norden

MERCURY

– Reductions are feasible

Reducing mercury releases
with known technologies
and management solutions

Mercury – Reductions are feasible
Inspiration for reduction of mercury releases with known technologies and management solutions

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Nordic co-operation

Nordic co-operation is one of the world's most extensive forms of regional collaboration, involving Denmark, Finland, Iceland, Norway, Sweden, and three autonomous areas: the Faroe Islands, Greenland, and Åland.

Nordic co-operation has firm traditions in politics, the economy, and culture. It plays an important role in European and international collaboration, and aims at creating a strong Nordic community in a strong Europe.

Nordic co-operation seeks to safeguard Nordic and regional interests and principles in the global community. Common Nordic values help the region solidify its position as one of the world's most innovative and competitive.

FOTO: STEEN EVALD

It is time to act

The international community has agreed to negotiate a global treaty on mercury. The reasons are more than obvious: Every year some 1200 – 2900 tonnes of mercury are released into the atmosphere from human activities, causing severe health problems for both humans and wildlife. Mercury has many toxic effects, but the most subtle for humans is the reduction in intellectual capacity due to the effects of mercury exposure on the developing nervous system of unborn babies and young children.

Humankind bears full responsibility. Since the start of the industrial age the deposition of mercury has doubled worldwide, and the concentration of mercury in lake sediments has tripled. It is time to act.

It is a top priority of the Nordic Council of Ministers to combat hazardous substances in our global environment. We strongly believe that the way forward is through international awareness and co-operation. This also goes for mercury. No matter where it is emitted, it can travel thousands of kilometres with the prevailing winds. And even after it has deposited on the ground, it can evaporate again and begin another journey.

While political negotiations on the global treaty are just about to begin, technology already gives us a range of tools with which to combat mercury releases. The scale and nature of the tools at our disposal vary from high-tech filters for waste incineration facilities to common sense solutions like phasing out mercury thermometers, and practical devices that can reduce mercury releases from small-scale gold mining.

With this publication the Nordic Council of Ministers would like to draw attention to some of the more efficient technologies available to tackle a range of mercury challenges. Our hope is that it will serve as a concrete contribution to the global call for action to combat mercury pollution.

Karen Ellemann
Danish Minister for the Environment and
Minister for Nordic Cooperation

OUR FUTURE

does not depend on mercury

On a global scale, human activities are responsible for doubling the deposition of mercury from the atmosphere. We generate 1200 – 2900 tonnes of mercury emissions to the atmosphere each year. Mercury can be transported in the atmosphere to even the most remote parts of the world. Fortunately, global mercury releases can be reduced by half with already existing measures.

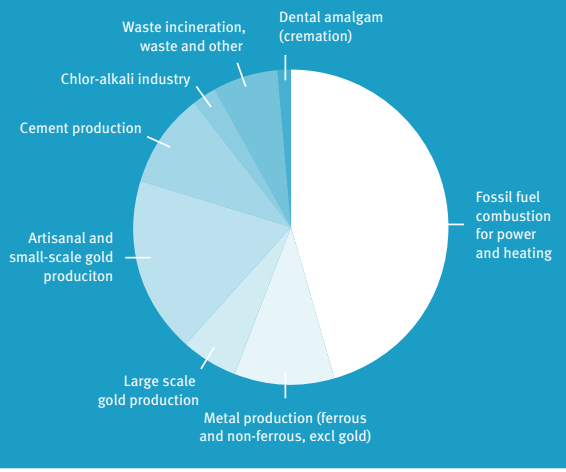
Each year some 1200 – 2900 tonnes of mercury are emitted to the atmosphere from human activities, and large amounts of mercury are released to our rivers, lakes, seas, and land areas. A considerable part of the emissions of mercury stem from our increasing need for energy, as mercury is emitted when we burn fossil fuels such as coal. Small-scale gold mining and industrial-scale metal production also release large amounts of mercury during processing.

Mercury is magnified in the food chain
Mercury causes health problems. In the environment mercury can be transformed into methylmercury, and methylmercury is *bio-accumulated* in fish and other freshwater and marine food sources. *Bio-accumulation* refers to the concentration of mercury increasing as it goes up the food chain. Mercury in the food we eat can accumulate in our bodies and can even be transmitted to our unborn babies.

Fishing communities and indigenous Arctic peoples tend to be more exposed to mercury than other people. The toxic effects of mercury poisoning are numerous; one of the major effects is that unborn babies and young children may suffer from reduced intellectual capacity when exposed to mercury at even low concentrations. Representative sampling in the USA has shown that 6% of women of child-bearing age (16-49 years) have high enough mercury concentrations in their blood to potentially affect the mental development of their children.

Global challenge
Once released, mercury can travel long distances and is thus a truly global challenge. It has been targeted by national and regional regulation for decades. Recently, through the forum of the Governing Council of the United Nations Environment Program (UNEP), the global community agreed to initiate negotiations for a global mercury treaty.

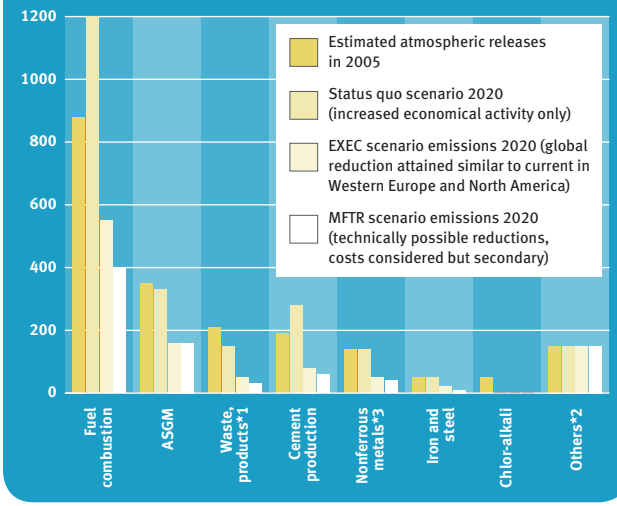
FIGURE 1:
GLOBAL ANTHROPOGENIC MERCURY EMISSIONS 2005



Repartition of global anthropogenic emissions to air in 2005 from different sources.

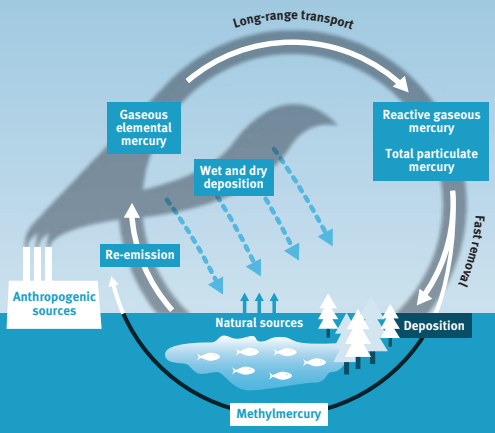
Source for Figure 1,2, and 3: Global Atmospheric Mercury Assessment: Sources, Emissions and Transport, UNEP Chemicals, 2009.

FIGURE 2: THREE SCENARIOS FOR 2020



Expected atmospheric mercury emissions in 2020 for three scenarios. 2009.
Notes:
**1 Including releases from waste handling and products.*
**2 Industrial gold production, primary mercury production and other by-product sources for which no change was assumed.*
**3 Except those mentioned under *2.*

FIGURE 3: WORLDWIDE MERCURY TRANSPORTATION CYCLE



Mercury is transported worldwide by global geo-chemical cycles, undergoing chemical reactions, deposition, and re-emission as it cycles through the environment and the food chain.

There are many methods to reduce emissions

It is possible to combat and reduce mercury emissions with a global response.

In recent decades atmospheric mercury emissions have been reduced in Europe and North America. One key reason is the increasing use of mercury substitutes. Another is the use of devices such as special filters that capture mercury emissions from coal-fired power plants and waste incinerators. In some cases sophisticated technology is needed; in others common sense and the diffusion and application of local knowledge can do the job.

It is possible, according to an assessment by UNEP, to cut the mercury emissions for all but a few sources by more than 50 percent using well established technologies and mercury management efforts. Using three different scenarios projected to 2020, the UNEP assessment looked at the future trends in atmospheric mercury emissions from major sources such as the burning of fossil fuels [see Figure 2].

Sometimes mercury is used intentionally, e.g. in dental clinics and small-scale gold mining. In such cases mercury can often be replaced by alternative materials, products and processes, thus preventing the release of mercury altogether. For other mercury sources, e.g. coal-fired power plants, which account for the majority of emissions, mercury is not added intentionally but is present in naturally occurring trace concentrations in materials (such as coal) used in large volumes. For these sources it is necessary to install emission reduction equipment such as filters, and to consider alternative raw material sources or possible changes in the production process.

