

# Mercury phase-out

A study of the experiences of Swedish companies





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# Contents

- Summary ..... 4
- 1 Introduction ..... 8
- 2 Objective and scope ..... 10
- 3 Method ..... 11
- 4 Results ..... 13
  - 4.1 Drivers of mercury phase-out ..... 13
    - 4.1.1 *Legislation* ..... 13
    - 4.1.2 *Voluntary market-based* ..... 14
    - 4.1.3 *Customer and employee awareness* ..... 16
  - 4.2 General effects of mercury phase-out ..... 17
    - 4.2.1 *Reduced toxic emissions* ..... 18
    - 4.2.2 *Product development* ..... 18
    - 4.2.3 *Some negative effects* ..... 20
  - 4.3 Economic effects of the ban on mercury ..... 21
    - 4.3.1 No negative economic effects ..... 21
    - 4.3.2 *Insensitive to economic effects* ..... 21
    - 4.3.3 *Sensitive to economic effects* ..... 22
    - 4.3.4 *Potential economic effects on small companies* ..... 23
- 5 Conclusions ..... 25
- 6 Companies' stories of practically phasing out mercury ..... 28
  - 6.1 Manufacturer of wildlife tracking devices ..... 28
  - 6.2 Producer of cars ..... 28
  - 6.3 Company offering dental care ..... 29
  - 6.4 Company offering medical care ..... 30
- References ..... 32
- Annex 1. Presentation of companies ..... 33

## Förord

Enveco Miljöekonomi AB har på uppdrag av Kemikalieinspektionen under våren och hösten 2011 genomfört en undersökning om företagens erfarenheter från utfasning av kvicksilver med anledning av det svenska förbudet som trädde i kraft 2009. Denna rapport utgör resultat av undersökningen.

Rapporten avser att belysa både möjligheter och svårigheter vid utfasningen. Studien har genomförts som intervjuer med företag och organisationer med sådan erfarenhet. Den har även kompletterats med några fallstudier för att visa på praktiska erfarenheter hos några företag.

Undersökningen genomfördes av Åsa Soutukorva och Anna Sundbaum vid Enveco Miljöekonomi AB. Kontaktpersoner vid Kemikalieinspektionen har varit Ulla Falk och Anna Fransson.

## Preface

Enveco Environmental Economics Consultancy was commissioned by the Swedish Chemicals Agency to conduct a survey of corporate experience from the phasing out of mercury as the Swedish ban came into force in 2009. This report contains the results from the investigation.

The report intends to highlight both the opportunities and difficulties in the phase-out process. The study was conducted as interviews with companies and organizations with such experience. It has also been supplemented by some case studies to demonstrate the practical experience of some companies.

The survey was conducted by Åsa Soutukorva and Anna Sundbaum at Enveco Environmental Economics Consultancy. Contact persons at the Swedish Chemicals Agency have been Ulla Falk and Anna Fransson.

## Summary

Since 2009 there is a general ban on mercury in Sweden. While the effects of the ban have been investigated before (KemI, 2004), a more detailed picture of the effects on Swedish companies due to the phase-out of mercury in processes and products has been lacking. The main objective of the present study is to provide such a picture. A phase-out process may involve challenges for companies but may also lead to many positive effects. The specific aims of the study are to illustrate a) drivers of phase-out, b) general effects of phase-out and c) economic effects of the ban, and the phase-out process it requires. Eleven companies and two actors involved with phasing out mercury were interviewed either by telephone or e-mail during late May – mid June 2011. 12 different uses of mercury are covered in total. This section summarizes the results from the interviews and the conclusions that can be made.

**As regards drivers of mercury phase-out** it is clear from the interviews that legislation, voluntary market-based drivers and customer/employee awareness have walked hand in hand in the Swedish mercury phase-out process. Half (50 %) of the interviewees refer to legislation as the most, or one of the most, important drivers for phasing out mercury, i.e. these would probably not even have started their phase-out process unless forced by legislation to do so. The importance of legislation is clearly twofold: a) catalyzing the phase-out process, and b) leading to a faster phase-out process. Other important drivers of phase-out have been voluntary, based on market/customer demand. The demand for mercury-free products has been critical for some companies to start their phase-out process, and this has sometimes even taken place long before the ban came into force. General awareness among customers/patients as well as employees has also been an important driver for the great majority of companies and actors. Knowledge about mercury and its toxic features is generally high in Sweden which is manifested by patients and customers requiring mercury-free dental fillings, thermometers, contact lens fluids etc.

**As regards general effects of mercury phase-out** it is evident from the interviews that the net effect of phasing out mercury has definitely been positive. The main positive effects of phase-out have been linked to a) reduced emissions and exposure to mercury for employees and customers and b) product development. The negative effects that few companies mention can be summarized as disposal of left-over mercury, more administration and difficulties motivating international suppliers to change their products for the Swedish market. A mercury ban at the EC level would reduce the problem of companies having to explain and give arguments for their demand of mercury free products since the same kind of legislation would apply to all EC countries.

**As regards economic effects of the ban on mercury** it is clear that the great majority of companies are very insensitive to the economic effects of mercury phase-out. Some companies report that they have had costs but no long-term negative economic effects. This can be interpreted as evidence for investments giving returns in terms of increased revenues and/or decreased costs. One opinion is that the investment would have happened anyway, with or without the ban on mercury. One company stresses the potential of investments in mercury free technologies to boost industrial development and give long term benefits to the local society.

Table 0 illustrates what the most important drivers and effects have been for companies belonging to the three main groups of mercury use: 1) Mercury, mercury compounds and mixtures containing mercury, 2) Products containing mercury, 3) Industrial processes

involving mercury. The table states, for example, that “Customer and employee awareness” has been the most important driver for companies belonging to group 1, compared to the other two groups. In the same way has “Legislation” been the most important driver for companies belonging to group 3, compared to the other two groups.

	<b>Main groups of mercury use</b> (x = the group for which a certain driver or effect has been most important, compared to the other groups)		
	<i>1. Mercury, mercury compounds and mixtures containing mercury</i>	<i>2. Products containing mercury</i>	<i>3. Industrial processes involving mercury</i>
<b>Drivers</b>			
Legislation			x
Voluntary market-based	x		
Customer and employee awareness	x		
<b>General effects</b>			
Reduced toxic emissions		x	
Product development			x
Negative effects	x		
<b>Economic effects</b>			
No negative economic effects	x		
Insensitive to economic effects		x	
Sensitive to economic effects			x

*Table 0. Summary of the most important drivers and effects for companies representing different groups of mercury use*

Finally, the practical procedures of mercury phase-out are also assessed in the report as a separate case study covering a subsample of companies in order to illuminate what a successful phase-out may look like for individual companies. Four companies representing different branches were interviewed by telephone or e-mail. Their individual stories of how they practically went about phasing out mercury constitute the main result of the case study.

# Sammanfattning

Sedan 2009 finns ett generellt förbud mot kvicksilver i Sverige. Effekterna av förbudet har undersökts tidigare (KemI, 2004), men en mer detaljerad bild av effekterna för svenska företag på grund av utfasningen av kvicksilver i processer och produkter har saknats. Målet för denna studie är att bidra med denna information. Processen för utfasning kan innebära utmaningar för företagen, men kan även leda till många positiva effekter. De särskilda målen för denna studie är att illustrera a) drivkrafter för utfasning, b) generella effekter av utfasningen samt c) ekonomiska effekter med anledning av det generella förbudet och utfasningen. Elva företag och två andra aktörer som fasat ut kvicksilver intervjuades via telefon eller e-post under slutet av maj – mitten av juni 2011. Totalt täcktes tolv skilda användningar av kvicksilver. Nedan sammanfattas resultaten från intervjuerna och de slutsatser som kan dras av dessa.

