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MERCURY FLOWS AND SAFE STORAGE OF SURPLUS MERCURY

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Mercury flows and safe storage of surplus mercury

Background

The Community Mercury Strategy (Mercury Strategy, 2005) was adopted January 2005. The Commission is now working on the implementation of the Strategy. Currently the Commission is drafting a proposal for a Regulation on the banning of mercury exports and the related safe storage of surplus mercury, i.e., Actions 5 and 9 of the Strategy. For this Regulation an impact assessment is required.

Objectives

The extended impact assessment (Mercury Strategy ExIA, 2005) already prepared in support of the Mercury Strategy contains much information that is still valid, but further information is needed to assess in greater detail the impacts of the introduction of an export ban and the storage obligation. In this report the information available in the extended impact assessment is updated and complementary information is also provided, in particular with regard to the newer member states of the EU-25.

1 International overview

The following tasks are included in Section 1:

1. Update of global mercury supply (mining, by-product, chlor-alkali, recycling, government or private stockpiles) specifically indicating contribution from the EU-25
2. Update of global mercury demand by use category and by region, specifically indicating EU-25 demand
3. Brief review of global mercury trade, and the role of the EU in that trade
4. Explanation of the recent evolution of mercury market prices
5. Estimates of supply, demand and relevant mercury trade 10 years into the future under a business-as-usual scenario, assuming there is no mercury export ban in place.

1.1 Mercury sources and supply

There are five common sources of mercury supply:

1. Recovery of mercury from mercury cell chlor-alkali plants (MCCAPs) converted to a mercury-free process, or occasionally closed.
2. Stocks of mercury accumulated from previous years (typically the source would have originally been mercury mine or by-product, chlor-alkali decommissioning, or mercury recovered from wastes).
3. Mining and processing of primary mercury ores.

4. By-product mercury from some ferrous and most non-ferrous metals mining or natural gas cleaning.
5. Recycled mercury.

1.1.1 MCCAP capacities and closures

There are a number of key issues related to the phase-out of mercury cell chlorine production capacity in the EU-25.

1.1.1.1 EU-25 chlorine production capacity

In 2005, there remained very close to 6 million tonnes of mercury cell chlorine capacity operating in the EU-25, as summarised in Annex 1 (valid as of January 2005). After several years of relatively limited mercury cell closures or conversions, during 2005-2007 the discontinuation of some one million tonnes of EU mercury cell chlorine capacity have been announced by industry, including two plants in Italy (ENS, 2005), one plant in Poland, etc. In addition, two of the UK plants and one in Sweden listed in Annex 1 closed during the course of 2005.

1.1.1.2 EU-25 phase-out of the mercury process

According to two studies carried out for Euro Chlor (SRIC, 1998 and Prochemics, 2002), subsequent closures are expected to reflect a fairly straight-line phase-out of remaining mercury cell capacity to 2020, the voluntary phase-out date agreed by Euro Chlor member companies as being consistent with the end of the economic lifetimes of most of the European mercury cell facilities. Even in 2020, however, as Euro Chlor has already informed the European Commission,[1] a few mercury cell plants (in particular, Euro Chlor mentioned Degussa and BASF in Germany – about 300 tonnes chlorine capacity) will remain open, as "cases where mercury cells are indispensable for the production of some speciality chemicals."[2] The Commission should also be aware that other EU-25 plants producing potassium hydroxide may argue they also need to stay open for technical reasons.[3] These EU plants that produce KOH comprise nearly 1300 tonnes chlorine capacity, in addition to the German plants previously mentioned.

1.1.1.3 Mercury cost relative to other operating costs

It has occasionally been argued that the cost of mercury for the chlor-alkali industry may be relevant to the EU industry's competitive position in the world chlorine and caustic markets.

At the beginning of 2005, the EU mercury-cell production capacity was very close to 50% of the total EU-25 capacity. In 2011 it will be 35-40%, according to information now available on announced closures, as well as SRIC (1998), Prochemics (2002), Euro Chlor (2005) and industry activity projections (SRIC, 2005).

One might ask whether the proposed export ban might in any way favour EU MCCA producers by ensuring them a supply of very cheap mercury. In response, it should be noted that the export ban will oblige EU MCCAP operators, after 2010-11, to sell mercury to each other or to store/dispose of it. At that time the EU-25 will have 30-35 MCCAPs with about 4 million tonnes of Cl_2 capacity, which will consume mercury at the rate of 20-25g/t

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[1] As confirmed by Dr. Seys during a meeting including Maxson, Andersson and Debelle, 24 May 2006.
[2] As quoted from Euro Chlor voluntary agreement concerning phase-out by 2020.
[3] The Chlor-Alkali BREF (2001) mentions some plants in Japan, which has a strong aversion to the industrial use of mercury, that continue to use mercury for such a process.

Cl_2 capacity, or 80-100 tonnes mercury per year, or 3 tonnes average per plant. In 2011, the typical EU MCCAP of 120 thousand tonnes Cl_2 capacity will produce 110 thousand tonnes of Cl_2 and 120 thousand tonnes of NaOH. Although European producers continue to take measures to limit transportation of chlorine for safety reasons, and now some 80% of chlorine produced in Europe is consumed "on site," one can still give a value to chlorine and caustic products based on market prices. 110 thousand tonnes of Cl_2 at a present value of €400-500/tonne, and 120 thousand tonnes of NaOH at a present value of €250-350/tonne, give a total basic product value of €49.5 million + 36 million = €86 million.

In comparison, if an MCCAP is obliged to pay market price for 3 tonnes of mercury, the present (relatively high) cost of the mercury would not be greater than €50 thousand. It is therefore impossible to argue that the cost of mercury (whatever it may cost, in the range of 0 - 0.1% of the chlorine and caustic product value) for the chlor-alkali industry has any significant bearing on the EU industry's competitive position in the world chlorine and caustic markets.

1.1.1.4 Residual mercury

Nevertheless, the discontinuation of nearly 6 million tonnes of mercury cell chlorine capacity in the EU will free up large amounts of process mercury. Besides the 12 thousand tonnes of mercury in the electrolytic cells, there is a great deal more to be recovered or disposed of during plant decommissioning and decontamination. This issue has been discussed at length in Maxson (2000). The mercury content of contaminated buildings and structures, soils, equipment, etc., may vary from tens of tonnes to hundreds of tonnes for one plant,[4] depending on the plant age and design, but especially on the plant operating, maintenance and waste disposal practices over the plant lifetime. An average mercury content of 25-75 tonnes per plant in the EU would likely find general agreement among experts. However, it should be noted that there is no legal or other obligation that this mercury should be recovered rather than disposed of.

If recovered, the cost of recovering this mercury varies greatly, from the ease of scooping up a pool of mercury accumulated in the soil under the cellroom, to the difficulty of cleaning mercury from masonry and other construction materials, or from soils typically contaminated at the level of many hundreds of ppm or more.

1.1.1.5 Chlorine capacity in the rest of the world

Outside the EU-25, there exists approximately 4 million tonnes of mercury cell chlorine capacity. In those regions MCCAPS occasionally close, and mercury-free plants are constructed, implying a slow transition away from the mercury cell process as well. For example, two plants in the US have announced they will close or convert during the next two years, which will also free up their process mercury. These are typically decisions taken by industry with little pressure from regulators. Apart from the recent Euro Chlor commitments in the EU (and the earlier OSPAR Decision 90/3), and some rumours of eventual phase-outs in India, no national or regional phase-outs of the mercury cell process have been agreed.

One point of occasional confusion in dealing with mercury data related to MCCAPs is that mercury recovered from decommissioned MCCAPs may be sold or transferred within the industry, or it may be sold outside the industry on the international market (presently via MAYASA, in the case of companies that are members of Euro Chlor). Information about

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[4] Two sites in the Czech Republic, for example, hold an estimated 472 tonnes of mercury in contaminated buildings and soils, in addition to the quantities in the cells, according to Czech Republic (2005).

the intra-industry transfers of mercury is not readily available, which makes it difficult to have a complete picture of how much mercury is recovered within the industry, and where it goes. It would seem, also in the interest of most of the stakeholders, that this level of transparency needs to improve as all aspects of the mercury life-cycle are more closely examined and regulated.

1.1.2 Stocks of mercury at Almadén and elsewhere

Following a site tour and on-site discussions with Almadén officials in 2005, the author estimated mercury stocks there at 1000-2000 tonnes. These have been accumulated over a number of years from previous mining activities (both from mines at Almadén and from mines elsewhere, such as the Kyrgyz Republic), as well as deliveries of mercury from chlor-alkali plants that have closed or converted to the membrane technology. For example, between 1997 and 2000, 8 German plants converted to mercury-free technology. Of the 2030 tonnes of mercury recovered from the German plants during this period, 1380 tonnes were sold to MAYASA in Spain, 190 tonnes were sold to other chlor-alkali plants, etc.[5]

According to Euro Chlor, its member companies sold 227 tonnes of mercury to MAYASA in 2003, 108 tonnes in 2004 (MAYASA said it received 164 tonnes of mercury from MCCAPs during the same year), and 294 tonnes in 2005. Since, in a typical year, MAYASA sells mercury to the industry and also purchases mercury from the industry, it is not clear from these numbers whether they are net purchases by MAYASA, or merely the mercury purchases separate from any sales.[6]

It is likely there are other stocks in Europe as well, especially in light of recent price rises and increased speculation by traders. One of the two major European mercury brokers, Lambert Metals, has storage facilities at the ports of Antwerp and Rotterdam (Fialka, 2006), where it maintains stocks of mercury, and the company has reportedly purchased mercury from the Kyrgyz Republic in recent years. The major Indian mercury broker has also been very actively searching to purchase mercury during the last two years.

Likewise, there appear to be some other stocks of mercury remaining. Despite claims some years ago by mercury brokers that the former Soviet stockpiles had been depleted, as mercury prices reached 40-year highs in 2005, suddenly 500 tonnes of mercury from “former FSU stocks” became available to the market – whether privately owned or government owned was not clear, although the origin was the Kyrgyz Republic, according to one of the Russian dealers, who provided the photo below. Lambert Metals (UK headquarters) has purchased about half of the 500 tonnes in 2006, and hopes to receive the rest later in 2006 or early in 2007. It is not clear how much more than this 500 tonnes may be available.

Now that MAYASA sells mercury only from its own inventory, one persistent question with regard to MAYASA mercury sales and “stocks” is how much of the mercury is actually originally from the Spanish mine (therefore a source of “new” mercury, although it should have been included in the mercury “supply” at the time it was mined), and how much may have been previously purchased from other sources such as the Kyrgyz Republic, in which case it should have been likewise accounted for as Kyrgyz production. In any case, this text does not consider mercury put on the market by MAYASA after 2004 as a “stockpile” source of previously uncounted mercury.

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[5] Germany (2005).

[6] In principle, such a clarification could easily be sought from MAYASA.

Photo of Kyrgyz-origin “Russian” stocks that came to the market in 2005.

1.1.3 Mining and processing of primary mercury ores

At the last operational EU mercury mining site, Almadén, the mining and processing of primary mercury ores in the EU stopped in 2003, and is not expected to restart. There remains a stockpile of cinnabar (mercury ore) that was excavated prior to the shutting down of process equipment. This unprocessed ore is now in a surface deposit, covered by a layer of soil and possibly a geo-textile sheet or similar barrier. The parent mining and trading company, MAYASA, continues actively trading in the mercury market, although from about 2004 it appears to be taking more care about which customers it sells mercury to. For example, its mercury sales declined from a typical level close to 900 tonnes in 2003 to just below 600 tonnes in 2004, as it refused to sell mercury to buyers who would not or could not confirm what the end uses of the mercury would be.[7]

Spain	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Mercury mine production (metric tons)	236	523	727	745	0	0

Source: MAYASA.

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[7] For example, due to increasing public concern, various mercury dealers have become more careful about selling mercury that might eventually be used in artisanal or small-scale gold mining.

Internationally, Algeria apparently closed its mercury mine at the end of 2004 in light of continuing technical problems, in spite of increasing world mercury prices. Since about 2000 Algeria rarely produced more than 200 t/yr.

During the last several years China has restricted mercury imports and increased domestic production of mercury as its long-term supply contract with the Kyrgyz Republic came to an end (2004), and as it determined that it could once again produce mercury at the Guizhou mines for less than it would cost to import the mercury from elsewhere. China has not historically exported mercury, and especially in light of international scrutiny, is not expected to start exporting, although it does have a substantial internal market for the metal.

China	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Mercury mine production (metric tons)	203	193	495	612	700	>700

Source: NRDC (2006), author estimate for 2005.

The only other major mercury mine still in operation is the Khaidarkan mining complex in the Kyrgyz Republic. Despite chronic technical challenges, this mine has recently been producing close to its practical capacity of 600 tonnes of mercury per year.

Kyrgyz Republic	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Mercury mine production (metric tons)	590.0	574.4	541.7	396.8	500.0	600.0

Sources: UNEP Kiev workshop (2000-2003), author estimate (2004 production), email from H. Masters (2005 production)

1.1.4 By-product mercury from non-ferrous metals mining

Mercury is found in trace quantities in most non-ferrous (zinc, copper, lead, gold, silver and other) ores, the quantities depending on a variety of geological characteristics. This is especially the case when these metals are extracted from sulphide ores, where mercury is often found as a trace element due to its affinity for sulphur (Hylander 2005).

Mercury is also found in ferrous ores – especially sulphide ores – and even if these ores are not the majority of those used in iron processing, they may still represent a considerable amount of mercury in wastes. However, because elemental mercury is less commonly retorted from these wastes, they are not included in the discussion below.

1.1.4.1 Zinc mining

Recovering mercury during the refining process may be done to comply with regulatory requirements, or it may be done if the value of the mercury recovered is greater than the cost of alternative disposal of mercury waste. For many years the largest producer of by-product mercury in the EU-25 has been Finland, where Boliden (formerly Outokumpu Oyj) has for many years refined zinc and copper ores, including zinc concentrates imported from Sweden.

Mercury occurs in all Boliden smelter wastes, and is believed to occur in the wastes at all smelters processing sulphide ores, although many other smelters in the EU have not reported it. Kokkola is the major site that sells recovered mercury, amounting to between 20 and 75 tonnes of mercury per year. As of 2004 or 2005, the mercury has been sold by Boliden to Lambert Metals (or affiliate) and stored in Rotterdam until resale, under the condition that it is resold to customers pre-approved by Boliden.[8] Recent Boliden mercury sales are summarised in the following table.

Finland	**2001**	**2002**	**2003**	**2004**	**2005**
Zinc smelter production (t zinc)	222880	247180	235300	265900	235000
Mercury exported to Netherlands (t)	82.8	77.6	54.9	25.5	23.5
Mercury export/zinc production	0.000372	0.000314	0.000233	0.000096	0.000100

Sources: ILZSG (2006) "Lead and Zinc Statistics," Boliden website, UNDESA/SD Comtrade (2006) export statistics.

It may be seen in this table that mercury sales to the Netherlands have declined greatly in recent years while the quantities of zinc smelted in Finland have remained relatively stable. This is explained largely by the fact that one of the key suppliers of zinc concentrate to Finland was a Spanish mine that phased out its operations in recent years. The Spanish concentrate had an especially high mercury content, in parity with most Swedish zinc concentrates.

Boliden has said that they have recovered mercury from zinc concentrates in Finland mostly for environmental reasons, and that economically the operation was basically a “breakeven.” In fact, the recovery and export of mercury from the Kokkola smelter may have been a specific condition required by the government at the time the smelter was expanded.

With the recent high mercury prices, the operation is certainly more profitable (depending on the mercury content of the (mostly) zinc concentrates). But the point is that, especially before the recent increase in the mercury price, and considering the typical cost of alternative waste disposal, one could not expect very many operators to make the effort to separate mercury from zinc wastes for purely economic reasons. If the market price of mercury is low (i.e., reflecting lower demand than supply), then a smelter often simply disposes of the mercury in the (calomel) waste. However, since the substantial increase in the mercury price, it is likely that more operators are already making the effort to separately recover mercury from zinc and other metal processing wastes. And others – for example those using electro-refining, especially for copper, lead and precious metals – are producing elemental mercury as part of the normal refining process.

With regard to other Boliden operations, the amount of mercury in wastes from the copper smelter at Rönnskär (Sweden) is approximately 20 tonnes mercury per year. Waste from the zinc smelter at Odda (Norway) contains 20 tonnes mercury and the copper smelter at Harjavalta (Finland) produces annually waste containing 5 tonnes mercury. The mercury from Harjavalta and Odda presently goes to final disposal in a bedrock depository. In the

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[8] Ref. Boliden website.

case of Rönnskär, the Swedish government has decided that all mercury should be disposed in a deep bedrock depository. One of the challenges is to find a location that will be suitable for the major waste producers – Boliden and SAKAB/EON. In the meantime the waste is held in an “intermediate disposal” facility.[9]

In order to have an idea of the potential mercury available in the EU-25 from zinc refining, the table below shows how much zinc is refined annually in the EU-25. Lawrence (Mercury 2002) noted that the main by-product mercury producers in the EU-25 include Finland, Italy, Germany and Spain. Belgium could possibly be added to this list, receiving large quantities of zinc concentrates from Sweden. From mercury exports and informal sources, however, it appears that mostly the Netherlands and Italy recover metallic mercury from the calomel, whilst Belgium, Germany, France and Norway are more likely to send the calomel for disposal.

Even assuming a far lower trace mercury content in other ores than in the Swedish and Finnish ores,[10] one can calculate an additional 50-100 tonnes of mercury contained in the EU zinc wastes in addition to those treated in Finland. Since there is no specific information available on quantities of mercury actually recovered from zinc wastes in other EU member states, but some is likely recovered consistent with the discussion above and Netherlands (2005), this author has estimated that an additional quantity equivalent to what is recovered in Finland is recovered by other EU countries. Therefore 48 tonnes of mercury in total, or twice the Finnish recovery, is estimated for the EU-25 as a whole.

Zinc smelter production in the EU-25 (thousand metric tonnes zinc) – mostly primary zinc

EU-25	**2000**	**2001**	**2002**	**2003**	**2004**
Belgium	252	259	260	244	263
Finland	223	247	235	266	235
France	350	347	350	253	260
Germany	328	358	379	388	364
Italy	170	178	176	123	130
Netherlands	217	205	203	223	225
Poland	173	175	159	153	153
Spain	386	418	488	519	525
UK	76	90	98	0	0
Total	2175	2277	2348	2169	2155

Sources: ILZSG (2006) "Lead and Zinc Statistics"

1.1.4.2 Gold mining

Regarding by-product recovery of mercury from industrial gold mining (as opposed to artisanal and small-scale gold mining), from which no mercury is known to be recovered in the EU-25:

1. In the aggregate, there are 5 gold mines in South America recovering mercury – three in Peru, one in Chile, and one just starting up in Argentina.

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[9] Information from the Boliden website.

[10] See UNEP (2005) for a detailed summary of the mercury content of various non-ferrous ores.

2. Not counting the Argentina operation (because it is too soon to estimate), the total amount of mercury recovered from these four mines is 80-100 tonnes annually.
3. The mine in Chile is an especially large operation.
4. Motivation for mercury recovery appears to be foreign-owned companies concerned about their environmental exposure (e.g., Newmont's recent travails), which suggests that mercury recovery is a practice that will likely expand.

NRDC (2006) covers this sector in some detail and, recalling that the US presently recovers at least 100 tonnes of mercury from gold mining operations, provides the basis for an estimate of about 225 tonnes of mercury presently recovered from gold mining operations worldwide.

1.1.4.3 Gold and silver mine tailings

Yet another likely source of mercury is the proposed recovery of mercury as a by-product of gold and silver recovery from mine tailings in Mexico, programmed during 2007-2015. As a by-product of other activities, it should be noted that this "new" source of mercury has no relation to the fact that primary (mined) mercury production is declining. With the operators estimating mercury production from this source at over 200 tonnes/year, it is further proof that there is no lack of mercury supplies as long as demand persists.[11]

1.1.4.4 Other non-ferrous ores

Likewise, with the help of the UNEP Chemicals Toolkit (UNEP, 2005) data on mercury content of non-ferrous ores, one can make a similar calculation and conservatively estimate about 50 tonnes of mercury in the lead concentrates refined in the EU-25, at least 30-40 tonnes in copper concentrates, etc. The total mercury content in all non-ferrous ores refined in the EU-25 is therefore likely in excess of 200 tonnes annually, although very little mercury is believed to be recovered apart from what is described above.

1.1.4.5 All non-ferrous ores combined

Since 5-10 times more non-ferrous metals are refined globally than in the EU-25, one may roughly estimate that 1000-1500 tonnes of mercury every year are released from these ores by refining processes. Much of that mercury goes to the atmosphere (perhaps 600 tonnes from zinc refining in China alone), much is captured and disposed of, and simply adding together all of the non-ferrous sources listed above give an estimated 345 tonnes of mercury recovered globally in 2005 (see summary table in Section 1.1.6 below). It is clear, however, that European and national regulations have a predominant influence on whether, and to what extent, by-product mercury is eventually recovered, released to the environment or disposed of.

It should be mentioned that the preceding by-product mercury summary does not include the approximately 4000 tonnes of accumulated Russian mining wastes (possibly mostly from the Chelyabinsk zinc smelter) transported to the Kyrgyz Republic for refining starting in 2004. This contract concerned a specific quantity of waste accumulated in Russia over several years, but suggests that significant (and likely increasing) quantities of mercury continue to be removed from Russian ores (many of them having a high trace mercury

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[11] See the Laguna Zacatecana Silver Tailings Project at http://www.minco.ie/default.php?category=Mining%20Projects&pageName=Project%20Overview&sub=Laguna%20Tailings%20Project

content) in compliance with regulatory requirements and customer needs. It has been estimated that approximately 2000 tonnes of mercury would be (or have been) extracted from these wastes at the Khaidarkan facility, after which the mercury would be owned and marketed by the Kyrgyz Republic.[12] It remains to be seen whether and how this mercury will appear in trade statistics.

1.1.5 By-product mercury from natural gas cleaning

Another source of by-product mercury, although not precisely mining related, is natural gas. Most natural gas contains some mercury in trace quantities. In many regions of the world, depending on geology, such as the Netherlands, North Sea, Algeria, Croatia, etc., the mercury concentrations are high enough to cause serious equipment problems during processing.[13] Pirrone *et al*. (2001) reported that "a reduction of mercury to below 10 μg/m^3 has to be obtained before the gas can be used, although mercury is reportedly removed from gas even at far lower concentrations. According to the Best Available Techniques Reference Document (BREF) Oil & Gas (2003), mercury is typically removed from the gas in a 'cold trap' (e.g. by gas expansion) and recovered as a mercury containing sludge. A mercury recycling company may later process this sludge by treatment in a vacuum distillation unit.

1.1.5.1 EU-25 natural gas

Together with the Czech Republic, which recovers only a very small amount of mercury from natural gas, the Netherlands and Croatia are the only two member states of the EU-25 who have reported cleaning mercury from gas supplies, due to the relatively important mercury content in gas from Groningen (in the case of the Netherlands), for example, and from the Pannonian basin near Molve (in the case of Croatia). Croatia reportedly recovers less than 2 tonnes of mercury per year, while the Netherlands recovers much more.

Using the Netherlands' estimate (Netherlands, 2005) that sludge from natural gas cleaning contains about 2% mercury, the 700 t of sludge generated in 2002 contained 14 t mercury, and the 900 t of sludge generated in 2003 contained 18 t mercury. Furthermore, the filtercake (17 t in 2002 and 14 t in 2003) from natural gas cleaning was assumed by the Netherlands to contain 40% mercury, equivalent to 7 t mercury in 2002 and 6 t mercury in 2003.[14] This results in 24 t mercury recovered by the Netherlands in 2002 and 20 t in 2003. However, this implies that virtually all of the gas produced by the Netherlands in 2002 and 2003 contained 250-300 µg mercury per m^3, which is not logical. Therefore it is more likely that these natural gas wastes were accumulated over several years, or imported from neighbouring countries, especially the UK,[15] and that the annual Dutch production of mercury from gas averages around 10 tonnes, as reported previously (Maxson, 2004).

Other major producers of natural gas in the EU-25 are shown in the following table.

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[12] Personal communication with Kyrgyz representative at the UNEP workshop in Kiev (UNEP, 2004).