THE MINING INDUSTRY

can cut emissions using cleaner technologies

Our use of mobile phones and jewellery is partly responsible for some of the mercury emissions into the atmosphere. Non-ferrous metal production is one of the major sources of atmospheric mercury emissions. If trace mercury is not removed during processing, one plant may emit tonnes of mercury, but cost-effective solutions are available and already widely applied.

Our increasing demand for copper and gold – among other metals – for such products as mobile phones and wedding rings is partly responsible for global atmospheric mercury emissions in 2005 of about 250 tonnes of mercury from such ores. Of that total, about 110 tonnes were emitted from large-scale gold production (mercury emissions from small-scale gold production are described elsewhere in this document). Mercury occurs naturally in the Earth's crust, and ores extracted for production of non-ferrous metals such as lead, zinc, copper, and gold may contain significant trace quantities of mercury. Metal production was the third largest source of atmospheric mercury emissions worldwide in 2005, but it is also one of the sources that can be reduced most cost-effectively.

A number of different Nordic technologies are already applied internationally for specifically reducing mercury emissions from both ferrous (iron and steel) and non-ferrous metallurgical processes.

One of the Nordic leaders in providing technological solutions for eliminating mercury emissions in the mining industry is Outotec in Finland. The company owns three of the technologies often applied for mercury removal from non-ferrous metal smelters: the Outotec mercury removal process, the thiosulphate process and selenium filters. The three technologies are described briefly below.

A mercury removal process currently reduces emissions by up to 300 tonnes per year

The Outotec mercury removal process can eliminate most of the mercury emitted by the metal mining industry. The process is already installed in plants producing zinc, lead, copper and gold. The total amount of mercury removed by the 38 plants worldwide using Outotec technology is estimated to be up to 300 tonnes per year – more than the remaining global mercury releases from this sector.

The Odda zinc smelter in Norway (formerly Norzink smelter). PHOTO: BOLIDEN AB

At each plant where it is installed, this mercury removal process removes an average of eight tonnes of mercury each year. The process was originally developed by the Swedish mining company Boliden AB, and the first industrial installation took place at the Norzink zinc smelter in Norway in 1973. Today, the process is operational in plants all over the world – most recently in plants in Canada, China and Brazil.

In the western US, gold is mined with lower mercury emissions

Since the beginning of this decade, the gold production used by the Barrick Goldstrike mine in the western US is emitting less mercury.

In 2000 the Barrick Gold Corporation in Toronto implemented an oxygen roasting process to treat carbonaceous ore from its Goldstrike property in Nevada, USA. The western United States, particularly the basin and range province that includes portions of California, Arizona, Nevada, Utah and Idaho, includes large areas where mercury occur naturally.

In 2001, the United States Environmental Protection Agency and the Nevada Division of Environmental Protection began a dialogue with major companies, including Barrick, that operate gold mines in Nevada. The Outotec process is now installed at the Goldstrike plant for reducing the mercury content of the off-gas stream. The mercury content of the gas at the inlet to the gas cleaning system is about 18 kg per hour, which is reduced to less than 0.07 kg at the outlet, corresponding to a removal efficiency of 99.5 percent. About 60 tonnes of mercury is removed annually from the off-gas by this process.

The Outotec Thiosulphate Process

The *thiosulphate* mercury removal process, installed in four sulphuric acid plants in the nonferrous metals sector in various countries, removes mercury in the form of solid mercuric selenide. The drying of the gas is carried out in two separate stages.

Outotec mercury removal process in zinc smelter. PHOTO: OUTOTEC

Installing Outotec Selenium Filters in non-ferrous metal smelting plant. PHOTO: OUTOTEC

THE OUTOTEC MERCURY REMOVAL PROCESS EXPLAINED

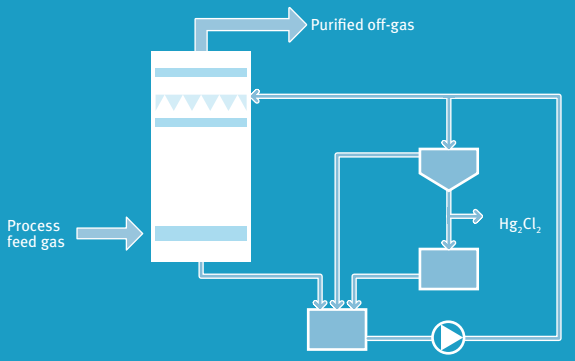
The basis for the Outotec Mercury Removal Process is the very rapid and complete reaction that takes place when mercury vapour comes into contact with a scrubber solution. A scrubber is a pollution control device that uses a liquid to wash pollutants from a gas stream. During the reaction between the gas and scrubber solution, insoluble mercurous chloride (calomel) is precipitated.

This process can remove almost all of the elemental mercury from the gas stream, even when the levels are very high. The resulting calomel can then be recycled into mercury metal or it can be sent to safe storage. The technology may also produce sulphuric acid, which contains typically 0.3-0.5 mg of mercury per kg of acid. An add-on process (based on the selenium filter technology) can purify the gas further, resulting in an acid containing no more than 0.05 mg of mercury per kg acid.

OUTOTEC'S MERCURY REMOVAL PROCESS

Main chemical reactions

Reaction tower:	Chlorination / Regeneration:	Summary reaction:
$Hg^0 + HgCl_2 \rightarrow Hg2Cl_2$	$Hg_2Cl_2 + Cl_2 \rightarrow 2HgCl_2$	$2\,Hg0 + Cl_2\ Hg_2Cl_2$



The first stage extracts most of the water vapour from the gas without excessive absorption of mercury. The second stage, operating at very high acid concentration, efficiently absorbs the mercury and the remaining water vapour. The acids from the dryers are then purified by precipitation of S-HgS, which is separated from the acid by filtration. Compared to the process developed by Boliden-Norzink, it can achieve a lower residual level of mercury in the sulphuric acid, but the installation cost is higher.

Outotec Selenium Filter for mercury removal from metal smelters and geothermal plants

The Outotec Selenium Filter is used at non-ferrous smelters to remove small amounts of mercury. The selenium filter reacts with elemental mercury and selenium, thereby forming the very stable mercury selenide (HgSe).

This substance can easily be removed with the filter and disposed of safely in landfills.

A unique feature of the selenium filter is that it can be used in applications where activated carbon does not work satisfactorily. It may also be installed in geothermal power plants.

- www.outotec.com
- www.barrick.com

ITALY:

Selenium filters reduce mercury emissions from geothermal plants

An AMIS plant in the Larderello area, Italy. The Outotec Selenium Filter is in the sphere at the left side of the photo.
PHOTO: ENEL SPA

In Italy today 1.2 tonnes of mercury are removed annually from 19 of the Italian power company Enel Spa's geothermal plants.

A special application for the Outotec Selenium Filter is removal of mercury from geothermal power plants, which generate electricity from underground steam. The geothermal steam is associated with non-condensable gases, which often contain high trace levels of naturally occurring mercury in elemental form.

In the geothermal fields south of Pisa, 32 geothermal plants annually generate over 5 billion kWh. In the late 1990s Enel Spa, Italy's largest power company, developed and patented a technology called AMIS, specially adapted to the characteristics of Italian geothermal plants. This technology reduces emissions of hydrogen sulphide and mercury, and employs the Outotec Selenium Filters. Today 19 operating plants in this region are fitted with AMIS technology, and three more are under construction.

Besides their use in geothermal plants, selenium filters are used to remove mercury from the flue gases of ferrous and non-ferrous metal smelters, as well as waste incinerators.

www.enel.com

THE HEALTH CARE SECTOR

can be mercury-free

Mercury is extremely toxic to humans, and the health care sector can reduce our exposure to mercury by choosing mercury-free alternatives. Many hospitals in Scandinavia have been doing well without mercury devices for more than ten years. In Delhi, India, the state government is promoting the phase-out of mercury in the health care sector, and many hospitals have already abandoned mercury.

For temperature and blood pressure measurements especially, mercury has traditionally been involved. In 2005 the total global mercury consumption for measuring equipment was estimated at 320-380 tonnes, and thermometers and other measuring equipment accounted for about nine percent of the total global mercury consumption.

The use of mercury containing equipment poses a risk of exposure to patients, staff and the environment. And when this medical equipment reaches the end of its life, the environment can be polluted. In many parts of the world medical waste is burned in incinerators. This process permits a significant part of the mercury to be released into the atmosphere.