**Vad gäller drivkrafter för utfasning av kvicksilver** så är det tydligt från intervjuerna att lagstiftning, frivilliga och marknadsbaserade drivkrafter samt medvetenhet hos kunder/anställda har gått hand i hand i den svenska utfasningsprocessen. Hälften (50 %) av de intervjuade refererar till lagstiftning som den viktigaste, eller en av de viktigaste, drivkrafterna för utfasning av kvicksilver, dvs. dessa skulle troligen inte ens påbörjat sin utfasning om de inte tvingats av lagstiftningen att göra det. Vikten av lagstiftning är dubbel: a) den katalyserar utfasningen och b) den leder till en snabbare utfasning. Andra viktiga drivkrafter har varit frivilliga, baserat på krav från marknaden/kunder. Efterfrågan på kvicksilverfria produkter har varit avgörande för en del företag att påbörja sin utfasningsprocess, vilket i en del fall skett lång innan förbudet trädde ikraft. Generell medvetenhet hos både kunder/patienter såväl som anställda har också utgjort en viktig drivkraft för majoriteten av företag och aktörer. Kunskap om kvicksilver och dess farliga egenskaper är generellt hög i Sverige, vilket märks genom att patienter och kunder kräver kvicksilverfria tandfyllningar, termometrar, linsvätskor etc.

**Vad gäller den generella effekten av utfasningen av kvicksilver** är det tydligt från intervjuerna att nettoeffekten av att fasa ut kvicksilver definitivt har varit positiv. Den huvudsakliga positiva effekten kan länkas till a) reducerade utsläpp och exponering för anställda och kunder samt b) produktutveckling. De negativa effekter som ett fåtal företag nämnde kan summeras av svårigheter kring deponering av överblivet kvicksilver, mer administration och svårigheter att motivera internationella leverantörer att ändra sina produkter för den svenska marknaden. Ett kvicksilverförbud på EU-nivå skulle minska problemen för de företag som måste förklara och argumentera för sina krav på kvicksilverfria produkter då samma lagstiftning skulle gälla för alla medlemsstater.

**Vad gäller ekonomiska effekter med anledning av det generella förbudet** är det tydligt att den stora majoriteten företag är väldigt okänsliga för ekonomiska effekter av utfasningen. Vissa företag rapporterar att de initialt hade kostnader men att det inte givit några långsiktiga negativa ekonomiska effekter. Det kan tolkas som ett bevis för att investeringar betalar sig genom ökade inkomster och/eller minskade kostnader. En uttryckt åsikt är att investeringarna skulle genomförts oavsett om förbudet funnits eller inte. Ett företag betonar att det finns en stor potential i att investera i kvicksilverfria tekniker för att stärka industriutveckling och ge långsiktiga fördelar för det lokala samhället.

Tabell 0 illustrerar vilka de viktigaste drivkrafterna och effekterna har varit för de företag som tillhör de tre huvudgrupperna av kvicksilveranvändning: 1) kvicksilver, kvicksilverföreningar och blandningar som innehåller kvicksilver, 2) varor som innehåller kvicksilver, 3)

industriella processer som involverar kvicksilver. Tabellen anger exempelvis att ”Medvetenhet hos kunder och anställda” har varit den viktigaste drivkraften för företag som tillhör grupp 1, jämfört med de andra två grupperna. På samma sätt har ”Lagstiftning” varit den viktigaste drivkraften för de företag som tillhör grupp 3 jämfört med de andra två grupperna.

	<b>Huvudgrupper av kvicksilveranvändning</b> (x = gruppen för vilken en särskild drivkraft eller effekt har varit viktigast, jämfört med de andra grupperna)		
	<i>1. Kviksilver, kvicksilverföreningar och blandningar som innehåller kvicksilver</i>	<i>2. Varor som innehåller kvicksilver</i>	<i>3. Industriella processer som involverar kvicksilver</i>
<b>Drivkrafter</b>			
Lagstiftning			x
Frivilliga marknadsbaserade	x		
Medvetenhet hos kunder och anställda	x		
<b>Generella effekter</b>			
Reduktion av farliga utsläpp		x	
Produktutveckling			x
Negativa effekter	x		
<b>Ekonomiska effekter</b>			
Inga negativa ekonomiska effekter	x		
Okänsliga för ekonomiska effekter		x	
Känsliga för ekonomiska effekter			x

*Tabell 0. Sammanfattning av de viktigaste drivkrafterna och effekterna för företag som representerar olika grupper av kvicksilveranvändning*

Slutligen har även de praktiska erfarenheterna av utfasning undersökts som en separat fallstudie, som täcker en del av de intervjuade företagen. Detta har gjorts för att belysa hur en lyckad utfasning kan se ut för individuella företag. Fyra företag som representerar olika branscher djupintervjuades via telefon eller e-post. Deras individuella berättelser om hur de praktiskt gick tillväga för att fasa ut kvicksilver utgör resultatet av fallstudien.

# 1 Introduction

In Sweden it is well-known that mercury causes serious health- and environmental damage. Precautionary action against the use of mercury started as early as 1966 when mercury compounds used as seed mordant was prohibited after a massive decline of raptors in the 1950s and 1960s. In the 1990s a product based ban on mercury in measurement gadgets and electrical components was introduced. A ban on exports was introduced in 1997 and since June 1 2009 there is a total ban on mercury in Sweden. Due to this 45-year process Sweden has quite unique and very valuable experiences of phasing out mercury in several products and processes.

The total ban of 2009 implies that:

- Mercury, or mercury compounds or preparations must not be placed on the Swedish market; nor is it allowed to use mercury in Sweden or to professionally export mercury from Sweden.
- Mercury-containing articles must not be placed on the Swedish market or professionally exported from Sweden.
- Mercury-containing articles already in use prior to the ban can still be used but must not be placed on the market or exported from Sweden. It is not allowed to refill these articles with new mercury.

The Swedish experiences show that it is definitely possible for a country to have a national ban on mercury, not least because exemptions can be made in specific cases and when no other alternatives exist. Box 1 summarizes the existing Swedish and EC-legislation regulating exceptions and exemptions from the ban. The Swedish regulation (KIFS 2009:2) specifies the few and time-limited general exceptions that exist. Uses for which harmonized European Community (EC) legislation applies are also excepted from the Swedish ban, e.g. light sources and other electrical and electronic articles and batteries.

## **SWEDISH LEGISLATION (Ordinance SFS 1998:944, KIFS 2009:2)**

The Swedish Chemicals Agency (KemI) may issue regulations concerning exceptions to and, in individual cases, grant exemptions from, the prohibitions if the exception or exemption does not signify any manifest contribution to humans or the environment being exposed to mercury and

- the use meets an essential public need and no other alternatives are available on the market, or
- there are special reasons.

A regulation or exemption in accordance with the first paragraph may not be formulated in such a way that it contravenes such prohibitions of discrimination as follow from Sweden's membership of the European Union. Important to note here is that exemptions, approved by KemI on individual application, have taken place very rarely, e.g. on two occasions only during 2011.

The general exceptions from KIFS 2009:2 cover e.g. the following main areas of use:

1. Chemicals used for analysis
2. Research and development
3. Disinfection of medical equipment
4. Dental amalgam in some very specific cases
5. Seam welders
6. Wildlife trackers

**EC LEGISLATION (Directive 2002/95/EC "RoHS Directive", Annex XVII of REACH, Regulation (EC) No 1907/2006, Registration, Evaluation, Authorization and Restriction of Chemicals)**

The RoHS Directive states that Member States shall ensure that, from 1 July 2006, new electrical and electronic equipment put on the market does not contain mercury (among other substances). National measures restricting or prohibiting the use of these substances in electrical and electronic equipment which were adopted in line with Community legislation before the adoption of this Directive may be maintained until 1 July 2006.

***General exceptions from the RoHS Directive***

Applications of lead, mercury, cadmium and hexavalent chromium, which are excepted from the requirements:

- Mercury in compact fluorescent lamps not exceeding 5 mg per lamp.
- Mercury in straight fluorescent lamps for general purposes not exceeding:
  - halophosphate 10 mg
  - triphosphate with normal lifetime 5 mg
  - triphosphate with long lifetime 8 mg.
- Mercury in straight fluorescent lamps for special purposes.
- Mercury in other lamps not specifically mentioned in this Annex

The general exceptions are regularly reviewed in order to cross out exceptions as new alternatives become available.

