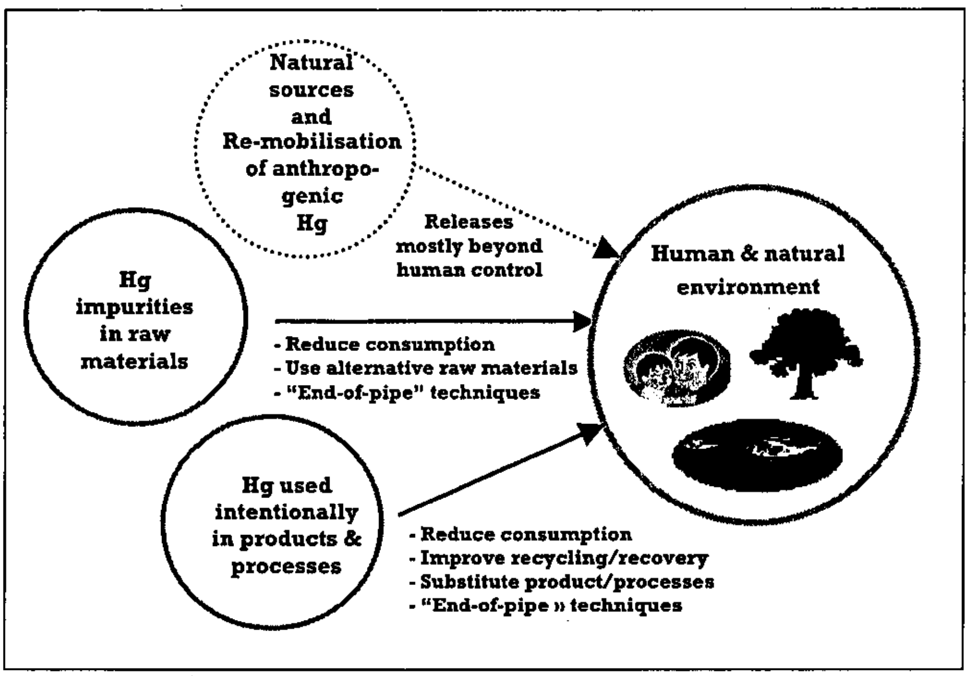
78. The figure below shows these release categories with main types of possible control mechanisms.



79. The recipients of mercury releases to the environment include the atmosphere, water environments (aquatic) and soil environments (terrestrial). There are continuing interactions – fluxes of mercury – between these compartments. The speciation – the chemical form – of the released mercury varies depending on the source types and other factors. This also influences the impacts on human health and environment as different mercury species have different toxicity.

80. Given the understanding of the global mercury cycle, current releases add to the global pool of mercury in the biosphere – mercury that is continuously mobilised, deposited on land and water surfaces, and re-mobilised. Being an element, mercury is persistent – it cannot be broken down to less toxic substances in the environment. The only long-term sinks for removal of mercury from the biosphere are deep-sea sediments and, to a certain extent, controlled landfills, in cases where the mercury is physio-chemically immobilised and remains undisturbed by anthropogenic or natural activity (climatic and geological). This also implies that even as the anthropogenic releases of mercury are gradually eliminated, decreases in some mercury concentrations – and related environmental improvements – will occur only slowly, most likely over several decades or longer. However, improvements may occur more quickly in specific locations or regions that are largely impacted by local or regional sources.

Local releases – global effects

81. The origins of atmospheric mercury deposition (flow of mercury from air to land and oceans) are local and regional as well as hemispherical or global. Several large studies have supported the conclusion that, in addition to local sources (such as chlor-alkali production, coal combustion and waste incineration facilities), the general background concentration of mercury in the global atmosphere contributes significantly to the mercury burden at most locations. Similarly, virtually any local source contributes to the background concentration – the global mercury pool in the biosphere - much of which represents anthropogenic releases accumulated over the decades. Also, the ocean currents are media for long-range mercury transport, and the oceans are important dynamic sinks of mercury in the global cycle.

82. The majority of atmospheric anthropogenic emissions are released as gaseous elemental mercury. This is capable of being transported over very long distances with the air masses. The remaining part of air emissions are in the form of gaseous divalent compounds (such as $HgCl_2$) or bound to particles present in the emission gas. These species have a shorter atmospheric lifetime than elemental vapour and will deposit via wet or dry processes within roughly 100 to 1000 kilometers. However, significant conversion

between mercury species may occur during atmospheric transport, which will affect the transport distance.