Mercury-free thermometers are in use in hospitals all over the world, and mercury containing thermometers are now banned in many countries. However, in many countries mercury sphygmomanometers (the devices that measure blood pressure) are still considered the "gold standard" for measuring blood pressure. With a content of 80-100 g mercury per unit, these devices represent one of the more significant uses of mercury.

Mercury-free manual *sphygmomanometers* have traditionally been considered less reliable. However, this is not true if a proper maintenance protocol is followed, according to the World Health Organisation (WHO) in their policy paper, *Mercury in health care*.

Furthermore, many manufacturers have introduced improved mercury-free alternatives that are validated in accordance with international protocols (see page 12).

One of the best – and mercury-free – for more than ten years

One of the premier hospitals in Scandinavia in the field of vascular diseases, Karolinska University Hospital in Stockholm, like many other hospitals in Scandinavia, has not used mercury containing thermometers or sphygmomanometers for more than ten years. Karolinska has 14,600 employees, 1,600 beds and 1.3 million patient visits per year. It has the largest department of cardiovascular and respiratory diseases in Scandinavia. The hospital treats the most severe cases of cardiac

PHOTO: ISTOCK

and vascular disease and is renowned for its research collaborations with international research centres.

Nation-wide ban on mercury in measuring equipment
Since 1992 the manufacturing and marketing of measuring instruments containing mercury, such as blood pressure devices, have been banned in Sweden. For some years mercury sphygmomanometers continued to be used in some departments of Karolinska University Hospital, but all had been phased out by the beginning of 2000.

Dr. Heikki Terio from Karolinska remembers that it was an easy decision to implement;

"Actually, it's so simple; in principle you can do it by just stopping the use of mercury manometers, because there is in fact no difference in the way you are reading the values."

Dr. Terio recognizes that some employees in the health industry are resistant to such changes, as they are responsible for other people's health:

"I am pretty sure that the medical staff often is very anxious that they are not making the right decisions. An advice to them is to try the equipment out for a period of time and compare the values."

Routine quality control is necessary
Karolinska Hospital has 3,000 manual blood measuring devices and 300 automatic devices. All the devices are examined once a week using a wall-mounted calibration standard in the clinics. Whenever a manual sphygmomanometer has been dropped, it is immediately examined. The quality control routine is part of the hospital's quality management system.

The test laboratory checks more that 400 manual and automated blood pressure measuring devices a year, from both Karolinska and other health care centres in the area. The typical lifetime of manual devices is 3-5 years.

Mercury-free health care is increasing in India
In the National Capital Territory of Delhi with its 13.8 million inhabitants, more

THE MERCURY-FREE EQUIPMENT IS IMPROVING

Mercury-free devices are available, and their adequacy is well documented. Several manufacturers have, in recent years, introduced improved types of mercury-free equipment, for example the Maxi-StabilTM series from Welch Allyn (USA) and R1 Shock-proof® from Riester (Germany).

A.C. Cossor & Son (Surgical) Ltd (UK) has introduced a new type of "manual digital" sphygmomanometer, Greenlight 300, which combines an electronic manometer with a dial for manual reading.

These devices have been tested in accordance with international protocols and are among others validated for clinical use by the British Hypertension Society.

However, there is still a need to educate health care personnel in the proper use of the new devices, and to convince them that mercury-free devices today are of adequate quality and meet their needs.

Test of manual mercury-free sphygmomanometer.
PHOTO: KAROLINSKA UNIVERSITY HOSPITAL

and more hospitals are abandoning mercury containing equipment. The state government is actively promoting this phase-out, reports Anu Agarwal of the Delhi based NGO, *Toxics Link:*

"The government has sent out direct communication to all the healthcare facilities in Delhi, and has issued public notices in all leading dailies. The communication states that the healthcare facilities have to actively do mercury minimization and have a proper protocol to handle spilled mercury. Mercury minimization and phase-out has been made a prerequisite for hospitals to get an authorization for bio-medical waste management."

She continues:

"More and more hospitals are in the process of phasing out mercury containing devices. Our state is almost mercury-free – only a few replacements are left to be done."

The national Ministry of Health of India issued guidelines on mercury usage for all hospitals under the Government of India in the spring of 2010. The hospitals are to develop phase-out plans and waste handling plans for mercury, and gradually phase out this equipment. The guideline recommends that new purchases of equipment be mercury-free.

- www.toxicslink.org
- www.mercuryfreehealthcare.org
- www.karolinska.se
- www.riester.de
- www.accoson.com
- www.welchallyn.com

MERCURY EMISSIONS

from waste treatment can be minimized

Many modern products contain mercury, and when we discard them they contribute to global mercury emissions. Emissions to the air from waste incineration in 2005 accounted for an estimated 125 tonnes of mercury, and large amounts of mercury were disposed of in landfills. Mercury emissions from waste treatment are most effectively reduced by phasing out the use of mercury in products. However, efficient systems for recycling of mercury and end-of-pipe solutions for waste incinerators are also available.

PHOTO: MRT

At the end of their service life, mercury containing products end up in the waste stream. Waste handling is by far the most important emission pathway for products containing mercury. Of the waste related emissions, waste incineration accounts for 47 percent of the total emissions, while 37 percent are released from breakage when the products are landfilled.

If waste is not managed properly the mercury ultimately ends up in the environment.

In waste incinerators mercury is released from the waste immediately, whereas the release of mercury from many landfilled products is a slow but inevitable process. The best solutions to combating these emissions may be prioritized as follows:

1) Phasing out mercury in products

2) Separate collection and recycling or safe disposal

3) End-of-pipe solutions.

Mercury recovered from waste products
MRT System International in Sweden has specialized in manufacturing equipment for recovering mercury from waste products. Their equipment is primarily used to recycle products such as fluorescent tubes, compact fluorescent lamps (CFL), batteries, switches and rectifiers.

The company also manufactures distillers for recovering mercury from dental waste, powders, catalysts, military waste, and a variety of mercury contaminated metals. All MRT systems have been developed bearing in mind that the recovered mercury should be returned to the industry to be reused or be safely disposed of.

Advanced technology for extraction of mercury from lamps
MRT System International has developed

The waste incinerator at TAS in Denmark. PHOTO: TAS I/S

a very advanced technique for recycling the phosphorous powders of fluorescent lamps in its so-called End Cut Machine. The machine is equipped with a detection system for identifying and collecting various phosphor powder qualities in order to re-use the powder.

The machine uses a unique blowing procedure, which provides clean glass for recycling, and its "end cap crush and sieve system" separates ferrous metals and aluminium components from the waste lamps. The machine has a capacity of 5,000 lamps per hour.

During the past year MRT has sold systems to clients in China, Spain, and Taiwan, among other countries. India and China are both launching major nationwide incentives for promoting energy efficient mercury light sources and MRT are actively contributing to the recycling network being built up in these countries.

Capture of 99 percent of the mercury in the waste

In Denmark all combustible waste is incinerated in order to recover the energy content of the waste. As a result, waste incineration has been the major source of mercury emissions to the atmosphere in the country.

In order to reduce mercury emissions, a general European Union emission limit value of 0.05 mg mercury per m^3 flue gas is now implemented, and all incinerators are today equipped with mercury-specific flue gas cleaning equipment.

The waste incinerator of the Danish waste company, TAS I/S in Kolding, can remove mercury from the gas almost completely.

The incinerator annually receives 120.000 tonnes of municipal solid waste. In 2004 the company upgraded the flue gas cleaning system of its old incineration line from 1994 with a dry flue gas cleaning system optimised for reducing the emission of mercury and dioxins. A similar system was installed on a new incineration line in 2007.

The new line converts 90 percent of the energy content of the waste to hot water for district heating, while the old line converts 87 percent of the energy into a combination of electricity and district heating.

By upgrading the old incineration line, the mercury emissions from the line

FLUE GAS

CLEANING SYSTEMS EXPLAINED

The flue gas cleaning system for the TAS incinerator in Kolding was provided by Simatek A/S in Denmark which develops, manufactures, and delivers high-technology pulse-jet fabric filters and filter systems for industrial processes and incineration plants.

The flue gas cleaning systems consist of a quench **(6)** for rapid cooling of the flue gas and prevention of dioxin formation, a reactor **(7)** in which lime and activated carbon is injected into the flue gas, and a bag filter **(8)**. An induced draught fan **(9)** draws the flue gas into the chimney **(10)**. The mercury and dioxins in the flue gas are adsorbed on the surface of the activated carbon particles and collected in the bag filter.

