Assistance to the Commission on Technological Socio-Economic and Cost-Benefit Assessment Related to Exemptions from the Substance Restrictions in Electrical and Electronic Equipment:

Study to assess renewal requests for 29 RoHS 2 Annex III exemptions [no. I(a to e -lighting purpose), no. I(f - special purpose), no. 2(a), no. 2(b)(3), no. 2(b)(4), no. 3, no. 4(a), no. 4(b), no. 4(c), no. 4(e), no. 4(f), no. 5(b), no. 6(a), no. 6(b), no. 6(c), no. 7(a), no. 7(c) - I, no. 7(c) - II, no. 7(c) - IV, no. 8(b), no. 9, no. 15, no. 18b, no. 21, no. 24, no. 29, no. 32, no. 34, no. 37]

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Report for The European Commission

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Disclaimer:

Eunomia Research & Consulting, Oeko-Institut and Fraunhofer Institute IZM have taken due care in the preparation of this report to ensure that all facts and analysis presented are as accurate as possible within the scope of the project. However no guarantee is provided in respect of the information presented, and Eunomia Research & Consulting, Oeko-Institut and Fraunhofer Institute IZM are not responsible for decisions or actions taken on the basis of the content of this report.

4.0 Exemptions 1-4 Regarding the Use of Mercury in Lamps – General Aspects

Declaration

In the sections that precede the "Critical Review" the phrasings and wordings of stakeholders' explanations and arguments have been adopted from the documents provided by the stakeholders as far as required and reasonable in the context of the evaluation at hand. Formulations have been altered in cases where it was necessary to maintain the readability and comprehensibility of the text. These sections are based exclusively on information provided by applicants and stakeholders, unless otherwise stated.

Acronyms and Definitions

CFL	Compact fluorescent lamps
Danish EPA	The Ministry of Environment and Food of the Danish Environmental Protection Agency
EEE	Electrical and electronic equipment
EEB	European Environmental Bureau
Health FGOV	Belgish Federal Public Services for Health, Food Chain Safety and Environment
Hg	Mercury
EoL	Early end of life
Lm/W	Lumen per watt
LEU	LightingEurope
MPP	The Mercury Policy Project
NARVA	NARVA Lichtquellen GmbH + Co. KG
PZPO	The Polish Association of Lighting Industry
RPN	The Responsible Purchasing Network
WEEE	Waste EEE

LightingEurope (LEU), a lighting industry association and NARVA Lichtquellen GmbH + Co. KG (NARVA)[6], a manufacturer, each submitted multiple applications requesting the renewal of some of the exemptions related to mercury in lamps listed in Annex III of RoHS (exemptions 1-4, for further details see Section E.2.0 as well as Chapters 5.0 through 16.0 to see what exemptions are being evaluated in the course of this project). Though there may be some differences in their individual requests, many aspects raised in their documentation and in the documents provided by stakeholders throughout the consultation are of general relevance to the Hg lamp exemptions. For this reason, the following chapter summarises general aspects in respect to the Hg lamp exemptions. Where possible, first conclusions and recommendations are made, that shall be referenced where relevant, in the evaluation of the specific exemptions under review (to follow in the next chapters).

4.1 Background

Exemptions 1-4 of Annex III of the RoHS Directive permit the use of mercury in various types of discharge lamps. In general, gas discharge lamps are a family of artificial light sources that generate light by sending an electrical discharge through an ionized gas. LightingEurope[7] explains that a small amount of mercury (Hg) is intentionally dosed in such lamps in order to create the gas discharge. When electric current flows through the lamp bulb (=burner), the mercury atoms inside are excited and produce UV radiation. For example, in fluorescent discharge lamps this UV light passes through a fluorescent coating on the interior of the lamp bulb glass and is thus converted into the required spectra of light (mostly into visible light) emitted from the lamp.

The exemptions for Hg in discharge lamps, listed in Annex III of the RoHS Directive and under review in the context of this evaluation process explicitly name the following technologies and families (only technologies falling in the scope of exemptions for which a renewal has been requested by LEU and/or by NARVA are named below):

- Fluorescent:
  - Compact fluorescent lamps (Ex. 1(a)-1(f));
  - Linear triband phosphor lamps for general lighting (Ex. 2(a)(1-5));
  - Nonlinear triband phosphor lamps (Ex. 2(b)(3));
  - Induction lamps (Ex. 2(b)(4));
  - Cold cathode fluorescent lamps (Ex. 3((a) – 3(c)).

[6] NARVA (2014a), NARVA Lichtquellen GmbH + Co. KG , Exemption request for using of mercury in fluorescent lamps, submitted 19.12.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_1_a-e_/NARVA/01_02_a__2b3_4a.pdf

[7] LEU Ex. 1a (2015a), Lighting Europe, Request to Renew Exemption 1(a) under the RoHS Directive 2011/65/EU Mercury in Single-Capped (Compact) Fluorescent Lamps Below 30 W, submitted 15.1.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_1_a-e_/Lighting_Europe/1a_LE_RoHS_Exemption_Req_Final.pdf

- Non-Fluorescent:
  - Low pressure discharge lamps (Ex. 4(a))
  - High pressure sodium (vapour) lamps (Ex. 4(b)(I-III) and Ex. 4(c)(I-III))
  - Metal halide lamps (HPMV – Exemptions 4(e))

4.2 Annex I Category Covered by this Exemption

LightingEurope[8] is of the opinion that lamps in general are category 5 because the most are used for general illumination. However, they have some of the characteristics of components (used in luminaires), consumables (finite lifetime and regularly replaced) and spare parts, lamps in luminaires have to be replaced when they cease functioning). Some manufacturers of electrical equipment in other RoHS categories may install fluorescent lamps into their equipment for general illumination purposes and so they will need to use lamps that comply with the RoHS Directive, however the products that they place on the market are not category 5 but may be household appliances, medical devices or potentially any RoHS category 1 - 11.

