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### Working Party on National Environmental Policies

#### INSTRUMENTS MIXES ADDRESSING MERCURY EMISSIONS TO AIR

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## FOREWORD

Between 2003 and 2006, OECD's Working Party on National Environmental Policy addressed the environmental effectiveness and economic efficiency of mixes of instruments used for environmental policy in a few selected areas, namely:

- Municipal solid waste management, with an emphasis on wastes from households;
- Non-point sources of water pollution, with an emphasis on nitrogen and phosphorous run-off and pesticide use in agriculture;
- Regional air pollution, with an emphasis on contributors to acidification (sulphur dioxide and nitrogen oxides); and
- Residential energy efficiency, with an emphasis on dwellings and on household appliances.
- Emissions to air of mercury.

Regarding each of these environment issues, a number of detailed country case studies were undertaken. These case studies have fed in to the synthesis report, *Instrument Mixes for Environmental Policy*, which is expected to be published in the summer of 2007.

This document presents case studies of instrument mixes addressing emissions to air of mercury in Norway, Sweden and the United States made as part of this project. It has benefited from comments on previous drafts from members of OECD's Working Party on National Environmental Policy.

A first draft of the report was prepared by Jakob Maag of COWI A/S, Denmark.

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## EXECUTIVE SUMMARY

As a chemical, mercury has typical as well as atypical aspects 1) Aspects similar to other hazardous chemicals (which has significance for work place environment, consumer safety etc.); 2) Atypical aspects (for a chemical), similar to bulk atmospheric pollutants such as SO<sub>x</sub>, NO<sub>x</sub>, etc. (in that the environmental impacts can be transported over long distances, and that there are certain major well-defined point-sources); 3) Like many other chemicals, mercury has also a large number of smaller, diffuse source categories, which are much more complex to address; 4) As a heavy metal, mercury's toxicity is persistent. It cannot be broken down to less toxic substances in the environment; as such it flows through societal sectors and environmental compartments with associated risks over a long time-span.

### ***Basics of mercury release sources***

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. The only known 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 both by anthropogenic or natural activity (climatic and geological).

According to UNEP (2002), the anthropogenic (human induced) releases of mercury to the biosphere can be grouped in three categories: 1) Current anthropogenic releases from the mobilisation of mercury-impurities in raw materials such as fossil fuels and other extracted, treated and recycled minerals; 2) Current anthropogenic releases resulting from mercury used intentionally in products and processes; and finally – with less attention in this report – 3) Re-mobilisation of historic anthropogenic mercury releases previously deposited in soils, sediments, water bodies, landfills and waste/tailings piles.

### ***Instruments addressing mercury emissions to air***

This study deals with “instruments used to address mercury emissions to air”, by which is meant all legislation, regulation and other measures intended to control or reduce anthropogenic, atmospheric mercury emissions. As the links are complex between actual inputs of mercury to society (consumption for intended use and mobilisation of mercury-impurities via industrial processes) and the final release sources, all types of measures addressing any phase in the life-cycle of mercury which may ultimately lead to atmospheric mercury emissions are included here. Due to its volatility, most forms of mercury released or discarded as waste – as vapour, as liquid elemental mercury, as compounds, as integrated in products, consumer waste or flue-gas cleaning residues – may lead to emissions to air.

Instruments used nationally today to address mercury have often been developed in the light of a typical, empirical, historical sequence of observations, motivations and policy reactions:

- Specific environment or health impacts are observed at certain local point-sources. This results in instruments being introduced to address the specific point source problems;
- Increased awareness of the pollutant triggers surveys of the presence and impacts of the pollutant in other natural recipients, foods, ground water etc. Major point source categories are identified and quantified This results in instruments being introduced to address these point source categories, locally or nationally;
- The knowledge and understanding increases with regard to impacts, exposures, mercury-releasing source categories and released quantities increase, but risks of exposures above estimated threshold levels

continue to be observed. This results in instruments being focused more broadly to address remaining source categories (e.g. smaller or more diffuse ones), and an integrated approach is sometimes introduced to understand (map) and address mercury release sources throughout the life-cycle of mercury in the products and processes.

The first two bullets above focus primarily on industrial and service sectors, which generally comprise relatively few, easily identifiable, actors on a national scale. On the contrary, the integrated approach and the smaller sources mentioned in the third bullet make it necessary to address a generally much larger, and more complex, group of actors on a national scale.

### ***The case studies***

The instruments used to address atmosphere emissions of mercury are examined in this report via three case studies (Norway, Sweden and the United States). Each of these countries has instruments that target the main groups of source categories: Mercury point sources, mercury-containing products and diffuse sources, and management of mercury-containing waste.

The major point sources are being addressed primarily through individual or general pollution permits and release limits and standards, as well as guidance on best available techniques (for controls and production technology). A new instrument – for mercury – has recently been introduced by the US, namely a cap-and-trade system to address atmospheric mercury releases from coal-fired power plants. That system is meant to obtain significant cost-efficient mercury release reductions. A number of individual US States are concerned, however, that the system will not secure sufficient reductions on the *local* or *regional* level, unless the programme is combined with maximum release limits. A number of US States therefore plan to opt out of the national trading programme.

Mercury-containing products are mainly being addressed through prevention instruments in the form of trade bans and limits on mercury content, and release-reduction instruments such as filters on dental clinics, as well as product-specific separate waste collection and treatment schemes.

Reduction of mercury releases in the waste-phase of the life-cycles of products and materials is being addressed by a number of parallel instruments. Besides the overall strategy of preventing mercury inputs to society (prevention measures described above), the dominant instruments include separate collection and treatment of mercury-containing products and materials, restrictions on which waste types can be landfilled, emission limits and residue management rules for waste incineration, limits on mercury contents in sewage sludge applied on farmland, and policies on retirement versus remarketing of (recyclable) excess mercury.

All three case study countries have policies that address the prevention of remarketing of surplus or recyclable mercury to the world market (totally or partially), with the aim of reducing subsequent releases from this mercury elsewhere. The issue of mercury retirement is currently being discussed extensively in national, regional (EU) and global fora (UNEP's Governing Council).

The three case study countries also see international co-operation as an important part of reducing mercury deposition and associated adverse effects on their territory, as well as regionally and globally. They have all pursued mercury release reductions nationally for several decades and still see a need for reductions in order to mitigate adverse impacts from mercury due to the global cycling of mercury in the atmosphere.

### ***Limit-based, incentive-based and voluntary instruments***

Most of the instruments targeting mercury described in this document are of the type sometimes designated "command-and-control". These include instruments such as release limits, specifications of release-reduction techniques, and limits (or bans) on mercury in products.

Some “incentive-based” instruments are also in use; for example a tax on releases from waste incineration in Norway and a cap-and-trade programme in the US. A third type of incentive-based instrument includes fees (or producer-paid collection systems) on products containing mercury, as for example a Swedish fee on mercury-containing batteries (which also serves to finance separate collection of spent batteries).

The pattern of mercury releases and exposures is complex. It might prove impossible to implement uniform economic instruments, such as a cap-and-trade scheme or mercury-release taxes, across all (or many) sectors in society. For certain major source categories (e.g. coal combustion, waste incineration, some manufacturing industries and non-ferrous metal extraction), a common cap-and-trade scheme could probably work. However, any local “hot spots” (areas with unacceptably high levels of mercury), would have to be addressed, for example through a combination of economic incentives and minimum reduction requirements (as is currently being done in Norway for waste incineration facilities).

Other instrument categories used include voluntary programmes, information sharing activities, education/outreach efforts, and subsidies for the development, or the promotion of, mercury-free alternatives.

Brief guidance on recommended approaches to plan and develop particular instruments addressing mercury releases to air is provided, based on lessons learned in the three country case studies.

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## INSTRUMENTS MIXES ADDRESSING MERCURY EMISSIONS TO AIR

### 1 Introduction

1. As a chemical, mercury has typical as well as atypical aspects:

- Mercury has aspects similar to other hazardous chemicals, which need to be addressed with regard to work place environment, consumer safety and other direct – and often complex – exposure risks.
- For a chemical, mercury has atypical aspects, similar to bulk atmospheric pollutants such as SO<sub>x</sub>, NO<sub>x</sub>, etc., in that the environmental impacts can be transported over long distances, and that there are certain major well-defined point-sources.
- Like many other chemicals, mercury has also many smaller, diffuse source categories, which are much more complex to address than the major, well-defined sources.
- As a heavy metal, mercury's toxicity is persistent. It cannot be destroyed and it remains harmful even if its chemical form changes; as such it flows through societal sectors and environmental compartments with associated risks over a long time-span.

#### 1.1 *Basics of mercury releases and cycling*

2. 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. 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. However, mercury does exhibit complex cycling in the environment where it undergoes various reactions and can change forms. Nonetheless, the only known 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 primarily impacted by local or regional sources (UNEP, 2002).

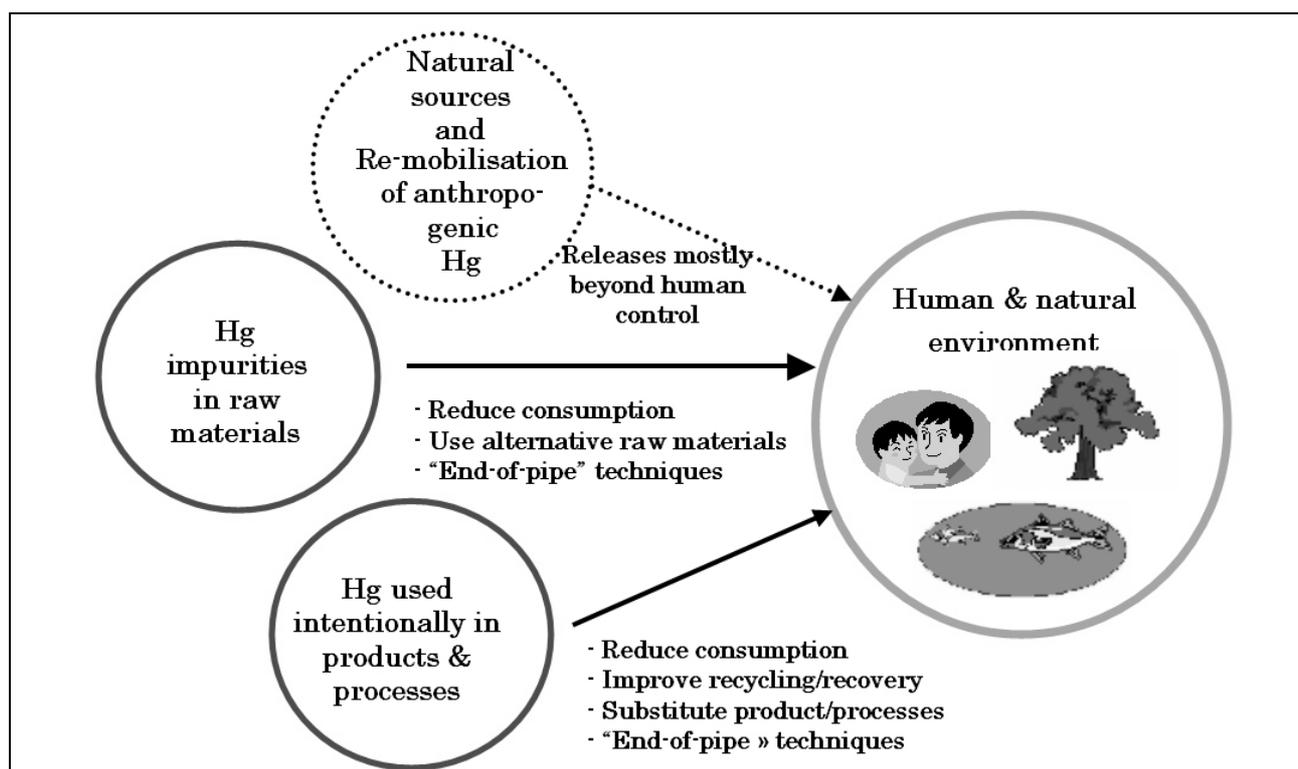
3. According to UNEP (2002), releases of mercury to the biosphere can be grouped in four categories:

- *Natural sources* – releases due to natural mobilisation of naturally occurring mercury from the Earth's crust, such as volcanic activity and weathering of rocks;
- Current anthropogenic (associated with human activity) releases from the *mobilisation of mercury impurities in raw materials* such as fossil fuels – particularly coal, and to a lesser extent gas and oil – and other extracted, treated and recycled minerals;

- Current anthropogenic releases resulting from *mercury used intentionally* in products and processes, due to releases during manufacturing, leaks, disposal or incineration of spent products or other re-releases;
- *Re-mobilisation* of historic anthropogenic mercury releases previously deposited in soils, sediments, water bodies, landfills and waste/tailings piles.

4. Figure 1 shows these release categories, as well as the main types of possible control mechanisms.

**Figure 1. Sources of mercury releases to the environment and main control options**



Source: UNEP (2002).

## 1.2 Mercury releases and their exchange between environmental media

5. This report deals with “instruments used to address mercury emissions to air”, by which is meant all legislation, regulation and other measures intended to control or reduce anthropogenic, atmospheric mercury emissions. As the links are complex between actual inputs of mercury to society (consumption for intended use and mobilisation of mercury impurities via industrial processes) and the final release sources, all types of measures addressing any phase in the life-cycle of mercury which may ultimately lead to atmospheric mercury emissions are included here. An example is that bans on mercury use in specific consumer products (*e.g.* batteries) which end up in incinerated household waste are included, as well as specific emission limits for mercury in emitted flue-gas in waste incinerators. Special inherent features of elemental mercury are its *liquid* form and its *volatility* at ambient temperatures. For example, elemental mercury that is spilled in a home will slowly vaporize to the air. Some other forms of mercury (*e.g.*, mercuric sulphide) are as less volatile. Nonetheless, most forms of mercury released or discarded as waste – as vapour, as liquid elemental mercury, as compounds, as integrated in products, consumer waste or flue-gas cleaning residues – may lead to emissions to air. Therefore the instruments addressing mercury emissions to air may be numerous and diverse. Note that instruments addressing mercury exposure in the

work place, and instruments that aim at reducing exposure from mercury already in the environment (such as fish consumption advisories) are not included systematically in this study.

6. In addressing pollutants such as mercury, an oft-used distinction between measures to decrease releases to the environment is *reduction measures* and *prevention measures*. Reduction measures aim at reducing releases to the environment through the use of emission control systems, for example filters retaining the pollutant from exhaust gasses. Prevention measures aim at cutting the input or generation of the polluting substances at the original source by using alternative materials or technologies, for example by banning the sale of products containing mercury or by substituting a mercury-containing fuel in energy production.

7. An overview of the types of instruments used to address mercury in its different life-cycle phases is given in Table 1, with indications of global state of implementation.

**Table 1. General overview of the types of instruments used to address mercury**

TYPE AND AIM OF MEASURE		STATE OF IMPLEMENTATION
<b>Production and use phases of the life cycle</b>		
<b>P O I N T  S O U R C E S</b>	Prevent or limit the intentional use of mercury in processes	General bans implemented in very few countries
	Prevent or limit mercury from industrial processes (such as chlor-alkali and metallurgic industry) from being released directly to the environment	Implemented in many countries, especially OECD countries
	Apply emission control technologies to limit emissions of mercury from combustion of fossil fuels and processing of mineral materials	Implemented in some OECD countries
	Prevent or limit the release of mercury from processes to the wastewater treatment system	Implemented in some OECD countries
	Prevent or limit use of obsolete technology and/or require use of best available technology to reduce or prevent mercury releases	Implemented in some countries, especially OECD countries
<b>P R O D U C T S</b>	Prevent or limit products containing mercury from being marketed nationally	General bans implemented in a few countries only. Bans or limits on specific products are more widespread, such as batteries, lighting, clinical thermometers
	Prevent products containing mercury from being exported	Only implemented in a few countries
	Prevent or limit the use of already purchased mercury and mercury-containing products	Only implemented in a few countries
	Limit the allowable content of mercury present as impurities in high-volume materials	Only implemented in a few countries
	Limit the allowed contents of mercury in commercial foodstuffs, particularly fish, and provide guidance (based on same or other limits values) regarding consumption of contaminated fish	Implemented in some countries, especially OECD countries. WHO guidelines used by some countries.
<b>Disposal phase of the life cycle</b>		
Prevent mercury in products and process waste from being released directly to the environment, by efficient waste collection		Implemented in many countries, especially OECD countries
Prevent mercury in products and process waste from being mixed with less hazardous waste in the general waste stream, by separate collection and treatment		Implemented in many countries, especially OECD countries
Prevent or limit mercury releases to the environment from treatment of household waste, hazardous waste and medical waste by emission control technologies		Implemented or implementation ongoing in some countries, especially OECD countries.
Set limit values for allowable mercury contents in sewage sludge spread on agricultural land		Implemented in a number of countries
Restrict the use of solid incineration residues in road-building, construction and other applications		Implemented in some OECD countries
Prevent the re-marketing of used, recycled mercury		Only implemented in a few countries

Source: Based on UNEP (2002).

### 1.3 *Historical aspects of the administration of mercury sources*

8. Instruments used nationally today to address mercury have typically been developed in reaction to a sequence of observations, motivations and policy reactions:

- Specific environment or health impacts are observed at certain local point-sources, *e.g.* paper mills using mercury biocides as was the case in Sweden (Swedish EPA, 2006). This results in instruments being introduced to address the specific point source problems.
- Increased awareness of the pollutant triggers surveys of the presence and impacts of the pollutant in other media and biota (such as groundwater, fish, wildlife, soils). Major point source categories releasing mercury to the local environment are identified and their releases quantified through on-site measurements of mercury releases or other methods (*e.g.*, mass balance calculations). This results in instruments being introduced to address these point source categories, locally or nationally.
- The knowledge and understanding increases with regard to impacts, exposures, mercury-releasing source categories and released quantities increase, but risks of exposures above estimated threshold levels and/or reference levels continue to be observed or modelled. This results in instruments being focused more broadly to address remaining source categories (*e.g.* smaller or more diffuse ones), and an integrated approach is sometimes introduced to understand and address mercury release sources throughout the life-cycle of mercury in the products and processes. This is done, for example, by introducing separate collection and treatment of mercury-containing waste, or by banning sales of mercury-containing products to minimise releases and exposure throughout the life-cycle and to reduce costs of measures aimed at minimizing downstream releases.

