Summary: Intervention & Options

Department /Agency:	Title:	
Defra	Impact Assessment for Regulation (EC) No 1102/2008 – Mercury Export Ban	
Stage: Consultation	Version:	Date: 11 September 2009
Related Publications:		

Available to view or download at:

http://www.

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What is the problem under consideration? Why is government intervention necessary?

Mercury is highly toxic to humans and wildlife. The European Union is a major exporter of mercury with significant surpluses of mercury in coming years mainly due to the decommissioning of mercury plant in the chlor-alkali industry. Currently regulations on the use of mercury following export from the EU are often unknown. However, some uses can result in mercury being released to the atmosphere where it can be deposited into bodies of water and can accumulate up the food chain. An export ban is being introduced in the form of a directly applicable regulation across the EU which will reduce the risk of mercury being released to the atmosphere. Government action is required in order to put in place domestic legislation that will

What are the policy objectives and the intended effects?

The policy objective is to help to continue to reduce levels of mercury in the environment to safe levels. Through reducing the supply of mercury to where its use may be unregulated and uncontrolled there is a reduction in the risk of emissions to the atmosphere. The intended effect is to reduce any impacts on human health and on the wider environment.

What policy options have been considered? Please justify any preferred option.

Option 1 - Describes the situation where mercury is still freely traded under the previous legislative framework. This is the counterfactual baseline against which the other options are assessed.

Option 2 - Enforcing a mercury export ban and introduction of information reporting obligations and provisions relating to the safe storage of metallic mercury.

Sub-option 2a - a one stage approach were all the obligations are dealt with by a single Statutory Instrument (SI).

Sub option 2b - a two stage approach with an in initial SI introducing provisions for the export ban and to enforce information reporting requirements and a second SI (to be introduced at a later stage) to address provisions relating to the safe storage of metallic mercury.

Option 2b is preferred as it reduces the possibility of mercury's detrimental impacts on human and wildlife health, but also allows the drafting of a later SI dealing with the safe storage of

When will the policy be reviewed to establish the actual costs and benefits and the achievement of the desired effects?

Not later than 15th March 2013.

Ministerial Sign-off For consultation stage Impact Assessments:

> ***I have read the Impact Assessment and I am satisfied that, given the available evidence, it represents a reasonable view of the likely costs, benefits and impact of the leading options.***

Signed by the responsible Minister:

.... Date:

Summary: Analysis & Evidence

Policy Option: 2a	Description: Enforcing a mercury export ban and introduction of information reporting obligations and provisions relating to the safe storage of metallic mercury with a one stage approach.

COSTS

ANNUAL COSTS		
One-off (Transition)	Yrs	
£ 0.607m - £0.748m	8	
Average Annual Cost (excluding one-off)		
£ 105,000	40	

Description and scale of **key monetised costs** by 'main affected groups' One-off and annual costs are taken from the costs of storing 500 tonnes of decommissioned chlor-alkali mercury in metallic form. The one off costs take place over an 8 year period because this is the time frame in which the current mercury cells will be decommissioned and replaced with mercury free technology.

Total Cost (PV) **£ 6.65 - 7.65 million**

Other **key non-monetised costs** by 'main affected groups' There may be small additional costs for the recycling sector. There will be a very small enforcement cost which will be explored during consultation. There will also be data reporting requirements which would amount to a cost of a few thousand pounds per year. The consultation costs of a one stage

BENEFITS

ANNUAL BENEFITS		
One-off	Yrs	
£ 0		
Average Annual Benefit (excluding one-off)		
£ 13.5 million	40	

Description and scale of **key monetised benefits** by 'main affected groups' Adoption of the preffered policy option would avoid the estimated current cost of IQ losses due to fetal methylmercury exposures of £13.5 million per annual birth cohort. The figures shown are based on the best available evidence and given the information available can only be seen to be indicative and are for the purposes of the impact

Total Benefit (PV) **£ 299.9 million**

Other **key non-monetised benefits** by 'main affected groups' The cost above only represents the cost of IQ deficits from fetal exposures to mercury but there are other health impacts of mercury such as cardiovascular damage and premature mortality. There are also expected to be other environmental benefits, especially to marine life.

Key Assumptions/Sensitivities/Risks The calculations of the benefits assume that there is no threshold below which health impacts do not occur. It also assumes that the levels of mercury in fish and the consumption rates of fish are the same in the US and the UK. The key risks are after the export ban countries outside the EU start new mining of mercury, and that mercury is still potentially available for export once stored.

Price Base Year 2009	Time Period Years 40	**Net Benefit Range** (NPV) **£ 292.25 - 293.25 million**	**NET BENEFIT** (NPV Best estimate) **£ 292.25 million**

What is the geographic coverage of the policy/option?		UK		
On what date will the policy be implemented?		4th December		
Which organisation(s) will enforce the policy?		TBA		
What is the total annual cost of enforcement for these organisations?		£ negligible		
Does enforcement comply with Hampton principles?		Yes		
Will implementation go beyond minimum EU requirements?		No		
What is the value of the proposed offsetting measure per year?		£ N/A		
What is the value of changes in greenhouse gas emissions?		£ N/A		
Will the proposal have a significant impact on competition?		No		
Annual cost (£-£) per organisation (excluding one-off)	Micro	Small	Medium	Large
Are any of these organisations exempt?	Yes/No	Yes/No	N/A	N/A

Impact on Admin Burdens Baseline (2005 Prices) (Increase - Decrease)

Increase of	£	Decrease	£	**Net Impact**	**£**

Key: **Annual costs and benefits: Constant Prices** **(Net) Present Value**

Summary: Analysis & Evidence

Policy Option: 2b	Description: Enforcing a mercury export ban and introduction of information reporting obligations and provisions relating to the safe storage of metallic mercury with a two stage approach.

COSTS

ANNUAL COSTS		
One-off (Transition)	**Yrs**	
£ 0.607m - £0.748m	8	
Average Annual Cost (excluding one-off)		
£ 105,000	40	

Description and scale of **key monetised costs** by 'main affected groups' One-off and annual costs are taken from the costs of storing 500 tonnes of decommissioned chlor-alkali mercury in metallic form. The one off costs take place over an 8 year period because this is the time frame in which the current mercury cells will be decommissioned and replaced with mercury free technology.

Total Cost (PV) **£ 6.65 - 7.65 million**

Other **key non-monetised costs** by 'main affected groups'. There may be small additional costs for the recycling sector. There will be a very small enforcement cost which will be explored during consultation. There will also be data reporting requirements which would amount to a cost of a few thousand pounds per year. The consultation costs of a two stage

BENEFITS

ANNUAL BENEFITS		
One-off	**Yrs**	
£ 0		
Average Annual Benefit (excluding one-off)		
£ 13.5 million	40	

Description and scale of **key monetised benefits** by 'main affected groups' Adoption of the preffered policy option would avoid the estimated current cost of IQ losses due to fetal methylmercury exposures of £13.5 million per annual birth cohort. The figures shown are based on the best available evidence and given the information available can only be seen to be indicative and are for the purposes of the impact

Total Benefit (PV) **£ 299.9 million**

Other **key non-monetised benefits** by 'main affected groups' The cost above only represents the cost of IQ deficits from fetal exposures to mercury but there are other health impacts of mercury such as cardiovascular damage and premature mortality. There are also expected to be other environmental benefits, especially to marine life.

Key Assumptions/Sensitivities/Risks The calculations of the benefits assume that there is no threshold below which health impacts do not occur. It also assumes that the levels of mercury in fish and the consumption rates of fish are the same in the US and the UK. The key risks are after the export ban countries outside the EU start new mining of mercury, and that mercury is still potentially available for export once stored.