***General exceptions from REACH***

The placing on the market of batteries and accumulators, containing more than 0,0005 % of mercury by weight, including in those cases where these batteries and accumulators are incorporated into appliances shall be prohibited. However, button cells and batteries composed of button cells with a mercury content of no more than 2 % by weight shall be exempted from a general prohibition.

*Box 1. Existing Swedish and EC legislation regulating general exceptions and exemptions*

From an international perspective important steps were taken in 2009 as world environment ministers (UNEP Governing Council) agreed to start negotiating a global mercury convention regulating all types of use and emissions. The convention is expected to be ready in 2013. To this international process there is a need to present good examples which makes the Swedish experiences welcome. Over the years of mercury phase-out in Sweden there has been a continuous dialogue between the Swedish Chemicals Agency (KemI) and affected companies. This has been important for KemI in order to a) learn more about the situation of companies and different uses of mercury, b) gain understanding for the ban, and c) enable decision making. This report is one more piece in this on-going dialogue.

The Swedish ban has contributed to product development that companies themselves bear the costs for. The opinions regarding this development, including positive as well as negative effects, have never been summarized before and this study aims to do so. The work has been carried out by Åsa Soutukorva and Anna Sundbaum at Enveco Environmental Economics Consultancy Ltd. for the Swedish Chemical Agency from late May - mid September 2011.

## 2 Objective and scope

While the effects of a general ban on mercury have been investigated before by the Swedish Chemicals Agency (KemI, 2004), a more detailed picture of the effects on Swedish companies due to the phase-out of mercury in processes and products has been lacking. The main objective of the present study is to provide such a picture. A phase-out process may involve challenges for companies but may also lead to many positive effects. The ban has contributed to product development, which may involve (short-term) costs for individual companies but also long-term benefits in terms of company image, brand, goodwill, increased effectiveness etc. The specific aims of the study are to illustrate a) drivers, b) general effects and c) economic effects of the ban, and the phase-out process it requires.

In order to also illuminate the practical procedures of mercury phase-out are in-depth interviews carried out with a subsample of companies. The expected main result of these interviews is an illustration of how a successful phase-out may look like for an individual company, e.g. what the obstacles were and how these were handled.

In 2010 the Swedish Chemicals Agency, in consultation with the Swedish National Board of Health and Welfare, was commissioned by the Swedish government to survey the use of mercury and mercury-containing products after the total ban came into force. The resulting government commission report (KemI, 2010) describes phase-out of mercury in a number of applications. The scope of the present study, regarding choice of applications and sample of companies, is based on what was reported in the government commission report. In the report the use of mercury was divided into the following three main groups and subgroups of products and processes:

1. Mercury, mercury compounds and mixtures containing mercury
  - Dental amalgam
  - Thiomersal
  - Biocides
  - Mercury compounds for analysis, research and development in medical diagnosis
2. Products containing mercury
  - Sphygmomanometers
  - Strain gauge plethysmographs
  - Relays, contractors, switches
  - Thermometers
  - Manometers
  - Hygrometers
  - Barometers
  - Pyrometers
  - Infra-red light detection semiconductors
  - Wildlife-tracking devices
  - Hand-drop electrodes for polarography, dropping mercury electrode (DME)
3. Industrial processes involving mercury
  - VCM (Vinyl chloride monomer) production
  - Polyurethane production
  - Chlor-alkali production

### 3 Method

Eleven companies, and two other relevant actors (see presentation below) involved with phasing out mercury, were interviewed either by telephone or e-mail during late May – mid June 2011. The selected sample of interviewees was chosen with the ambition to cover as many of the above listed applications as possible, but also with the purpose to achieve a satisfying distribution as regards size of companies and actors. For a presentation of companies and actors see annex 1.

The questions asked were:

1. Was the phase-out voluntary or enforced by legislation?
2. If the phase-out was voluntary – why was it initiated and when in time?
3. What are the positive effects of phase-out, i.e. with respect to less hazardous emissions, less safety equipment, easier waste management, company image/brand/good will?
4. What are the negative effects of phase-out, i.e. with respect to hazardous emissions, safety equipment, waste management, company image/brand/good will?
5. How has the company been affected in economic terms, i.e. short-term and long-term?
6. How long did it take for the company to get investment return on the new mercury-free technologies?
7. Have the company's employees and/or customers been aware of the toxic effects of mercury and if so, has that been a driving factor for the phase-out?
8. Any other aspects or information regarding the phase-out of mercury?

Questions 1-7 are linked to the main issues of the study in the following way:

- Questions 1, 2 and 7 give information on *the drivers of phase-out* (see section 4.1.)
- Question 3 and 4 illustrate *the general effects of phase-out* (see section 4.2).
- Questions 4, 5 and 6 give information on *the economic effects of phase-out* (see section 4.3).

Question 8 gives remaining other opinions that the respondents may have regarding phase-out.

Table 1 illustrates the study's wide coverage of products and processes that have been subject to mercury phase-out. The table presents the mercury uses for which the companies and actors have answered, i.e. which are perceived as the most important, although some companies have used mercury in more than one way. In total are 12 different uses of mercury covered by eleven companies and two actors in the following way:

1. Mercury, mercury compounds and mixtures containing mercury (four companies)
2. Products containing mercury (seven companies/actors)
3. Industrial processes involving mercury (three companies)

Two actors have been interviewed for this report. One is a center for research and innovation with experience of phasing out relays, contactors and switches (actor E in table 1) and the other is a member organization for engineering industries (actor H in table 1). Actor E is part of the analysis as it has actively phased out mercury used in its research methods. Actor H however, is an association of engineering industries representing 3500 different members with varying experiences and opinions, and hence cannot answer for itself only. The actor is included in table 1 since it has provided general experiences that are valuable to the study, but it is not included in the further analysis of the report.

To the products and processes described in KemI (2010) is one more use added: chlor-alkali production (belongs to the group *industrial processes involving mercury*). Another difference compared to the government commission report is that the product “thermometers” covers all kinds of thermometers. Finally, in KemI (2010) it is concluded that one company only in Sweden produces VCM (vinyl chloride monomer), and mercury is not used in that process. This explains why VCM production is not included in table 1.

Product/process	Company/actor												
	A	B	C	D	E	F	G	H	I	J	K	L	M
<b><i>Mercury, mercury compounds and mixtures containing mercury</i></b>													
Dental amalgam										X			
Thiomersal							X						
Biocides for preservation							X						
Chemical analysis									X			X	
<b><i>Products containing mercury</i></b>													
Sphygmomanometers											X		
Strain gauge plethysmographs											X		
Relays, contactors, switches			X	X	X			X					
Thermometers			X								X	X	
Manometers													
Hygrometers													
Barometers													
Pyrometers						X							
Infra-red light detection semiconductors													
Wildlife-tracking devices				X									X
Hang-drop electrodes													
<b><i>Industrial processes involving mercury</i></b>													
VCM production													
Polyurethane production			X										
Chlor-alkali production	X	X											

Table 1. Selected companies and actors (A-M) and their use of products and processes

While the coverage of different uses of mercury is satisfying it has been a greater challenge finding a sample of companies with a good distribution as regards size. The EU Commission (2003) classifies small and medium-sized enterprises (SMEs) in the following way:

**A small enterprise:** is defined as an enterprise which employs fewer than 50 persons and whose annual turnover and/or annual balance sheet total does not exceed 10 million EUR (approximately 86 million SEK).

**A medium-sized enterprise:** is defined as an enterprise which employs fewer than 250 persons and whose annual turnover or annual balance-sheet total does not exceed 50 million EUR (approximately 432 million SEK).

From the definitions of SME:s, a large-sized enterprise may be defined as an enterprise which employs at least 250 persons and whose annual turnover or annual balance-sheet total exceeds 50 million EUR (approximately 432 million SEK).