[13] Specifically, mercury condenses as liquid mercury on the inside of piping and equipment, or it amalgamates with aluminium (most problematic) and other metals (except iron), gradually corroding and weakening the metals, which has resulted in serious industrial accidents.

[14] See Netherlands (2005). These numbers are more specific and considered to be more accurate than those suggested in BREF Oil & Gas (2003), p.137.

[15] This interpretation is consistent with suggestions in UK (2005), and as seen in Annex 2.

Major natural gas production in the EU and Norway

PJ = TJ*1000	2002	2003	2004	Hg recovery
Netherlands	2525	2430	2856	yes
Italy	555	524	494	likely
Czech Republic	1.8	1.6	3	yes
UK	4031	4029	3758	yes
Norway	2755	3083	3277	no
Denmark	322	307	356	no
Germany	740	765	710	minimal

Sources:
Eurogas at http://www.eurogas.org/
IAEA statistics at http://www.iea.org/textbase/stats/

Assuming the UK and others (Norway disposes of most mercury wastes) remove some mercury from their natural gas wastes, this author estimates that this source may generate 26 tonnes of mercury per year in the EU-25.

1.1.5.2 Global natural gas

The data in the following table would suggest that mercury is certainly removed from natural gas as well in such diverse regions as South Africa, the Far East and Sumatra. Once again, however, there is no information as to whether the wastes are treated to separate the mercury.

Examples of mercury concentrations in wellhead gas

Notes	Range (μg/Nm^3)
USA wellhead gas (estimated)	
Russian Federation, wellhead gas from oil wells	0.05-70 *
Russian Federation, free gas from gas wells (after primary condensate separator)	0.07-14 *
San Joaquin Valley, California	1.9-21
Middle East	<50
Netherlands	0.001-180
South Africa	100
Netherlands	0-300
Groningen	180
Far East	50-300
Sumatra	180-300
South America	69-119
North Africa	0.3-130

* The sources use the unit μg/m^3 without indicating whether the volume is normalized to Nm^3.

Sources: UNEP (2005), Openshaw & Woodward (2001).

ACAP (2005) provided a rough estimate of mobilisation of mercury during the extraction and use of natural gas in Russia. The main source of mercury for the gas processing industry is mercury in gas condensates. As a best estimate, some 8.2 tonnes may be mobilised (but probably not recovered) with natural gas and gas condensate. Considering the high uncertainty, the range is estimated at 2-10 t mercury per year.

Johnson-Matthey's website reports that its PURASPEC equipment is in service for the removal of traces of mercury from natural gas in a number of countries. Again, the quantities and final disposition of the mercury vary from one country (or gas company) to another.

PURASPEC mercury removal equipment in service

Location	Start-up Date
UK, North Sea	1996
UK	1998
Germany	1999
Norway	2000
Malaysia	2000
UK, North Sea	2001
Libya	2001
Thailand	2002
Japan	2002
Australia	2002
Nigeria	2003
Egypt	2004

Overall, while data from UNEP (2005) suggests that, outside the EU, there may be 50-100 tonnes of mercury in this waste stream, there is no specific information with which to estimate significant production of by-product mercury from natural gas . Therefore the author has made a conservative estimate of only 10 tonnes mercury actually produced from gas wastes outside the EU.

1.1.6 Summary of by-product mercury production

The quantities of mercury from all by-product sources are summarized in the following table. Due to the various uncertainties described previously, it is estimated that both totals below are accurate to ±25%.

By-product mercury recovered world-wide in 2005 (tonnes)

	2005	**2005**
SUMMARY BY-PRODUCT (TONNES MERCURY)	**EU-25**	**Global**
Zinc refining	48	90
Gold refining	0	225
Copper, lead, silver refining	5	30
Other by-product:		
Russian Federation incl. Ukraine	0	80
Tajikistan Sb-Hg mine	0	40
Other	0	30
Natural gas cleaning	26	36
Totals	**79**	**531**

Sources: Hylander (2003), Maxson (2004 and 2005),
Brooks (2005), NRDC (2006), UNDESA/SD Comtrade (2006) and US ITC trade statistics

1.1.7 Recycled mercury

There are two main sources of recycled mercury. One source is the mercury that may be recovered from various wastes produced by industries using mercury in a production process; the other is mercury containing products that have reached the end of their life.

1.1.7.1 Process mercury

The two key industries of concern are the chlor-alkali industry and the VCM/PVC production process using a mercury catalyst.

In the US, most mercury wastes from the chlor-alkali industry are treated and the mercury recovered, whereas in the EU some of the wastes are recycled but it is more typical (and less expensive) for the mercury wastes to be disposed of. On average, recycling of mercury wastes in the rest of the world is rather limited. It should be mentioned that a greater percentage of the EU-25 plants use rock salt as a raw material, which generates higher volumes of mercury waste than purer brine solutions. While admitting that there are often significant variations in design and management from one chlor-alkali plant to another, for the purposes of calculating the quantities of chlor-alkali mercury waste currently recycled, the global mercury-cell capacity has been divided among four main groups: the EU-25, the US, other similar operators, and the rest of the world (ROW), as in the following table.

Global recycling of mercury by the chlor-alkali industry, 2005

Region	Mercury cell Cl capacity (t/yr)	Mercury consumption (g/t Cl2 capacity)	Mercury net consumption total (t)	Mercury recycled & recovered (%)	Mercury recycled & recovered (t)
EU-25	5,886,868	27	158	20%	32
US	1,231,050	22	27	50%	13
Other similar performers	1,500,000	25	38	20%	8
Rest of the world	2,500,000	125	313	10%	31
Total	11,117,917	48	**535**	16%	**84**

Sources: Author calculations based on Euro Chlor reports to OSPAR, US industry reports to the US EPA, SRIC (2005), Maxson (2004), ACAP (2005) and Toxics Link (2004). See also Section 1.2.2.1.

The table indicates that about 535 tonnes (net) of mercury annually are "consumed" (i.e., put into the process, no recovery) by the chlor-alkali industry, of which some are emissions, some are left as trace contaminants in products, and the rest are disposed of in various wastes. An additional 84 tonnes/year of mercury are put into the chlor-alkali process that are recovered each year as elemental mercury, i.e., typically contained in wastes that are retorted or otherwise treated to recover the mercury. Note that mercury retorted or recovered from mercury wastes is typically reused within the industry. In other words, the total annual throughput (sometimes referred to as "consumption") of mercury by the industry in 2005 is estimated here at 619 tonnes, of which 84 is estimated to be recycled/recovered.

With regard to the use of mercury in vinyl chloride monomer (VCM) production, two main processes are used to manufacture vinyl chloride. The choice of process in the past depended mostly on the source and availability of raw materials (e.g. calcium carbide), as well as other local conditions such as energy supply, etc. One process (acetylene process) typically uses mercuric chloride on carbon pellets as a catalyst, and the other (mercury-free) is based on the oxychlorination of ethylene.

There are no known remaining VCM producers in the EU-25 using the mercury process. One facility in the USA used the mercuric chloride process (US EPA, 1997) until 2001, but is now closed. In Russia four enterprises were identified by Lassen et al. (2004) that still use the mercuric chloride process. In China, on the other hand, many facilities are known to use this process,[16] consuming some 6 thousand metric tons of catalyst (containing an estimated 600 t of mercury) in 2004 – and the number continues to increase along with China's rapid economic expansion (NRDC, 2006). Some facilities in other parts of the world may continue to use the mercuric chloride process as well, but China surely represents 80-90% of the total.

Theoretically, the mercuric chloride VCM process is not especially polluting because the catalyst can be recycled and the hydrochloric acid product can be cleaned. In practice, however, there are steps in the process where mercury may be released (including large quantities of methyl mercury when the mercuric sulphate catalyst is used), and if the spent catalyst is not recycled (which was routine practice when world mercury prices were

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[16] Some plants may still use a mercuric sulphate catalyst, which was known to be used in the past, but these have not been specifically identified. See Feng (2004).

lower), then mercury is disposed of with the spent catalyst. In 2004, during a year of high mercury prices, Chinese industry estimated that they recycled nearly half of the mercury contained in the catalyst consumed that year (NRDC, 2006).

1.1.7.2 Product mercury

The second main source of recycled mercury is mercury containing products (batteries, switches, relays, lamps, dental amalgam, etc.), manufacturing wastes from the production of mercury containing products, etc. The mercury recovered from these sources may be expected to increase in the near term as environmental regulations are strengthened and extended throughout the EU-25, and then decrease as the quantities of mercury in these products and wastes decrease.

The key sources of recycled product mercury in the EU-25 are separately collected batteries (both button cells and cylindrical batteries), control and measuring instruments (thermometers, barometers, manometers, hospital equipment such as sphygmomanometers, etc.), dental wastes, electrical and electronic equipment, etc., although the collection rates vary from nil to well over 50% depending on the country and the product category. Mercury containing lamps are also collected by many countries, and while the mercury content is not as high as other mercury products, the large volumes of lamps and the typical disposal practices make used lamps an important waste stream for mercury.

A reasonable estimate of recycled mercury in the EU-25 requires, first, an estimate of the mercury in the relevant waste streams, and second, estimates of the mercury recovered from each of the key waste streams. Some of the most current such information comes from the responses to the Stakeholder questions posed by DG ENV to the different Member States in September 2005,[17] in some cases based on increasing attention to the European Waste Catalogue (EWC), and generally improved attention to mercury flows. The table in Annex 2 summarises the recycling information in many of these responses. While the responses do not cover (in a consistent manner) enough Member States to permit very reliable recycling calculations, they do provide enough information, together with what is already known, to give some indications of the general state of mercury recycling in the EU-25.

The following table provides estimates of the main mercury product and process waste streams, the amounts of mercury recycled in the EU-25 and, with even greater uncertainty, globally. Estimating separately the mercury content of each of these waste streams based on product turnover, it has been assumed that the EU-25 recovers, on average, some 20-30% of the mercury content of this waste, although the size of the total waste stream may be larger, and the actual percentage recycled may be lower based on different methodologies such as that used by Mukherjee *et al.* (2004) with regard to mercury in the waste streams of several EU countries. A direct comparison with this source is complicated by the fact that Mukherjee *et al.* used reported waste streams from a limited number of countries, they included by-product and other waste streams, some of which are included elsewhere in this report, etc. The total below for recycled mercury in the EU is believed to be accurate to ±30%. Globally, average recycling rates are known to be lower than those in the EU and US, but relevant data are very limited. Especially due to the uncertainty of VCM-related mercury recycling in China, the total below for recycled

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[17] See Czech Republic (2005), France (2005), Germany (2005), Netherlands (2005), Slovakia (2005), UK (2005).

mercury globally could be 50% lower, but probably not more than 10% higher than the figure shown.

EU-25 and global product/process mercury recycling – 2005

EU25 and global product and process mercury recycling - 2005	Hg in EU-25 waste stream (t)	EU-25 Hg recycled or recovered (%)	EU-25 Hg recycled or recovered (t)	Hg in global waste stream (t)	Global Hg recycled or recovered (%)	Global Hg recycled or recovered (t)
SS gold mining	not applicable	not applicable	not applicable	not applicable	not applicable	not applicable
Chlor-alkali	not applicable	not applicable	32	not applicable	not applicable	84
Batteries	40	25%	10	500	15%	75
Dental	72	25%	18	200	15%	30
Measuring & control	42	25%	11	160	15%	24
Lighting	46	25%	11	150	15%	23
Electrical & electronic	42	25%	11	150	15%	23
VCM	unknown	unknown	unknown	700	43%	301
Other, laboratory, pharmaceutical, etc.	36	25%	9	50	15%	8
Total for these categories	278		101	1910		566

Note: If the Chinese industry estimate of VCM mercury catalyst recycling turns out to be optimistic (for example, if it is closer to 100 tonnes than 300 tonnes/yr), that single correction could make a very large difference in the global total for recycled mercury.

Sources: Author calculations based on responses to the Stakeholder questions posed by DG ENV to the different Member States in September 2005. See Czech Republic (2005), France (2005), Germany (2005), Netherlands (2005), Slovakia (2005), UK (2005). Also Brooks (2005), Maxson (2004, 2005), Euro Chlor reports to OSPAR.

As mentioned previously, government regulations and policies, as well as mercury recovery vs. disposal costs, of course, determine how much of this mercury waste stream is eventually recovered.

1.1.8 Summary mercury supply

Any summary of mercury sources obliges the analyst to deal with the recurrent problem of deciding at what point to account for a given source. For example, mined cinnabar may be accounted for as “mercury production” in the year it is refined into elemental mercury (this is the convention used here). Or it may be accounted for in the year it is sold by the mine. Or if it is sold by the mine in bulk to a broker, it may not be accounted for until it is eventually sold by the broker to an end-user.

Likewise, mercury from a decommissioned chlor-alkali plant may be assumed to be “available,” and accounted for, in the year the plant is closed. Or it may be accounted for (the convention used here) in the year it is removed from the cells and sold to another party, e.g. MAYASA, in the case of EU plants. It is generally not yet possible to obtain the necessary detailed information in order to make all of these sorts of distinctions. This is one of the arguments for better reporting of all mercury movements, which will greatly help our understanding of mercury flows through the economy.

Even in the case of mercury stocks that have recently become available in the FSU, it has not been possible to determine whether they have come from Kyrgyz mine production during the last several years (and therefore should have already been included in previous accounting of primary mine production); or whether they originate from large quantities of

Russian mercury wastes being refined by the Kyrgyz Republic (and should therefore be considered as recycled mercury); or whether they represent a stockpile that has been warehoused in Russia already for many years (the assumption made in this report).

From the previous analysis, the following table summarises the estimated global and EU-25 mercury supply during 2005. Note that at current levels of recycling and recovery, the non-chlorine sources of mercury in the EU-25 are not large.

As suggested in the above text, despite best efforts to clarify these data, there remain many uncertainties. It is estimated that the total global supply of mercury – according to the definitions used in this report – is accurate to within ±15%, while the EU-25 mercury supply is accurate to within ±20%, considering the lack of reporting on several of these categories.

Global and EU-25 mercury supply during 2005

2005	**Global supply (t)**	**EU-25 supply (t)**
Mining & by-product	1996	79
Recycled mercury from chlor-alkali wastes[a]	84	32
Recycled mercury - other[b]	566	69
Hg from chlor-alkali cells (decommissioning)[c]	644	444
Stocks	400[d]	0[e]
Total	**3690**	**625**

Notes:

a) Recycled mercury from chlor-alkali plants includes mercury from sludges and wastes that are retorted on-site, as well as mercury from wastes that are sent off-site for recycling.

b) “Recycled mercury – other” includes all non-chlor-alkali sources

c) “Hg from chlor-alkali cells” is elemental mercury removed from cells at decommissioning.

d) The mercury estimated to have been delivered from FSU stocks was included in the 2005 accounting before it was learned very late that there had been no delivery until early 2006, as described in Section 1.1.2. This misallocation has no material effect on this report’s subsequent discussions or conclusions.

e) Despite the fact that mercury was drawn from storage and sold by MAYASA during 2005, this “source” of mercury to the EU is not included as “stocks” because all mercury now stored by MAYASA should have been accounted for already in previous years when it was produced at Almadén (EU mining supply), produced in the Kyrgyz Republic (non-EU mining supply), recovered from chlor-alkali cells (decommissioning), etc. See the discussion in Section 1.1.2.

The following table summarises the global mercury supply during the period 1995-2005. While the mercury supply and demand for 2005 have been calculated separately for this report, in previous years it has generally been assumed that supply and demand for mercury were in reasonable balance, with data on mercury supply (such as Hylander and Meili [2003], for example) naturally suggesting equivalent demand over time.

Global mercury supply

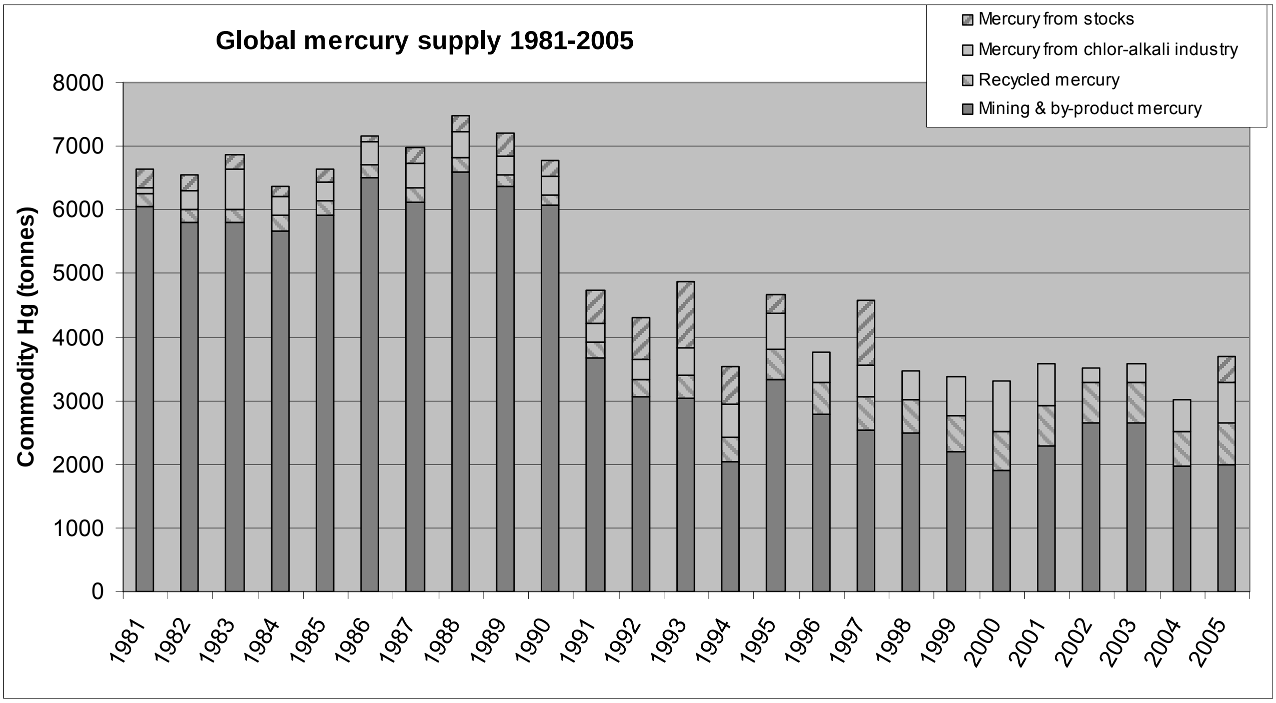
	Mining & by-product mercury	Recycled mercury incl. chlor-alkali wastes	Mercury recovered from decommiss. MCCAPs	Mercury from stocks	Total
1995	3338	459	575	300	4672
1996	2782	501	475	0	3758
1997	2529	539	500	1000	4568
1998	2496	510	460	0	3466
1999	2200	575	600	0	3375
2000	1900	610	800	0	3310
2001	2300	620	650	0	3570
2002	2650	630	230	0	3510
2003	2650	640	290	0	3580
2004	1965	560	489	0	3014
2005	1996	650	644	400	3690

Note “Mercury recovered from decommissioned MCCAPs” in 2002 and 2003 is not directly comparable to the figures for the other years due to different methods of calculation.

Sources: Hylander (2003), Maxson (2004 and 2005), Euro Chlor publications (http://www.eurochlor.org/).

The following figure summarizes the longer-term global mercury supply, and graphically demonstrates the serious supply deficit that developed in 2004, and strongly influenced the price run-up in 2004-5 (see further discussion in a later section of the report).

Global mercury supply 1981-2005



1.2 EU and global mercury demand

1.2.1 The concept of "direct mercury demand" within the EU-25

It is important to mention that, since the purpose of part of this analysis is to compare – for the purpose of the proposed mercury export ban – the EU-25 mercury supply with EU-25 demand, the precise demand with which we are concerned is the direct domestic (manufacturing, industry, laboratory, etc.) demand for elemental mercury that will be converted to products and processes inside the EU, rather than the broad consumer purchase of products (including imports) that contain mercury.[18]

The difference between the two is significant. In the case of mercury thermometers, for example, there are still major consumer and hospital purchases within the EU-25, while the actual manufacturing of thermometers within the EU-25 is quite limited. I.e., the mercury content of all thermometers consumed (many imported) in the EU in 2005 was about 15 tonnes, while the amount of elemental mercury that was consumed by EU thermometer manufacturers whose thermometers were sold within the EU was no more than 2-3 tonnes (see, for example, Czech Republic (2005) regarding thermometer production).

In fact, the latter "direct demand" for elemental mercury is the focus here, as we wish to ensure an adequate EU-25 supply that will be sufficient to meet that "direct demand." We will return to this concept later. In the meantime, however, in the interest of making conservative estimates, the following basic calculations will be made in the traditional manner, reflecting broad consumer demand for (domestic and imported) mercury-containing goods, and industry demand for mercury in processes.

1.2.2 Typical uses

Through recent history, mercury demand has been marked by new and significant applications that wax and eventually wane several decades later – typically for health and environmental reasons. Chlor-alkali electrolysis with mercury has more than a 100-year history that saw maximum demand for mercury in the 1970s. Small-scale gold and silver mining with mercury has been pursued for millennia, and has gone through many cycles of greater and lesser demand for mercury. Apart from the staggering use of mercury for gold and silver mining over this long period, chlor-alkali and batteries have been the biggest users of mercury in the 20th century, both declining steadily since the late 1980s.

Demand for mercury has long been widespread, although the global mercury commodity market is small in both tonnage and value of sales. Even though mercury may routinely be traded several times before final "consumption," the available statistics suggest that global yearly trades of mercury and its compounds are probably in the range of €100 million in value. Most transactions are among private parties and are not publicly reported. Mercury is consumed in a broad range of products and processes around the world. The major categories of mercury demand in higher income countries include:

- chlor-alkali production
- dental amalgams
- fever and other thermometers

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[18] It is perhaps useful to clarify that most consumers do not specifically ask for a product that contains mercury. "Consumer purchase of mercury products" in this case means only that in the normal purchasing process, a certain number of those products purchased will contain mercury.

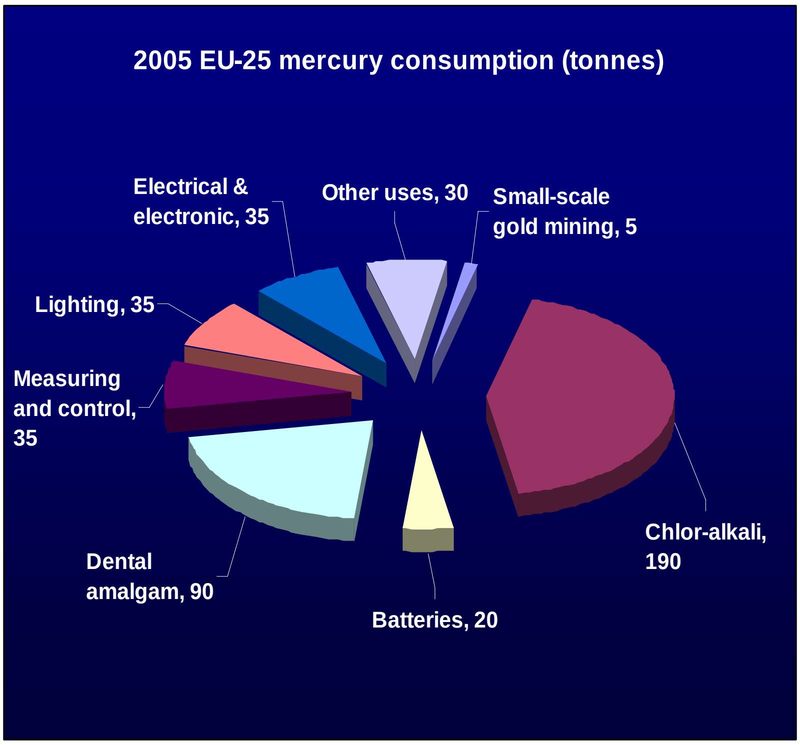
- other measuring and control equipment
- mercuric oxide and other batteries
- neon, compact fluorescent, HID and other energy-efficient lamps
- electrical switches, contacts and relays
- laboratory and educational uses
- other industrial processes requiring catalysts, etc.
- pharmaceutical processes, products and preservatives
- other product uses, such as cosmetics, fungicides, toys, etc.