9. The first two bullets above focus primarily on industrial and service sectors, which generally comprise relatively few, easily identifiable, actors on a national scale. On the contrary, the integrated approach and the smaller sources mentioned in the third bullet make it necessary to address a generally much larger, and more complex, group of actors on a national scale, *e.g.* a large number of import/export trade companies, and retailer shops with their own imports, who may in many cases be unaware that their activities cause mercury releases and exposures.

10. As a consequence of the historical sequence of events described above, because of the practical aspects of environmental management and enforcement work, and perhaps because of the indicated differences between the sectors involved, the instruments addressing mercury releases to the environment, and the enforcement procedures of the environmental authorities, tend to be divided according to the major groups “point-sources”, “diffuse/other sources” and “waste management”.

11. Table 2 gives examples of mercury release source categories grouped according to the original source of the mercury (intentional use versus mobilization of mercury impurities, see Figure 1), and by group of instruments/enforcement often applied by environmental authorities. As can be seen in Table 2, some source types do naturally belong to more than one of the groups. For convenience, however, they are described under one heading in this report. Note that direct emissions from some of the source categories are primarily released to environmental media other than the atmosphere.

**Table 2. Examples of mercury release source categories**

Grouped according to the original source of the mercury, and by group of instruments/enforcement often applied by environmental authorities

Origin of mercury released	Point-sources	Diffuse/other sources	Waste management and similar end-of-use aspects
Intentional mercury use	Chlor-alkali production with Hg cells Mercury mining Small-scale gold and silver mining (amalgamation process) Manufacture of Hg containing products	Mercury-containing products: Dental amalgam, thermometers, switches, batteries, manometers etc. Dental clinics	Hazardous/medical waste incineration Waste water facilities and sludge incineration Special Hg waste treatment: Recycling, deposition, storage Cremation Cemeteries
Mobilization of mercury impurities	Coal combustion Other fossil carbon fuels combustion Non-ferrous metal extraction (zinc, gold, etc.)	Combustion of oil and gas Combustion of wood and other bio-fuels	
A combination of the above	Waste incineration Cement production (mercury in lime and waste used as fuel) Landfills		Waste incineration <sup>1)</sup> Landfills <sup>1)</sup>

1. Only a handful of dedicated mercury mines remain in operation in the World, but mercury is produced as a by-product in certain zinc, gold, lead and copper mines.

Source: UNEP (2002).

## 2. Main cross-cutting findings

### 2.1 Instruments' coverage of mercury release source categories

12. All three countries investigated in case studies, Norway, Sweden and the United States, have instruments that target the main groups of source categories: Mercury point sources, mercury-containing products and diffuse sources, and management of mercury-containing waste.

#### *Major point-sources*

13. The major point-sources, such as coal combustion, non-ferrous metal extraction plants and chlor-alkali production plants with mercury technology, are primarily addressed through individual or general pollution permissions and release limits based on national (and EU) regulation with associated environmental quality standards. Standards and guidance on Best Available Techniques (BAT, as it is termed in Europe) and the similar Maximum Achievable Control Technology and New Source Performance Standards (MACT and NSPS, concepts used in the US) support the regulations.

14. The US recently introduced a cap-and-trade system to address atmospheric mercury releases from coal-fired power plants. This approach is new for mercury but has been used to control other pollutants. The system is meant to obtain significant, cost-efficient mercury release reductions. The system was chosen instead of a traditional system based on general mercury release limits which all facilities should meet ("MACT" based system). Under the cap-and-trade system, emission permits would be allocated to the power plants based on a total *national* "cap" (maximum amounts of mercury released annually). Facilities that face high abatement costs due to their state of technology, etc., can choose to buy release permits from plants that find it cheaper to reduce their emissions.

15. However, a number of individual US States are concerned that the system will not secure sufficient reductions on the *local* or *regional* level where specific individual facilities are major sources of

mercury pollution in the local or regional environment. Coal-fired power plants are the single largest mercury source category in the US, as well as globally. Norway and Sweden have very limited dependence on coal-fired power plants, so this is not a major source category in these countries. Other examples exist, however, of countries with high dependency on coal combustion for energy production and similarly high levels of mercury controls and ambitions for mercury reductions (for example Denmark; see description in ACAP, 2004).

#### *Products and diffuse sources*

16. Mercury-containing products are mainly addressed with prevention instruments in the form of trade bans and limits on mercury contents, and release-reduction instruments such as product-specific separate waste collection and treatment schemes (see also “waste management” below). In the US, several mercury-containing products are addressed in these ways at the State level, and to a lesser degree at the Federal level (see Section 5.2). Also, information instruments are used to support other instruments; for example labelling informing consumers on mercury contents and special waste deposition requirements, and information campaigns targeting specific industry sectors and/or the general public.

17. Dental clinics are addressed with national or local waste water cleaning regulations, or similar voluntary measures.

#### *Waste management*

18. Reduction of mercury releases in the waste phase of products’ and materials’ life-cycles are addressed by a number of parallel instruments. The reason for the applied mix of instruments is that most mercury in waste originates from intentional mercury use in products, while trace concentrations in large volume wastes like packaging and other bulk materials also contribute. Another important factor is the choice of waste-to-energy solutions widely applied in the most economically developed countries, where waste is incinerated and mercury present in the waste is released to the flue gas and must be retained in flue-gas filters. Besides the overall strategy of preventing mercury inputs to society (prevention measures described above), the dominant instruments addressing mercury releases from waste management are separate collection and treatment of mercury-containing products and materials, restrictions on which waste types can be landfilled, emission limits and residue management rules for waste incineration, limits to mercury contents in sewage sludge applied on farmland, and policies on retirement versus remarketing of recyclable excess mercury.

19. Separate collection and treatment of mercury-containing products (thermometers, switches, certain batteries etc.) is a generally applied release-reduction measure in many OECD member countries. Such schemes may be managed as an integral part of public waste management and be funded by general public means or specific taxes. Alternatively, such programmes may be undertaken and funded by private entities such as producer-take-back-schemes, but generally under the supervision of national or State-level environment authorities. While such systems are currently common, it must be noted that consumer-involving systems generally can collect only parts of the amounts of waste of the targeted product types; collection rates rarely exceed 50-60%, and do so only with intensive collection and information activities.

20. Generally, waste with mercury concentrations above certain thresholds is considered hazardous waste. Such waste may not be landfilled in general municipal waste landfills or incinerated in municipal waste incineration plants. Instead, other special waste treatment methods are specified in national or local regulation (specially secured deposition sites, mercury recovery and recycling, or special long-time/permanent retirement of excess mercury).

21. Incineration of municipal, hazardous and medical waste are potentially large sources of mercury releases (especially due to contents of mercury-containing products). Generally, specific national (or regional, *i.e.* EU) or state limits are set for mercury concentrations in flue gasses and management practices for incineration residues (ashes and other solid, and sometimes liquid, flue-gas cleaning residues).

22. Municipal wastewater is also contaminated with mercury, especially due to the use of amalgam dental fillings. In wastewater treatment plants, a substantial part of the mercury ends up in sewage sludge. Consequently, limits have been set for mercury concentrations in sewage sludge applied as fertilizer on agricultural land – *in part* because the mercury later can evaporate to air. Some countries incinerate wastewater sludge, and instruments prescribing mercury release limits and management requirements similar to those described for waste incineration above are applied.

23. All three case study countries have policies that address the prevention of remarketing of surplus or recyclable mercury to the world market. In Sweden and Norway, this is a general requirement. In the US, certain federally owned excess mercury stocks are retained in long-time storage while other mercury amounts from hazardous waste and mining by-products are recycled/recovered and marketed. Mercury use in developed countries has declined substantially for many years due to environmental and human health concerns, and the domestic markets for recycled/recovered mercury are therefore limited. The aim of retiring excess mercury from society, rather than re-introducing it on the global market, is to prevent this mercury from being exported to, and used in other parts of the world where mercury management is less developed and therefore releases may occur, leading to local, regional and global deposition and potential adverse environmental impacts. The issue of mercury retirement is currently discussed extensively in national, regional (EU; the EU Mercury Strategy and its implementation; EC, 2005) and global fora (UNEP's Governing Council).

24. An EU ban on mercury exports by 2011, including provisions for retirement/storage of excess mercury, was proposed by the European Commission in October 2006, and will undergo negotiations in the Council and the European Parliament [see European Commission (2006a) and (2006b)].

25. An EU-wide mercury retirement and storage programme could perhaps further promote common solutions between several countries under controlled conditions. Such common solutions are in operation in Europe for some waste types today. For example, certain mercury-containing wastes from Denmark are deposited in Norwegian hazardous waste deposits. The Swedish position to require domestic handling of its mercury waste should be seen in the light that Sweden has been among the most active countries in the region as regards safe mercury retirement.

## **2.2 *Limit-based, incentive-based and voluntary instruments***

26. Most of the instruments targeting mercury described in this document are of the type sometimes designated “command-and-control”. These include instruments such as emission limits for mercury in flue gasses, use of specific release-reduction techniques in production facilities, limits for mercury concentrations in sewage sludge applied on agricultural land, limits for mercury concentrations in products such as for example batteries, and bans on the sale of specific mercury-containing products, for example mercury thermometers. This is the traditional approach for mercury reduction regulatory instruments.

27. A few instruments identified in the case studies are incentive based, meaning that incentives for compliance with the instrument goals – normally in the form of some kind of payment – are defined by the responsible authorities. One example is a tax per gram of mercury released to the atmosphere from waste incineration in Norway (see Section 3.3). Another example is the mercury cap-and-trade programme in the US mentioned above. In these two examples, the instrument structure is designed to enhance economic efficiency in the reduction efforts at the same time as reducing mercury emissions, because the incentive

for environmental improvements would be largest where the costs of reduction measures are lowest. A third type of incentive-based instrument is fees (or producer-paid collection systems) on marketed products containing mercury and sometimes also other toxic substances, as for example the Swedish fee on marketed mercury-containing batteries (which also serves to finance separate collection of spent batteries, thereby associating the collection costs specifically with the products that create the need for such collection activities (internalise the collection costs).

28. Incentive-based instruments are a new element in national instruments regulating mercury, resulting from an increased focus on cost-effective environmental policies. Such instruments have been facilitated by better data on many of the factors involved in economic assessments of instrument options targeting a specific environmental problem.

29. A fourth category of instruments is voluntary instruments, in which environmental authorities promote, and perhaps support, voluntary mercury-reducing activities in relevant sectors. Examples of such instruments are described in this report, but have not been collected systematically. Other instruments, such as information activities and subsidies for development of mercury-free alternatives, have also not been investigated systematically.

30. Voluntary programmes and information gathering and sharing activities have in some cases been promoted as precursors of the introduction of regulatory instruments, whereby the signal of expected introduction of regulation has provided motivation for environmental improvements in the involved sectors. For example, the Danish ban on sales of mercury-containing products was signalled many years before its introduction, and studies have shown that consumption of mercury-containing products had already dropped significantly by the time the ban entered into force (other reasons may also have contributed to the drop in consumption; see Maag *et al.*, 1996).

### **2.3 Current status for incentive-based instruments on mercury**

31. While some of the technological principles for release-reduction equipment for mercury and other priority pollutants are similar across several mercury emitting sectors, the level of implementation of mercury controls is not uniform. There are likely several historical and approach-based reasons for this. Pursuing the most easily attainable solutions first seems to have been the general trend.

32. One important reason for sluggish implementation of mercury controls in some sectors is that for some of the major point-sources of mercury releases, for example coal combustion and waste incineration, mercury reductions have so far not been the major driving force for regulations requiring the sectors to implement release-reduction equipment (“controls”). However, implemented controls for SO<sub>x</sub>, NO<sub>x</sub> and particulate matter (“PM” containing several organic priority pollutants and heavy metals) have – as a co-benefit – yielded mercury release reductions that may so far have reduced the incentive for developing and installing mercury-specific release-reduction equipment.

33. Mercury-specific release-reduction equipment on coal-fired power plants is only on the edge of implementation on a commercial scale. The long-term mercury reduction cap stipulated in the new US *Clean Air Mercury Rule* for power plants (see Section 5.3) is the first example of a general legal instrument specifically targeting mercury that probably will require the introduction of mercury-specific controls at coal-fired power plants. The *Clean Air Mercury Rule* should also be seen in the light that there is currently a potential for more power plants being equipped with SO<sub>x</sub> and NO<sub>x</sub> reduction equipment in the US (ACAP, 2004). The *Clean Air Mercury Rule* is, perhaps partly for this reason, designed to rely on co-benefits from SO<sub>x</sub> and NO<sub>x</sub> reductions in Phase 1. In the second Phase, the cap is reduced to a lower level, in which mercury-specific controls are expected to be needed.

34. Enhanced mercury retention with techniques similar to those nearing commercial maturation for coal combustion have been applied for some years on some waste incineration plants, but these filters have other operational conditions due to quite different chemicals characteristics of the emitted flue-gasses from waste incineration plants, and are in some cases designed to also retain dioxin releases (another prioritized hazardous substance).

35. Chlor-alkali production is an example of a source category where mercury releases have been the specific target for environmental policy instruments. Other types of equipment and process procedures are however applied in this chemical industry. As another example, non-ferrous metal extraction (especially zinc, copper and industrial gold extraction) have implemented mercury-specific mercury controls in some countries due to both environmental factors and the need to meet technical standards (such as maximum mercury concentrations that are commercially accepted in the important by-product sulphuric acid).

36. Across all mercury-release sources, mercury-specific release-reduction equipment should likely be considered a step up in both reduction achievements and reduction costs as compared to the present situation. This step has been taken only to a limited degree in developed societies today (and not at all in most countries) [see UNEP (2002)].

37. For intentional mercury use in products, some countries (for example Norway and Sweden) have opted for bans/restrictions on trade, while other countries have not found the benefits of such approaches sufficiently large to merit the related economic costs.

38. The pattern of mercury releases to the environment, including direct releases to the atmosphere, and human mercury exposure patterns, is complex. It might prove impossible to implement uniform economic instruments, such as a cap-and-trade scheme or mercury release taxes, across all (or many) sectors in society. For certain major source categories (*e.g.* coal combustion, waste incineration, some manufacturing industries and non-ferrous metal extraction), a common cap-and-trade scheme could probably work.

39. Any local problems stemming from facilities that prefer to pay instead of reducing their releases, should be addressed according to the exact local environmental impacts and other political priorities. Ways of addressing such problems include combining economic incentives with minimum reduction requirements (as is currently being done in Norway for waste incineration facilities).

40. Other instruments would probably still be needed in parallel to incentive-based instruments (*e.g.* information needs, separate waste collection and treatment, regulations on management of mercury-containing solid and liquid combustion residues, etc).

41. A thorough analysis of the effectiveness and economic efficiency of incentive-based instruments such as “cap-and-trade” programmes versus traditional “command-and-control” instruments has not been possible within the framework of this project. On mercury, most experience has been gained so far with a command-and-control approach (emission limits, bans, BAT requirements etc.). For point sources, emission limits are often set based on assessments of local pollution loads. Cap-and-trade approaches should in principle achieve the desired overall (*e.g.* national) release reductions with the least cost, because the abatement efforts will be directed to the facilities/operations where they are most cost-effective.<sup>1</sup> On

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1. SO<sub>2</sub> and NO<sub>x</sub> emissions in the US are controlled by cap-and-trade systems. In 2005, SO<sub>2</sub> emissions from electric power generation in the US were more than 5.5 million tons below 1990 levels. NO<sub>x</sub> emissions were down by about 3 million tons below 1990 levels. The program’s emission cuts have reduced acid deposition and improved water quality in US lakes and streams. Chestnut and Mills (2005) estimated the value of the programme’s human health and environmental benefits in the year 2010 to be \$122 billion annually (2000\$). Most of these benefits result from the prevention of air quality-related health impacts,

the other hand, effective enforcement of a cap-and-trade programme requires a generally well-controlled and transparent economy, as well as public administrative capacity adequate to control and enforce compliance.

#### **2.4 Regional and global aspects of instruments targeting mercury**

42. All three countries investigated in country studies see international co-operation as an important part of reducing mercury deposition and associated adverse effects on their territory, as well as regionally and globally. This is because all three countries have pursued mercury release-reductions nationally for several decades and still observe a need for reductions in order to mitigate adverse impacts from mercury due to the global cycling of mercury in the atmosphere.

43. In general, countries have historically designed their instruments profile on mercury to primarily address national impacts from mercury pollution, and secondarily to address regional impacts.

44. As regards the regional dimension, all three case study countries are, for example, parties to the Convention on Long-range Transboundary Air Pollution (CLRTAP) and its 1998 Heavy Metals Protocol (which entered into force in December 2003). The heavy metals protocol addresses transboundary air pollution of heavy metals, including mercury. Earlier CLRTAP protocols address emissions of acid gasses, SO<sub>x</sub>, NO<sub>x</sub>, etc., the reduction of which has also driven substantial mercury release reductions (due to co-benefits of reduction technologies). The CLRTAP currently relates to the European region and North America.

45. Norway and Sweden are close to their common goal of a total elimination of anthropogenic mercury releases and still aim at even further reduction. They have thereby also contributed significantly to regional, as well as global, mercury release reductions (see Chapters 3 and 4). The US has also achieved substantial mercury release reductions and has thereby also contributed significantly to regional and global reductions; the US EPA has calculated that the country only contributes a few percent of the global atmospheric releases of mercury. Significant domestic release sources exist, however, which are still considered in the US to warrant the investment in further reduction efforts (see Chapter 5).

46. All three case study countries receive significant portions of the mercury deposition on their territories from sources abroad – from regional sources and the global mercury pool.<sup>2</sup> As mentioned, they still observe mercury concentrations in their environment at levels which motivate them to pursue mercury reductions further. Determining how far a country should pursue mercury deposition reductions is fundamentally a political question, which is summarised in Section 2.5.

47. As mentioned, Norway and Sweden also focus on promoting mercury release reductions abroad to further reduce mercury exposures on their own territories. All three case study countries currently make substantial investments and efforts in promoting regional and global mercury reductions.

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such as premature deaths and workdays missed due to illness, but they also include improved visibility in parks and other recreational and ecosystem improvements.

2. For example, US anthropogenic mercury emissions are estimated to account for roughly 3% of the global total, and emissions from the US power sector are estimated to account for about 1% of total global emissions (UNEP, 2002). EPA currently estimates that less than half of all mercury deposition within the US comes from US sources. This proportion, however, varies by region. For example, US sources represent a greater fraction of the total deposition in parts of the Northeast, because of the direction of the prevailing winds.

48. The mercury retirement policies mentioned above, which are aimed at reducing the global mercury supply, are examples of instruments implemented by the three case study countries to focus on the global dimension of the mercury problem.