83. The atmospheric residence time of elemental mercury is in the range of months to roughly one year. This makes transport on a hemispherical scale possible and emissions in any continent can thus contribute to the deposition in other continents. For example, based on modelling of the intercontinental mercury transport performed by EMEP/MSC-E (Travnikov and Ryaboshapko, 2002), up to 50 percent of anthropogenic mercury deposited to North America is from external sources. Similarly, contributions of external sources to anthropogenic mercury depositions to Europe and Asia were estimated to be about 20 percent and 15 percent, respectively.

84. Furthermore, as mentioned, mercury is also capable of re-emissions from water and soil surfaces. This process greatly enhances the overall residence time of mercury in the environment. Recent findings by Lindberg *et al.* (2001) indicate re-emission rates of approximately 20 percent over a two-year period, based on stable mercury isotope measurements in north-western Ontario, Canada.

Anthropogenic sources of mercury releases

85. A large portion of the mercury present in the atmosphere today is the result of many years of releases due to anthropogenic activities. The natural component of the total atmospheric burden is difficult to estimate, although a recent study (Munthe *et al.*, 2001) has suggested that anthropogenic activities have increased the overall levels of mercury in the atmosphere by roughly a factor of 3.

86. While there are some natural emissions of mercury from the earth's crust, anthropogenic sources are the major contributors to releases of mercury to the atmosphere, water and soil.

Examples of important sources of anthropogenic releases of mercury

Releases from mobilisation of mercury impurities:

- Coal-fired power and heat production (largest single source to atmospheric emissions)
- Energy production from other fossil carbon fuels
- Cement production (mercury in lime)
- Mining and other metallurgic activities involving the extraction and processing of virgin and recycled mineral materials, for example production of:
  - iron and steel
  - ferromanganese
  - zinc
  - gold
  - other non-ferrous metals

Releases from intentional extraction and use of mercury:

- Mercury mining
- Small-scale gold and silver mining (amalgamation process)
- Chlor-alkali production
- Use of fluorescent lamps, various instruments and dental amalgam fillings.
- Manufacturing of products containing mercury, for example:
  - thermometers
  - manometers and other instruments
  - electrical and electronic switches

Releases from waste treatment, cremation etc. (originating from both impurities and intentional uses of mercury):

- Waste incineration (municipal, medical and hazardous wastes)
- Landfills
- Cremation
- Cemeteries (release to soil)

87. There are significant uncertainties in the available release inventories, not only by source, but also by country. The best available estimates of mercury emissions to air from various significant sources are shown in the table below.

Table *Estimates of global atmospheric releases of mercury from a number of major anthropogenic sources in 1995 (metric tons/year). Releases to other media are not accounted for here. *1.*

Continent	**Stationary combustion**	**Non-ferrous metal production *5**	**Pig iron and steel production**	**Cement production**	**Waste disposal *2**	**Artisanal gold mining *4**	**Sum, quantified sources *3**
Europe	186	15	10	26	12		250
Africa	197	7.9	0.5	5.2			210
Asia	**860**	**87**	**12**	**82**	33		1070
North America	105	25	4.6	13	**66**		210
South America	27	25	1.4	5.5			60
Australia and Oceania	100	4.4	0.3	0.8	0.1		100
Sum, quantified sources, 1995 *3,4	1470	170	30	130	110	300	1900 +300
Based on references:	Pirrone *et al.* (2001)	Pirrone *et al.* (2001)	Pirrone *et al.* (2001)	Pirrone *et al.* (2001)	Pirrone *et al.* (2001)	Lacerda (1997)	

1 Note that releases to aquatic and terrestrial environments - as well as atmospheric releases from a number of other sources - are not included in the table, because no recent global estimates have been made. See chapter 6 for description of this issue.

2 Considered underestimated by authors of the inventory, see notes to table 6.10.

3 Represents total of the sources mentioned in this table, not all known sources. Sums are rounded and may therefore not sum up precisely.

4 Estimated emissions from artisanal gold mining refer to late 1980's/early 1990's situation. A newer reference (MMSD, 2002) indicates that mercury consumption for artisanal gold mining - and thereby most likely also mercury releases - may be even higher than presented here.