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

- artisanal gold mining
- cosmetics and skin creams
- cultural uses and traditional medicine
- paints and pesticides/agricultural chemicals.

While continuing its long-term decline in most of the EU-25 and other higher income countries, there is evidence that demand for mercury remains relatively robust in many lower income economies, especially South and East Asia (especially mercury use in products, VCM production and artisanal gold mining), and Central and South America (especially mercury use in artisanal gold mining). At the same time, there is little detailed data pertaining to its end use in many nations. The main factors behind the decrease in mercury demand in the EU-25 are the substantial reduction or substitution of mercury content in regulated products and processes (paints, batteries, pesticides, chlor-alkali, etc.), and a general shift of mercury product manufacturing operations (thermometers, batteries, etc.) from EU-25 countries to third countries.

A breakdown of mercury demand (including the mercury contained in imported products) among different categories of use within the EU-25 is presented below. Other than the chlor-alkali industry, where the mercury cell process is more widely used in the EU-25 than in other regions of the world, this distribution of mercury uses is reasonably representative of other “industrialized” economies.



Note: Small-scale gold mining use of mercury in the EU appears to be restricted to French Guiana, formally part of the EU. By Prefectoral Decree of June 2004, the use of mercury for gold extraction was prohibited in French Guiana as of January 1, 2006.

Sources: Brooks (2005), Maxson (2004 and 2005), Euro Chlor reports to OSPAR, WWF (2005), Czech Republic (2005), France (2005), Germany (2005), Netherlands (2005), Slovakia (2005), UK (2005).

1.2.2.1 Chlor-alkali

With regard to the largest category shown, based on consumption and release data provided to Euro Chlor by industry operators,[19] it is estimated that the throughput of mercury through the industry in the EU-25 is about 190 tonnes per year. Of that, about 86 tonnes of mercury is disposed of in waste, an estimated 32 tonnes is recycled and reused within the industry, and the remaining mercury is contained in products (chlorine, caustic, etc.), released to the environment and/or unaccounted for ("difference-to-balance," in the Euro Chlor reports).

As seen in the table below, the EU-25 represented in 2005 about 53% of global mercury cell chlorine capacity. Another 10-12% of global mercury cell chlorine capacity is based in the US. It is logical that the performance of the US plants is comparable to those in the EU. On the other hand, approximately 2.5 million tonnes of mercury cell capacity are located in countries where management practices and environmental controls are not as rigorous, and there is evidence that average consumption and releases of mercury at these locations are considerably higher, per tonne of production capacity, than the EU

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[19] 2005 mercury demand by EU-25 chlor-alkali plants is based on data reported by industry to Euro Chlor. See http://www.eurochlor.org/.

average (see, for example, ACAP (2005) and Toxics Link (2004)). This explains the global demand of over 600 tonnes of mercury for the industry, as shown in the table below.[20]

EU-25 & global mercury cell chlorine production capacity and mercury consumption (2005)

	Mercury cell Cl capacity (t/yr)	**Mercury consumption (g/t Cl capacity)**	**Mercury net consumption total (t)**	**Mercury recycled & recovered (t)**	**Mercury total consumption (t)**
EU-25	5,886,868	27	158	32	190
US	1,231,050	22	27	13	40
Other good performers	1,500,000	25	38	8	46
ROW	2,500,000	125	313	31	344
Total	11,117,917		**535**	**84**	**619**

Sources: Euro Chlor; Chlorine Institute; UNEP Chemicals (2002); consultant calculations.

In order to put these numbers in context, the only sector that consumes more mercury, now that the demand for mercury in batteries has dropped significantly during recent years, is the artisanal and small-scale gold mining (SSGM) sector.

1.2.2.2 Gold mining

There are reports that many of the more easily accessible ore deposits have been exhausted, and it is certain that overall mercury consumption must decrease over time for this reason if no other – at some point mining sites will no longer be found and worked as easily as in the past. However, recent detailed studies of mercury demand around the world for artisanal and small-scale gold mining give an estimate that may be as high as 1000 tonnes of mercury per year (Veiga, 2006).[21] This demand may be greatly reduced in various ways, but the barriers to doing so are formidable. One would be obliged to seriously address, among other issues, the fact that gold mining provides higher cash revenues than traditional (and generally more sustainable) activities such as farming and fishing. Further, the typically limited education of miners limits their alternative opportunities. And not least, the (frequently transient) miners are engaged in an activity that is illegal in some countries, and in other countries where it is not illegal, it exists on the very margins of the formal economy.

As a result, economic signals remain, at least for now, the most effective means of changing SSGM behaviour. A high mercury price generally leads to reduced use and emissions of mercury because it is used more efficiently, or because of a shift to mercury-free techniques. Education campaigns about the health risks of mercury have not substantially reduced the use, and in fact sometimes merely end up transferring some of the risks, such as emissions from burning off mercury, to more vulnerable groups such as women.

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[20] According to *Mercury in India* by Toxics Link (2004), cited by Brooks (2005), mercury is widely used in India for chlorine-caustic soda production (23 plants use 100-150 t annually), although this information has not been recently confirmed by this author.

[21] It should be noted that not all SSGM use mercury. Some use cyanide, permitting more gold to be recovered than when using mercury. Others use gravimetric methods without mercury or cyanide.

Likewise, a drastic fall in the market price of gold would greatly reduce the extent of SSGM activities as well as the consumption of mercury, because most SSGM investments are small, and most of the costs are for daily mining and smelting operations.

1.2.2.3 Batteries

Previous estimates (Maxson, 2004), based on trade data, of high mercury demand for batteries, especially in China, have recently been more closely investigated (NRDC, 2006). While mercury use in Chinese batteries was confirmed to have been quite high through 2000, most manufacturers have now shifted to lower mercury designs, following commercial trends and customer demand in other parts of the world. However, there are still vast quantities (tens of billions) of batteries with lower mercury content produced in China, and there continues to be a significant ongoing trade in mercuric oxide batteries (NRDC, 2006), some produced in China, and more apparently produced in Chinese-operated free-trade zones. Therefore, the global consumption of mercury in batteries still numbers in the hundreds of tonnes annually, and battery waste should continue to be collected separately, to the extent possible.

It is assumed that there also remain a large number of button cell batteries manufactured in the EU-25 containing on the order of 1% mercury. These will surely be replaced by mercury-free button cells in the next several years. The mercury content of new alkaline batteries produced in the EU is considered to be quite low.

1.2.2.4 VCM

The previously mentioned investigations in China have confirmed the demand of some 600 tonnes of mercury per year for catalysts for VCM production – a number that is actually increasing as the Chinese economy booms, and as Chinese demand for VCM increases. Meanwhile, the use of products based on VCM in EU hospitals is declining due to concerns about the health effects of softeners added (HCWH, 2004; NRDC, 2006).

1.2.2.5 Measuring and control

There is a rather wide selection of mercury containing measuring and control devices, including thermometers, barometers, manometers, etc., still manufactured in the EU-25, although most suppliers now offer mercury-free alternatives as well. European legislation is being developed in line with the Community Strategy on Mercury to reduce mercury demand for this equipment.

1.2.2.6 Electrical and electronic devices

Due to the RoHS Directive and similar initiatives in California and Japan, among others, mercury-free substitutes for mercury switches, relays, etc., are being actively promoted.[22] At the same time, the Interstate Mercury Education and Reduction Clearinghouse (IMERC) database[23] indicates that mercury use in these devices remains significant.

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[22] For California, see http://www.dtsc.ca.gov/HazardousWaste/EWaste/. For Korea’s RoHS/WEEE/ELV-like legislation called "The Act for Resource Recycling of Electrical/Electronic Products and Automobiles,” see http://www.europeanleadfree.net/pooled/articles/BF_NEWSART/view.asp?Q=BF_NEWSART_195645. For Japan, see http://www.jeita.or.jp/index.htm; also see http://uk.farnell.com/jsp/bespoke/bespoke8.jsp?bespokepage=farnell/en/rohs/rohs/facts.jsp.

[23] http://www.newmoa.org.

1.2.2.7 Dental

In many EU-25 countries, dental use of mercury is declining. In others, however, better access to dental care may actually increase mercury use temporarily, especially where the cost of treatment is most critical. Amalgam fillings remain less expensive as long as the related costs of amalgam separators, etc., are not charged to the patient. Many (especially older) practitioners seem to be hesitant to change long-standing methods of treatment, are less concerned or aware of environmental issues, or they may be less familiar with the newer mercury-free alternatives.

1.2.2.8 Mercury lamps

Mercury use in energy-efficient lamps remains the standard, where ongoing industry efforts to reduce the amount of mercury in each lamp are countered, to some extent, by the ever-increasing number of lamps produced and consumed in the EU. There are indications that mercury-free alternatives will eventually encroach on this market, but for most applications the alternatives are still quite limited.

1.2.3 EU-25 and global demand summary

At the beginning of this section there was a note about EU “direct demand” for elemental mercury that will be made into products and processes within the EU, as opposed to overall EU consumption of products (both domestically produced and imported) that contain mercury.

When calculating EU-25 mercury demand for the purposes of this report, imports of mercury-containing products should theoretically be excluded. What we may refer to as “direct demand” is the elemental mercury that needs to be available to the EU-25 economy as a direct input into products manufactured in the EU (“EU-origin”), or as an input into industrial processes that take place within the EU. In effect, this is the quantity of mercury that the EU-25 would hope to provide from internal sources in the event of all chlor-alkali (and possibly other) mercury being stored.

On the contrary, any exports of mercury-containing products do not need to be specially considered in this analysis, as they are all part of what is referred to above as EU-25 “direct demand.” Mercury products known to be manufactured in the EU-25 include thermometers, energy-efficient lamps, batteries, laboratory chemicals, dental amalgams, and some barometers and other measuring and control instruments. In any case, the exports of these products from the EU are relatively insignificant, especially in terms of the mercury content.

Since specific data are not available, it may be roughly estimated that “direct demand” for mercury in products is 50-100 t/yr, or about 20-40%, less than overall EU-25 consumption of mercury in products , representing mostly the mercury content of imported measuring and control devices, batteries, energy-efficient lamps, electrical and electronic equipment, and “other” mercury uses.

In total, global mercury demand (uncertainty estimated at ± 15%) and EU-25 mercury demand (uncertainty estimated at ± 10%) for mercury are summarised in the following table.

EU-25 and global mercury demand by sector (2005)

Mercury demand	**Global demand (t)**	**EU-25 market demand (t)***
Small-scale gold mining	1000	5
Chlor-alkali	619	190
Batteries	400	20
Dental	270	90
Measuring & control	150	35
Lighting	120	35
Electrical & electronic	140	35
VCM	700	probably zero
Other, laboratory, pharmaceutical, etc.	40	30
Total	**3439**	**440**

* “Market demand” represents all mercury consumed in the EU-25, including mercury imported in products, etc. This may be contrasted with “direct demand” for elemental mercury that needs to be available to the EU-25 economy as a direct input into products manufactured in the EU (“EU-origin”), or industrial processes that take place within the EU. As discussed in the text, the latter is estimated to be 20-40% less than “market demand” for mercury.

Sources: Euro Chlor (http://www.eurochlor.org/), Czech Republic (2005), France (2005), Germany (2005), Netherlands (2005), Slovakia (2005), UK (2005), Maxson (2004, 2005), NRDC (2006).

It may be noted that the chlor-alkali industry is responsible for 43% of EU-25 mercury demand (or 36% if one considers the estimated 32 tonnes of mercury recycled by the industry) and 18% of global mercury demand. Most chlor-alkali industry mercury requirements, especially within the EU-25, may be assumed to be sourced from within the industry as other MCCAPs close or convert to the membrane process.

Largely as a result of increasing awareness and regulation, the global demand for mercury has declined from more than nine thousand tonnes annual average in the 1960s, to just under seven thousand tonnes in the 1980s, and less than four thousand tonnes since the late 1990s.[24] In 2005 global demand for mercury, on the strength of high gold prices and strong mercury demand for artisanal and small-scale gold mining, remains in the vicinity of 3400 tonnes per year, as seen in the above table. About 13 percent of this total represents mercury consumption in the EU-25, and just over half of the EU-25’s level of consumption is estimated to be consumed in North America. Global mercury demand broken down by geographical region is estimated in the table below. Uncertainty in the total, as mentioned above, is estimated at ± 15%, while regional uncertainties, especially for regions that are not well reported, may be as high as ± 25-30%.

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[24] Historical mercury demand through the 1990s is based on mercury production data compiled by Hylander and Meili (2003).

Global mercury demand by region (2005)

Region	Metric tonnes
EU-25	440
North America	230
Other OECD	100
Eastern Europe/CIS	210
Arab States	100
East Asia & Pacific	1550
Latin America & Caribbean	270
South Asia	450
Sub-Saharan Africa	100
TOTAL	3450

Sources: Maxson (2004), NRDC (2006), UNDESA/SD Comtrade (2006) statistics, consultant estimates.

1.3 Mercury trade

1.3.1 Basic market structure

The small market for commodity mercury is characterized by a limited number of virgin mercury producers, and a larger number of secondary mercury producers. These actors are complemented by another relatively small group of mercury traders and brokers, mostly located (in addition to the main mining sites) in the Netherlands, the UK, Germany, the US, India and Hong Kong. All of these “market-makers” buy and sell mercury, timing their trades to influence market movements and to profit from price fluctuations. MAYASA, the Spanish mercury mining and trading company, purchased most of the USSR stockpile in the 1990s, for example. In recent years, MAYASA has also purchased residual mercury inventories from Western European chlor-alkali plants as they close or convert to a mercury-free process. Lambert Metals is the other main market-maker in the EU, with a presence in the UK, Rotterdam and Amsterdam, among other locations.

Most mercury traders deal as well in other non-ferrous metals, frequently in other commodities, and sometimes in mercury and other compounds. The mercury business by itself, in recent years, has not been reliable or profitable enough for a company to depend on for its livelihood.

Recyclers of mercury, on the other hand, may deal exclusively with mercury, or they may extract precious metals as well. Since their survival does not depend on the market price of mercury, they occupy a very different niche from the traders.

There are also some special cases such as MAYASA, which has long been a mercury trader, but due to its past mining operations it also has (or had recently) laboratory facilities, storage facilities, refining and filtering equipment, emission controls, waste treatment and disposal facilities and sites, a technical assistance group for selling services related to refining and emission controls, etc.

1.3.2 Global and EU-25 mercury movements

The picture of global mercury trade, and the role of the EU in that trade, in general terms, remains virtually the same as described in Maxson (2004). The identification of the EU-25 region rather than the EU-15 does not change significantly the nature of these trade flows, since the main EU mercury traders were part of the former EU-15. The most significant change in recent years is that EU traders seem to be generally more careful about whom they sell mercury to. Due to increased public awareness, traders increasingly prefer to deal with buyers for whom the end use of mercury is clear and “legitimate,” e.g., they prefer not to knowingly sell mercury for use in small scale and artisanal gold mining, skin-lightening creams, or other such uses. This attitude has likely contributed to a decrease in mercury exports from the EU, especially since 2003.

The UNDESA/SD Comtrade (2006) statistics are the most comprehensive publicly available records of global mercury trade. Even so, in the analysis of these statistics, several points should be kept in mind:

- Publicly available trade data show only discrete freight movements – the country origin and country destination of one or more shipments (it is not indicated how many) grouped together, and the quantity (and generally the value) of the total shipments from one country to another during the course of a year.
- There is no indication whether the source of a country-to-country shipment is the real origin of the material, or whether the destination of the shipment is the final destination. Nor is there any indication of the end use of the mercury.
- There is no indication of the time scale of shipments. For example, a bulk mercury shipment could be recorded from Spain to the Netherlands in 2005, and the same mercury could be shipped out in smaller quantities to many different countries in 2005, or in 2006. In such a case there may be double counting of the same mercury in one year or over several years.
- The trade statistics for commodity mercury do not include trade in mercury compounds, which would increase the mercury flows shown here by an estimated 10-15 percent. There are some separate statistics on mercury compounds, but the number of compounds is very limited, and the reporting is neither widespread nor consistent.
- Likewise, if one were to assume a certain number of unreported trade movements of elemental mercury, or recognize the internal trade within certain countries such as China, India, the US, etc., that does not appear in these statistics, one would see much larger trade flows.

For all of these reasons and more, countries inside the EU and outside should be encouraged to collect better statistics on all mercury movements in order to improve our understanding, and facilitate more effective policy formulation. This was the general observation of the 2005 UNEP Governing Council Meeting, whose decision 23/9 IV requested, among other things, a report to be prepared on mercury trade before the next meeting in February 2007.

Recent EU mercury imports and exports are summarised below, while several tables providing further details of previous mercury flows have been attached in Annex 3 summarising EU-25 trade with the rest of the world. These include:

- Netherlands – main mercury exports 2003;
- Spain – main mercury exports 2003;
- Other significant European mercury exports 2003;

- Major EU mercury movements, 2000-2003;
- Global exports of mercury from key EU countries to OECD partners; and
- Global exports of mercury from key EU countries to non-OECD partners.

The UNDESA/SD Comtrade (2006) statistics used in the following analysis are sufficient to show the general trends in EU-25 mercury trade, and are probably accurate to within ±20%, depending on the assumptions one makes about certain incomplete or conflicting statistics in the database.

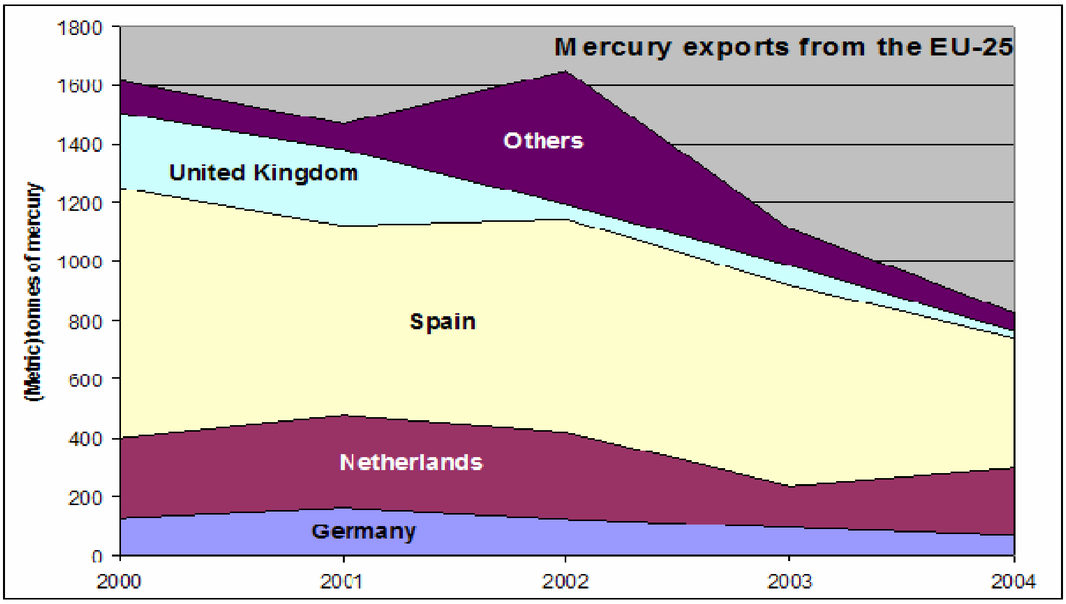
EU-25 elemental mercury exports, 2000-2005

Major EU-25 exporters (tonnes elemental Hg)					
	2000	**2001**	**2002**	**2003**	**2004**
Germany	128	162	125	93	69
Netherlands	272	312	292	145	228
Spain	850	648	730	678	444
United Kingdom	255	259	47	70	24
Others	111	89	455	123	59
Total	1616	1470	1648	1110	824

Source: Author analysis of the trade flows of the 25 present country members of the EU, according to UNDESA/SD Comtrade (2006) statistics

The first two figures below show the main country contributors to EU mercury exports and imports during 2000-2005, while the third figure shows aggregate imports into and exports from the EU for these years.

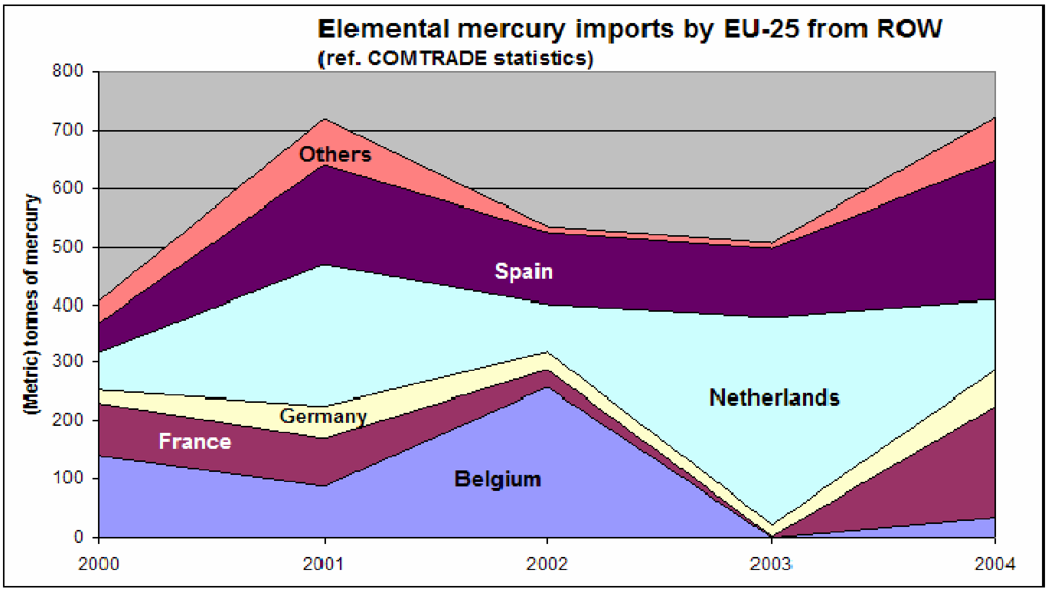
EU-25 elemental mercury exports, 2000-2005



Source: Author analysis of the trade flows of the 25 present country members of the EU, according to UNDESA/SD Comtrade (2006) statistics

The following graph of EU-25 imports shows a general increase after Almadén closed in 2003. However, the annual variation in EU imports is so great (see Spain, France and Netherlands data) that it is difficult to draw any conclusions. The major transfer from Switzerland to France in 2004 was likely related to the chlorine industry.

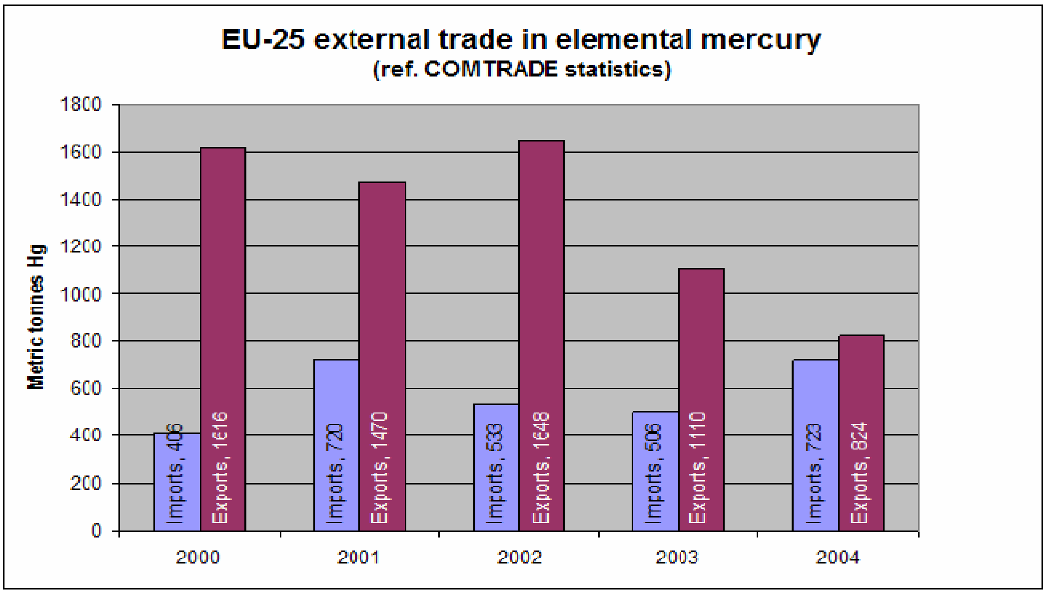
EU-25 elemental mercury imports, 2000-2005



Source: Author analysis of the trade flows of the 25 present country members of the EU, according to UNDESA/SD Comtrade (2006) statistics

The following figure shows net exports from the EU-25 over five years in order to better integrate the effects of any double counting in the statistics. In general, net exports have decreased considerably since 2000, although indications for 2005 seem to be that the net exports were not as small in 2005 as they were in 2004.

