is well known that mercury produced in Europe was shipped all around the world.

Global mercury supply has previously been derived as shown in Table 11. The mercury supply prior to 1980 was derived in proportion to the US supply, which is available in Jasinski (1994). Long-term market prices for mercury used here are an average of London prices (Metallgesellschaft, 1939-98), US prices (US Bureau of Mines, USGS) and “world” prices from Roskill Information Services (Roskill, 2000). They have been converted to constant $US of 2000 for purposes of accurate long-term comparison.[9]

[9] With significant data and methodological support from L. Hylander, Uppsala University.

It is immediately evident from the graph the sharp decline in both price and mercury supply during the last 40 years. Moreover, one can readily see, in cases where the mercury supply increased significantly over several years and then decreased specifically 1975-81 and 1983-89), the equal and opposite reaction in mercury price. From the early 1990s, with the influx of Soviet mercury stocks, the mercury price appears to have "bottomed out" at a level that reflects more than merely the excess supply situation. In this dilemma, the mercury price has been remarkably weak (and remarkably stable) for the last 10 years.

It may be reading too much into this sort of data, but US analysts had the following comments several years ago. They estimated that the downward pressure applied to market prices in 1990 due to government stockpile sales was about $60/flask, or some 25-30 percent (Rieber, 1994). One noted that since the US government's suspension of mercury sales (early 1994), US imports of mercury escalated, exports declined, and world market prices strengthened considerably. It was later noted that mercury prices quoted on the New York market rose about 20 percent during the second half of 1994, following suspension of government stockpile sales (Lawrence, 1995).

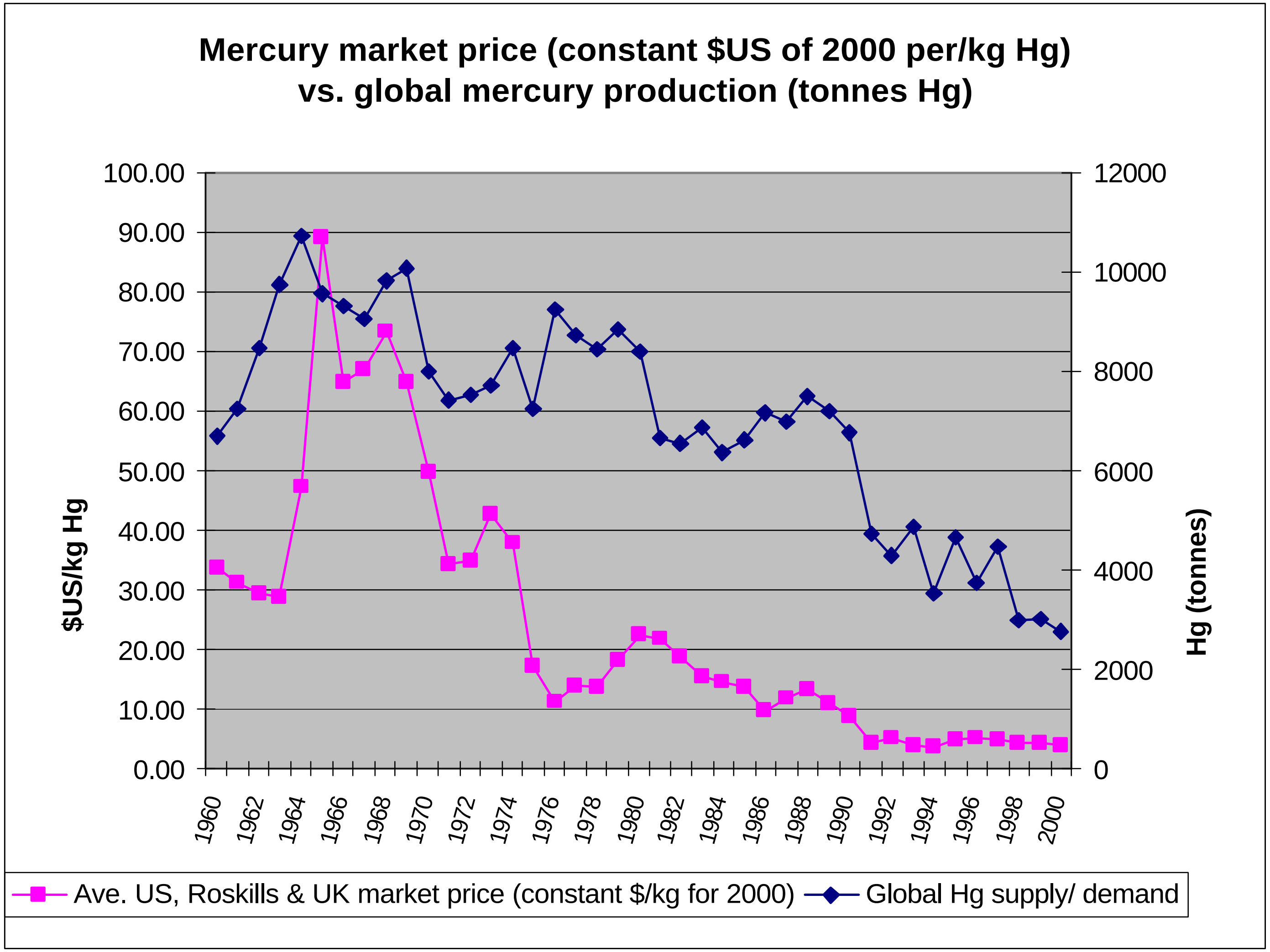
6.2 Typical mercury production, treatment, disposal costs

Table 23 below summarises a number of production, treatment and disposal costs associated with mercury.

Table 23 - Typical mercury production, treatment, disposal costs

Source	type of cost	dollars US/ flask	dollars US/ kg Hg
Kyrgyzstan (Khaidarkan) 1997 (source?) 1995 (Masters, 1995-98)	Hg mining cost	 41 130-140	 1.20 3.75-4.05
Spain (Almadén mine)	Hg mining cost	90-95	2.65-2.80
China (State mines - 1995) (ref. Masters, 1995-98)	Hg mining cost	180	5.20
Bethlehem Apparatus (major US mercury recycling firm)	retorting cost		0.50-2.50
Mercury market price, 1991-2000	spot markets		4.00-5.00
Price paid by MAYASA for used mercury cell chlor-alkali plant mercury, 2000	"negotiated" agreement		1.20-2.00
Hazardous waste landfill cost (consultant estimate)	one-time disposal cost		5.00-20.00
Zinc refining sludge waste (Budelco, zinc refining, Netherlands) (ref. Maxson, 1996)	recovery cost	3-4,000 gld/tonne sludge	7.00-10.00
Terminal storage of mercury (Swedish estimate)	present value		14.00-20.00
Consolidated storage of US stocks (DNSC, 2003)	present value	160-500	4.60-14.00

Figure 8 – Mercury market price vs. global mercury production



All of the production cost figures are estimates from diverse sources, but are generally reliable enough to draw some conclusions. From these figures, it is not difficult to understand:

- why generators of mercury wastes may find it more attractive to recycle than to pay for hazardous waste disposal;
- why an increasing part of the mercury supply is coming from secondary sources;
- why the mines in China would have been encouraged to close recently, as they can reliably buy cheaper mercury on the open market.
- why even the Spanish mine finds it more attractive (from a purely economic point of view) to buy up mercury from decommissioned mercury cell chlor-alkali plants at a fraction of the spot market price than to continue mine production; and
- why one could expect the mine in Kyrgyzstan to continue producing for the foreseeable future despite historically low world market prices for mercury.

As noted in UNEP Chemicals (2002a), "The cost of acceptable disposal of mercury waste in some countries is such that many producers now investigate whether alternatives exist in which they would not have to produce and deal with mercury waste. Mercury waste management, as it is most commonly done today, in accordance with national and local regulations, increasingly requires long-term oversight and investment."

6.3 World mercury market trends

It is important to note that the similarity between European and US mercury prices indicates the close linking of the global mercury markets, where a buyer can source and transport mercury from nearly any region at a predictable price. In this sense the market, although dominated by relatively few players, seems to work rather efficiently. On the other hand, any national or regional attempt to impose restrictions on these markets may have little positive effect on environmental quality.

Despite various attempts by major mercury market players to influence market prices,[10] world market prices have clearly fallen to a level that reflects excess mercury supply over demand. As mercury prices plummeted over the years, the privately owned mines closed, while the publicly owned mines, mainly in Spain, Algeria and Kyrgyzstan, all admittedly low-cost producers, continued operations. However, as low raw mercury prices have shown no sustainable signs of recovering since 1990, as mercury from government stockpiles and closing chlor-alkali plants has flooded the market, and as increasing regulation has encouraged lower-cost (in many cases) mercury recycling and recovery operations, even most government-owned mines (Kyrgyzstan may be the exception) have reduced their production levels. As a result, since the low-cost producer is now the large-scale recycler who may be paid to receive used mercury, such an operation can now undercut the price of mined virgin mercury, and market prices that have hovered around $US 4.00-5.00 per kg mercury for the last 10 years may well be poised to go even lower.

One final but important observation resulting from previous analyses of mercury prices (Maxson, 1996), is that the price of mercury – whether $US 2.00 or $US 10.00 per kg – is not a determining factor to most mercury users, unless they need the mercury to be highly refined, and these are not high volume uses. This is because the price of raw mercury is such a small percentage of the final selling price of the relevant product, whether it is a thermometer, a switch, gold or chlorine/caustic. Therefore, the following analysis of the market impacts of mercury from decommissioned mercury cell chlor-alkali plants may ignore any price effects, particularly as long as the market is expected to maintain a supply surplus for the foreseeable future.

[10] MAYASA purchased most of the former USSR stockpile as it became available during the 1990s in order to keep it from inundating the market and depressing prices.