5 Production of non-ferrous metals releasing mercury, including mercury, zinc, gold, lead, copper, nickel.

88. The emissions from stationary combustion of fossil fuels (especially coal) and incineration of waste materials accounts for approximately 70 percent of the total quantified atmospheric emissions from major anthropogenic sources. As combustion of fossil fuels is increasing in order to meet the growing energy demands of both developing and developed nations, mercury emissions can be expected to increase accordingly in the absence of the deployment of control technologies or the use of alternative energy sources. Control technologies have been developed for coal combustion plants and waste incinerators with the primary intention of addressing acidifying substances (especially SO_2 and NO_x), and particulate matter (PM). Such existing technologies may provide some level of mercury control, but when viewed at the global level, currently these controls result in only a small reduction of mercury from these sources. Many control technologies are significantly less effective at reducing emissions of elemental mercury compared to other forms. Optimised technologies for mercury control are being developed and demonstrated, but are not yet commercially deployed.

89. Available global estimates of atmospheric emissions from waste incineration, as well as other releases originating from intentional uses of mercury in processes and products, are deemed underestimated, and to some degree incomplete. However, recorded virgin mercury production has been decreasing from about 6000 to about 2000 metric tons per year during the last two decades, and consequently, related releases from mining and usage of mercury may also be declining.

90. Anthropogenic emissions from a number of major sources have decreased during the last decade in North America and Europe due to reduction efforts. Also, total anthropogenic emissions to air have been declining in some developed countries in the last decade. For example, Canadian emissions were reduced from about 33 metric tons to 6 metric tons between 1990 and 2000.

Natural sources of mercury releases

91. Natural sources include volcanoes, evaporation from soil and water surfaces, degradation of minerals and forest fires. The natural mercury emissions are beyond our control, and must be considered part of our local and global living environment. It is necessary to keep this source in mind, however, as it does contribute to the environmental mercury levels. In some areas of the world, the mercury concentrations in the Earth's crust are naturally elevated, and contribute to elevated local and regional mercury concentrations in those areas.

92. Today's emissions of mercury from soil and water surfaces are composed of both natural sources and re-emission of previous deposition of mercury from both anthropogenic and natural sources. This makes it very difficult to determine the actual natural mercury emissions.

93. Published estimates of natural versus anthropogenic mercury emissions show significant variation, although more recent efforts have emphasized the importance of human contributions. Attempts to directly measure natural emissions are ongoing. Nonetheless, available information indicates that natural sources account for less than 50 percent of the total releases.

94. On average around the globe, there are indications that anthropogenic emissions of mercury have resulted in deposition rates today that are 1.5 to 3 times higher than those during pre-industrial times. In and around industrial areas the deposition rates have increased by 2 to 10 times during the last 200 years.

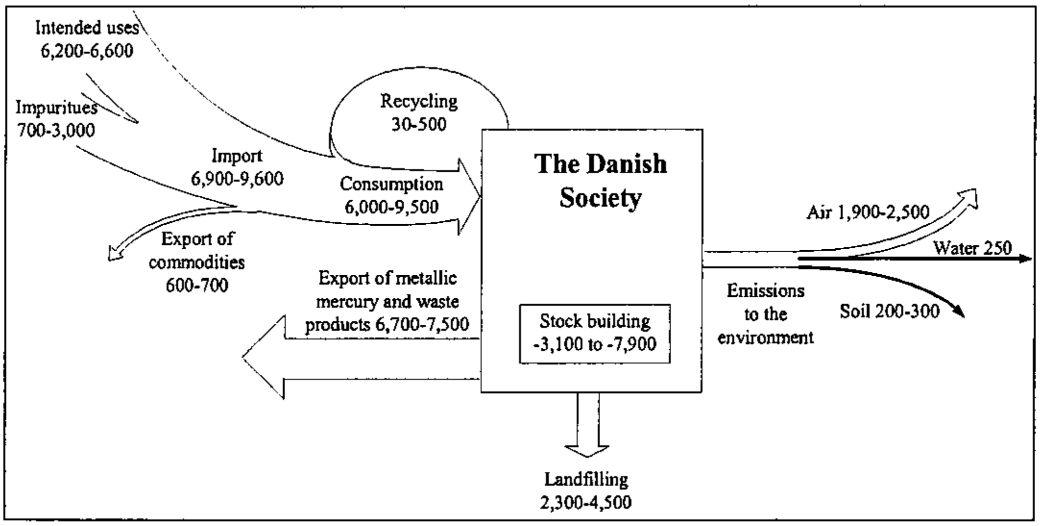
Contributions from intentional uses versus impurities in high volume materials

95. Regarding anthropogenic releases, the relative importance of intentional uses versus mobilisation of mercury impurities varies between countries and regions, particularly depending on:

- State of substitution of intentional uses (products and processes);
- Reliance on fossil fuels for energy production, particularly coal, and the presence of controls for other pollutants, which also reduce mercury emissions;
- Extent of mining and mineral extraction industry;
- Waste disposal pattern – incineration/landfilling;
- State of implementation of release control technologies in power production, waste incineration and various industrial processes.