The companies and actors interviewed for the present study are all, except for two, large or medium-sized. It is therefore important to keep in mind that the opinions of small companies are not thoroughly covered by the present study. By referring to the results from an impact assessment targeted at small companies and carried out prior to the ban (KemI, 2004) an attempt is made in section 4.3.4 to compensate for this relative lack of representation of small companies.

## 4 Results

### 4.1 Drivers of mercury phase-out

This section presents the different drivers of mercury phase-out and summarizes what the most important factors have been for the sample of companies. The three main types of drivers have been: i) legislation, ii) voluntary market-based and iii) customer and employee awareness.

#### 4.1.1 Legislation

Six (50 %) companies in total, state that the phase-out of mercury was enforced by legislation. Legislation was the only driver for company B, C and M, whereas companies E, I and L mentioned legislation *and* voluntary reasons as equally important drivers. Below are presented opinions of companies representing the three main groups of products and processes included in the study.

#### **Mercury, mercury compounds and mixtures containing mercury (companies I, L)**

Company I, a global distributor of laboratory equipment, states that the drivers for the phase-out were voluntary, but at the same time mentions legislation as an important eye-opener to the problems with mercury. The company has phased out mercury from several products but is allowed to distribute some products that contain the substance, i.e. mainly products for lab analysis where substitutes to mercury are lacking or alternative methods are not available (see box 1 on the existing regulation of exceptions and exemptions). In these cases are buyers informed about the current mercury legislation and they also need to fill out a customer declaration to ensure that the substance will be used according to existing legislation.

Company L, a company in medical care (a hospital), started its phase-out process 20 years ago (early 1990's). In its own environmental assessments, mercury has been acknowledged as a hazardous substance, which triggered the phase-out to start. For this company it can be concluded that even if the starting point was voluntary, the ban has made the direction clear.

### **Products containing mercury (actor E, company M)**

Actor E, a center for research and innovation, states that the drivers for the phase-out were voluntary, but at the same time mentions legislation as an important catalyst for this process.

Company M, a small-sized enterprise and specialist in mobile positioning of e.g. vehicles, animals, people and valuable property, the phase-out was driven by the ban alone. The ban made the company invest in product development to be able to continue its business.

### **Industrial processes involving mercury (companies B, C)**

Company B, a producer in the chlor-alkali industry, reports that the timing of the phase-out was driven by legislation. It still uses mercury in its production and thus belongs to the very small minority (two only during 2011) of companies that have applied and been approved an exemption from the mercury ban, according to current legislation (see box 1). The company is now dependent on an extended deadline for use of mercury until it will invest in a larger and converted chlor-alkali production site, where mercury-free production can take place.

Company C, a provider of chemicals and plastic materials, states that the phase-out of mercury was enforced by legislation for thermometers and electrical switches.

The amount of time allowed for carrying out the phase-out seem to have been generous enough for most companies, i.e. December 2015 the latest (KIFS 2009:2). Companies have thus in general had enough time to transit into other technologies and to find substitutes for mercury.

#### **4.1.2 Voluntary market-based**

Five (42 %) companies in total, say that the phase-out was voluntary, i.e. mainly due to market and customer demand. Below are presented the opinions of companies representing the three groups of products and processes included in the study.

### **Mercury, mercury compounds and mixtures containing mercury (companies G, J)**

The customers of company G, a producer of fluids for contact lenses, experienced that the substance thiomersal caused eye irritation. The demand for these products fell dramatically and they were voluntarily phased out in the 1980s, and have not been used since then. For a long time the company had to label its products “thiomersal free product”. It can thus be concluded that there were strong market demands triggering company G to change and that this change took place long before the national ban came into force.

Company J, a company in dental care which previously used dental amalgam, introduced an internal ban on mercury in 2008, i.e. prior to the ban. The most important driver was the negative environmental impacts of mercury. The process was strongly facilitated by the fact that other alternatives to dental amalgam existed. Box 2 below gives a brief background to the Swedish history of phasing out dental amalgam.

## **PHASE-OUT OF DENTAL AMALGAM**

When the general ban on mercury came into force in Sweden in 2009, the use of dental amalgam in Swedish dental care had already been nearly phased out. This can be illustrated by the fact that the quantities of mercury sold for amalgam decreased from 980 kg in 1997 to around 100 kg in 2003. The most important explanations to this is summarized in KemI (2005):

- High awareness of the environmental and health risks of mercury among patients and dentists.
- Access to and demand for other alternatives.
- Voluntary agreement between the government and the county councils to phase out use of amalgam in children and young people (1995)
- Parliament decision to stop financial support for amalgam fillings from the national dental insurance service (1999)

One important key for the success is that there has been a good access and demand for alternatives to amalgam. The shares (measured by weight) of different dental filling materials have been estimated in KemI (2005) to composites (78 %), glassionomers (13 %), amalgam (6 %), compomers (3 %) and ceramics (less than 1 %). Furthermore, due to the fact that composites are lighter than amalgam, the same amount of composites (in kg) will restore more teeth than the same amount of amalgam would do. Hence, it is argued that in terms of fixed teeth, the proportion of composites will increase even more. In the report it is also concluded that while there are already numerous alternatives to amalgam, research is constantly taking place to develop new materials. One example of this is hydrated ceramics.

Although the insertion of new amalgam fillings has come to a nearly complete stop in Sweden (in total 25 patients June 2009-June 2011 according to The National Board of Health and Welfare in Sweden), there are still existing amalgam fillings that will constitute a source of mercury for decades. It is estimated by KemI (2010) that there are 3.4 tonnes of mercury in the teeth of the inhabitants of Stockholm. A lot of this already existing mercury in amalgam fillings leaks and will consequently contaminate the environment. The amount of mercury reaching sewage treatment plants have decreased but it is still estimated that 90 % of the mercury contaminating the sludge from sewage treatment plants in the Stockholm area is due to the continuous leakage of mercury from amalgam fillings, dental clinics and sediments in water pipes etc. KemI (2010) summarizes the most important benefits from shifting to mercury-free dental materials:

- Dentists, dental nurses and patients will no longer be exposed to mercury from new amalgam restorations.
- The release of mercury to atmosphere and water will be reduced.
- Composite (white) fillings are more aesthetically appealing.

KIFS 2009:2 specifies the time-limited exceptions that exist for dental amalgam. Dental amalgam may be placed on the market until 2011.12.31 and used on adults in hospital care or equivalent function until 2012.06.30 if the following conditions are met: i) there are special medical reasons, ii) other treatment methods do not provide a sufficiently good result in an individual case, iii) the clinic is adequately arranged, from an environmental point of view, for the use of dental amalgam.

*Box 2. Phase-out of dental amalgam in Swedish dental care*

### **Products containing mercury (companies D, F)**

Company D, a distributor of different measurement instruments, stopped selling a mercury containing wildlife tracking device completely due to changed customer demand. The company is one of two small companies in the sample and states that the product did not have any major impact on the company's total sales prior to the change in customer demand. Therefore, the decrease in sales had only marginal economic impacts on the company as a whole.

Company F, a producer of e.g. pulp and paper, states that the forest industry and legislation walk "hand-in-hand". The company is convinced that it is simply not desirable for companies to use hazardous substances like mercury.

### **Industrial processes involving mercury (company A)**

Company A lost its production factory due to unspecified market reasons. The company manufactures bleaching and performance chemicals for the pulp and paper industry. As late as 2010 the company had a chlor-alkali production using mercury cells, but since the production factory was lost it was considered too expensive to invest in a new membrane cell plant, i.e. the company stopped its chlor-alkali production altogether.

The company is critical against the fact that some companies are approved exemptions to keep using mercury (see box 1 regarding exceptions and exemptions). Some companies may, although there are alternatives to mercury, await stricter legislation before they start their own phase-out work. KemI would like to see that companies who make serious efforts shifting to alternative technologies are rewarded when the ban is in place, for example in terms of competitive advantages.