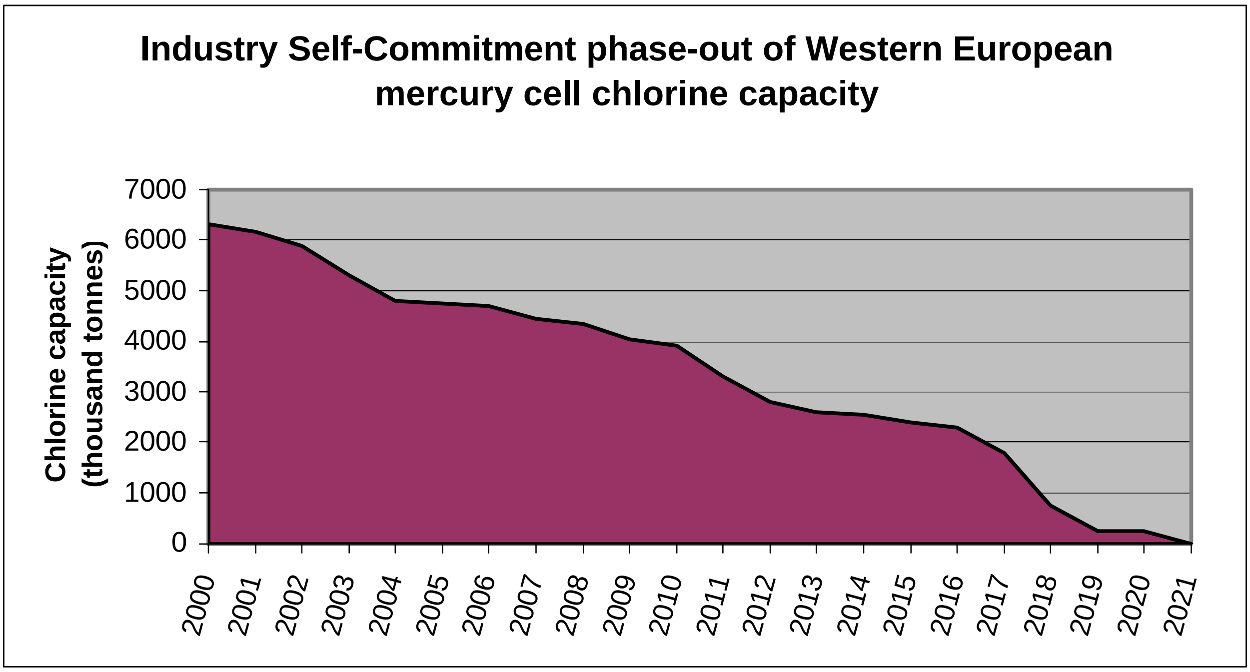
7 Future mercury supply scenarios

7.1 Identifying supply scenarios

In order to determine the impact on the mercury market of mercury coming from decommissioned mercury cell chlor-alkali plants, three mercury supply scenarios have been proposed that reflect alternative assumptions. The main variable for each scenario is the speed at which Western European mercury cell chlor-alkali plants are decommissioned, and the rate at which their mercury inventories are put on the world market. It was set out in an agreement between Euro Chlor and MAYASA that Western European mercury inventories would be sent by mercury cell chlor-alkali plants to MAYASA or to another "established mercury producer so as to displace new production of the equivalent quantity of virgin mercury." Since MAYASA is no longer (as of 2002) a mercury "producer," and no longer has any production to displace, this agreement has largely lost its relevance.

7.1.1 Scenario 1 – Industry Self-Commitment

A logical baseline scenario has been developed around the Western European industry estimate (Euro Chlor, 2002c) that mercury cell chlor-alkali plants will have been converted by 2020, which is roughly based on business-as-usual assumptions that take into account the economic lifetime of existing mercury cell chlor-alkali installations. This Industry Self-Commitment scenario assumes no major new legislative initiatives (that would significantly alter supply or demand) with regard to mercury, and a more or less "natural" or "economically realistic" phase-out of Western European mercury cell chlor-alkali production. This scenario reflects work done for Euro Chlor by Stanford Research Institute Consulting (SRIC, 1998), one objective of which was to describe in detail the normal economic lifetimes of the Western European mercury cell chlor-alkali plants. The SRIC study results are reflected in two figures below.



shows the rate at which these plants' production capacity is expected to be phased out under the Industry Self-Commitment scenario. Figure 10 shows the quantities of mercury that will be released as a result of this phase-out schedule, and approximate timing. Appendix 5 of the main report provides a list of the remaining (in 2001) chlor-alkali plants in the EU and EFTA countries, totalling about 5.9 million tonnes of annual chlorine production capacity, and containing some 12 thousand tonnes of mercury relevant to this analysis.

7.1.2 Scenario 2 – Strict IPPC Application

In line with a strict reading of the Integrated Pollution Prevention and Control (IPPC) Directive[11] requirements, existing chlor-alkali installations must be operated in full compliance with an integrated permit based on BAT by 30 October 2007, and it has been argued that this may be economically feasible as well (Cadiou and Sørup, 2001). Therefore this second scenario, which may be referred to as the "Strict IPPC Application" scenario, assumes the more rapid phase-out of Western European mercury cell chlor-alkali plants by 2007. In this scenario, over 10 thousand tonnes of Western European chlor-alkali mercury could deluge the international market between about 2005 and approximately 2009 (see Figure 10).

7.1.3 Scenario 3 - Flexible IPPC Application

The third scenario, which may be referred to as the "Flexible IPPC Application" scenario, recognizes that in certain cases "flexibility" is required in the application of the Directive (see Directive Article 9, paragraph 4), which could permit some installations to delay the implementation of best available techniques (BAT) for a few years. The Flexible IPPC Application scenario therefore assumes a slightly less rapid phase-out of Western European mercury cell chlor-alkali plants by 2010, and a different schedule for mercury releases (see Figure 10).

[11] Council Directive 96/61/EC.

Figure 9 – Industry Self-Commitment phase-out of Western European mercury cell chlorine capacity

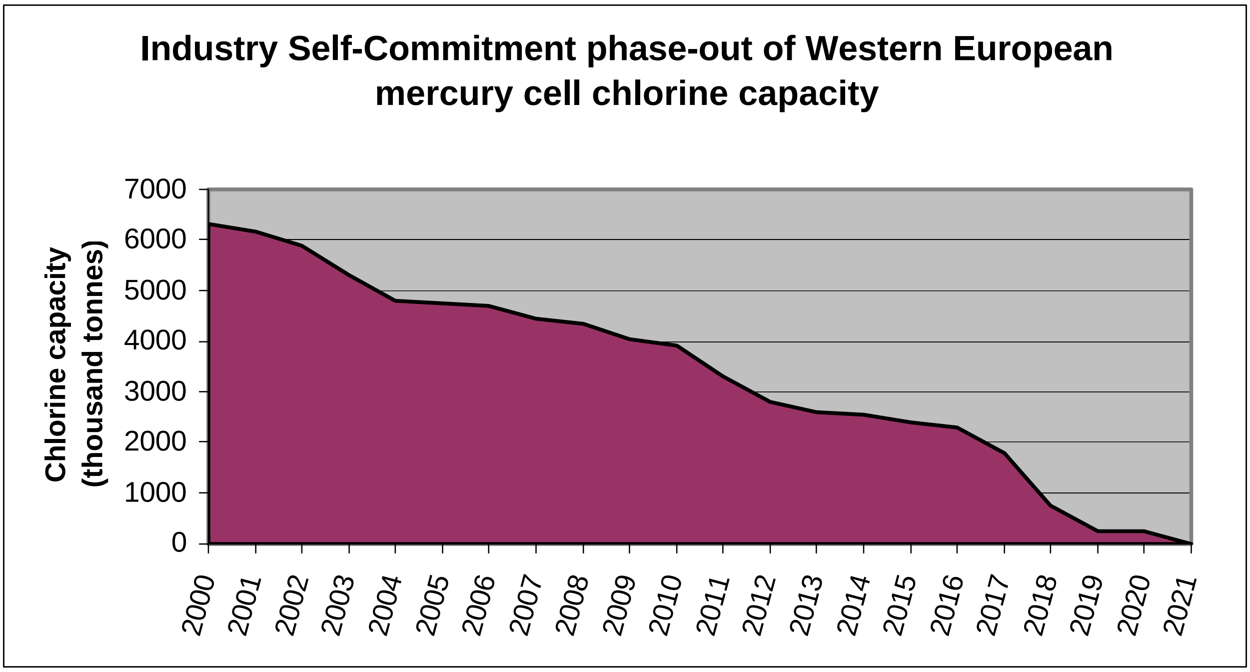
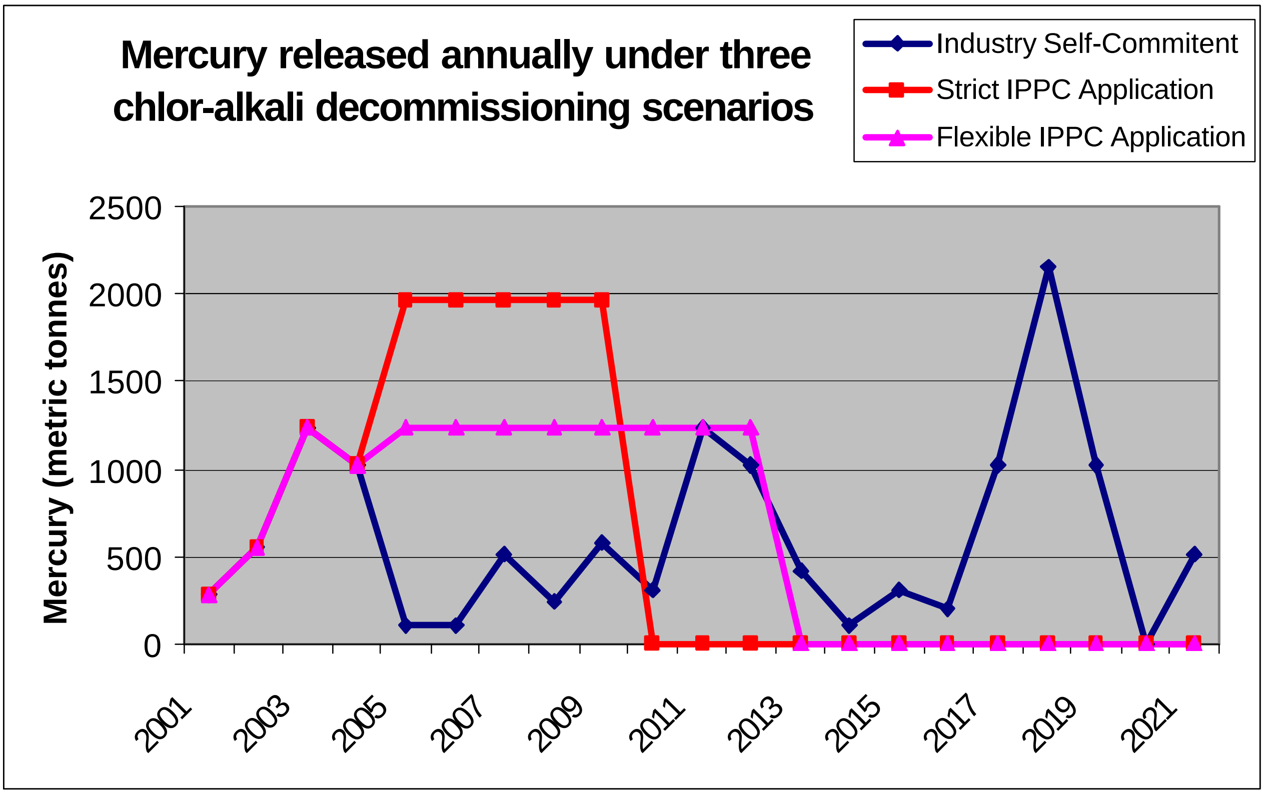


Figure 10 – Mercury released annually under three chlor-alkali decommissioning scenarios



7.2 Projected global mercury supply

The various sources of mercury supply may be expected to develop differently up to 2020 depending upon the specific characteristics of each scenario.