96. For a number of countries, estimated contributions of intentional uses vary between 10 and 80 percent of the total domestic emissions to air, depending on the influence of the factors listed above. Rough estimates of distribution by main anthropogenic source types in each of these countries are shown in the chapter.

97. As an illustration, the figure below shows the overall turnover of mercury in the Danish society in 1992/93 in kilograms mercury/year (based on Maag *et al.*, 1996). (Note that inputs and outputs in the figure do not balance because outputs reflect higher inputs from previous years. Net change in stocks was negative.)



98. Denmark is a quite small country with relatively accurate monitoring of the flows of products and waste in the economy and the environment. Therefore, it has been possible to perform rather detailed balances, so-called substance flow assessments for mercury, which provide useful information on the contributions from different sectors to the total mercury burden in society and the environment. As shown in the figure, the majority of the input – more than two thirds – originated from intentional uses (chlor-alkali production and products), and the contributions from intentional uses to releases to air in 1992/93 could roughly be estimated at 50-80 percent of the total releases to air from Denmark. It should be noted that primary mineral extraction and processing is not as large a sector in Denmark, as in many other countries.

99. Examples of national distributions of anthropogenic mercury releases from different individual source types are given in the chapter. In countries where mercury mining or intentional use of mercury for small-scale gold mining is taking place, these sources can be significant.

CHAPTER 7 – Current production and use of mercury

Origin of mercury

100. Mercury is a natural component of the earth, with an average abundance of approximately 0.05 mg/kg in the earth's crust, with significant local variations. Mercury ores that are mined generally contain about one percent mercury, although the strata mined in Spain typically contain up to 12-14 percent mercury. While about 25 principal mercury minerals are known, virtually the only deposits that have been harvested for the extraction of mercury are cinnabar. Mercury is also present at very low levels throughout the biosphere. Its absorption by plants may account for the presence of mercury within fossil fuels like coal, oil, and gas, since these fuels are conventionally thought to be formed from geologic transformation of organic residues.

Sources of mercury to the market

101. The mercury available on the world market is supplied from a number of different sources, including (not listed in order of importance):

- Mine production of primary mercury (meaning extracted from ores within the earth's crust):
  - either as the main product of the mining activity,
  - or as by-product of mining or refining of other metals (such as zinc, gold, silver) or minerals;
- Recovered primary mercury from refining of natural gas (actually a by-product, when marketed, however, is not marketed in all countries);
- Reprocessing or secondary mining of historic mine tailings containing mercury;
- Recycled mercury recovered from spent products and waste from industrial production processes. Large amounts ("reservoirs") of mercury are "stored" in society within products still in use and "on the users' shelves";

- Mercury from government reserve stocks, or inventories;
- Private stocks (such as mercury in use in chlor-alkali and other industries), some of which may later be returned to the market.

102. The mining and other mineral extraction of primary mercury constitute the human mobilisation of mercury for intentional use in products and processes. Recycled mercury and mercury from stocks can be regarded as an anthropogenic re-mobilisation of mercury previously extracted from the Earth.

Continued mining of primary mercury

103. Despite a decline in global mercury consumption (global demand is less than half of 1980 levels), supply from competing sources and low prices, production of mercury from mining is still occurring in a number of countries. Spain, China, Kyrgyzstan and Algeria have dominated this activity in recent years, and several of the mines are state-owned. The table below gives information on recorded global primary production of mercury since 1981. There are also reports of small-scale, artisanal mining of mercury in China, Russia (Siberia), Outer Mongolia, Peru, and Mexico. It is likely that this production serves robust local demand for mercury, often for artisanal mining of gold – whether legal or illegal. Such mercury production would require both accessible mercury ores and low-cost labor in order for it to occur despite low-priced mercury available in the global commodity market.

