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Health & Consumer Protection
Directorate-General

Scientific Committee on Health and Environmental Risks

SCHER

Opinion on Mercury in Certain Energy-saving Light Bulbs

The SCHER adopted this opinion at its 7th plenary on 18 May 2010

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SCHER

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All Declarations of working group members are available at the following webpage: http://ec.europa.eu/health/scientific_committees/environmental_risks/members_wg/index_en.htm

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1. BACKGROUND

Certain energy-saving light bulbs, namely compact fluorescent lamps (CFLs), are widely available on the market and are offered for saving electricity. They also eventually reduce carbon dioxide emissions particularly from coal-fired power plants. They fulfil the requirements of Commission Regulation (EC) No 244/2009 on ecodesign requirements for non-directional household lamps[1] (Ecodesign Regulation), in contrast to traditional incandescent light bulbs which will be phased out progressively in accordance with the Regulation.

According to Directive 2002/95/EC on the restriction of hazardous substances in electrical and electronic equipment (RoHS Directive)[2], a mercury content in CFLs not exceeding 5 mg per lamp is allowed (the mercury exemption for CFLs is listed as n° 1 in the Annex to the RoHS Directive). An indicative benchmark (best available technology) of 1.23 mg of mercury in energy efficient CFLs is provided in the above-mentioned Ecodesign Regulation (Annex IV, n° 3 of the Ecodesign Regulation).

The above-mentioned 5 mg mercury tolerance for CFLs is being reviewed on a regular basis, in line with the four-year-review period prescribed by the RoHS Directive. Such reviews aim at assessing whether the elimination or substitution of mercury is technically possible through specific design changes or through the use of other materials, provided that the negative impacts for the environment, health and/or consumer safety generated by the substitution do not outweigh the possible benefits thereof. This is indicated in Article 5 (1.c) of the RoHS Directive.

At the end of 2007, DG Environment commissioned a technical and scientific assessment of this exemption including, among others, consultation of interested stakeholders (e.g. producers of electrical and electronic equipment, environmental organisations and consumer associations). According to this assessment (Öko-Institut and Fraunhofer IZM 2009), finalised in March 2009, the elimination of mercury in CFLs is still technically and scientifically impracticable.

On the basis of this assessment, the Commission will take a decision for the review of this mercury exemption before July 2010, after consultation with the RoHS Technical Adaptation Committee (RoHS Directive, Article 7). In support of any future review, it may further be appropriate to consider the potential risks associated with the release of mercury from a CFL when it accidentally breaks in the hands of a consumer, for example while replacing a CFL. In such a case, long-term toxicological limit values may be exceeded up to 6,000 times, and the consumer's exposure to mercury may only be 10-fold below acute intoxication. Further information can be found in annex 2. Further considerations on the risk from mercury have been published elsewhere (Groth 2008), including in the event of a CFL breakage in a consumer home.

Clean-up of the debris of a broken CFL has been described as complicated, requiring, for example, the removal of the mercury droplets with adhesive tape and their disposal as special waste. This again points to the relevance of the risk caused by the breakage of a CFL in a consumer's home.

As regards the impacts of mercury emissions related to CFLs, the life-cycle of CFLs should be considered so as to weigh the risks of a mercury escape from CFLs, be it by accidental breakage or disposal as waste (instead of an appropriate recycling) against the reduction of mercury emissions from coal-based power plants due to the lower electricity consumption of CFLs (Aucott et al. 2004). Available information indicates that the reduced electricity consumption of CFLs reduces the need for

[1] OJ L 76, 24.3.2009, p. 3

[2] OJ L 17, 13.2.2003, p. 19

electricity, thus the electricity production would release less mercury, and such a decrease could, on balance, save about 10% of the mercury emissions into the environment.