The bag filter system is divided into two parallel sections, each consisting of 280 bags and a total filter area of 1232 m².

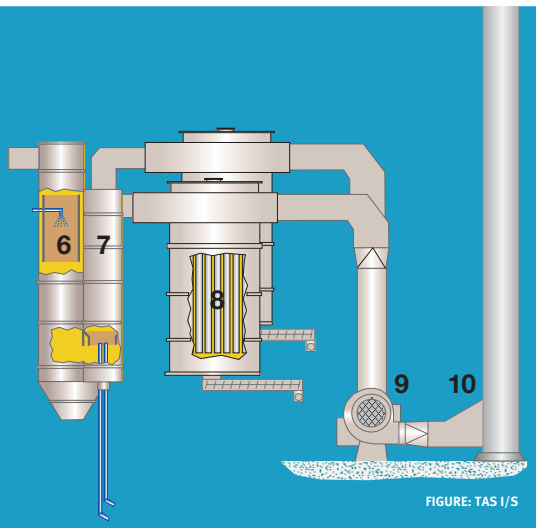


FIGURE: TAS I/S

The filter bags are cleaned, alternating between the two sections, by inducing an excess pressure. The resulting flue gas cleaning wastes are safely deposited in old salt mines in Germany.

MercOx-scrubber.
PHOTO: GÖTAVERKEN MILJÖ AB

Bag filters at the TAS waste incinerator, Denmark
PHOTO: TAS I/S

decreased from about 15 kg per year to less than 0.5 kg per year. With an estimated input with the waste of about 100 kg mercury, the efficiency of the new flue gas cleaning system exceeds 99 percent.

Mercury removal from hazardous waste incineration

The flue gas cleaning system at the SAKAB AB incineration plant for hazardous waste in Norrtorp, Sweden was upgraded in 2000 with a MercOx process scrubber plant.

In the MercOx process mercury is separated from the flue gas by injecting the environmentally friendly oxidizing agent, hydrogen peroxide, plus an additive. In this process the metallic mercury, which is insoluble in water, is oxidised to water-soluble forms. During the same cleaning stage hydrochloric acid and sulphur dioxide are also separated. An acid water flow containing mercury is transferred from the scrubber to the water cleaning process for neutralisation and precipitation of the mercury.

The EU legislation on emissions of HCl, SO_2 and Hg necessitated an extension of the plant's flue gas cleaning system. With this installation, SAKAB was able to manage the peaks that occasionally occur during combustion and still reduce mercury emissions. At the same time, the plant was prepared for flue gas condensation to recover energy from the flue gas.

In addition to the MercOx scrubber, the incinerator was equipped in 2004 with an ADIOX® dioxin removal system. The MercOx and ADIOX® processes were developed by the company Götaverken Miljö AB in Göteborg, Sweden, in close collaboration with Forschungszentrum Karlsruhe, Germany.

- www.mrtsystem.com
- www.tas-is.dk
- www.gmab.se
- www.simatek.dk

SMALL BATTERIES

– button-cells – can be produced without mercury

Although banned in many countries, batteries with high mercury content are still used. In 2005 batteries accounted for 280-460 tonnes of mercury, corresponding to about 10 percent of the global mercury consumption. For one particular type of battery, the button cell, it has been particularly difficult to develop mercury-free alternatives. Button cells contain mercury in typical concentrations of 0.4-1 percent. However, mercury-free button cells are now available at slightly higher prices.

Mercury has traditionally been used in both large cylindrical batteries and small button cells. Mercury in the large cylindrical batteries has been phased out in many countries for years, but is still used in some countries. The use of mercury oxide button cells is now banned in many countries. However, most other types of button cells – not yet banned – contain in the range of 0.4-1 percent mercury.

In 2005 batteries accounted for 280-460 tonnes of the total mercury consumption. This means that significant amounts of mercury end up in the general waste stream.

In button cells the function of the mercury is to inhibit hydrogen gas formation inside the battery. Other technologies can also suppress this gas.

A Hong Kong company was the first to introduce mercury-free button cells
Early in 2001 the New Leader Battery Industry Ltd. in Hong Kong launched the world's first mercury-free alkaline button cells. The company is one of the world's largest manufacturers of button cells, with a monthly capacity of 400 million batteries.

In the New Leader Battery Industry's patented button cell batteries the mercury has been replaced by indium, which is pre-electroplated on the inner surface of the cathode. Indium is a metal, but it is not associated with the same severe health risks as mercury.

"We invented the mercury-free button batteries in order to stop damaging human life from heavy metal pollution," Quality Service Manager Mr. Sunny Chow says, and continues: "We have to think about the next generation." Major producers of toys today demand these and other mercury-free button cells even though these alternatives are slightly more pricy than the mercury containing ones.

PHOTO: ISTOCK

PHOTO: NEW LEADER BATTERY INDUSTRY LTD.

Other companies now also provide mercury-free button cells, such as Sony Corporation, Seiko Instruments and Chung Pak.

The LEGO® Group uses mercury-free button cells

One of the users of mercury-free button cells is the LEGO® Group. The Danish toy manufacturer LEGO® has over the years tested a range of mercury-free batteries with regard to chemistry, energy content, self discharge and physical properties.

In particular for button cells it has been difficult for battery manufacturers to stabilise the chemical process in the cells without using mercury. However, batteries complying with the technical standards are now available from several manufacturers.

The LEGO® Group uses three million button cells every year for electronic components of the company's construction toys – and today all are mercury-free.

newleader.smeitrade.com

MERCURY CAN BE REMOVED

from natural gas during processing

In some areas of the world natural gas contains significant quantities of mercury, and the gas processed at a single production site may contain several tonnes of mercury per year. Mercury releases may take place during extraction, processing and use of the final refined products. Technologies are available for capturing the mercury at the very first step of the gas processing system, preventing mercury emissions from other parts of the process, as well as in the end product.

Like some other raw materials, fossil fuels such as oil and natural gas contain trace amounts of mercury. The mercury content varies considerably, reflecting the wide variability of natural geological conditions. The concentrations of mercury in natural gas vary from 0.01 to 5000 µg/m³ while the mercury concentration in crude oil may range from 0.1 to 10000 mg mercury per tonne. Mercury releases may take place during the extraction, processing and/or use of the final refined products.

Mercury releases from extraction of natural gas

High levels of mercury have been found in gas fields in Southeast Asia, the Netherlands and Central Asia, among other places, but measurable amounts are found in most natural gas reservoirs. The mercury releases during extraction may be significant, but these releases are still not very well quantified.

In areas with high mercury concentration in the natural gas, mercury may even be extracted as a by-product. In the Netherlands some 20 tonnes of mercury is annually recovered from the gas.

Moreover, mercury in the natural gas causes corrosion of the equipment by reacting with aluminium and other metals which may result in equipment failure and accidents.

Different technologies are employed for removing mercury from natural gas and crude oil including reaction with sulphur-impregnated activated carbon or metal sulphides.

Absorbent removes mercury in natural gas processing

PURASPEC$_{JM}$, produced by the London-based Johnson Matthey Plc., is a mixed metal sulphide absorbent for removal of mercury from natural gas streams and liquid hydrocarbons. An absorbent bed, or “reactor,” installed in offshore gas platforms has the potential to remove between 0.2 and 2 tonnes of mercury per year in each platform.

Worldwide more than 250 such reactors are in service and the company has suggested that a more widespread adoption of this technology would

South East Asian gas platform using PURASPEC$_{JM}$ mercury absorbent bed. PHOTO: JOHNSON MATTHEY PLC

www.matthey.com

greatly reduce the quantity of mercury emitted by refineries and gas processing plants.

Unlike other systems, the PURASPEC$_{JM}$ absorbent bed can be located upstream of dryers and also of the acid gas removal section of a gas purification plant. This ensures that the bed provides mercury corrosion protection for much of the plant and reduces the mercury emissions.

A few cubic meters of absorbent can remove most of the incoming mercury in the natural gas, and the beds can be in use for 10 to 15 years. They are replaced when the mercury content is about 10-15 percent of the total bed weight. The spent material is collected in airtight metal drums and shipped for recycling or safe disposal.

If not captured at the platform, some of the mercury may be released during the initial processing, although the majority ends up in the on-shore gas processing plants, which may or may not be equipped with mercury removal units.