49. The Nordic countries, including Norway and Sweden, and the European Union (of which most Nordic countries are members), hold the position that mercury release reductions should be addressed in a global agreement due to the global cycling of mercury in the environment, and because mercury and mercury-containing products are globally traded commodities. The US prefers other options for international mercury reductions. The issue is currently discussed in global fora, particularly in the Governing Council of the United Nations Environmental Programme (UNEP).<sup>3</sup>

## **2.5 Determining benefits and costs of introducing instruments to reduce mercury emissions**

50. A fundamental question for a country considering how far to go as regards implementation of mercury reduction instruments could be: What level of risk from mercury contamination is acceptable to this society? To try to answer this question, it is necessary to: 1) understand the human health and environmental risk associated with various levels of mercury-exposure; 2) determine whether people or ecosystems are exposed at levels that may cause these adverse effects, and the extent and magnitude of such exposures; and 3) decide what level of exposures, and what costs for reducing the exposures, the society in question can accept.

51. The level of exposure capable of causing adverse effects is relatively well established for mercury (and the most critical mercury compound, methylmercury) compared to many other toxic substances.<sup>4</sup> The most advanced work of translating these scientific findings into “steering points” for policy formulation is probably the so-called *Reference Dose*, used by US EPA as a threshold level.<sup>5</sup> The *Reference Dose* is currently also globally among the lowest reference levels (or assessment levels) used for methylmercury.

52. As regards which level of risk a society is prepared to accept, it is necessary to consider which benefits (environmental, etc.) can be achieved by implementing pollution reduction actions, and at what costs (economic, social, etc.). The first observed environmental risks may appear so significant that most countries would be prepared to initiate abatement measures with minimal prior economic assessment (as was the situation a couple of decades ago in some of the case study countries). In societies with basic pollution abatement measures already implemented, any additional measures are today normally undergoing some level of impact assessment, where environmental, economic and social consequences of the investigated options for abatement are investigated. As one element of this, during the last few years, new studies, including several related to the US CAMR regulation for power plants, have attempted to estimate major cost elements of the damages from mercury pollution to allow comparisons with estimates of costs of mercury emission reduction instruments.

53. So far, relatively few instruments regarding mercury reductions have undergone comprehensive, publicly available impact assessments prior to their adoption. How such impact assessments are performed

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3. See [www.chem.unep.ch/mercury](http://www.chem.unep.ch/mercury).

4. Methylmercury is the most relevant substance in this respect, because exposure of methylmercury with fish/aquatic foods is considered the most critical adverse effect from mercury in the general population. Mercury from human and natural sources is transformed to methylmercury by micro-organisms in the nature and is accumulated up the aquatic food chain.

5. “An estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. ...” See [www.epa.gov/iris/gloss8.htm#r](http://www.epa.gov/iris/gloss8.htm#r).

depends greatly on: 1) the presence and approach of any general legal or procedural requirements for the introduction of new instruments (laws, regulation, etc.); and 2) the societal and political conditions under which an instrument and an associated impact assessment are considered. While some such impact assessments are mostly qualitative or semi-quantitative assessments, describing the major elements of benefits and costs, others establish aggregated monetised estimates of costs and benefits, in which the environmental benefits of the instrument are quantified in terms of saved costs from reduced effects on health and the environment. The latter analyses tend to be relatively complex, warranting further methodological development, and they are associated with substantial uncertainties. They have the advantage of a high level of aggregation (for example, one figure showing the total net benefit), which may be very operational in a political setting, along with the potential disadvantage that uncertainties and important nuances may be obscured because of the apparent completeness signalled by one or a few numbers or indicators. Based on current trends, the aggregated monetized type of impact assessment may likely become more dominant in the future.

54. In the Norwegian assessment of environmental costs of waste incineration, ECON (2000) states that the different methods used for cost estimation for environmental effects have a tendency to produce different and sometimes highly variable results. This indicates, in their opinion, that the derived cost estimates include uncertainty. This uncertainty may be caused by lack of knowledge regarding adverse effects of pollutant releases, difficulties in estimating how people value these effects, or how much society is willing to pay to reduce or avoid the effects. The fact that the scope of different study varies – covering *e.g.* only human health impacts or (also) environmental impacts more broadly – can also explain some of the differences in estimates made.

55. The preamble to the final *Clean Air Mercury Rule* issued by the US EPA (US EPA, 2005a) states the following concerning general uncertainties and limitations of economical evaluation of environmental effects:

“Every benefit-cost analysis examining the potential effects of a change in environmental protection requirements is limited to some extent by data gaps, limitations in model capabilities (such as geographic coverage), and uncertainties in the underlying scientific and economic studies used to configure the benefit and cost models. Gaps in the scientific literature often result in the inability to estimate quantitative changes in health and environmental effects. Gaps in the economics literature often result in the inability to assign economic values even to those health and environmental outcomes that can be quantified.”

56. The following paragraphs provide brief examples of different approaches for impact assessment used for instruments on mercury.

57. For the proposal of a general ban of mercury sales, use, imports and exports in Sweden (see section 4), an impact assessment was made for all existing mercury-related activities that would be affected by the ban (KEMI, 2004). The assessment included a qualitative and, for some elements, a semi-qualitative description of the impacts of the proposed ban. The study assesses benefits at an overview level and provides quite detailed background information indicating the cost levels for each of the affected sectors. An aggregated monetised cost estimate, however, is not calculated. The report states that, besides forming the background for overall consideration of the ban, the assessment was used to determine suitable sector-specific transition periods, during which exemptions would be given to allow affected sectors to adjust to the proposed ban with minimal/reduced costs. The assessment concludes that “the impacts of the proposal on companies and users will ... be in reasonable proportion to the positive effects the proposal will have on the environment” [see KEMI (2004) for further details].

58. A Norwegian estimation of costs of adverse effects of waste incineration releases (see Chapter 3) discusses emissions of several pollutants from this sector [see ECON (2000)]. The estimated damage cost per gram mercury released from waste incineration is exposure-scenario-specific (*i.e.* specific for waste

incineration under conditions prevalent in Norway). The cost was assessed to be NOK 27 (in the order of 3€) per g mercury, which appears from the report to be a low-end estimate. The methodology used is based on relative indices for environmental effects between different hazardous substances developed based on life-cycle analysis. The exact background for the data is not presented in ECON (2000), so it is difficult to make a deeper evaluation of the derived cost estimate and how/if this includes specific and updated data on mercury's adverse effects, a field which has experienced rapid developments since the mid 1990s [see ECON (2000) for further details].

59. The impacts of the US *Clean Air Mercury Rule* (see Chapter 5) have been assessed in (at least) two detailed studies [see US EPA (2005) and Rice and Hammit (2005)]. Of these, only US EPA's assessment estimated the costs of the implementation of the Rule (around 500 million US dollars per year; varying with scenarios and between years in the period 2010-2020). Both studies estimated the national benefits, monetised in US dollars, of quite similar scenarios for mercury release reductions in coal-fired power plants in the United States. The studies, both of which appear comprehensive, are examples of how the results of cost assessments of an environmental problem can vary depending on the approach used in the assessment. US EPA (2005) estimated the benefits of reduced IQ loss from neuro-developmental effects of prenatal exposure to methylmercury at 0.2 - 3 million US (1999) dollars per year, depending on the release-reduction scenario assessed. Rice and Hammit (2005) estimated the same benefits of at USD 75-288 million per year, depending on the release-reduction and exposure scenario assessed. In addition, Rice and Hammit (2005) estimated the benefits of reduced cardiovascular effects of exposure to methylmercury (an effect which is determined with less certainty than neuro-developmental deficits) in the US at USD 48 - 4,900 million per year, depending on the release reduction scenario, the exposure scenario, and the monetisation principle assessed (see original reference for details).

60. An in-depth evaluation of the differences in predicted benefits from reduced neuro-developmental deficits has not been possible within this project, but two clear distinctions are that the US EPA report focuses on a narrower target group of potentially exposed citizens and only on exposure through consumption of recreationally caught freshwater fish. The US EPA report states that it considers the major contributions included, but that the derived results likely underestimate the total benefits from reducing mercury emissions from power plants. Rice and Hammit (2005) state that the high-end estimates of their study are associated with higher uncertainty. It is important to note that neither of the studies quantified environmental benefits from reduced mercury exposure other than those mentioned here.

## 2.6 Questionnaire responses

61. As an initial part of this study, a questionnaire on instruments targeting mercury releases to air was sent to the 30 OECD member countries. Thirteen responses were received. Table 3 below gives an overview of how many countries reported examples of the main types of instruments mentioned in the questionnaire. The questionnaire responses were also used in the description of the in-depth case studies of selected countries.

**Table 3. Overview of questionnaire responses on main instruments addressing mercury.**

<b>Countries that reported that they had:</b>	<b>Number</b>
Examples of instruments addressing industries with intentional mercury use	11
Examples of instruments addressing activities mobilising mercury in raw materials etc., including carbon fuels	10
Examples of instruments addressing mercury emissions from waste incineration	11
Examples of instruments addressing separate collection of mercury-containing wastes	5
Examples of instruments addressing mercury emissions from the life-cycle of products	7
Examples of producer take-back requirements (specifically)	7

## 2.7 *Lessons learned on mercury instruments*

62. If a country should start from afresh today in the pursuit of mercury release reductions, it would be advisable to take an integrated approach from the beginning, based on a life-cycle management principle; *i.e.* looking at mercury throughput and releases from all phases of the life-cycle of each source category in order to target mercury reductions in the most efficient and cost-effective way. If a total overview and a targeting of all major releases from the start is not possible, then target the major releases stepwise, but in an integrated, comprehensive plan.

63. Based other countries' experience in identifying mercury release source categories, quantification of mercury releases, and development of measures/instruments targeting mercury release reductions, such work can be done with less effort and investments today. Generally, identification of mercury release sources in a country and rough quantifications of the releases from major source categories will be required as part of the priority setting at an early stage. Assistance for this aspect has been provided through UNEP Chemicals' *Global Mercury Programme* in the form of the "Toolkit for identification and quantification of mercury releases" with descriptions of proposed methodologies, extensive information on release source categories, and a spreadsheet for calculating first estimates of mercury releases.<sup>6</sup>

64. Next steps could be to define and implement environmental permits to point sources or to introduce an incentive-based approach, if feasible (see discussion in Section 2.3). Environmental permits would usually describe conditions and principles for pollution abatement (including all relevant potential environmental impacts) for the specific facility, typically including release limits and requirements for use of environmentally best available techniques (BAT). National (or regional) sector guidelines giving general advice on limits, BAT, etc. might be useful tools for establishing such environmental permits. Examples of such guideline documents are the EU BREF documents, which can also be of relevance for other geographical areas than Europe.<sup>7</sup> Where possible and feasible, solutions that lead to reductions in emissions of several pollutants may be preferred.

65. Final steps in implementation could include – again based on an integrated approach and overview – instruments addressing minor or diffuse sources, including products and materials with significant mercury contents. Also here, extensive help can be found in existing initiatives and experience from other countries or regions.

66. Ensuring adequate procedures and capacity for monitoring progress and enforcing compliance to the implemented instruments are an indispensable part of pursuing pollutant release reductions. These aspects however are beyond the scope of the descriptions in this study.

## 3. **Instruments addressing mercury emissions to air in Norway**

### 3.1 *Introduction*

67. Norway is among the countries globally with an ambitious mercury regulation. Mercury release reductions have been a national priority for the last 20 years. Norway's extensive focus on eliminating mercury releases is motivated by the observation that mercury is an extremely dangerous pollutant and currently represents a threat to the environment and human health in Norway and globally. Global releases of mercury are rising, and the pollution does not stop at national borders. In the Arctic, where there are no local sources of mercury, current levels of mercury pollution are a threat to health and the environment, and the pollution load is increasing.

6. Available at [www.chem.unep.ch/mercury/Toolkit/default.htm](http://www.chem.unep.ch/mercury/Toolkit/default.htm).

7. See <http://eippcb.jrc.es/pages/Fmembers.htm> or <http://eippcb.jrc.es/>.

68. Norway has set ambitious targets for reducing mercury releases. Mercury releases are to be substantially reduced from the 1995 level by 2010, and the use and releases of mercury are to be eliminated within one generation, *i.e.* by 2020.

69. By 2003, Norway's releases had been reduced by 60% since 1995. Further action will be required to ensure that the national targets are achieved. Mercury pollution in Norway is caused both by national emissions and by long-range transport of pollution. Thus, to reduce the total pollution in Norway, both international efforts and steps to reduce Norwegian releases are necessary.

70. The Norwegian Ministry of Environment has adopted an *Action Plan* to intensify actions to deal with mercury pollution.<sup>8</sup> The *Action Plan* identifies important steps to eliminate mercury releases as far as possible, both in Norway and internationally.

71. Norway is not a member of the EU. Norway must, however, meet EU environmental regulation as a consequence of the *European Economic Area Agreement* with the EU. Much of the Norwegian environmental regulation therefore implements EU legislation, but in several cases Norway applies stricter regulation than the EU.

72. Besides the directly referenced information provided here, substantial information provided in the Norwegian questionnaire response to this study was used in the description.

### **3.2 Overview of instruments addressing mercury**

#### **3.2.1 Point-sources**

73. Emission limits in discharge permits issued pursuant to Norway's *Pollution Control Act* are the most important tool for reducing mercury releases from the manufacturing sector. This regulation prescribes maximum allowable releases of mercury (and other pollutants) from industrial facilities to the environment (air, water and soil/groundwater). These sources of mercury to the environment are generally termed "point sources". The releases from such point sources are regulated individually on a basis of national standards or guidelines. In addition, several industrial plants are covered by BAT requirements of the EU IPPC directive (EU, 1996).

74. Mercury is a by-product in the *production of zinc*. There is one zinc production site in Norway. The mercury residue from this site is considered as hazardous waste, and is cemented in sarcophagi and placed in bedrock at the production site. There are no emissions of mercury from this activity.

75. Mercury emissions come from the production of *ferromanganese and other manganese alloys*. There are four such production sites in Norway. All manganese ores have traces of mercury, but one of the commercial types of ore is substantially more contaminated than the others. The producers in Norway must apply for discharge permits for mercury. Conditions set in discharge permits for ferro-manganese producers require them to install equipment to control mercury emissions if the ore they use has too high a content of mercury.

76. Strict mercury emissions limits have been set for secondary steel manufacturing. However, in order to ensure equal conditions for competition with EU actors in the same industry, these requirements will enter into force when EU countries adopt the regulation for the sector (SFT, 2006).

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8. See [www.sft.no/arbeidsomr/kjemikalier/kvikksolv/mercury\\_actionplan.pdf](http://www.sft.no/arbeidsomr/kjemikalier/kvikksolv/mercury_actionplan.pdf).

77. Norwegian *chlor-alkali* plants have changed from mercury-cell technology to diaphragm and membrane technology, thereby eliminating mercury releases from this sector. This is a general trend in OECD countries, but Norway is ahead of many countries in this aspect.

78. Crematoria have purification requirements on the emissions of Mercury since 1 January 2003. For units existing before this date, the regulation entered into force from 1 January 2007.

### 3.2.2 *Products and other diffuse sources*

79. Legislation is in place preventing certain products containing mercury from being marketed nationally.

80. *Thermometers*: The trade of mercury-containing thermometers for both consumer and professional use was banned in 1998 (Order of 26 March 1998).

81. Norwegian regulations on scrapped *electrical and electronic products* came into force in 1998. Similar regulations are now included in the EU RoHS and WEEE Directives.<sup>9</sup> The RoHS Directive sets limits for allowable mercury contents in certain electrical and electronic devices. The WEEE Directive prescribes how the wastes of such products should be handled due to environmental considerations. Norwegian national regulation on waste comprises more products than the WEEE Directive; e.g. industrial electrical and electronic equipment waste.

82. Norwegian regulations of *batteries* came into force in 1990. Similar regulations are now included in the EU Battery Directive (1991) with later revisions, setting limits for allowable mercury contents in batteries and requiring the labelling and separate collection of the same.

83. There is no ban of mercury in *paints*. However, no amounts are registered for use in the Norwegian Product Register. There is a ban on use of mercury compounds in antifouling preparations and wood preservatives since 1994.

84. *Pesticides* must be authorized for use in Norway. Although there is no general ban on mercury, mercury-containing products for pesticide use have not been authorized since 1992.

85. *Dental amalgam*: The dental clinics must collect remaining amalgam and amalgam as waste by a filter device before the waste water enters into municipal sewage systems. The waste must be delivered to reception stations for hazardous waste. This measure came into force in 1998. Filter devices must retain 95% of the amalgam. This measure came into force in 2006. National guidelines have been developed for the use and disposal of dental amalgam.<sup>10</sup>

86. Legislation set limits on mercury content in *packaging materials* as a result of the EU packaging directive (EU, 1994), which aims to enhance packaging materials recycling/energy recovery and limit the flow of heavy metals to waste treatment and resultant environmental releases (among other aims; ACAP, 2004).

87. *General instruments for products and materials* containing chemicals (including mercury) in Norway include a general substitution requirement (to substitute with less hazardous substances whenever

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9. *Restriction of the use of Certain Hazardous Substances in Electrical and Electronic Equipment Directive and Waste Electrical and Electronic Equipment Directive*, see EU (2002a) and (2002b).

10. See [www.shdir.no/vp/multimedia/archive/00001/IS-1136\\_1661a.pdf](http://www.shdir.no/vp/multimedia/archive/00001/IS-1136_1661a.pdf).

possible), general labelling requirements (for contents of hazardous substances) and various information activities targeting specific industry sectors and/or the general public (SFT, 2006).

88. Norway has proposed a national general prohibition on the production, import, export, marketing and use of mercury and mercury-containing products. The proposal has been notified to the European Commission and the WTO. The Norwegian Ministry of Environment expects such a ban to enter into force in 2007.

### 3.2.3 Waste management

89. The Norwegian legislation prescribes separate collection and environmentally sound waste treatment of products and process waste containing mercury such as batteries, electric articles, fluorescent light tubes and dental amalgam filter residues.

90. Collection of scrapped electrical and electronic products has been covered by national regulation since 1999. This was later implemented with the EU RoHS and WEEE Directives. Norwegian national regulation on waste comprises more products than the WEEE directive – e.g., Norwegian regulation also includes industrial electrical and electronic equipment waste.

91. Treatment facilities for end-of-life vehicles are required to remove components that contain mercury from all vehicles. Until 2007, the collectors receive subsidies supporting this activity from the Norwegian Pollution Authority (SFT). From 2007 this obligation is part of the obligations of the take-back system set up in accordance with the EU Directive on End-of-Life Vehicles, cf. EU (2000). The components are delivered to a plant for hazardous waste deposition.