Concerning disposal, Directive 2002/96/EC on waste from electrical and electronic equipment[3] (WEEE Directive) requires Member States to adopt appropriate measures in order to minimise the disposal of WEEE, including CFLs, as unsorted municipal waste and to remove mercury from the collected CFLs [see article 5 and Annex II (2) of the WEEE Directive]. A proposal to recast the Directive, made by the Commission in December 2008, strengthens the requirements for separate collection, and specifies that transport of WEEE is to be carried out in a way which optimises the confinement of hazardous substances[4].

2. TERMS OF REFERENCE

Against the above background, taking into account all available scientific assessments on mercury, including the Risk Assessment under 793/93/EEC and the previous opinions of SCHER, CSTEE, SCENIHR and the EFSA Scientific Panel on Contaminants in the Food Chain, the SCHER is requested to:

A) Assess the possible health risks to consumers, from the mercury released from accidental breakage of CFLs. In doing so, the SCHER is asked to consider risks to certain vulnerable groups of population such as children or pregnant women;

B) Taking into account the technical and scientific assessment from Öko-Institut and Fraunhofer IZM (2009), assess the potential risks to human health and environment of the alternatives available to reduce, eliminate or substitute the mercury in CFLs;

C) Assess the risk to the environment from the mercury liberated upon disposal of CFLs, taking into account the above-mentioned limit of 5 mg mercury per CFL, the requirements for separate collection of the CFLs and for removal of the mercury from the collected CFLs. Would the risk be significantly reduced by strengthening these requirements?

D) Weigh the risks identified in A), B) and C) against the reduction of mercury emissions from coal-based power plants due to the lower electricity consumption of CFLs compared to conventional household lamps. Incorporate and consider the potential health risks from mercury when CFLs are broken, accidentally in the household or after disposal, into the life cycle analysis of CFLs, taking into account the reduction of human health and environment risks resulting from the potential reduction in mercury emissions from coal-based power plants and the reduction of the emission of other pollutants due to the lower electricity consumption of CFLs compared to conventional household lamps.

[3] OJ L 17, 13.2.2003, p.24.
[4] Articles 5 and 6 of the WEEE proposal: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0810:FIN:EN:PDF

3. OPINION

3.1 Question A

Assess the possible health risks to consumers, from the mercury released from accidental breakage of CFLs. In doing so, the SCHER is asked to consider risks to certain vulnerable groups of the population such as children or pregnant women

Toxicology of elemental Hg

Effects of Hg^0 inhalation in humans have mainly been characterised after accidental short-term and high-concentration exposures, and after long-term occupational exposures. After inhalation of very high concentrations, orders of magnitude above currently valid occupational exposure limits (e.g., the German MAK-value is 84 µg/m^3) symptoms of acute toxicity characterised by restlessness, inflammatory responses in the lung, gastroenteritis and renal damage have been reported. In addition, neurotoxic symptoms such as tremor and increased sensitivity to stimuli are also reported.

After long-term Hg^0 inhalation exposures, effects on the central nervous system and kidney apparently are the most sensitive end-points of toxicity. These include effects on a wide variety of cognitive, sensory, personality and motor functions. In general, symptoms subside after removal from exposure. However, persistent effects (tremor, cognitive deficits) have been observed in occupationally exposed subjects 10-30 years after cessation of exposure.

Persons in rooms after breakage of a CFL may be exposed to mercury by inhalation and by oral intake. After inhalation, more than 80% of inhaled Hg^0 vapour is absorbed by the lungs. Ingested Hg^0 is poorly absorbed in the gastrointestinal tract (less than 0.01%). Skin absorption is insignificant in relation to human exposure to mercury vapour. The elimination of Hg^0 after inhalation is slow (half-life of inhaled Hg^0 is 60 days) with most being eliminated through urine (as mercury ions) and faeces (as Hg^0). A small amount of absorbed Hg^0 is also eliminated via exhalation and sweat (ATSDR 1992; Goldman and Shannon 2001; Halbach and Clarkson 1978; Houeto et al. 1994).