Price Base Year 2009	Time Period Years 40	**Net Benefit Range** (NPV) **£ 292.25 - 293.25 million**	**NET BENEFIT** (NPV Best estimate) **£ 292.25 million**

What is the geographic coverage of the policy/option?			UK	
On what date will the policy be implemented?			4th December	
Which organisation(s) will enforce the policy?			TBA	
What is the total annual cost of enforcement for these organisations?			£ negligible	
Does enforcement comply with Hampton principles?			Yes	
Will implementation go beyond minimum EU requirements?			No	
What is the value of the proposed offsetting measure per year?			£ N/A	
What is the value of changes in greenhouse gas emissions?			£ N/A	
Will the proposal have a significant impact on competition?			No	
Annual cost (£-£) per organisation (excluding one-off)	Micro	Small	Medium	Large
Are any of these organisations exempt?	Yes/No	Yes/No	N/A	N/A

Impact on Admin Burdens Baseline (2005 Prices) (Increase - Decrease)

Increase of	£	Decrease	£	**Net Impact**	**£**

Key: **Annual costs and benefits: Constant Prices** **(Net) Present Value**

Evidence Base (for summary sheets)

[Use this space (with a recommended maximum of 30 pages) to set out the evidence, analysis and detailed narrative from which you have generated your policy options or proposal. Ensure that the information is organised in such a way as to explain clearly the summary information on the preceding pages of this form.]

Problem Outline

Mercury Toxicity

Mercury and its compounds are highly toxic to humans and wildlife and have caused a variety of documented, significant adverse impacts on human health and the environment throughout the world (UNEP, 2008). Mercury poisoning can occur from ingestion, inhalation or dermal absorption. Toxicity depends on the type of exposure and the chemical form of mercury.

Breathing in a high amount of mercury vapour for a short time damages the lining of the mouth and lungs, causing breathlessness, coughing, burning sensation in the lungs and chest pains. Other effects such as stomach irritation, nausea, vomiting, diarrhoea, skin rashes, eye irritation and increased blood pressure may also occur. Damage to the nervous system may also arise, causing irritability, nervousness, tremor and visual disturbances. Cognitive, personality, sensory or motor disturbances may also arise, including muscle weakness and headaches.

High doses can be fatal to humans, but even relatively low doses can have serious adverse neuro-developmental impacts and have recently been linked with possible harmful effects on the cardiovascular, immune and reproductive systems. According to the World Health Organization (2005), recent studies suggest that mercury may have no threshold below which some adverse effects do not occur.

Mercury can retard microbiological activity in soil, and is a priority hazardous substance under the Water Framework Directive.

Mercury can be converted in the environment into methylmercury, the most toxic form. Methylmercury can accumulate along food chains, especially in aquatic ecosystems to 10,000–100,000 times the concentration in ambient water. So populations with high fish intakes (for example, around the Mediterranean) may be particularly vulnerable to health impacts. It readily passes both the placental barrier and the blood-brain barrier, inhibiting potential mental development even before birth. Exposure of women of child-bearing age and children is therefore of greatest concern. In Japan in the 1950s, methylmercury in Minamata Bay was consumed by people via fish, causing over 70 deaths and 2,265 cases of poisoning, most tragically involving newly born infants.

From a human health point of view, exposure to methylmercury via diet is the main problem. Fortunately, in the UK the amount of mercury we get from food isn't harmful for most people and the UK Food Standards Agency (FSA) issues advice on the amounts of fish consumption at which there are clear nutritional benefits without undue risks from the methyl mercury. However, the European Union acknowledged that action was needed to protect human health and the environment from all releases of mercury; it therefore adopted a *Community Strategy Concerning Mercury* in 2005, with the aim of reducing mercury supply and demand. The UK fully supports the Strategy.

Mercury in the Environment

Initially seen as an acute and local problem, mercury pollution is now also understood to be global, diffuse and chronic. As an element, it is persistent in the environment once released and can be transported long distances via the atmosphere and oceans.

Since mercury accumulates in soils, sediments and aquatic creatures, the cumulative level of emissions over time is important, with further emissions adding to the global pool. Mercury may continue to be released from sediments and soils over long periods of time and levels in sensitive water bodies and aquatic life may only respond slowly to changes in emissions.

The majority of air emissions are in the form of gaseous elemental mercury, which can be transported globally to regions far from the emissions source, so that even regions with no significant mercury releases, such as the Arctic, are adversely affected due to the transcontinental and global transport of mercury (UNEP, 2008).

Mercury exported from the EU can therefore not only affect the regions which import it, it can also cause long-distance problems back in the EU itself.

Human Use of Mercury

Although mercury is released naturally, by volcanoes for example, its use by humans has led to a ‘global pool’, which may significantly increase human and environmental exposure. Its use has greatly declined in recent decades, but it still has applications around the World, including small-scale artisanal gold mining, dental amalgam, lighting and in the chlor-alkali sector, which produces chlorine and caustic soda – key building blocks of the wider chemical industry. As a consequence of the Integrated Pollution Prevention and Control (IPPC) Directive (1996) and the fact that many of its mercury facilities are nearing the end of their operational life and thus becoming uneconomic to run, the chlor-alkali sector is phasing out the use of mercury. This conversion is expected to lead to the decommissioning of 12-15,000 tonnes of surplus mercury across the EU in coming years.

The European Union is a main exporter of metallic mercury. After mining in the Spanish Almadén mine stopped in 2003, the biggest European Union supply of mercury came from the chlor-alkali industry, which hitherto sold its surplus mercury when switching to mercury-free technology. Most of the surplus mercury was exported - according to international trade statistics, 824 tonnes in 2004. Mercury may also arise from the cleaning of natural gas and non-ferrous mining and smelting, as well as from primary production (mining of cinnabar ore).

The EU Mercury Surplus

The European Union will face significant surpluses in the coming years that, if exported, would contribute to global mercury pollution. At the same time, global demand is expected to decrease as mercury free alternatives increasingly replace mercury products and processes. The issue is how to deal with this surplus mercury.

The Overall Policy Objective

The key long term aim of the *Community Strategy Concerning Mercury* is that levels of mercury in the environment will be reduced so that there is no longer any need for concern over methylmercury in fish. This will probably take decades, since the present levels of mercury in the environment are also representative of past mercury emissions. Even without further emissions, it would take some time for existing levels to fall sufficiently. To reach this long term aim, goals to globally reduce the supply and demand of mercury are needed:

To reduce global supply of mercury. Since the European Union is a main exporter, an export ban from the EU will significantly reduce the global supply. Together with other measures (see below), this will help to reduce the anthropogenic mercury releases into the environment. Introducing an export ban has been envisaged in the Mercury Strategy and the circumstances that led to such an EC proposal have not changed.

To reduce global demand for mercury. Mercury is used in many products and applications also where mercury-free alternatives exist. A big supply of mercury from the European Union means there is no incentive to find or use alternatives. In parallel to the actions cited it is important actively to reduce the demand for mercury. Work is on-going in the European Union further to restrict mercury use in products and applications. The general policy approach is to support continued use of mercury only in applications where it is essential, or where there is at present no appropriate mercury-free alternative.

To find a safe and sustainable solution for the surplus mercury. Given the declining use of mercury and the planned export ban from the Community and the large stocks of mercury in society that will eventually become surplus, the issue of the long term fate of surplus mercury needs to be addressed. A viable solution to this excess mercury must be found so that it does not re-enter the environment. A main concern is the surplus mercury from the chlor-alkali industry.

To make progress at a global level. There is a significant global dimension to the mercury problem. Consequently, the mercury problem cannot be solved by the European Union acting alone. It is important to reduce global mercury use and thereby help in reducing emissions. A main concern is the use of mercury in small-scale gold-mining and other non-desirable uses in developing countries.

Regulation 1102/2008

To prevent decommissioned mercury going onto the world market, the European Commission presented proposals to prohibit the export of metallic mercury from the Community from 1st July 2011. The proposals were in line with commitments under the *Community Strategy Concerning Mercury* to phase out the export of mercury from the European Union and concurrently pursue its cost-efficient storage.

Subsequently, following extensive discussions between Member States and the European Parliament, the European Council adopted Regulation No 1102/2008 on the banning of exports of metallic mercury and certain mercury compounds and mixtures and the safe storage of metallic mercury. This prohibits the export of metallic mercury, certain mercury compounds and mixtures/alloys from the Community from 15th March 2011 and sets out the requirement to store these materials in ways safe for human health and the environment; companies in certain industry sectors are also required to pass information to the relevant Competent Authority on use/gains, storage and import and export of mercury.