Period	1981-1985	1986-1989	1990-1995	1996	1997	1998	1999	2000
Recorded annual, global primary production (in metric tons)	5500-7100	4900-6700	3300-6100	2600-2800	2500-2900	2000-2800	2100-2200	1800

Sources: See section 7.2.1.

Large supplies of recycled mercury may be marketed

104. Large quantities of mercury have come onto the market as a result of ongoing substitution and closing of mercury-based chlor-alkali production in Europe and other regions. Market analysis indicates that 700 - 900 metric tons per year of recycled mercury (corresponding to about 30 percent of the recorded primary production) has been marketed globally since the mid-1990's, of which the majority originated from chlor-alkali production facilities. However, to the extent there remains a legitimate demand for mercury, the re-use and recycling of mercury replaces the mining and smelting of virgin mercury, which would involve additional releases and would result in mobilising new mercury into the market and the environment.

105. The preference for reuse and recycling of mercury over mining - especially in the context of large mercury inventories coming onto the market - is complicated by the generally accepted economic rule that an **excess** supply of mercury drives the market price lower, which in turn encourages additional use or waste of mercury. For this reason, certain precautions are being taken, as described below.

106. Within the current decade and beyond, vast supplies of mercury will become available from conversion or shutdown of chlor-alkali facilities using the mercury process, as many European countries press for a phase-out of this process before 2010. From the European Union alone, this may introduce up to 13,000 metric tons of additional mercury to the market (equal to some 6-12 years of primary mercury production). In response to this potential glut of mercury, Euro Chlor, which represents the European chlor-alkali industry, has signed a contractual agreement with Miñas de Almadén in Spain. The agreement provides that Miñas de Almadén will buy the surplus mercury from the West-European chlor-alkali plants and put it on the market in place of mercury Almadén would otherwise have mined. All EU members of Euro Chlor have agreed to sell their surplus mercury to Almadén according to this agreement, and Euro Chlor believes most of the central and eastern European chlorine producers will also commit to this agreement. While this agreement clearly represents an effort by all parties to responsibly address the problem of surplus mercury, some people have the view that there are not yet adequate controls on where this mercury would be sold or how it would be used.

107. Similarly, large reserve stocks of mercury held by various governments have become superfluous, and are subject to future sales on the world market if approved by the relevant national authorities. This is the case in the USA, for example, which holds a 4,435 metric ton inventory of mercury. The sale of this mercury has been suspended since 1994, awaiting a determination of its potential environmental and market impacts. Prior to that, however, the sale of some of these stocks contributed significantly to the supply of mercury on the domestic US-market, and to exports as well. US government sales were equivalent to 18 to 97 percent of the domestic US demand for mercury in the years 1990-94 (US EPA, 1997; Maxson and Vonkeman, 1996).

Uses of mercury

108. The element mercury has been known for thousands of years, fascinating as the only liquid metal, and applied in a large number of products and processes utilising its unique characteristics. Being liquid at room temperature, being a good electrical conductor, having very high density and high surface tension, expanding/contracting uniformly over its entire liquid range in response to changes in pressure and temperature, and being toxic to micro-organisms (including pathogenic organisms) and other pests, mercury is an excellent material for many purposes.

109. In the past, a number of organic mercury compounds were used quite broadly, for example in pesticides (extensive use in seed dressing among others) and biocides in some paints, pharmaceuticals and cosmetics. While many of these uses have diminished in some parts of the world, organic mercury compounds are still used for several purposes. Some examples are the use of seed dressing with mercury compounds in some countries, use of dimethylmercury in small amounts as a reference standard for some chemical tests, and thimerosal (which contains ethylmercury) used as a preservative in some vaccines and other medical and cosmetic products since the 1930's. As the awareness of mercury's potential adverse impacts on health and the environment has been rising, the number of applications (for inorganic and organic mercury) as well as the volume of mercury used have been reduced significantly in many of the industrialised countries, particularly during the last two decades.

Examples of uses of mercury

As the metal (among others):

- for extraction of gold and silver (for centuries)
- as a catalyst for chlor-alkali production
- in manometers for measuring and controlling pressure
- in thermometers
- in electrical and electronic switches
- in fluorescent lamps
- in dental amalgam fillings

As chemical compounds (among others):

- in batteries (as a dioxide)
- biocides in paper industry, paints and on seed grain
- as antiseptics in pharmaceuticals
- laboratory analyses reactants
- catalysts
- pigments and dyes (may be historical)
- detergents (may be historical)
- explosives (may be historical)

110. However, many of the uses discontinued in the OECD countries are still alive in other parts of the world. Several of these uses have been prohibited or severely restricted in a number of countries because of their adverse impacts on humans and the environment.