LightingEurope[9] is aware of the difficulty to unambiguously classify certain lamps in the category set out by RoHS legislation. For lamp manufacturers it is essential to have legal certainty regarding the possibility to put the products on the market irrespective of the planned application as manufacturers are not able to control the use of the lamps in products falling in other categories in or out of the RoHS scope. In practice, most lamps are installed in buildings for lighting applications (category 5) but some are used in other types of equipment, potentially, in all other RoHS categories. The way that lamps are used has no effect on lamp design so will not affect the exemption requests.

Therefore lamp manufacturers consider the lamps in scope of this document to belong exclusively to category 5 as individual products.

The Test and Measurement Coalition (TMC)[10] includes the seven leading companies in the sector representing roughly 60% of the global production of industrial test and measurement products. It is TMC's understanding that, according to the RoHS Directive, the exemptions listed in Annex III and Annex IV for which no expiry date has been specified, apply to sub-category 9 industrial with a validity period of 7 years, starting from 22 July 2017. This is also said to be explained in the RoHS FAQ, p. 26 http://ec.europa.eu/environment/waste/rohs_eee/pdf/faq.pdf. TMC, thus does not interpret the current exemption evaluation related to package 9 to concern category 9 industrial equipment, for which the exemptions evaluated in pack 9 are understood to remain valid, and has not provided exemption specific information.

[8] Op. cit. Lighting Europe, Ex. 1a (2014a)
[9] Op. cit. Lighting Europe, Ex. 1a (2014a)
[10] TMC (2015), Test & Measurement Coalition, General comments related to RoHS exemption package 9, submitted 16.10.2015, available under http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_1_a-e_/General_Contribution_Test___Measurement_Coalition_package_9_exemptions_20151016.pdf

Though similar contributions have not been made by other sectors, the aspect raised is understood to be of relevance to all products of categories, which first came into scope under RoHS 2 and for which Article 5(2) specifies durations different from those relevant to categories 1-7 and 10, namely Cat. 8 (medical devices) and Cat. 9 (monitoring and control instruments).

4.3 Justification for the Exemption Renewals

For many of the exemptions for Hg-based lamps, the main argumentation revolves around a few main points that shall be detailed shortly below:

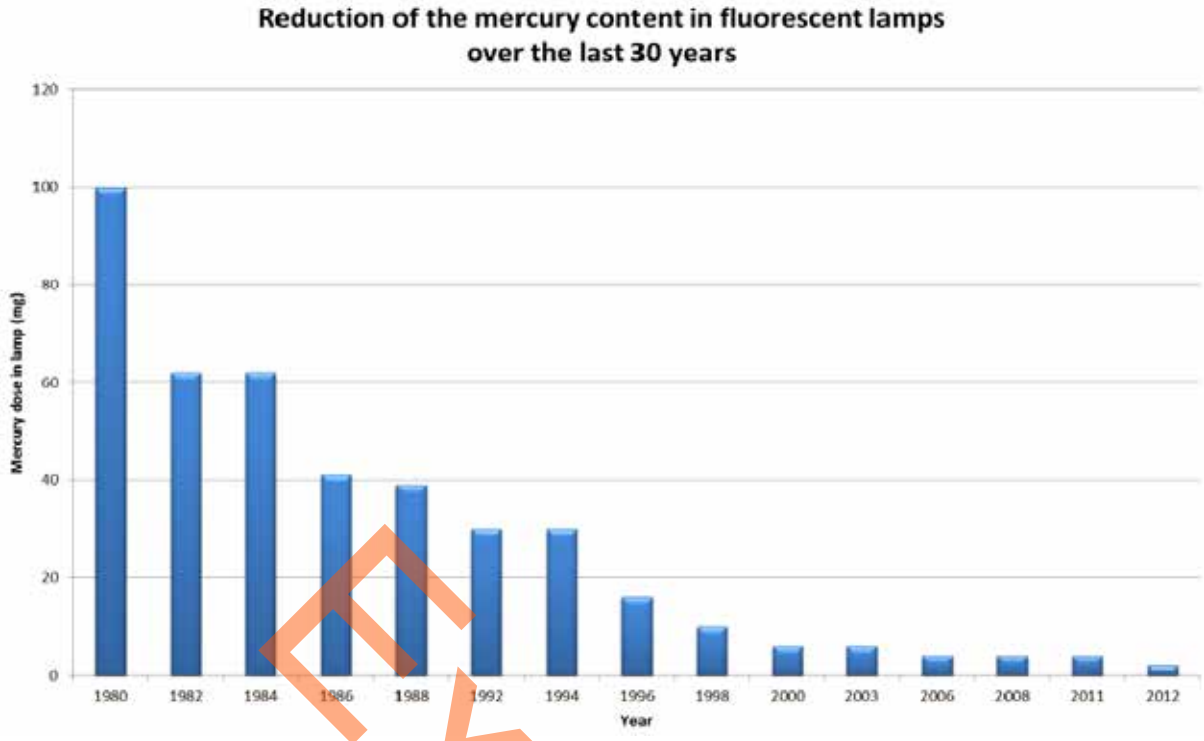
- The limited potential for reducing the amount of Hg dosed in lamps;
- The lack of substitutes for Hg in lamps covered by Ex. 1-4 (substance substitute);
- The limited applicability and product range of Hg-free lamps that may allow eliminating the use of Hg associated with Ex. 1-4, as well as possible restrictions to their use as replacements;
- Possible environmental costs and benefits related to the use of Hg-based lamps and to their possible early phase-out.