Policy Options

The options for approaching this issue are as follows:

Option 1 - The situation where mercury is still freely traded under the previous legislative framework. This is the counterfactual baseline against which the other options are assessed.

No constraints would be placed on mercury supply and trade, allowing the mercury to be returned to the market via the only mercury mine in Europe (MAYASA, at Almadén in Spain), in lieu of new production. Raw mercury could continue to be exported from the EU without restriction.

Option 2 - Enforcing a mercury export ban and introduction of information reporting obligations and provisions relating to the safe storage of metallic mercury.

Relative to the baseline the prohibition of the export of mercury would come into force. This would result in considerable amounts of surplus mercury in the Community that should be prevented from re-entering the market. Therefore, the safe storage within the Community of this mercury needs to be ensured. Mercury is likely to be stored in its liquid metallic form (termed 'storage' here), but with technological advances it may become possible to dispose of mercury in a solid form as a sulphide and securely placed out of normal human reach in deep bedrock (termed 'disposal' here). Research into the disposal option has taken place and it is currently not technically feasible to dispose of large quantities of mercury.

> ***Sub option 2a*** - a one stage approach where all the obligations and enforcement are dealt with by a single SI.
>
> ***Sub option 2b*** - A two stage approach with an initial Statutory Instrument (SI) to enforce information reporting obligations, the export ban, and put in place an appropriate enforcement regime; and a second SI in due course (following further consultation) which deals with provisions relating to the safe storage of metallic mercury.

Discussion of Options

Option 1 - The situation where mercury is still freely traded under the previous legislative framework. This is the counterfactual baseline against which the other options are assessed.

Mercury would continue to be traded freely on the world market with the European Union being the main global exporter, historically as a result of the mercury produced in Almadén, and recently because of the resale of surplus mercury from the chlor-alkali industry, coupled with a low internal demand for mercury. However, in the UK there is only one chlor-alkali company that would provide mercury for export.

Benefits

The total stock of chlor-alkali mercury has been estimated to be worth about €58 million at a market price of €5/kg; if sold at 30-50% of this price, producers would receive around €17-29 million in total and shippers etc. would also derive income, estimated by the Commission at around €29-41 million.

Sale of the surplus mercury could offset new production thus avoiding emissions of mercury arising from mining operations, encourage the re-cycling of existing products and effect societal and economic benefits.

Qualitative Costs/Negative Impacts

The EU would continue to be in the morally ambiguous position of phasing out its internal use of mercury whilst continuing to export it to developing countries. Therefore it could not credibly argue for, and support active efforts worldwide to reduce mercury supply and demand on the one hand, while remaining the main global supplier on the other.

Continued production of mercury by the EU could give a signal that the associated problems were not serious. Global prices would be kept low, hence stimulating demand and increasing supply (including from other sources), consumption and emissions. Some of the mercury could end up in illegal or poorly controlled applications with high emission levels.

Methodology for Quantitative Assessment

The current health impacts need to be quantified and valued under the business as usual scenario to enable the comparison of the health benefits that result with the preferred option. Box 1 provides an overview and results of a study carried out in America on valuing the detrimental health impacts of mercury. The method of valuing the neurological health effects is outlined below with details of the specific information and considerations that are needed to value the effects of the export ban. There is also information on the data availability. It follows a similar approach to the impact pathway approach and that used in the American study, and a more detailed methodology is provided in the annex. Following this the current impact of mercury emissions that might arise from export is estimated.

• Quantification of emissions for both the baseline and additional policy measures;
For an export ban this is complicated by the fact that any possible emissions will occur outside of the UK. Information on where mercury is exported, its use after exportation, and the resulting quantity of emissions from each use is needed. This would be more complicated if mercury users import mercury from both the UK and other countries, as the proportion of emissions resulting from UK exported mercury would need to be calculated. There would be large data requirements to calculate both the baseline emissions and those under the policy alternatives. A spatial model would be needed to estimate the emissions, the flow of these emissions through the atmosphere and the deposition rate across regions were fish are caught for UK consumption.

• Conversion of projected emissions into population weighted concentrations for the baseline and differing policy scenarios;
Following the deposition of mercury into bodies of water micro organisms convert small fractions (typically 1 or 2%) into methylmercury. This methylmercury bio-accumulates up the food chain, starting with invertebrates such as zooplankton leading up to the larger species of fish. Some of these fish species are consumed by humans where the methylmercury enters to body. To determine the concentrations of methylmercury in the body, information on the concentrations in fish can be combined with consumption rates. Also knowledge on how the changes in deposition rate relate to changes in fish methylmercury concentrations is needed to determine the effect of the alternative policies.

• Quantification of health impacts associated with the change in methylmercury concentration; Exposure-response functions have been calculated for several health effects, predominantly for IQ losses, cardiovascular effects and premature mortality. Here and in the annex there is a greater focus on the IQ deficits resulting from foetal methylmercury exposure. This is because there has been rigorous statistical analysis of the group of papers studying the neuro-developmental effects of methylmercury by a number of research and advisory groups, but the same has not happened for studies of the cardiovascular and other effects. [Therefore this should be considered as a conservative estimate of the benefits]

A range of plausible slope estimates for changes in IQ associated with intrauterine methylmercury exposures might include values close to 0 up to values of -1. Studies by Cohen et al.[1] developed a slope estimated of -0.7 and Kjellstrom et al. (1989) and Crump et al. (1998) reported a decrease of 0.5 IQ points per each 1 part per million (ppm) increase in maternal hair methylmercury concentration. These studies were carried out from investigations in the Seychelles, Farrow islands and New Zealand and are considered to provide the best available evidence of health impacts.

• Valuation (monetisation) of the health impacts;
For valuing the losses in IQ as a result of methylmercury exposures an estimate of the loss of lifetime earnings due to a reduction in IQ by 1 point has been used. The method involves estimating the proportional impact of a 1 point change in IQ on lifetime earnings, estimating the average lifetime earnings for individuals born in the UK, and combining these results to estimate the absolute impact of a 1 point change in IQ on lifetime earnings. More detailed information about this approach is given in Annex A. The estimate of lost lifetime earnings would only represent a proportion of the total willingness to pay to avoid a decrease in an infant's IQ and therefore would underestimate society's willingness to pay. Research by Salkever (1995) into the lost lifetime earnings due to a 1 point decrease in IQ can be used in combination with data on average lifetime earnings in the UK. Salkever's results found the proportional affect of a lost IQ point to be 2.39% of lifetime earnings.

[1] Cohen, M., R. Artz, R. Draxler et al. 2004. "Modeling the transport and deposition of mercury to the Great Lakes." Environ. Res.

Box 1: Nescuam Study Valuing the Health Impacts of Mercury

A study by Nescuam (Northeast States for Coordinated Air Use Management) (2005) quantified and valued changes in the health impacts of mercury exposures resulting from changes in mercury emissions from coal fired power stations in the US, which would result if mercury filters were installed. The health effects researched were persistent IQ deficits from *in utero* methylmercury exposures, cardiovascular effects and premature mortality. It is a substantial study using a robust methodology and evidence and provides a good indication of the benefits resulting from reduced mercury emissions. It found that there were significant gains from reducing mercury emission from coal fired power stations with the current costs of mercury emissions relating to lost IQ estimated to be $19 billion in the US per annual birth cohort. The results are summarised below in table 1 with more information on the methodology and results in the annex.

Some of the results from the study can be combined with UK data to provide an estimate of the total benefit of reducing the amount of mercury emitted resulting from the export ban. Scenario 1 and 2 are shown here but only Scenario 1 has been used in the UK analysis below.

Table 1		Benefits from avoided mercury emissions to air (m Euro 2000 per tonne)			
		Certain → Less Certain			
	Emissions reductions per year (tonnes)	Persistent IQ deficits lower bound (with neurotoxicity threshold)	Persistent IQ deficits upper bound (no neurotoxicity threshold)	Cardiovascular effects (only limited male population)	Cardiovascular effects and premature mortality in all fish consumers
Scenario 1	23	3.01	7.79	1.93	132.52
Scenario 2	34	3.23	7.82	2.34	133.11

UK analysis

In this section the current costs of mercury emissions in terms of IQ deficits are quantified and valued for the baseline scenario in the UK. The above methodology is used but as far as is practicable. Where there is a shortage of data from the American Nescuam (2005) study has been used instead. This methodology is seen as the best available along with the data taken from it. But there are certain pieces of data that were not available for the UK analysis which is mentioned below and therefore the monetised benefits provided can only be taken as indicative.