Close-up of the PURASPEC$_{JM}$ absorbent bed.
PHOTO: JOHNSON MATTHEY PLC

MERCURY AND COAL

– cutting mercury emissions by improving air quality

Our need for producing electricity and heat is a large contributor to global mercury emissions. In 2005 the burning of fossil fuels (primarily coal) to produce electricity or heat accounted for about 45 percent of total anthropogenic mercury emissions. However, many countries still have a large potential for reducing mercury emissions by focussing on improving air quality. When we improve the air quality, we use technologies to control other pollutants like dust, sulphur dioxide and nitrogen oxides, and the co-benefit is mercury capture. Mercury-specific abatement systems have been tested in a number of full-scale tests, but cost-efficient technologies are still under development.

The world's need for electricity and heat is increasing and it may be expected that our consumption of coal will increase. Coal contains between 0.01 and 1.5 g mercury per tonne and coal combustion is the single largest source of anthropogenic mercury emissions to the atmosphere.

In 2005 fossil fuel combustion (primarily coal) accounted for about 45 percent of total anthropogenic mercury emissions. We are facing a future of increasing mercury emissions unless more efficient abatement technologies are implemented.

Mercury has to be converted to a form that can be removed

The efficiency of air pollution control systems for mercury removal depends greatly on the form of the mercury in the flue gas. Three mercury forms are normally considered when dealing with flue gasses from power plants:

- elemental mercury (Hg^0)
- particulate bound mercury (Hg^p)
- oxidized mercury (Hg^{2+})

Mercury in coal is converted to elemental gaseous mercury in the combustion chamber and afterwards it is partly converted to oxidized and particulate bound mercury as the combustion gas starts to cool.

The distribution among the different forms of mercury is highly dependent on the coal type, and in particular, the halogen content of the coal influences the percentage of oxidized and particulate bound mercury.

Typical mercury capture efficiencies of different conventional air pollution control systems are shown in the box below. A particulate control device such as an electrostatic precipitator (ESP) will catch

Taishan Power Plant, China – with Topsøe SCR DeNOx solution. The SCR reactor is situated in the middle of the photo and the ESP in the left side.
PHOTO: HALDOR TOPSØE A/S

a large fraction of particulate bound mercury, but is not efficient in catching elemental and oxidised mercury.

Electrostatic precipitators are commonly used throughout the world to reduce particulate emissions from coal burning power plants, and they remove up to 30 percent of the total mercury as well. Higher removal efficiencies may be obtained by using desulphurisation systems. In these systems sulphur dioxide emissions are typically abated by the reaction with lime or limestone, and some of the oxidised mercury is captured as well.

SCR for NOx abatement promotes mercury removal

As shown in the Table 1 at page 23, more than 90 percent of mercury can be removed from coal-fired power plants when they are equipped with Selective Catalytic Reduction (SCR) for abatement of nitrogen oxides (NOx) in combination with a wet system for flue gas desulphurisation (FGD).

The SCR promotes the formation of oxidized mercury which can be removed in the wet desulphurisation system. However, the mercury removal efficiency varies considerably depending on e.g. the coal type, and may be as low as 25 percent.

The most important parameters determining the effectiveness of the SCR for mercury removal are the coal type and halogen content, the amount of unburned carbon in the fly ash, and the residence time and temperature distribution in the flue gas duct.

Haldor Topsøe in Denmark is a major supplier of SCR DeNOx catalysts, and Topsøe's SCR systems are installed and operating world-wide.

THE SCR PROCESS EXPLAINED

The SCR DeNOx catalyst from Haldor Topsøe is a porous titanium-dioxide carrier material in which the catalytically active components (in the form of vanadium pentoxide combined with tungsten trioxide) are dispersed.

The main objective of the catalyst is to reduce nitrogen oxides (NOx) formed by the combustion process by reacting the NOx with ammonia at the surface of the catalyst. As a co-benefit, however, the SCR catalyzes the oxidation of elemental mercury in the flue gas. The catalyst is delivered in standard-sized single cassettes grouped in modules on a metal frame for easy installation in the SCR reactor.

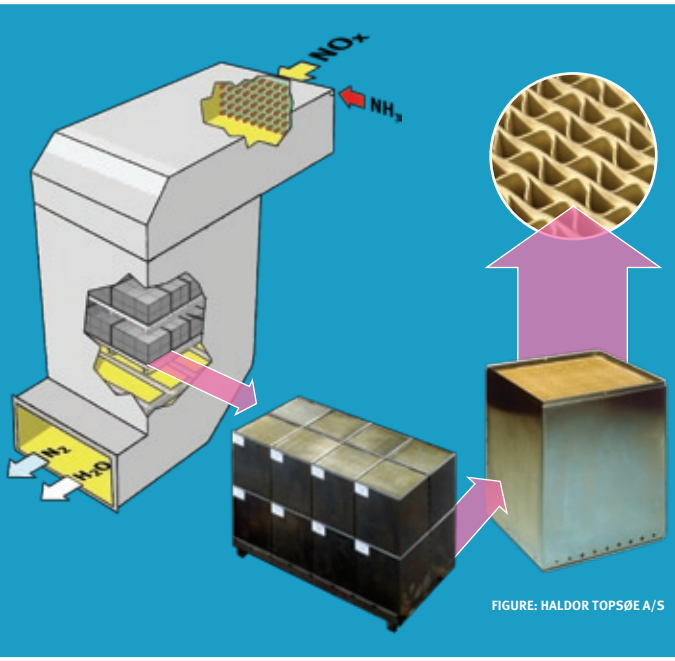


FIGURE: HALDOR TOPSØE A/S

High chlorine content increases mercury capture

High chlorine content during the SCR process increases the mercury capture. This was tested in 2009 in a pilot SCR unit at Southern Company's Plant Crist in Pensacola, Florida, which installed a SCR catalyst from Haldor Topsøe.

Collaborating with the Electric Power Research Institute (EPRI), Southern Company carried out a full-scale test scheme studying, among other things, the effect of adding hydrogen chloride to the flue gas. By increasing the concentration of hydrogen chloride from about 10 to 350 parts per million, the percentage of oxidized mercury increased from 50 to 95 percent.

China decreases mercury emissions with SCR

SCR units in Chinese coal-fired power plants may have a significant effect on mercury emissions. Since 2008 all new power plants in China have been required to install SCR systems for NOx abatement in combination with equipment for desulphurisation. The Taishan Power plant has installed SCR units from Haldor Topsøe, as have eight other coal-fired power plants in China.

Coals burned at Chinese power plants are generally of low quality with a low chlorine concentration that implies a low level of mercury oxidation. Based on existing models, it is expected that for typical SCR operating conditions and average Chinese coals, 45-90 percent of the mercury will be oxidized, and a significant amount of mercury will be removed by the downstream air pollution control equipment.

Mercury specific removal systems under development

A range of different mercury specific control technologies for coal-fired boilers have been tested in pilot scale to full-scale tests. The techniques fall into two main groups:

- Injection of different types of activated carbon, like the methods used in waste incinerators.
- Addition of chemicals to enhance the conversion of elemental mercury to oxidised mercury.

TABLE 1: MERCURY CAPTURE BY CONVENTIONAL AIR POLLUTION CONTROL SYSTEMS

Air pollution control system		Overall Percentage Mercury Capture (averages)				
		Bituminous coal		Subbituminous coal		Lignite
		÷ SCR	+ SCR	÷ SCR	+ SCR	÷ SCR
Particle control only	CS-ESP	28	8	13	69	8
	HS-ESP	15		7		
	FF	90		72		
	PS			9		
Particle control and wet flue gas desulphurisation	CS-ESP + Wet FGD	69	85	29		44
	HS-ESP + Wet FGD	49		29		
	FF + Wet FGD	98				
	PS + Wet FGD	32	91	10		33
Particle control and spray dryer adsorber desulphurisation	SDA + FF	98	95	19		4
	SDA + CS-ESP			38		

SCR = Selective catalytic reduction
ESP = Electrostatic precipitator
CS-ESP = Cold-side ESP
HS-ESP = Hot-side ESP
FF = Fabric filter (bag filter)
PS = Particulate scrubber
SDA = Spray dryer adsorber.
Empty cell indicates "No data".

SOURCE: "MERCURY CAPTURE AND FATE USING WET FGD AT COAL-FIRED POWER PLANTS", 2006, U.S. DEPARTMENT OF ENERGY.

Added bromine greatly augments mercury oxidation

A technology based on added bromine and patented by Vosteen Consulting GmbH in Germany takes advantage of the efficient oxidation of mercury in the presence of bromine.

The Vosteen Technology has been commercialised for coal-fired boilers by ALSTOM in the USA.