EU-25 elemental mercury imports and exports, 2000-2005



Source: Author analysis of the trade flows of the 25 present country members of the EU, according to UNDESA/SD Comtrade (2006) statistics

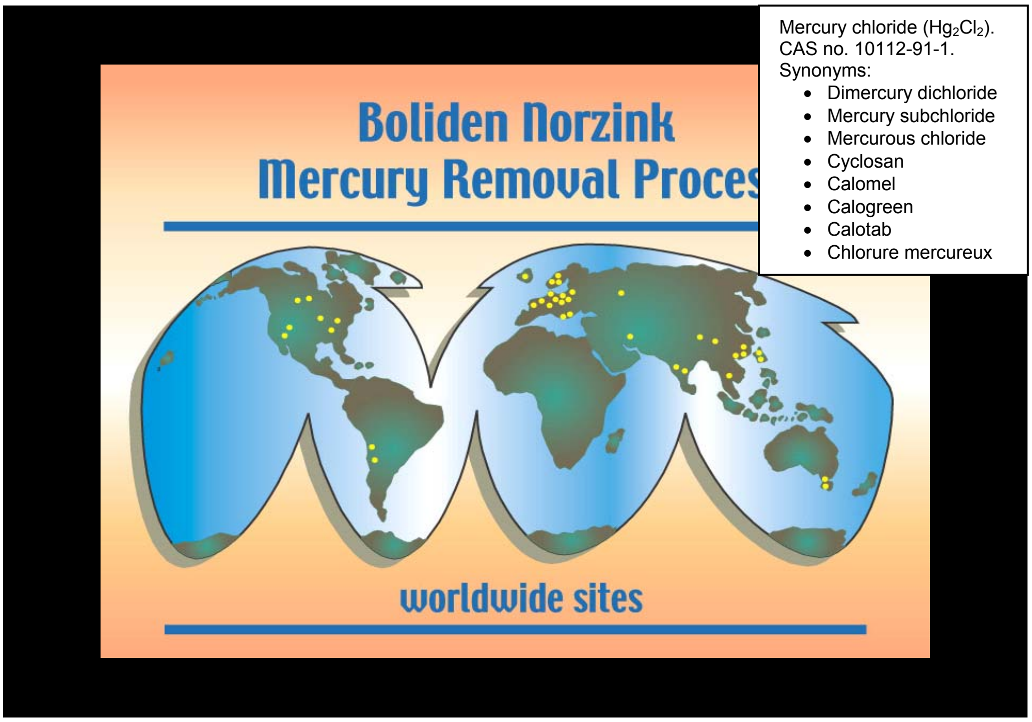
1.3.3 Possible trade in mercury compounds

If exports of mercury compounds are not banned along with elemental mercury, there is a possibility that mercury could be converted to one of several compounds to circumvent the ban on elemental mercury exports, exported as a compound, and then re-converted to elemental mercury outside the EU. A prominent mercury recycler wrote in September 2005:

> *“With regard to the costs of converting mercury into a compound and then recovering the mercury from a compound, our guess is that it shouldn't cost more than $200 per flask.”*

Since this cost is less than one-third of the market price for mercury at present, it could be argued that there is at least an economic rationale for doing this.

However, the compound we should initially be most concerned with is calomel, since it is already produced in significant quantities as a “waste” from the Boliden-Norzink process, which is used most commonly to remove mercury from flue gases during zinc, gold, copper, etc., refining. According to Lawrence (Lawrence, 2002), in 2002 there were 42 Boliden-Norzink mercury removal systems installed around the world, as indicated in the figure below. According to NRDC (2006) there are now about 35, based on information provided by Boliden representatives to NRDC. Together they have estimated that the mercury content of the calomel produced by all of the zinc smelters around the world (most other non-ferrous ores do not have a high enough mercury content to justify recovering the mercury separately – at least until the recent high mercury prices), added to the 24 tonnes of by-product mercury produced in Finland with the Outokumpu process, amounts to 284 tonnes annually. However, as noted in the discussion of mercury by-product, most of this mercury content is not presently recovered separately.



Mercury chloride (Hg_2Cl_2).
CAS no. 10112-91-1.
Synonyms:

- Dimercury dichloride
- Mercury subchloride
- Mercurous chloride
- Cyclosan
- Calomel
- Calogreen
- Calotab
- Chlorure mercureux

Source: Lawrence (2002)

Boliden-Norzink mercury removal systems have been installed on zinc smelters in Belgium, France, Netherlands, Germany, Italy, and Norway within the EU and neighbouring countries. From mercury exports and informal sources, it appears that mostly the Netherlands, Italy and possibly Belgium and Germany recover mercury from the calomel, while France and Norway are more likely to send it for disposal.

The concern is that when calomel waste is generated within the EU, it could be exported as a mercury waste or as a compound, after which a third-country processor could recover the mercury rather inexpensively (probably less than $100/flask). Under existing regulations (which are not intended to be changed under the mercury export ban), such wastes can be legally exported with the consent of the receiving country. If the waste had to stay within the EU, on the other hand, it would simply be disposed unless the EU market happened to need the supply.

1.4 Mercury price

The market price of mercury, and the trend in that price, are important for a number of reasons:

1. significant changes in the price of mercury generally reflect changes in supply and demand, or they could sometimes be related to other factors;
2. according to economic theory (not always evident in the mercury market), mercury demand should soften if the price rises, and may increase as the price decreases;
3. mercury mines that have been closed could view rising mercury prices as an encouragement to resume mining, if they can sell mercury at prices that would exceed the costs of mining;
4. likewise, suppliers of by-product mercury, recyclers, metal traders and anyone who may be holding mercury inventories may all adapt their behaviour in relation to mercury market prices.

1.4.1 Evolution of mercury supply vs. price

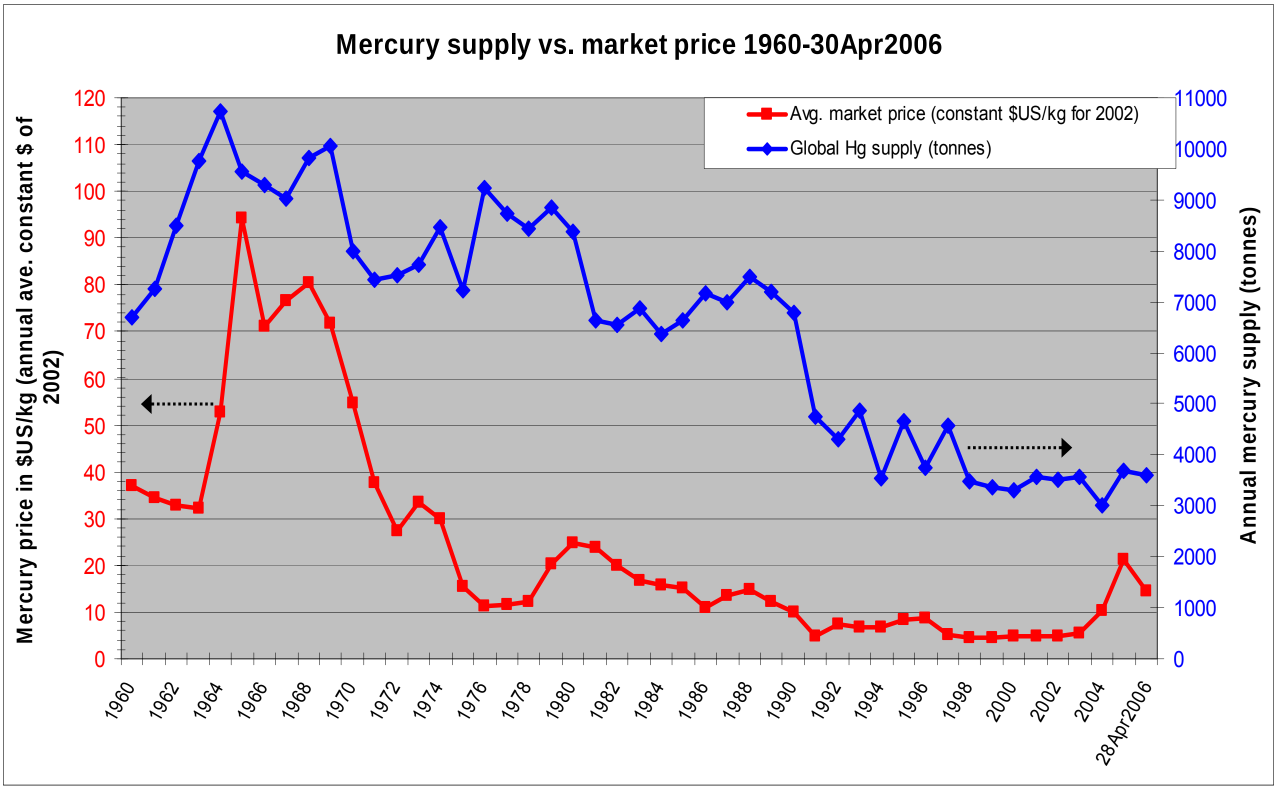
As evident in the following figure, mercury prices have been on a downhill slide for most of the past 40 years. During the last 10 years they stabilized at about their lowest levels ever – in the range of €4-5 per kg of mercury – before spiking up considerably from the middle of 2004 . Adjusting for inflation, mercury at €5 per kg was worth less than five percent of its peak price during the 1960s. That price level reflected a chronic oversupply driven, increasingly, by the regulatory pressures on industry, e.g., to reduce emissions, to organize separate collection of mercury products, and to deal with the increasing restrictions and costs of mercury waste disposal by sending the wastes to recyclers.

The subsequent 2004-2005 increase in mercury prices can be explained almost entirely by the tightening of mercury supplies during 2004. The following events coincided:

- Rising gold prices stimulated ASM demand for mercury, which increased by more than 300 tonnes during 2002-2005;
- The mercury supply decreased significantly especially during 2004, due to the closure of both the Spanish and Algerian mercury mines, among other factors;

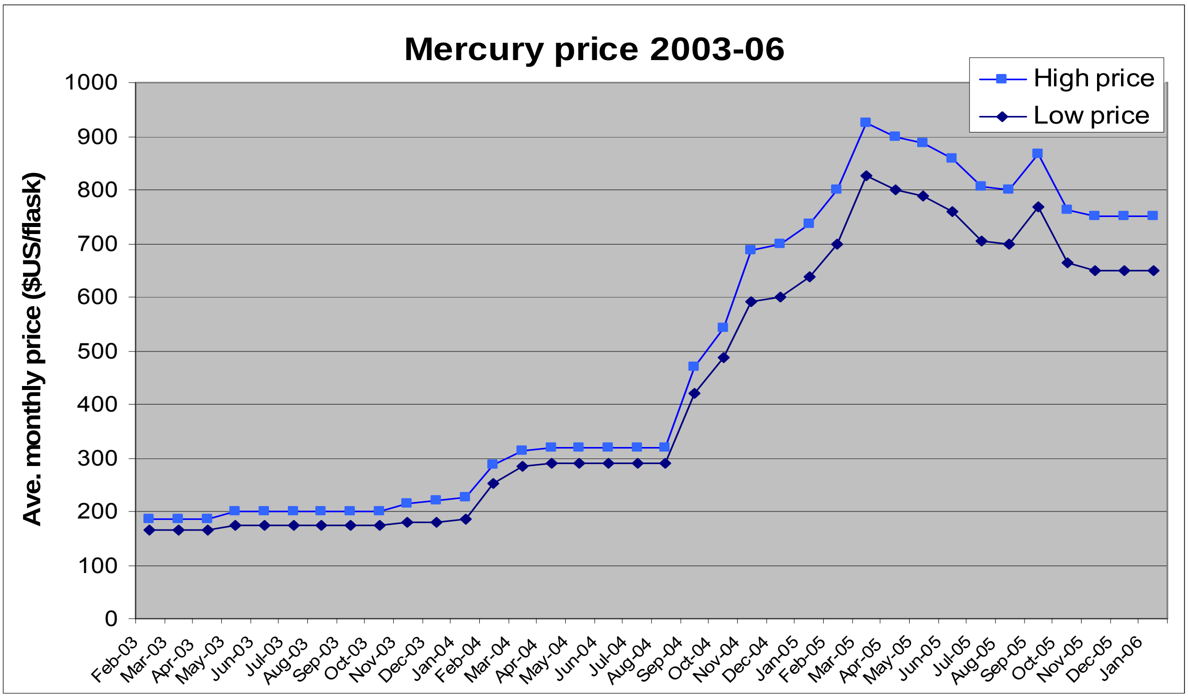
- China reduced its annual mercury imports by about 500t between 2000-2002, and subsequently increased domestic mercury production in 2002 and 2003, but not enough to meet its own needs, creating tight supplies in the large Chinese market as well;
- Mercury demand is relatively inelastic, at least over periods of 12 months or less, so that even a relatively small shortfall in supply can have a large impact;
- Uncertainty over the implications of the EU Mercury Strategy led to some market speculation;
- The change in dollar/euro exchange rates inflated dollar prices of mercury;
- The Kyrgyz mine has a limited ability to increase production at the best of times;
- Inventories (other than MAYASA) were limited, and MAYASA decided in 2004 to exercise more care over whom its mercury was sold to, effectively reducing deliveries by some 30%;
- The resulting market “panic” led to further speculation and price increases:
  - mercury users wanted to secure supplies quickly;
  - Speculators wanted to buy and hold supplies while waiting for further price increases.

As can be seen below, supplies of mercury eventually appeared on the market in 2005 to accommodate high prices and to meet excess demand, leading to a rapid fall in the mercury price, although still well above the levels of 2003 and before.



Sources: Hylander (2003), Maxson (2004), etc.

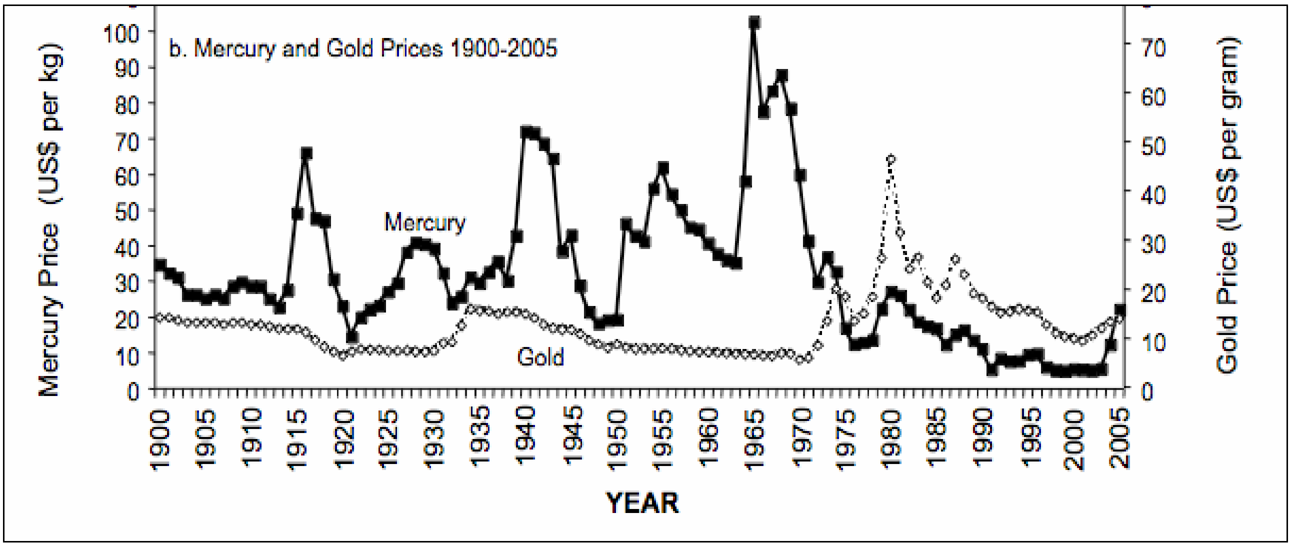
The evolution of the 2003-2006 mercury price can be seen in more detail in the following graph.



Source: *Metal Bulletin*

1.4.2 Evolution of the mercury price with the gold price

The price of gold has increased significantly, leading to ever increasing artisanal and small scale gold mining (SSGM) around the world, which so far has meant increased demand for mercury. Meanwhile, the price of mercury increased much faster than gold in 2005, slowing somewhat the increase in consumption of mercury among gold miners. It would be a mistake to look for a close correlation between gold prices and mercury prices because there are other factors that play a much greater role in the mercury price (especially periods of tight mercury supply, the difficulty of getting mercury to remote areas, etc.). Nevertheless, there is no doubt that increasing gold prices are closely correlated with the number of SSGM miners who are active, which may be directly correlated with demand for mercury. The following figure shows the relative movements of gold and mercury prices since 1900.



Source: Swain *et al.* (2006)

In an attempt to address the high levels of mercury emissions and health hazards in SSGM regions, UNIDO and other donors have been carrying out a $30 million programme to work with SSGM – six countries in particular – to reduce their mercury releases. The next UNEP Governing Council meeting, in February 2007, is expecting a report on the issues of most concern to SSGM. UNIDO has agreed to submit a report on mercury trade issues associated with the small scale gold mining sector, based on its extensive work in this sector, including its experience in supporting a number of developing countries in addressing these issues. The USEPA is also taking a close look at SSGM through their partnership program, but it is not yet clear what constructive measures may be taken. Finally, the considerable efforts of several national governments with important numbers of SSGM activities on their territory must also be recognised.

1.4.3 Elasticity of demand, and future mercury prices

The elasticity of mercury demand with price changes is impossible to calculate due to the small size of the market, the limited number of market makers, the lack of sufficiently detailed and precise data, etc. Maxson (2004) described how many mercury uses are relatively immune to variations in the mercury price. Likewise, there is no reliable information on mercury prices for future transactions being concluded now.

1.5 “Business-as-usual” scenario – global supply

In order to determine the mercury supply entering the market under the Business-as-usual (BAU) scenario, the assumptions about mercury coming from decommissioned mercury cell chlor-alkali plants are all-important, i.e., the speed at which Western European mercury cell chlor-alkali plants are decommissioned, and their mercury inventories put on the world market. According to the agreement between Euro Chlor and MAYASA, most Western European mercury inventories from decommissioned MCCAPs are either transferred for use at other chlor-alkali sites, or are sold to MAYASA or to another “established mercury producer,” from where they are then put on the world market.

1.5.1 BAU mercury supply scenario

A BAU scenario has been developed around the Western European industry commitment that most regional mercury cell chlor-alkali plants will have been converted to mercury-free or closed 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 BAU scenario assumes a more or less "natural" or "economically realistic" phase-out of Western European mercury cell chlor-alkali production.

Many EU countries (Belgium, the Netherlands, Sweden, Finland, etc.) have chosen to implement OSPAR Decision 90/3, which stipulates a phase-out of MCCAPs by 2010. Nevertheless, the major EU chlorine producing countries have been unwilling to take such a step without assurance that their EU competitors will do the same. And even in some cases where national authorities have accepted the date of 2010, specific companies have not seriously considered such a change because the phase-out date was so far off, or because the national authorities themselves have not reached a consensus among the various agencies and ministries involved.

As a result, one might also question how seriously companies may consider the Euro Chlor voluntary phase-out date of 2020. It is the author's impression that this date is being taken rather seriously by industry, but it is far in the future and, lacking any backup legislation, there is no legal guarantee or penalty in case of non-compliance. Some conversions have already been announced, and there have been some country plans/strategies for further closures reported by Euro Chlor to OSPAR. Furthermore, according to work done for Euro Chlor by SRI Consulting (SRIC, 1998), and basically confirmed by Prochemics (2002), one objective of which was to describe in detail the normal economic lifetimes of the Western European MCCAPs, it is reasonable to assume a roughly straight-line phase-out schedule for most remaining EU-25 MCCAPs from now until 2020. This paper assumes there will be some 500 thousand to one million tonnes MCCAP "specialty chemical" production capacity remaining in 2020.

The rate of closures also depends to some extent on industry health and restructuring plans, not to mention political pressure, and the chlor-alkali industry is in an exceptionally healthy economic situation for the foreseeable future (SRIC, 2005). A steadily increasing energy cost may further accelerate the transition to the more energy efficient membrane technology.

Annex 1 provides a list of the remaining (in January 2005) mercury cell chlor-alkali plants in the EU-25 countries, totalling some 5.9 million tonnes of annual chlorine production capacity, and containing some 12 thousand tonnes of easily recoverable mercury relevant to this analysis.

In addition to closures and conversions expected in the Western European chlor-alkali industry, some mercury cell plants in other parts of the world will be closed or converted during the period up to 2020, especially some already announced in the US.

The following table summarises other basic assumptions used in forecasting mercury supply through 2015, in particular by looking a bit farther ahead to 2020.

Source	**Global mercury supply assumptions 2005-2020 - Business-as-usual scenario**
	Note: If anything, the following assumptions should err on the side of lower mercury supply estimates in 2020 rather than higher, since one purpose of this assessment is to determine whether there is adequate EU-25 mercury supply to meet anticipated demand.
Mercury mining	China is expected to continue mining to supply domestic demand, which may increase for VCM, at least in the near term, as it decreases for batteries and most other applications. The Kyrgyz Republic is assumed to continue to produce up to 600 MT/yr as long as there is remaining demand at the price they ask. Mining is a relatively expensive source of mercury (especially compared to recovery of mercury from waste, which is basically “paid” for prior to recycling) and, without government subsidies, will be reduced before most other mercury sources, as demand is reduced. Therefore mercury mine supply (especially China and the Kyrgyz Republic) may fall off by more than 600 t/yr between 2005 and 2015 as demand decreases in this scenario.
By-product	Based on the previous discussion of by-product sources, most by-product mercury that could be recovered seems presently to be disposed of for economic or practical reasons. More is expected to be recovered if mercury prices stay high, and also as more raw materials (esp. zinc and lead) are consumed, and as regulations may require recovery of the mercury.
Chlor-alkali	EU-25 mercury cell chlorine capacity is assumed to decrease from 5.9 million tonnes of chlorine in 2005 to 0.8 million tonnes in 2020. US capacity is assumed to decrease from 1.2 million tonnes of chlorine in 2005 to 0.8 million tonnes in 2020. ROW capacity is assumed to decrease from 3 million tonnes of chlorine in 2005 to 2.5 million tonnes in 2020. On average 2 tonnes of mercury are recovered for each 1000 tonnes of chlorine production capacity. In total 10.1 million tonnes (MT) chlorine capacity in 2005 is assumed to decrease to 4.1 MT capacity in 2020, releasing at least 12,000 tonnes of mercury, or about 800 tonnes/yr. The total mercury demand (consumption) for operating chlor-alkali plants includes all mercury that goes into process wastes, some of which are later retorted on-site in order to recover the mercury. Any mercury recycled from wastes is included in the “recycled” category below.
Recycled mercury	Separate collection of mercury products is assumed to increase, but how much mercury is recovered from them will depend on mercury prices, legal requirements, etc. Under present regulation, mercury from recycled products, etc., is expected to increase modestly by about 50 tonnes/yr by 2010. Recovery of mercury from spent VCM catalyst in China may be expected to increase considerably, from some 300 t at present to at least 600 t/yr in 2010, even if mercury demand for VCM is somewhat slowed by the Chinese authorities (see below). After 2010, mercury supply from recycling is assumed to hold steady at about 1000 t/yr, heavily dependent on the regulatory environment, and lacking any other indication as to which direction it may go.
Mercury from stocks	Lacking further details, the most conservative assumption is that the FSU stocks made available in 2005 comprise 500 tonnes of mercury total, 400 tonnes were sold in 2005 and the final 100 tonnes in 2006. After this FSU stock is sold, all stocks will theoretically have been exhausted, although experience tells us there are probably other stocks around. If so, they will surely appear when the mercury price is right.