Though some of these points require a detailed discussion in the context of the specific exemption, many general aspects are common aspects that have been addressed and evaluated in the following sections. These aspects shall only be further detailed in the exemption specific chapters where detailed information is relevant for the exemption at hand. The critical review of each exemption shall otherwise make reference to this section and only shortly summarise the main conclusions of relevance, where this serves the purpose of supporting exemption-specific conclusions and recommendations.

4.3.1 Amount of Mercury Used under the Exemptions

LEU explains that the level of mercury dosed in fluorescent lamps has decreased considerably during the last years. Examples of this decrease are given in the various requests for exemption renewal. Likewise, LEU has provided Figure 4-1, to show the achieved mercury reduction of the total fluorescent family.

Figure 4-1: Mercury content of fluorescent lamps



Source: Lighting Europe, Ex. 1a (2014a)

LEU[11] states that mercury is dosed in the burner during lamp manufacturing as a homogeneous material (pill, capsule or as amalgam). This technology enables dosing of the small and accurate amount of mercury that is needed, without unintended losses. The amount of mercury dosed per lamp depends on aspects like lamp power, optical performance and anticipated lamp life. In some of the Annex III exemptions, this is reflected through the specification of a maximum allowance of mercury permitted per burner. During lamp life, apparent consumption of mercury takes place inside the burner itself. Throughout operation Hg bonds to the glass and in some lamps to the phosphor layer, after which, it is no longer available to emit ultraviolet light. LEU provides further indication of aspects that may influence the availability of Hg during lamp life and thus of considerations for determining the optimal Hg dose of a specific lamp, among others mentioning:

- Lamp dimensions – "*higher lamp wattage involves more glass and phosphor surface, thus more mercury consumption during lamp life and therefore a higher initial mercury dose*";
- Lamp life time;

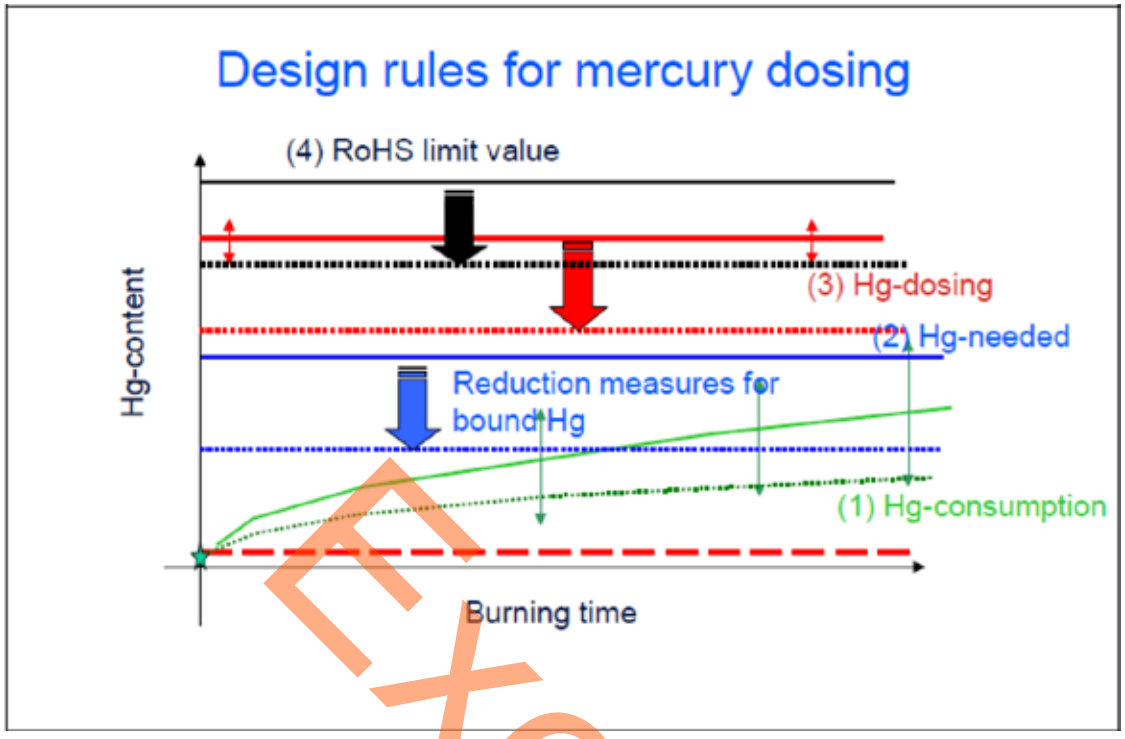
[11] Op. cit. LEU Ex. 1a (2015a)

- *"Coating of phosphors and glass can give a reduction of the Hg 'consumption' over lamp life"*;
- Lamp processing during manufacturing – "*actual dose per lamp scatters around the nominal dose, while the threshold value as set by RoHS directive sets a maximum limit*"
- Mercury 'consumption' – *"processes within the burner, which make a large part of the mercury unavailable for the discharge over lifetime. This is the reason why more mercury has to be dosed to make sure the intended lifetime is not shortened due to too little available mercury"*, e.g. lamp-ballast interaction during operation and interaction with gasses and impurities.