#### Producer take-back requirements

92. An overview of take-back requirements for products that may contain mercury is given in Table 4.

**Table 4. Overview of take-back requirements for products which may contain mercury.**

Product category	Share required to be taken back			Organisation of the take-back system			Financing of the take-back system					
	> 80%	50-80%	< 50%	Individual collection	Voluntary participation in a PRO	Obligatory participation in a PRO	No separate financing	Fee on all products within the product category	PRO fees based on the market share of each firm	PRO fees based on the recycling costs of each product	Public subsidies	Other
EE-waste (incl. fluorescent lamps)	X			X 2)	X 2)			X				
Batteries		X				X		X				
Vehicles	X					X 1)		X				

Source: Norwegian questionnaire response.

1) Partly from 1 July 2002, completely from 1 January 2007 (End-of-life Directive).

2) Individual collection or participation in Produce Responsibility Organisations (PROs) for EE-waste.

*Sewage sludge*

93. There is legislation prescribing maximum allowable concentrations of mercury in wastewater sludge used as fertiliser on agricultural land (3 mg per kg total residue) and on other areas (5 mg per kg total residue). It is not allowed to use wastewater sludge on agricultural land with soil containing more than 1 mg per kg total residue (ACAP, 2004).

*Hazardous waste treatment including incineration*

94. Waste containing more than 0.25 % mercury is treated in accordance with the legislation for hazardous waste. Generally hazardous waste containing mercury is disposed of in an authorized landfill for *inorganic* hazardous waste.

95. The release of mercury from incineration plants for medical and household wastes is restricted by specified emission limits in their permits. All municipal incineration plants have 0.03 mg/Nm<sup>3</sup> mercury as emission limit. This stringent limit was in force from 01.01.2003 for new facilities incinerating medical and hazardous wastes. Before 01.01.2006, this limit will be in force for all existing incinerators. The new limits are more stringent than in the EU. From 1.1.2003, ashes and slag are on the European Union waste list and are considered hazardous waste if contains hazardous substances. For mercury, the limit is (as mentioned before) 0.25% (see ACAP, 2004).

*Incineration of municipal waste*

96. Emissions of mercury are low in Norway, but are still considered to be relatively significant. Norwegian atmospheric emission limit values for mercury from municipal waste incineration (0.03 mg mercury per Nm<sup>3</sup> flue-gas) are lower than required by the EU Waste Incineration Directive 2000/76/EC (0.05 mg mercury per Nm<sup>3</sup> flue-gas).

97. As a unique aspect globally, Norway has introduced a tax on the atmospheric emissions from incineration of municipal waste in order to give operators of the plants economic incentives to reduce emissions of mercury and a number of other pollutants beyond the already strict limit values (Norwegian questionnaire response, 2006; SFT, 2006). See further description of this tax in the next section.

**3.3 More information on the tax on mercury releases from waste incineration**

98. In 1999, Norway introduced general taxes on municipal waste based on tonnes of waste treated by incineration, deposition or other methods. The tax combined a basic tax (75 NOK per tonne) for all waste incineration and an additional tax depending on the level of energy generation from the incineration (0-225 NOK per tonne waste). This tax resulted in reduced waste generation, increased materials recycling, decreased waste deposition, and somewhat better energy recovery. This may have had indirect effects on atmospheric mercury emissions.

99. From 1 July 2004, the tax on incineration of waste was changed into a tax on measured or estimated emissions of a number of substances, including mercury. The tax rate for atmospheric mercury emissions were set at 27 NOK per g mercury emitted, based on assessments of the costs of mercury's adverse environmental impacts [SFT (2006); assessment by ECON (2000) and (2000)]. The tax rate is being price adjusted annually. In 2006, the national environmental authority (SFT) reviewed the tax on all substances and found that no relevant, available material suggested that a change in the level of the tax was needed. The tax rate on mercury was introduced to promote implementation of release-reduction equipment on the waste incineration plants earlier than required by the EU *Waste Incineration Directive*. The Directive had a relatively long transition period for existing incineration plants. In economic terms, the tax internalises the environmental costs of mercury-releases from the incineration plants.

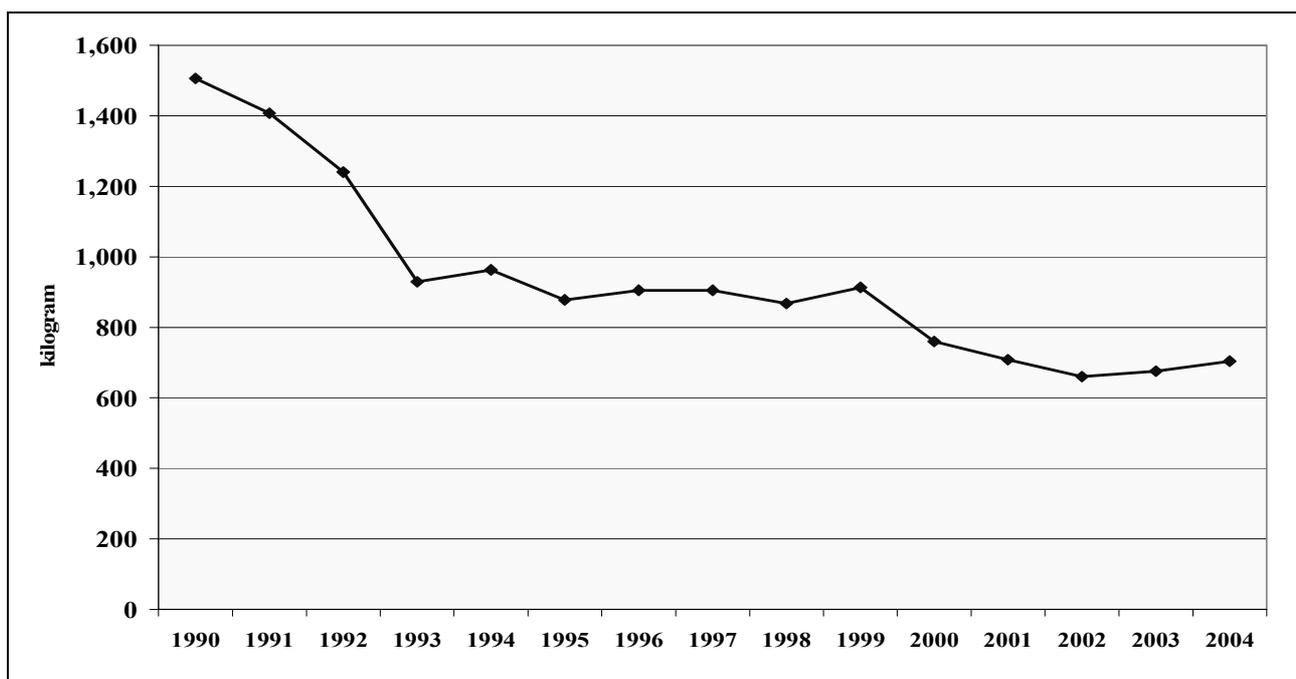
100. While combining emission limits and the emission tax may be valid for environmental reasons, it could be argued that the tax instrument would have been more economically effective (at least in the national perspective) if a less restricted use of incentives had been allowed, to direct the investments to facilities where release reductions could have been achieved at lowest costs.

101. According to sources interviewed during the case study, there have been some considerations concerning the exemptions to the tax. At present, the tax principally includes incineration of *municipal waste*. The disadvantages of including the incineration of *hazardous wastes* were considered too large. Due to concern for negative sectoral competitiveness impacts, Norway has not considered including mercury emissions to air from industry in the tax. It was also stated that existing pollution permits for mercury cover these sources well already.

### 3.4 Environmental impacts of instruments

102. Figure 2 illustrates that mercury emissions to air in Norway decreased from 1,500 kg in 1990 to 660 kg in 2002. However, the emissions increased to 700 kg in 2004, *inter alia* due to an increase in metals production between 2002 and 2004.

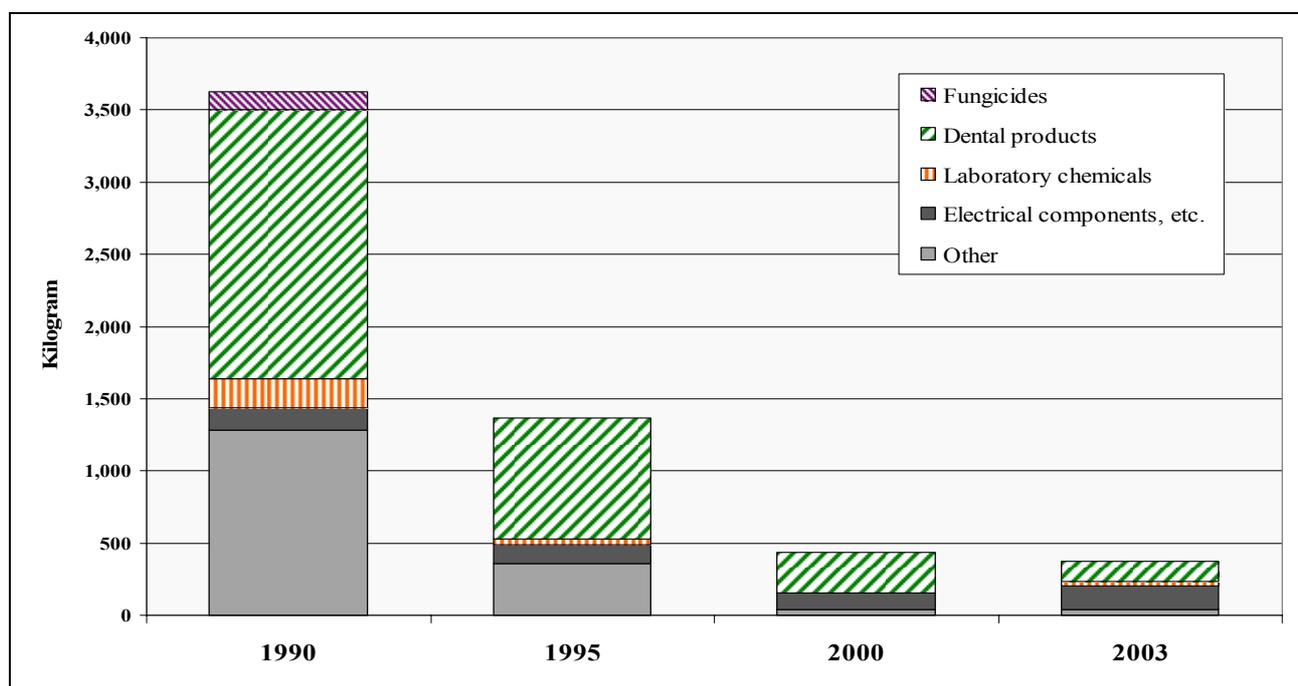
**Figure 2. Emissions to air of mercury in Norway**  
Kilogram, 1990 - 2004.



Source: Statistics Norway and [www.environment.no](http://www.environment.no).

103. Figure 3 shows that the use of mercury in products in Norway decreased from more than 3,600 kg in 1990 to 370 kg in 2003. Most of the reduction stem from dental products and “other” products. The use of mercury in electrical components, etc., was at the same level in 2003 as in 1990.

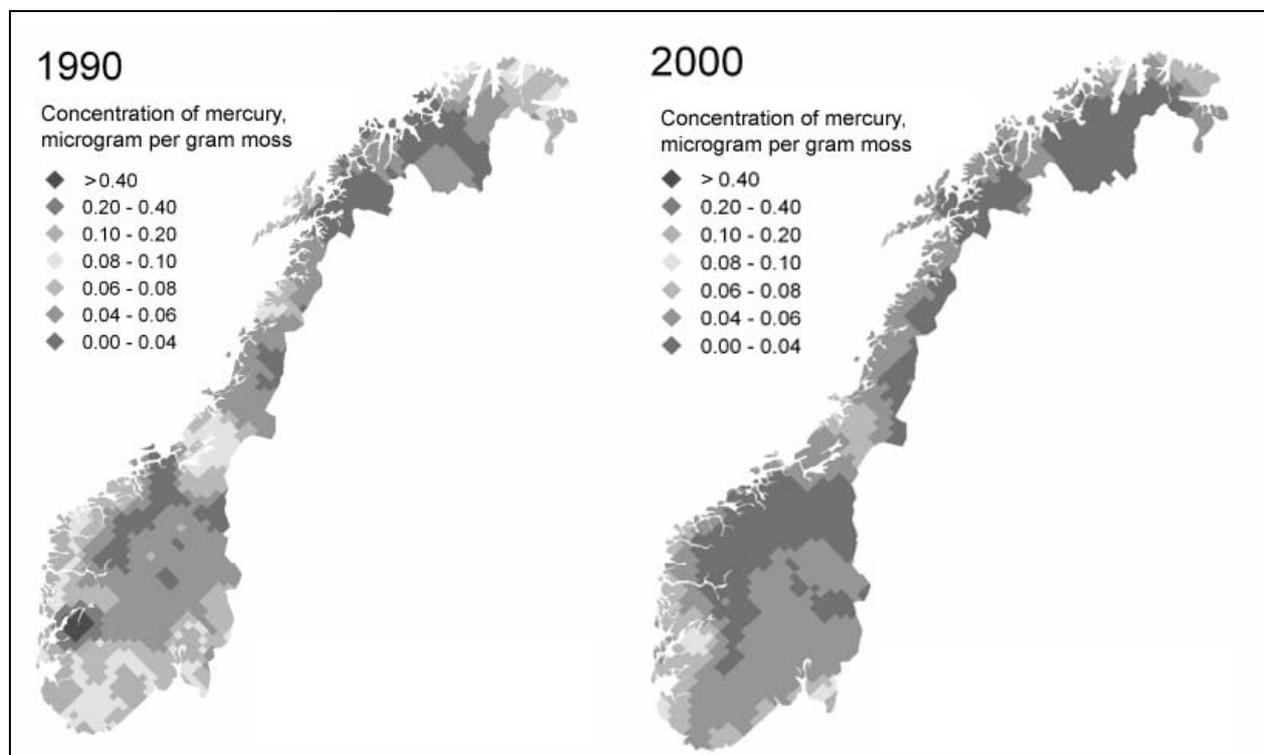
**Figure 3. Use of mercury in products in Norway**  
Kilogram, 1990 - 2003



Source: Statistics Norway and [www.environment.no](http://www.environment.no).

104. Changes in mercury depositions over Norway are illustrated in Figure 4. The Figure shows concentrations of mercury per gram of moss in different parts of the country and indicates that very significant reductions in these concentrations have occurred in many parts of the country.

**Figure 4. Concentrations of mercury per gram of moss in different parts of Norway  
1990 and 2000**



Source: [www.environment.no](http://www.environment.no).

#### 4. Instruments addressing mercury emissions to air in Sweden

##### 4.1 Introduction

105. Sweden is among the countries globally with the most ambitious mercury regulation, and Sweden was one of the countries which initiated international co-operation on mercury release reductions several decades ago. Mercury has been a target for political decisions in Sweden for a long time due to findings of high levels of mercury in the environment. Thousands of Swedish lakes contain fish with mercury levels above the limit value set by the World Health Organisation (0.5 mg mercury per kg fish). The overall aim for Swedish policy is to reduce the levels of mercury in the environment to normal background levels. In the 1960s, most of the work on this issue was related to reducing emissions from point-sources. This was not enough to achieve this target, and it was concluded that stopping the use of products and processes, and international measures were needed, as most of the mercury deposited in Sweden is coming from other countries.

106. The Swedish Government and Parliament decided in the early 1990s to reduce the use of mercury in products – mainly by regulatory means, but also supported by voluntary measures, with the *ultimate aim of a total phase-out*. The official policy on mercury has led to an awareness and acceptance in Swedish industry and society to avoid mercury, and between 1992 and 2003 approximately 95% of the sold amounts of mercury in products were phased out. A national goal adopted by the Government and Parliament in 2000 stated that mercury in products and industrial processes should be phased out as far as possible by 2003 (changed in 2004 to “as soon as possible, but latest by 2007”). According to present goals, remaining mercury use in the chlor-alkali industry will be allowed until the end of 2009.

107. The Swedish strategy to achieve a "mercury-free environment" consists of measures to reduce the input of mercury into society by imposing a ban on it in different products and processes, collect mercury from the so-called "hidden mercury store" and to implement a terminal disposal of mercury. Mercury should not be recycled but should be disposed of terminally in a safe and environmentally sound way. Substantive actions are also taken to restrict emissions of mercury to air, land and water. The principles of precaution and substitution guide the policy on mercury – and policy on hazardous substances in general – and are legal requirements under the Swedish Environmental Code.

108. In spite of substantial reductions in domestic mercury releases and examples of reduced mercury concentrations in some Swedish lakes, an accumulation of mercury in top soil is still observed. An important reason for this is that mercury released from sources abroad is still deposited on Swedish territory. This is the background for the continued efforts made by Sweden to reduce mercury releases internationally (Swedish EPA, 2006).

109. Preservation of nature has been a major motivation for controlling mercury pollution in Sweden, and it has had a major influence on how mercury has been prioritised and targeted with instruments over the past several decades. Nature is an important aspect of peoples' life in Sweden. For example, many people appreciate being able to catch and eat their own fish, and this may have helped in getting political support for protection of the environment, including for abating mercury pollution.

110. The Swedish Parliament decides the *Environmental Quality Objectives* in Sweden (based on proposals from the Swedish Environmental Objectives Council). The overall political targets for environmental protection are reviewed and communicated in reports and pamphlets dedicated for this purpose and in other media at least every four years (once in every Government period) by the Swedish Environmental Objectives Council. Presently, the Council has defined 16 main quality objectives for environmental protection. Interim targets are set for each quality objective, and there are 9 interim targets concerning hazardous substances, such as mercury, under the *Environmental Quality Objective* "A Non-Toxic Environment" (Swedish EPA, 2006).<sup>11</sup>

111. Sweden has been a member of the EU since 1995. Sweden has, however, had stricter legislation on mercury than the EU since the early 1990s, when a national regulation entered into force that prohibits certain mercury-containing products. As of 1 July 1997, mercury and chemical compounds, and preparations containing mercury, may not be commercially exported from Sweden. The EU *Mercury Strategy* [see European Commission (2005)], which discusses most of the mercury issues at stake here, proposes certain instruments in line with Swedish priorities on mercury, or otherwise likely to affect Swedish policies on mercury in the coming years.

## **4.2 Overview of instruments addressing mercury**

112. Besides the directly referenced information provided in section below, substantial information provided in the Swedish questionnaire response to this study was used in the description here.