7.2.1 Chlor-alkali

The mercury contributions from closing Western European (including EFTA) chlor-alkali plants have been detailed in Figure 10 above. In addition to mercury released by the Western European chlor-alkali industry, other mercury cell plants will be closed during the period up to 2020, especially those in the US. Assuming all of the plants in the US will close as planned (2,500-3,000 tonnes of mercury available) between 2000 and 2020, and a somewhat lower number in other parts of the world, one could assume at least 4,000 tonnes added to the mercury supply over a 20-year period, or approximately 200 tonnes per year. These assumptions would remain similar under all three EU scenarios.

7.2.2 Stockpile sales

In line with the preference expressed by DNSC in its recent environmental impact assessment (DNSC, 2003), it would be reasonable to assume no further commercial sales from the US stockpile, although some politicians have stated that they will try to resume sales in 2007. No other national stockpile sales are anticipated.

7.2.3 Mining and by-product mercury

Mercury production by MAYASA ended in 2002. With regard to other mining operations, the longer they are subjected to international scrutiny, the longer the mercury price stays low, and the faster mercury cell chlor-alkali plants are decommissioned, adding to the world surplus of mercury, the faster the mines will reduce output.

For the Industry Self-Commitment scenario, in line with current trends, it has been assumed that global primary mercury production will be significantly reduced by 2020, and by-product mercury will continue to be produced, and will even increase. For both combined, an overall reduction from 1800 tonnes per year in 2000 to 1000 tonnes (700 of this would be by-product mercury) per year in 2020 is projected.

For the other two scenarios, a faster supply of mercury from chlor-alkali plants is expected to initially depress global mine output more rapidly, after which it would recover slightly as chlor-alkali supplies contribute less mercury to the overall supply.

7.2.4 Recycled mercury

Under the Industry Self-Commitment scenario, recycling is expected to continue to gradually increase its recovery of mercury through the foreseeable future. However, under the two IPPC scenarios, it is expected that the recycling industry would be hard hit by large mercury supplies coming from the chlor-alkali sector, which would likely sell their mercury at almost any price. This would depress recycling activities significantly as chlor-alkali mercury flows onto the market, to the extent that recycling activities would probably not yet recover by 2020 to levels they would have attained under the Industry Self-Commitment scenario. (A specific exception would be in cases where recycling continues to be mandated by the government, and may continue to be seen by producers of hazardous waste as a viable option to disposal.) For the Industry Self-Commitment scenario, recycled mercury output (including mercury recycled from wastes of operating chlor-alkali plants, both on-site and off-site) is expected to continue increasing due to continued international scrutiny and regulatory pressure, from 600 tonnes in 2000 to 1200 tonnes in 2020.

7.2.5 Overall projection

Modelled upon the previous discussion, the evolution of the global mercury supply that could be anticipated under the three different supply scenarios is summarised in Table 24. This table shows the five main supply sources across the top row. Then, for each of the key years 2000 (base year), 2007 (strict IPPC phase-out), 2010 (flexible IPPC phase-out) and 2020 (industry commitment), the table shows the expected contribution from each of these supply sources under each of the three scenarios.

Table 24 - Sources of global mercury supply, and periodic data points for the three supply-demand scenarios (tonnes) – 2000-2020

		Major sources of mercury supply				
	Scenario	**Western European chlor-alkali decommis-sioning**	**Other chlor-alkali decommis-sioning**	**Stockpile sales**	**Virgin & by-product mercury from min-ing**	**Recycling & other sec-ondary production**
2000	**Industry Self-Commitment**	287	200	0	1800	600
	Strict IPPC Application	287	200	0	1800	600
	Flexible IPPC Application	287	200	0	1800	600
2007	**Industry Self-Commitment**	513	200	0	1600	800
	Strict IPPC Application	1968	200	0	800	400
	Flexible IPPC Application	1230	200	0	900	600
2010	**Industry Self-Commitment**	308	200	0	1400	900
	Strict IPPC Application	0	200	0	800	400
	Flexible IPPC Application	1230	200	0	800	600
2020	**Industry Self-Commitment**	0	200	0	1000	1200
	Strict IPPC Application	0	200	0	1000	900
	Flexible IPPC Application	0	200	0	1000	1000

8 Future mercury demand

8.1 Anticipated mercury use patterns

As mentioned earlier, the history of mercury demand has been marked by new and significant uses for the metal that wax and eventually wane. Chlor-alkali electrolysis has been a long-term use that hit maximum demand for mercury in the 1970s. Small-scale gold and silver mining with mercury has been very long-term, and has already gone through many cycles of greater and lesser demand for mercury. Second only to chlor-alkali, batteries were one of the biggest users of mercury in the 1970s and 1980s, and, based on data for 2000, may continue to consume as much mercury as the chlor-alkali sector. More recent product uses for mercury, such as lighting applications, while not showing any tendency to move away from a dependence on mercury, do not have the potential to consume the vast quantities that other technologies did. This brief section will outline 20-year trends for the major categories of mercury demand, and lay the foundation for a global demand projection.

8.1.1 Chlor-alkali industry

The main focus of this paper, the chlor-alkali industry estimates the phase out of the mercury cell process in Western Europe by 2020, unless it is obliged to accelerate the process. Already, however, most of the Western European countries have announced plans to phase out mercury cell chlor-alkali plants by 2010. At this writing, only France, Germany, Switzerland and the UK, admittedly significant producers, expect to have plants still operating after 2010. Until receiving more detailed information, however, it is reasonable to rely on the estimates prepared for Euro Chlor by SRIC (1998) laying out the Western European industry's probable long-term phase-out program. A previous calculation (see Table 13) demonstrated that Western Europe and the US will reduce their annual mercury demand by 167 tonnes by phasing out mercury cell chlor-alkali plants. If the rest of the world closes 10-15 percent of their mercury cell plants during the same period, and reduces mercury consumption by an average of 50%, then worldwide mercury demand for chlor-alkali will be reduced to less than 300 tonnes per year by 2020.

8.1.2 Gold and silver mining

Unfortunately the ready availability and low price of mercury will continue to encourage artisanal gold and silver mining, seen by millions of people in at least 25 countries around the world as a possible way out of poverty. The practice, with a range of mercury hazards, has drawn international attention for many years, but continues relatively unabated. There are reports that many of the more easily accessible ore deposits have been exhausted, and it is likely that overall mercury consumption must decrease somewhat over time, to perhaps 400 tonnes in 2020, if only because mining sites can no longer be found and worked as easily as in the past. Since there is apparently already a sufficient supply of mercury to miners, at a relatively low price, it is not expected that future mercury market surpluses would significantly change this projection of mercury demand.

8.1.3 Dental uses of mercury

For reasons described in Section 4.4.4, global use of mercury for dental purposes may be expected to decrease by less than 10 percent through 2020.

8.1.4 Mercury containing products

Based upon the trade data for batteries reported earlier, it seems that the phasing-out period for marketing and use of mercury-containing batteries in the EU may have some years left to run, despite the formal requirements of Directives 91/157/EEC and 98/101/EC. Furthermore, if international action on mercury is relatively relaxed, and especially if mercury surpluses continue and even increase in the marketplace, countries like China will not apply the same pressure on battery producers as they say they have applied to their mercury mines in recent years. In this case the reduction of mercury use in batteries will be slower than otherwise. This could also be the case for electrical and electronic equipment, lamps and a range of other products produced in great volumes in China.

As mentioned previously, Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, is intended to phase out most relevant uses of mercury in the EU after 2006, although third countries are not subject to the same constraints, as evident in the case of batteries.

The same Directive intends to limit the mercury content of standard and compact fluorescent lamps in the EU; however, increased use of these lamps may be expected, for many years, to outpace gradual reductions in mercury content. For example Table 25, dealing only with the narrow application of LCD back-lighting, shows the extent to which these lamps are increasingly present in our surroundings. Furthermore, third countries are not subject to the same restrictions.

Table 25 - Mercury content of typical products containing LCDs

Mercury content of typical products containing LCDs		
Product	**Mercury-containing component**	**Amount of mercury per device (mg)**
Camcorder	lamp	0-5
Camera	lamp	0-5
Laptop	lamp	0-50
Telephone	lamp	0-5
DVD player	lamp	0-5
Flat panel LCD display	lamp	0-50
Fax machine	lamp	0-5
Scanner	lamp	0-50
Photocopier	lamp	0-10
Personal digital assistant (PDA)	lamp	0-5
Measurement devices	lamp	0-5
Medical devices	lamp	0-5
LCD projector television	lamp	50-100
Other products with LCD display	lamp or backlight	0-5
Source: Electronic Industries Alliance (EIA), undated.		

Modelled upon the above assumptions and discussion, and assuming no other significant changes in regulations or restrictions, Table 26 below summarises general prospects for global mercury demand for 2000-2020, consistent with the more-or-less even mercury releases assumed by the baseline Industry Self-Commitment scenario. These projections are used both to elaborate Scenario 1 (Industry Self-Commitment) mercury demand, as well as to underpin projections for mercury demand in Scenarios 2 (Strict IPPC) and 3 (Flexible IPPC).

Of course, the projected global mercury demand shown in Table 26, which is assumed to decline to around 1500 tonnes by 2020, is subject to a large number of regulatory and other policy variables, many of which have been discussed in the preceding paragraphs. Nevertheless, based on present trends, there are few analysts who would consider that demand in 2020 would be much higher than this, and many who expect it to be lower. This is relevant to the following discussion because any mercury supply-demand surpluses anticipated during 2000-2020 would only be greater if demand were reduced.