LEU goes on to explain – "*Therefore a balance has to be found between mercury needed over lifetime, mercury variance per dosing unit but also the measurement accuracy when estimating the amount of mercury in a lamp for market surveillance. The lowest (red dashed) line in* Figure 4-2 *gives the ideal situation for a low pressure mercury discharge: there is just enough mercury for the discharge to properly function... However, because of the mercury consumption mechanisms a significantly higher amount must be dosed... In practice, mercury from the discharge is consumed over lamp life. The mercury is mostly deposited and effectively bonded to the glass and the phosphor layer. This is reflected by the full green curve (1) in* Figure 4-2*, which represents more or less a square root relationship with lamp life. The longer the burning time, the higher the amount of mercury needed. The variance in this mercury consumption, as depicted by the green arrows, is considerable and depends on many factors (see below for counteracting measures). To obtain the designed lamp life, the right amount of mercury has to be dosed, taking into account the consumption during lamp lifetime and the variance. The solid blue line 2 in* Figure 4-2 *represents the typical amount that is needed and the solid red line 3 is the amount that also incorporates the variance. Alternatively, this target value is called nominal or average value, and can be listed in catalogues. This average value is lower than the threshold value so the actual amount per lamp is lower than the limit set by the Directive. The solid black line 4 in* Figure 4-2 *is the line representing the RoHS limit (expressed as mg per lamp), the value of which, as explained before, has to take into account both variances of mercury consumption and of mercury dosing. On the one hand, we would like to have this value as low as possible, but on the other hand, it should be safely chosen to (1) eliminate the customer risk of a non-performing product over the designed lamp life and (2) to be able to demonstrate in internal manufacturer's tests and in market surveillance tests that products comply with the RoHS Directive. This leads to a built-in safety margin on top of the target mercury dose, finally leading to RoHS content limit*."[12]

[12] Op. cit. LEU Ex. 1a (2015a)

Figure 4-2: Design rules for mercury dosing in fluorescent lamps, schematically showing the process of setting RoHS limit values based on insights in mercury consumption and mercury dosing.



Source: Lighting Europe, Ex. 1a (2014a)

4.3.1.1 Overview of Mercury in Lamps

Where available, information is detailed in the various exemption evaluation reports as to the amounts of mercury brought on the European market through discharge lamps of various types. Table 4-1 provides an overview of this information in order to provide context for the individual figures and to allow an indicative understanding of the total amount of mercury placed on the market through lamps. Unless otherwise stated, data originates from the documents provided by LightingEurope and is referenced in the separate chapters where the amounts are discussed.

Table 4-1: Overview of Hg amounts brought on the market through discharge lamps

Ex. (entry)	Hg dose per lamp general comments	2013 unless otherwise stated				Comments
		Number of lamps	Average Hg per lamp	Hg	Share of total	
1	**Various CFL lamps**			**947 kg**	**33.01 %**	**Calculated total**
1(a)		291 million	2.5 mg	727 kg	25.34 %	
1(b)		34 million	3.5 mg	120 kg	4.16 %	
1(c)		10 million	5 mg	51 kg	1.78%	
1(d)		2 million	15 mg	26 kg	0.91 %	
1(e)		3 million	7 mg	21 kg	0.73 %	
1(f)	Up to 5 mg per lamp	400	Not	2 kg	0.07%	

Ex. (entry)	Hg dose per lamp general comments	2013 unless otherwise stated				Comments
		Number of lamps	Average Hg per lamp	Hg	Share of total	
	(exemption limit)	thousand	detailed			
2(a)	**Various tri-band phosphor LFL lamps**			**982 kg**	**34.23 %**	**Calculated total**
2(a)(1)		400 thousand	2.5-5 mg	1-1.2 kg	0.03 % (calculated for 1 kg)	
2(a)(2)		76 million	2.5 mg	190 kg	6.62 %	
2(a)(3)		247 million	3 mg	751 kg	26.18 %	
2(a)(4)	-	-	-	-	-	Entry not applied for by LEU. Data not provided by NARVA
2(a)(5)		8-10 million in 2014	4 mg in 2014	40 kg in 2014	1.39 %	
2(b)(3)	Up to 15 mg lamp (exemption limit)	18.6 million*	10 mg*	188 kg*	6.55 %*	*Data provided for exemptions 1(e), 2(b)(2), 2(b)(3), 2(b)(4) and 4(a) – Ex. 1(e) figures have been subtracted. Ex. 2(b)(2) share assumed negligible as it expires in April 2015
2(b)(4)	8 mg average; Up to 15 mg lamp (exemption limit)	18.6 million*	10 mg*	188 kg*	6.55 %*	*Data provided for exemptions 1(e), 2(b)(2), 2(b)(3), 2(b)(4) and 4(a) – Ex. 1(e) figures have been subtracted. Ex. 2(b)(2) share assumed negligible as it expires in April 2015
3	3.5-13 mg per lamp (exemption limit)	Not detailed	Not detailed	Less than 2 kg	< 0.07 %	
4(a)	Hg content from < 4 mg - 15 mg	18.6 million*	10 mg*	188 kg*	6.55 %*	*Data provided for exemptions 1(e), 2(b)(2), 2(b)(3), 2(b)(4) and 4(a) – Ex. 1(e) figures have been subtracted. Ex.