The ALSTOM KNX™ bromine addition technology has been tested in a number of full scale tests in power plants. Using this technique, a calcium bromide solution is sprayed on the coal prior to combustion to enhance mercury oxidation, which in turn greatly augments mercury collection by conventional downstream air pollution control equipment. The addition of bromine has no known secondary effects on boiler performance. The technique may also be used in combination with activated carbon injection like the ALSTOM MerCure™ process.

The effectiveness of mercury removal by adding bromine depends on the coal type, injection of absorbents and the type of conventional downstream air pollution control equipment.

In one recent full-scale test the KNX™ technology was installed in a 600 MW boiler burning a subbituminous coal. The boiler was equipped with an electrostatic precipitator, selective catalytic reduction (SCR) and a wet flue gas desulphurisation system. With the addition of just 4 parts per million bromide, the mercury removal rate increased from about 55 percent to about 90 percent. Similar results have been observed in other full-scale tests, and the method has now been commercialised for full scale application.

- www.vosteen-consulting.de
- www.alstom.com
- www.topsoe.com
- www.epri.com
- www.netl.doe.gov

MERCURY-FREE ENERGY-EFFICIENT

lighting with LEDs

Energy-efficient light emitting diodes (LEDs) are – compared to mercury containing lamps – able to provide a much wider range of light qualities. The price is still relatively high, but environmental concern and the new lighting applications available with LEDs have speeded up the development of this successor to incandescent lamps and mercury containing lamps. Globally, 120-150 tonnes of mercury were used in 2005 to produce light sources.

Light can be produced energy-efficiently by light emitting diodes (LEDs), which do not use mercury.

Most energy-efficient light sources worldwide are still produced with fluorescent tubes and other mercury containing lamps. These lamps were, until recently, the only energy-efficient alternatives to the incandescent lamp that was introduced in the 19th century and revolutionised human life.

Although the mercury content per lamp has decreased over the years, mercury is still used in significant amounts and frequently released into the environment.

Globally, 120-150 tonnes of mercury were used in 2005 to produce light sources, corresponding to about four percent of global mercury consumption.

Light emitting diodes – the new light revolution

The light emitting diode (LED) is in the process of revolutionizing our use of light. LEDs are based on a semiconductor technology and are produced in many different shapes and colours. The most efficient LEDs are as energy-efficient as mercury light sources.

LEDs have been used since the 1960s in electronics, and the major growth in the use of LEDs today is as an alternative to mercury lamps lighting LCD flat screens.

As we increasingly respond to environmental concerns related to light sources containing mercury, and as the price of LEDs decrease, these light sources are increasingly used in automotive lighting, architectural lighting and general illumination for the consumer market.

Energy-efficient lights in Denmark

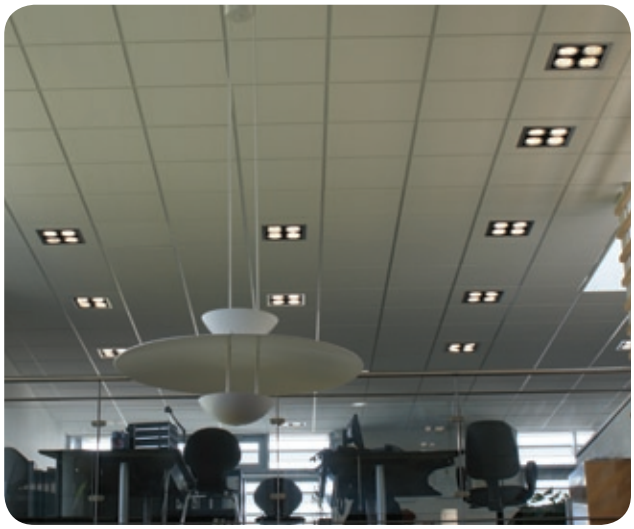
At many intersections in Denmark a long-lived energy-efficient traffic light tells Danes when to stop and when to go. It is the Danish company TTS –Technical Traffic Solution A/S – that

ENERGY-EFFICIENT LIGHT
FOR THE CROWN REGALIA

The LED light reduces the energy consumption for illumination of the Rosenborg treasury by 80% PHOTO: DEPARTMENT OF PHOTONICS ENGINEERING, DTU

The Danish Crown Regalia at Rosenborg Castle is lit with a specially developed LED that ensures the optimal colour representation of the regalia. This LED was developed by the Department of Photonics Engineering at the Technical University of Denmark (DTU), together with the company Lumodan Aps.

The department develops new LED light sources with a focus on the quality of light, colour control, light fixture design, and high efficiency. It has developed a holographic diffuser which is integrated into the LED lamps. The diffuser helps obtain the desired quality of light.



PHOTOS: TTS –TECHNICAL TRAFFIC SOLUTION A/S

has created the Green Light traffic light series based on LED technology.

The LED traffic light consumes little energy and has a typical lifetime of 20,000-30,000 working hours.

In 2002 the company won the European Business Award for Environment 2002 for its Green Light.

TTS also decided to install only LEDs in its new head office, built in 2008, in order to walk the talk:

“We had been advocating for environmental solutions in our traffic light for years and were at the same time using a lot of energy on conventional incandescent lamps in our offices... something did not match,” Managing Director Ove G. Rasmussen says.

Basically two qualities of lighting are used in the building. In the corridors and stairways a relatively cold light quality is used, whereas at the work stations the light has a warmer colour closer to the colour of standard incandescent lamps.

LEDs provided new architectural opportunities as the basic illumination is provided by flat panels integrated into ceilings, stairwells and other structures. Conventional light sources have been used in a few work stations in order to obtain enough light of a specific quality. In all other workplaces the staff have been satisfied with the light provided by the LEDs.

- www.tts.dk
- www.fotonik.dtu.dk

GOLD EXTRACTION

– local technological solutions reduce mercury releases

One of the world's largest mercury problems is the use of metallic mercury for gold extraction throughout the developing world. It results in severe local contamination and substantial contributions to global mercury pollution. It is estimated to release some 650-1350 tonnes of mercury annually. Reducing mercury releases here is challenging, but not out of reach if local technology is adopted, along with focused training and increased investments.

The old gold rush has never stopped, it has just moved to other parts of the world. And one of the world's largest mercury problems moved along with it: The use of metallic mercury for extracting gold. Small-scale gold mining is estimated to release 650-1350 tonnes of mercury annually – and this mining represents more than 25 percent of global mercury consumption.

Today artisanal and small-scale gold mining (ASGM) involves some 10 million miners, many women and children, throughout the developing world.

The miners dig out gold-bearing ores by hand and use liquid metal mercury to dissolve the gold from the ores. They leave behind vast areas that are barren and contaminated with mercury, as each gold deposit is eventually exhausted and the miners move on to another.

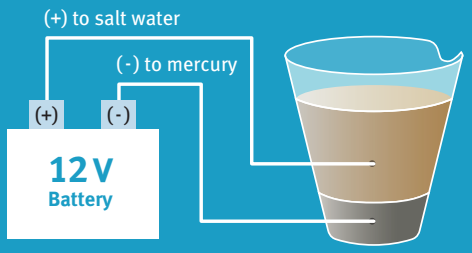
Poverty drives people to the mines

Small-scale gold mining is poverty driven and involves millions of individuals in an informal and often illegal economy. This makes the business complex, and increases the difficulty of achieving improvements to the environment and the health of the mining communities.

Small-scale gold mining is an important means of providing a livelihood in many countries. In fact primary miners may locally receive 70 percent of the world market price for their gold. This is far beyond what producers in developing countries generally get for their agricultural crops or other primary products. Small-scale gold mining is perceived as the only future for many people in these countries.

"There is no single technological "silver bullet" to move to a mercury-free system, but there are lots of moving pieces that can be individually tackled, leading to a significant improvement," says Kevin Telmer, Artisanal Gold Council and University of Victoria, Canada – one of the acknowledged experts in the area.

FIGURE 4: COMMON SENSE SOLUTION



With a car battery and salt water, used mercury can be cleaned, "re-activated", and reused instead of being discarded, thus reducing mercury consumption and releases to the environment. GRAPHICS: KEVIN TELMER

FIGURE 5: A RETORT

An example of a retort that captures the mercury when it is evaporated from the gold/mercury mix after extraction. At the bottom gold/mercury amalgam (left), and the produced gold (right).
PHOTOS: KEVIN TELMER

"With the spreading of well known local technology, we estimate, however, that the mercury releases from small-scale gold mining can be halved within ten years," adds Telmer.