The first stage was to quantify the current emissions from mercury that is exported. These emissions would then result in depositions of mercury across geographic areas where fish are caught for UK consumption, as well as other areas where there will be no impact on the UK. There is currently no data available on emissions from exported mercury or in fact on the current deposition rate. Therefore data on the deposition rates from the Nescuam study are used for the UK. This will, however, require the assumption that deposition rates in the US are the same in the UK. The average deposition rate resulting from emissions from US sources was $13 \mu g/m^2$/year.

This deposition rate relates to methylmercury concentrations in fish and consumption of this fish leads to intakes of methylmercury resulting in concentrations in the blood and hair which can be measured. As we have used the American deposition rates it is correct to use the American data on methylmercury concentrations in fish and resulting concentrations in humans. As we have already assumed that the deposition rates are the same for the US and UK it is reasonable to assume that the methylmercury concentrations in fish are the same. However to use the same human concentrations it is assumed that the consumption rates of the different types of fish are the same.

Using the American data the average methylmercury concentration in maternal hair was 0.559 µg/g hair. This figure is then used with an exposure response function to determine the number of IQ points lost per person. The Nescuam study used a value of -0.6 IQ points per 1 ppm hair mercury concentration as it is assumed that this approximates a central tendency for this slope. The value above is then inserted into the equation below;

$$IQ_D = -0.6 \text{ IQ points} \times Hg_h$$

where:

IQ_D = IQ point lost given maternal mercury exposure
Hg_h = maternal hair mercury concentration

This results in an average of 0.335 IQ points lost per child. It should be noted that this analysis assumes that there is no threshold concentration at which there are no effects on IQ from methylmercury.

In the UK in 2005 there were 722500 births[2] which means that the total number of IQ points lost is around 242,038. To value the total health impacts results from Salkever (1995) can be used to estimate the lost lifetime earnings. Salkever (1995) estimated for the US the proportional effect of a 1 IQ point loss was 2.39% of lifetime earnings[3].

Using an average wage of £24,908 (2008 prices, data from ONS) the net present value of lifetime earnings has been calculated assuming that a child born today will begin work in 30 years time and work for 40 years. This works out at £213,998 and assumes a constant wage and provides a lower bound value. Using this estimate the actual cost of a lost IQ point in terms of lost lifetime earnings is £5,114. Therefore the estimated current cost of intrauterine methylmercury exposures is £1.2 billion per annual birth cohort.

Option 2 - Enforcing a mercury export ban and introduction of information reporting obligations and provisions relating to the safe storage of metallic mercury

Benefits

[2] ONS Regional Trends 40
[3] This takes into account the effects IQ has on labour market participation.

An export ban would eliminate the potential for mercury from the chlor-alkali industry to be released to the atmosphere. The EU would no longer be the dominant global mercury supplier and in the morally ambiguous position of actively phasing out its internal use of mercury in order to reduce its own citizens' exposure, whilst continuing to export mercury for continued use in developing countries. Residual negative effects associated with global mercury could no longer be attributable to EU supply. A ban would give a clear signal that the EU considered the problems associated with continued use of mercury to be extremely serious and that it was prepared to take action, so providing a lead to others and improving the EU's international credibility.

The key, long term benefit of reducing mercury emissions will be decreased levels of mercury in the environment. This, in turn, will lead to lower levels of human exposure to mercury, including methylmercury in fish, with resultant health benefits. It will also reduce the impacts of mercury on soils and biodiversity, in particular in the marine environment (e.g. on marine mammals).

Currently, mercury exported from the European Union is mainly used in small-scale gold mining, causing negative effects on the global environment and to humans; it is estimated that this sector uses around 1000 tonnes/year, pollutes thousands of sites and contributes more than 10% of the anthropogenic loading of mercury to the atmosphere.

Quantified Benefits

To quantify the health benefits of this option it needs to be known by how much the emissions of mercury will decrease with an export ban. It is predicted that 500 tonnes will be released over an 8 year period as the chlor-alkali industry changes to new technology. However it is not expected that this amount would be exported at once for two reasons. Firstly the full 500 tonnes would not be released in once large amount and secondly the amount exported depends both on demand and supply. It would be expected that offering 500 tonnes of mercury for export would cause a downward pressure on price which would mean lower profits. Therefore the firm would benefit from limiting the amount it exports. For these reasons the amount of mercury the UK exported in 2004 which was 24 tonnes shall be used as an indication.

It is assumed that all of the mercury released from the chlor-alkali industry is exported outside of Europe and that all this mercury is released to the atmosphere. Once it is in the environment it can remain there for a very long time and can be deposited and re-released. In the Nescuam study there was a reduction in emissions of 23 tonnes which resulted in an average decrease in deposition of 3% or 0.39µg/m^2/year. That is an average decrease of 0.017µg/m^2/year per tonne, and using the UKs 24 tonnes the deposition decrease works out at 0.41µg/m^2/year.

Note that the deposition rates given in the Nescuam study (2005) relate to emissions of coal fired power stations and the corresponding deposition in the US. Not all of the emissions are deposited in the US but these are not included. Therefore it has to be assumed that the proportion of mercury emissions deposited is the same for the UK and the US. However as mercury emissions arising from exported mercury will occur in countries outside the UK and EU it could be expected that the deposition rate is less than that for the US. There is no data to suggest that this would be the case. It is also known that deposition rates can be high in areas where no emissions occur such as the Arctic, and therefore the deposition rate could be higher than in the US.

This reduction in deposition will lead to a reduction in the average maternal hair methylmercury concentration by 0.0061µg/g per person assuming that fish consumption rates remain the same. This figure is an average concentration calculated using results from the Nescuam (2005) study. The number of IQ points not lost is therefore 0.0037 per child. The total benefit of the export ban in terms of IQ points is 2644 with a corresponding value of £13.5 million per birth cohort. This equates to £563,467 per tonne. In accordance with the green book guidelines for calculating present values, the yearly benefit of £13.5 million is discounted over a 40 year time period to give a present value of £299.9 million.

To provide some idea of the sensitivity of the results the factor relating methylmercury concentration to IQ losses (the concentration-response slope factor, currently -0.6) is changed to -0.5 and -0.1. The value of -0.5 was reported by Cohen et al and a slope of -0.1 is seen as an extreme.

Using the slope of -0.5 instead of -0.6 results in the IQ lost per child falling to 0.00305 and for the annual birth cohort to 2203. This has a value of £11.2million or £469,555 per tonne. Using the extreme value of -0.1 still means a total cost of £2.3 million or £93,911 per tonne.

Another adjustment that can be made to provide an indication of the sensitivity is to half the change in maternal methylmercury concentration which would relate to a smaller change in the deposition rate. Half the change in methylmercury concentration leads to a reduction in the number of IQ points lost by 1322 per annual birth cohort from the baseline, with a corresponding monetary benefit of £6.7 million. In fact in order for a cost neutral outcome the amount of mercury deposited would have to be 0.7% of the emissions. The initial analysis above used the same proportion of emissions deposited as that in the American study which was approximately 16.5% of emissions.

This only provides a limited sensitivity analysis but because of the large assumptions made and the use of American data it is difficult to do more than this. The Nescuam (2005) study performed it's own sensitivity analysis with the result that although the different factors over or under estimate the results, they balance out overall.

The benefits given above only relate to the UK as the green book states that focus should be on the UK only, but there will clearly be benefits to the rest of the world. It would not be practicable to quantify these external benefits.