Studies on workers exposed to Hg vapour have reported a clear increase in symptoms of dysfunction of the central nervous system at exposure levels greater than 0.1 mg/m^3. Some studies also reported subtle neurotoxicity at lower concentrations. Self-reported memory disturbances, sleep disorders, anger, fatigue, and/or hand tremors were increased in workers chronically exposed to an estimated air concentration of 0.025 mg/m^3. In a recent assessment of all studies on the exposure-response relationship between inhaled Hg vapour and adverse health effects, IPCS concluded that several studies consistently demonstrate subtle effects on the central nervous system in long-term occupational exposures to mercury vapour at exposure levels of approximately 20 µg/m^3 or higher (WHO/IPCS, 2002 Hg).

The kidney is, together with the central nervous system, a critical organ for exposure to mercury vapour. Elemental mercury can be oxidized to Hg^{2+}. The kidney accumulates inorganic mercury to a larger extent than most other tissue. High-dose exposure to Hg^{2+} may cause (immune-complex mediated) glomerulonephritis with proteinuria and nephritic syndrome. Effects on the renal tubules, as demonstrated by increased excretion of low molecular proteins, have been shown at low-level exposure, and may constitute the earliest biological effect occurring after long-term exposure to air concentrations of 25-30 µg Hg^0/m^3.

A large number of serious and even fatal intoxications have been described after ingestion of inorganic mercury compounds, but data from humans do not allow identification of no-adverse exposure levels, especially in long-term exposure. From studies on experimental animals, a No-Observed-Adverse-Effect Level (NOAEL) of 0.23 mg/kg per day was identified (US ATSDR, 1999; WHO/IPCS, 2002)

Children exposed to Hg^0 vapours may exhibit symptoms like breathing difficulty, swelling and erythema of the hands and feet, and pealing pink skin at the tips of the fingers and toes. These symptoms are collectively called acrodynia (Albers et al. 1982; ATSDR, 1992, 1999; CDC 1991; Clarkson 2002; Isselbacher et al. 1994; Satoh 2000).

Children and the foetus during various stages of their development are more vulnerable than adults. Fast cell proliferation and migration occur during the second and third trimester of gestation and continues to occur in the first 2-3 years of age. Neural development extends from the embryonic period through adolescence (Rice and Barone, 2000). Since mercury inhibits cell division and migration during development, the foetus and young children are particularly at risk when exposed.

Exposure assessment

A fluorescent light bulb contains 5 mg of Hg. Assuming release of the total Hg-content of a lamp after breakage into an average room, Hg concentrations in the range of or above occupational exposure limits (100 µg/m^3) can be derived. These concentrations are also well above regulatory limits for Hg in a general environment. Regarding environmental exposures, the US EPA has defined a reference concentration (RfC) of 300 ng/m^3, and the US CDC derived a maximum residue limit (MRL) of 200 ng/m^3. However, it needs to be recognized that these concentrations are applied to life-long inhalation exposures, are based on conservative extrapolations, and are considered protective for all groups of the population, including potentially sensitive subgroups. . The US EPA also has defined an acute RfC of 1.8 µg/m^3 for Hg. The acute RfC is an estimate (with uncertainty spanning an order of magnitude) of an acute continuous inhalation exposure (time weighted average with a duration up to 24 hours) without appreciable risks of deleterious effects during a life time for the human population also including sensitive subgroups.

The simple assumption of a complete evaporation of the Hg content from a broken light bulb apparently results in a wide overestimation of air concentrations of Hg over time. Indeed, most of the released Hg may re-condense, due to the low volatility of Hg. Measured data suggest that a broken CFL may produce Hg concentrations of 8 to 20 µg Hg/m^3 for a short time after the breakage. Air concentrations rapidly decline: concentrations $\leq$2 µg Hg/m^3 have been measured in a house two days after an Hg spill from a CFL. An experimental study indicates even lower concentrations, between 0.8 and 0.1 µg/m^3 Hg^0, depending on CFL lamp type, in a room after CFL-breakage (Fig. 1).