Table 26 - Projected global mercury demand, 2020, by use category

Mercury use category	**Global demand for mercury, 2000 (ref. Table 21) (tonnes)**	**Prospects for mercury demand to 2020, consistent with the Industry Self-Commitment scenario**	**Projected global demand for mercury, 2020 (tonnes)**
Chlor-alkali industry	797	significant decline in demand for mercury over next 10-20 years	280
Small-scale gold/ silver mining	650	unpredictable, but present level of exploitation is not sustainable	400
Batteries	1081	steep decline	100
Dental amalgam	272	gentle decline	250
Measuring & control	166	general decline	100
Lighting	91	gradual increase, at least in the foreseeable future	120
Electrical control & switching	154	general decline	100
Other uses	175	variable, especially mercury use in cosmetics	150
Total demand	**3386**		**1500**

8.2 Influence of IPPC scenarios on the basic mercury demand projections

As noted previously, additional surpluses (and continued low prices) of mercury due to accelerated EU closure of chlor-alkali plants (as assumed in the two IPPC scenarios) could have two possible effects compared to the demand projections of the Industry Self-Commitment scenario:

1. Mercury market surpluses could spur additional consumption of mercury. This is unlikely to happen for most of the specific product categories discussed here, especially since mercury is already available and inexpensive. Further surpluses may, however, encourage some additional demand in the category of "other uses," especially in areas of the world that would previously have had more limited access to mercury. For example, additional uses may be found in traditional or herbal medicines, locally produced cosmetics and soaps, frivolous toys and games, etc.
2. More important, additional mercury surpluses, combined with a lack of EU or international action to address them, could fuel the belief that the international community does not really set mercury issues as a very high priority. Such a response could greatly slow measures that are already in place to reduce mercury consumption, or cause various countries to put a low priority on the enforcement of regulations that may already be on the books. In this case, the general reduction in mercury demand that is already underway could be significantly slowed.

Both of these effects are integrated into the mercury demand response to the two IPPC scenarios. Modelled upon the previous discussion, the evolution of global mercury demand (2000-2020) that could be anticipated under the three different scenarios is summarised in Table 27. This table shows eight major demand categories across the top row. Then, for each of the key years 2000 (base year), 2007 (strict IPPC phase-out), 2010 (flexible IPPC phase-out) and 2020 (industry commitment), the table shows the expected demand within each of these categories under each of the three scenarios.

Table 27 - Major demand categories for mercury, and periodic data points for the three supply-demand scenarios (tonnes) – 2000-2020

Year	Scenario	Chlor-alkali	Small-scale gold & silver mining	Bat-teries	Dental amal-gam	Meas-uring and control	Lighting	Elec-trical control & switch-ing	Other uses
		Major demand categories for mercury							
2000	**Industry Self-Commitment**	797	650	1081	272	166	91	154	175
2000	**Strict IPPC Application**	797	650	1081	272	166	91	154	175
2000	**Flexible IPPC Application**	797	650	1081	272	166	91	154	175
2007	**Industry Self-Commitment**	616	563	738	264	143	114	135	166
2007	**Strict IPPC Application**	550	563	808	264	150	125	142	184
2007	**Flexible IPPC Application**	597	563	773	264	146	120	139	175
2010	**Industry Self-Commitment**	539	525	591	261	133	124	127	163
2010	**Strict IPPC Application**	492	525	691	261	143	140	137	188
2010	**Flexible IPPC Application**	516	525	641	261	138	132	132	175
2020	**Industry Self-Commitment**	280	400	100	250	100	120	100	150
2020	**Strict IPPC Application**	300	400	300	250	120	140	120	200
2020	**Flexible IPPC Application**	280	400	200	250	110	130	110	175

With regard to the first effect mentioned in Section 8.2 above, it can be seen that the added surpluses of mercury on the market in the two IPPC scenarios generate some additional mercury demand in "other uses" over time - more of an increase in demand (and sooner) under the Strict IPPC Application scenario (greater initial mercury surplus) than under the Flexible IPPC Application scenario.

With regard to the second effect mentioned in Section 8.2, it can be seen that the added surpluses of mercury in the two IPPC scenarios dampen international efforts to reduce mercury demand – especially the mercury content of products. Again, the Strict IPPC Application scenario (greater initial mercury surplus) has more of an impact (i.e., a greater dampening effect, and sooner) than the Flexible IPPC Application scenario. Thus, less EU and international concern for mercury control leads to a greater relative demand for mercury, especially evident with regard to batteries, chlor-alkali and "other uses."

8.3 Observations regarding the scenarios

Figure 11, Figure 12, Figure 13, and accompanying Table 28 compare the global supply of mercury with global demand (2000-2020) for each of the three scenarios, resulting in several interesting observations.

8.3.1 Industry Self-Commitment scenario

The Industry Self-Commitment scenario is a reasonable baseline assessment of mercury supply and demand (see Figure 11) if current trends continue, and if no other special measures are taken. Briefly, mercury prices soften further as surpluses continue. Use patterns follow the trends suggested in Table 26. Mercury demand is cut in half by 2020, and the mercury supply shows a significant long-term surplus over demand. The surplus could reach a total of 13,000 to 14,000 tonnes during the period 2005-2020, forcing more suppliers out of the market in response to steadily lower mercury prices.

8.3.2 Strict IPPC Application scenario

Under the Strict IPPC Application scenario, significant mercury supply surpluses appear immediately (see Figure 12), whereas in the Industry Self-Commitment scenario, surpluses are not a serious issue until about 2009. The Strict IPPC Application scenario therefore severely disrupts the market equilibrium for about 10 years, from 2005 to 2015. During the period 2005-2010, mercury supply heavily outweighs mercury demand, and during the period 2010-2015, just the opposite occurs. Furthermore, the five years of exceptional mercury surpluses send a psychological message to the marketplace that international authorities do not put a high priority on restricting the marketing and use of mercury, which basically endorses business-as-usual, and undermines the range of mercury reduction efforts that are already in place in various parts of the world. Therefore, while the Strict IPPC Application scenario does not necessarily encourage increased consumption of mercury through 2020, it certainly slows mercury reduction efforts, which effectively results in a relatively higher consumption compared to the Industry Self-Commitment scenario.

The Strict IPPC Application scenario results in a lower mercury price during the years of exceptional surplus 2005-2010, and a higher price during the subsequent years of relatively low supply 2010-2015. Furthermore, the early massive surplus of chlor-alkali mercury stunts many recycling efforts as well as primary mining activities, so that the total supply 2005-2020 is less overall for this scenario than it is for the two other scenarios. These supply sources would take some years to recover once the supply-demand imbalance shifts back in the other direction. In fact, due to its suppression of mercury supply sources, this scenario results in the closest long-term balance between estimated mercury supply and estimated mercury demand (both accumulated 2005 to 2020), although this comes at the expense of serious market shocks, and it also results in an increased overall demand (perhaps up to 10 percent increase) relative to the Industry Self-Commitment scenario.

8.3.3 Flexible IPPC Application scenario

The Flexible IPPC Application scenario is something of a mix of the previous two scenarios. It shows some mild disruption of the supply-demand market balance, but only for a few years (see Figure 13). It does not much hinder other supply sources, nor does it significantly slow down existing mercury reduction efforts. It influences mercury market prices or use patterns relatively little. And while it leads to slightly higher long-term mercury demand than the Industry Self-Commitment scenario, its long-term (2005-2020) surplus supply over demand (less than 3,000 tonnes) is significantly smaller than that of the Industry Self-Commitment scenario, while somewhat larger than that of the Strict IPPC Application scenario.

Figure 11 – Global mercury supply vs. demand – Industry Self-Commitment scenario

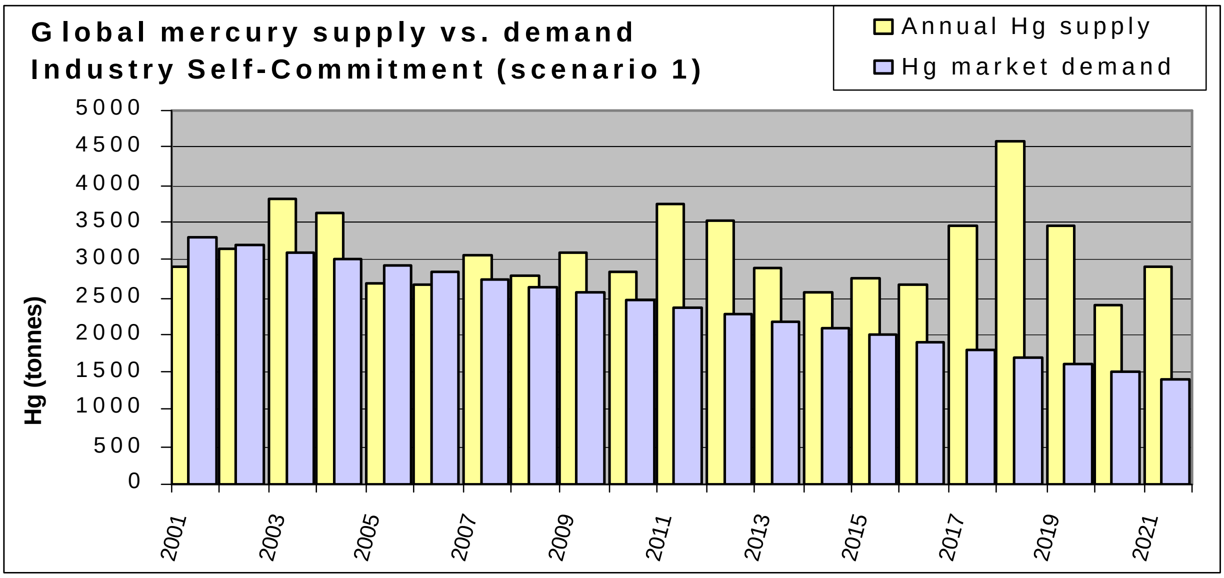


Figure 12 - Global mercury supply vs. demand – Strict IPPC Application scenario

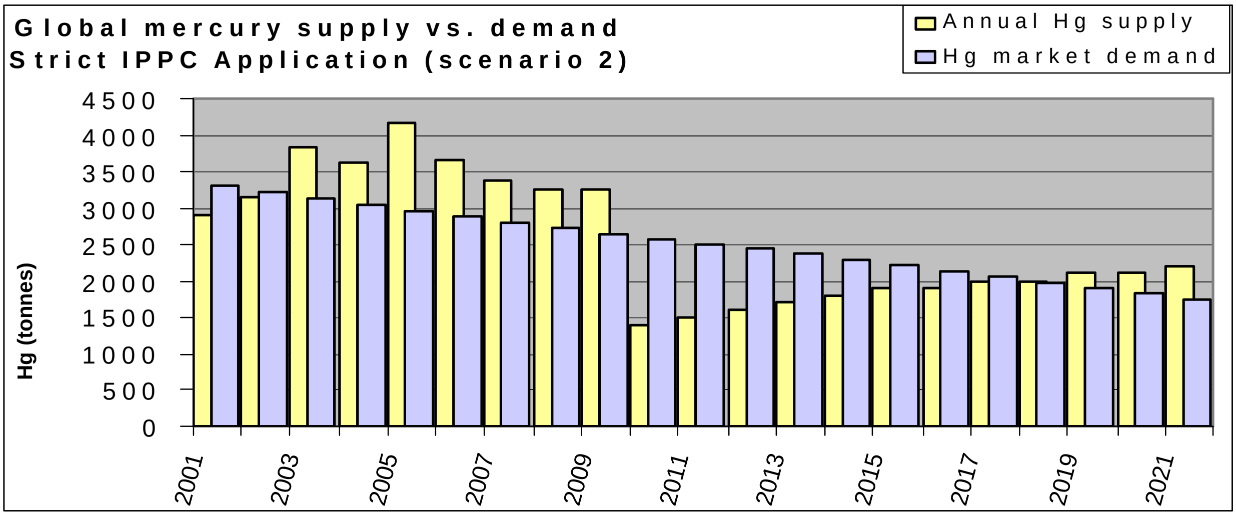


Figure 13 - Global mercury supply vs. demand – Flexible IPPC Application scenario