Costs of an export ban

This section describes the potential costs of a mercury export ban. A significant proportion of the costs come from the lost opportunity for selling mercury. With mercury prohibited from leaving the EU market there would be large amounts surplus to requirements that would need stored in a safe, secure and environmentally responsible way. At present there is only one technically feasible method for storing mercury in large quantities which is storage in its liquid form. There is the possibility of a disposal option but this would depend on technological advances being made. Indicative costs have been provided for both storage and disposal options and these will be reviewed at a later date.

Another cost that will be incurred is that by firms providing data to the European Commission. More information on this is given below.

Costs of storage

Liquid mercury would be stored in corrosion proof carbon steel containers in a secure facility where any risk of mercury leakage is controlled. Indicative figures have been provided by Ineos (a company in the chlor-alkali industry) which expects that 500 tonnes of mercury will be made available during the conversion of mercury cells to membrane cells over an 8 year period finishing in 2020. The one- off cost of storing the full 500 tonnes is between £4.32m and £5.32m. The largest component of this cost is due to the lost sales opportunity. Ongoing annual costs are estimated to be £105,000 for the 500 tonnes. These costs were developed on the basis of the Eurochlor proposal/agreement on storage and a breakdown of the costs is shown in Table 2. Surface storage of mercury is considered to have negligible environmental and health risks but long term surveillance is necessary. Ineos has a profit incentive to reduce the ongoing annual costs of storage.

Also a small amount of mercury is produced in the UK from the cleaning of natural gas, but this is already safely disposed of as a waste product. Little or no additional costs would therefore be expected from an export ban.

Table 2: One off and ongoing costs for the storage of mercury

Item	Unit cost £/tonne Mercury	Cost for 500 tonnes Mercury £m
One Off Costs		
Lost sale opportunity	5,000-7,000	2.5-3.5
Packaging	1,100	0.55
Transport	40	0.02
Emplacement in mine	500	0.25
Provision of secure area in mine	-	0.3
Provision of monitoring instruments	-	0.1
Administration	-	0.6
Total	-	4.32-5.32
Ongoing Annual Costs		
Ongoing space rental charges	50	0.025
Ongoing monitoring	-	0.05
Ongoing instrument maintenance	-	0.02
Ongoing administration	-	0.01
Total	-	0.105

In order for the storage costs to be directly comparable with the disposal costs below they have been annualised using a 40 year period. This works out at £329 to £379 per tonne per year or £164,500 – £189,500 for 500 tonnes per year. In the initial period, however, storage costs would be lower since there would be less material to store – although there would be large start-up costs.

As mentioned above the lost sales opportunity forms the largest component of the once of costs and is also the component which is most likely to be volatile. It should be noted that the prices to be used to show the lost sales opportunity should be those before the export ban comes into force. This is because once the mercury has been taken out of the market there can be no lost sales opportunity. It is tempting to say that the losses will be higher after the export ban as prices will be higher due to a reduction in supply. However this reduction in supply and resulting price increase is a result of the export ban, and it is incorrect to use a price that has been changed by their own actions.

To calculate the Present Value (PV) first the average annual discounted one-off cost was calculated for an 8 year time period as £0.607-0.747 million. Adding the average annual one-off costs and ongoing annual costs and discounting for a period of 40 years give a PV range of £6.65 – 7.65 million.

Using the present value of benefits above the (Net Present Value) can be calculated. This is simply the benefits net of costs and using the costs range above gives a NPV range of £292.25 - 293.25 million. The more conservative estimate has been used for the point estimate NPV in the summary sheet.

Costs of disposal

Under disposal mercury would be chemically converted to a stabilised form and disposed of in deep bedrock. This is not yet technically feasible at large volumes and the costs below for different options have been provided to give a rough idea of the scale compared to the costs of storage. These initial figures show the costs of disposal are significantly higher than those of storage. The “per tonne” values do not include transportation costs or the lost sales opportunity cost. As the disposal options are still in the planning stage and there has been relatively little research on mercury disposal options it is expected these costs will be revised as more research is carried out. The costs given are seen to have relatively little connection with the volume of mercury to be disposed as most of the costs relate to the development of the site and the facility. There may also be significant costs of mercury treatment pre-disposal as well as smaller ongoing costs of monitoring.

Table 3: Overview of disposal estimates

	Costs per tonne per year		Costs adjusted to £[4] per tonne per year		Cost for 500 tonnes £million including lost sale opportunity per year		Environmental aspects
Type of disposal	Low end	High end	Low end	High end	Low end	High end	
Deep bedrock repository (permanent disposal in a stabilised form)	SEK 250,000	SEK 650,000	£24,192	£62,901	£12.2	£31.5	Considered to be the safest solution for Swedish conditions. Long term safety expected. No surveillance needed in the long-term. Final design still to be developed.
Surface disposal	SEK 16,667	SEK 43,333	£1,613	£4,193	£0.8	£2.2	Less safe than bedrock in the long-

[4] The value in pound has been converted from Swedish kroners at April 2009 exchange rates.

facility (permanent disposal in a stabilised form)							term and not considered to be an acceptable solution in Sweden.
Disposal in monofill (including macro encapsulation)	USD 6,000	USD16, 000	£4,226	£11,269	£2.2	£5.7	Considered to be environmentally safe.

Discounting appropriately for a period of 40 years using the figures above gives a present value range of £19.4 - 48.1 million. Accounting for the benefits gives a Net Present Value range of £251.8 - 280.5 million.

'Permanently' stored mercury would be outside human control and not easily available for any future essential application, which might give rise to future costs.

As mercury will initially be stored further transportation costs would arise from later relocation to the disposal site. The conversion process would require the building of large plant and costs would be incurred in its construction and operation which could not be recovered afterwards since it would have no further role.

Member States may have difficulties in either identifying suitable deep bedrock sites or storing waste mercury in an above-ground facility. Even when a suitable site is found, the logistics might require several years to make it operational, adding further costs.

There are also concerns over possible emissions of mercury during the solidification process and from the stabilised form itself; the latter might also be leached if stored directly in rock, or via corroded containers, or through the effects of natural geological processes.

In 2000, the OSPAR Convention for the Protection of the Marine Environment of the North-east Atlantic's Programmes and Measures Committee (PRAM) (2000) recognised that deep mine disposal [of stabilised mercury] might not be practicable for all countries and that other forms of safe long term permanent storage could also be acceptable.

Description of sub options for enforcement

Sub option 1 is a one stage approach where all the obligations and enforcement are dealt with by a single SI.

Sub option 2 is A two stage approach with an initial Statutory Instrument (SI) to enforce information reporting obligations, the export ban, and put in place an appropriate enforcement regime; and a second SI in due course (following further consultation) which deals with provisions relating to the safe storage of metallic mercury.

The regulation has three key elements which both sub options need to deal with:

1. A requirement for UK companies in certain industry sectors to pass information to the relevant competent authority on use/gains and storage (by 4th December 2009 and then on a yearly basis by the 31st May in each subsequent year), and on import and export of mercury (by 1st July 2012);
2. The introduction of an export ban for mercury outside the European Union (to start on the 15th March 2011) and mixing of metallic mercury with other substances for the sole purposes of export of metallic mercury, and;
3. Management of safe and appropriate storage methods for mercury to deal with surpluses, following the introduction of and export ban.

Both sub options would meet the UK's obligations under Regulation 1102/2008, the only difference being that sub option 2b would delay dealing with the provisions relating to the waste management of mercury.

However, sub option 2b is preferred as it will realise the benefits of reducing mercury's detrimental impacts on human and wildlife health, but also allows the drafting of a later SI addressing the safe storage of metallic mercury to be informed by the increased level of information available on amounts in the UK and on the ongoing development of technological options for its storage.

Although informal industry discussions indicated that, within the UK, mercury usage is limited to a very small number of companies, mainly Ineos in the chlor-alkali industry, there does appear to be some limited gaining of mercury as a result of natural gas cleaning.

Further, as noted above in the discussion of option 2, there are outstanding issues in the UK with regard to storage/disposal options for waste mercury, arising from the scarcity of potential underground sites. As a result, the UK will need to consider taking advantage of a derogation from the Landfill Directive in 1102/2008 which enables waste mercury to be stored for more than a year in above-ground facilities without designation as landfill. There are also continuing developments in storage/disposal technologies. A two-stage approach (sub option 2b) would enable further consultation to inform the development of an effective waste management regime. Given that it is not until 15th March 2011 that the types of mercury set out in Article 2 will be automatically regarded as waste, there is time for such further consultation and introduction of a second Statutory Instrument.