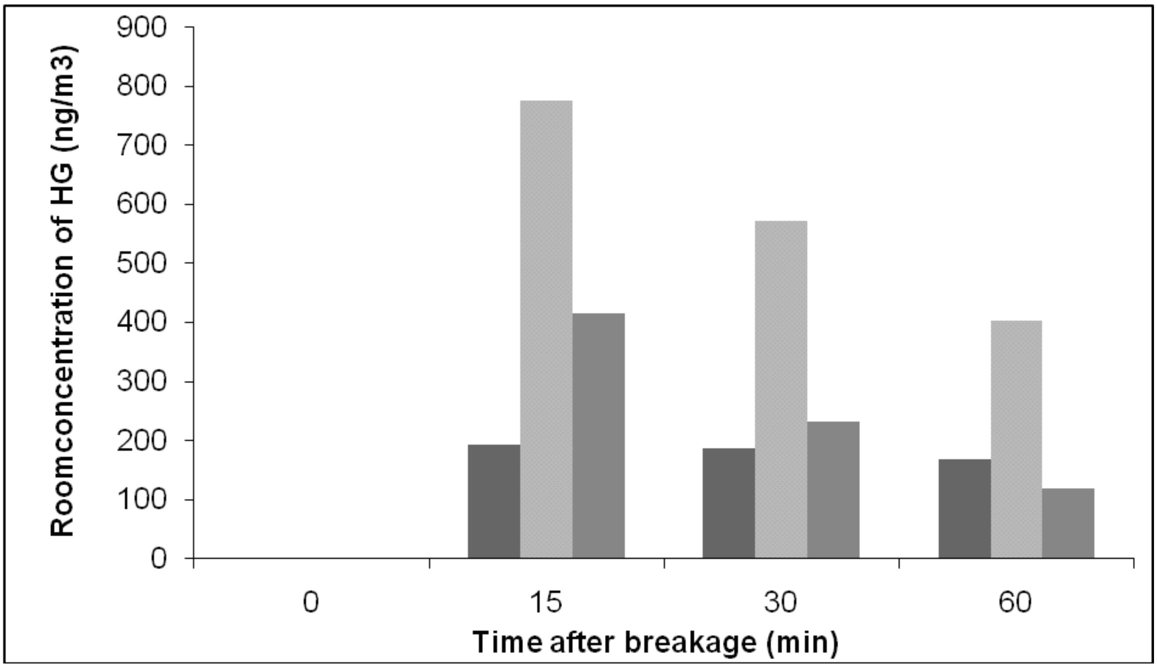

Figure 1: Time course of average air concentrations of Hg (ng/m^3) in a standard room after breakage of different types (different bar colours) of CFLs (data extracted from: Maine compact fluorescent lamp study, 2008).

However, the measured indoor air concentrations may not be indicative of the total Hg intake after a CFL breakage, since most of the Hg released may condense on surfaces, where it can persist if inadequate ventilation is present or in the absence of specific cleanup procedures. Equilibrium between Hg in air and condensed Hg will be reached and then Hg will be slowly oxidized to Hg ions. As a consequence, in addition to inhalation exposure, oral exposure to both elemental Hg and Hg ions may occur in children, due to ingestion of dust and hand-to-mouth contact. There are no data available on the potential contribution of such an exposure to total Hg-intake.

Compared to adults, children have higher exposure via various routes and internal doses of Hg due to several reasons. Children breathe more air per kg of body weight than adults at rest and tend to be more physically active than adults. Therefore, mercury vapours, if present in indoor air, may be delivered to children at higher internal doses than to adults (Miller et al. 2002). The foetus is also exposed during gestation as certain mercury species ($HgCH_3^+$) cross the placenta. A comprehensive review on mercury exposure in children is available in Counter and Buchanan (2004).