*"If legislation exists, it should be followed"*  
(Company A)

### **4.1.3 Customer and employee awareness**

Seven (58 %) companies in total, state that customer and/or employee awareness regarding the negative health and environmental impacts of mercury has been a driving force, to varying degrees. Below are presented the opinions of companies representing the three groups of products and processes included in the study.

### **Mercury, mercury compounds and mixtures containing mercury (companies G, I, J, L)**

From the interviews with companies G (producer of fluids for contact lenses), I (global distributor of laboratory equipment), J (company in dental care) and L (company in medical care (hospital)) it is evident that the customer and employee awareness is high and that this has played an important role as motivation for the companies in their phase-out processes. This is captured by the below statement of company I.

*"The awareness has played a major role, since everybody wants to do it the right way"*  
(Company I)

### **Products containing mercury (companies F, C, K)**

Company C is a provider of chemical and plastic materials and company F is a producer of pulp and paper. The employees of company C are aware of the hazardous effects of mercury, but it is not reckoned that this has been an important driver for the phase-out process. The employee awareness in company F is high, and is also considered as an important driver, walking hand in hand with legislation.

*“Some employees refuse to use the measurement instruments that contain mercury”*

(Company F)

As concerns medical instruments however, the patients’ awareness of mercury seems to be rather limited. They have often not been aware of the type of gadgets used and if they contain mercury or not. Not even all medical employees have enough knowledge about all medical instruments, and would consequently not be able to say if a blood pressure gadget contains a mercury hose or not. One exception however is thermometers, where patients have reacted if a mercury thermometer has been used. Company K, a company in medical care (hospital department), started its phase-out process of mercury in thermometers long before the national ban came into practice, in the late 1980s. The process was strongly driven by increasing knowledge of the negative environmental impacts of the substance. A continuous exchange of equipment containing mercury to other kinds of equipment became a natural process.

### **Industrial processes involving mercury (company B)**

Company B is a company in the chlor-alkali industry and also a member of the “petrochemical cluster” located on the Swedish west coast. The company strives to phase-out mercury by the end of 2015. The fact that the employees are highly aware of the negative impacts of mercury is regarded as an important driver for taking actions to phase-out mercury.

*“All of the company’s employees are aware of the effects of mercury and are dedicated to reduce emissions of the substance”*

(Company B)

## **4.2 General effects of mercury phase-out**

This section presents general, i.e. not necessarily economic, effects of mercury phase-out and summarizes what the most important positive and negative effects have been for the sample of companies. The main positive effects of phase-out have been linked to i) reduced toxic emissions, and ii) product development. One important negative consequence of the ban is the difficulties some companies have reported of motivating international suppliers to offer mercury-free products to the Swedish market.

#### **4.2.1 Reduced toxic emissions**

Five (42 %) companies in total, state that reduced toxic emissions is an important positive effect related to the phase-out of mercury. Below are presented the opinions of companies representing the three groups of products and processes included in the study.

##### **Mercury, mercury compounds and mixtures containing mercury (company J)**

Company J, a company in dental care which previously used dental amalgam, mentions several positive effects arising from reduced emissions of mercury. Examples given by this company are: a) reduced negative effects in terms of emissions to watercourses and sewage sludge, b) reduced amount of hazardous substances in the mouth, c) reduced emissions during cremation, and d) reduced exposure to mercury among dentists. See box 2 for a further discussion about phase-out of dental amalgam in Sweden and section 6 for the company's practical procedures of phasing out mercury.

##### **Products containing mercury (companies C, F, K)**

Company C is a provider of chemical and plastic materials, company F is a producer of pulp and paper etc. and company K is a company in medical care (hospital department). They all agree that reduced toxic emissions are a major positive effect of phasing out mercury.

##### **Industrial processes involving mercury (company B)**

Company B, in the chlor-alkali industry, still uses mercury in its production and is thus in a different position, striving towards a phase-out which will require a major investment. The investment will assure a conversion to a larger chloral factory, which will not only stop the local emissions of mercury but also reduce global emissions of mercury as the company will be able to shut down one of its other production sites in Europe. The production sites outside Sweden have much higher emissions than the Swedish factory, so this is an important environmental gain.

#### **4.2.2 Product development**

Six (50 %) of the companies in total, state that the replacement of old technologies has resulted in product development of different kinds, e.g. better and more efficient methods leading to higher production and/or more exact measurement. Below are presented the opinions of companies representing the three groups of products and processes included in the study.

##### **Mercury, mercury compounds and mixtures containing mercury (companies G, J)**

For company G, a producer of fluids for contact lenses, the major positive effect was that it could offer a better product, i.e. thiomersal free fluids, to its customers. See further discussion about this in section 4.1.2 above.

Company J, a company in dental care, stresses the positive health effects for its patients, i.e. that dental fillings containing mercury can be avoided. Today it uses dental amalgam to a very limited extent and the employees are much less exposed to the substance than before. In Swedish dental care there is great demand for and access to alternatives to dental amalgam and research is constantly going on in the search for new alternatives, i.e. a product development has been triggered by the phase-out of dental mercury. A brief historical

presentation of the phase-out of dental amalgam in Sweden is given in box 2, and a more detailed description of the practical procedures of company J is presented in section 6.

### **Products containing mercury (actor E, companies K, M)**

For actor E, a center for research and innovation with experience of research and development of measuring electrical resistance (Ohm), the phase-out of mercury resulted in more accurate measurements. It previously used a method that implied connection of resistances in series and parallels with amalgamated contactors. The equipment was immersed in oil to maintain temperature. The new method implies use of a cryogenic comparator, i.e. instead of immersing the equipment in oil it is immersed in liquid helium. By using this new method the measurements have become more accurate, but not necessarily easier or faster. Another positive effect was that the actor got rid of the oil baths that were previously necessary.

Company M, a producer of e.g. wildlife tracking devices, developed a new mercury-free product due to the ban (see section 6 for a description of the practical procedures the company went through).

Company K, a company in medical care (hospital department), has three different types of measurement instruments affected by the phase-out of mercury: sphygmomanometers, thermometers and strain gauge plethysmographs. For sphygmomanometers the measurement gadget has been replaced, from a mercury manometer to a mercury-free aneroid sphygmomanometer. Professional users in Sweden have experienced that the use of mercury free instruments in Swedish health care give adequate test results, and also that the calibration of these instruments is easy and cost-effective.

For all mercury containing thermometers the switch to the new technique “thermistors” has resulted in a much more accurate measure, which is also easier to read. For plethysmographs the gauge had to be replaced, which lead to a faster and to some extent more accurate method. Mercury-free technologies also imply much easier usage of the instruments. One concrete example of this is that a broken mercury thermometer used to involve a difficult clean-up process, which is now avoided.

Box 3 provides a brief presentation of what the health care measurement instruments discussed above are used for, and the phase-out of mercury that has taken place. Section 6 describes further the practical procedures that company K went through phasing out the substance.

## **MEASUREMENT INSTRUMENTS**

### **Sphygmomanometers**

Sphygmomanometers are used for both routine- and very exact blood pressure measurements. Two methods are available, mercury manometers or mercury-free aneroid sphygmomanometers. In Sweden the mercury-free method was first used in the 1960s. Today mercury free equipment is used in all applications.

### **Strain gauge plethysmographs**

Strain gauge plethysmographs are used for measuring blood pressure in fingers and toes. It can also be used for measurement of the variation in the size of an organ or body part based on the amount of blood passing through in the body part. To fill the strain gauge tubes, mercury may be used for instance to measure the pressure in small arteries. New equipment using photo cell or laser Doppler techniques have replaced the older technology. For strain gauge plethysmographs mercury was substituted by gallium and indium.

### **Thermometers**

In 1991 a ban on mercury containing measurement instrument was introduced. All kinds of thermometers (with a few exceptions) had to be phased out of the market. All thermometers for general purposes today are mercury-free and modern digital devices are usual used.