1.6 “Business-as-usual” scenario – global demand

This section will outline 15-year trends for the major categories of mercury demand, and lay the foundation for a global demand projection.

1.6.1 Chlor-alkali industry

As mentioned, the chlor-alkali industry presently plans to largely phase out the mercury cell process in Western Europe by 2020. Already, some of the Western European countries have phased out their mercury cell chlor-alkali plants, or have announced plans to phase them out by 2010. Perhaps unsurprisingly, however, the largest chlor-alkali producers – France, Germany, Italy, Spain and the UK – expect to have plants still operating after 2010.

1.6.2 Other demand sectors

For other mercury demand sectors, a "business-as-usual" (i.e., no other significant changes in regulations or restrictions) demand forecast for mercury during the period 2005-2015 has been developed.

The impact of the RoHS Directive on mercury demand in electrical and electronic equipment is discussed in the Mercury Strategy ExIA (2005) document. During the period 2005-2015, at the global level, this will have some impact on the use of mercury as other countries comply with, or imitate, the EU regulation.

The proposed Directive on measuring & control equipment has a limited scope – mainly "consumer" uses such as fever thermometers. There is also some discussion in the Mercury Strategy ExIA (2005). This will certainly have some impact within the EU-25 up to 2015, but the impact will be more limited at the global level.

There are some other initiatives, however, such as the Health Care Without Harm programme to eliminate mercury from medical care (HCWH, 2004), that are expanding to many countries and may have a significant impact on the use of mercury in measuring & control equipment, laboratory uses, etc.

These and other considerations are factored into the following table, which summarises the basic assumptions used in forecasting mercury demand through 2015, by looking a bit farther ahead to 2020.

Mercury use in:	Global mercury demand assumptions 2005-2020 – "Business-as-usual" scenario
	Note: If anything, the following assumptions should err on the side of higher estimates of mercury demand in 2020 rather than lower, since one purpose of this assessment is to determine whether there is adequate EU-25 mercury supply to meet anticipated demand.
Artisanal & small-scale gold mining	The informal mining sector is very difficult to predict, it seems there will be a high gold price for the foreseeable future, it is difficult for UNIDO and other programs to reach significant numbers of miners except in the medium-term, etc. On the other hand, there are already signs that the relatively high price of mercury has encouraged miners to seek ways to use mercury more efficiently. Therefore, it is conservatively estimated that there may still be 1000 tonnes of SSGM mercury demand in 2010, possibly decreasing to 600-700 tonnes by 2020, depending certainly on the market price of mercury (and gold). Based upon experience over the last five years, if the mercury market price is above €20/kg, retorting of mercury (and other efficiencies) will increase significantly; if the mercury market price is below €10/kg, retorting of mercury will increase much more slowly, in spite of the efforts of UNIDO and other field programs.

Chlor-alkali	EU-25 mercury cell capacity expected to decrease from 5.9 million tonnes of chlorine in 2005 to 0.8 million tonnes in 2020. US capacity expected to decrease from 1.2 million tonnes of chlorine in 2005 to 0.8 million tonnes in 2020. ROW capacity expected to decrease from 3 million tonnes of chlorine in 2005 to 2.5 million tonnes in 2020. In total 10.1 MT capacity in 2005 expected to decrease to 4.1 MT in 2020. 619 tonnes of total mercury consumption (56 g/t capacity, weighted significantly by the performance of the EU-25) during 2005, expected to decrease to 300 tonnes of mercury (est. average 80 g/t capacity, no longer weighted so much by EU-25 performance) in 2020. This number represents all mercury releases to emissions, products, unexplained and wastes, some of which are later retorted to recover mercury.
Batteries	Continued pressure on East Asian producers to decrease mercury content of batteries. As described in NRDC (2006), implementation of Chinese and other legislation to reduce mercury content of batteries, possible remaining military demand for mercuric-oxide batteries, etc., expected to reduce mercury demand from est. 400 tonnes in 2005 to no more than 100 tonnes by 2020.
Dental	Advances in mercury-free dental care, and reductions in mercury use in many countries will be offset by improved dental care in others, including likely increased use of inexpensive and low-tech mercury amalgam fillings. While aesthetic considerations may encourage whiter fillings, and new materials will gradually come on the market, a conservative approach would assume that there will be little or no reduction in mercury use to 2020.
Measuring & control	Encouraged by the EU Directive and such programs as HCWH, the general trend is for users to request mercury-free devices, and producers to supply mercury-free devices. Conservative estimate would see a reduction of about 50% worldwide by 2020.
Lighting	mercury-free alternatives are appearing, but the range of applications remains very limited. The mercury content of the average lamp continues to decline. Meanwhile demand for energy-efficient lighting increases, especially as energy prices continue to climb. Overall, therefore, no significant reduction in mercury consumption is expected by 2020.
Electrical & electronic	The impact of the RoHS and similar legislation may be more significant than reductions of mercury in measuring & control devices, especially through 2010, with a continued, but more gradual, reduction after 2010.
VCM production	China is the source of 90% of the industry capacity using the mercury process for VCM production. Economic conditions in China suggest VCM production will continue to expand, and the mercury catalyst process will surely be used for much of that capacity. NRDC (2006) estimates that mercury demand could increase from about 700 tonnes to 1000 tonnes by 2010. At the same time, however, there will be substantial political pressure on China to recycle more of the spent catalyst (see "supply" comments in the previous table), not to mention the considerable economic incentive if the mercury price stays relatively high. VCM mercury demand after 2010 is virtually impossible to predict, so it has been left at 1000 t/yr. Meanwhile, the European chemical industry is concerned that China should be "permitted" to produce VCM/PVC at a very low cost using a process that is no longer "acceptable" in the EU for environmental reasons. Some political pressure could be applied, but again, the impact is impossible to predict at present.
Other uses	General trends suggest other demand for mercury may decrease some, but past experience has taught us that unexpected uses tend to appear periodically. Therefore a conservative estimate assumes no reduced demand by 2020.

If it were not for the large projected increase in mercury demand for VCM, the total global demand for mercury would show a much greater decline between 2005 and 2015.

Of course, any projection of global mercury demand is subject to a large number of regulatory and other policy variables. Nevertheless, based on present information and trends, this is the best that can be done under the circumstances.

1.7 Combined global mercury supply and demand – BAU

Combining the above projections of mercury supply and demand, the “business-as-usual” scenario may be presented as in the following figure.

Global mercury demand and supply (tonnes) - "Business-as-usual" scenario

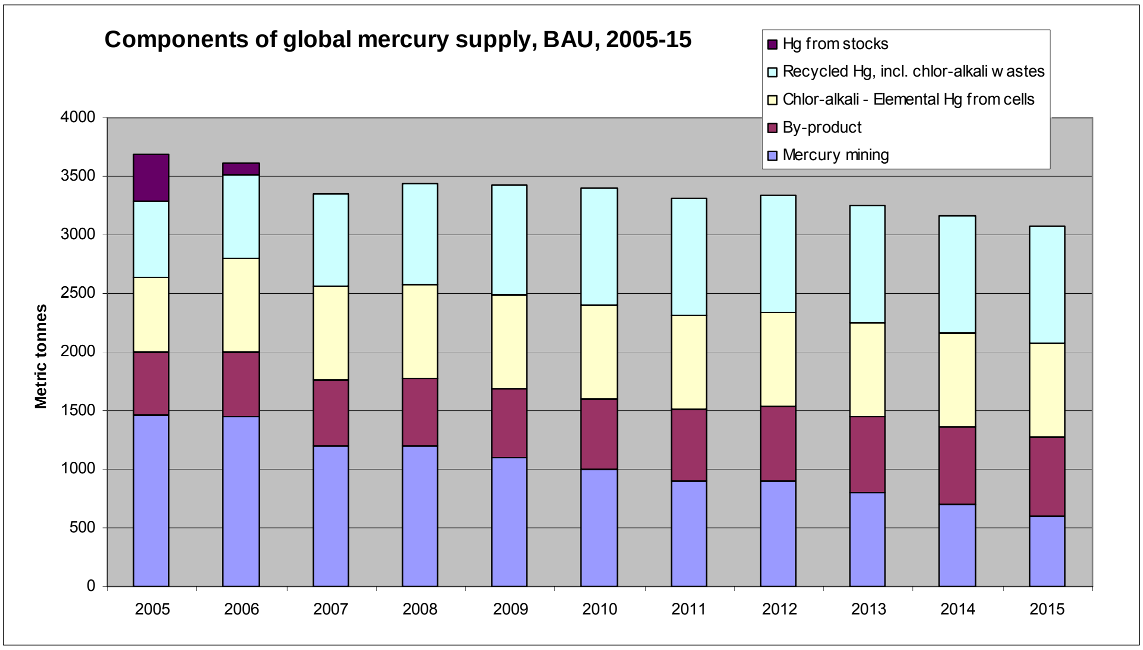
Global mercury demand - “Business-as-usual”											
(assumptions in bold - see text)	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
SS gold mining	**1000**	1000	1000	1000	1000	**1000**	970	940	910	880	850
Chlor-alkali	**619**	597	576	555	534	512	491	470	449	427	406
Batteries	**400**	380	360	340	320	300	280	260	240	220	200
Dental	**270**	270	270	270	270	270	270	270	270	270	270
Measuring & control	**150**	145	140	135	130	125	120	115	110	105	100
Lighting	**120**	120	120	120	120	120	120	120	120	120	120
Electrical & electronic	**140**	128	116	104	92	**80**	77	74	71	68	65
VCM	**700**	760	820	880	940	**1000**	1000	1000	1000	1000	1000
Other, laboratory, pharmaceutical, etc.	**40**	40	40	40	40	40	40	40	40	40	40
Total	**3439**	**3440**	**3442**	**3444**	**3446**	**3447**	**3368**	**3289**	**3210**	**3130**	**3051**
Global mercury supply - “Business-as-usual”											
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Mercury mining	**1465**	1450	1200	1200	1100	1000	900	900	800	700	600
By-product	**531**	546	560	575	590	604	619	633	648	662	677
Chlor-alkali - Elemental mercury from cells	**644**	**800**	800	800	800	800	800	800	800	800	800
Recycled mercury, incl. chlor-alkali wastes	**650**	720	790	860	930	**1000**	1000	1000	1000	1000	1000
Mercury from stocks	**400**	100	**0**	0	0	0	0	0	0	0	0
Total	**3690**	**3616**	**3350**	**3435**	**3420**	**3404**	**3319**	**3333**	**3248**	**3162**	**3077**

Supply-demand	252	175	-92	-9	-26	-43	-49	44	38	32	26
Cumulative	252	427	335	326	300	257	208	252	290	322	348

The BAU summary above shows an overall reduction in mercury demand of some 400 tonnes through 2015, which would be a reduction of 700 tonnes but for the increase in demand for VCM. The demand is met by increased recycling (esp. VCM catalyst), increased by-product recovery, and greatly reduced dedicated, primary mining.

Looking specifically at the sources of mercury for the BAU scenario during 2005-15 gives us the following graph, where it can be seen again that primary mercury mining plays a decreasing role in global mercury supply for the various reasons explained in the text. Recycled mercury is the major supply source, largely due to the amount of VCM catalyst recycled. Chlor-alkali sources are next, and could be larger if more mercury is recovered during decommissioning besides from the electrolytic cells. Finally, by-product mercury is also a key source of supply, and could also be larger if appropriate incentives are offered.

Any increases in these last three mercury sources would serve to further decrease the mercury needed from primary mining.



Despite the number of uncertainties inherent in the data available for this analysis, a sensitivity analysis of global mercury supply and demand would not add any important information to the above analysis. If mercury demand were somewhat higher than estimated, then primary mercury mining (mostly) would simply decrease less slowly than shown here.

According to the mercury demand and supply projections combined and presented above, the global mercury market shows a more or less “permanent” oversupply through 2015 and beyond. In such a case, of course, economic theory suggests that the various sources of supply will come into a rough balance with demand in order to maintain the market price of mercury, over time, at a level that reflects the average cost of supply plus a profit margin. It has been demonstrated in previous works (ECOS, 2001 and Maxson, 2004), however, that economic theory is not the only influence on a mercury market that is supplied not only by government-owned mines, but also by substantial supplies of mercury with a low (or even negative) value due to the fact that they were recycled from mercury wastes, etc., in order to meet regulatory requirements, or as an alternative to hazardous waste disposal.

Therefore, while one can reasonably predict that mercury demand and supply will come into balance, predictions of future mercury prices are more problematic.

1.8 Mercury market price 2005-2015 – BAU

The recent volatility of the market price for mercury has been discussed in a previous section. The supply of mercury became quite tight in 2004-5, and despite the fact that the Spanish and Algerian mines remained closed, mercury supplies appeared on the market (at over $20/kg) to bring supply and demand back into relative equilibrium during the first quarter of 2006, and the market price soon dropped back to about $15/kg. It may be assumed that mercury users are better attuned to the new higher price than in the past, and mercury suppliers may feel they can exercise more influence over a finely tuned market, but the increasing diversity of mercury supplies can only prove more difficult for market participants to manipulate.

While one should keep in mind that mercury markets are far from predictable, one could expect that with EU chlor-alkali mercury flooding onto the market until exports are banned, prices will continue falling to $10/kg or lower over the next year, and continue to fall to $5/kg (the price several years ago) if the large amounts of mercury from the chlor-alkali industry are not stored.

1.9 "Business-as-usual" scenario – EU-25 supply

Beyond the previous discussion of global mercury supply projections, there are some additional comments to make about projections of EU-25 mercury supply to 2015 or 2020.

With regard to the EU-25 chlor-alkali industry, 5.9 million tonnes chlorine capacity in 2005 will be reduced to an estimated 0.8 million tonnes chlorine capacity in 2020. This implies the availability of about 10,000 t mercury from the electrolytic cells over 15 years, for an average of about 667 t/yr.

With regard to other mercury sources in the EU-25, under the BAU scenario by-product mercury from zinc is expected to increase only modestly, and from other non-ferrous metals perhaps a bit more. On the other hand, as natural gas reserves in the North Sea decline, the recovery of mercury from that source is expected to decline as well. For all of these sources, the potential mercury that could be recovered separately is much higher, but under the BAU scenario there is no obvious incentive to do so.

Sources of recycled mercury may increase about 3% per year, so that overall, the EU-25 mercury supply is expected to be quite stable through 2015, as in the figure below.

1.10 "Business-as-usual" scenario – EU-25 demand

With regard to mercury demand in the EU-25, we may recall that some mercury products are imported and a few mercury products are exported, as explained above, but this will have little influence on the trends in demand for mercury. On the other hand, one should recall that EU-25 actual direct demand for mercury will likely be 20-40% less than "market" demand if we consider that mercury imported in products is not the same as EU-25 internal demand for elemental mercury (see discussion in Section1.2.3).

The projected mercury market demand (using conservative estimates) for individual classes of products, starting from the 2005 demand described in Section 1.2.3, is shown in the table below.

- Chlor-alkali reductions are in line with the assumptions described above.
- Actual EU-25 use of mercury in batteries is significantly below the "market" content of mercury in batteries shown below.
- Dental use of mercury will continue to decline overall in the EU-25.
- The proposed Directive on measuring & control equipment has a limited scope, but combined with other initiatives such as those promoted by Health Care Without Harm (HCWH), it is still expected to have a reasonable impact on mercury consumption by 2010, and somewhat less impact to 2015 and beyond.
- Actual EU-25 use of mercury in lamps is significantly below the "market" content of mercury in lamps shown below.

- The impact of the RoHS Directive is assumed to be significant within the EU-25, reducing the mercury content in electrical and electronic equipment to near zero by 2010.
- Despite an apparent misunderstanding in the report from Slovakia (2005), it is believed there are no plants in the EU-25 using a mercury catalyst to produce VCM.
- The HCWH programme is also expected to help reduce mercury demand for laboratory and pharmaceutical applications.

Overall, the EU-25 demand for mercury should decrease by about 50% from 2005-2015 under the BAU scenario.

1.11 Combined EU-25 mercury supply and demand – BAU

The supply and demand projections for the EU-25 under the “Business-as-usual” scenario are combined in the table below.

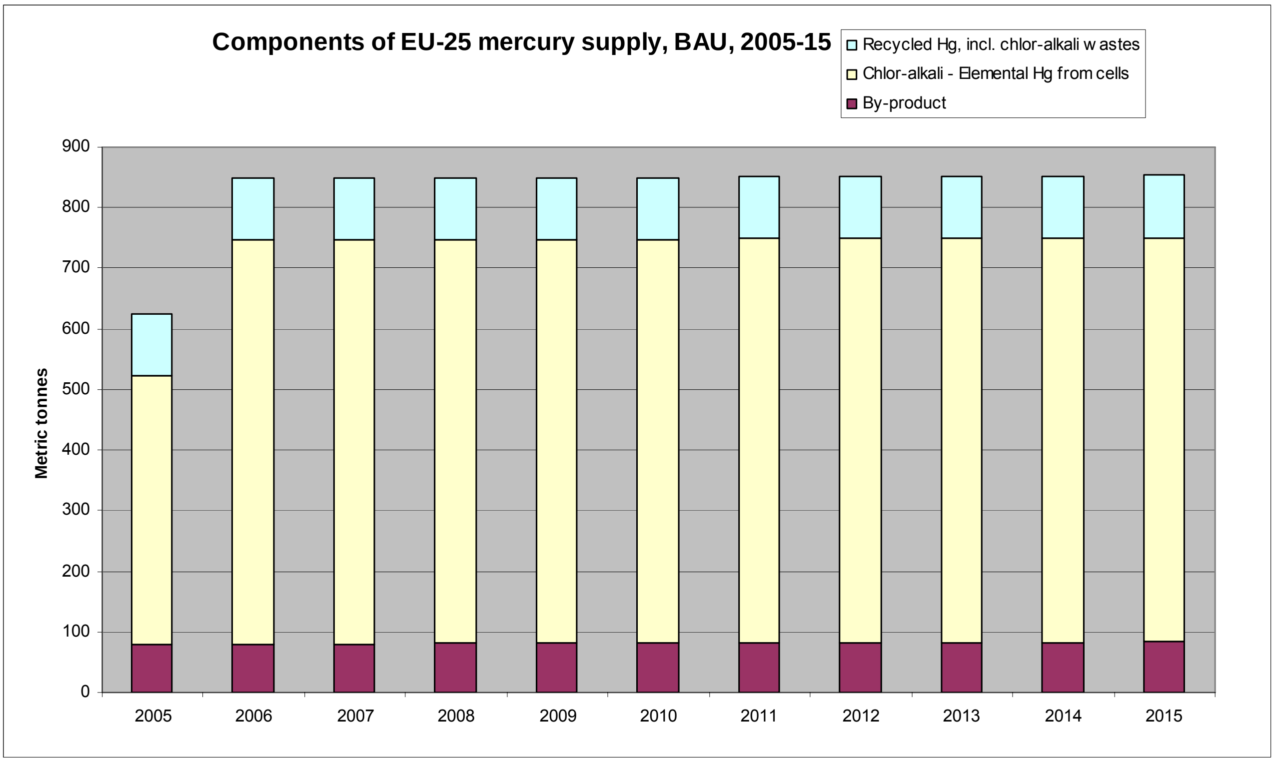
EU-25 mercury demand and supply (tonnes) - "Business-as-usual" scenario

EU-25 mercury demand - “Business-as-usual”											
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
(assumptions in bold - see text)											
SS gold mining	**5**	2	1	0	0	0	0	0	0	0	0
Chlor-alkali	**190**	179	168	157	146	135	124	113	102	91	80
Batteries	**20**	19	18	16	15	14	13	12	10	9	8
Dental	**90**	89	87	86	85	83	82	81	79	78	77
Measuring & control	**35**	32	29	26	23	**20**	19	18	17	16	15
Lighting	**35**	34	33	32	31	30	29	28	27	26	25
Electrical & electronic	**35**	28	21	14	7	**0**	0	0	0	0	0
VCM	**n.a.**	**n.a.**	**n.a.**	**n.a.**	**n.a.**	**n.a.**	**n.a.**	**n.a.**	**n.a.**	**n.a.**	**n.a.**
Other, laboratory, pharmaceutical, etc.	**30**	29	29	28	27	27	26	25	25	24	23
Total demand	**440**	**412**	**386**	**359**	**334**	**309**	**293**	**277**	**260**	**244**	**228**
EU-25 mercury supply - “Business-as-usual”											
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Mercury mining	**0**	0	0	0	0	0	0	0	0	0	0
By-product total includes:	**79**	80	80	80	81	81	82	82	82	83	83
By-product - zinc	**48**	49	50	50	51	52	53	54	54	55	56
By-product - other non-ferrous	**5**	6	7	8	9	10	11	12	13	14	15
By-product - natural gas	**26**	25	23	22	21	19	18	16	15	13	12
Chlor-alkali - Elemental mercury from cells	**444**	**667**	667	667	667	667	667	667	667	667	667
Recycled total includes:	**101**	101	101	102	102	102	102	102	103	103	103
Recycled mercury from chlor-alkali wastes	**32**	**30**	28	26	24	22	21	19	17	15	13
Other recycled mercury	**69**	71	73	76	78	80	82	84	86	88	90
Mercury from EU stocks	**0**	0	0	0	0	0	0	0	0	0	0
Total supply	**625**	**848**	**848**	**849**	**850**	**850**	**851**	**851**	**852**	**853**	**853**

Total supply - demand	185	436	463	490	515	541	558	575	592	608	625

By 2015, as seen in the table above, chlor-alkali demand for mercury in the EU should have decreased to a level similar to that of dental demand, while use of mercury in electric lamps (many of them probably imported) will be only a third of each of those.

Analyzing the sources of mercury within the EU-25 that are expected to supply EU-25 demand gives us the following figure, where it can be clearly seen that for the BAU scenario the phase-out of MCCAPs is the predominant source of supply, with recycled and by-product mercury far behind.



2 Impact of the EU mercury export ban

The intent of this section of the report is to:

- summarise the basic elements of the proposed mercury export ban.
- describe how the global supply and demand assessment above will be altered by an EU export ban that takes effect in Year 5 of the 10-year projection, e.g., show whether there will be an expected surplus/deficit of mercury during this period, and how the mercury price might respond to such a surplus/deficit.
- look closely at the EU-25 situation, and show where mercury supplies will come from, and assess whether there will be a mercury surplus within the EU.
- try to assess any significant changes in the above if mercury prices should change.

2.1 Brief overview of the proposed mercury export ban

As presently drafted, the mercury export ban and storage legislation focuses on the following key points:

- it deals only with elemental mercury;

- it implements a ban on mercury exports as of 2011 (or 2010, according to the preference of the European Parliament);
- it requires all chlor-alkali mercury not needed within the industry to go to long-term storage or disposal; and
- several years before the export ban, it implements tracking requirements for all movements of mercury and some compounds.

In terms of this analysis, the main thrust of the mercury "Export ban & storage" (EB&S) scenario is that as of 2011, all chlor-alkali mercury will have to remain within the EU. Therefore, the large EU surpluses evident in the BAU scenario will not be available to the rest of the world, and this analysis will show where mercury users may expect to find alternative sources.

2.2 "Export ban & storage" scenario – global supply

Compared to the "business-as-usual" scenario, the changes in the global mercury supply assumed to result from the proposed export ban are the following:

- As of 2011, mercury from decommissioned MCCAPs in the EU is available to supply the industry's needs within the EU, but the remaining mercury is removed from the market.
- Likewise, from 2011, any mercury recycled from chlor-alkali wastes in the EU is available to supply the industry's needs within the EU, but the remaining mercury is removed from the market.

2.3 "Export ban & storage" scenario – global demand

It is assumed that there will be no particular changes in mercury demand merely due to the proposed EU export ban. There may eventually be changes in demand if the mercury price changes significantly, but that is a separate issue from this assessment. Mercury price changes are discussed below.

2.4 Combined global mercury supply and demand – EB&S

The following summary table combines the above projections of global mercury supply and demand in response to the "Export ban & storage" scenario.

As can be seen in the table below, without mercury from the EU chlor-alkali industry, the non-EU mercury supply in 2011 is not sufficient to meet non-EU mercury demand. This condition may be expected to persist for 2-3 years.