Since no data on the potential contribution of oral exposure to total Hg-intake are available for children, the SCHER recommends assessing potential Hg exposures from broken CFL lamps in an experimental setting specifically considering child behaviour. SCHER also recommends providing to customers specific instructions for Hg removal after breakage of a CFL and info for protecting children.

Based on the room air concentrations determined after breaking a CFL, a health risk for adults is not expected, since the exposure is in the range of occupational exposure limits for only a very short time. The occupational exposure limits are intended to protect adults for a 40-year work life. Due to the very low exposures and their very short duration, even sensitive subgroups in the adult population should be protected.

Given the measured Hg air concentrations after CFL breakage, the rapid decrease of these concentrations and the above-stated considerations on the RfC of Hg, the SCHER is of the opinion that a human health risk for adults due to CFL breakage is unlikely. Regarding risk for children, possible exposures from oral intake of dust and hand-to-mouth contact cannot be evaluated due to lack of scientific data; therefore, no conclusions on potential risk are possible. The external peak exposure to Hg^0 by inhalation in adults after a CFL breakage is not translated into a sharp peak exposure of the foetus. Transfer of Hg^0 from the maternal circulation to the foetus is limited. Therefore, foetal exposure is expected to be negligible.

3.2 Question B

Taking into account the technical and scientific assessment from Öko-Institut and Fraunhofer IZM (2009), assess the potential risks to human health and the environment of the alternatives available to reduce, eliminate or substitute the mercury in CFLs.

In the context of the RoHS directive (2002/95/EC) on hazardous substances in electrical and electronic equipment, the report prepared by the Öko-Institut and Fraunhofer IZM (2009) has reviewed the Hg content in various types of lamps: compact lamps, straight fluorescent lamps for general purposes, straight fluorescent lamps for special purposes and 'other lamps' such as high-pressure sodium lamps. However, due to the absence of detailed information on the number of lamps/types used in the EU, on the disposal practices and the life time of the lamps used, the risks to the environment cannot be assessed with the information presented in this report.

The study commissioned by DG TREN and performed by the Flemish institute for technological research (or VITO), has assessed the environmental impact and life cycle of 6 types of lamps, i.e. the so-called base cases (VITO 2009). The information contained in this report allows, be it indirectly, to make an initial risk assessment of Hg contained in these types of lamps. The base cases discussed in this report and used for this opinion are:

1. Incandescent lamp, clear (CLS-C): 54 W
2. Incandescent lamp, frosted (CLS-F): 54 W
3. Halogen lamp, low voltage (HL-LV): 30 W
4. Halogen lamp, mains voltage, low wattage (HL-MV-LW): 40W
5. Halogen lamp, mains voltage, high wattage (HL-MV-HW): 300W
6. Compact fluorescent lamp, with integrated ballast (CFLi): 13W

Exposure assessment based on number of lamps sold in 2007:

The EU-27 electricity consumption in 2007 of non-directional light sources in all sectors is about 112.5 TWh (VITO 2009). This is approximately 4 % of the EU-27 total electricity consumption with 2.95% being used by the domestic sector and 1.05% in the non-domestic sector. The share of each lamp type in the energy consumption for all sectors is given in Table 1.

Table 1: Comparison of unit sales per base case in the EU 27 area (VITO et al., 2008)

	CLS-C	CLS-F	HL-MV-LW	HL-MV-HW	HL-LV	CFLi	Total
Lumen output per (lm)	594.0	572.4	480.0	5177.3	435.0	559.0	
EU 27 sales	297	767	97	84	147	353	1746

(min unit)							
Share of the EU 27 sales	17.0%	44.0%	5.6%	4.8%	8.4%	20.2%	100.0%

According to the VITO (2009) report, the production of 1 KWh releases 16 ng of Hg into the air; the production of 112.5 TWh in the EU-27 area thus emits 16 x 112.5x109 ng = 1800 kg Hg to the EU-27 air compartment.