Both sub options would realise the same benefits and incur the same costs as discussed above. No differences are anticipated in costs to industry between the two options, apart from the need to respond to two consultation exercises instead of one. Similarly, there would be some slight additional costs to Government in preparing two SIs instead of one. But these small costs would be offset by a more effective waste management approach via sub option 2b, which would reinforce the benefits to be accrued from the Regulation.

Starting Date for an Export Ban

An early entry into force for the proposed ban would cause severe technical and financial disruption to the chlor-alkali industry in the UK and Europe, which might inhibit its conversion to mercury-free technology and also lead to increased production of mercury elsewhere in the World, to lower environmental standards. However, discussions with industry have indicated that an enforcement date of 15th March 2011 (as per the Regulation) would not impose such disruption.

Scope of the Export Ban

The Regulation prohibits the export of metallic mercury (Hg, CAS RN 7439-97-6), cinnabar ore, mercury (I) chloride (Hg_2Cl_2, CAS RN 10112-91-1), mercury (II) oxide (HgO, CAS RN 21908-53-2) and mixtures of metallic mercury with other substances, including alloys of mercury, with a mercury concentration of at least 95 % weight by weight.

Metallic mercury is by far the most relevant substance in terms of quantity and the mercury compounds and mixtures included cover the main mercury compounds used or produced in the European Union. Widening the scope would require deeper analysis of better regulation principles, administrative costs and impacts on business competitiveness. The export of products containing mercury is excluded from the provisions of this regulation

No unacceptable burdens on UK industry have been identified from the current scope of the Regulation.

Data Reporting Requirements

The Regulation imposes certain mercury data reporting requirements, by which the specified information must be sent to the European Commission and the Competent Authority by 4th December 2009; and 31st May in each subsequent year.

The data to be sent in accordance with the Regulation are:

(a) In respect of companies concerned in the chlor-alkali sector, data relating to decommissioning as to the:
  - (i) best estimate of the total amount of mercury still in use in the chlor-alkali cell;
  - (ii) total amount of mercury stored in the facility; and
  - (iii) the amount of waste mercury sent to individual temporary or permanent storage facilities and the location of such facilities.

Discussions with UK stakeholders indicate that these reporting requirements will not add any unacceptable burdens and that the costs for meeting them would amount to a few thousand pounds per year. These costs do not change the overall outcome of a net benefit of the mercury export ban

Tracking/enforcement

Introducing the export ban in 2011 would also require an efficient monitoring system to ensure that the mercury is not illegally shipped to the global markets. Such a system will entail some administrative costs, but these are considered negligible. This will be further investigated as part of the consultation.

Mercury sources to be considered as waste

Regulation 1102/2008 considers the following sources to be waste, to be disposed of in accordance with Directive 2006/12/EC of the European Parliament and of the Council of 5 April 2006 on waste in a way that is safe for human health and the environment:

(a) metallic mercury that is no longer used in the chlor-alkali industry;
(b) metallic mercury gained from the cleaning of natural gas;
(c) metallic mercury gained from non-ferrous mining and smelting operations; and
(d) metallic mercury extracted from cinnabar ore in the Community as from 15 March 2011.

Apart from a small amount of mercury from natural gas cleaning, no other mercury arising from these sources has been identified other than from the chlor-alkali industry, so little or no additional costs or benefits are expected.

Option 2- Risks

There is a risk with option 2 that firms sell off and export large amounts of mercury before the export ban comes into force. Doing this would allow firms to reduce the costs of storage/disposal. For the chlor-alkali industry this would be limited by the rate at which conversion to mercury-free technology takes place. The rate is variable across countries and does not seem to be driven by the price of mercury.

An export ban might increase mercury emissions in the EU if previously exported and recycled material went instead to waste disposal, but this is expected to be limited by good waste management practice arising from existing Regulations. However, this issue can be investigated further during the consultation process.

Another concern that arises with an export ban is that it would create a supply deficit, and would lead to a substantial increase in the price of mercury, which in turn would encourage new mercury mining (or higher mercury emissions from alternative mercury sources) outside the EU.

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

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

The only country for which there could now be some risk of adding to global supplies through mining is China, which has in fact increased domestic mine production in recent years, but for the key reason that Chinese imports have been restricted since 2003 in an attempt to dampen domestic demand. China's mercury production is, however, not traded globally as it is for domestic consumption.

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

Another risk relating to an increase in price after the export ban is the increased incentive it gives companies to break the export ban and sell the stored mercury on the "black market". This would provide the company with a one off gain in profits. This risk would only occur if mercury was stored in metallic form as with the disposal option, once disposed of there is no access to the mercury. Price developments are discussed below.

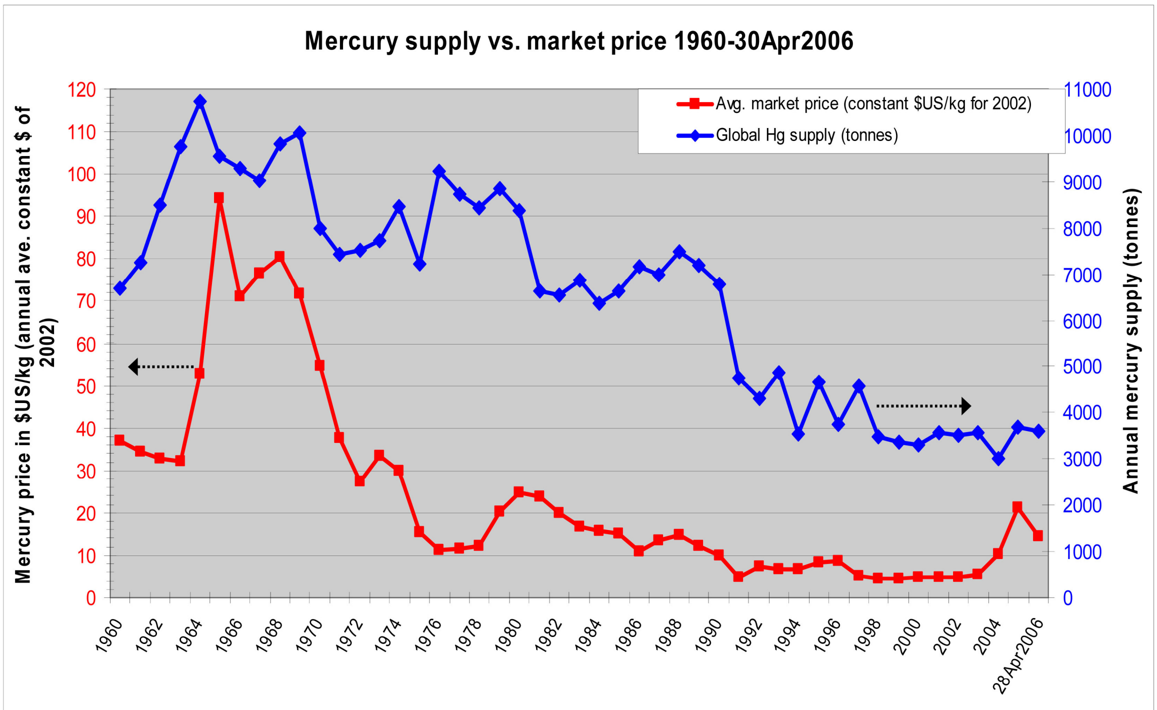
In the longer term, an export ban may not decrease supply as expected and the moral argument that developed countries should not export harmful substances to less developed countries may be undermined if demand from within Europe continues to support production outside Europe. In parallel, therefore, policies that influence demand, both within and outside Europe, may be required. This could include an import ban in Europe, technology transfer to developing countries, and incentives to research mercury substitutes.

Price developments

Some of the risks above relate to the price of mercury and this section shows past trends which help understand how the price might develop under an export ban. It also shows the likely loss per unit if mercury is disposed of.