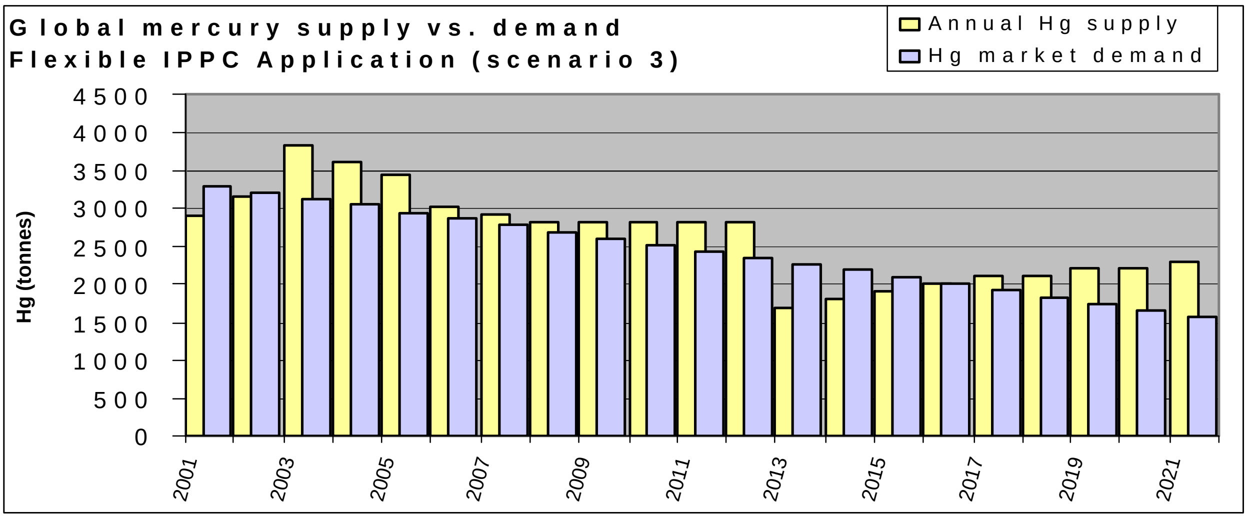


Table 28 – Global projected mercury supply vs. demand (2001-2021), including percentage contribution of mercury from decommissioned Western European chlor-alkali plants (tonnes)

	Industry Self-Commitment			**Strict IPPC Application**			**Flexible IPPC Application**		
	Annual Hg supply (tonnes)	Western Europe chlor-alkali supply (%)	Hg market demand (tonnes)	Annual Hg supply (tonnes)	Western Europe chlor-alkali supply (%)	Hg market demand (tonnes)	Annual Hg supply (tonnes)	Western Europe chlor-alkali supply (%)	Hg market demand (tonnes)
2001	2907	10	3294	2907	10	3300	2907	10	3299
2002	3159	17	3201	3158	17	3214	3158	17	3212
2003	3827	32	3109	3827	32	3129	3827	32	3125
2004	3610	28	3016	3610	28	3043	3610	28	3038
2005	2676	4	2924	4168	47	2957	3430	36	2950
2006	2665	4	2831	3668	54	2871	3030	41	2863
2007	3063	17	2739	3368	58	2786	2930	42	2776
2008	2785	9	2646	3268	60	2716	2830	43	2689
2009	3101	19	2554	3268	60	2646	2830	43	2602
2010	2823	11	2461	1400	0	2576	2830	43	2520
2011	3734	33	2369	1500	0	2507	2830	43	2437
2012	3518	29	2276	1600	0	2437	2830	43	2355
2013	2891	14	2179	1700	0	2361	1700	0	2268
2014	2572	4	2082	1800	0	2285	1800	0	2180
2015	2765	11	1985	1900	0	2209	1900	0	2093
2016	2651	8	1888	1900	0	2134	2000	0	2005
2017	3460	30	1791	2000	0	2058	2100	0	1918
2018	4576	47	1694	2000	0	1982	2100	0	1830
2019	3437	30	1597	2100	0	1906	2200	0	1743
2020	2400	0	1500	2100	0	1830	2200	0	1655
2021	2912	18	1403	2200	0	1753	2300	0	1567
Total 2005-2020	49117	19	35514	37740	26	38261	39540	25	36884

9 Observations and conclusions

9.1 Observations

9.1.1 Mercury markets

To fully appreciate EU and global mercury markets, a number of observations should be brought together from the discussion and analysis presented in this paper:

- The markets for mercury are global, and the EU is a key player. The EU provides 20-30 percent of the global mercury supply, it is a partner in over 50 percent of global mercury trade, and it consumes some 10 percent of global demand;
- Raw mercury is extensively traded around the world, at the rate of at least three times the annual consumption;
- World mercury markets are dominated by a relatively few key players, whose dominance, however, is weakening as primary mine production decreases (primary mercury mining in Western Europe has now ended), by-product and other secondary mercury recovery increases and a more diverse group of secondary suppliers and recyclers appears;
- Mercury prices are at a lower level in real terms than at any time in history, and there are no market reasons for any firming of prices in the foreseeable future;
- Mercury markets will gradually bear less and less resemblance to free markets. Depending

on other developments, by 2020 there may be no more mercury mining, and the "market" price of mercury will reflect only recycling and recovery costs, which are driven by regulation, and could therefore go even lower. In fact, regulations tend to give mercury a negative value - whether it is raw mercury or mercury waste. Holding mercury is a liability, and it costs money to dispose of it. The only way to add value to mercury is to put it in a product and sell it, or to use it in an industrial process, with the obvious risk of eventual emissions and exposures;

- Overall mercury supplies are slowly decreasing in response to low prices and diminishing demand;
- Consumption of mercury has declined significantly in the EU and other OECD countries, but this decline is not so evident in the rest of the world;
- Under any reasonable assumptions (i.e., declining global demand, gradually declining supply, increasingly from secondary sources, etc.), a net surplus of mercury supply over demand is expected to remain a hallmark of mercury markets into the foreseeable future. These surpluses could accumulate to 10-15,000 tonnes by 2020;
- Although mercury demand is rather slow to change, an extended period of low prices and surpluses may encourage uses (and eventual emissions) that would not otherwise have occurred, or at the least, they may discourage a number of other mercury reduction efforts;
- In general terms, the more mercury circulating in the economy and the environment, the more chance for emissions and exposure, misuse and abuse:

9.1.2 Mercury from chlor-alkali plants

Likewise, there are a number of key observations concerning residual mercury that becomes available from decommissioned chlor-alkali plants:

- The most easily recoverable mercury inventories of Western European mercury cell chlor-alkali plants amount to some 12,000 tonnes – approximately half of the global total held by chlor-alkali plants;
- Following industry estimates, these plants will close between now and 2020, and this mercury will come onto the international market - not to mention additional mercury from US and other decommissionings;
- Once the mercury from chlor-alkali plants is transferred to another party, the chlor-alkali industry - however responsible - loses control over its ultimate destination and use;
- Chlor-alkali mercury has become an increasingly important contributor to global mercury supplies, accounting for 10-20 percent of global supplies in recent years, and estimated to contribute 25-30 percent in the near future;
- The quantities of residual mercury that will be most easily recovered from Western European chlor-alkali plant closures up to 2020 are roughly equivalent to the expected mercury market surpluses during the same period.

9.1.3 Perspective of the mercury problem

Finally, an observation concerning the common Western perspective of the mercury problem is perhaps in order. There seems to be a tendency, especially in the EU and the US, to believe that because we are reasonably aware of mercury issues and have taken various measures to address them, including a number of national and regional regulations, therefore mercury is a problem that has been adequately addressed, if not yet entirely resolved. It is easy to forget that mercury issues in other parts of the world are not normally given the same priority. Or we may assume, as with many polluting substances, that mercury problems in other countries are the primary responsibility of the authorities of those countries. But data from the rest of the world demonstrate clearly what an extraordinary educational challenge mercury poses, and they show how few measures are actually in place outside the OECD to effectively deal with mercury, especially considering that it is a rather unique substance of global concern. In fact, due to the tendency of mercury to long-range atmospheric transport, EU legislation is unable to address the distant mercury emissions – to which EU activities contribute - that may return to affect human health and the environment in the EU.

9.2 Conclusions

9.2.1 Mercury supply scenarios

This analysis was requested to address the question of whether mercury coming from decommissioned mercury cell chlor-alkali plants might disrupt the functioning of the international mercury market.

Three scenarios for global supply and demand of mercury during 2000-2020 were identified and assessed, representing three alternative schedules for closing Western European chlor-alkali plants. With regard to the specific study objective of avoiding mercury market disruption, the Industry Self-Commitment scenario (plant closures by 2020) has the advantage of the least disruption of expected mercury markets. On the other hand, the Flexible IPPC Application scenario (plant closures by 2010) has the advantage of fixing a mercury cell decommissioning deadline that is flexibly consistent with the IPPC Directive, while at the same time causing relatively minor market disruption. While the Strict IPPC Application scenario (plant closures by 2007) would respect the formal IPPC decommissioning deadline of 2007, it would also bring the greatest shock to the mercury market.

9.2.2 Dangers of continued mercury surpluses

As previously noted, ongoing mercury surpluses could encourage additional consumption. More important, however, growing mercury surpluses, and the lack of international action to address them, could fuel the belief that the international community does not set mercury issues as a very high priority. Such a response could greatly slow measures that are already in place to reduce mercury consumption in products and processes, or cause various countries to put a lower priority on the enforcement of regulations that may already be on the books. In this case, the general reduction in mercury demand that is already underway could be significantly slowed.

9.2.3 Need for a better balance between markets and health/quality of life concerns

The Joint FAO/WHO Expert Committee on Food Additives, the primary international food safety committee, recently called for a tougher standard for levels of mercury in food, cutting the provisional tolerable weekly intake (PTWI) of methylmercury from 3.3 micrograms per kilo of body weight, to 1.6 micrograms. The committee said the revised standard is merited because of growing evidence of health risks from mercury to pregnant women and children (ENS, 2003). This is just the latest of a long series of increasing restrictions on environmental releases of, and human exposure to mercury. While the preceding analysis has addressed emissions and exposures only indirectly, via the closely related aspects of mercury marketing and use, it is necessary for the reader to consider, as we increase our understanding of mercury markets and flows, whether all feasible measures are being undertaken to limit emissions and related health risks.