An overview of the Hg emission of each lamp type during its use and end-of-life phase is given in Table 2. For example, the 767 million CLS-F lamps which were sold in 2007, released 659.6 kg Hg in the EU-27. This calculation is based on each lamp's emission of 0.86 mg Hg during its use and end-of-life phases. Similarly, 353 million CFLi units with an emission of 4.51 mg Hg/lamp were sold resulting in a total release of 1592 kg Hg. The higher emission per CFLi unit (4.51 mg/unit) is mainly due to the end-of-life phase (3.2 mg/unit) in which it is assumed that only 20% are recycled. The total Hg release for all lamp types in 2007 was 5264 kg Hg.

Table 2: Hg emissions and sales per lamp type in the EU 27 area (data taken from VITO, 2009).

	CLS-C	CLS-F	HL-MV-LW	HL-MV-HW	HL-LV	CFLi	Total
EU 27 sales (min unit)	297	767	97	84	147	353	1746
Hg emission during use phase (mg)	0.86	0.86	0.96	7.20	1.60	1.31	
Hg emission during the end of life phase (mg)	0	0	0	0	0	3.2	
Hg emission all lamps in the EU-27 (kg)	255.4	659.6	93.1	604.8	235.2	1592	5264
Product life time (hours)	1000	1000	1500	1500	3000	6000	
Lumen output per lamp (lm)	594.0	572.4	480.0	5177.3	435.0	559.0	
Hg emitted over life time per lumen per hour (ng)	1.45	1.51	1.33	0.93	1.22	1.34	

The VITO (2009) report is unclear about the inclusion of possible Hg release during the production phase of the lamps in the assessment. Considering the industrial and local nature of lamp production, the SCHER assumes that these potential Hg emissions will be strictly controlled and managed.

Comparison of Hg release of lamps and some other Hg sources/emissions – comparative risks assessment:

Mercury emissions from both natural sources and anthropogenic activities have been assessed in detail by UNEP (2002). Worldwide release of mercury to the atmosphere is estimated to be between 2,000 and 3,000 metric tons from anthropogenic sources and 1,400 to 2,300, due to natural sources. An assessment covering most likely uses of mercury in the US (based on data from 1995) concluded that mercury emissions into the air from anthropogenic sources amount to 145 metric tons with dental preparations contributing 0.6 tons (UNEP, 2002). An updated assessment for the year 2000 estimated a total anthropogenic release of mercury to the atmosphere of 126 tons and a contribution of 4.5 tons due to the use of dental amalgams. This updated assessment also estimated mercury releases to water from anthropogenic activities (a total of 46 tons, with 0.8 tons from intentional uses including 0.4 tons due to dental amalgams) and to soil (total of 2700 tons, with 106 tons from intentional uses including 28 tons due to dental amalgams) mostly from mining activities (Cain et al. 2007).

The European Environmental Bureau has published a detailed mass balance analysis of mercury used in dental applications (EEB 2007). This report has examined – in a quantitative manner and across the EU-27 - all sources of amalgam Hg and the pathways by which it can enter the environment. This report states that the EU-27 discharges 109 tonnes/y of mercury from dental practices and that mercury in the teeth of deceased persons contributes 14 tons Hg/y to the EU waste stream. The authors state that of this total of 123 tons, 77 tons will 'likely' end up in various environmental media: i.e. 30 tonnes in soil, 23 tonnes in the atmosphere, 14 tonnes in surface water and 10 tonnes in groundwater.

The Risk Policy Analysis report estimates that approximately 70 tons Hg/year is released (into the environment) by the EU-15 (Floyd et al. 2002). The value given for Denmark is 1 ton/y which is comparable to the values reported in the above-mentioned report (Danish EPA 2004). No further comparisons of the use quantities, release patterns and possible (predicted) environmental concentrations could be made as the type of information and calculations provided in the various reports is too diverse in nature.