Ex. (entry)	Hg dose per lamp general comments	2013 unless otherwise stated				Comments
		Number of lamps	Average Hg per lamp	Hg	Share of total	
						2(b)(2) share assumed negligible as it expires in April 2015
4(b), 4(c), 4(e)	**Various high intensity discharge lamps (HID)**			**528.5 kg**	**18.42 %**	**Calculated total**
4(b)	Up to 30 mg for entry (I) and up to 40 mg for entries (II and III)	Not detailed	Not detailed	5-10 kg	0.26 % (calculated for 7.5 kg)	
4(c)	Hg amounts vary between 1 - 40 mg	23 million	15 mg	345 kg	12.03 %	
4(e)	In most lamps 3-30 mg, but higher power lamps 200mg is more common and up to 2 gram can be dosed in a small share of lamps	16 million	11 mg (mean)	176 kg	6.14 %	
4(f)	**Various lamps**			**211 kg**	**7.7 %**	**Calculated total**
4(f) Projection lamps	10-40 mg	3 million	15 mg	45 kg	1.57 %	
4(f) UV short arc mercury	up to 100 g per lamp	Not detailed	1 g	20 Kg	0.7 %	
4(f) UV curing lamps	10-3000 mg	132 thousand lamps in 2012[13]	Not specified	75 kg in 2014	2.61 %	Market increase of 6% was applied to 2012 data
4(f) UV Disinfection lamps		178 thousand in 2012[13]		81 kg	2.82 %	Data mentioned in VDMA application for exemption. LEU estimates that 45.7% of lamps are collected for recycling (see Figure 4-3).
Calculated Total				**2868 kg**	**100%**	

Source: Compiled from Information Available from Applicants, see references in individual exemption evaluation reports

[13] Referenced as "UV LED Market" report from Yole Dveloppement, 2012

4.3.2 Alternatives to Hg-based Discharge Lamps

4.3.2.1 Possible Alternatives for Substituting RoHS Substances

Regarding the possible substance substitution of Hg in lamps NARVA[14] states that low pressure discharge lamps do not work without mercury.

LEU[15] agrees with this point, explaining that the mercury discharge is highly efficient in transforming electrical energy into light. The technology has only two drawbacks: first that the generated UV radiation needs to be transformed into visible light, a process from which large energy losses occur due to the Stokes shift[16] and secondly that the discharge inherently contains Hg as the source to create the UV photons. Attempts to generate UV with noble gases have succeeded partially. However the plasma radiates in the deep UV and at such wavelengths that the Stokes shift is even larger causing lower energy efficiency. Some alternatives were developed on the basis of research, however the energy efficiency in prototype lamps is said to be significantly reduced (40 lm/W or below)[17]. In light of the progress of developing alternatives to the discharge lamp (e.g. LEDs) research of substance alternative gas discharges has stopped at most companies and universities. Some additional examples are detailed in the application dossiers; however, none are explained to have resulted in a substance-substitute for Hg in discharge lamps.

4.3.2.2 Possible Alternatives for Eliminating RoHS Substances

Regarding possible technological substitutes for mercury-based discharge lamps, the main mercury free alternatives that have been (or that are becoming) available on the market are incandescent lamps, halogen lamps and light emitting diodes (LEDs).

The well-known conventional incandescent lamps and halogen lamps are less efficient in terms of lm/W and in this respect exhibit negative environmental impacts related to energy and energy related environmental impacts. These would need to be considered under the Article 5(1)(a) criteria related to environmental and health impacts of substitutes. However, both lamp types are subjected to various restrictions through the EcoDesign Directive under which the placing on the EU market of lamps with an energy class lower than B shall be forbidden from 2018. This is expected to effectively ban most incandescent and halogen lamps, and in any case those used for general lighting. Such

[14] Op. cit. NARVA (2014a)

[15] LEU Ex. 2(a)(1)(2015a), Lighting Europe, Request to Renew Exemption 2(a) under the RoHS Directive 2011/65/EU 2(a) Mercury in double-capped linear fluorescent lamps for general lighting purposes not exceeding (per lamp): 2(a)(1) Tri-band phosphor with normal lifetime and a tube diameter < 9 mm (e.g. T2): 4 mg may be used per lamp after 31 December 2011, submitted 15.1.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_2_a__1-5_/Lighting_Europe/2a1_LE_RoHS_Exemption__Req_Final.pdf

[16] LEU explains that an energetic UV photon generates a visible photon which has a much lower energy.

[17] Such values differ depending on technology; however for comparison CFL lamps currently available on the market often have energy efficiencies of 50-65 lm/w, LFLs exhibit energy efficiencies of 80-100 lm/w.

lamps would thus not comprise a practical alternative and shall therefore not be discussed further in detail, unless relevant to the discussion on a specific exemption.

The quickly developing LED technology offers a wide range of Hg-free alternatives that could serve to substitute fluorescent lamps in many cases, thus eliminating the need to use Hg-based technologies. Various stakeholders, including LEU[18] and NARVA[19], claim that the discussion on the suitability of LEDs as technological substitutes for discharge lamps needs to distinguish between two cases:

- Use **as replacement lamps** in existing installations; and
- Use in new installations and **in replacement installations** - new luminaires used to replace luminaires compatible with discharge lamps with ones compatible with LEDs (in some cases luminaires with integrated LED).