### **4.2.1 Point sources**

113. Point sources are regulated by the Swedish *Environmental Code* (1998:808; replacing the earlier the *Environmental Protection Act* (1969:387)). The specific point sources are regulated individually on the basis of national and European Union standards/guidelines. Discharge of pollutants from point sources to air, water and soil may in general not be undertaken without prior permission from a competent authority. In the permission procedure, firms are generally required to use "Best Available Techniques" (BAT). This

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11. See [www.miljomal.nu/english/english.php](http://www.miljomal.nu/english/english.php).

code implements the requirements of the EU IPPC Directive. Reference documents on Best Available Techniques have been developed in the EU context for a number of source categories relevant for mercury, such as chlor-alkali production (BAT is mercury-free techniques only), non-ferrous metal extraction and several others.

114. There is currently one *chlor-alkali plant* in Sweden that still uses the mercury cell process. The more environmentally friendly membrane process is used at one site. In line with the OSPAR<sup>12</sup> Decision 90/3 on phase-out of mercury cells in chlor-alkali plants, the Swedish Government has in several Bills stated that the amalgam process should be eliminated by the end of 2009 (ACAP, 2004, and UNEP, 2002).

115. Due to the use of dental amalgam, *crematoria* are one of the largest sources of mercury releases in Sweden today (about 110 kg per year). All larger crematoria have mercury-specific emission filters, mainly carbon filters in a number of different configurations. A sector guidance document on pollution abatement on crematoria describes the different emission reduction options and present experience with achieved reductions. The guidance document builds on an OSPAR background document on crematoria in combination with Swedish experience.

#### 4.2.2 *Products and other diffuse sources*

116. Legislation prohibiting certain products containing mercury from being professionally manufactured, sold, exported or imported is implemented through Government Ordinance 1998:944 and includes thermometers and other measuring instruments as well as electrical components such as switches, thermostats, relays, contacts and circuit breakers. Also, according to the Ordinance, mercury and chemical compounds and preparations containing mercury may not be professionally exported from Sweden. Additionally there are restrictions regarding batteries, packaging and end-of-life vehicles. Swedish product regulation for mercury has so far been stricter than common EU regulation for most mercury uses.

117. Besides limits/bans for *mercury content in batteries*, a marketing fee is charged on certain batteries containing mercury, cadmium and lead. The fee provides funding for separate collection and end treatment of spent batteries containing mercury, cadmium and lead (Swedish EPA, 2006).

118. Mercury-containing *chemicals* for analysis and reagents are used mainly in the environmental control, by its use of mercury sulphate in COD (chemical oxygen consumption) analyses. Information activities have been ineffective to phase-out this particular use (ACAP, 2004, and UNEP, 2002).

119. For *dental amalgam* a voluntary instrument was made in 1995 not to use amalgam for fillings in children's teeth up to the age of 19. In 1999, public dental care compensation ceased to pay for amalgam fillings (but not for mercury-free alternative fillings). In 2003, less than 2% of the total number of fillings were made with amalgam.

120. Sweden has proposed a *national general ban* on the marketing, use, exports and imports of mercury and mercury-containing products. The European Commission and the WTO have been notified of this proposal. This procedure is a formal requirement for members of the EU who wish to adopt national regulation stricter than the EU regulation of the same issue. Sweden is currently in the process of responding to the Commission's statements on the proposal (Swedish EPA, 2006).

121. Table 5 presents some of the major initiatives on mercury use that have been implemented in Sweden to achieve the 1990 overall goal of total phase-out of mercury.

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12. OSPAR: The Convention for the Protection of the Marine Environment of the North-East Atlantic, see [www.ospar.org/eng/html/convention/welcome.html](http://www.ospar.org/eng/html/convention/welcome.html).

**Table 5. Major initiatives on mercury use in Sweden**

Year	Source	Major initiatives on mercury use in Sweden
1979	Dental releases	A voluntary agreement was made with dentists associations, requiring all dental clinics to be equipped with amalgam separators.
1979	Seed dressings	The use of mercury-containing seed dressings was banned (SFS 1979:349).
1985	Biocides	Import, sale, transfer and use of mercury and mercury compounds as biocides were not approved (SFS 1985:836).
1990	Goal setting - phase-out	Government Bill 1990:91/90 proposed a numerous set of legislative and voluntary actions, with the ultimate aim of a total phase-out of mercury use.
1991	Dental amalgam	The overall goal of a phase-out of mercury also included dental amalgam, as a precautionary measure to minimise the exposure of these groups to metal mercury vapour. This led to a voluntary reduction of new amalgam fillings in children's teeth from 30 to 1.5% between 1991 and 1995. The use in adult's teeth decreased from 32 to 15%.
1992	Clinical thermometers	The import, professional manufacture and sale of clinical mercury thermometers were prohibited.
1993	Thermometers, measuring instruments and electrical equipment	Professional manufacture, import and sale of thermometers, level switches, pressure switches, thermostats, relays, electrical contacts and other measuring instruments were banned (Ordinance 1991:1290). Some exemptions, mainly for spare parts, still exist. (Ordinance 1998:944). Time-schedule for phase-out is stipulated for each exemption. (Regulation 1998:8)
1993	Goal setting – timing of phase-out	Government Bill 1993/94:163 set a goal of phase-out of mercury and mercury-containing products by the year 2000. After that date, mercury should be offered for sale only in vital products and for uses to which no alternative techniques were known or fully developed.
1995	Dental amalgam	An agreement was reached between the state and the county councils that amalgam should be phased out from children's and young people's dentistry as a precautionary measure to minimise the exposure of these groups to metal mercury vapour.
1998	Batteries	The EU Battery Directive that also applies in Sweden was amended in 1998. Batteries with mercury content in excess of 0.0005 % by weight are defined as dangerous for the environment and may not be marketed as such or incorporated into appliances. Button cells with a mercury content of no more than 2% by weight are exempted. The rules meant that mercury oxide batteries may no longer be sold – such batteries accounted for 700 of the 800 kg of mercury in batteries in 1997. The new rules led to a sharp reduction in sold quantities of mercury in batteries – in 1999, the amount of mercury in batteries sold is estimated to approximately 100 kg.
1998	Sewage sludge	In Ordinance 1998:944 the contents of heavy metals in sewage was regulated in cases where sewage sludge was sold or conveyed for agricultural purposes. Regulations for when, where and how much sludge may be used in agriculture are found in SNFS 1994:2 (changed SNFS 1998:4). At present the maximum content of mercury allowed in sludge is 2.5 mg per kg dry matter and the maximum application is 1.5 g per hectare and year.
1997	Export of mercury	As of 1 July 1997 mercury and chemical compounds and preparations containing mercury may not be commercially exported from Sweden. Also, mercury-containing measuring instruments and electrical components may not be exported (Ordinance 1998:944).
1999	Dental amalgam	Dental care compensation ceased to be paid for amalgam fillings, which made the cost for a composite filling and amalgam about the same for the patient. In 2003, amalgam was used for 0.05% of the fillings in children and young people and 1.8% of the fillings in adults in Sweden [see Keml (2004)].
2000	New products containing mercury Production processes	Bill 2000/01:65, Chemical Strategy for a Non-Toxic Environment requires that new goods put on the market should be, as far as possible, free from mercury by 2003, at the latest. Also, mercury should not be used in production processes, unless the producer can prove that neither human health nor the environment would be harmed.
2006	All product uses and production processes	Proposal of a national general ban on the marketing and use of mercury and mercury-containing products, export and import. The proposal has been notified to the European Commission and to the WTO.

Source: Based on ACAP (2004) and UNEP (2002).

#### 4.2.3 Waste management

122. Municipalities have the responsibility to set up collection schemes for hazardous household waste. Hazardous (mercury-containing) waste should not be mixed but collected separately and treated according to its properties. There are separate collection systems for batteries, fluorescent lamps, amalgam waste, waste electronic and electrical equipment and mercury devices in end-of-life vehicles (NMR, 2001).

123. For waste incineration, legislation prescribes maximum allowable releases of a number of pollutants to the atmosphere and wastewater, as well as specifics for depositing solid incineration residues (Ordinance 2002:1060). Swedish EPA Regulation (2002:28) implements the EU Waste Incineration Directive. There were laws and regulations in place before as well.

124. Between 1995 and 1999, the Government allocated almost SEK 30 million in subsidies to an action programme for the collection of mercury. This programme was implemented by the Swedish Environmental Protection Agency, in co-operation with the Swedish County Administrative Boards and the municipalities. The programme included projects for the inventory and collection of clinical thermometers, mercury in technical goods and products, and metallic mercury on shelves and in storerooms. Schools, universities and colleges have been purged of mercury. A project to identify hidden mercury in industry has also been carried out. The world's first mercury-tracking dogs were used in the projects. In addition, previously unemployed electricians were hired as "mercury hunters", with the task of identifying mercury in goods and products. The project included many awareness-raising activities, which were considered essential to reach a good result. As of late 2003, a total of 10-11 tonnes of mercury had been identified, 6-7 tonnes of which were collected. At that time, the Swedish EPA estimated that there were about 30 tonnes of mercury still left in technical products and goods that are either in use or in storage, as well as more mercury in households and agriculture (Swedish EPA, 2006).

#### *Producer take-back schemes*

125. Batteries, electronic and electrical waste (WEEE) are subject to producer take-back obligations. For small batteries it is not a real producer responsibility. Municipalities have the responsibility to set up collection schemes, and the producers are obliged to pay the cost of collection and treatment and other costs connected to the handling of discarded small batteries.

#### **4.3 More information on instruments addressing final storage of mercury waste**

126. The Swedish position is that mercury is a substance that remains a threat to human health and the environment in perpetuity, and for this reason it *should not be recycled*. Instead, mercury-containing waste should be dealt with in a permanently safe and environmentally acceptable way. Therefore, the Swedish Government has decided that waste containing more than 0.1% mercury shall be finally stored in a deep bedrock repository by 2015 (Swedish Ordinances (2001:1063) and (1998:899)).

127. The Swedish decision to ban mercury export is based on a conviction that countries should not export environmental problems. Very extensive investigations have been performed to identify the technically, environmentally and economically most feasible final storage depot, and several options have been under consideration. A deep rock depot in granite rock has been deemed the safest, and the costs for this approach were found to be defensible due to the political priority given to this project. Detailed economic analyses of the investment and operation costs versus the environment and health benefits have not been performed. The deep rock mercury depot will be run by a private company, under the responsibility (and with the funding) of the mercury waste owners (primarily a few large enterprises). It will be constructed and run according to requirements defined by the Swedish Environmental Court and will be controlled by the environmental authorities (Swedish EPA, 2006).

128. The possibility of establishing a common Nordic strategy for mercury containing waste was discussed in a working group under the Nordic Council of Ministers (Endre *et al*, 1999). Issues such as retirement of mercury versus re-marketing, and making common use of Nordic waste treatment facilities, were discussed. It was, however, concluded that common solutions were premature at that time, due to differences in short-term priorities.

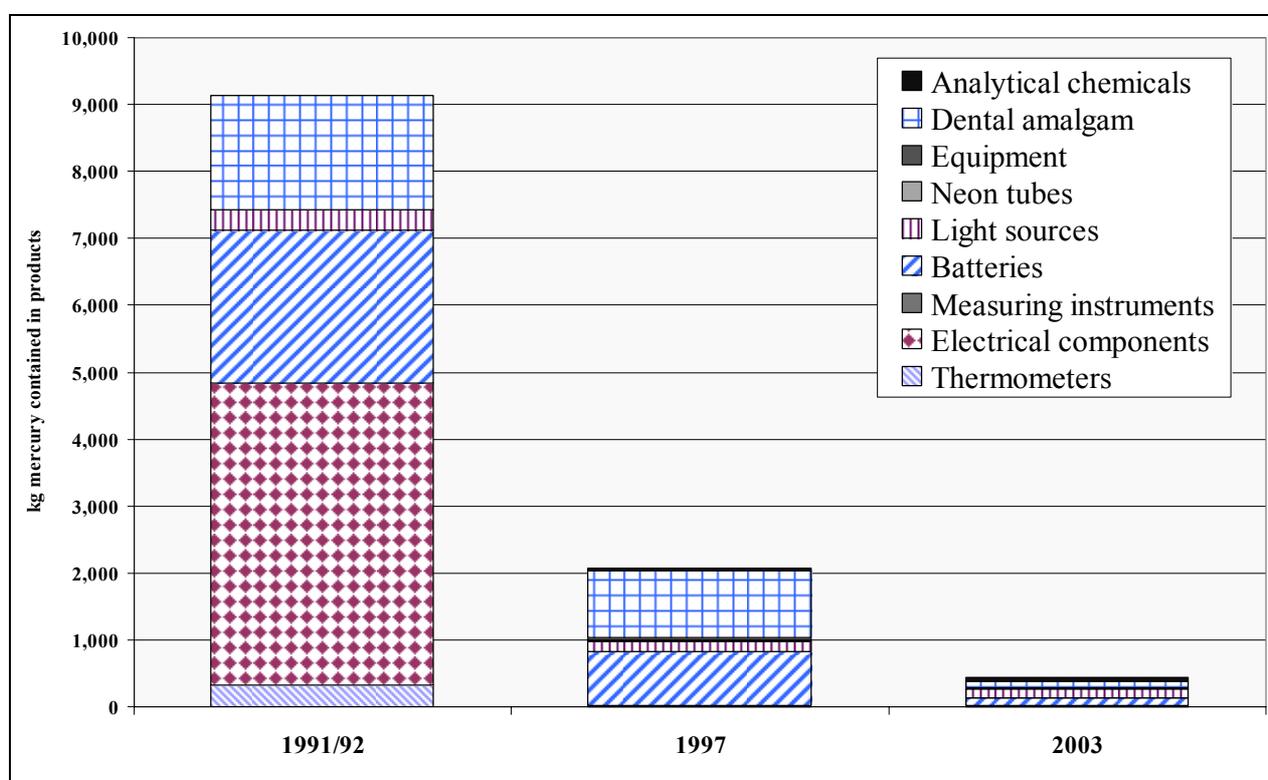
129. Establishment of the Swedish deep rock depot could potentially be reviewed depending of the outcome of current (spring 2007) EU negotiations about establishing temporary or final storage for excess mercury in conjunction with an EU-wide export ban for metallic mercury [see European Commission (2006a) and (2006b)].

130. The expected EU export ban (by 2011), including storage requirements, was proposed by the European Commission in October 2006, and it will now undergo negotiations in the Council and the European Parliament. An EU-wide mercury retirement and storage programme could perhaps result in common solutions between several countries.

#### 4.4 Environmental impacts of instruments

131. Figure 5 illustrates that the amount of mercury contained in products sold in Sweden in 2003 represented only a small fraction of the amount in 1991/1992. The reductions in consumption are closely linked to increased use of substitutes to mercury. UNEP (2002) points out that besides legislation, improvements in technological performance have also been driving forces behind the substitution of mercury in many uses.

Figure 5. Amounts of mercury contained in products sold in Sweden

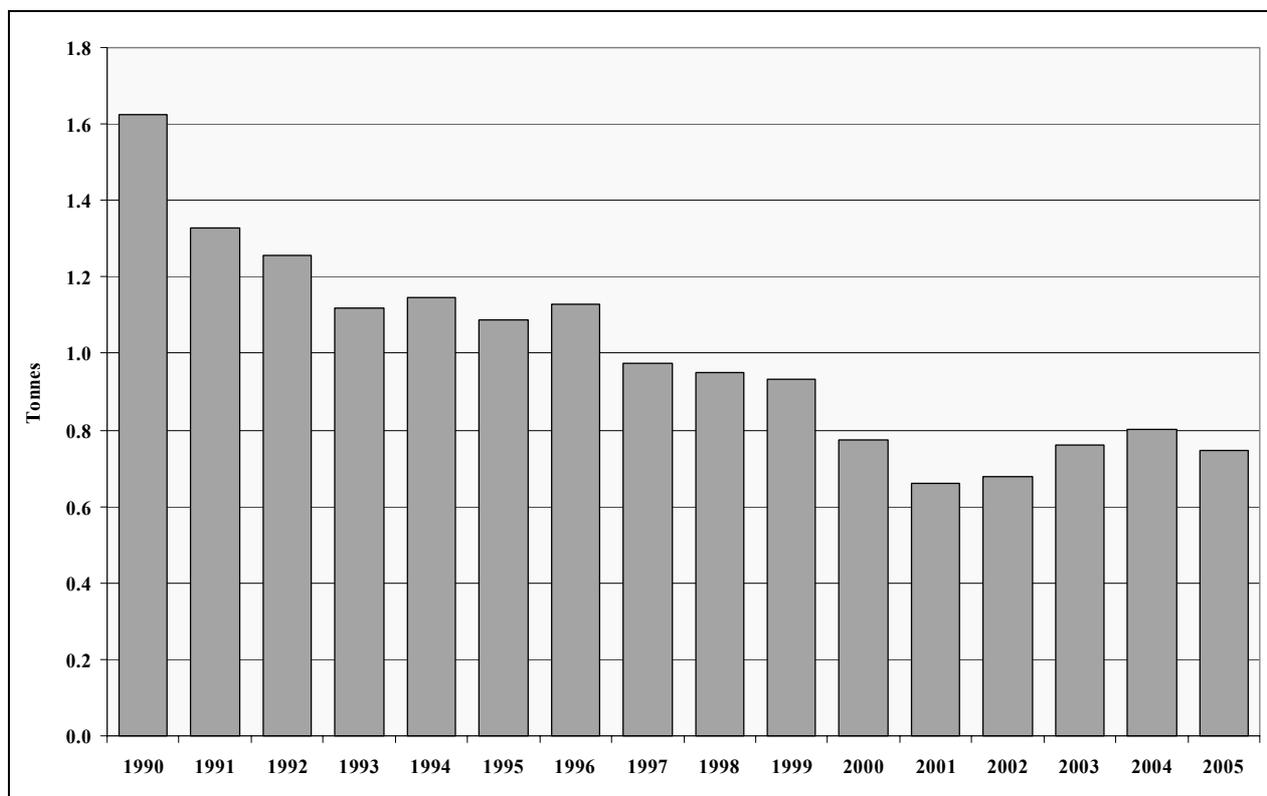


Amounts of mercury sold in Sweden contained in products, including batteries, light sources and dental amalgam. Sales of mercury metal (for chlor-alkali production etc) are not included.

Source: Swedish Environmental Protection Agency, based on KEMI (2004).