95 percent of the mercury can be trapped and reused

Already a few local technologies allow for large reductions in mercury emissions – some manage to reuse the mercury.

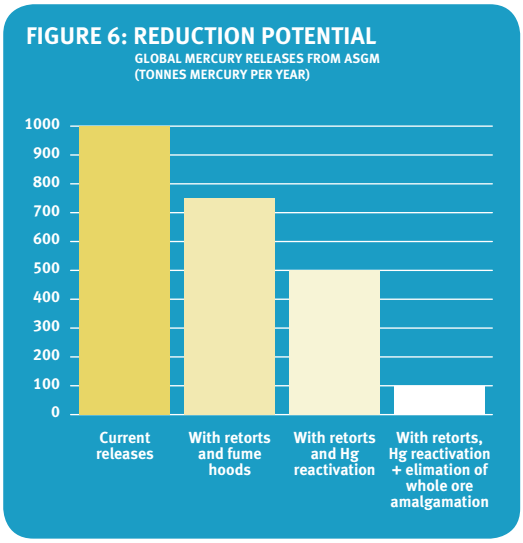
Once the gold has been dissolved from the ore with metal mercury, excess mercury is squeezed out of the mixture, often with a piece of cloth in the bare hands, producing a solid gold/mercury amalgam known as doré.

This doré is then typically heated in open air to make the mercury evaporate to the environment, leaving behind gold with a minor mercury content. If instead the mercury is heated in a so-called retort, a locally produced closed container with a fume pipe that ends in a container of cold water, some 95 percent of the mercury can be trapped in the water and reused [Figure 5].

Alternatively, it is possible to obtain 80 percent reductions if the mercury/gold amalgam is heated under a ventilated fume hood. The hood leads the fumes through a similar cold trap where the mercury vapour condenses and can be reused.

Another technique that can prevent mercury from being discarded in the environment is reactivating used "dirty" mercury by separating it from impurities acquired during previous use. This can be done using a simple electrolytic process with mercury and salt water in a glass vessel driven by a 12V battery [Figure 4].

The most effective way of extracting gold is concentrating the ore first to eliminate ore particles that contain little or no gold. Instead, mercury is often added directly to the un-concentrated ore; this is called whole ore amalgamation. With whole ore amalgamation, much more mercury is used and lost to



Reduction potential in small-scale gold mining.

SOURCE: KEVIN TELMER, ARTISANAL GOLD COUNCIL AND UNIVERSITY OF VICTORIA, CANADA

Two Asian men amalgamating with a pan with visible mercury.

PHOTO: DANIEL STAPPER

- www.artisanalgold.org

UNEP Partnership on Artisanal and Small-scale Mining:
- www.chem.unep.ch/mercury/Sector-Specific-Information/Artisanal-small-scale-mining.htm

UNIDO's Global Mercury Project:
- www.globalmercuryproject.org/front_page.htm

the environment, sometimes up to 500 times more per kilo of gold produced.

"Elimination of whole ore amalgamation could reduce global mercury consumption for small-scale gold mining by another 45 percent or more. This is profitable but somewhat more complicated than the simpler technological improvements, because more capital, more organisation and more sophisticated processing are needed," says Kevin Telmer [Figure 6].

He underlines the fact that awareness-raising and training are needed to implement these changes broadly. He believes that a global treaty on mercury could help raise awareness, channel funds to pilot projects, set goals to focus efforts, and reduce the supply of cheap mercury on the world market, which would motivate miners to better manage their mercury.

Cyanide for extraction of gold

Other methods for extraction of gold exist. Non-mercury, non-cyanide extraction technologies suitable for small scale miners are being developed at by some parties. But they are currently not widespread and their use may have longer perspectives. The only technically mature method is, however, extraction with cyanide. This method is used in many small-scale operations today, and in most industrial scale gold extraction operations. But cyanide is acutely toxic, which means that its poisonous effects are strong and can be seen right away, while mercury intoxication occurs more slowly but persists much longer in humans and in the environment.

Cyanidation therefore requires a higher level of investment in order to be done safely. Unfortunately, some gold mining operations use cyanidation to get the last fractions of gold from ores that have already been amalgamated with mercury. This dissolves the mercury in the wastewater discharges and makes it more bio-available, with even worse environmental effects.

DENTAL TREATMENT

without mercury is becoming the norm

The traditional use of mercury in dental amalgam is diminishing in some parts of the world due to environmental concerns. In 2005 amalgam fillings constituted a global mercury consumption of about 310-410 tonnes annually, thus being among the largest consumer uses of mercury in the world. The alternative filling materials today have a quality that makes them viable substitutes for amalgam in almost all cases. The Nordic countries now have nearly amalgam-free dental care.

PHOTO: ISTOCK

The well known silver coloured amalgam fillings are now being substituted around the world with tooth coloured mercury-free filling materials. In 2005 amalgam fillings constituted a global mercury consumption of about 310-410 tonnes annually, thus being among the largest consumer uses of mercury in the world, and representing about 10 percent of total mercury consumption. It is also among the major non-industrial sources of mercury releases to water.

In Denmark, dental amalgam has been the number one mercury source to wastewater discharges for many years. The lifecycle of mercury in dental amalgam is complex; the mercury ends up in the environment by many different routes as illustrated by the mercury flow in Denmark in 2001 due to the use of amalgam fillings [Figure 7].

Nordic countries have nearly eliminated the use of amalgam fillings

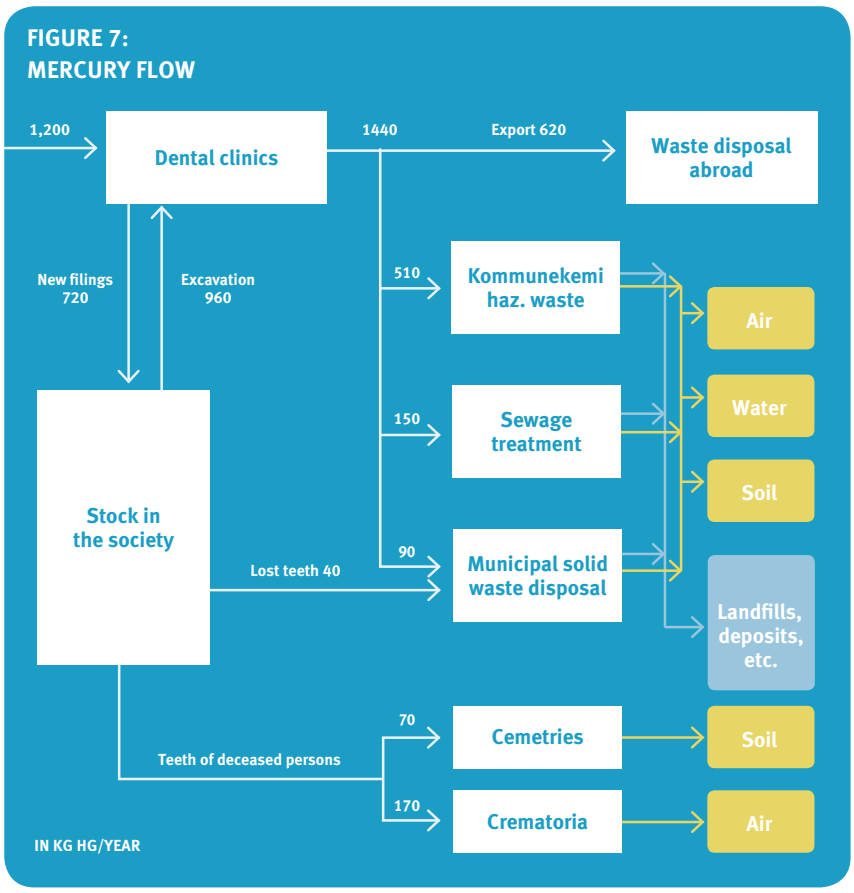
The mercury pollution of Nordic waters has made the reduction of mercury releases a priority for at least two decades.

Regulatory pressure and voluntary initiatives have driven substitution, and this movement has enhanced the introduction of alternative filling materials and filters called amalgam separators installed in dental clinics. These filters can capture most of the mercury discharges from clinics to the sewage system.