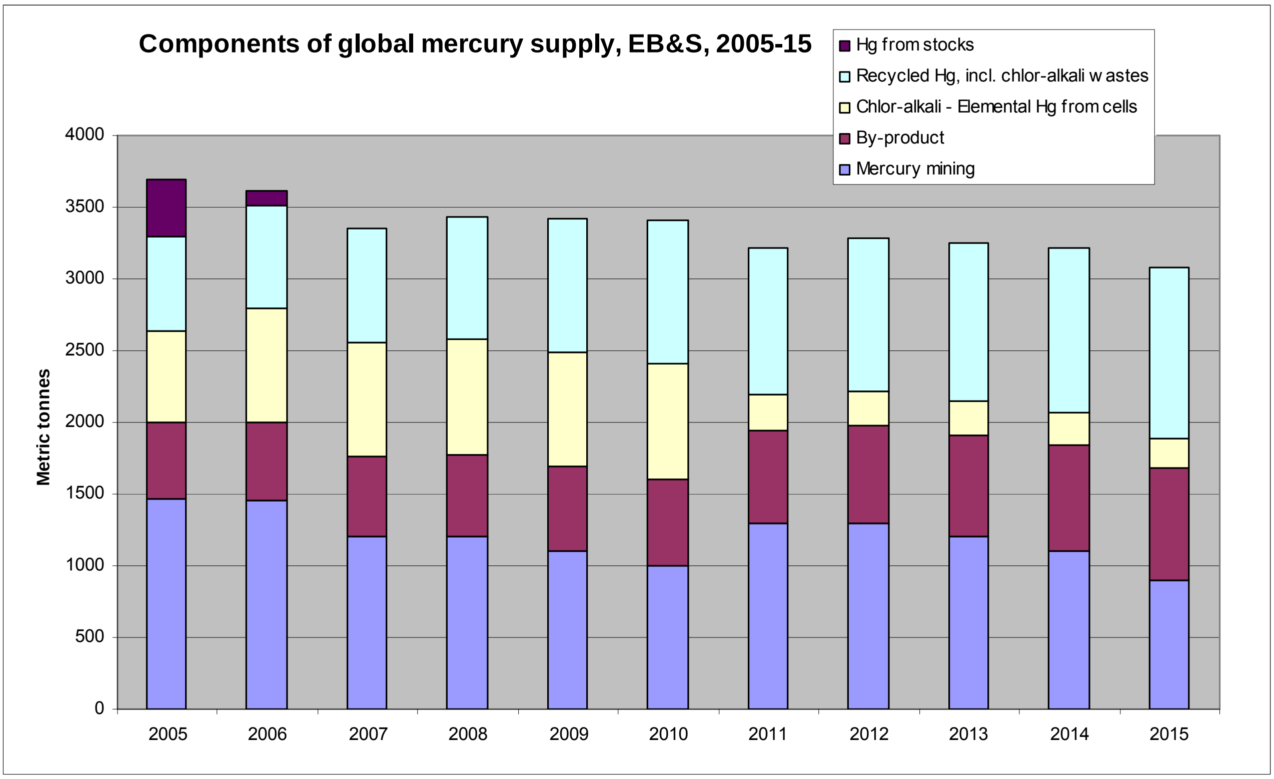
In response to the sudden (in 2011) global deficit in mercury supply, and the possible related rise in the market price of mercury, recycled, by-product and mined mercury could all play a role in meeting the short-term deficit. This would be logical, and is reflected in the table below. However, the reality may be rather different, as explained following the "Components of global mercury supply" graph below.

Global mercury demand and supply (tonnes) - "Export ban & storage" scenario

Global mercury demand - "Export ban & storage"											
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
(assumptions in bold - see text)											
SS gold mining	**1000**	1000	1000	1000	1000	**1000**	970	940	910	880	850
Chlor-alkali	**619**	597	576	555	534	512	491	470	449	427	406
Batteries	**400**	380	360	340	320	300	280	260	240	220	200
Dental	**270**	270	270	270	270	270	270	270	270	270	270
Measuring & control	**150**	145	140	135	130	125	120	115	110	105	100
Lighting	**120**	120	120	120	120	120	120	120	120	120	120
Electrical & electronic	**140**	128	116	104	92	**80**	77	74	71	68	65
VCM	**700**	760	820	880	940	**1000**	1000	1000	1000	1000	1000
Other, laboratory, pharmaceutical, etc.	**40**	40	40	40	40	40	40	40	40	40	40
Total	**3439**	**3440**	**3442**	**3444**	**3446**	**3447**	**3368**	**3289**	**3210**	**3130**	**3051**
Global mercury supply - "Export ban & storage"											
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Mercury mining	**1465**	1450	1200	1200	1100	1000	1300	1300	1200	1100	900
By-product	**531**	546	560	575	590	604	639	673	708	742	777
Chlor-alkali - Elemental mercury from cells	**644**	**800**	**800**	**800**	**800**	**800**	257	246	235	224	213
Recycled mercury, incl. chlor-alkali wastes	**650**	720	790	860	930	1000	1019	1061	1103	1145	1187
Mercury from stocks	**400**	100	0	0	0	0	0	0	0	0	0
Total	**3690**	**3616**	**3350**	**3435**	**3420**	**3404**	**3215**	**3280**	**3246**	**3211**	**3077**

Supply-demand	252	175	-92	-9	-26	-43	-153	-8	36	81	26
Cumulative	252	427	335	326	300	257	104	95	132	212	238

A summary of the global sources of mercury that are assumed in this table to satisfy global demand gives us the following figure, where it can be clearly seen that for the EB&S scenario, recycled, by-product and mined mercury <u>may</u> logically all play a role.



2.4.1 Global mercury supply – EB&S scenario vs. BAU scenario

In the EB&S scenario, from 2011, not surprisingly, other sources of mercury will be needed to provide the supply that will no longer be available from the EU chlor-alkali industry. When the mercury supply grows tight, experience shows that the market price for mercury will soon rise. The low-cost sources that could respond rapidly include recycled and by-product mercury – for example, more VCM catalyst recycled, more by-product mercury recovered from zinc or natural gas wastes, etc. Referring back to the discussion of Section 1.1.7.2, recycling is presently no more than 25% of the waste stream globally, even if one accepts that VCM recycling in China approaches 50%.

However, recyclers and by-product mercury producers do not typically see their business as selling mercury, but rather as avoiding mercury waste. Therefore, they may not respond as rapidly to (increased) price signals as a primary mercury producer, for example. But let us assume, as an alternative, that recycling could readily recover 200 tonnes more (than estimated in the BAU scenario) by 2015. And let us assume that by-product mercury, which now recovers less than 10% of the global by-product mercury waste stream, could also provide 200 tonnes more mercury by 2020. Even under these assumptions, compared to the BAU scenario,[25] there would be a short-term supply deficit between about 2011 and 2013. After 2013, a supply-demand balance would be re-established.

While the summary table above assumes a temporary increase in the primary (mined) mercury supply to fill any such deficit, these observations invite two more attractive

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[25] Note that due to the large quantities of chlor-alkali mercury available from the EU, the BAU scenario assumes a serious reduction (<500 tonnes) in mercury mining between 2005 and 2011. It is only because the EB&S scenario retains that estimate of such a large decline in mercury mining that, when suddenly the chlor-alkali mercury is removed from the market, there is a short-term mercury scarcity.

alternatives that would entirely avoid the need to briefly increase mined mercury (compared to the BAU scenario):

1. The first is to take measures to encourage the expansion of by-product and recycled mercury sources before the implementation of the EU mercury export ban, so that the extra mercury supply will be available to global markets when the EU supply is cut off.
2. The second is to gradually reduce, during the years prior to 2011, the quantity of EU mercury that may be exported, rather than to ban exports suddenly in 2011.

Neither of these options may be necessary, however, if, prior to the export ban, mercury brokers (or others) build adequate stocks to satisfy global demand during the several years just after 2011! Brokers may have plans already to keep such stocks outside the EU. Alternatively, chlor-alkali mercury sent to temporary storage inside the EU could remain exceptionally available for such a purpose during a limited number of years.

It must be kept in mind that there are significant uncertainties associated with many of the numbers in the previous analysis, especially the forecasts, as discussed in the text. A typical sensitivity analysis would assume lower mercury supply than suggested here, and in combination or separately, higher mercury demand. These alternative assumptions would simply make the mercury supply deficit immediately after 2011 deeper, and/or lasting for several more years. However, even the “worst-case” feasible alternative assumptions would not create a mercury deficit that would not be perfectly well handled with a bit of advance planning, such as that suggested above with regard to mercury stocks.

2.5 Mercury market price 2005-2015 – EB&S

As discussed above, while one should keep in mind that mercury markets are far from predictable, one could expect that with EU chlor-alkali mercury flooding onto the market until exports are banned, prices will continue falling to $10/kg or lower over the next year, and stay there until EU mercury exports are cut off. After the export ban, with great confidence in suppliers’ ability to plan ahead, as suggested above, one could assume there will be quite adequate mercury stocks set aside to accommodate mercury demand during the several years just following the mercury export ban. If so, apart from any psychological shock to the market in 2011, prices would likely change little, at least through 2015, probably maintaining a level of close to $10/kg in constant dollars.

2.6 “Export ban & storage” scenario – EU-25 supply

Within the EU-25, under the EB&S scenario, all mercury produced within the chlor-alkali industry (667 tonnes of mercury per year from decommissioned MCCAPs, plus some mercury from recycled wastes) but not needed by the industry would go to storage or disposal as of 2011. The changes from the BAU scenario are shown in the summary table below. Therefore, EU-25 supply would consist only of (non-chlor-alkali) recycled mercury and by-product mercury from non-ferrous metals and natural gas cleaning.

2.7 “Export ban & storage” scenario – EU-25 demand

With regard to EU-25 mercury demand, all of the assumptions are the same as in the BAU scenario. Since chlor-alkali demand from 2011 to 2020 will be supplied from within the industry, one can effectively separate the chlorine industry from the rest of the EU supply and demand balance.

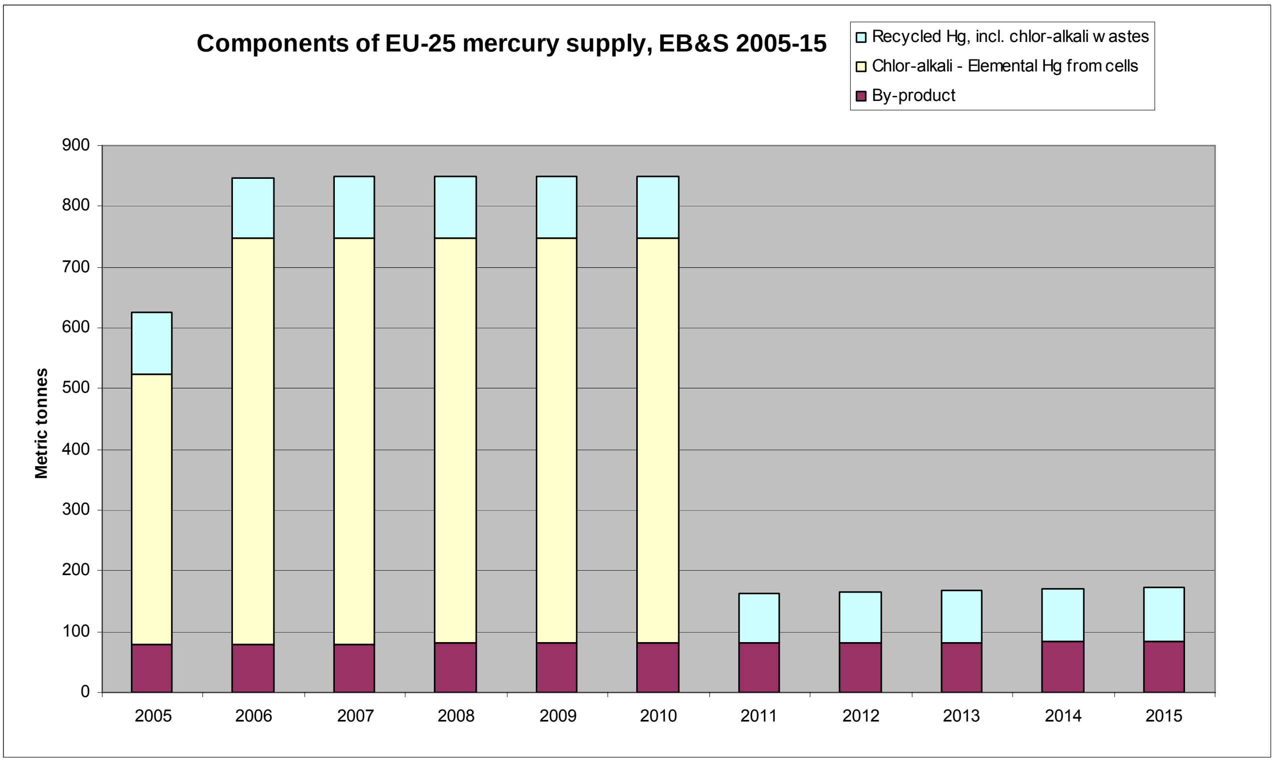
2.8 Combined EU-25 mercury supply and demand – EB&S

The combined mercury supply and demand projections for the EU-25 under the EB&S scenario are presented in the following table.

EU-25 mercury demand and supply (tonnes) - "Export ban & storage" scenario

EU-25 mercury demand - "Export ban & storage"											
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
(assumptions in bold - see text)											
SS gold mining	**5**	2	1	0	0	0	0	0	0	0	0
Chlor-alkali	**190**	179	168	157	146	135	0	0	0	0	0
Batteries	**20**	19	18	16	15	14	13	12	10	9	8
Dental	**90**	89	87	86	85	83	82	81	79	78	77
Measuring & control	**35**	32	29	26	23	**20**	19	18	17	16	15
Lighting	**35**	34	33	32	31	30	29	28	27	26	25
Electrical & electronic	**35**	28	21	14	7	**0**	0	0	0	0	0
VCM	**n.a.**	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Other, laboratory, pharmaceutical, etc.	**30**	29	29	28	27	27	26	25	25	24	23
Total demand	**440**	**412**	**386**	**359**	**334**	**309**	**169**	**164**	**158**	**153**	**148**
EU-25 mercury supply - "Export ban & storage"											
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Mercury mining	**0**	0	0	0	0	0	0	0	0	0	0
By-product total includes:	**79**	80	80	80	81	81	82	82	82	83	83
By-product - zinc	**48**	49	50	50	51	52	53	54	54	55	56
By-product - other non-ferrous	**5**	6	7	8	9	10	11	12	13	14	15
By-product - natural gas	**26**	25	23	22	21	19	18	16	15	13	12
Chlor-alkali - Elemental mercury from cells	**444**	**667**	667	667	667	667	0	0	0	0	0
Recycled total includes:	**101**	101	101	102	102	102	82	84	86	88	90
Recycled mercury from chlor-alkali wastes	**32**	**30**	28	26	24	22	0	0	0	0	0
Other recycled mercury	**69**	71	73	76	78	80	82	84	86	88	90
Mercury from EU stocks	**0**	0	0	0	0	0	0	0	0	0	0
Total supply	**625**	**848**	**848**	**849**	**850**	**850**	**163**	**166**	**168**	**170**	**173**
Total supply - demand	185	436	463	490	515	541	-6	2	10	17	25

The main sources of mercury supply for the EU-25 under the EB&S scenario are shown graphically below.



2.8.1 EB&S scenario compared to the BAU scenario

It may be seen that prior to the export ban, the EU-25 has a great excess of mercury supply that has in the past been sent to all parts of the world.

It can also be seen that the EU-25 under the EB&S scenario, in all likelihood, will still have adequate resources to meet its own needs. This is even more likely if one recalls (see Sections 1.2.1 and 1.2.3) that the EU-25 "direct" demand for (elemental) mercury will be 20-40% smaller than the “market” demand used in the projections. In the unlikely event that post-2011 mercury demand in the EU may exceed the EU mercury supply temporarily, one could resort to a solution such as that suggested in Section 2.4.1 above, in which a stock of “surplus” mercury accumulated prior to 2011 could be drawn down to meet any temporary urgent needs.

2.9 Impact on mercury trade

In the past, most EU exports of mercury have been handled by MAYASA from Almadén, and by Lambert Metals, whose main office is in London, who has storage facilities in Antwerp and in Rotterdam, and who maintains offices, etc., in various other parts of the world. MAYASA has started to turn some of its attentions to longer-term mercury storage, anticipating the time when it will no longer be permitted to export mercury. However, both MAYASA and Lambert have networks all over the world, could easily move stocks of mercury outside the EU before the export ban takes effect, and after the ban is in place, would have no problem making deals inside the EU to move mercury that could by then be physically located outside the EU.

It may be assumed that if MAYASA is able to establish itself in the business of storing and/or disposing of mercury, it will eventually get out of the mercury trading business. It has been preparing to get out of the mercury trading business for some time, so will not be financially hurt by the export ban any more than already anticipated. As for Lambert Metals, it may maintain its trading operations in the EU after 2011, while physically storing its mercury stocks outside the EU. The mercury export ban will cause Lambert to rethink some of its operations, but will not impose any significant financial hardship, especially as it has five years to prepare for the change.

3 Other relevant issues

The intent of Section 3 is to address any further issues that may be relevant to the implementation of an EU mercury export ban and storage requirement. In particular, three issues that have not been discussed in detail above include:

- the possibility of an increase in primary mercury mining due either to an increase in the market price of mercury, or due to a supply shortfall at such time as EU mercury is no longer available to the international market.
- a discussion of whether mercury storage legislation accompanying a mercury export ban should strive for a surplus or a deficit in the internal EU supply of mercury, assuming that a perfect balance between supply and demand would be impossible to achieve.
- any new information related to mercury storage – temporary surface storage or permanent underground storage – that could add to the ongoing debate, such as key issues and possible costs.

3.1 High mercury price and new mining

For many years the EU has produced 20-30% of the world supply of mercury. It has occasionally been argued that closing Almadén, or eliminating chlor-alkali mercury from the world or EU markets would create a supply deficit, and would lead to a substantial increase in the mercury price, which in turn would encourage new mercury mining (or higher mercury emissions from alternative mercury sources) outside the EU.

This concern must first be separated into two parts: a) that tight mercury supplies lead to higher prices, which has recently been demonstrated, and which many consider a positive development that helps to dampen demand; and b) that higher mercury prices may encourage increased mercury mining.

With regard to the second concern, it may be pointed out that mercury prices have been relatively high for nearly two years due to a tightening of mercury supplies in 2004. Primary (mined) mercury production has halted in both Spain (in 2003) and Algeria (in 2004). As mentioned in the Mercury Strategy ExIA (2005), the Kyrgyz Republic appears to be operating at capacity. It has difficulty producing more than 600 tonnes per year at its mine, and has often produced less as it encounters technical problems, difficulty getting spare parts, etc. Alternatively, it has been refining mine concentrates from Russia, but this is by-product mercury, not primary mercury.

The only country for which there could now be some risk of adding to global supplies through mining is China, which has in fact increased domestic mine production in recent years, but for the key reason that Chinese imports have been restricted since 2003 in an attempt to dampen domestic demand. NRDC (2006) has recently confirmed that virtually all of China's mercury production is (and has long been) for domestic consumption, and thus not traded globally. NRDC (2006) has further noted that behind its import restrictions, China has increased domestic production of mercury in recent years primarily to satisfy increasing demand from domestic VCM producers.

Therefore, as the global mercury supply that used to come from primary mining has declined by about 600 tonnes/yr net since 2002, and global demand has not much changed, the supply has been made up by increased recycling, by-product and chlor-alkali mercury (as well as the mysterious "stocks" that appeared in 2005 from the FSU) rather than new mining. Especially in a climate of higher hazardous waste disposal costs (and stricter regulations on emissions) than in the past, the recovery of mercury as a by-product of other mining activities may already be higher than it has been in the past.

In fact, the supply of mercury from sources other than mining makes general socio-economic sense as well. All of these alternative (non-mining) sources of mercury occur in response to environmental pressures, regulations, efforts to reduce legal liability, customer requirements for a product without significant traces of mercury, the economic realities of waste disposal, etc. These are much more like mercury <u>disposal</u> options than mercury <u>supply</u> options, and therefore deliver mercury to the market at a generally much lower economic cost.

3.2 How much of the EU mercury supply should be stored?

One key question that needs to be addressed with regard to the proposed mercury export ban is, following the implementation of the ban, how much of the expected mercury supply should be stored, and how should such a determination be made? The following discussion addresses a number of relevant points, through which it should be remembered that any mercury supply vs. demand imbalance is only temporary, but may cause disruptions nonetheless during that period, especially in a semi-closed market such as that anticipated after the EU export ban is in place.

<u>If the EU does not store enough mercury</u>, and there is an excess of mercury supply compared to demand within the EU:

- the EU price for mercury will drop; it may drop below the world mercury price, since the only mechanism to raise it is to make mercury more scarce. There are no sectors or uses (other than arbitrary accumulation of stocks) where one would expect EU mercury demand to expand to soak up excess mercury supply.
- At a low EU mercury price, and in the absence of specific legislation, it is more likely that mercury wastes will go directly to disposal rather than via recyclers.
- If the imbalance between excess supply and demand is too great, some recyclers could be hurt since there may never be sufficient EU demand to justify their previous level of mercury output.
- In this manner, the EU mercury supply will contract until such time as the supply returns to a rough equilibrium with demand, at which point the EU mercury price will rise again to the level of the world mercury price. It will not rise above the world price because, at that level, imported mercury will enter the EU to meet any excess demand.

- Therefore, if “too little” mercury is stored and an EU excess supply results, we could anticipate a generally depressed EU mercury price, and some possible economic hardship, until such time as the EU mercury supply sources come into rough balance with EU demand.

On the other hand, if the EU stores too much mercury, and there is not enough mercury supply remaining to meet demand within the EU:

- The EU price for mercury will quickly attain the same level as the price of imported mercury, and mercury will be imported to fill any gap; i.e., the EU mercury price will be maintained at the same level as the world mercury price.
- Any mercury recycling operations within the EU that are economically viable, compared with alternative mercury sources, will start up and/or continue in operation, in a manner that in no way disrupts the free market.
- Likewise, any other mercury sources within the EU will be stimulated to produce, to the extent they are competitive with external mercury sources.
- If the imbalance between limited EU mercury supply and normal EU demand is substantial, more mercury will be imported and no economic harm will be felt.
- Therefore, if “too much” mercury is stored, mercury supplies will be imported in the near term at world prices, as EU recyclers or other sources are stimulated to supply mercury as they can at the same price level.
- If the EU is obliged to import mercury, it would surely come from a source where emissions associated with its “production” are higher than if EU (chlor-alkali) mercury were available.

While both situations of mercury excess or mercury scarcity will rather quickly find a new market equilibrium, the EU would clearly prefer to create a situation of moderately tight mercury supply (and generally higher mercury price) rather than excess mercury supply (and generally lower mercury price).

Meanwhile, if any party attempts to stimulate the EU mercury market price by buying up EU mercury supplies, imported mercury will simply flow into the EU to keep the EU price no higher than the world price.

Likewise, if any party maintains stocks of mercury within the EU, the stocks will never be worth more than the world mercury market price.

When the EU mercury market is in equilibrium and world mercury prices move up or down, the EU mercury price will move up or down as well, as at present. A longer period of low world mercury prices could bring some economic hardship to EU recyclers, but that is not much different from the present free-market situation.

It is useful to note that, after the implementation of an EU mercury export ban, the fact of keeping the EU open to mercury imports permits the EU mercury economy to react in a very similar manner to a free market situation.

After the export ban, if mercury waste is recycled and mercury is recovered, it could be offered on the EU market at a lower price than the world market price. But this would also influence the world price, which needs to reflect what customers are willing to pay, after considering the available options. And one option for EU mercury users will always be imported mercury. For mercury sources within the EU, there are only two options –

undercut the price asked by external mercury suppliers, or send your mercury for storage or disposal.

EU recyclers presently sell to a variety of customers. Closing down EU exports of mercury will cut off access of EU suppliers to all non-EU customers. With regard to limiting (by banning exports from the EU) the number of potential buyers for recycled mercury, it is useful to consider the following comment by a recycler:

> *"The mercury recycling industry does not make money on the resale of the recovered metal. The money is made up front as a charge to process hazardous waste that happens to contain mercury. Outside of caustic soda, the volumes of mercury recovered are very low. If the industry were forced to landfill or put mercury into storage, there would be little effect on the operations."*

In any case, the relevant mercury export ban and storage legislation must remain flexible enough to respond to any unforeseen imbalances, e.g., through modifications to the mercury storage requirements.