At the specific request of member governments, UNEP recently devoted one million euro to convening all relevant stakeholders and to producing the Global Mercury Assessment (UNEP Chemicals, 2002a) - the most comprehensive global overview of mercury to date. The general consensus of the experts was that concerted global efforts must be made to **reduce** the supply of, transfer of and demand for mercury - not because free markets may be disrupted (the issue was never discussed), but because human health and environmental quality are at risk. Far from reducing the quantities of mercury circulating in society, the scenarios considered in this analysis would substantially increase it.

9.2.4 Questioning the objective of maintaining a free market for mercury

In the Reference Document for BAT on the Management of Tailings and Waste-Rock in Mining Activities (EIPPCB, 2003), the stakeholders cited the European Commission's report to the Council on mercury from the chlor-alkali industry (European Commission, 2002): "[OECD] mercury is exported to developing countries for re-use in gold recovery [and] for use in the production of cosmetics, paints and pesticides, in addition to application types shared with OECD countries, such as in measurement and electrical devices. In this respect, the effects of the continuing exports of mercury by European countries to developing countries, where its use may lead to pollution and adverse health effects, need to be given full consideration. Furthermore, a significant part of the mercury could return to Europe as long-range transboundary air pollution."

With regard to free markets, there are numerous reasons for considering mercury a special case. It does not make economic or environmental sense for the European Commission to protect (or at least not distort) the free-functioning market for a toxic substance. EU governments already spend increasing amounts of money to collect mercury containing products that have been freely traded, in order to prevent mercury from getting into the waste stream. They would surely embrace restrictions on the free trade of mercury if they knew it would reduce eventual waste disposal costs, as well as health and environmental hazards.

9.2.5 EU responsibility to lead

This paper confirms that there are ongoing, large and many unnecessary transfers and uses of mercury around the world, that the EU continues to play a large role in those mercury movements, that they result in health and environmental impacts on third countries, and that some of the eventual impacts of those flows return to Europe.

The European Commission has unparalleled ability to influence environmental policy – not only within Western Europe, but also globally. At a time when fresh fish sold in Californian supermarkets bear warning labels that their mercury content is a possible hazard to health; when eight percent of (US) women of childbearing age exceed the US EPA reference dose for mercury in blood (US EPA, 2003); when the US chlor-alkali industry has offered to donate its residual mercury to the US government for storage in order to keep it from circulation; when the result of a US government environmental impact statement has concluded that it would be preferable to keep the remaining mercury stockpile in storage; and when there are already a range of regulations and measures in place to deal with mercury, and more under consideration, the EU cannot be seen to be unconcerned or even hesitant about addressing the present and growing worldwide mercury surplus.

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APPENDIX 1 - UN regional divisions employed for data analysis

North America	Other OECD	Central and Eastern Europe and the CIS	Arab States	East Asia and Pacific	Latin America & Caribbean	South Asia	Sub-Saharan Africa
United States	Iceland	Armenia	Algeria	Brunei Darussalam	Antigua and Barbuda	Bangladesh	Angola
Canada	Japan	Azerbaijan	Bahrain	Cambodia	Argentina	Bhutan	Benin
	Switzerland	Belarus	Djibouti	China	Bahamas	India	Botswana
	Norway	Bulgaria	Egypt	Fiji	Barbados	Iran, Islamic Rep. of	Burkina Faso
	Australia	Croatia	Jordan	Hong Kong, China (SAR)	Belize	Maldives	Burundi
	New Zealand	Czech Republic	Kuwait	Indonesia	Bolivia	Nepal	Cameroon
	Israel	Estonia	Lebanon	Korea, Rep. of	Brazil	Pakistan	Cape Verde
	Turkey	Georgia	Libyan Arab Jamahiriya	Lao People's Dem. Rep.	Chile	Sri Lanka	Central African Republic
		Hungary	Morocco	Malaysia	Colombia		Chad
		Kazakhstan	Oman	Mongolia	Costa Rica		Comoros
		Kyrgyzstan	Qatar	Myanmar	Cuba		Congo
		Latvia	Saudi Arabia	Papua New Guinea	Dominica		Congo, Dem. Rep. of
		Lithuania	Sudan	Philippines	Dominican Republic		Côte d'Ivoire
		Macedonia, TFYR	Syrian Arab Republic	Samoa (Western)	Ecuador		Equatorial Guinea
		Moldova, Rep. of	Tunisia	Singapore	El Salvador		Eritrea
		Poland	United Arab Emirates	Solomon Islands	Grenada		Ethiopia
		Romania	Yemen	Thailand	Guatemala		Gabon
		Russian Federation		Vanuatu	Guyana		Gambia
		Slovakia		Viet Nam	Haiti		Ghana
		Slovenia			Honduras		Guinea
		Tajikistan			Jamaica		Guinea-Bissau
		Turkmenistan			Mexico		Kenya
		Ukraine			Nicaragua		Lesotho
		Uzbekistan			Panama		Madagascar
					Paraguay		Malawi
					Peru		Mali
					Saint Kitts and Nevis		Mauritania
					Saint Lucia		Mauritius
					Saint Vincent and the Grenadines		Mozambique
					Suriname		Namibia
					Trinidad and Tobago		Niger
					Uruguay		Nigeria
					Venezuela		Rwanda
							São Tomé and Principe
							Senegal
							Seychelles
							Sierra Leone
							South Africa
							Swaziland
							Tanzania, U. Rep. of
							Togo
							Uganda
							Zambia
							Zimbabwe

APPENDIX 2 – European, North American and Asian traders and recyclers

TABLE A - EUROPEAN MERCURY TRADERS AND RECYCLERS

Country	Recycling or trading firm	Comments
Belgium	INDAVAR B Haven 1940 B - 9130 Doel-Beveren Belgium Tel.: (0032) 03 568 4812	recycler
Denmark	ELEKTRO MILJO Ulvehavevej 38b 71 00 Vejle Dänemark Tel.: (0045) 75 833700 Fax: (0045) 75 833717	recycler
Finland	OY EKOKEM AB Kuulojankatu 1 P.O. Box 181 FI-11101 Riihimaki Finland Tel.: (00358) 19 7151 Fax: (00358) 19 715 305	recycler
France	LUMIVER 33 rue V. Tilmant BP 350 59026 Lille tel 03 28? 52 05 19 **Tél : 03 20 52 05 19** **Fax : 03 20 85 97 58** **mobile 06 62 47 63 73** fdutriez@nordnet.fr Email : contact@lumiver.fr	fluorescent ("neon") tubes mercury vapor lamps sodium vapor lamps metallic iodide lamps low-energy lamps
	TCM SERVICES 36, rue des Philippats BP 10 10800 SAINT-JULIEN-LES-VILLAS Tél. 03 25 71 04 05 Fax 03 25 71 04 09 email: tcms-recycling@wanadoo.fr Site internet www.tcms-recycling.com	Recyclage du mercure Recyclage des WEEE Recyclage des sources lumineuses (tubes, lampes...)
	SUEZ 72 avenue de la Liberté 92753 NANTERRE CEDEX Tél. 01 46 95 50 00 Fax 01 46 95 51 68	Recyclage du mercure Recyclage des WEEE Recyclage des sources lumineuses (tubes, lampes...) Recyclage des piles et accumu-lateurs
	MERCURE BOYS MANUFACTURE ZA Les Randonnays 77210 VOIVRES Tél. 02 43 8 52 15 Fax 02 43 88 52 15 Email: mercure.boys.manufacture@wanadoo.fr	Recyclage du mercure Recyclage des WEEE
	DUCLOS ENVIRONNEMENT 86, Route nationale 13240 SEPTEMES LES VALLONS Tél. 04 91 96 30 00 Fax 04 91 96 25 27 email: fmargnat@duclos-sa.com Site internet www.duclos-sa.com	Recyclage du mercure Recyclage des sources lumineuses (tubes, lampes...) Recyclage des piles et accumu-lateurs

Country	Recycling or trading firm	Comments
	SITA SA 132, rue des Trois Fontanot 92578 NANTERRE Tél. 01 42 91 63 63 Fax 01 42 91 68 84 Site internet www.sitagroup.com	Recyclage du mercure Recyclage des sources lumineuses (tubes, lampes...) Recyclage des piles et accumu-lateurs Valorisation des mâchefers d'UIOM
	PROVALOR Parc D'activite du Furst 39 rue de la Bienfaisance BP 24 75 008 Paris 57 730 Folschviller France Tel.: (0033) 3 8792 62 44 oder Tel.: (0033) 1 53 77 60 60 Fax: (0033) 3 87 92 62 45 oder Fax: (0033) 1 53 77 60 61G	light tubes, lamps
Germany	RETHMANN Entsorgungs AG & Co. Head Office Brunnenstraße 138 D-44536 Lünen Germany Telephone: +49(0)2306/106-0 Telefax: +49(0)2306/21206 http://www.rethmann.com	Fluorescent tubes Button cells Thermometers Rectifiers, switches etc
	GMR Gesellschaft für Metallrecycling mbH Naumburger Straße 24 D - 04229 Leipzig Tel.: 0049-341-4012512 Fax.: 0049-341-4011295 E-mail info@gmr-leipzig.de	**Combination metal/mercury** (steel electric rectifier, ring balance manometers, water level indicator, steam volumeter, Ignitrons, feather/spring thermometer, button cells, batteries, Hg-contaminated waste from natural gas and chlor-alkali-industry) **Combination glass/mercury** (thermometer, barometer, relay, switch, manometer, blood-pressure devices, radio tubes, glass electric rectifier, high-pressure lamps, bro-ken glass) **Combination plastic/mercury** (absorption masses, filter papers, protective clothing, process wastes) **Production wastes** (dental amalgam, touching wastes, separator contents, wastes from battery production) **Other** (dredging materials, types of dust, soils, building debris, old mercury, contaminated oils)
	Nordische Quecksilberrückgewinnung GmbH & Co. Bei der Gasanstalt 9 D-23550 Lübeck Tel. 0451/57057 und 52560 Fax 0451/581913	
	ALBA HERBORN GmbH Baving-Entsorgung GmbH & Co Entsorgung-Umweltschutz Kanalstr. 64 Lange Streng 9 48432 Rheine 65462 Ginsheim-Gustavsburg Germany Tel.: (0049) 5971 88001 oder Tel.: (0049) 6134 51025 Fax: (0049) 5971 88003 oder Fax: (0049) 6134 54984	