111. Furthermore, while there is a general understanding of mercury production and use around the world, it is crucial to gain an even better understanding of global mercury markets and flows in order to assess demand, to design appropriate pollution prevention and reduction measures, and to monitor progress towards specific objectives.

CHAPTER 8 – Prevention and control technologies and practises

112. As noted in chapter 6, the sources of releases of mercury to the biosphere can be grouped in four major categories. Two of these categories (releases due to natural mobilisation of mercury and re-mobilisation of anthropogenic mercury previously deposited in soils, sediments and water bodies) are not well understood and largely beyond human control.

113. The other two are current anthropogenic mercury releases. Reducing or eliminating these releases may require:

- Investments in controlling releases from and substituting the use of mercury-contaminated raw materials and feedstocks, the main source of mercury releases from "unintentional" uses; and
- Reducing or eliminating the use of mercury in products and processes, the main source of releases caused by the "intentional" use of mercury.

114. The specific methods for controlling mercury releases from these sources vary widely, depending upon local circumstances, but fall generally under the following four groups:

A. Reducing mercury mining and consumption of raw materials and products that generate mercury releases;

B. Substitution (or elimination) of products, processes and practices containing or using mercury with non-mercury alternatives;

C. Controlling mercury releases through end-of-pipe techniques;

D. Mercury waste management.

115. The first two of these are "preventive" measures – preventing some uses or releases of mercury from occurring at all. The latter two are "control" measures, which reduce (or delay) some releases from reaching the environment. Within these very general groupings are a large number of specific techniques and strategies for reducing mercury releases and exposures. Whether or not they are applied in different countries depends upon government and local priorities, information and education about possible risks, the legal framework, enforcement, implementation costs, perceived benefits and other factors.

A. Reducing consumption of raw materials and products that generate mercury releases

116. Reducing consumption of raw materials and products that generate mercury releases is a preventive measure that is most often targeted at mercury containing products and processes, but may also result from improved efficiencies in the use of raw materials or in the use of fuels for power generation. This group of measures could potentially include the choice of an alternative raw material such as using natural gas for power generation instead of coal, or possibly by using a coal type with special constituents (such as more chlorine), because the mercury emissions from burning this type of coal might be easier to control than other coal types.

117. Another possible approach in some regions might be the use of coal with a lower trace mercury content (mercury concentrations appear to vary considerably in some regions depending on the origin of the raw materials). However, there are some limitations and potential problems with this approach. For example, as in the case of the utility preference for low-sulfur crude oil, it is likely that some utilities might be willing to pay more for low-mercury coal, which effectively lowers the market value of all high-mercury coal, which in turn might lead to higher consumption of high-mercury coal in regions where utilities have less rigorous emission controls. Moreover, data collected recently in the US indicate that coal supplies in the US do not vary significantly in mercury content.

118. Nonetheless, such preventive measures aimed at reducing mercury emissions are generally cost-effective, except in cases where an alternative raw material is significantly more expensive or where other problems limit this approach.

B. Substitution of products and processes containing or using mercury

119. Substitution of products and processes containing or using mercury with products and processes without mercury may be one of the most powerful preventive measures for influencing the entire flow of mercury through the economy and environment. It may substantially reduce mercury in households (and reduce accidental releases, as from a broken thermometer), the environment, the waste stream, incinerator emissions and landfills. Substitutions are mostly cost-effective, especially as they are demanded by a larger and larger market. This group of measures would also include the conversion of a fossil-fueled generating plant to a non-fossil technology.

120. At the same time, it would be a mistake to assume that substitution is always a clear winner. For example, in the case of energy-efficient fluorescent lamps, as long as there are no competitive substitutes that do not contain mercury, it is generally preferable from a product-life-cycle perspective to use a mercury-containing energy-efficient lamp rather than to use a less efficient standard incandescent lamp containing no mercury, as a result of current electricity production practises.