From the literature available to the SCHER it may be concluded that, while dental amalgams may represent one of the major intentional uses of Hg today, the contribution of dental amalgams to Hg emission into the air is only a small fraction of the total release of Hg into the atmosphere. Releases from dental amalgams to water may be more significant, but the relative contributions of the various sources vary considerably depending on the literature source used. Information on the Hg releases of dental amalgams to the soil compartment is too scarce to assess it's relative importance and potential risks.

Finally, it should be noted that Hg releases associated with the present use of amalgams represent a small fraction of the total Hg emissions into the atmosphere and the global Hg pool due to the much larger emissions from other sources (UNEP 2002).

Compared to the above-stated 109 tons/y Hg released from dental practices, the Hg emissions originating from electricity production, lamp use and disposal is much lower (approximately 5.3 tons/y, i.e. 4.9 % of Hg originating from dental practices). For elemental Hg and Me-Hg emitted from dental practice amalgams, it was concluded that, except for point sources, no to very low environmental risks are expected. Considering that the Hg emissions from all six types of lamps discussed here is about 20 times lower than that from dental practices emissions, SCHER is of the opinion that environmental risks occurring from Hg released from all lamps, and CLFs in particular, is unlikely. However, the SCHER would like to point out that for local situations, such as lamp collection and disposal facilities which do not manage potential Hg releases properly, site-specific risks to the environment cannot be excluded. These need to be evaluated taking the site-specific characteristics of the facility and environment into account.

As stated in the answer to question A, the Hg room air concentration after breakage of a CFL is not expected to lead to a health risk for adults. For children, conclusions on the potential risk cannot be provided as the potential contribution of the oral intake route is unknown. Regarding the alternatives and assuming similar release rates after breakage, the short-term peak exposures to Hg will be related to the amount of Hg present. However, peak concentrations of Hg after breakage of lamps with highest Hg concentrations will likely be above long-term occupational limits, but only for a very short time. Therefore, no health risks for adults are expected. Conclusions regarding health risks for children cannot be made due to absence of exposure estimations.

In conclusion, regarding the alternatives, i.e. the six types of lamps listed above, no health risks for adults are expected and the environmental risks are unlikely.

3.3 Question C

Assess the risk to the environment from the mercury liberated upon disposal of CFLs, taking into account the above-mentioned limit of 5 mg mercury per CFL, the requirements for separate collection of the CFLs and for removal of the mercury from the collected CFLs. Would the risk be significantly reduced by strengthening these requirements?

In 3.2 the SCHER concluded that environmental risks due to use and disposal of CFLs are unlikely.

To assess the effect of separate collection (and removal of Hg from the collected Hg - i.e. recycling) and a reduced Hg content of the CFLs on the total Hg release into the environment, SCHER calculated different scenarios (Table 3). In the exposure assessment performed in 3.2, it was assumed that each CFL unit contained 4.5 mg and that 20% of the CFLi units were recycled. Using this scenario and the 2007 sales data, this calculation resulted in an Hg emission of 1592 kg in the EU-27 area. Increasing the recycling efficiency to 100% will result in 71% less Hg being released (reduced from 1592 to 462 kg /y).

A 50% reduction in the Hg content (to 2.25 mg) of the CFL (combined with 20% recycling) will decrease the Hg emission to 660 kg/y.

Table 3: Effect different recycling efficiency and Hg content of the CFL on the total environmental release of Hg.

Recycling efficiency (%)	Hg content of CFL (mg)	Hg release in environment (kg/y)
20	4.5	1592
50	4.5	1027
100	4.5	462
20	2.25	891
50	2.25	660
100	2.25	462

As indicated above, present use and disposal of CFLs are unlikely to pose environmental risks. Separate collection of the CFLs and removal of the mercury from the collected CFLs will reduce Hg emission (Table 3).