LEU[20] explains that new luminaires and lighting systems are now frequently based on LED technology. However, it is claimed that for the current installed base of luminaires and lighting systems operating with discharge lamps, LEDs may in some cases not be suitable drop-in replacements. Towards the development of possible alternatives, the LED technology developments are also addressing one-on-one replacements, but this will not result in a situation which would allow for full replacement of the current discharge lamps portfolio within the timeframe of the exemptions. On this basis it is argued that the availability of suitable discharge lamps needs to be secured to prevent a forced, early refurbishment of installations resulting in extra costs and environmental burden.

Related to lamp replacement, LEU describes three replacement strategies:

- **Retrofit route**: a discharge lamp is substituted by a Hg-free lamp (e.g., LED). The luminaire itself is not rebuilt. Where relevant, the control gear remains in the installation. Driver compatibility is assumed in such cases.
- **Conversion route**: the discharge lamp is replaced, and technical changes also need to be made to the luminaire: ballasts and/or internal wiring may need to be replaced or altered – it is explained that this shifts the responsibility for the technical and the safety consequences of the conversion to the party carrying out the conversion.
- **Rewiring route** – replacing the discharge lamp with an Hg free alternative requires removing the control gear (CG) from the existing installation to establish driver compatibility.[21]

[18] Op. cit. LEU Ex. 2(a)(1) (2015a)
[19] Op. cit. NARVA (2014a)
[20] Op. cit. LEU Ex. 2(a)(1) (2015a)
[21] The exact difference between rewiring and conversion is not clear from the available information, however it can be understood that the scope of changes to the equipment in conversion is wider than in rewiring. A conversion can include rewiring adjustment, but also replacement of drivers, dimmers, etc.

In the exemption renewal documents, LEU[22] describes various aspects that may limit the applicability of LED substitutes as replacements for the full range of discharge lamps covered by the exemptions. Among others the following points are raised:

- Limited variety in terms of shape, sizes, wattage, colour;
- Lacking suitability of LED replacements in light of thermal performance or electric compatibility when used in discharge luminaires;
- Lacking comparability in light output (luminous flux; light pattern and distribution);
- Lack of standards to support product safety certification and to assist in identifying compatible replacement lamps;

4.3.3 Environmental Arguments

4.3.3.1 Life Cycle Aspects

According to LEU[23] several external life-cycle-analysis' (LCA) have been performed regarding lighting. LEU explains that there is general agreement, that the main environmental impact is created during the use phase, meaning through electricity consumption when burning the lamp. This means that currently the energy efficiency (i.e. during the use phase) of the lamp is the determining parameter for almost all environmental impacts throughout the life cycle of a lamp. Specifically regarding mercury, the biggest amount is released to the environment by power plants when generating energy (especially when fossil fuel is the primary power source).

A summary and critical review of the more recent LCA studies cited is presented in Section 5.5.2.2 of the review on Ex. 1(a-e). The location of this information has been determined in light of most of the comparative LCAs to have been performed between LED lamps, incandescent and compact fluorescent lamps. Though the general statements are assumed to be indicative of performance in comparison to other discharge technologies, results of available studies do not address this in detail and are therefore not discussed in depth in this chapter.

4.3.3.2 Use of Materials and Hazardous Substances

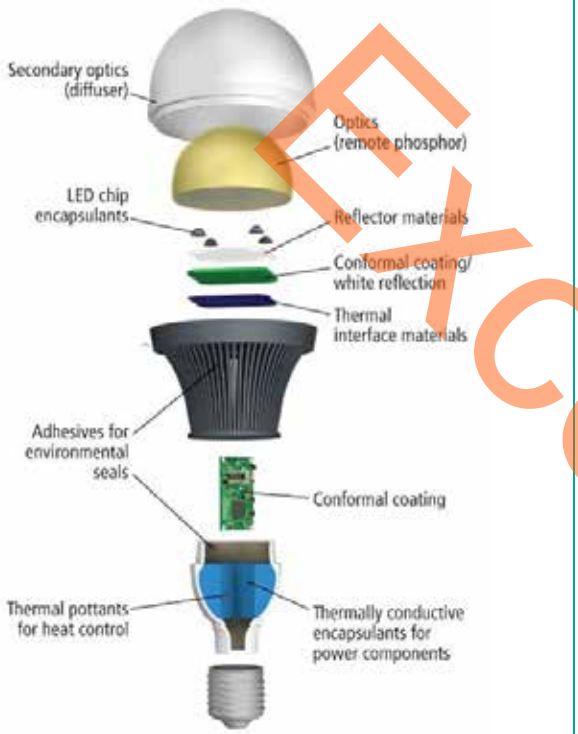
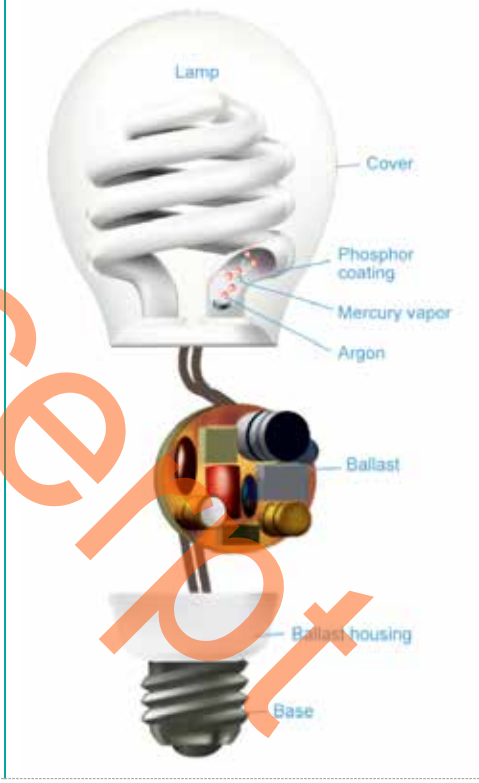
LEU[24] claims that concerning material composition it is also necessary to have a case by case view. Fluorescent lamps contain glass, metals, phosphors and mercury. These components can be effectively recycled. LED based alternatives contain electrical and electronic components such as a control gear and a light engine with mounted LEDs. Like in most other electrical and electronic equipment electronic LED luminaires contain components and other materials using substances regulated in RoHS but exempted in certain exempted applications (e.g. lead in high melting temperature type solders in