132. Atmospheric mercury releases from Sweden peaked in the 1960s at around 30 tonnes per year [see UNEP (2002)]. Figure 6 describes the trend in mercury emissions to air in Sweden between 1990 and 2004. The emissions decreased significantly until 2001, when the total releases represented about 2% of the peak level in the 1960s. However, there was an *increase* in emissions of approximately 20% between 2001 and 2004. This could be linked to an increase in metals production, which in turn is linked to a favourable business cycle for metal industries.

**Figure 6. Emissions to air of mercury in Sweden  
1990 - 2005**



Source: Swedish Environment Protection Agency.

## 5. Instruments addressing mercury emissions to air in the United States

### 5.1 Introduction

133. The United States has been actively addressing the risks posed by exposure to mercury for many years, both through implementation of regulatory activities and voluntary reduction programmes (ACAP, 2004). For example, in 1991 the US EPA initiated the “33/50 Program”, a special programme to help reduce releases of mercury and 16 other toxic substances into the environment. The goal of the programme was to encourage companies to commit to voluntarily reduce their releases of some or all of these toxics by 33% by 1992, and 50% by 1995. As a result, between 1988 and 1991, environmental releases of mercury were reduced by 38% and transfers of mercury for off-site treatment or disposal were reduced by 30% (OECD, 1995). However, while the 33/50 Program may have served as an initiation of later activities, the quantitative results were found to be moderate when corrected for other factors contributing to the observed reductions, according to studies by Khanna and Damon (1999) and Vidovic and Khanna (2007).

134. Also, the National Partnership for Environmental Priorities Program (NPEP) encourages public and private organizations to form voluntary partnerships with EPA that reduce the use or release of any of 31 priority chemicals, including mercury. To date, 26 partners have committed to reducing their use of 38,375 pounds of mercury (US EPA, 2006b).

135. Understanding the characteristics and magnitude of mercury releases is critical to the design of effective risk management strategies. The *Clean Air Act*, as amended in 1990, required US EPA to prepare an assessment of the magnitude of US mercury emissions by source, the health and environmental effects

of the emissions, and the cost and availability of control technologies. The resulting report, *Mercury Study Report to Congress* (US EPA, 1997) was published in December 1997. As the state-of-the-science for mercury is continuously and rapidly evolving, the report represents a “snapshot” of the mid 1990s understanding of mercury in the US. The report is a comprehensive document, consisting of eight volumes.

136. The US EPA’s Office of Research and Development (ORD) published in September 2000 its *Mercury Research Strategy*, which was intended to guide the mercury research programme through 2005. The Strategy identifies the key scientific questions of greatest importance to the Agency and describes a research programme to answer those questions. The goal in addressing the questions is to reduce scientific uncertainties limiting US EPA’s ability to assess and manage mercury and methylmercury risks. An integral part of the strategy involves study of atmospheric mercury transport, transformation and fate.

137. In July 2006, US EPA issued its *Roadmap for Mercury*. This report describes the Agency’s progress to date in addressing mercury issues domestically and internationally, and outlines EPA’s major ongoing and planned actions to address risks associated with mercury (US EPA, 2006c).

## **5.2 Overview of instruments addressing mercury at the Federal level**

138. The US approach to designing effective risk management strategies for mercury comprises both specific regulatory limits on releases and voluntary efforts with industry to reduce mercury use, implemented by a number of agencies at the Federal and State levels. The most important initiatives at the Federal level are summarized below, based primarily on a review prepared by the US EPA for an Arctic Council report (ACAP, 2004).

139. In the US, individual States can define their own measures to reduce environmental impacts from mercury. There is a distinction between Federal environmental statutes, which are laws passed by the U.S. Congress, and agency regulations, which are written by EPA and other agencies to implement the statutes. Statutes define some aspects of environmental programmes in detail and leave other aspects up to the discretion of the EPA administrator. State environmental programmes must conform to the statutes and regulations, but are generally allowed to be more stringent than Federal standards and, in some cases, to diverge from the detail of the regulations if such programmes can demonstrate that they meet or exceed the expectations of the regulations. Summary information on instruments used to address mercury at the State level is given in Section 5.3.

### *5.2.1 Point-sources*

#### *Air point sources*

140. Mercury and mercury compounds are considered hazardous air pollutants (HAPs) under the *Clean Air Act*. US EPA established National Emission Standards for Hazardous Air Pollutants (NESHAPs) for mercury emissions based on risk under the pre-1990 version of the *Clean Air Act*. Under the *Clean Air Act Amendments* of 1990, US EPA regulates hazardous air pollutant emissions by source categories, using Maximum Achievable Control Technology (MACT) standards for each “major source” in any listed source category. The Maximum Achievable Control Technology level for new sources is the level of HAP emissions control currently achieved by the best-controlled similar source. The MACT level for existing sources is the average level of mercury emissions control achieved by the top 12 % of the currently operating sources. (See also the description of the cap-and-trade programme for coal-fired power plants below, a major mercury point source type.)

### *Water point sources*

141. Mercury is listed as a toxic pollutant under the *Clean Water Act*. The *Clean Water Act* regulations specify technology-based effluent limits for mercury discharges from different industries, and provide that States may be more stringent than technology-based standards. States must set water quality standards for pollutants including mercury if necessary to protect designated water uses. The *Clean Water Act* relies on a permit system, known as the National Pollutant Discharge Elimination System (NPDES), to regulate direct discharges to surface water bodies. Facilities may be assigned a specific mercury discharge limit based on either the technology-based effluent limit or a more stringent water-quality based limit necessary to meet any applicable water quality criteria for mercury, and/or may be required to monitor their discharge for mercury. Facilities report actual discharge levels in Discharge Monitoring Reports, which serve as the basis for determining compliance. A large number of industry point-sources, such as chlor-alkali, steam electric power generation, battery manufacturing etc., are subject to the NPDES permitting programme.

### *Chlor-alkali industry*

142. In August 2003, EPA promulgated a rule that limits mercury emissions from plants that produce chlorine using the mercury-cell method. The rule includes emissions limits based on MACT and on stringent management practices. EPA estimates that this regulation will reduce stack emissions by 1,500 pounds, or 74 % from previous levels, in addition to unquantifiable reductions in fugitive emissions expected as a result of improved work practice standards. This standard does not allow any new chlor-alkali mercury cell facilities to be built.<sup>13</sup> The last US mercury-cell based factory was built in 1970.

143. In addition, as a voluntary measure, the Chlorine Institute, on behalf of US mercury cell chlor-alkali facilities, committed in 1997 to reduce mercury use 50% by 2005 and to report annually on progress. In July 2004, the Chlorine Institute provided its seventh annual report, which indicated that mercury consumption by US chlor-alkali factories has declined by 76% over eight years, or a 69% reduction after adjusting for shut down of facilities. This is a decline from 160 tons per year (during a baseline period of 1990-1995) to 30 tons during 2001.<sup>14</sup>

### *Energy production*

144. Currently, the largest anthropogenic source of mercury emissions in the US is coal-fired power plants. After considering several options for addressing this sector, the US EPA issued the *Clean Air Mercury Rule* in 2005, which addresses mercury reductions with a cap-and-trade system for atmospheric mercury releases from this sector. Facilities facing high emission reduction costs, due to their state of technology or other factors, can buy emission allowances from facilities that can reduce mercury releases at lower cost. The rule has two phases. The total mercury cap in Phase 1 is 38 short tons per year to be achieved by 2010, and in Phase 2 (from 2018) the cap is reduced to 15 short tons per year. (See Section 5.6 for further discussion.)

### *Information and reporting requirements*

145. Under the US Toxics Release Inventory (TRI), starting with the 2000 reporting year, the reporting threshold for mercury and its compounds has been lowered to 10 pounds (about 4.5 kg) per year. The previous threshold was 25,000 pounds (about 11,300 kg) for manufacture or processing and 10,000 pounds (about 4,500 kg) for otherwise use. Through this action, the US got a much more

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13. See <http://www.epa.gov/ttn/atw/hgcellcl/hgcellclpg.html>.

14. Progress reports may be found at [www.epa.gov/Region5/air/mercury/reducing.html#heavy%20industry](http://www.epa.gov/Region5/air/mercury/reducing.html#heavy%20industry).

comprehensive picture of the amounts of mercury and its compounds that are released to air, water, land, transferred off-site for disposal, transferred off-site for recycling or recycled on-site within industrial facilities.

### 5.2.2 *Products and other diffuse sources*

#### *Mercury in products*

146. Mercury-containing products are regulated in several different ways. At the Federal level, mercury product regulation has generally centred around health-based reasons to eliminate mercury from products, using the *Federal Insecticide, Fungicide, and Rodenticide Act* (FIFRA) and the *Federal Food, Drug, and Cosmetic Act* (FFDCA) regulations. In recent years, many States have taken a different approach. Restrictions on mercury-containing products, once used sparingly by the Federal Government, are increasing rapidly at the State level. (For more details, see Section 5.3 below.)

#### *Batteries*

147. Between late 1989 and early 1991, all US manufacturers converted production so that mercury content, except in button and “coin” cells, did not exceed 0.025% mercury by weight. A Federal law (*Mercury-Containing and Rechargeable Battery Management Act*) went into effect in May 1996. This Act prohibits the sale of:

- alkaline-manganese batteries containing mercury (alkaline-manganese button cell batteries are limited to 25 mg mercury per button cell),
- zinc carbon batteries containing mercury,
- button cell mercuric-oxide batteries for use in the US, and
- any mercuric-oxide battery unless the manufacturer identifies a collection site that has all required Federal, State, and local government approvals, to which persons may send batteries for recycling and disposal

148. The Act contains labelling requirements and encourages voluntary industry programmes by eliminating barriers to funding the collection and recycling or proper disposal of used rechargeable batteries. The Act also grants States the authority to add other batteries to the recycling programme. This Federal law followed the lead of several States that passed legislation in the early 1990s limiting the mercury content of batteries.

#### *Auto switches*

149. In July 2006, US EPA proposed a Significant New Use Rule (SNUR) to require notification 90 days prior to US manufacture, import or processing of elemental mercury for use in certain convenience light switches, anti-lock brake system (ABS) switches and active ride control system switches for certain motor vehicles. On 1 January 2003, US automakers voluntarily discontinued the use of mercury switches in convenience lights, ABS systems, and ride control systems. Foreign automakers had previously discontinued use of such switches. The proposed rule does not include mercury switches used as aftermarket replacement parts for ABS and ride control systems in pre-2003 vehicles, because there are currently no suitable non-mercury substitutes for these replacement parts and the remaining market for these products is very limited and declining. The required notice would provide US EPA with the opportunity to evaluate any resumption of use of mercury in these switches, and, if necessary, to prohibit or limit such activity before it occurs in order to prevent unreasonable risk of injury to human health or the environment (US EPA, 2006d).

### *Cosmetics*

150. According to the *Federal Food, Drug, and Cosmetic Act* (FFDCA), mercury use as a preservative or anti-microbial is limited to eye-area cosmetics or ointments in concentrations below 60 ppm. Yellow mercuric oxide is not recognized as a safe and effective ophthalmic anti-infective ingredient.

### *Dental amalgam*

151. The Food and Drug Administration (FDA) also regulates dental amalgam under FFDCA. Dental mercury is classified as a Class I medical device, with extensive safety regulations on its use. Dental amalgam alloy is classified as a Class II device, subject to additional special controls.

### *Paints*

152. As of May 1991, all registrations for mercury biocides used in paints were voluntarily cancelled by the registrants, thus causing a drastic decrease in the use of mercury in paint. In addition to the paint industry reformulating its paints to eliminate mercury, US EPA banned the use of mercury in interior paint in 1990 and in exterior paint in 1991.

### *Pesticides*

153. The *Federal Insecticide, Fungicide and Rodenticide Act* (FIFRA) covers the sale and use of pesticides, including registration of chemicals that meet health and safety tests. Earlier, several mercury compounds were registered as pesticides, bactericides, and fungicides, but registrations of the last mercury-based pesticides for use to control pink and grey snow mold were voluntarily cancelled by the manufacturer in November 1993.

### *Vaccines*

154. Under the *Food and Drug Administration Modernization Act* of 1997, FDA is required to assess the risk of all mercury-containing food and drugs. Under this provision, FDA asked vaccine manufacturers to provide information about thimerisol (mercury based biocide) content of vaccines. Based on this information, the Public Health Service, the American Academy of Pediatrics, and vaccine manufacturers agreed that thimerisol-containing vaccines should be removed as soon as possible. Manufacturers have been asked for a clear commitment to eliminate mercury from vaccines, and FDA will do expedited reviews of resulting revisions to product license applications.

### *Thermostats*

155. As a voluntary measure, the industry-funded Thermostat Recycling Corporation (TRC) launched a programme in 1998 to recycle mercury-switch thermostats in nine States.<sup>15</sup> It has since been expanded to 48 States in the US, and in 2005 the programme collected 87,900 thermostats and 820 pounds of mercury. Between its inception in January 1998 and June 2006, it collected over 450,000 thermostats and removed more than 3,900 pounds of mercury from the waste stream. The mercury is purified for re-use.

156. US EPA is exploring other avenues, such as voluntary waste minimization partnerships focusing on mercury applications, to reach its environmental goals quickly and efficiently without imposing unfair burdens on particular industries, small businesses, or other groups.

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15. See <http://www.nema.org/gov/ehs/trc/>.

*Recreational mining*

157. There is no active mercury mining in the US. There is also no use of mercury in large-scale gold mining in the US. There has been minor recovery of mercury by recreational miners in California, but the mercury is recovered as elemental free mercury in stream bottoms where mercury was used in the distant past for gold extraction. The mercury is incidentally recovered on the sluices of recreational portable dredge operators. The US EPA and California are working on ways to set up collection points for waste mercury to ensure that recreational miners do not dump their waste mercury in streams.

*Transportation*

158. The US Department of Transportation regulates hazardous materials transport under the Hazardous Materials Transportation Act. Mercury and mercury compounds are hazardous substances subject to packaging, shipping and transportation rules for hazardous materials.

5.2.3 *Waste management**Waste treatment including incineration*

159. Prior to 1995, municipal waste combustors and medical waste incinerators were the largest identifiable sources of man-made mercury emissions to the atmosphere. Regulations that have been finalized for municipal waste combustors and medical waste incinerators will, when fully implemented, reduce emissions from these source categories by an additional 90% over 1995 levels.

160. In December 1995, the US EPA finalised New Source Performance Standards (NSPSs) and Emission Guidelines (EGs) applicable to *municipal waste combustor* (MWC) units with a capacity greater than 227 metric tonnes per day (*i.e.* large MWCs). All 167 large MWCs that are subject to the regulations that came into compliance by December 2000 and mercury emissions (based on year 2000 stack test compliance data) from this source category have been reduced by about 95% from 1990 levels. A companion rule (NSPSs and EGs) for a small MWC unit (32 to 227 metric tonnes per day) was adopted in December 2000 with retrofit required by December 2005. The same mercury emissions limits apply and the same control technology was expected to be used.<sup>16</sup>

161. Since 1997, mercury emissions from medical waste incinerators have been limited by a US EPA regulation that sets strict standards for new sources and that requires existing sources to reduce emissions by 93 to 95%. The regulations also require training and qualification of operators, incorporate siting requirements, specify testing and monitoring requirements to demonstrate compliance with the emission limits, and establish reporting and record keeping requirements.<sup>17</sup>

162. As a voluntary measure, US EPA and the American Hospital Association in 1998 signed a Memorandum of Understanding committing to work together to significantly cut hospital wastes by 2005. The agreement envisions the virtual elimination of mercury-containing hospital wastes and a one-third reduction in total hospital wastes by 2005.

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16. Final 5-year compliance data has been collected from these units has been collected and is currently under evaluation.

17. In 2007, US EPA proposed a 5-year technology review for municipal waste incinerators; cf. Federal Register, February 6, 2007, pp 5509-5550.

*Hazardous waste incinerators*

163. In 2002, US EPA promulgated interim emission standards for hazardous waste incinerators, hazardous waste burning cement kilns, and hazardous waste burning lightweight aggregate kilns under joint authority of the *Clean Air Act* and *Resource Conservation and Recovery Act* (RCRA). The standards limit emissions of chlorinated dioxins and furans, other toxic organic compounds, toxic metals (including mercury), hydrochloric acid, chlorine gas, and particulate matter.

*Waste disposal*

164. The RCRA hazardous waste regulations identify those solid wastes that should be managed as hazardous waste and specifies treatment, storage, and disposal requirements. They describe specific disposal requirements for some specific wastes. Generally, mercury-bearing wastes are subject to land disposal restrictions. That is, the mercury concentration in these wastes must be below the regulatory concentration level before the wastes may be landfilled. For some types of waste, the regulations require a specific treatment, such as recovery of the mercury or incineration.

165. RCRA regulations also influence product disposal and recycling options for mercury-containing products. Discarded products considered to be hazardous wastes are potentially subject to transportation requirements, and permitting requirements for storage, treatment and disposal of the waste. Currently, certain spent mercury-containing equipment and other types of hazardous wastes are included in a *Universal Waste Rule* (UWR) that, since 1995, eases RCRA hazardous waste management requirements for those wastes and enables States to set up special collection programmes. “Universal wastes” are items commonly thrown into the trash by entities including households and small businesses. UWR is designed to reduce the amount of hazardous waste in the municipal solid waste stream, to encourage the recycling and proper disposal of some common hazardous wastes, and to reduce the regulatory burden on businesses that wish to collect or generate these wastes. Although handlers of universal wastes face less stringent standards for storing and collecting wastes, and transporters for moving wastes, than handlers and transporters of hazardous waste, the waste must comply with full hazardous waste requirements for final recycling, treatment, or disposal. This management structure helps remove these wastes from municipal landfills and incinerators. In July 1999, EPA added hazardous waste lamps to the *Universal Waste Rule*, which already covered some batteries, thermostats, and pesticides. In 2005, EPA added other mercury-containing wastes to the UWR.

*End-of-life Vehicles*

166. In an effort to reduce mercury emitted from electric arc furnaces that consume scrap from recycled automobiles – which US EPA estimates emit about 8 - 12 tons per year of mercury – US EPA has pursued a multiple programme efforts to encourage the removal of mercury switches from scrap automobiles prior to recycling. Nearly all obsolete automobiles in the US are dismantled and shredded to recycle the metal (ACAP, 2004). The US *Clean Air Act* gives the US EPA authority to regulate the steel mills – but not the car dismantlers. However, there is little the steel producers can do about the problem, other than installing expensive end-of-pipe cleaning equipment. The car dismantlers can relatively easily take out the switches before the cars are flattened – but have no incentive to do so, due to the low value of the mercury metal and the additional costs of doing so. Hence, the US *National Vehicle Mercury Switch Removal Program* (NVMSRP) Memorandum of Understanding (MoU) was signed in August 2006. The MoU is with automobile and steel manufacturers, scrap recycling, vehicle dismantling, environmental groups, and the States. This is a voluntary programme to reduce the presence of mercury switches originating from automobile convenience lighting and anti-lock brake systems from the scrap metal supply chain. Removing switches before automobiles are crushed and sent to electric arc furnaces will prevent up to 75 tons of mercury emissions over the next 15 years (US EPA, 2006b).