*Box 3. Presentation of measurement instruments used in health care*

## **Industrial processes involving mercury (B)**

In section 4.1.1 it is explained how company B is currently waiting for a necessary investment to take place which will enable mercury-free production in a converted chlor-alkali production site. Given that this happens, the company anticipates a positive development of its products. The company stresses that one major long term positive economic effect of the planned investment is that it would boost industrial development in an area on the west coast of Sweden, known as the “petrochemical cluster”.

### **4.2.3 Some negative effects**

The interviewed companies and actors are altogether positive to phasing out mercury, although there are naturally also some negative aspects of the process. Four (33 %) companies (A, I, J and L) mention that they, although at least partly driven by voluntary reasons, have experienced some negative effects related to the phase-out process.

- When company A, manufacturer of bleaching and performance chemicals for the pulp and paper industry, stopped its production it was left with 210 tonnes of mercury needing disposal. Legislation limited the company to, in practice, only one option: transformation and storage in German salt mines. A small amount of the mercury was recycled into other approved products, like fluorescent lights.
- Company I, the global distributor of laboratory equipment, is allowed to distribute some products that contain mercury, i.e. mainly products for lab analysis where substitutes to some of the analytical reagents in use are still not available (see box 1 on the existing regulation of exceptions and exemptions). However, purchasing the

product requires a customer declaration, which causes more administration and also delayed deliveries.

- Finally, due to the stricter Swedish legislation compared to the rest of non-Nordic Europe, company L in medical care (a hospital) has experienced difficulties motivating international suppliers to change their products for the Swedish market. The company therefore seeks further arguments, other than legislation, that may be used in negotiations with international suppliers to explain and give support to the company's demand for mercury-free products.

Some companies, e.g. company J, have mentioned the investment costs for new technologies, e.g. training of staff as negative effects of phasing out mercury. But this company has also experienced cost savings due to the reduced amounts of hazardous waste it has to take care of. Moreover, for society as a whole, it should be undisputable that the net health and environmental effects of these investments are positive.

### **4.3 Economic effects of the ban on mercury**

This section presents the economic effects of the ban and the mercury phase-out it requires, and summarizes what they have been for the sample of companies. The companies are categorized by the kind of economic experiences they have had due to the ban: i) no negative economic effects, ii) insensitive to economic effects, iii) sensitive to economic effects.

#### **4.3.1 No negative economic effects**

Five (42 %) companies in total (C, D, G, I, and K) state that they in general have experienced no negative economic effects due to the phase-out of mercury, i.e. this is a view shared also by one of the small companies (D) in the sample. The phasing out of the substance has often taken place naturally when old equipment needed replacement, i.e. old methods were simply replaced with mercury-free technologies.

Company K, the company in medical care (hospital department), illustrates a nearly complete insensitivity to economic effects by stating that if it would invest in a new measurement technique, the decision would not be based on cost primarily. There are no available estimations of the costs of phasing out mercury which may be explained by the “zero vision” that this, and other, companies have regarding mercury. Cost is simply not an issue.

#### **4.3.2 Insensitive to economic effects**

Four (33 %) of the companies in total, seem rather insensitive to the economic effects resulting from the transition to mercury-free technologies. One reason for this may be that these companies are all, except for one, medium-sized or large and thus possibly less sensitive to changes in general. Below are presented the opinions of companies representing two groups of products and processes included in the study.

#### **Products containing mercury (actor E, companies J, L)**

For actor E, enterprise and center for research and innovation with experience of phasing out relays, contactors and switches, the costs were related to both new equipment and investment in new skills in order to be able to use the new technique. The cost has been estimated to a few million SEK, but a change of technology might have happened anyway, i.e. with or without the ban. The transition to mercury free production is thus regarded as an investment

rather than a cost, but an investment that has not given economic returns. Even so, the actor was still willing to make the necessary investments for environmental and health reasons.

*“A transition to another technology might have happened anyway. There is no loss not to use mercury any more”*

(Actor E)

Company J, the company in dental care, states that it has had costs for training staff, administration etc. The largest cost item was to educate staff in new filling technologies, estimated to about SEK 12 million (1,3 million euro) in terms of revenue shortfalls. At the same time, the company has reduced its costs for taking care of mercury containing waste since the amount of such waste has dropped when there are no residues from new fillings. However, the company has not estimated the size of these cost savings. A further discussion of the practical procedures of phasing out mercury in company J is presented in section 6.

Company L in medical care (a hospital), states that there has been no financial impacts on company level due to the ban of mercury, although the cost for some specific materials used for treatment has been marginally higher.

### **Industrial processes involving mercury (company A)**

For company A, a manufacturer of bleaching and performance chemicals for the pulp and paper industry, the cost landed on a few million SEK, but the company states that the phase-out has had no effect in the long term, which is probably due to its large size. The cost would however been smaller if it had not been restricted by legislation to dispose the left-over mercury. Although company A has experienced disposal of left-over mercury as a cost it is worth noting that a company which uses mercury in one way or another is responsible for taking care of its hazardous waste. At least in the long run, there are hence no obvious reasons why the costs involved with phasing out mercury should exceed the costs for continuous disposal of mercury. On the contrary, as companies phase out mercury and start using other technologies, they will no longer have costs for taking care of their waste.

### **4.3.3 Sensitive to economic effects**

Three (25 %) of the companies (B, F and M) seem more sensitive to the economic effects of the ban and the phase-out process it requires. Major investments in mercury free technologies (company B) and access to mercury free alternatives (company F) are crucial for these companies in the long run, although they are both currently exempted from the ban.

Company B, in the chlor-alkali industry, anticipates an investment of SEK 1,7 billion (185 million euro) in new mercury free technology, but is dependent on the Swedish government to approve an extended exemption for it to continue using mercury until year 2015. A shift to mercury free technologies is necessary to keep the production, but the company needs more time to carry out the investment.

Company F, a producer of pulp and paper, would consider a mercury-free equipment if it was available on the market to a reasonable cost. However, today there exist no mercury free alternatives to porosimeters, which the company uses to measure the size of pores, and the company that provides the device to company F is thus exempted from the ban.

Company M, a specialist in mobile positioning and manufacturer of a wildlife tracking device, invested a lump sum of approximately SEK 200 000 – 300 000 (22 000-32 000 euro) in product development. This investment was crucial for the company to stay in the market since it could no longer sell its mercury containing device. The new product both functions and looks like it did before the product development took place, which might explain why sales have not dropped since the shift in technologies.

#### ***4.3.4 Potential economic effects on small companies***

Two small companies are included in the present study, which implies that the representation of opinions of small companies is limited. This relative lack of representativeness is compensated, at least partly, by referring to the most important conclusions from an impact assessment carried out by KemI (2004) prior to the ban. Important results from the impact assessment are summarized in box 5 below.

## RESULTS FROM IMPACT ASSESSMENT ON SMALL COMPANIES

**The economic impacts** on small companies in terms of charges, costs for changed processes, salary costs and investments in plant and new staff due to phase-out of mercury were assessed for three areas of use: i) dental amalgam, ii) analytical chemicals and reagents and iii) seam welding. It is concluded that there in general will be no negative economic impacts due to the phase-out period and the resulting new duties for small companies. Below are the results for dental amalgam presented.

**Competition conditions** are described as e.g. barriers to entry, market access, possibility to growth, the competitiveness of Swedish entrepreneurs, stricter environmental and safety requirements and any relationship of dependency of small enterprises in relation to large competitors.

- For dental amalgam it is concluded that the competitive situation may change due to the ban, but it can also stimulate possibilities for manufacturers and distribution companies to grow and gain market shares in the Swedish market, at least as regards filling materials. Worth noting is the argument that the competitiveness of Swedish companies may benefit in relation to other actors since they have already made the necessary changes due to the stricter environmental legislation. In other words, a company that changes its activities due to the ban will likely experience some initial costs but the long term effect of these changes, e.g. in terms of improved competitiveness, may still be positive.