Country	Recycling or trading firm	Comments
	LAREC Lampen Recycling GmbH LVG Leuchtstofflampen- Erzstr. 18 Verwertungs GmbH 09618 Brand-Erbisdorf Alte Landstr. 4 D- 45329 Essen Germany Tel.: (0049) 37322 2340 oder Tel.: (0049) 201 382747 Fax: (0049) 37322 2341 oder Fax: (0049) 201 382747	
	RELUX Recycling und Lampenverwertung GmbH & Co. KG Umwelttechnik GmbH Viele Brunnen 2/1 Bruckenstr. 9 74912 Kirchardt-Berwangen 32546 Bad Oeynhausen Germany Tel.: (0049) 7266 911994 oder Tel.: (0049) 5731 480061 Fax: (0049) 7266 911997 oder Fax: (0049) 5731480070	
	WEREC GmbH Berlin WVT-Verwertungstechnik GmbH Grunower Weg 5 Pottskamp 6 15345 Strausberg-Hohenstein 31515 Wunstorf Germany Tel.: (0049) 3341 34670 oder Tel.: (0049) 5031 95160 Fax: (0049) 3341 346718 oder Fax: (0049) 5031 95032	
Ireland	Irish Lamp Recycling Co. Ltd. Blackpark Kilkenny Rd Athy Co Kildare Contacts: John Cuddy or Willie O'Connell Tel: +00353 0507 31377 Fax: +00353 0507 31377 Email: info@ilr.ie	main activity of the company is the collection and recycling of fluores-cent and other gas filled lamps, we also treat other mercury waste
Netherlands	Claushuis Metaalmaatschappij B.V. Nijverheidsweg 26 NL-3899 AH ZEEWOLDE Telefoon: 036-5222800 Telefax: 036-5222564 Email: info@claushuis.nl	Bewaren en verwerken van seleen-, cadmium-, kwik- en nikkelhoudende voorwerpen, verontreinigd metal-lisch kwik, kwikverbindingen, loodrestanten, amalgaamafval en batterijen
	Peperzeel W.A. van B.V. Tolweg 22 NL-3851 SK ERMELO Telefoon: 0341-562430 Telefax: 0341-553560	Bewaren van accu's en batterijen, bewaren en bewerken van nonferro-metaalafvalstoffen (o.a. kwik-houdend) en bewaren van metal-lisch kwik
	SITA Ecoservice Bedrijvenpark Twente 243 NL-7602 KJ ALMELO Telefoon: 0546-588588 Telefax: 0546-577866	Inzamelen en bewaren van gevaar-lijk afval, verwerken van verontre-inigde oplosmiddelen, verfafval, kwikafval, anorganische zuren en basen, galvanische baden, beits-baden en gebruikte chemicaliënver-pakkingen
	Metalchem DRS B.V. Industrieweg 4 NL-9636 DB ZUIDBROEK Telefoon: 0598-453338 Telefax: 0598-453588	Inzamelen en/of bewaren en bew-erken van fotografisch afval, amal-gaam, kwikhoudend afval en afval uit de tandheelkunde
	Central Mudplant and Fluid Services B.V. Wijkermeerweg 7 (EuroBase) NL-1951 AH VELSEN-NOORD Telefoon: 0251-229101 Telefax: 0251-221433	Bewaren en verwerken van olie-houdende en/of kwikhoudende afvalstoffen, afkomstig van de olie of gasindustrie

Country	**Recycling or trading firm**	**Comments**
	Dotremont B.V. Klipperweg 16 NL-6222 PC MAASTRICHT Telefoon: 043-3632500 Telefax: 043-3632423	Bewaren van oude accu's en kwik en het bewaren en bewerken van non-ferrometalen
	LUMINEX 's-Hertogenbosch	alle typen gasontladingslampen
	Franke Edelmetaal B.V. Maarsen	kwikafval, amalgaamafval, batterijen
Norway	RENAS Karenlyst Alle 9A Postboks 268 Skoyen 02 12 Oslo Norway Tel.: (0047) 22 13 5200 Fax: (0047) 22 12 1507	
Poland	MAYA ??	
Spain	VAERSA SENDA AMBIENTAL S.A. C/Francisca Cubells, no 5 Dom Social Avda Paral.lel, 51 46011 Valencia 08004 Barcelona Spain Tel.: (0034) 96 367 3149 oder Tel.: (0034) 93 404 1788 Fax: (0034) 96 367 2736 oder Fax: (0034) 93 443 3429	
	URBASER Complejo Medio Ambiental de Juan Grande C/Mesa de Toledo s/n (San Bartolome de Tirajana) 35107 Juan Grande Las Palmas de Gran Canaria Fax: (0034) 928 73 2497	
Sweden	MRT Systems AB BJASTA ATERVINNING Kaliumvagen 3 Box 114 S371 50 Karlskrona S 893 23 Bjasta Sweden Tel.: (0046) 455 28700 oder Tel.: (0046) 660 22 31 00 Fax: (0046) 455 28755 oder Fax: (0046) 660 22 31 55	
	SAKEB Norrtorp Box 904 S692 29 Kumla Sweden Tel.: (0046) 19 30 5100 Fax: (0046) 19 57 7021	Especially batteries

Country	**Recycling or trading firm**	**Comments**
Switzerland	Batrec Industrie AG Postfach 20 CH-3752 Wimmis Switzerland Telephone: 33 657 25 55 Email: batrec@batrec.ch	Dental wastes (silver/mercury amalgams etc); Tennis court and track & field coverings that contain trace quantities of mercury; Activated carbon used for filtering effluents containing mercury; Metal hydroxide sludges from industries such as galvanizing; Thermometers; Mercury containing electronic scrap such as mercury switches; Slurries and filter cakes containing metallic mercury or amalgams; Mercury-containing waste water; Sludge from the metal plating industry; Ion exchanger resins and activated carbon containing mercury and zinc; Contaminated parts of plants; Fluorescent lights; Metal vapour lights (HID); Batteries
	RECYTEC I, rue Perdtemps CH - 1260 NYON Switzerland Tel.: (0041) 22 362 17 77 Fax: (0041) 22 362 16 69	
United Kingdom	Lambert Metals International Ltd Laburnum House 1 Spring Villa Road, Edgware London HA8 7EB United Kingdom t: +44 (0)20 8951 4844 f: +44 (0)20 8951 1151 e: HowardMasters@lambert-metals.co.uk	trader, broker
	Wogen Resources Limited (WRL) 4 The Sanctuary Westminster London W1P 3JS http://www.wogen.com	trader, broker
	MERCURY RECYCLING LIMITED Unit G Canalside North John Gilbert Way Trafford Park Manchester, M17 1DP UK Tel.: (0044) 161 877 0977 Fax: (0044) 161 877 0390 email: info@mercuryrecycling.co.uk	recycler

TABLE B – NORTH AMERICAN MERCURY TRADERS AND RECYCLERS

Company Information Address Phone Webpage	**Types of Waste Accepted** E=Electronic devices S=Compounds/Solutions/ Salts/Solids L=Lamps/ballasts C=Contaminated Soils D=Contaminated debris A=Amalgams B=Batteries T=All of the above	**Full Services Available *** Yes or No	**Recycling Classification** B=Broker S=Storage R=Distillation and reclamation T=All of the above
Advanced Environmental Recycling Co. (AERC) 2591 Mitchell Ave. Allentown, PA 18103 Phone: 800-554-AERC (2372) http://www.aerc-mti.com/	T	Yes	T
ALR-American Lamp Recycling, LLC 22 Stage Door Rd. Fishkill, NY 12524 Phone: 800-315-6262	L	Yes	T
Bethlehem Apparatus Co. Inc. Resource Recovery and Recycling Division 890 Front St., P.O. Box Y Hellertown, PA 18055 Phone: 610-838-7034 Fax: 610-838-6333	T	Yes	T
Clean Harbors, Inc. Braintree, MA Phone: 781-849-1800 http://www.cleanharbors.com/	T	Yes	B, S
Conservation Lighting Inc. 470 Riverside Street Portland ME 04103 (207) 878-5534	L		
Dental Recycling North America, Inc. P.O. Box 1069 Hackensack, NJ 07601 Phone: 800-525-3793 www.DRNA.com	A	Yes	B
D.F. Goldsmith Chemical & Metal Corp. 909 Pitner Avenue Evanston, IL 60202 USA Phone: (847) 869-7800 Fax: (847) 869-2531 Email: goldchem@aol.com http://www.dfgoldsmith.com/	A	Yes	T
Dorell Refinery 533 Atlantic Ave. Freeport, NY 11520 Phone: 800-645-2794	A	Yes	B, S
Dynex Environmental, Inc. 4747 Mustang Circle St. Paul, MN 55112 (800) 733-9639 Note: subsidiary of Superior Special Services (see below)	L		
EnviroChem 21821 Industrial Blvd. Rogers, MN 55374 Phone: 612-428-4002	A	No Can provide containers but customer responsible for transportation	B, S
Environmental Enterprises Inc. 10163 Cincinnati-Dayton Road Cincinnati OH 45241-1005 (513) 772-2818 (800) 722-2818	L		

Company Information Address Phone Webpage	**Types of Waste Accepted** E=Electronic devices S=Compounds/Solutions/Salts/Solids L=Lamps/ballasts C=Contaminated Soils D=Contaminated debris A=Amalgams B=Batteries T=All of the above	**Full Services Available *** Yes or No	**Recycling Classification** B=Broker S=Storage R=Distillation and reclamation T=All of the above
Full Circle, Inc. 509 Manida St. Bronx, NY 10474 Phone: 800-775-1516 718-328-4667	L, B	Yes	B
Garfield Refining 810 E. Cayuga Philadelphia, PA 19124-3892 Phone: 800-523-0968, ext. 300	A	Yes Suggested that customers provide transportation for small quantities	B, S
Light Cycle, Inc. 1222 University Avenue St. Paul, MN 55104 (612) 641-1309	L		
Mercury Technologies of Minnesota, Inc. PO Box 13 Pine City, MN 55063-0013 (800) 864-3821	L		
Mercury Waste Solutions 1002 West Troy Avenue Indianapolis, IN 46225 (317) 782-3228 and 2007 West County Road C-2 Roseville, MN 55113 (612) 628-9370 (800) 741-3343	L		
Mercury Refining Co. (MERCO) 1218 Central Ave. Albany, NY 12205 Phone: 800-833-3505 518-459-0820	A, L	No Can provide containers but customer responsible for transportation	B, S Partial R done on site (remainder handled by 3rd party)
Northeast Lamp Recycling, Inc. 250 Main St. E. Windsor, CT 06088 Phone: 860-292-1992	L	Yes	B, S Partial R done on site (remainder handled by 3rd party)
ONYX (formerly Global Recycling Technologies, Inc.) 218 Canton St. Stoughton, MA 02072 Phone: 781-341-6080, ext. 232 http://www.grtonline.com	T	Yes	T This is the only licensed complete R in New England
Recyclights 401 W. 86th St. Bloomington, MN 55420-2707 Phone: 800-831-2852 http://www.recyclights.com Note: subsidiary of Superior Special Services (see below)	T	Yes	B, S R done on site for some materials (remainder handled by 3rd party)