C. Controlling mercury emissions through end-of-pipe techniques

121. Controlling mercury emissions through end-of-pipe techniques, such as exhaust gas filtering, may be especially appropriate to raw materials with trace mercury contamination, including fossil-fueled power plants, cement production (in which the lime raw material often contains trace mercury), the extraction and processing of primary raw materials such as iron and steel, ferromanganese, zinc, gold and other non-ferrous metals and the processing of secondary raw materials such as iron and steel scrap. Existing control technologies that reduce SO_2, NO_x and PM for coal-fired boilers and incinerators, while not yet widely used in many countries, also yield some level of mercury control. For coal-fired boilers, reductions range from 0 to 96 percent, depending on coal type, boiler design, and emission control equipment. On average, the lower the coal rank, the lower the mercury reductions; however, reductions may also vary within a given coal rank. Technology for additional mercury control is under development and demonstration, but is not yet commercially deployed. In the long run, control strategies that target multiple pollutants, including SO_2, NO_x, PM and mercury, may be a cost-effective approach. However, end-of-pipe control technologies, while mitigating the problem of atmospheric mercury pollution, still result in mercury wastes that are potential sources of future emissions and must be disposed of or reused in an environmentally acceptable manner.

D. Mercury waste management

122. Mercury wastes, including those residues recovered by end-of-pipe technologies, constitute a special category of mercury releases, with the potential to affect populations far from the initial source of the mercury. Mercury waste management, the fourth "control" measure mentioned above, may consist of rendering inert the mercury content of waste, followed by controlled landfill, or it may not treat the waste prior to landfill. In Sweden, the only acceptable disposal of mercury waste now consists of "final storage" of the treated waste deep underground, although some technical aspects of this method are yet to be finalised.

123. Mercury waste management has become more complex as more mercury is collected from a greater variety of sources, including gas filtering products, sludges from the chlor-alkali industry, ashes, slags, and inert mineral residues, as well as used fluorescent tubes, batteries and other products that are often not recycled. Low concentrations of mercury in waste are generally permitted in normal landfills, while some nations only allow waste with higher mercury concentrations to be deposited in landfills that are designed with enhanced release control technologies to limit mercury leaching and evaporation. The cost of acceptable disposal of mercury waste in some countries is such that many producers now investigate whether alternatives exist in which they would not have to produce and deal with mercury waste. Mercury waste management, as it is most commonly done today, in accordance with national and local

regulations, increasingly requires long-term oversight and investment. Proper management of mercury wastes is important to reduce releases to the environment, such as those that occur due to spills (i.e. from broken thermometers and manometers) or releases that occur over time due to leakage from certain uses (e.g., auto switches, dental amalgams). In addition, given that there is a market demand for mercury, collection of mercury-containing products for recycling limits the need for new mercury mining.

Emission prevention and control measures

124. A well thought-out combination of emission prevention and control measures is an effective way to achieve optimal reduction of mercury releases. If one considers some of the more important sources of anthropogenic mercury releases, one may see how prevention and control measures might be combined and applied to these sources:

- Mercury emissions from **municipal and medical waste incinerators** may be reduced by separating the small fraction of mercury containing waste before it is combusted. For example, in the USA, free household mercury waste collections have been very successful in turning up significant quantities of mercury-containing products and even jars of elemental mercury. Also, separation programmes have proved successful in the hospital sector and a number of hospitals have pledged to avoid purchasing mercury-containing products through joint industry-NGO-Government programmes. However, separation programmes are sometimes difficult or costly to implement widely, especially when dealing with the general public. In such cases a better long-term solution may be to strongly encourage the substitution of non-mercury products for those containing mercury. As a medium term solution, separation programmes may be pursued, and mercury removed from the combustion stack gases. Mercury emissions from medical and municipal waste incineration can be controlled relatively well by addition of a carbon sorbent to existing PM and SO_2 control equipment, however, control is not 100% effective and mercury-containing wastes are generated from the process;
- Mercury emissions from **utility and non-utility boilers**, especially those burning coal, may be effectively addressed through pre-combustion coal cleaning, reducing the quantities of coal consumed through increased energy efficiency, end-of-pipe measures such as stack gas cleaning and/or switching to non-coal fuel sources, if possible. Another potential approach might be the use of coal with a lower mercury content. Coal cleaning and other pre-treatment options can certainly be used for reducing mercury emissions when they are viable and cost-effective. Also, additional mercury capture may be achieved by the introduction of a sorbent prior to existing SO_2 and PM control technologies. These technologies are under development and demonstration, but are not yet commercially deployed. Also, by-products of these processes are potential sources of future emissions and must be disposed of or reused in an environmentally acceptable manner;
- Mercury emissions due to **trace contamination of raw materials or feedstocks** such as in the cement, mining and metallurgical industries may be reduced by end-of-pipe controls, and sometimes by selecting a raw material or feedstock with lower trace contamination, if possible.
- Mercury emissions during **scrap steel production,** scrap yards, shredders and secondary steel production, result primarily from convenience light and anti-lock brake system (ABS) switches in motor vehicles; therefore a solution may include effective switch removal/collection programmes;
- Mercury releases and health hazards from **artisanal gold mining** activities may be reduced by educating the miners and their families about hazards, by promoting certain techniques that are safer and that use less or no mercury and, where feasible, by putting in place facilities where the miners can take concentrated ores for the final refining process. Some countries have tried banning the use of mercury by artisanal miners, which may serve to encourage their use of central processing facilities, for example, but enforcement of such a ban can be difficult;
- Mercury releases and occupational exposures during **chlor-alkali production** may be substantially reduced through strict mercury accounting procedures, "good housekeeping" measures to keep mercury from being dispersed, properly filtering exhaust air from the facility and careful handling and proper disposal of mercury wastes. There are a number of specific prevention methods to reduce mercury emissions to the atmosphere. The US chlor-alkali industry invented the use of ultraviolet lights to reveal mercury vapour leaks from production equipment, so that they could be plugged.