[22] Op. cit. LEU Ex. 2(a)(1) (2015a)
[23] Op. cit. LEU Ex. 1a (2015a)
[24] Op. cit. LEU Ex. 2(1)(a) (2015a)

diodes, lead in glass or ceramic in electronic components, lead in aluminium alloys used for the heatsink, lead in copper alloys etc.).

LEU was asked to further substantiate statements related to the use of materials and hazardous substances in discharge lamps and in LEDs. In this regard LEU[25] answered that both lamp technologies use similar electronic circuits and similar components. The lamps as well as luminaires might use exemptions 5(b), 6(a, b, c), 7(a), 7(c)(I, II, IV) or 15, all permitting the use of the element lead. No differentiation between lamps covered by different exemptions is observed. Examples provided can be observed in Table 4-2 (general examples of lamp composition) and Table 4-3 (real examples of electronics used in LED retrofit and compact fluorescent lamps).

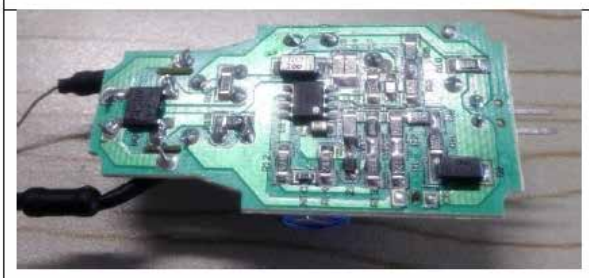
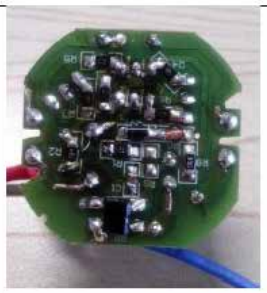
Table 4-2: General composition of LED and CFLi lamps

Example of a LED lamp composition	Example of a compact fluorescent (with integrated ballast) lamp composition
	

Source: Sources provided in LEU (Ex. 1-4) (2015a) by LEU as follows: Left image: http://www.ledsmagazine.com/content/dam/leds/migrated/objects/features/9/10/14/MoldableFig3.jpg Right image: Source: U.S. EPA/ DOE Energy Star Program. "Learn About Compact Fluorescent Light Bulbs" http://www.energystar.gov/index.cfm?c=cfls.pr_cfls_about

[25] LEU Ex. 1-4 (2015a), LightingEurope, Response To Oeko-Institut regarding the 1st Questionnaire Exemption No. 1-4 (renewal requests) General Questions for Lamp Exemptions Related to Mercury, submitted 25.9.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Contribution_Exemption_1-4/LE_Ex_1-4_LightingEurope_General_Clarification-Questions_Final.pdf

Table 4-3: Example of electronics used in LED and CFLi lamps

Example of a LED electronic driver	Example of a compact fluorescent driver (lamp with integrated ballast)
	
	