The figure below shows that the mercury prices have been on a downward slide for most of the past 40 years. During the last ten years they stabilised at their lowest level ever - in the range of €4-5 - before spiking up considerably in the middle of 2004. The low price level reflected a chronic oversupply driven, increasingly, by the regulatory pressures on industry, e.g., to reduce emissions, to organize separate collection of mercury products, and to deal with the increasing restrictions and costs of mercury waste disposal by sending the wastes to recyclers. It then spiked with the tightening of mercury supplies in 2004 after the closure of the Spanish mine in Almadén. There was also an increase in artisanal mining demand for mercury stimulated by rising gold prices. Mercury demand is also relatively inelastic, at least over periods of 12 months or less, so that even a relatively small shortfall in supply can have a large impact.

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



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

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

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

Summary and Conclusion

Option 2, banning the export of mercury and mercury compounds and introducing compulsory storage and information requirements is expected to reduce emissions resulting from the use of currently exported mercury, although the scale of the emissions reduction is difficult to quantify. Whilst there are a number of uncertainties in the analysis (such as how much the deposition rate would change) the benefits of an export ban calculated here for just one health effect give an idea of the magnitude of the potential benefits.

The monetised benefits from adopting option 2 are estimated to be £299.9m for the United Kingdom over 40 years, while there will also be wider global benefits (which it was not practicable to assess). The likely costs to the United Kingdom are £6m-£8m over the same period. However, it should be noted that the benefits have been calculated from the best available evidence and it would be too costly to collect primary data to refine them, therefore they should be viewed as indicative of the relative scale of the likely benefits.

But it is clear that the benefits from option 2 are large and would have to decrease significantly for the costs to outweigh them.

Recommendation

This Impact Assessment therefore recommends that:

- Sub option 2b - that will realise the benefits of reducing mercury's detrimental impacts on human and wildlife health, but also allows the drafting of a later SI addressing the safe storage of metallic mercury to be informed by the increased level of information available on amounts in the UK and on the ongoing development of technological options for its storage - is the most appropriate means of meeting the UK's enforcement obligations under Regulation 1101/2008.

Specific Impact Tests: Checklist

Use the table below to demonstrate how broadly you have considered the potential impacts of your policy options.

Ensure that the results of any tests that impact on the cost-benefit analysis are contained within the main evidence base; other results may be annexed.

Type of testing undertaken	***Results in Evidence Base?***	***Results annexed?***
Competition Assessment	No	Yes
Small Firms Impact Test	No	Yes
Legal Aid	No	Yes
Sustainable Development	Yes	Yes
Carbon Assessment	No	Yes
Other Environment	Yes	Yes
Health Impact Assessment	Yes	Yes
Race Equality	No	Yes
Disability Equality	No	Yes
Gender Equality	No	Yes
Human Rights	No	Yes
Rural Proofing	No	Yes

Annexes

Annex A: Cost Benefit Analysis Methodology

This annex looks at the methodology used for quantifying and valuing the health effects of mercury. The study by Nescuam (2005) values the human health benefits from reducing mercury emissions from coal fired power stations in the US and uses a methodology similar to the impact-pathway approach. The steps are set out below with details of how the study predicted the impacts of methylmercury on neurological development with its corresponding monetary benefit.

The first step is to quantify the emissions of mercury to the atmosphere from both anthropogenic and natural sources. It is estimated that total global emissions were 4850 tonnes and total global anthropogenic emissions were 2850 tonnes (Lamborg et al., 2002). The Nescuam study used data on emissions from coal fired power stations as an input into a spatial model to estimate how much of the mercury deposited on US soils and waters originates from US power stations. The study split the US into 5 land regions and 3 ocean regions and determined the deposition rates for each one.

There are five emissions scenarios used which have corresponding deposition rates. These are: Current emissions, mercury emissions in 2010 (Baseline 1) [This includes projected changes in US mercury emissions], mercury emissions in 2010 with a 47% reduction in US power plant emissions (Scenario 1), mercury emissions in 2020 (Baseline 2), and mercury emissions in 2020 with a 69% reduction in US power plant emissions (Scenario 2). This equates to 23 tonnes and 34 tonnes emissions reduction for Scenarios 1 and 2 respectively. Only Baseline 1 and Scenario 1 have been used in the calculation of benefits for the UK and this information is provided to give an understanding of some of the results taken from the Nescuam study.

Once the mercury in the atmosphere is deposited it methylates and bio-accumulates up the food chain. It also biomagnifies up the food chain, where the concentration in the top predators is much high than those at the bottom of the food chain such as zooplankton. The Nescuam study assumes that equilibria exist between deposited mercury and fish methylmercury concentrations, and that changes in the quantity of mercury deposited lead to linear and proportional changes in fish methylmercury concentrations. This assumption enables the changes in fish methylmercury concentrations to be determined from modelled changes in deposition rate.

The study then uses per capita fish consumption data combined with the data on methylmercury levels in the different species of fish to obtain a weighted mean methylmercury concentration in humans. Average per capita consumption was estimated to be 16.8g/day fish. Combining the weighted mean fish methylmercury concentration and the daily intake fish rate and dividing by the average body weight yields an average daily intake of 0.03 µg/kg-day per capita. From this the corresponding average blood methylmercury concentration is estimated to be 1.56 µg/L for current emissions. This is close to the concentration reported by Maheffey (a mean of 1.64 µg/L from observed blood mercury concentrations) and so provides support for the use of predicted changes in the weighted mean methylmercury concentration of commercial fish to predict the associated changes in the distribution of the blood methylmercury concentration in the US population.

The study used two slightly differing approaches to estimate the impact of methylmercury concentrations; it used a threshold where it was assumed that only those above it suffered IQ losses and a no threshold model were it is assumed that any concentration of methylmercury leads to IQ deficits. The threshold used is the same as the EPA's reference dose (RfD) which is considered to be robust and uses results from several epidemiological studies. It is generally defined as an "estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. The EPA's RfD is 0.1µg Me-Hg/kg body weight per day which is the equivalent of 5.8 µg Me-Hg/l blood (where Me-Hg represents methylmercury). A study of a representative group of about 1700 women in the US (aged between 19 and 49 years) for the years 1999-2000 found about 8 per cent of the women had methylmercury concentrations in blood and hair exceeding the levels corresponding to the EPA's RfD.

There are several health effects that result from exposures to methylmercury but those quantified and valued in the Nescuam study were neurological effects in children exposed to intrauterine methylmercury and adult cardiovascular events. The following section explains how dose-response relationships have been developed for neurological effect but I shall not go into aspects of valuing cardiovascular effects. This is because neurological effects of *in utero* methylmercury exposures are well documented and have been thoroughly evaluated by a number of research and advisory groups. Studies do exist for cardiovascular effects but while the scientific basis seems to be sound and the study results appear credible, no rigorous scientific analysis of the group of studies has taken place.

Quantifying the relationships between human exposure to methylmercury and health effects.

Concentration-response functions have been found by three methylmercury epidemiologic studies (from the Faroe Islands, Seychelles Islands and New Zealand) for the decreases in IQ that result from increases in methylmercury exposure. Cohen et al developed a slope estimate of -0.7 IQ points per 1ppm increase in hair methylmercury concentration. Cohen et al. used a weighting procedure for the neurological test results from the Seychelles Islands, Faroe Islands, and New Zealand studies. In a re-analysis of the New Zealand cohort study (Kjellstrom et al., 1989), Crump et al. (1998) reported a decrease of 0.5 IQ points on the Wechsler Intelligence Scale for Children-Revised Full Scale IQ for each increase of 1 ppm methylmercury in average maternal hair during pregnancy.

The Nescuam study used an estimate of -0.6 IQ points per 1ppm increase in hair mercury concentration as it is assumed that this approximates a central tendency value for this slope. With this slope estimate and data for maternal hair methylmercury concentration the total IQ loss can be calculated using the equation below.