Company Information Address Phone Webpage	**Types of Waste Accepted** E=Electronic devices S=Compounds/Solutions/ Salts/Solids L=Lamps/ballasts C=Contaminated Soils D=Contaminated debris A=Amalgams B=Batteries T=All of the above	**Full Services Available *** Yes or No	**Recycling Classification** B=Broker S=Storage R=Distillation and reclamation T=All of the above
Safety Kleen 221 Sutton St North Andover, MA Phone: 978-685-2121 Note: Bought out Laidlaw and 4255 Research Parkway Clarence, NY 14031 Phone: (716) 759-2868 Fax: (716) 759-6034 Contact: Joel Guptill	T	Yes	B, S
Superior Special Services P.O. Box 556 Port Washington, WI 53074-0556 Phone: 800-556-5267 Note: Bought out Recyclights and Dynex	T	Yes	B, S
ToxCo, Inc. 8090 Lancaster Newark Road P.O. Box 66 Baltimore, Ohio 43105 Phone: (877) 461-2345 Phone: (740) 862-9013 Fax: (740) 862-4308 Contact: Ed Green email: edgreen@kinsbursky.com	B	authorized Defense Reutilization & Marketing Service (DRMS) C-68 Facility	
Waste and Recycling Services 44744 Helm Street Plymouth, MI 48170 Phone: (734) 397-5801	B		
Belmont Metals Inc. (subsidiary Belmont Metals Inc.of Brooklyn, NY) 5336 Yonge St., Ste. 201 Toronto, ON M2N 5P9 Phone: 416-250-0003 Fax: 416-250-0022 E-Mail: mail@oemsales.com	dental, prime virgin, redistilled, refined grades, scrap		
Recyclage des lampes fluorescentes inc.(RLF) Coteau-du-Lac Québec	première usine de recyclage de fluorescents usés au Québec. l'ouverture de l'usine, en octobre 1998		
Raw Materials Corporation PO Box 6 Port Colborne, Ontario L3K 5V7 Phone: (905) 835-1203 Fax: (905) 835-6824	Battery recycling: Air Depolarized Zinc Batteries, Alkaline Batteries (Household Sealed Cells), Zinc Carbon, Nickel Cadmium, Nickel Iron, Mercury Oxide, Lithium, Lead Acid		

TABLE C – ASIAN MERCURY TRADERS AND RECYCLERS

Company information	Comments
Wogen Resources Limited (WRL) 4 The Sanctuary Westminster London W1P 3JS http://www.wogen.com	Major trader/broker with office in Guangzhou. See discussion under UK above.
Huaken Trading Co. Ltd. No.41-1,Youhao North Road Urumqi, Xinjiang China 830000 Tel : 86-991-4833-052 Fax : 86-991-4826-894	This company describes itself merely as an international trading company dealing in the import and export of chemicals.
Shanghai J. Sun Trading Consultants Ltd. Apt. 501-502 750-19 Luoyang Road Shanghai China 201100 Tel : 86-21-6413-9841 Fax : 86-21-3412-0225	J. Sun, chartered and established in Shanghai, China in 1999, act as trading consultants for Chinese companies (especially manufacturers, suppliers, end-users, etc.) and overseas customers. J. Sun have customers in Korea, Japan, Hong Kong, Taiwan, Malaysia, Indonesia, India, Europe, USA, South America, etc.
Guizhou Provincial Metals & Minerals Import/Export Corporation 328# North Zhonghua Road Minmetals Building Guiyang Guizhou China	The company, also known as Minmetals Guizhou, was established over 40 years ago in Guiyang, a central city in Yungui Plateau -- one of the most important metals and minerals locations in China. With subsidiaries and factories in Houston, Frankfurt, Hongkong, Guiyang, Shanghai, Shenzhen, Hainan, Zhanjiang, Beihai, and Changshun, and hundreds of customers around the world, the company has become one of the leading import & export groups in southwest China. Business activities include non-ferrous metals, ferro alloys, minerals, chemicals, abrasives, mechanical and electrical products, hardware, cereals, oils and foodstuffs, phosphate rock, barite, bauxite, zinc ingots, antimony, ferro silicon, silicon manganese, ferro phosphorous and abrasives.
Tae Won International Co. Suite A-1419 Samho Center Bldg. 275-1, Yangjae-dong Seocho-ku Seoul Korea (South) 137-130 Tel : 82-2-589-0961 Fax : 82-2-589-0964	Tae Won International concentrated chemicals (bulk chemicals for detergents, paints & gold mines) are exporting into Australia since 1993. They also have substantial business experience importing and exporting industrial chemicals, with sales exceeding $US 10 million annually. They specialise in trading organic & inorganic chemicals to and from Korea.
Waseem Traders H-811, Lal Haveli Akbarl Mandi Lahore, Punjab Pakistan 54000 Tel : 92-42-765-3376 92-300-944-1001 Fax : 92-42-741-9113 1-413-691-8265	Trade in mercury, mercuric chloride, and cinnabar.

APPENDIX 3 – Mercury-bearing materials and wastes for recycling

Bethlehem Apparatus claims it can handle more kinds of mercury bearing waste than any other recycler, including those on the following list, available on the company's web-site: <http://www.bethlehemapparatus.com/page03.htm>

Batteries
Alkaline dry cells
Button cells
Carbon-air batteries
Large zinc-air batteries
Mercury oxide batteries
Silver cells

Electrical Equipment
Glass switches
Ignitron tubes
Mercury pressure regulators
Mercury rectifiers
Mercury relays
Mercury switches
Metal switches
Telephone switches
Thermocouples
Thermostats
Other mercury containing devices

Solids
Activated charcoal
Carbon
Debris contaminated with mercury
Dental amalgam
Mercury sludge
Mercury spill kits
Metallic mercury (pure/impure)
Phosphor Powders
Soil contaminated with mercury

Liquids
COD test solutions
Mercury solutions
Nessler's reagent
Water contaminated with mercury

Lamps
Fluorescent lamps (whole, broken, crushed)
HID (high intensity discharge) lamps
High-pressure sodium lamps
Mercury vapour lamps
Metal halide lamps
Quartz lamps
Ultraviolet lamps

Thermometers
Barometers
Industrial thermometers
Manometers
Medical thermometers
Sphygmomanometers

Mercury Salts & Compounds
Mercuric Acetate
Mercuric Bromate(?)
Mercuric Bromide
Mercuric Chloride
Mercuric Chloride (ammoniated)
Mercuric Iodate
Mercuric Iodide
Mercuric Nitrate
Mercuric Oxide
Mercuric Sulfate
Mercuric Sulfide
Mercurous Bromide
Mercurous Chloride (calomel)
Mercurous Iodide
Mercurous Nitrate
Mercurous Oxide
Mercurous Sulfate
Kelpak

Mercury wastes from:
Chlorine caustic soda operations
Gold mining operations
Norzink pollution control process
Zinc mining operations

APPENDIX 4 – Trade names for a common mercury compound

The Registry of Toxic Effects of Chemical Substances

Mercury, (acetato) phenyl -

RTECS #: OV6475000
CAS #: 62-38-4

UPDATE: July 2000	MW: 336.75	MF: $C_8H_8HgO_2$

SYNONYMS:

1. Dyanacide
2. Nuodex PMA 18
3. Nylmerate
4. Norforms
5. Trigosan
6. Troysan 30
7. Troysan PMA 30
8. Verdasan
9. Volpar
10. Programin
11. PMAS
12. PMAC
13. PMA (fungicide)
14. Zaprawa Nasienna R
15. Ziarnik
16. Liquiphene
17. Mercury (II) acetate, phenyl -
18. Mercuriphenyl acetate
19. Mercuron
20. Acetate phenylmercurique (French)
21. (Acetato) phenylmercury
22. Bufen
23. Bufen 30
24. Ceresol
25. Hexasan (fungicide)
26. Phix
27. Spruce Seal
28. Spor - Kil
29. Shimmerex
30. RCRA waste number P092
31. Quicksan 20
32. Quicksan
33. Intercide PMA 18
34. Purasan - SC - 10
35. Lorophyn
36. Phenylquecksilberacetat (German)
37. Neantina
38. Mersolite 8
39. Mersolite D
40. Mergal A 25
41. Mercury, acetoxyphenyl -
42. Hexasan
43. Puraturf 10
44. Intercide 60
45. Femma
46. Fenylmerkuriacetat (Czech)
47. Fungicide R
48. Fungitox OR
49. Contra Creme
50. Antimucin WDR
51. Antimucin WBR
52. Anticon
53. Benzene, (acetoxymercuri) -
54. Phenomercuric acetate
55. Phenylmercuriacetate
56. Phenylmercury acetate
57. Phenyl mercuric acetate
58. Phenylmercury (II) acetate
59. Ruberon
60. Setrete
61. Samtol
62. Scutl
63. Sanitized SPG
64. Seed Dressing R
65. Seedtox
66. Tag fungicide
67. Tag
68. Tag 331
69. Tag HL 331
70. Acetoxyphenylmercury
71. (Acetoxymercuri) benzene
72. Acetic acid, phenylmercury deriv.
73. Algimycin 200
74. Panomatic
75. Octan fenylrtutnaty (Czech)

APPENDIX 5 – Mercury cell chlor-alkali plants and chlorine production capacities in Western Europe, 2001

Mercury cell chlor-alkali plants and chlorine production capacities in Western Europe, 2001				
Country	**Mercury-cell process**		**Total chlorine capacity ('000 tonnes)**	**Mercury cell process as a percent of total capacity**
	Number of installations	**Chlorine capacity ('000 tonnes)**		
EU & EFTA countries				
Austria	0	0	55	0%
Belgium	3	550	752	74%
Finland	1	40	115	35%
France	7	874	1686	52%
Germany	10	1482	3972	37%
Greece	1	37	37	100%
Ireland	0	0	6	0%
Italy	9	812	982	83%
Netherlands	1	70	624	11%
Portugal	1	43	89	48%
Spain	9	762	802	95%
Sweden	2	220	310	71%
United Kingdom	3	856	1091	78%
EU total	**47**	**5746**	**10521**	**55%**
Norway	0	0	180	0%
Switzerland	3	104	104	100%
EU+EFTA total	**50**	**5850**	**10805**	**54%**
Accession countries				
Bulgaria	1	105	105	100%
Czech Republic	2	183	183	100%
Hungary	1	125	125	100%
Poland	3	230	460	50%
Romania	1	88	633	14%
Slovak Republic	1	76	76	100%
Turkey	0	0	168	0%
Accession countries total	**9**	**807**	**1750**	**46%**

Sources: Communication with A. Seys, Euro Chlor; European Commission (2002).