3.4 Question D

Weigh the risks identified in A), B) and C) against the reduction of mercury emissions from coal-based power plants due to the lower electricity consumption of CFLs compared to conventional household lamps. Incorporate and consider the potential health risks from mercury when CFLs are broken, accidentally in the household or after disposal, into the life cycle analysis of CFLs, taking into account the reduction of human health and environment risks resulting from the potential reduction in mercury emissions from coal-based power plants and the reduction of the emission of other pollutants due to the lower electricity consumption of CFLs compared to conventional household lamps.

In A, B, C, the SCHER concluded that the environmental risks of Hg due to the use of CFLs are very low. The VITO (2009) report demonstrated that the amount of Hg emitted over a CFL lifetime per lumen is approximately 10% lower than that of conventional CLS bulbs (Table 2). Considering that this normalized life cycle estimation (per lumen per hour) includes both the Hg emissions from the use and disposal phase, the net emission reduction would be in that order of magnitude, if all conventional household lamps were replaced by CLFs. It is noted that halogen lamps emit even less Hg (up to 39% less) per lumen per hour.

The SCHER would like to point out, that weighing risks to different targets (human health and ecosystems) from different outputs (Hg and greenhouse gases) from different products (various kinds of light bulbs) presents some considerable challenges that are only just now being addressed in risk assessment. Hence, SCHER is only able to give a partial and somewhat tentative response to this question.

That said, from an environmental perspective, the weighing of the adverse effects of mercury emissions on ecosystems and the climate effects of greenhouse gas emissions is made easier by virtue of the mercury emissions per lumen per hour being roughly similar across lamp types (see Table 2). On the other hand the environmental impacts of the CFLi lamps is considerably less than the rest, Thus the VITO (2009) report presents data per lumen per hour for each environmental indicator including two main environmental impact indicators, i.e. total energy consumption (GER) and total global warming potential (GWP). These indicators for CFLi lamps are about 25% of those of GLS-C and GLS-F lamps. Compared to HL-MV-LW, HL-MV-HW and HL-LV lamps, CFLis have 13%, 53% and 22% less impact on the GER indicator and 13, 47 and 25% less impact on the GWP indicator, respectively.

The SCHER is therefore of the opinion that CFLis offer a net environmental benefit as compared with the other light bulbs considered. This could have been more equivocal had the Hg released from disposal caused the life cycle emissions from the CFLis to exceed that of the other light bulbs. And it is more equivocal in weighing the environmental gains from CFLis with any risks to human lives from accidental exposures. Often, weighing different effects across different targets is based on expert judgements.

Another approach is to weigh different effects on the basis of public values and with a common monetary measure. Thus, the variations per lumen per hour across light bulb types would be modulated as follows: for greenhouse gases with the social cost of carbon; for human health with values for life and/or healthy life years; for ecosystems with the values of ecosystem services. That would put all the risks in the same monetary units.

SCHER counsels some caution with this kind of approach but is of the opinion that for the sake of developing transparent assessment that properly informs management and policy the above-described approach to risk-benefit analysis needs to be given more critical attention. For example, without this kind of approach, it would not be possible at this stage for SCHER to give an opinion that weighs the benefits from greenhouse gas reductions with any increased risks of accidental exposure for human health. That has to remain a matter for judgement in the risk management process.

4. LIST OF ABBREVIATIONS

CFL	Compact Fluorescent Lamp
GER	Total Energy Consumption
CLS-C	Incandescent Lamp, Clear
CLS-F	Incandescent Lamp, Frosted
GWP	Global Warming Potential
HL-LV	Halogen Lamp, Low Voltage
HL-MV-LW	Halogen Lamp, Mains Voltage, Low Wattage
HL-MV-HW	Halogen Lamp, Mains Voltage, High Wattage
KWh	Kilowatt hour
NOAEL	No-Adverse-Effect Level
TWh	Terawatt hour

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