3.3 Mercury storage & disposal options

Under Action 9 of the Community Strategy on Mercury:

> *"The Commission will take action to pursue the storage of mercury from the chlor-alkali industry, according to a timetable consistent with the intended phase-out of mercury exports by 2011. In the first instance the Commission will explore the scope for an agreement with industry."*

The purpose of this section is to raise the main issues and options involved in storage/disposal of mercury, which will highlight some of the main advantages and disadvantages, and to review some cost estimates presented in different sources. The ability of the author to treat this subject in full detail is not possible within the scope of this study, but this section is intended to provide a useful framework and background information for the various discussions of mercury storage and disposal that have already been initiated, and will continue through 2006.[26]

3.3.1 Main issues

The main issues that must be considered with regard to storage and disposal may be grouped in several categories.

I. Scope of Storage – elemental mercury

  A. Chlor-alkali mercury from decommissioned plants is clearly covered.
  B. Mercury from wastes, used products, compounds clearly not covered
  C. By-product mercury
  D. Is there a need for a hierarchy of sources in case more mercury needs to be stored?

II. Storage Infrastructure

  A. Is there a centralized storage facility for the EU, or multiple regional/national facilities?
  B. If there is not one centralized facility, how many are needed and who decides?

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[26] Note especially the European Commission sponsored international mercury conference to be held on 26/27 October 2006 in Brussels with significant non-EU participation.

C. If there is one centralized facility, where is it and who decides?
D. Is it possible, and/or how important is it, to foster competition among different disposal facilities?
E. What if one facility is for temporary storage and the other is for permanent disposal, and the costs are vastly different? Why would any industry opt for the more expensive?
F. Is there any advantage in the selection of a site that is already contaminated with mercury, e.g. abandoned mercury mines, where it could be argued that additional mercury burden from mercury storage will be minimal, as compared to a mercury-free site, e.g. salt mines, that are not yet contaminated with mercury?

III. Storage Means

A. Is it temporary, semi-permanent, or permanent? How retrievable should the mercury be?
B. What management standards apply to the storage?
C. What related legislation may need to be adapted?
D. Are there mechanisms for removing mercury from storage if needed to satisfy EU demand? What conditions trigger mercury removal from storage, what are the mechanisms for making the requisite findings, and who makes the decisions?
E. Are emergency procedures necessary?
F. What sort of impact assessment must be carried out, and who decides whether it is acceptable?

IV. Responsibility for Storage

A. Who pays for the storage?
B. Who operates the storage?
C. Who fixes the standards that must be met, and who ensures the facility or facilities are operated consistent with such standards? Is there a need for a technical board of overseers, or periodic evaluation reports? Is there a role for non-governmental stakeholders on such a body? What happens if the facility or facilities are found to be violating their operating permit? Is there a mechanism by which a member state or the EU takes over control of a facility in case of bankruptcy or failure to maintain standards?
D. At what point do the mercury generators remove themselves of any liability for the mercury they store/dispose?

3.3.2 Cost indications

A number of documents are referenced below, with indicative costs of mercury storage, treatment and/or disposal. As a body of work they are quite interesting, but for comparative purposes they are of little use since the assumptions and qualifications are so varied from one report to the next. Nevertheless, they provide a general framework for the costs that must be expected from a range of mercury management options.

It is useful to note that the costs cited have relatively little connection with the volume of mercury to be stored or disposed of. Most of the cost is related to the development of the site and facility, unless there are pre-disposal mercury treatment costs, which are directly related to the volume of waste treated, and may be quite significant.

3.3.2.1 SRIC report

SRIC (2005) cited an unnamed source that estimated “permanent storage” of MCCAP mercury in the EU will cost about 1.5 million euro/year. Assuming about 15,000 tonnes of mercury to be recovered from MCCAPs, the authors calculated the equivalent of about €100/tonne/yr for mercury stored.

3.3.2.2 Swedish EPA report

The Swedish EPA report estimated the cost of a deep bedrock repository having a capacity of about 1,000 – 20,000 tonnes of high-level mercury waste to be about SEK 200 – 300 million. This represents a cost of approximately SEK 250,000 – 650,000 per tonne of pure mercury. (The higher figure represents storage of mixed waste such as process waste containing 1 – 10 per cent mercury.) A large proportion of the cost will be the fixed cost of preparing the shaft and blasting access and storage tunnels. The actual volume of the repository will only have a marginal effect on the overall cost, perhaps less than 20 percent. It thus follows that significant savings can be made if the companies involved can work together to achieve a joint storage facility. The cost of storing waste at a Class 1 surface facility is about SEK 1,300 per tonne of waste, i.e., about SEK 15 million for 10,000 tonnes. Hence, a deep bedrock repository will be about 15 times more expensive than a surface facility.

In addition to the cost of the repository itself, there will be the cost of any processing and stabilisation. These depend very much on the type of waste and desired end product. The consultants' report suggests that the cost will typically be SEK 10 – 20 per kilo, although it may be as much as SEK 100 per kilo for certain types of waste and treatment methods. This means that the cost of processing and stabilising Swedish waste containing mercury concentrations over one per cent (approx. 15,000 tonnes) will be about the same as the cost of the repository itself. It should be noted that approximately the same costs may be expected for processing and stabilising waste stored in a surface or shallow repository. Thus, bearing in mind the costs involved here, there are compelling reasons for finding optimal solutions for the entire chain of processing → stabilisation → final storage so as to keep costs down while still meeting safety requirements. Responsibility for finding optimal solutions of this kind rests with the waste owners (Swedish EPA, 2003).

3.3.2.3 SAKAB – Svensson thesis

As this thesis (Svensson, 2005) reminds us, the owners of mercury waste (>1% mercury content) in Sweden are responsible for finding ways to convert the mercury waste to insoluble forms.

The aim of this thesis was to investigate different low-cost immobilization methods for mercury. Choice of treatment method depends on the nature of the waste, such as the mercury concentration and matrix constituents. High-contaminated waste would be suitable to transform to chemically insoluble mercury forms, while low-contaminated wastes would be suitable to treat with an encapsulation method. The investigations assessed conditions favourable for the formation of mercury sulphide at room temperature from elemental mercury as well as from mercury oxide.

The stabilization/solidification (S/S) method was estimated as a suitable treatment method for low contaminated mercury waste.

The SAKAB study did not estimate costs, but confirmed that a range of treatment options are available.

3.3.2.4 Euro Chlor storage proposal

Euro Chlor's draft mercury storage proposal seeks a "definitive and permanent disposal solution," under the stated assumption that permanent disposal of liquid mercury is preferred from a safety point of view:

"The preferred storage facilities that will be used are geologically stable underground salt mines that are classified and authorized for the disposal of hazardous wastes under Council Decision 2003/33/EC and Directive 1999/31."

The draft goes on to state:

"Other facilities, namely warehouse storage [facilities] that are classified and authorized for the disposal of hazardous wastes under Council Decision 2003/33/EC and Directive 1999/31 and national regulatory requirements, may be evaluated for storage on a case-by-case basis, e.g. Minas de Almadén as suggested by the European Parliament."

Euro Chlor has mentioned to the author[27] that the Germans have an impressive long-term risk assessment concerning underground waste disposal that has recently been updated (to include storage of liquid mercury??).

3.3.2.5 US DNSC report

Contrary to the above suggestion by Euro Chlor that underground disposal of liquid mercury can be done without significant risk, the DNSC (2003) report stated:

"Based on the immaturity of… technologies and the lack of a U.S. EPA approved path forward, bulk treatment and disposal of elemental mercury is not considered viable at this time, and is not evaluated in detail in the Draft EIS."

Responding to concerns about warehouse storage and the possibility that the storage facilities might be neglected or damaged in the future, "the risks related to warehouse storage were assessed for a 40-year period, and the assessments concluded that the risks are negligible."

In the U.S. DNSC Federal Register Statement, the U.S. EPA expressed its concerns regarding bulk treatment of elemental mercury:

- Difficulty in getting elemental mercury to react with reagents, resulting in a heterogeneous waste form [refer to details of report for explanation]
- Leachate data can't determine efficacy of treatment
- Test conditions are NOT worst case, more aggressive conditions could leach more
- Treatment results in large volume waste increases
- Additional barriers would be necessary to inhibit leachate [releases] (e.g. macro-encapsulation)

Their preferred alternative was consolidated storage for the following reasons:

- Safe long-term management
- Environmental/health risks are "negligible" to "low"
- Economies of scale
- Consistent with business plans

Regarding relevant storage & consolidation costs, they suggested:

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[27] As confirmed by Dr. Seys during a meeting including Maxson, Andersson and Debelle, 24 May 2006.

- One-time: Facility upgrade estimated to cost $2.5 million
- One-time: Over-packing costs—$1.53 million (approx. $12/flask), including a) 128,662 mercury flasks (4436 tonnes) and b) 21,444 thirty-gallon drums (6 flasks per drum)
- One-time: Floor sealing—$4-5 per square foot, i.e., about $1 million
- One-time: Transportation costs (300 trucks * approx. 15 tonnes mercury/truck)
- Annual mercury storage costs— $1.08 million per year, based on 200,000 square-foot (approx. 20,000 sq. m.) storage facility

As shown in the following table, the overall average cost of consolidated surface storage of 4436 tonnes of mercury for 40 years was estimated at a present value of about $45 million, or about $10,000/tonne of mercury, or about $250/tonne/yr.

Summary costs of surface storage alternatives over 40 years

Alternatives	**Present value ($US million)**
No Action	30.0
Consolidated Storage	
New Haven Dept	20.7
Somerville Depot	46.9
Warren Depot	21.8
Hawthorne Army Depot	62.2
PEZ Lake Development	62.4
Utah Industrial Depot	62.4

3.3.2.6 SAIC report

The SAIC (2005) report later referred to the DNSC (2003) report and other sources:

“Currently, the most prevalent method is to store the elemental, liquid [mercury] in flasks and stockpile them in warehouses. The risks associated with this method of storing elemental mercury have been extensively discussed in the *Final Mercury Management Environmental Impact Statement* (DLA 2004).”

“Independently of DLA, EPA’s Offices of Research and Development (ORD) and Solid Waste (OSW) have been working with DOE to evaluate technologies for permanently stabilizing and disposing of wastes containing mercury (e.g., DOE 1999a-1999e; USEPA 2001, 2002a,b). Other comprehensive studies carried out in the recent past include one by SENES Consultants (SENES 2001) who produced a draft report for Environment Canada evaluating 67 technologies for the retirement and long-term storage of mercury. In addition, OSW is considering revisions to the Land Disposal Restrictions (LDRs) for mercury. Land disposal of hazardous wastes containing greater than 260 mg/kg mercury is currently prohibited. OSW has pursued options which would allow land disposal of waste containing greater than 260 mg/kg mercury; however, no specific revisions are forthcoming.”

"Using the above-referenced work as a starting point, EPA prepared report EPA/600/R-03/048, *Preliminary Analysis of Alternatives for the Long-Term Management of Excess Mercury* (USEPA 2002c). USEPA (2002c) Appendix B provides a concise review of the SENES 2001 mercury treatment technologies and why certain treatment technologies were not selected by the USEPA for further analysis. The purpose of the [SAIC] work is the logical next step, which is to focus on just a few of the alternatives considered in EPA/600/R-03/048. This allows a more detailed breakdown and analysis of the stabilization/amalgamation alternatives than was possible in EPA/600/R-03/048, and also allows more effort to be applied to developing cost information."

Drawn from a great range of options assessed, SAIC (2005) concluded that final disposal of approximately 12,000 tonnes of liquid mercury in an environmentally preferable manner, comprising a mobile treatment facility, followed by macro-encapsulation, with ultimate disposal in a monofill, would cost $6-16/kg elemental mercury, depending on the treatment process, etc.

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Annex 1

Mercury Cell Chlor-Alkali Plants in Western Europe as of January 2005

Country	Company	Site	Chlorine capacity (thousand tonnes)	MCCAPS in 1990
BELGIUM	SolVin	Antwerp (Lillo)	330	4
	Tessenderlo Chemie	Tessenderlo	250	
CZECH REPUBLIC	Spolana	Neratovice	135	2
	Spolchemie	Usti	61	
FINLAND	Akzo Nobel	Oulu	43	4
FRANCE	Albemarle	Thann	72	8
	Arkema	Jarrie	170	
	Arkema	Lavera	166	
	Arkema	Saint Auban	184	
	Prod. Chim. d'Harbonnières	Harbonnières	23	
	Solvay	Tavaux	241	
	Tessenderlo Chemie	Loos	18	
GERMANY	BASF	Ludwigshafen	160	17
	Bayer	Uerdingen	110	
	Vinnolit	Knapsack	120	
	Akzo Nobel	Ibbenbüren	125	
	Degussa	Lülsdorf	136	
	Ineos Chlor	Wilhelmshaven	149	
	LII Europe	Frankfurt	167	
	Vestolit	Marl	176	
	Vinnolit	Gendorf	82	
GREECE	Hellenic Petroleum	Thessaloniki	40	1
HUNGARY	BorsodChem	Kazincbarcika	137	3
ITALY	Altair Chimica	Volterra	27	13
	Solvay Ausimont	Bussi	87	
	Caffarro	Toreviscosa	68	
	Syndial	Porto Marghera	200	
	Syndial	Priolo	204	
	Eredi Zarelli	Picinisco	6	
	Solvay	Rosignano	125	
	Tessenderlo Chemie	Pieve Vergonte	42	
THE NETHERLANDS	Akzo Nobel	Hengelo	74	3
POLAND	Rokita	Brzeg Dolny	125	3
	Dwory	Oswiecim	39	
	Tarnow	Tarnow	43	
SLOVAK REPUBLIC	Novacke Chemicke	Novaky	76	2
SPAIN	EIASA (Aragonesas)	Huelva	101	10
	EIASA (Aragonesas)	Sabinanigo	25	
	EIASA (Aragonesas)	Villaseca	135	
	Elnosa	Lourizan	34	
	Ercros	Flix	150	
	Quimica del Cinca	Monzon	31	
	SolVin	Martorell	218	
	Solvay	Torrelavega	63	
SWEDEN	Akzo Nobel	Bohus	100	6
	Norsk Hydro	Stenungsund	120	
SWITZERLAND	SF-Chem	Pratteln	27	4
UK	Albion Chemicals	Sandbach	90	5
	Ineos Chlor	Runcorn	738	
	Rhodia	Staveley	29	
Total plants		**50**	**6072**	**85**

Source: Chlorine Industry Review 2004-2005, Euro Chlor, Brussels, 2005.

Notes: To complete the picture for Western Europe, it is necessary to recall that a few companies (including two in the list above) are not members of Euro Chlor. According to information gleaned from Chlorine/Sodium Hydroxide (2005) and other sources, none of which is entirely complete or accurate, non-Euro Chlor members operate 2 MCCAPs in Romania of 186,000t and 5,000t capacity, 2 MCCAPs in Bosnia of 17,000t and 35,000t capacity, 3 MCCAPs in Serbia of about 6,000t capacity, 115,000t capacity and 15,000t capacity, of which the latter 2 may be out of commission, and 1 in Macedonia of 10,000t capacity, which may also be out of commission.

To the final column above, for Western European MCCAPs operating in 1990, should be added: Austria 2, Ireland 1, Norway 1, Portugal 2, Romania 3 and Yugoslavia 8.

Annex 2

Member States’ responses to diverse Stakeholder questions posed by DG ENV - September 2005 (unless source is otherwise indicated) and submissions to UNEP.

[Author comments in brackets.]

Country	**Recycling-related comments submitted**
Austria	No mercury recycling except dental waste. For dentists, an amalgam recovery system is mandatory. The amalgam is recycled in Austria (recovery of Ag and mercury) by a specialised company. Batteries are collected and disposed of in MWI or HWI. Mercury waste is treated and disposed underground.
Belgium (Flanders)	Batteries are collected and recycled (button cells and “black mass” from the treatment of alkaline batteries are treated in Wallonia). In 2004 approx. 7.46 t of **mixed button cells** were collected in Belgium. According to recent experience, from 1000 kg of button cells, approximately 200 kg of mercury can be recovered, 750 kg of scrap and the rest is mainly consisting of organic material. In 2004 approx. 1515 tonnes of **alkaline batteries** were collected in Belgium. These batteries are crushed, the metal and other fractions are recovered, and approximately 61% of the collected weight makes up the so-called “black mass.” This is rich in zinc, manganese and carbon, and contains approximately 170 ppm mercury. [Therefore, the concentration of mercury by weight is 104 ppm of the total weight of the collected alkaline cells.] The concentration of mercury in the black mass is showing a downward evolution as less and less mercury occurs in the collected batteries.
	Most of the dental amalgam collected (required) in Flanders is treated in installations in the Netherlands and Germany to recover silver and mercury. 19 t of dental waste was colleced in 2002, 7.5 t in 2003, and 2.6 t in 2004. [No indication of the mercury content.]
	In Flanders there is one installation for the recycling of metallic mercury by vacuum distillation, treating waste from other companies, e.g., fluorescent powder from treatment of fluorescent tubes, thermometers, button cells, and mainly mercury-containing wastes from the chlorine industry. The recovered mercury is sold mostly to the chloralkali-industry. There is also another installation treating mercury containing lamps in Flanders. Together the two facilities can treat approximately 2200 + 300 tonnes of mercury containing lamps/yr, much of the waste imported. Belgium imported for recycling 1060 t of mercury lamps and waste in 2002, 1130 t in 2003, and 1362 t in 2004.

	2 Belgian chlor-alkali plants export their waste. One chloralkali plant has an installation for some mercury waste distillation. The recovered mercury [how much?] of this installation is mainly used internally. In 2002 Belgium exported 38 t mixed mercury waste (mostly chlor-alkali and lamp waste) to Germany for disposal and 16 t “graphite” [activated carbon?] waste for recycling. In 2003 no recorded chlor-alkali waste was exported. In 2004 Belgium exported 51 t mercury waste (mostly chlor-alkali and lamp waste) to Germany for disposal and 10 t “graphite” waste for recycling. Besides the chlor-alkali waste, lamps, etc., in 2004 over 100 t of filter cake and slag/dust waste containing mercury was also sent to Germany for disposal.
	In Flanders, crematoria are subjected to legislation concerning emissions to air with emission limit values and measuring obligations for mercury. From the flue gas wastes, mercury is recovered by distillation.
Cyprus	(In 2004?) 180 t of mercuric oxide batteries were imported, about 30% mercury, therefore 54 t mercury, no incineration, no recycling, all battery waste landfilled. [Needs to be checked. If Cyprus consumed 54 t mercury in batteries, global consumption must be > 400 t.]
Czech Republic	Most mercury wastes are recycled, esp. batteries, lamps, construction wastes, vehicles, dental waste. Recycled and recovered mercury put on the market was 17 t in 2001, 19.4 t in 2002, 14.1 t in 2003 and 17 t in 2004.
	0.1 t mercury waste [not the same as mercury content] generated from gas cleaning in 2002, and 0.2 t waste in 2003.
	In 2004 there were 197 t of batteries collected, 90% of which have less than 250 ppm mercury. [How much mercury in the others?]
	There is one Czech producer of thermometers, using about 0.9-1.0 g mercury per thermometer. Including imports of 185,000 thermometers, total use in 2004 was about 200,000 thermometers of all types. Total consumption of mercury in production of thermometers and other measuring, medical or technical devices is about 2.8 t, including approx. 305 kg mercury/yr in medical thermometers in hospitals.
	There are 6,500 dental clinics and labs. More than 50% have mercury separators with an estimated [theoretical] 95% effectiveness at end 2004. Consumption of dental mercury is about 16 t/yr.
	2 chlor-alkali sites need cleanup, with estimated 472 t mercury in buildings and soil – not including mercury in electrolytic cells.
Denmark	In Denmark an estimated 20-30% of the button cell consumption was collected separately in 2001, while the number was higher - an estimated 30-60% - for larger alkali batteries (Hansen and Hansen, 2003). The remaining batteries were assumed to be disposed of with household waste, of which most ended up in waste incineration.
Finland	In 2000 recovered 79 t mercury from zinc refining.
	Mercury-oxide batteries collected are exported to Switzerland. Annual collected amount in year 2000 was about 1 t containing 0,5 t mercury. Est. 50% collection rate.
	EEE recycling system was introduced in August 2005.

	Mercury from Boliden Kokkola Oy distillation of amalgam (0,5 t/y) was exported in 2000. Boliden Kokkola Oy is the only company that exports mercury from Finland.
	Mercury from thermometers and meas. & control instruments is also recovered, less than 1 t/yr.
France	2004 amalgam waste contained 15-20 t mercury (compared to dental demand for mercury estimated at 35 t mercury). [This seems high.] Only 2 facilities in France recycle dental amalgam waste, no indication how much.
	12 million thermometers in households, estimated to contain 24 t mercury. Est. replacement (in hospitals) by mercury-free thermometers at 10%/yr.
	Also significant mercury trapped in hospital wastewater system.
	24-25,000 t of batteries disposed/yr. Mercury content decreased from 250 ppm in 1998 to 40-70 ppm 2005. About 9200 t [assume included in the 24-25,000 t total] batteries recycled in 2003, i.e., about 1 t mercury recovered.
	Household barometer disposal 4 t mercury/yr ca. 2000.
	47 million mercury lamps disposed/yr (ca. 2000), equal 2-3 t mercury, i.e., about 50 mg/lamp. Lamps are supposed to be separated and recycled after 2000.
	Chlor-alkali plants contain 3-4,000 t mercury in 2000. They create solid waste containing about 25 t mercury, of which 20 t is recycled and re-used on site, 5 t disposed.
Germany	If there is no market for recycled mercury anymore, mercury containing wastes have to be disposed without harming the environment. Recyclers will look for new options like immobilisation or packaging of mercury for the final storage facility.
	Mercury lamps, 35-45 million collected @ 0.2 kg/lamp = 7-9,000 t/yr collected. Est. 10 mg mercury/lamp = 400 kg mercury [probably at least 20 mg/lamp] in the lamps, most of which are landfilled after collection.
	76 t of button cells collected and recycled in 2004 (and from previous storage) containing 5 t mercury, approx. 6.6% average mercury content. Also 700 t other "batteries containing mercury" were collected [no indication of mercury content].
	70 t/yr dental amalgam waste collected, recycling company est. 3-5% mercury, therefore 2-3.5 t mercury recovered from recycling. About 10 t [dental?] mercury waste exported annually to Austria.
	6,500 t/yr chemical industry mercury waste, mostly chlor-alkali, average mercury content 0.5%. German submittal translates that to 35 t mercury final disposal and 37 t mercury landfilled in 2003. [The author's math calculates 30-35 t mercury total, not 72 t mercury.]
	Mercury content in municipal wastes in Germany is 0.12 g/t.[28] Of the 20 Mio. t/yr domestic wastes in Germany, 10 Mio. t are incinerated and the other 10 Mio. t are landfilled. The total amount of mercury is approximately 2.4 t mercury/yr. Therefore app. 1.2 t mercury are incinerated and 1.2 t mercury are landfilled above ground.