*Stockpiles of mercury*

167. The US Government maintains a supply of mercury as part of the *National Defense Stockpile*, established at the end of World War I to maintain adequate supplies of materials deemed critical to national defence. The Defense Logistics Agency (DLA), a unit of the Department of Defense, manages the stockpile.<sup>18</sup> The *Strategic and Critical Materials Stockpile Act* regulates mercury that the DLA sells from the national stockpile. In July 1994, DLA suspended future mercury sales pending analysis of the environmental consequences (such as national or global mercury releases resulting from the use of sold mercury). An *Environmental Impact Statement* to determine the disposition of the stockpile was completed in April, 2004. In the meantime, a complete review of the four facilities across the US currently storing its mercury and inspection of all the mercury-containing flasks to ensure proper and safe storage was undertaken. The US Department of Defense announced that its “preferred option” is consolidated storage of its mercury at one location for at least 40 years. This option has been chosen for implementation.

168. Also, US EPA’s *Roadmap for Mercury* commits the Agency to establishing an interagency process to address how to best manage domestic supplies of commodity-grade mercury, in light of an emerging global mercury surplus that is expected over the next ten years (US EPA, 2006b).

### 5.3 *State-level instruments addressing mercury*

169. Restrictions on mercury-containing products, once used sparingly by the Federal Government, are increasing rapidly at the State level. Certain US States have initiated a variety of initiatives aimed at reducing mercury releases from the use and disposal of products. These initiatives include notification and labelling requirements to gain information on the mercury content of particular products and inform purchasers that products contain mercury; prohibitions on the sale of a variety of products for which alternatives were deemed readily available (such as fever thermometers, dairy manometers, novelty items, switches in automobiles, and thermostats in residential and commercial applications); concentration limits on other products such as batteries and packaging; restrictions on product disposal so that the products must be segregated from the solid waste stream and ultimately recycled; and State-sponsored collection programmes for items such as fever thermometers, historic dental inventories, and products found in schools (ACAP, 2004).

170. A 2005 overview of State instruments and activities on mercury is provided in the report *2005 Compendium of States’ Mercury Activities* (ECOS, 2005). The overview is based on a questionnaire to States, which was answered by 45 of the 50 States in the country. The report provides summary text of the States’ mercury related activities as of 2005. For reference, overview tables from that report of types of instruments and States which are engaged in each type of instrument are also given in the annex to the present document. New activities have been introduced since 2005. Those pertaining to coal combustion in power production are described in Section 5.6.

171. According to ECOS (2005), many States are coordinating their mercury activities via an action plan or strategy or through task forces and workgroups, and even more States are addressing mercury in consumer products. More than 40% of the States responding to the survey made for the compendium have taken steps to curb mercury use in products and to prevent improper disposal. States’ activities range from phase-outs and bans to labelling and collection of mercury and mercury-containing products. The most common activity related to mercury-containing products is voluntary mercury take-back programmes – 80% of the States reported sponsoring such activities and over one-third of the States also reported having phase-outs and sales bans of some products.

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18. In addition, the US Department of Energy has stocks of approximately 1,200 tonnes of mercury.

172. Many States are also taking action to address mercury-containing switches in vehicles. Nearly half of the States reported proposed or enacted vehicle-switch legislation. Although only a handful has mandatory switch removal, over a quarter of the States had activities related to voluntary switch removal from end-of-life vehicles. While States reported facing many challenges in dealing with the issue of vehicle switches, the most frequently cited was the lack of funding for removal programs.

173. Two additional mercury sources that States are beginning to address are electric utilities and the dental sector. Emissions from coal-fired electric power plants are a widely recognized problem. Twenty-four States report that they are the largest source of mercury emitted within their State. States are also beginning to look for ways to reduce mercury from dentists. Four States reported having regulations on mercury releases from dental separators. Eleven States take into account the number of dentists with amalgam separators when quantifying their mercury-reduction progress.

174. All States responding to the survey were engaged in some mercury-related outreach or education activity. Nearly all perform mercury monitoring (ECOS, 2005).

#### **5.4 *Instruments addressing mercury in the State of Massachusetts***

175. Some highlights on State-level instruments used to address mercury in Massachusetts are summarised below, based on (ECOS, 2005) and (MA DEP, 2006).

176. Massachusetts participates in a regional mercury action plan (the New England Governors and Eastern Canadian Premiers Mercury Action Plan), and also has an overall mercury action plan, the MA Zero Mercury Strategy, with the goal of virtually eliminating all anthropogenic sources of mercury and a milestone goal of 75% reduction by 2010.<sup>19</sup> Major elements of the plan include: small business, household, medical and dental mercury waste management; strict mercury emission limits; limiting mercury discharges to water; reduction of mercury use in products; recycling; and outreach and education. The State has policies, statutes, and regulations relating to the mercury action plan.

177. Massachusetts has strict regulations on mercury releases from coal-fired power plants (85% reduction efficiency by 2008 and 95% by 2010), for municipal waste incinerators (three-fold more stringent than Federal US EPA requirements), for dental offices, and for wastewater treatment. Massachusetts has a voluntary programme that provides dentists with an incentive to install amalgam separators, and adopted regulations in 2006 requiring dentists to install amalgam separators.<sup>20</sup>

178. Massachusetts has banned the sale of mercury thermometers and completed a State-wide collection programme that recycled more than 95,000 thermometers. Massachusetts' waste incinerator rules require facilities to implement mercury source separation plans (separate collection) in their respective geographical areas. Mercury products are managed as hazardous wastes and recycled. Massachusetts monitors collection activities through audits, inspections, and self-certification provisions. The Massachusetts Department for Environmental Protection supports mercury cleanouts and education programmes in schools and other community recycling efforts.

179. According to the Massachusetts Department of Environmental Protection, a 1996 report on mercury, and subsequent work, found that there are significant local impacts of mercury emissions to air in North-eastern parts of the State. This is part of the reason that Massachusetts has decided to opt out of the Federal mercury rule for coal-fired power plants – to avoid contributing to or creating local “hot spots” or disproportionate impacts. The State has also found that it may be impossible to meet total maximum daily

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19. See [www.mass.gov/dep/toxics/stypes/hgres.htm](http://www.mass.gov/dep/toxics/stypes/hgres.htm).

20. See [www.mass.gov/dep/service/dentists.htm#regs](http://www.mass.gov/dep/service/dentists.htm#regs).

loads for mercury for its freshwater (so-called “TMDLs”), as required under the *Clean Water Act*, with the US EPA approach to mercury emission management. The Massachusetts Department of Environmental Protection also concluded that emissions could be reduced from coal-fired energy-generating utilities to a much greater degree and on a faster timeline (MA DEP, 2006).

180. According to the Massachusetts Department of Environmental Protection, an integrated approach taking into account all mercury release sources (including products etc.) and all environmental media is necessary to achieve acceptable levels of mercury exposure.

181. The Massachusetts Department of Environmental Protection has undertaken substantial monitoring in the State and have already seen reductions in mercury levels in fish of some 20-30%, after some local sources reduced their emissions 80-90% around 2000/2001 (MA DEP, 2006).

### **5.5 *Instruments addressing mercury in the State of Michigan***

182. Some highlights on State-level instruments used to address mercury in Michigan are summarised below, based on (ECOS, 2005) and (MDEQ, 2006).

183. Michigan also has an overall mercury action plan. Major elements of the plan include: medical/dental mercury waste management; limits on mercury discharges into water; reduction of mercury use in consumer products; technical assistance for industries; mercury recycling; and public outreach and education.

184. Michigan has regulations on mercury releases from wastewater treatment and industrial facilities, municipal waste incinerators, and medical waste incinerators. Air permits for certain sources such as shredders and sewage sludge incinerators include mercury-specific limits or Best Management Practices (BMP) Requirements.

185. Michigan has a mercury-free purchasing policy for state procurement. It has phased out the sale of mercury-containing thermometers, the use of mercury-containing devices in certain schools, and the sale of mercury-containing batteries that exceed allowable mercury amounts. Michigan has separate collection programmes for elemental mercury, mercury waste, and mercury-containing products.

186. The State pursues voluntary removal of mercury switches (hood lights, trunk lights, and ABS brake sensors) from end-of-life non-commercial vehicles. Vehicle manufacturers provide training materials, buckets, pick-up and transport of collected switches. Dismantlers receive payments for switches that are collected under the National Vehicle Mercury Switch Recovery Program (MDEQ, 2007).

187. Michigan is not going to participate in the trading programme under the 2006 Federal *Clean Air Mercury Rule* for mercury emissions from power plants. Instead, they require a 90% reduction from input mercury levels in coal by 2015 or an emission standard (MDEQ, 2007).

188. An industrial-scale pilot experiment was started at a 270 MW coal-fired power plant in Michigan in 2006, using active carbon technology to reduce mercury emissions. Preliminary parametric testing has demonstrated that a 90% reduction in mercury emissions is possible (MDEQ, 2007).

### **5.6 *More information on instruments addressing mercury emissions from coal combustion***

#### **5.6.1 *A cap-and-trade system***

189. As stated earlier, the largest anthropogenic source of mercury emissions in the US is currently coal-fired power plants. Utility steam generating sources were subject to special study and required a

determination by the US EPA as to whether it would be “appropriate and necessary” to regulate them under Section 112 of the *Clean Air Act*.<sup>21</sup> In December 2000, US EPA released its *Regulatory Finding on the Emissions of Hazardous Air Pollutants from Electric Utility Steam Generating Units*. It concluded that regulation of hazardous air pollutants under Section 112 from coal- and oil-fired electric (but not natural gas-fired) utility steam generating units was indeed appropriate and necessary, and that mercury was the air toxic of most serious concern. On 30 January 2004, the US EPA proposed alternative approaches to regulating mercury from coal-fired power plants. Under one approach, the Agency would continue along its original path and establish MACT standards for hazardous air pollutants. Under another approach, the Agency would revise its December 2000 finding that it is “appropriate and necessary” to regulate utility hazardous air emissions using the MACT standards provisions (section 112) of the Clean Air Act. This would give EPA the flexibility to consider a more efficient and more cost effective way to control mercury emissions based on a market-based cap-and-trade system (US EPA, 2006a).

190. As mentioned earlier, the US EPA issued the *Clean Air Mercury Rule* in 2005, which is based on a cap-and-trade system and new source performance standards for new units. A total national “cap” on annual mercury releases from coal-fired power-plants is shared among the participating States and Tribes, who decide on how their total number of allowances should be allocated to individual power plants.<sup>22 23</sup> Facilities facing high emission reduction costs, due to their state of technology or other factors, can buy allowances from facilities that can reduce mercury releases at lower cost. Facilities that reduce their emissions below the number of allowances they hold for a given year can sell the “surplus” allowances in the market, or “bank” them for use in later year. The *Mercury Rule* has two phases. The total mercury cap in Phase 1 is 38 short tons per year to be achieved by 2010, and in Phase 2 (from 2018) the cap is set at 15 short tons per year. The 38 tons cap is designed to be fulfilled solely by expected co-benefits of the new SO<sub>2</sub> and NO<sub>x</sub> rules (the US EPA *Clean Air Interstate Rule*). That is, no specific mercury emission reduction equipment will be required. Some power plants would, however, probably invest in such measures – which would generate bankable permits that can be used once the total cap is reduced to 15 tons in 2018.

191. A number of individual US States fear that the cap-and-trade system will not secure sufficient reductions on the local or regional level where specific facilities are major sources of mercury pollution in the local or regional environment. In addition, some States (and other opponents) claim the *Clean Air Mercury Rule* does not meet their assessment of the needs for mercury reductions.

192. For example STAPPA, the “State and Territorial Air Pollution Program Administrators”, has suggested a model rule for states and localities’ that would aim for a 90% reduction by around 2015, whereas US EPA aims for a 70% reduction target of mercury emissions from power plants by 2018. According to STAPPA, one reason for setting a more ambitious target than US EPA is that the costs of using activated carbon to clean the end-of-pipe emissions are rapidly falling (STAPPA, 2006).

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21. Section 112 of the Act requires EPA to first establish Maximum Achievable Control Standards (MACT) for hazardous air pollutants. MACT standards are applicable to both new and existing sources. For existing sources MACT standards must at a minimum reflect the performance of the “best” 12% of existing sources in the category. For new sources, MACT standards must at a minimum reflect the performance of the “best controlled similar source.” Under Section 112, the Administrator must also, within 8 years of establishing MACT standards, set additional standards to protect human health and the environment with “an ample margin of safety” from any residual risks remaining after the application of MACT.
22. “...although there are some clear potential benefits to using auctions for allocating allowances ... , EPA believes that the decision regarding utilizing auctions rightly belongs to the States and Tribes. EPA is not requiring, restricting, or barring State use of auctions for allocating allowances.” US EPA (2005a).
23. 5 % of the allowances will go to a new source set aside, see US EPA (2005a).

193. Concerns about “hot spots” have been raised by some,<sup>24</sup> despite the success and growing use of cap-and-trade programmes. The US EPA believes that a trading approach will help to address this problem. In addition to the reductions required by the cap, all States would have the ability to address local health-based concerns separate from the mercury cap-and-trade programme requirements (US EPA, 2006b).

194. In early drafts of the *Mercury Rule*, the 2010 cap was set at 34 short tons annually. According to US EPA (2006a), the cap was later revised because calculations showed that co-benefits from SO<sub>x</sub> and NO<sub>x</sub> emission reduction could only yield mercury reductions down to 38 tons. The US EPA expects, however, that actual emissions in 2010 of 31 short tons could not be ruled out.

195. All in all, out of the 48 States that have coal-fired power utilities, about two-thirds are planning to introduce mercury permit trading, according to US EPA (2007). Of these, three-fifths will implement the CAMR “as-is”. About one-fifth of the States with trading will have more stringent, direct (*e.g.*, permit limits) local control requirements in addition to trading, whereas about one-fifth of these States will introduce trading, but will hold back part of their State-wide emissions quota. About one-third of the 48 states with coal-fired power utilities will either not participate in the trading programme or have not provided clear indication of their plans. Those that have indicated that they will not participate in the trading programme will likely introduce more stringent direct controls.

#### 5.6.2 *Differentiation depending on domestic coal types*

196. The 2005 *Clean Air Mercury Rule* also contains emission limits on new coal-fired power plants that vary with the type of coal being used (because of physical engineering design differences in plant design, differences in mercury concentrations and other chemical characteristics that also influence mercury retention efficiency in control equipment). According to the US EPA (2006a), it was important to keep all types of domestic coal reserves viable for power production to provide national energy reliability and security. In general, the fuel choice would in any case be more determined by the price and the sulphur content than by the mercury content of each fuel.

#### 5.6.3 *Potential for inclusion of other source categories in the trade-and-cap system*

197. The US EPA did not see any engineering or economic rationale for allowing non-utility sources to take part in the national cap and trade program that is being prepared for controlling mercury emissions from coal-fired power plants; however, under the *Clean Air Interstate Rule* (CAIR), there are opt-in provisions for SO<sub>2</sub> and NO<sub>x</sub> control from non-utility sources. This was reasoned partly by administrative factors – different sources are regulated through different sections of the *Clean Air Act*, and a revision of the Act could not be envisaged at present – and partly by technical differences between mercury source categories. For example, according to the US EPA (2006a) there would be few benefits by including waste incinerators in the same mercury trading scheme as coal-fired power plants, because all the incinerators in the US are relatively similar and can be governed efficiently and economically by conventional command-and-control emission limit regulations. However, for coal-fired power plants there are significant engineering differences that render traditional command-and-control approaches less effective. In a market-based approach, such as CAIR and CAMR, the larger plants are expected to invest in pollution control measures early in the transition period, while the smaller power plants would tend to delay this expenditure by purchasing pollution allowances instead.

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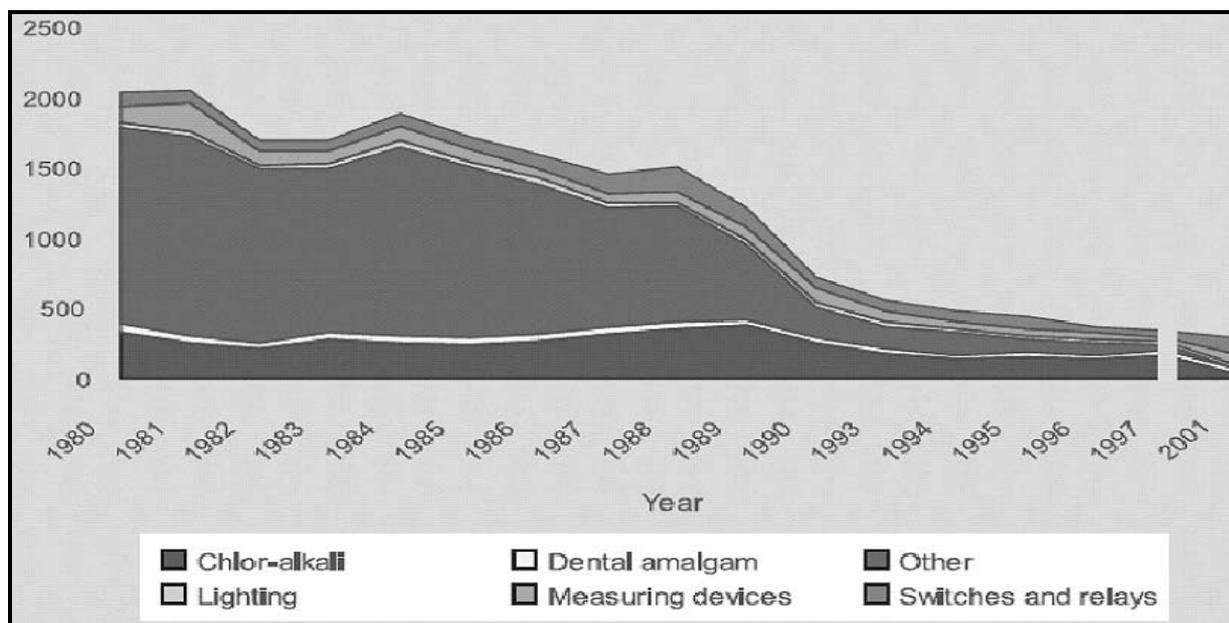
24. According to US EPA’s definition, “hot spots” are “Localized areas with unacceptably high levels of mercury.” See [www.epa.gov/oig/reports/2006/20060515-2006-P-00025.pdf](http://www.epa.gov/oig/reports/2006/20060515-2006-P-00025.pdf).