Equipment is allowed to cool before it is opened, reducing mercury emissions to the atmosphere. A continuous mercury vapour analyser can be employed to detect mercury vapour leaks and to alert workers so that they can take remedial measures. The generally accepted long-term solution is to encourage the orderly phase-out of chlor-alkali production processes that require mercury, and their substitution with technologies that are mercury free;

- Mercury releases and exposures related to mercury-containing **paints, soaps, various switch applications, thermostats, thermometers, manometers, and barometers**, as well as **contact lens solutions, pharmaceuticals and cosmetics** may be reduced by substituting these products with non-mercury products;
- Mercury releases from **dental practices** may be reduced by preparing mercury amalgams more efficiently, by substituting other materials for mercury amalgams, and by installing appropriate traps in the wastewater system;
- Mercury emissions from dental amalgams during **cremation** may only be reduced by removing the amalgams before cremation, which is not a common practice, or by filtering the gaseous emissions when the practice takes place in a crematorium. Since a flue gas cleaner is an expensive control technique for a crematorium, prevention by substituting other materials for mercury amalgams during normal dental care might be a preferred approach;
- In cases of **uncontrolled disposal of mercury-containing products or wastes**, possible reductions in releases from such practises might be obtained by making these practices illegal and adequately enforcing the law, by enhancing access to hazardous waste facilities, and, over the longer term, by reducing the quantities of mercury involved through a range of measures encouraging the substitution of non-mercury products and processes.

CHAPTER 9 - Initiatives for controlling releases and limiting use and exposures

National initiatives

125. The environmental authorities in a number of countries consider mercury to be a high-priority substance with recognised adverse effects. They are aware of the potential problems caused by use and release of mercury and mercury compounds, and therefore have implemented measures to limit or prevent certain uses and releases. Types of measures that have been implemented by various countries include:

- Environmental quality standards, specifying a maximum acceptable mercury concentration for different media such as drinking water, surface waters, air and soil and for foodstuffs such as fish;
- Environmental source actions and regulations that control mercury releases into the environment, including emission limits on air and water point sources and promoting use of best available technologies and waste treatment and disposal restrictions;
- Product control actions and regulations for mercury-containing products, such as batteries, cosmetics, dental amalgams, electrical switches, laboratory chemicals, lighting, paints/pigments, pesticides, pharmaceuticals, thermometers and measuring equipment;
- Other standards, actions and programmes, such as regulations on exposures to mercury in the workplace, requirements for information and reporting on use and releases of mercury in industry, fish consumption advisories and consumer safety measures.

126. Although legislation is the key components of most national initiatives, safe management of mercury also includes efforts to reduce the volume of mercury in use by developing and introducing safer alternatives and cleaner technology, the use of subsidies to support substitution efforts and voluntary agreements with industry or users of mercury. A number of countries have through implementation of this range of measures obtained significant reductions in mercury consumption, and corresponding reductions of uses and releases.

127. The table below gives a general overview of some of the types of implemented measures of importance to management and control of mercury, as related to its production and use life-cycle and an in-