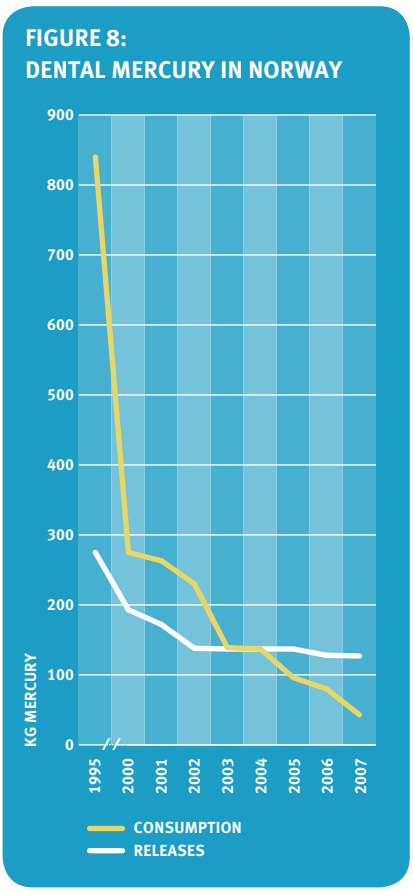
In Norway the consumption of dental amalgam has declined steeply and the consumption in 2007 was only five percent of the 1995 level [Figure 8]. The decrease was a result of a voluntary phase-out of amalgam fillings and clearly demonstrates that acceptable alternatives are available for nearly all applications.

The corresponding mercury releases to the environment tend to decline more slowly because people still have older amalgam fillings in their teeth.

A prohibition of amalgam use in Norway was introduced in 2008. The prohibition has an exemption for the treatment of patients who must be treated under



Mercury flow in Denmark in 2001 due to the use of amalgam fillings.



Decreases in amalgam consumption and mercury releases from dental clinics in Norway.

general anaesthesia or who are allergic to certain materials in mercury-free dental fillings.

Substantial reductions have also been seen in Denmark and Sweden over a longer time period. Denmark introduced a partial ban in 1994 and today the use is minimal, while Sweden has worked intensively for substitution for years, implementing a total ban in 2009.

It takes time to accept new alternatives

Alternative mercury-free fillings exist in a range of qualities, some more durable, others easier to use under low-tech conditions. The alternative fillings consist of a mix of sophisticated plastic materials and fillers made of ceramics or special types of glass.

The alternative filling materials sometimes take longer to apply, and may thus be more expensive than the traditional amalgam fillings. Today there is enough experience with these filling materials to show that the best of them have a durability comparable to the traditional amalgam fillings, but without the environmental effects of mercury.

Nevertheless, some dentists still consider amalgam to be the best solution for some types of complicated fillings, and the difficulty of substituting amalgam in complicated fillings has been carefully studied.

Real life studies affirm durability of mercury-free fillings

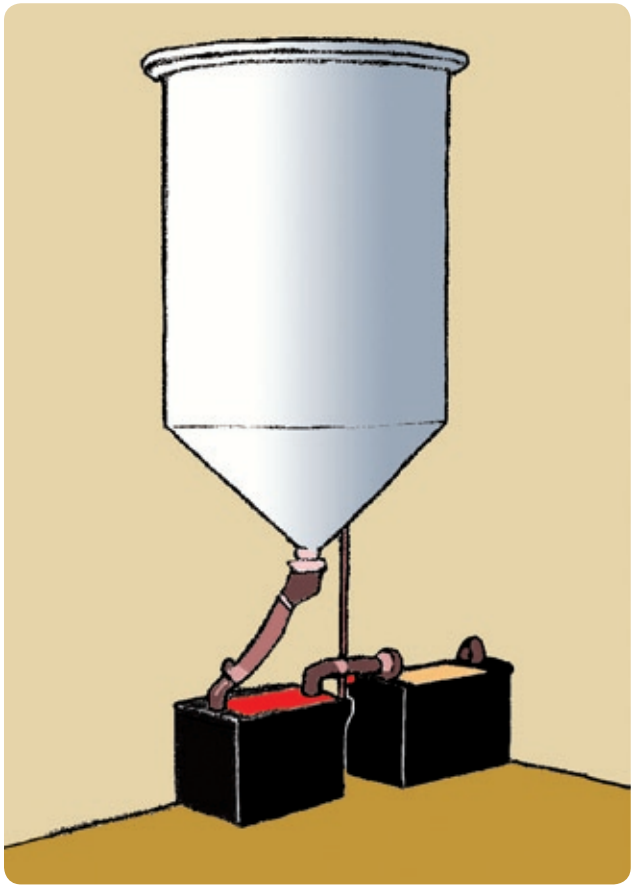
Simon Vidnes-Kopperud and his colleagues at the dental faculty of the University of Oslo, in Norway, investigated the quality of 4030 dental fillings made with some common dental filling materials 4-7 years after the fillings were placed.

The goal was to check how well the different filling materials performed under real life conditions with average dental care. 27 dentists in Norway had earlier placed the fillings in the teeth of 1912 young people.

The results of this study showed that amalgam and one alternative filling type called compomer had similar durability. Another alternative called a composite filling, which represented the majority of the fillings placed, lasted for a somewhat shorter time than amalgam fillings, whereas the so-called GIC fillings (glass ionomer cement) had a significantly shorter lifetime. Similar results were found in the Danish part of this project, led by Vibeke Qvist of the University of Copenhagen.

The primary reason for failure of the composite fillings was secondary caries, meaning new holes or cavities around the existing filling due to bacterial activity. According to Qvist, the metal mix in amalgam fillings has an antibacterial effect which reduces such caries. The compomer fillings generate a slow release of fluoride over time, which

The inside of a used amalgam separator.
PHOTO: ANDERS LINDVALL



Two amalgam separators (main and back-up) mounted under the separator tank of the suction system. DRAWING: EVA LINDH

reduces the dissolving effect of bacteria on the tooth enamel. Composites do not have either of these effects.

Amalgam separators cut mercury releases from dental clinics

As long as dental amalgam is still used in the teeth of consumers, mercury is released to the sewers from dental clinics. Amalgam separators, which are high-efficiency filters for dental clinics can, however, greatly reduce mercury discharges to the environment.

ISO-tested amalgam separators installed in the central suction system in dental clinics can cut mercury releases by 95 percent or more if correctly installed and maintained.

An amalgam separator is a filter device that can be introduced between the clinic's suction system and the sewer outlet. A separator can work with just one dental chair or it can serve up to 4-6 dental chairs if it is regularly maintained.

In the Nordic countries, a filter can be installed, regularly maintained and recycled for around 400 Euros a year. Because most of the cost is associated with labour, the price would likely be lower in other regions of the world.

"During the 1980s and 1990s most dental clinics in the Nordic countries have been equipped with amalgam separators", says Erik Petersen of Rectus, a Danish producer of amalgam separators.

"The other European countries are also well on the way, and we sell separators as far away as Iran and Korea," adds Mr Petersen.

In Denmark a significant impact on mercury discharges to the environment in wastewater has been observed. Here discharges to wastewater from dental clinics dropped by 80 percent to around 200 kg of mercury per year between 1983 and 1993.

The resulting filter residue has to be collected and treated separately to prevent it from being released to the environment via general waste management.

According to Mr Petersen, an effective way is to participate in a recycling system set up by the filter suppliers, who can reuse parts of the filter and ensure that the hazardous mercury containing residues are treated or disposed of properly.

www.rectus.dk

norden

Nordic Council of Ministers

Ved Stranden 18
DK-1061 Copenhagen K
www.norden.org

DANISH MINISTRY
OF THE ENVIRONMENT
Environmental
Protection Agency

Want to know more?

Web-sites

UNEP Mercury Programme
www.chem.unep.ch/mercury
Information on mercury activities under United Nations Environment Programme and UNEP Global Mercury Partnerships.

Global Mercury Project
www.globalmercuryproject.org
Joint GEF, UNDP and UNIDO project in cooperation with six countries. Addresses the environmental issue of mercury contamination from artisanal and small-scale gold mining.

Mercury-free Health Care
www.mercuryfreehealthcare.org
The NGO Health Care Without Harm and the World Health Organization are co-leading a global initiative to achieve virtual elimination of mercury-based thermometers and sphygmomanometers.

Zero Mercury Campaign
www.zeromercury.org
The Zero Mercury Campaign website is part of the Global Zero Mercury Campaign Project involving a large number of NGOs. Provides information on events and news and an electronic library.

Artisanal Gold Council
www.artisanalgold.org
The Artisanal Gold Council works for sustainable development in artisanal and small-scale gold mining communities. Includes the Mercury Watch Database, a joint project between the Artisanal Gold Council and UNEP.

European Commission mercury site
ec.europa.eu/environment/chemicals/mercury/index.htm
Provides information on mercury activities in the European Union and links to various study reports.

US EPA mercury site
www.epa.gov/mercury
Provides information on mercury activities in the USA and links to various study reports.

Documents

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