$IQ_D = -0.6 \text{ IQ points} \times Hg_h$ (Eq. 1)

where:

IQ_D = IQ point lost given maternal mercury exposure
Hg_h = maternal hair methylmercury concentration (ppm)

As mentioned above a mean methylmercury concentrations can be estimated from data on fish consumption data and fish methylmercury concentrations. An estimate of the IQ points lost per child can then be calculated and multiplied by the estimated number of children born with methylmercury concentrations above the threshold value to estimate the total number of IQ points lost.

Valuing changes in children's intelligence

Models have been developed to address the monetisation of a subset of the effects of decreased IQ. These effects would represent a component of society's willingness to pay to avoid IQ decreases. One of the more measurable effects is the impact on lifetime earnings from decreases in IQ.

There are several steps in estimating this impact. The first is to estimate the proportional impact of a 1 point change in IQ on lifetime earnings. Average lifetime earnings for individuals born in the US were then quantified. The results of these two steps were then combined to estimate the absolute impact of a 1 point change in IQ on lifetime earnings.

There are several caveats to note: First the results serve as a conservative estimate of the total value individuals place on changes in IQ because they may also value changes independently of their impact on lifetime earnings. Secondly it is assumed that intrauterine methylmercury exposures impacts on IQ are permanent, although epidemiological evidence of such an impact has only been reported in children up to 7 years of age (Grandjean et al 1997, 1999). Finally the estimate does not account for the value of uncompensated labour, such as work in the home and volunteer labour. It is plausible that the value of work in these sectors could be similarly affected by changes in IQ.

To estimate the proportional impact of a one-point change in IQ on lifetime earnings Nescuam adapted a previous cost-of-illness model (Schwartz, 1994; Salkever, 1995). The original posited that individual's lifetime earnings (E) are equal to the product of the average wage (W) and the participation rate (P). Differentiating this equation with respect to IQ yields the relationship:

$$\frac{dE}{dIQ} = P\frac{dW}{dIQ} + W\frac{dP}{dIQ} + \frac{dW}{dIQ}\frac{dP}{dIQ} \quad \text{(eq. 2)}$$

It is assumed that the second order term is small relative to the remaining terms and so is dropped. Rearranging the remaining terms in equation 2 yields:

$$\frac{dE}{dIQ} = E\left(\frac{dW/dIQ}{W} + \frac{dP/dIQ}{P}\right) \quad \text{(eq. 3)}$$

Thus the change in lifetime earnings equals the product of the present value of those earnings (E) and the sum of the proportional changes in wages associated with the change in IQ and the proportional change in workforce participation associated with a change in IQ.

The model assumes that *in utero* methylmercury exposures affect the wage rate and participation rates directly and indirectly, via their impact on scholastic attainment and the subsequent impact of scholastic attainment on both wages and labour force participation. Salkever developed parameters to quantify these direct and indirect impacts given in table 4 below.

Table 4:

Effect	Symbol	Male	Female
Direct impact of a 1 IQ point change on:			
Years of Schooling	IQ_S	0.1007	.1007
Workforce participation probability	IQ_P	0.0016	0.0037
Wages (proportional wage change)	IQ_W	0.0124	0.014
Direct impact of a 1 year of schooling change on:			
Workforce participation probability	SP_P	0.0035	0.0282
Wages (proportional wage change)	SP_W	0.049	0.10

Salkever's model consists of three equations. The first model equation combines the direct and indirect effects of IQ in order to quantify its total proportional impact on labour force participation. In particular, $\frac{dP/dIQ}{P} = IQ_p + IQ_s S_p$, where the first term on the right side of the equation represents the direct effect of IQ on labour force participation, and the second term represents its indirect effect (i.e., the effect of IQ on the level of education attained [S_p]). Similarly, $\frac{dW/dIQ}{W} = IQ_w + IQ_s S_w$. Substituting the right side of these two equations into Equation 3 yields

$$\frac{dE}{dIQ} = E[(IQ_w + IQ_s S_w) + (IQ_p + IQ_s S_p)] \qquad \text{(Eq. 4)}$$

Substituting the values from Table 4 into Equation 4 yields values of E × 1.9% for males and E × 3.2% for females. Using labour force participation rates for males and females, Salkever estimated a weighted average value of E × 2.39%.

The next step is to estimate a baseline lifetime earnings value (E). The Nescuam study used results produced by Grosse (2003) of estimated average lifetime earnings for each age group and gender. Grosse (2003) estimated the present value of labour market earnings over a lifetime of an infant was $692,000 (2000$).

Combining findings in the first two steps the impact of a 1 point change in IQ on the present value of lifetime earnings (evaluated at the time an individual was born) can be calculated. The product of the proportional change (2.39%) and baseline lifetime earnings ($691,830) yields a value of around $16,500 (2000$) per IQ point lost.

Results

Assuming that there is no neurotoxicity threshold the model predicts that when compared to Baseline 1 and Baseline 2, the mean IQ point losses per child across the entire population under Scenarios 1 and 2 are predicted to decrease by roughly 0.003 and 0.004 IQ points, respectively. They decrease from 0.301 to 0.298 between Baseline 1 and Scenario 1 and from 0.299 to 0.295 between Baseline 2 and Scenario 2. Table 5 summarizes the estimated IQ points lost per annual birth cohort in the entire population for each emissions scenario. Rows 2 and 3 of Table 6 show that the predicted incremental gain in average IQ between Baseline1 and Scenario1 is associated with a societal benefit of approximately $194 million and the societal benefit associated with the predicted incremental gain in average IQ between Baseline 2 and Scenario 2 is $288 million.

With a neurotoxicity threshold of 0.1µg/kg day the IQ points gained under Scenarios 1 and 2 are predicted to be roughly 0.001 and 0.006 IQ points when compared to Baseline 1 and Baseline 2, respectively. When compared to the current estimate, under Scenario 2 the mean IQ point losses per child are predicted to decrease roughly 0.015 IQ points. Table 6 shows that the incremental gain in mean IQ in each annual birth cohort between Baseline 1 and Scenario 1 is associated with a societal benefit of approximately $75 million. The societal benefit associated with mean IQ gain between Baseline 2 and Scenario 2 is $119 million.

Table 5: Summary of IQ Point Losses and Associated Costs per Annual Birth Cohort for the Entire U.S. Population (2000$)

	IQ points lost per annual birth cohort	Monetary value of lost IQ points
Assuming no neurotoxicity threshold		
Current	1,185,600	$19,906,000,000
Baseline 1	1,154,400	$19,382,000,000
Scenario 1	1,143,000	$19,188,000,000
Baseline 2	1,149,100	$19,296,000,000
Scenario 2	1,132,200	$19,008,000,000
Assuming a neurotoxicity threshold		
Current	187,000	$3,137,000,000
Baseline 1	173,000	$2,897,000,000
Scenario 1	168,000	$2,821,000,000
Baseline 2	170,000	$2,862,000,000
Scenario 2	163,000	$2,743,000,000

Table 6: Predicted Incremental IQ Gains per Annual U.S. Birth Cohort and Incremental Estimated Monetary Value of the IQ Gains (2000$)

	IQ point gain per annual birth cohort	$ value IQ point gain	Number of children born above RfD annually
Scenario 1 (assuming no neurotoxicity threshold)	11,600	$193,940,000	
Scenario 2 (assuming no neurotoxicity threshold)	17,200	$288,247,000	
Scenario 1 (assuming RfD = neurotoxicity threshold)	4,500	$75,311,000	7,400
Scenario 2 (assuming RfD – neurotoxicity threshold)	7,100	$119,002,000	9,600

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Annex C: Specific Impact Tests

Competition Assessment

An export ban is not considered to have any significant effects on competition as it will be adopted across Europe.

Small Firms Impact Test

There are no small firms affected.

Legal Aid

This policy will not affect legal aid.

Sustainable Development

Sustainable development is included in the main analysis

Carbon Assessment

Carbon assessment will be very insignificant

Health Impact Assessment

This is included in the main evidence base

Race Equality

The policy affects all those that eat fish and will not have a disproportionate effect.

Disability Equality

The policy affects all those that eat fish and will not have a disproportionate effect.

Gender Equality

The policy affects all those that eat fish and will not have a disproportionate effect.

Human Rights

There are no human rights implications

Rural Proofing

There will be no difference in impact between rural and urban areas