**5.7 Environmental impacts of instruments**

198. Total reported atmospheric mercury releases in the US have been reduced from 191 tonnes per year in 1990 to 107 tonnes per year in 1999, a 44% reduction [see ACAP (2004)]. Between 1980 and 2001, annual intentional mercury use in the US – another indicator of effects of instruments – shrank from 2,225 to 271 metric tonnes per year – an 88% reduction (Doa, 2006).

199. Figure 7 shows developments in the use of mercury among industrial sectors in the United States. The Figure shows a decrease in consumption of more than 75% since 1980. Between 1990 and 2001, total reported consumption fell by more than 50% – from more than 700 to less than 350 metric tonnes.

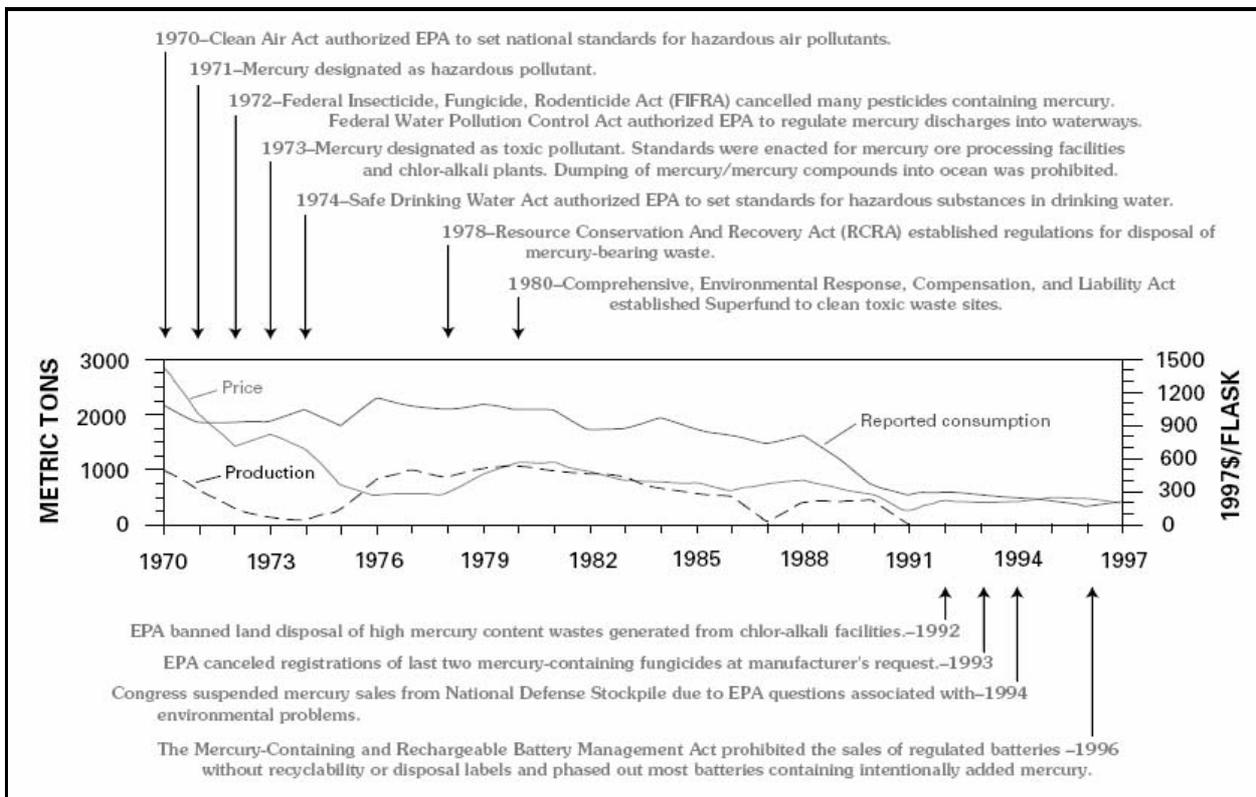
**Figure 7. Use of mercury in the United States**  
Metric tonnes, 1980 - 2001



Source: US EPA (2006c).

200. The two major causes of this reduction were the elimination of mercury in batteries by regulation and technological advancements, and elimination of mercury-based fungicides in paints by regulation. Figure 8 provides more details on the phasing-in of various policies in the US up to 1997, and their impacts on the production, use and price of mercury.

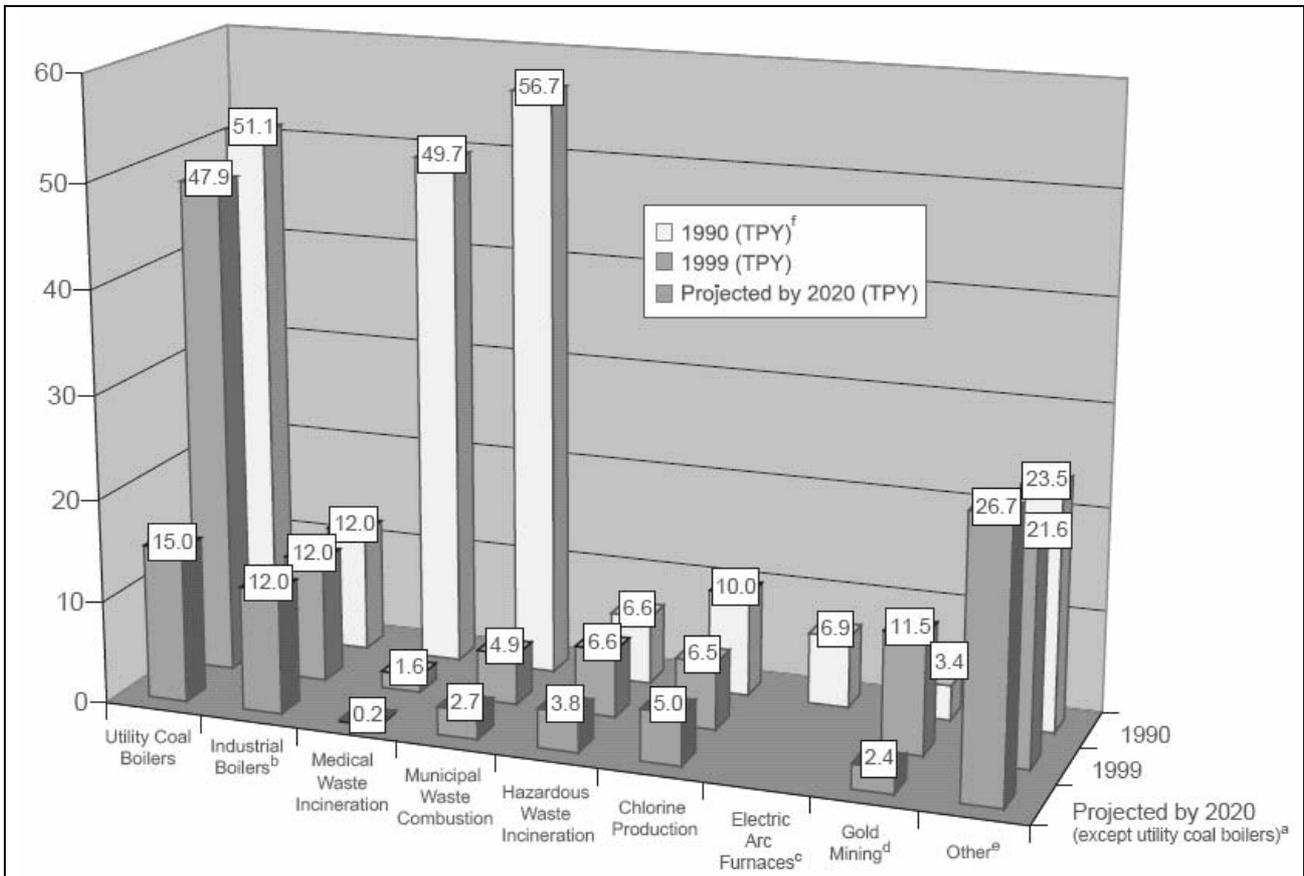
**Figure 8. Mercury production, consumption, prices and legislation in the United States 1970 - 1997**



Source: Sznoppek and Goonan (2000).

201. Figure 9 illustrates developments in emissions to air of mercury between 1990 and 1999 in the United States, and presents projections for how the emissions are expected to develop until 2020. Clearly, there was a very strong reduction in emissions from municipal and medical waste incineration between 1990 and 1999. As regards other emission sources, the developments are much more modest – and varied – with *increases* in the emissions from some sources. Whereas the reduction in emissions from coal-fired power plants was modest between 1990 and 1999, much more significant reductions in emissions will be made when the new cap-and-trade system comes into operation.

**Figure 9. Emissions to air of mercury in the United States**  
Short tons. 1990, 1999 and projections for 2020.



1. Fifteen tons per year will be achieved when full implementation of the *Clean Air Mercury Rule* is achieved, which may exceed 2020.
  2. Growth in this sector is being offset by regulation.
  3. Electric Arc Furnaces data not available for 1999. The 2002 estimate is 10 tons per year.
  4. The 1990 emissions estimate is a preliminary estimate and is based on back calculations and assumptions using data from 1999 along with information about types of processes, production rates, and ores used in 1990 compared to 1999.
  5. These projected emissions do not account for reductions from non-regulatory actions described elsewhere in the Roadmap.
  6. 1 ton equals 0.9070 metric tonnes.
- Source: US EPA (2006c). Explanations are reproduced as they are provided in the source.

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**ANNEX: OVERVIEW OF STATE LEVEL INSTRUMENTS ON MERCURY IN THE USA**

(Taken from ECOS, 2005)

National Overview of State Actions

State	Overall Mercury Action Plan	Quantify Progress Reducing Mercury	Inventory Mercury Sources	Conduct Mercury Monitoring	Mercury TMDLs, Watershed Plans, or Other Alternatives	Mercury Fish Consumption Advisory	Labeling Mercury-Containing Products	Phase-out Mercury-Containing Products	Mercury Collection Program	Mercury Vehicle Switch Removal	On-going Public Outreach	Mercury Related Research/Studies
Total Number of States	22	25	29	43	18	42	12	18	37	19	45	28
Alaska				✓				✓			✓	
Arizona	✓			✓	✓	✓			✓	✓	✓	✓
Arkansas				✓	✓	✓			✓	✓	✓	
California		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Colorado	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓
Connecticut	✓	✓	✓	✓		✓*	✓	✓	✓	✓	✓	✓
Delaware			✓	✓		✓			✓		✓	✓
Florida	✓	✓	✓	✓		✓*		✓	✓		✓	✓
Georgia				✓	✓	✓			✓		✓	
Hawaii				✓		✓*			✓	✓	✓	✓
Illinois		✓	✓	✓		✓*		✓	✓		✓	✓
Indiana		✓	✓	✓		✓*		✓	✓		✓	
Kansas				✓	✓	✓			✓		✓	
Kentucky	P			✓		✓*					✓	
Louisiana	P	✓	✓	✓	✓	✓			✓	✓	✓	✓
Maine	✓	✓	✓	✓	✓	✓*	✓	✓	✓	✓	✓	✓
Maryland		✓	✓	✓	✓	✓*	✓	✓	✓		✓	✓
Massachusetts	✓	✓	✓	✓	✓	✓*		✓	✓		✓	✓
Michigan	✓	✓	✓	✓	✓	✓*		✓	✓	✓	✓	✓
Minnesota	✓	✓	✓	✓		✓*	✓	✓	✓	✓	✓	✓
Mississippi				✓	✓	✓			✓		✓	✓
Missouri	✓		✓	✓		✓*			✓		✓	

✓ = Yes  
 ✓\* = Statewide Advisory  
 P = Planned

National Overview of State Actions, cont.

State	Overall Mercury Action Plan	Quantify Progress Reducing Mercury	Inventory Mercury Sources	Conduct Mercury Monitoring	Mercury TMDLs, Watershed Plans, or Other Alternatives	Mercury Fish Consumption Advisory	Labeling Mercury-Containing Products	Phase-out Mercury-Containing Products	Mercury Collection Program	Mercury Vehicle Switch Removal	On-going Public Outreach	Mercury Related Research/Studies
Montana				✓		✓*			✓		✓	
Nebraska				✓		✓		✓	✓		✓	
Nevada			✓			✓			✓		✓	✓
New Hampshire	✓	✓	✓	✓		✓*		✓	✓	✓	✓	✓
New Jersey	✓	✓	✓	✓		✓*	✓	✓			✓	✓
New York	P	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
North Carolina		✓	✓	✓	✓	✓			✓		✓	✓
North Dakota		✓		✓		✓*					✓	✓
Oklahoma	P		✓	✓					✓		✓	
Oregon	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Pennsylvania	✓	✓	✓	✓	✓	✓*			✓	✓	✓	
Rhode Island	✓	✓	✓		✓	✓*	✓	P			✓	
South Carolina	P		✓	✓		✓					✓	✓
South Dakota			✓	✓		✓					✓	
Tennessee				✓		✓			✓		✓	
Texas		✓	✓	✓		✓			✓		✓	✓
Utah				✓		✓			✓	✓	✓	
Vermont		✓	✓	✓		✓*	✓		✓	✓	✓	✓
Virginia	P	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
Washington	✓	✓	✓	✓	✓	✓*	✓	✓	✓	✓	✓	✓
West Virginia		✓	✓	✓		✓*			✓		✓	
Wisconsin	✓		✓	✓		✓*			✓	✓	✓	✓
Wyoming				✓							✓	

✓ = Yes  
 ✓\* = Statewide Advisory  
 P = Planned

## States Regulating Mercury Releases

	Coal-Fired Power Plants	Electric Arc Furnaces	Industrial Boilers	Steel Recycling Facilities	Sewage Sludge Incinerators	Wastewater Treatment	Chlor-alkali Plants	Municipal Solid Waste Incinerators	Medical Waste Incinerators	Mining	Cement kilns
Arizona						✓				✓	
Arkansas	✓			✓		✓	✓		✓		✓
California											✓
Connecticut	✓							✓	✓		
Delaware	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Florida								✓	✓		
Georgia						✓					
Indiana					✓			✓	✓		✓
Kentucky			✓	✓	✓	✓	✓				✓
Louisiana		✓		✓			✓	✓	✓		
Maine			✓	✓		✓		✓			✓
Maryland		✓	✓	✓	✓		✓	✓	✓		✓
Massachusetts	✓					✓					
Michigan						✓		✓	✓		
Minnesota						✓		✓	✓		
Montana	✓		✓								✓
New Hampshire								✓	✓		
New Jersey	✓	✓						✓	✓		
New York		✓		✓		✓		✓			
North Carolina					✓			✓	✓		
Oregon			✓					✓			
Pennsylvania						✓					
Rhode Island									✓		
South Carolina	✓	✓	✓		✓		✓	✓	✓		✓
South Dakota						✓					
Texas	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Virginia	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
Washington						✓	✓	✓			
West Virginia						✓					
Wisconsin	✓					✓					
Wyoming						✓				✓	
Total	10	8	9	8	8	18	9	18	16	5	11

State Actions Related to Mercury in Products (Excluding Vehicle Switches)

State	Labeling Requirements	Ban Mercury in Schools	Sales ban, use ban, or phase out						Limits on Mercury in Products	Disposal Ban
			Thermometers	Thermostats	Manometers	Novelty Items	Certain Types of Switches	Other		
California	✓		✓	✓		✓	✓		✓	
Connecticut	✓		✓	✓	✓	✓	✓	✓		
Florida								✓	✓	
Illinois		✓	✓			✓	✓			
Indiana			✓**			✓				
Maine	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Maryland	✓	✓	✓						✓	
Massachusetts			✓							
Michigan		✓	✓					✓	✓	
Minnesota	✓		✓		✓	✓	✓	✓	✓	
Nebraska			✓							
New Hampshire		✓	✓					✓	✓	
New Jersey	✓							✓	✓	
New York	✓		✓	✓	✓	✓	✓	✓	✓	
Oregon	✓		✓	✓				✓	✓	
Rhode Island	✓		✓			✓		✓	✓	
South Dakota									✓	
Vermont	✓								✓	
Virginia	✓*							✓	✓	
Washington	✓		✓					✓	✓	
<b>Total</b>	<b>12</b>	<b>5</b>	<b>15</b>	<b>5</b>	<b>4</b>	<b>8</b>	<b>6</b>	<b>9</b>	<b>12</b>	<b>11</b>

✓ = Yes

\* limits mercury in packaging only

\*\* must be sold behind the counter

State Vehicle Switch Activities							
State	Proposed or Enacted Mercury Switch Legislation or Regulation	Removal from End-of-Life Vehicles	Removal from On-the-Road vehicles	Prohibit Replacement Mercury Switches	Prohibit in New vehicles	Vehicle Manufacturer Responsibility in Switch Removal	State Financial Incentives for Switch Removal
Arizona	✓	M					
Arkansas	✓	M				✓	
California	✓	M	V		✓		
Colorado		V					✓
Connecticut	✓	V	V		✓		✓
Hawaii		V					
Illinois	✓						
Indiana		P					
Louisiana	✓	V*	V*				
Maine	✓	M	V	✓	✓	✓	✓
Massachusetts	✓	P		P	P		
Michigan	✓	V				✓	
Minnesota	✓	M	V			✓	✓
Missouri		P					
New Hampshire		V					✓
New Jersey	✓	P				✓	✓
New York	✓	V*	V				
North Carolina	✓						✓
Oregon	✓	M	V		✓		✓
Pennsylvania	✓	V*					✓
Rhode Island	✓	P				✓	
South Carolina	✓						
Texas	✓	P	P				
Utah		V					
Vermont	✓	V					
Virginia		V					✓
Washington	✓	V*		✓	✓		
Wisconsin	✓	V					✓
<b>Total</b>	<b>21</b>	<b>25</b>	<b>8</b>	<b>3</b>	<b>6</b>	<b>6</b>	<b>11</b>

- ✓ = Yes  
 M = Mandatory  
 V = Voluntary  
 V\* = Have voluntary removal, plan to implement mandatory removal  
 P = Plan to Implement