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[28] Bayerisches Landesamt für Umweltschutz (Hrsg.): Zusammensetzung und Schadstoffgehalt von Siedlungsabfällen. 2003

	400-450,000 cremations/yr. Most flue gases treated, no information about mercury recovery.
Hungary	Collected 38 t of battery waste in 2003.
	Collected 340 t of lamp waste in 2003. Some was recycled within the [lamp] production facility.
Netherlands	If mercury wastes are contaminated with other substances like mercaptans, volatile aromatic hydrocarbons or other hydrocarbons, landfilling is no option. In these cases mercury and the other volatile compounds are preferably separated from the waste by distillation. Examples of these wastes are sludge from natural gas cleaning, activated carbon from cleaning waste gases and wastewater.
	Steering wastes to a desirable way of handling can be done with legal instruments or with financial instruments. A landfill ban on (specific) wastes containing mercury is a possibility, or a tax on landfilling waste containing mercury is another possibility.
	Sludge from natural gas cleaning assumed to contain 2% mercury (sludge mostly dry from Thailand has about 13% mercury). 700 t in 2002 = 14 t mercury. 900 t in 2003 = 18 t mercury. Filtercake from natural gas cleaning assumed to contain 40% mercury. 17 t in 2002 = 7 t mercury. 14 t in 2003 = 6 t mercury.
	Dental amalgam and amalgam waste assumed to contain 50% mercury. 6 t waste in 2002 = 3 t mercury. 4 t waste in 2003 = 2 t mercury. Other dental waste 3-5% mercury [as in Germany] 117 t waste 2002 [5 t mercury], 131 t waste 2003 [5 t mercury].
	Mercury-selenium residue from zinc production contains 5-40% mercury. [No indication how much zinc production or Hg-Se residue in NL].
	“Metallic” mercury waste 1.4 t in 2002, and 15.9 t in 2003. [From what sources?]
	Measuring & control equip. est. to contain 1-15% mercury. 9.1 t in 2002 could yield 0.5 t mercury. 7.7 t in 2003 would be somewhat less.
	46 t mercury lamps collected in 2000, 53 t est. 2006, 58 t est. 2012.
	In the Netherlands, collection efficiency across all battery types can be estimated at about 50-70% of the potential, depending on how the collection efficiency is calculated. [Collection rates at, or slightly below, this level were also reported for the (large) municipality of Göteborg in Sweden (based on Hansen and Hansen, 2003). These examples are likely to be among the highest collection rates among current battery collection schemes.]
Norway	In Norway there is a requirement to store mercury from zinc-production (on site). Mercury from zinc-production is a by-product and is treated as waste for final disposal. The mercury-residue from zinc-production is cemented in sarcophagus and placed in a bedrock hall [chamber?] at the production site. The [main] mercury waste from industry is mercury as a by-product from production of zinc. The mercury content of the waste is 30-40%. Approximately 56 tonnes of zinc residues were disposed in 2004, i.e., 17-22 t mercury.
	On average Norway exports annually approximately 10 tonnes mercury containing waste per year. This is mainly waste from products. Mercury is not recycled in Norway.

	The distinction between the words ‘recovery’ and ‘recycling’ may be unclear. In order to clarify the Norwegian point of view, we would like to state that we primarily want mercury out of circulation. Norway advocates less recycling of mercury from waste.
Portugal	At the moment there is one company (AMBICARE INDUSTRIAL – Tratamento de Resíduos, S.A.) authorized to treat fluorescent tubes and other mercury containing wastes (such as dental amalgams, batteries, thermometers, sphygmomanometers and other mercury containing equipment). The treatment process includes crushing, mechanic separation and/or distillation operations. The recovered mercury is considered a product of the treatment process [rather than a waste?] and sold with a purity of approximately 98%.
	Portugal produces about 150 t of mercury wastes/yr (2002), and typically exports 40-50 t mercury wastes to Belgium, Germany, Spain and Switzerland for recovery.
	P. appears to be collecting and recycling 150-200 t of batteries/yr.
Romania	200 kg mercury used in [gold?] mining, of which 80% recycled.
	460 kg mercury recycled [annually?] by chlor-alkali plants.
Spain	There exist no data about recycling, which is applied mainly to batteries and fluorescents. The process is expensive and cannot compete with illegal landfill.
	The national association of batteries estimates a total annual use of 27 tonnes of mercury containing batteries [what mercury content?], and some 8 tonnes are selectively separated, while it’s supposed that the rest ends in a landfill. In the community of Catalonia in 2004 some 4,2 tonnes of mercury containing batteries were used, and 1,3 tonnes were collected and treated by mercury extraction.
	Similar to the mercury containing batteries, fluorescents are collected separately, to be treated in such a way that the mercury is retained. In Catalonia some 150 to 190 tonnes/year of fluorescents are treated.
Sweden	There is no recycling of mercury in Sweden except for within the chlor-alkali industry. Mercury containing waste such as thermometers, light sources, measuring equipment and electrical components are however reprocessed to separate the mercury fraction from the rest of the waste. The mercury fraction is then stored, awaiting final storage or stabilized and landfilled if the concentration of mercury is low. There are separate waste collection systems and already existing efforts for the collection of batteries, fluorescent lamps, amalgam waste etc.

	Boliden Mineral AB is currently storing about 8,000 tonnes of waste with a mercury content over one per cent, which represents approximately 330 tonnes of mercury. The waste is in intermediate storage. A further 400 tonnes of waste is generated each year, containing just over 20 tonnes/yr of mercury. The quantities involved for the two chlor-alkali industries Eka Chemicals AB and Hydro Polymers AB is estimated to be about 200 tonnes for each company. SAKAB's store of mercury waste is currently 2,000 tonnes, of which approximately 1,000 tonnes contain mercury levels over 1%. In many cases the quantity of mercury in the waste is not known, although SAKAB estimates that its store represents 80 tonnes of mercury. In addition to this, SAKAB also stores 1,800 tonnes of batteries, containing some 30 tonnes of mercury. An additional 50 – 100 tonnes of various mercury wastes arrives each year. The amount of mercury in the additional waste cannot be specified.
	During 2003 the Swedish EPA approved application to export mercury waste of 256 tonnes, including 226 tonnes discarded fluorescent tubes [0.005-0.015 % mercury, according to Netherlands], 10 tonnes fluorescent tube powder [0.05-0.3 % mercury, according to Netherlands] and 7 tonnes dental fillings [i.e., 23 + 20 + 3000 kg = about 3 t mercury].
UK	The UK generates about 100million used lamps per year. In 2004, about 16million were recycled. It is expected that around 20million lamps will be processed in 2005. 200 t mercury lamps exported to Belgium and Germany in 2003 for recovery. 96 t mercury lamps exported to Belgium and Germany in 2004 for recovery. In Scotland, there are at least two waste treatment businesses that recover (metallic) mercury from fluorescent light tubes.
	At present, practically all chlor-alkali mercury contaminated waste in the UK arises from two sites. Generally, these generate 60 to 70 tonnes of waste per annum, with very high mercury content.
	No tonnage figures available [for mercury in natural gas cleaning wastes], but it is understood that this material is normally sent to a processor in mainland Europe [probably the Netherlands] for treatment.
	18 t of laboratory reagents exported to Germany in 2003 for mercury recovery, 20 t exported to Germany in 2004.
	A report to the (then) Department of the Environment in 1996 (produced by the consultants ERM) estimated that approximately 1 tonne of mercury per annum was released in the UK waste stream from clinical thermometers, extrapolating from the use in one Health Authority. However, it is understood that use of mercury-in-glass thermometers in the Health Service has declined since this report.
	In 2002, dental waste was estimated at 6.3 t, of which est. 3 t sent for disposal/recycling. One UK Company processes about 1.5 tonnes of dental amalgam per annum. A second Company process some, but figures are not available.
EU	For mercury in all measuring and control equipment in the European Union, RPA (2002) estimate that 15% is collected for recovery, 80% is disposed of to solid waste and 5% break during use.

	In 2002, Belgium collected 59 percent of all portable batteries, Sweden 55 percent, Austria 44 percent, Germany 39 percent, Netherlands 32 percent and France 16 percent (ref. Reuters via Planet Ark website, 13 June 2006). By 2012, 25% of all batteries sold must be collected. By 2016, the target will rise to 45 percent. The [new] rules also determine how they must be recycled, once collected. The average European household uses 21 batteries a year, according to EU figures. In 2002, that added up to more than 158,000 metric tons of batteries, of which 28 percent were rechargeable. (Assoc. Press, 3May2006)
US	US recycling (Brooks, 2005) – Fig. 1 (ref 2000): Assumes 86 t chlor-alkali “replacement” (net) mercury [in 2002?] 115 t mercury for fabrication of products (US mkt), of which 5 t waste 250 t mercury in waste generated(excl. MCCAPs), of which 95 t mercury disposed, and 115 t mercury recycled US mine by-product mercury est. 120 t/yr. in 2000.
Australia	In Australia, several mercury cell chlorine-caustic soda plants were closed at the end of 2000 as plants using non-mercury technology were opened, thereby releasing that mercury onto the global market for management and recycling (ACTED Consultants, 2004). In 2002, for example, the United States imported 107 t of mercury from Australia as a result of the closure of these plants. (Brooks, 2005)

Annex 3

Netherlands main mercury exports 2003

		From	To	Commodity	Value ($US)	Weight (kg)	Unit value ($/kg)
2003	Export	Netherlands	Argentina	Mercury [SITC Rev.1 code 51325]	$16,978	2,562	$6.63
2003	Export	Netherlands	Australia	Mercury [SITC Rev.1 code 51325]	$36,678	6,875	$5.33
2003	Export	Netherlands	Belgium	Mercury [SITC Rev.1 code 51325]	$115,469	18,523	$6.23
2003	Export	Netherlands	Brazil	Mercury [SITC Rev.1 code 51325]	$179,972	11,250	$16.00
2003	Export	Netherlands	Bulgaria	Mercury [SITC Rev.1 code 51325]	$3,395	296	$11.47
2003	Export	Netherlands	China	Mercury [SITC Rev.1 code 51325]	$89,420	789	$113.33
2003	Export	Netherlands	Egypt	Mercury [SITC Rev.1 code 51325]	$1,011	507	$1.99
2003	Export	Netherlands	Germany	Mercury [SITC Rev.1 code 51325]	$9,055	324	$27.95
2003	Export	Netherlands	India	Mercury [SITC Rev.1 code 51325]	$71,309	17,250	$4.13
2003	Export	Netherlands	Iran	Mercury [SITC Rev.1 code 51325]	$4,527	515	$8.79
2003	Export	Netherlands	Kenya	Mercury [SITC Rev.1 code 51325]	$15,679	2,062	$7.60
2003	Export	Netherlands	Dem. People's Rep. of Korea	Mercury [SITC Rev.1 code 51325]	$31,693	2,500	$12.68
2003	Export	Netherlands	Rep. of Korea	Mercury [SITC Rev.1 code 51325]	$58,858	11,062	$5.32
2003	Export	Netherlands	Mexico	Mercury [SITC Rev.1 code 51325]	$253,412	722	$350.99
2003	Export	Netherlands	Morocco	Mercury [SITC Rev.1 code 51325]	$6,791	398	$17.06
2003	Export	Netherlands	Pakistan	Mercury [SITC Rev.1 code 51325]	$132,940	23,941	$5.55
2003	Export	Netherlands	Peru	Mercury [SITC Rev.1 code 51325]	$13,582	2,187	$6.21
2003	Export	Netherlands	Poland	Mercury [SITC Rev.1 code 51325]	$382,582	2,937	$130.26
2003	Export	Netherlands	Saudi Arabia	Mercury [SITC Rev.1 code 51325]	$6,791	359	$18.92
2003	Export	Netherlands	Singapore	Mercury [SITC Rev.1 code 51325]	$104,063	18,664	$5.58
2003	Export	Netherlands	South Africa	Mercury [SITC Rev.1 code 51325]	$71,309	10,812	$6.60
2003	Export	Netherlands	Spain	Mercury [SITC Rev.1 code 51325]	$60,001	10,812	$5.55

2003	Export	Netherlands	Suriname	Mercury [SITC Rev.1 code 51325]	$37,352	6,875	$5.43
2003	Export	Netherlands	Switzerland	Mercury [SITC Rev.1 code 51325]	$8,022	1,750	$4.58
2003	Export	Netherlands	Thailand	Mercury [SITC Rev.1 code 51325]	$435,781	2,812	$154.97
2003	Export	Netherlands	Togo	Mercury [SITC Rev.1 code 51325]	$5,870	3,437	$1.71
2003	Export	Netherlands	Turkey	Mercury [SITC Rev.1 code 51325]	$9,847	2,500	$3.94
2003	Export	Netherlands	United Arab Emirates	Mercury [SITC Rev.1 code 51325]	$7,923	1,125	$7.04
2003	Export	Netherlands	United Kingdom	Mercury [SITC Rev.1 code 51325]	$59,418	3,812	$15.59
2003	Export	Netherlands	Zimbabwe	Mercury [SITC Rev.1 code 51325]	$55,463	8,625	$6.43

Note: most statistics as reported by Dutch authorities to the UN Statistics Division; some statistics as reported by the trading partner.

Source: UN Statistics Division, based on statistics submitted by UN member countries.

Spain – main mercury exports 2003

		From	To	Commodity	Value ($US)	Weight (kg)	Unit value ($/kg)
2003	Export	Spain	Argentina	Mercury [SITC Rev.1 code 51325]	$27,095	10,000	$2.71
2003	Export	Spain	Australia	Mercury [SITC Rev.1 code 51325]	$273,793	44,851	$6.10
2003	Export	Spain	Belgium	Mercury [SITC Rev.1 code 51325]	$19,696	5,000	$3.94
2003	Export	Spain	Brazil	Mercury [SITC Rev.1 code 51325]	$83,822	26,175	$3.20
2003	Export	Spain	Chile	Mercury [SITC Rev.1 code 51325]	$6,926	1,000	$6.93
2003	Export	Spain	Colombia	Mercury [SITC Rev.1 code 51325]	$487,995	92,105	$5.30
2003	Export	Spain	Ecuador	Mercury [SITC Rev.1 code 51325]	$5,844	1,062	$5.50
2003	Export	Spain	Egypt	Mercury [SITC Rev.1 code 51325]	$5,972	1,625	$3.68
2003	Export	Spain	France	Mercury [SITC Rev.1 code 51325]	$130,056	19,898	$6.54
2003	Export	Spain	Germany	Mercury [SITC Rev.1 code 51325]	$52,000	10,000	$5.20
2003	Export	Spain	India	Mercury [SITC Rev.1 code 51325]	$160,650	31,394	$5.12
2003	Export	Spain	Indonesia	Mercury [SITC Rev.1 code 51325]	$100,979	18,976	$5.32
2003	Export	Spain	Iran	Mercury [SITC Rev.1 code 51325]	$896,862	170,582	$5.26
2003	Export	Spain	Italy	Mercury [SITC Rev.1 code 51325]	$53,890	15,875	$3.39
2003	Export	Spain	Japan	Mercury [SITC Rev.1 code 51325]	$60,315	5,437	$11.09
2003	Export	Spain	Rep. of Korea	Mercury [SITC Rev.1 code 51325]	$97,477	17,183	$5.67
2003	Export	Spain	Malaysia	Mercury [SITC Rev.1 code 51325]	$10,184	1,562	$6.52
2003	Export	Spain	Netherlands	Mercury [SITC Rev.1 code 51325]	$741,483	148,351	$5.00
2003	Export	Spain	Pakistan	Mercury [SITC Rev.1 code 51325]	$20,022	3,437	$5.83
2003	Export	Spain	Panama	Mercury [SITC Rev.1 code 51325]	$68,702	12,062	$5.70
2003	Export	Spain	Peru	Mercury [SITC Rev.1 code 51325]	$316,860	52,730	$6.01
2003	Export	Spain	Philippines	Mercury [SITC Rev.1 code 51325]	$28,192	5,125	$5.50
2003	Export	Spain	Portugal	Mercury [SITC Rev.1 code 51325]	$24,723	13,625	$1.81
2003	Export	Spain	Singapore	Mercury	$767,523	141,777	$5.41

				[SITC Rev.1 code 51325]			
2003	Export	Spain	South Africa	Mercury [SITC Rev.1 code 51325]	$43,335	6,875	$6.30
2003	Export	Spain	Sri Lanka	Mercury [SITC Rev.1 code 51325]	$3,657	687	$5.32
2003	Export	Spain	Thailand	Mercury [SITC Rev.1 code 51325]	$43,405	7,187	$6.04
2003	Export	Spain	Togo	Mercury [SITC Rev.1 code 51325]	$105,143	15,500	$6.78
2003	Export	Spain	Turkey	Mercury [SITC Rev.1 code 51325]	$31,319	4,812	$6.51
2003	Export	Spain	United Kingdom	Mercury [SITC Rev.1 code 51325]	$227,330	40,000	$5.68
2003	Export	Spain	USA	Mercury [SITC Rev.1 code 51325]	$10,682	1,000	$10.68

Note: most statistics as reported by Spanish authorities to the UN Statistics Division; some statistics as reported by the trading partner.

Source: UN Statistics Division, based on statistics submitted by UN member countries.

Other significant European mercury exports 2003

		From	To	Commodity	Value ($US)	Weight (kg)	Unit value ($/kg)
2003	Export	Belgium	Zimbabwe	Mercury [SITC Rev.1 code 51325]	$56,240	8,812	$6.38
2003	Export	Finland	Brazil	Mercury [SITC Rev.1 code 51325]	$42,225	7,750	$5.45
2003	Export	Finland	South Africa	Mercury [SITC Rev.1 code 51325]	$23,393	3,437	$6.81
2003	Export	France	Colombia	Mercury [SITC Rev.1 code 51325]	$8,158	4,000	$2.04
2003	Export	Germany	Argentina	Mercury [SITC Rev.1 code 51325]	$19,000	3,125	$6.08
2003	Export	Germany	Colombia	Mercury [SITC Rev.1 code 51325]	$43,195	7,625	$5.66
2003	Export	Germany	Ecuador	Mercury [SITC Rev.1 code 51325]	$19,000	3,125	$6.08
2003	Export	Germany	Kenya	Mercury [SITC Rev.1 code 51325]	$16,940	2,750	$6.16
2003	Export	Germany	Pakistan	Mercury [SITC Rev.1 code 51325]	$59,918	6,875	$8.72
2003	Export	Germany	Peru	Mercury [SITC Rev.1 code 51325]	$49,916	7,750	$6.44
2003	Export	Germany	Singapore	Mercury [SITC Rev.1 code 51325]	$135,701	24,496	$5.54
2003	Export	Italy	India	Mercury [SITC Rev.1 code 51325]	$35,156	6,187	$5.68
2003	Export	Slovenia	Areas not specified	Mercury [SITC Rev.1 code 51325]	$973	15,671	$0.06
2003	Export	Sweden	Indonesia	Mercury [SITC Rev.1 code 51325]	$47,199	40,000	$1.18
2003	Export	TFYR of Macedonia	India	Mercury [SITC Rev.1 code 51325]	$52,966	18,019	$2.94
2003	Export	United Kingdom	Brazil	Mercury [SITC Rev.1 code 51325]	$101,634	31,222	$3.26
2003	Export	United Kingdom	India	Mercury [SITC Rev.1 code 51325]	$155,461	35,500	$4.38

Note: some statistics as reported by the exporter to the UN Statistics Division; some statistics as reported by the trading partner.

Source: UN Statistics Division, based on statistics submitted by UN member countries.

Major EU mercury movements, 2000-2003 (metric tons)

From	To	2000	2001	2002	2003
Germany	Spain	429	423	162	181
Germany	UK	40			
Germany	Greece		**125**		
Germany	Netherlands		61	77	60
Netherlands	Spain	108	59	34	
Netherlands	Brazil	62			
Netherlands	Germany	48		105	
Netherlands	Argentina		38		
Netherlands	Viet Nam		35	52	
Netherlands	Colombia		34	43	
Netherlands	Hong Kong			35	
Netherlands	Pakistan				24
Spain	China	345	138	49	
Spain	Colombia				92
Spain	India	87	34	148	31
Spain	Iran	70	125	100	171
Spain	Netherlands	169	7	22	148
Spain	Singapore	145	86	166	142
Spain	Pakistan		38	30	3
Spain	Peru		48	33	53
Spain	Brazil		42	2	26
Spain	Viet Nam			57	
Belgium	Netherlands	**860**	**397**	**61**	
Belgium	Spain		105		
Belgium	Hong Kong			52	
UK	India	**113**	**188**		36
UK	Iran	**80**			
UK	Pakistan	26			
UK	Singapore		33		
UK	Netherlands		**275**	**455**	**75**
UK	Brazil				31
Finland	Netherlands	83	78	55	26
Finland	Brazil			28	
Sweden	Indonesia				40
Italy	India			**222**	
Poland	Hungary	66	50		
Portugal	Netherlands			43	
Turkey	Netherlands		157		
Japan	Netherlands				102
Russian Fed.	Netherlands				99

Source: All data courtesy of UNDESA Statistics Division – Comtrade database.

Global exports of mercury by key countries to OECD partners (countries receiving > 5 metric tons/yr), according to Comtrade

	Spanish exports				Netherlands exports				United States exports				United Kingdom exports				German exports				Belgian exports				Australian exports			
OECD countries	2000	2001	2002	2003	2000	2001	2002	2003	2000	2001	2002	2003	2000	2001	2002	2003	2000	2001	2002	2003	2000	2001	2002	2003	2000	2001	2002	2003
Australia		7	46	45	22	12		7			6				12		13	21										
Austria																												
Belgium				5	16	18	22	19		5																		
Canada									12	7	6	8																
Czech Republic																												
Denmark																												
Finland																												
France	7	10	6	20	9	5	7				8						8	6	8				7					
Germany	7			10	48	9	105			5	21	5																
Greece					20													125										
Hungary																												
Iceland																												
Ireland																12												
Israel																	5											
Italy			7	16	25								9			14						10	6					
Japan	7			5					16																			
Korea	8	7	11	17				11	14	5	7																	
Luxembourg																												
Mexico						26	7		7	12	33	35																
Netherlands	169	7	22	148					56	17	73	57	25	275	455	75	28	61	77	60	860	397	61	8				
New Zealand	8																											
Norway																												
Poland	17	17	35		5	5	20																					
Portugal		4		14		7																						
Slovak Republic																												
Spain					108	59	34	11		18							429	423	162	181		105		14				
Sweden																		6	5									
Switzerland					21	9	9										7	15	9	7								
Turkey				5			5																					
United Kingdom		20	20	40	5		7		5								40	8				7						
United States					17	8							17	13			25	22	20	19					30		118	
Transfers < 5 tons/country	6	6	10	1	2	12	5	12	7	11	6	8	9	12	9	2	17	7	7	12	1	6	2	2				
Total exports to OECD	229	78	157	326	298	170	221	60	117	80	160	113	60	300	476	103	572	694	288	279	861	525	76	24	30	0	118	0

Global exports of mercury by key countries to non-OECD partners (countries receiving > 5 metric tons/yr), according to Comtrade

Non-OECD countries	Spanish exports				Netherlands exports				United States exports				United Kingdom exports				German exports				Belgian exports				Australian exports			
	2000	2001	2002	2003	2000	2001	2002	2003	2000	2001	2002	2003	2000	2001	2002	2003	2000	2001	2002	2003	2000	2001	2002	2003	2000	2001	2002	2003
Algeria																							5					
Argentina	5	18	7	10	20	38													7									
Belize	5																						52					
Brazil	11	42		26	62	12	19	11			19	9			8	31												
China	345	138	49																									
China, Hong Kong	5					17	35				18	17		19														
Colombia	23	18	15	92	14	34	43										14	5		8								
Cuba	5		5				5											10										
Ecuador																		6										
Egypt		10																										
Ghana					7																							
Guatemala																												
Guyana											10	9	9		8													
India	87	34	181	31	13	17	26	17	98	19	21	25	113	188		36			7						18	18		
Indonesia	28			19	17							7						30									6	26
Iran	70	125	100	171									80															
Jordan																	12											
Kenya																	6	7	19									
Lebanon					16	6	6																					
Liechtenstein																												
Malaysia																						6						
Morocco			6																									
Myanmar			12																									
Pakistan	30	38	30		21	17	16	24					26					7	6	7								
Panama				12																								
Papua New Guinea																												7
Peru	19	48	33	53	9	23	9				23	51								8								
Philippines	20	19		5																								
Russian Federation		17	17																									
Saudi Arabia																												
Senegal																												
Singapore	145	86	166	142	6	29	12	19			19	56		33	10		25	17	29	24								
South Africa				7	8	5	5	11																				
Sri Lanka												19																
Suriname								7																				
Taiwan																												
Thailand	7	7	8	7		5						6															14	34
Togo		6	9	16																								
Trinidad & Tobago																												
Turkey																												
U. Arab Emirates																												
Uruguay																							10	9				
Venezuela	7																											
Viet Nam		10	57			35	52				91	40									3	5	3	3				
Zimbabwe						10	20	9																				
Others not specified	5		6				6												5									
Transfers < 5 tons/country	10	14	26	13	18	6	16	18	25	26	11	11	5	10	2	1	14	22	15	18					5	2	4	2
Total exports to non-OECD	827	630	727	604	211	254	270	116	123	45	212	250	233	250	28	68	71	104	88	65	3	11	70	12	23	20	24	69