**Administrative and practical impacts** are expected to occur for companies adopting the ban, but it is also reckoned that these costs should not be overstated.

- For small companies in dental trade there are no significant administrative costs assumed, due to the fact that alternative filling materials are already in the market.

The major positive impacts of a general ban on mercury for small companies are listed:

- Workplaces provides a safer working environment with simpler procedures
- Increased efficiency and productivity
- Reduced costs, including environmental costs

Due to the above it was concluded from the impact assessment that there were no special time-limited exceptions needed for small companies. The existing exceptions were judged sufficient for small companies too.

*Box 5. Potential effects on small companies due to the general ban*

## 5 Conclusions

This section summarizes what the most important a) drivers b) general and c) economic effects of phase-out have been for the interviewed sample of Swedish companies and actors.

**The most important drivers of mercury phase-out.** From the interviews it is clear that legislation, voluntary market-based drivers and customer/employee awareness have walked hand in hand in the Swedish mercury phase-out process. Half (50 %) of the interviewees refer to legislation as the most, or one of the most, important drivers for phasing out mercury, i.e. these would probably not even have started their phase-out process unless forced by legislation to do so. The importance of legislation is clearly twofold: a) catalyzing the phase-out process, and b) leading to a faster phase-out process. Other important drivers of phase-out have been voluntary, based on market/customer demand. The demand for mercury-free products has been critical for some companies to start their phase-out process, and this has sometimes even taken place long before the ban came into force. General awareness among customers/patients as well as employees has also been an important factor for change for the great majority of companies and actors. The knowledge about mercury and its toxic features is generally high in Sweden which is manifested by patients and customers requiring mercury-free dental fillings, thermometers, contact lens fluids etc.

**The most important general effects of phase-out.** From the interviews it is evident that the net effect of phasing out mercury has definitely been positive. The main positive effects of phase-out have been linked to a) reduced emissions and exposure to mercury for employees and customers and b) product development. The negative effects that few companies mention can be summarized as disposal of left-over mercury, more administration and difficulties motivating international suppliers to change their products for the Swedish market. A mercury ban at the EC level would reduce the problem of companies having to explain and give arguments for their demand of mercury free products since the same kind of legislation would apply to all EC countries.

**The most important economic effects of the ban on mercury.** From the interviews it is clear that the great majority of companies are very insensitive to the economic effects of mercury phase-out. Some companies report that they have had costs but no long-term negative economic effects. This can be interpreted as evidence for investments giving returns in terms of increased revenues or decreased costs. One opinion is that the investment would have happened anyway, with or without the ban on mercury. One company stresses the potential of investments in mercury free technologies to boost industrial development and give long term benefits to the local society.

Table 2 illustrates what the most important drivers and effects have been for companies belonging to the three main groups of mercury use: 1) Mercury, mercury compounds and mixtures containing mercury, 2) Products containing mercury, 3) Industrial processes involving mercury.

	<b>Main groups of mercury use</b> (x = the group for which a certain driver or effect has been most important, compared to the other groups)		
	<i>1. Mercury, mercury compounds and mixtures containing mercury</i>	<i>2. Products containing mercury</i>	<i>3. Industrial processes involving mercury</i>
<b>Drivers</b>			
Legislation			x
Voluntary market-based	x		
Customer and employee awareness	x		
<b>General effects</b>			
Reduced toxic emissions		x	
Product development			x
Negative effects	x		
<b>Economic effects</b>			
No negative economic effects	x		
Insensitive to economic effects		x	
Sensitive to economic effects			x

*Table 2. Summary of the most important drivers and effects for companies representing different groups of mercury use*

**For drivers** of mercury phase-out, table 2 indicates that:

- *Legislation* has been the most important driver for companies belonging to group 3, compared to the other groups.
- *Voluntary market-based* reasons have been the most important driver for companies belonging to group 1, compared to the other groups.
- *Customer and employee awareness* has been important for all three groups, but especially for companies belonging to group 1.

**For general effects** of mercury phase-out, table 2 indicates that:

- *Reduced toxic emissions* are regarded as an important effect of phase-out, especially by companies belonging to group 2.
- *Product development* is regarded as an important effect of phase-out, especially by companies belonging to group 3.
- *Negative effects* of phase-out have been experienced primarily by companies belonging to group 1.

**For economic effects** of the ban on mercury, table 2 indicates that:

- Especially companies belonging to group 1 have stated that they experienced *no negative economic effects* due to the phase-out of mercury.
- A majority of companies belonging to group 2 have been *insensitive to economic effects* of phase-out.
- Companies belonging to group 3 are the most *sensitive to economic effects* of the ban, and the phase-out it requires.

The above indicates that companies strongly driven by voluntary market-based reasons and awareness about mercury tend to have experienced no or only limited negative economic effects of the phase-out. From the interviews it has become clear that some companies have experienced that the mercury phase-out process was not costly at all, at least not in the long run, products and methods have gradually been replaced by better alternatives. The companies are well aware of the toxic characteristics of mercury and they view mercury as something highly unwanted. Some companies will do almost anything to phase-out the substance, i.e. they are very insensitive to costs.

Furthermore, companies strongly driven by legislation tend to have been more sensitive to negative economic effects of the mercury ban and the phase-out it requires. Product development is regarded important to a larger extent than for other companies. From the interviews it has become clear that companies forced by legislation to phase out mercury are very motivated to make necessary efforts to find mercury free products and methods.

## **6 Companies' stories of practically phasing out mercury**

This section reports the results from a minor case study of the practical procedures of phase-out. In-depth interviews have been carried out with four companies, representing four different branches:

- A manufacturer of wildlife tracking devices
- A producer of cars
- A company offering dental care
- A company offering medical care (hospital department)

Three of the 13 companies interviewed in the first part of the study, dealing with drivers and effects of phase-out, are approached again in this practically oriented case study. The three companies included in both parts of the report are: the manufacturer of wildlife tracking devices (company M), and the companies offering dental care (company J) and medical care (company K, hospital department). Although the focus in this section of the report is the detailed practical procedure of companies, there will necessarily be some overlaps for the companies that are included in both parts of the report. To the subsample of companies is also added a producer of cars.

Each of the four companies has answered detailed questions such as: How and when did the phase-out process begin? How long did it take? What kinds of investments were made? Who was responsible for the product development – the company itself or suppliers far away? Was education of staff necessary, and if so, who provided this education? Does the company sell more or less after the product development took place? The remainder of this section contains the companies' stories of how they practically went about phasing out mercury.

### **6.1 Manufacturer of wildlife tracking devices**

This company assembles circuit boards, which previously contained a mercury component, for its product wildlife tracking devices. The company started its phase-out of mercury due to legislative requirements in the 1990s. In order to continue its production of wildlife tracking devices, the company saw now other possibility than to invent a new mercury free product. A one-year exemption was approved for the company, which allowed it enough time to transit to alternative technologies. The product development was driven and funded by the company itself with primary focus to find an alternative circuit card. The only investment made was in terms of the time required for the company to search for alternative methods. The company has estimated this cost to around SEK 200 000 – 300 000 (22 000-32 000 euro). There were no other costs, e.g. for education and administration, involved with this product development.

### **6.2 Producer of cars**

The total ban of 2009 was the primary driver for this company to start phasing out mercury. At the time when the company initiated its own phase-out process there was a pretty lively debate and awareness in Sweden about the hazardousness of mercury, which also triggered the company to act. The Swedish market is the largest and thus most important for the company, which has been forced to adapt to the existing Swedish legal requirements.

The product subject to mercury phase-out was a switch. The company started its phase-out process by surveying the market to find suitable substitutes. Alternatives were found relatively easily and after about one to two years the switches were all substituted. The company explains that the procedure was simple, i.e. basically just replacing one component to another mercury-free one. The company is organized so that a special internal unit is responsible for environmental issues concerning the company's products. One important task for this unit is to ensure that the company complies with existing legal requirements and it also supports the corporate management by giving recommendations in the environmental field. This has also been the case for mercury phase-out, e.g. the corporate management was recommended to make a decision to phase out mercury. This recommendation was followed and the phase-out process began in practice once the ban came into force.

As already noted there was no need for major investments, since one supplier detail was simply swapped for another. Replacement parts are generally, however, always around 5 % more expensive the first years of use. Then prices normally drop and are adjusted.

The company mentions that they have experienced reduced costs in terms of waste management. This is especially the case in the U.S. where most states have a charge on mercury, which implies that the company is obliged to pay a fee for each car containing mercury components, in this case the switch, when the car is scrapped. The company estimates the cost saved by avoiding this to around SEK 100 (11 euro) per car in the U.S. market. The company needs to investigate further the total number of affected cars, and the total cost saved is thus not estimated. When there are no more cars in the market, containing these components, the cost savings will consequently decrease.

At the EU level, the EC Directive on end-of life vehicles from 2000 (2000/53/EC) regulates how end-of life vehicles shall be taken care of. The EU has signed agreements with recycling companies and the company cannot answer to which extent the costs for these agreements are due to taking care of mercury. The use of the new mercury free switch implies that the company no longer needs to disassemble its cars and no longer have to pay the mercury charge. Furthermore, the labour cost of manually removing the switch before scrapping the car, an operation estimated to take about 10-20 minutes/car at a cost of approximately SEK 50-100 (7-11 euro)/car, is now avoided.

The product development was carried out by the suppliers. The company provided the supplier with a set of requirements and the actual product development was hence carried out by the supplier, and not the company itself. The supplier had to bear some of the costs for this development, although the cost was at least partly reflected by the price which the company had to pay for the new mercury free component.

The company cannot answer where the product development took place in practice. Although its supplier is Swedish, it is not obvious that the components were actually manufactured in Sweden. The company has not experienced any drops in sales, efficiency etc. These parameters have not changed due to the phase-out of mercury.

### **6.3 Company offering dental care**

The driving force for the phase-out of mercury in this company was primarily health and environmental aspects and, of course, the existence of a voluntary agreement between the government and the county councils to phase out use of amalgam in children and young people from 1995 (see box 2). Efforts to phase out mercury began with the introduction of

internal environmental management, i.e. basically the company started to work with set targets. Investments to educate staff were carried out and in 1995 all employees were trained in new technologies, so called white fillings. The education implied in total 2.5 days of training. In 2001 the company carried out very few amalgam fillings, a number that continued to fall each year until year 2009 when it dropped even more due to the introduction of the total ban on mercury.

The largest cost item was for training all staff on how to apply the new filling technology. This cost is estimated to about SEK 12 million (1,3 million euro) in terms of revenue shortfalls (based on current (2011) price level). With a total turnover of 1 378 MSEK (149 million euro) in 2010 (see annex 1) this should imply a minor cost. Appropriate training in the new filling technologies (which need to be hardened) should lead to a treatment time that is not longer than treatment with amalgam (which does not need to be hardened). The costs for alternative filling materials were initially higher than for amalgam, but have dropped as the new technologies have developed. The company has not experienced any administrative costs due to the change in technology. The company still handles amalgam when drilling out old fillings. Therefore all chairs must be equipped with amalgam separators requiring regular service. Another cost item is water samples to measure the levels of mercury. Furthermore, equipment hoses etc. must be handled as hazardous waste, implying costs that will drop to zero only when people no longer have amalgam fillings. The company estimates this to take at least one, perhaps even more generations.

Finally, costs for taking care of mercury containing waste have dropped since the amount of such waste is reduced when there are no residues from new fillings. The company has not estimated the size of these cost savings.

The company cannot say in any more detail how product development has taken place in practice since the development of new restorative materials was likely carried out by dental companies that sell dental consumables.

The company concludes that its activities are far less dangerous today without the use of dental amalgam. Some allergy problems linked to e.g. plastic fillings existed initially, but these have been considerably reduced when the involved staff has learned how to handle the new products (KemI, 2004). In the development of dental materials it is still important to be aware of chemicals, other than mercury, which may also be harmful to humans and the environment.

## **6.4 Company offering medical care**

This company, which is a hospital department, began its phase-out process long before the ban came into force, in the late 1980s already. It was perceived as a natural step, since hazardous substances should simply be avoided.

Thermometers were the first products to be phased out. All hospital departments replaced their thermometers gradually. Thermometers including mercury have been used since ancient times. Today when the temperature of patients is taken, mercury-free thermistors are used, which in fact also give more accurate results. Another positive aspect is that many problems of practical nature are avoided, for example broken thermometers.

For some measurement gadgets, like blood pressure monitors (sphygmomanometers), the method itself was not changed. Instead of using a mercury column, a manometer watch was used. The uncertainty of the measurement is the same, regardless of whether a mercury column or manometer watch is used. For other measurement gadgets, like plethysmographs, an alternative sensor was needed. Strain gauges were chosen as the best alternative. The phase-out took place as the equipment got older. The new measurement method proved to be both somewhat faster and safer than the old one.

Prices for the measurement instruments discussed above have not significantly increased. Mercury thermometers were initially marginally cheaper than other mercury free alternatives. Today however purchase prices barely differ, although this fact is not of great interest for this company who simply does not want mercury in its activities. The substitution of instruments containing mercury to mercury-free alternatives has occurred gradually.

The total costs of making the necessary investments discussed have not been estimated. For environmental and health reasons the company saw no other alternatives to phasing out mercury.

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## Annex 1. Presentation of companies

A. Large-sized enterprise and manufacturer of chemicals for the pulp and paper industry. It also has a history of chlor-alkali production and a member of the “petrochemical cluster” on the west coast of Sweden.

Turnover: 1044 MEUR (2010)

Employees: Around 2 550 (2010)

B: Large-sized enterprise with chlor-alkali production and a member of the “petrochemical cluster” on the west coast of Sweden.

Turnover: 2 131 MSEK (2010)

Employees: 300 (2010)

C: Large-sized enterprise and provider of chemicals and plastic materials with history of phase-out of thermometers and switches. Member of the “petrochemical cluster” on the west coast of Sweden.

Turnover: 13 366 MSEK (2010)

Employees: 913 (2010)

D: Small-sized enterprise and a distributor of screens with history of phase-out of a wildlife-tracking device.

Turnover: 18,9 MSEK (2010)

Employees: 5 (2010)

E: Large-sized actor and center for research and innovation with experience of research and development for measurements of electrical resistance.

Turnover: 713 MSEK (2010)

Employees: 649 (2010)

F: Medium-sized enterprise and producer of e.g. pulp and paper. The company still uses mercury containing pyrometers.

Turnover: 335 MSEK (2010)

Employees: 270 (2010)

G: Large-sized enterprise and producer of fluids for contact lenses with history of phasing-out mercury in its products biocides for preservation and thiomersal.

Turnover: 2.29 billion USD (2006). Global figures.

Employees: 13 000 (2006). Global figures.

H: Medium-sized actor (member organization), with 3500 members. The organization is an association of engineering industries.

Turnover: 190 MSEK (2010)

Employees: 120 (2010)

I: Large-sized enterprise and global distributor of laboratory equipment.

Turnover: 350 MSEK (2010)

Employees: 140 (2010)

J: Medium-sized enterprise in dental care with a history of phasing out amalgam.

Turnover: 1 378 MSEK (2010)

Employees: 1885 (2010)

K: Medium-sized enterprise, a company in medical care (hospital department) with a history of phasing out mercury from the following medical instruments: sphygmomanometers, strain gauge plethysmographs and thermometers.

Turnover: 280 MSEK (2010)

Employees: 190 (2010)

L: Large-sized enterprise, a company in medical care (hospital), with a history of phasing out mercury from different uses, e.g. chemical analysis and thermometers.

Turnover: 14,2 billion SEK (2010)

Employees: 15 500 (2010)

M: Small-sized enterprise, specialist in mobile positioning with for example wildlife tracking devices.

Turnover: 20 MSEK (2010)

Employees: 14 (2010)





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