Source: Source provided in LEU (Ex. 1-4) (2015a) as LightingEurope

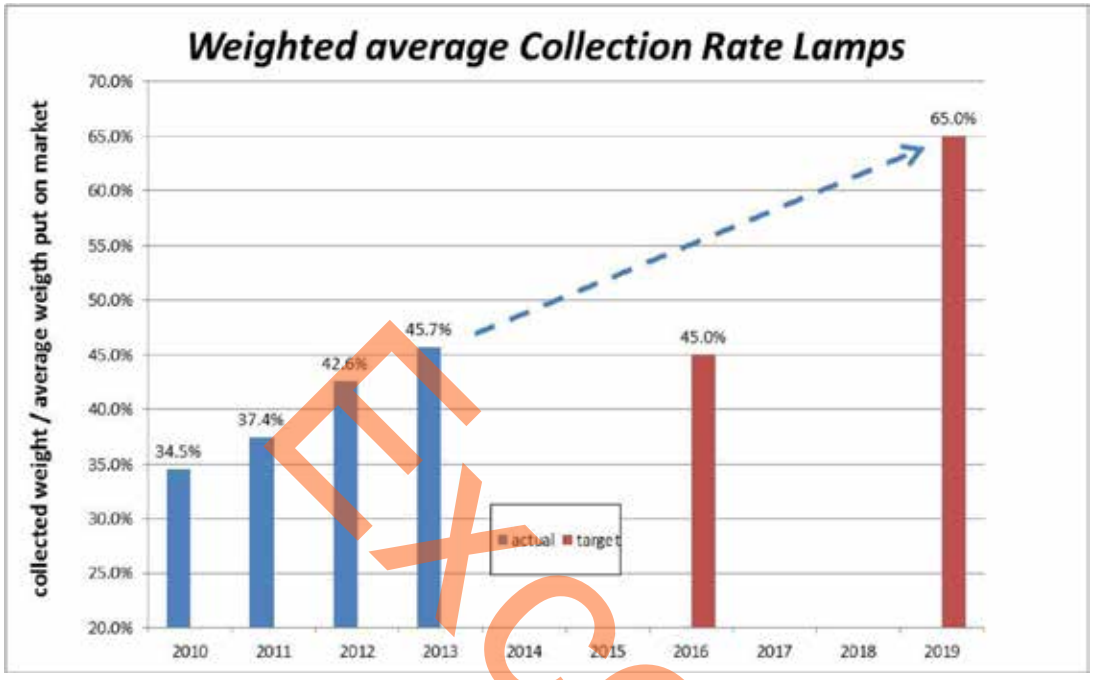
4.3.3.3 Waste management

Information in many of the LEU exemption requests regarding waste streams and recycling is very similar and based on the general approach of industry in the EU towards recycling as a result of the WEEE Directive. LEU[26] states that lamps are in the scope of EU Directives 2002/96/EC (WEEE) and 2012/19/EU (WEEE Recast). The WEEE European legislation stipulates that producers are responsible for end of life products within this category as from August 13th, 2005. Target setting as consequence of the present legislation is 45%/annum of EEE placed on the market by 2016, rising to 65%/annum in 2020. The European Lamp Companies are explained to have founded 'Collection & Recycling Organisations' in the EU Member-States, with the objective to organise the collection and recycling of gas discharge lamps. The goal is to comply with present and probable future EU legislation and to meet or exceed national targets. "*Take back systems are installed in all EU Member States: end users and most commercial customers have to bring back the lamps free of charge... are collected separately from general household waste and separately from other WEEE waste. Also a dedicated recycling process exists for lamps because, according to legislation, the mercury shall be removed from the gas discharge lamps. Mercury is recovered in specialised facilities by distillation.*"

[26] Op. cit. LEU Ex. 1a (2015a)

LEU[27] provides Figure 4-3 showing the collection rate of lamps in Europe compared to the average amount of lamps put on the market during 2010 – 2013. The figure is based on Collection & Recycling Service Organization (CRSO) data for all lamp types, consolidated by Philips Lighting and includes the targets set for 2016 and 2019.

Figure 4-3: Collection rate of lamps in Europe compared to the average amount of lamps placed on the market between 2010 and 2019



Source: LEU Ex. 1a (2015a)

4.3.4 Socio-economic Impact of Substitution

Regarding the costs of substitution, LEU[28] claims that for many applications the prices of LED-based alternatives for discharge lamps (especially for increased wattages) are still significantly higher while the system energy efficiency and lifetime in principle are comparable. This means higher investments and a longer payback time are to be expected. This statement is referenced to a McKinsey Report[29] from 2011.

LEU expects a premature phase out of discharge lamps to result in (amongst others):

- Increase in fixed costs;
- Possible social impacts within the EU;
- Possible social impacts external to the EU;

[27] Op. cit. LEU Ex. 1a (2015a)
[28] Op. cit. LEU Ex. 2(1)(a)(2015a)
[29] Quoted as: McKinsey, Lighting the way : Perspectives on the global lighting market, July 2011

- "*…an increased spend of EU consumers due to enforced usage of more expensive LED lamps (no cheaper alternative yet) and pre-mature refurbishment in professional applications*" [quote unchanged from the LEU text to avoid any unintended shift in the interpretation];
- Banning mercury shall result not only in a reduction of product choice in general but particularly in relation to energy efficient lighting solutions.
- Some discharge lamp families are manufactured in Europe. Not granting the exemptions will lead to the closing of such factories in the EU, and to subsequent loss of jobs.
- "*RoHS is copied by many countries in the world (e.g. Asia, Middle East, the America's). Ending the exemption would have as consequence that also people in other countries would not be able to buy energy efficient and affordable CFL lamps and will go back to using incandescent lamps. This has a very negative impact on the environment*."
- An extension of the exemptions will have a positive effect on the efforts to further innovate in LED technologies, as CFL is the benchmark to be outperformed by LED.

Further information substantiating and quantifying the magnitude of the possible impacts mentioned was not detailed.

4.3.5 Road Map to Substitution

In its various exemption renewal application documents LEU[30] explains that further extension of the various exemptions shall not affect innovation into new LED technologies. It further clarifies that innovative R&D related to discharge lamps has already ceased as LEDs are seen as the future substitute.

4.3.6 The Minamata Convention

The Minamata Convention on Mercury is a global treaty to protect human health and the environment from the adverse effects of mercury. It was agreed at the fifth session of the Intergovernmental Negotiating Committee in Geneva, Switzerland on 19 January 2013. The Convention draws attention to a global and ubiquitous metal that, while naturally occurring, has broad uses in everyday objects and is released to the atmosphere, soil and water from a variety of sources. Controlling the anthropogenic releases of mercury throughout its lifecycle has been a key factor in shaping the obligations under the convention. [31]

Among others the convention requires that:

[30] See for example LEU Ex. 2(1)(a) (2015a)
[31] UNEP, 2016, Minamata Convention on Mercury Website, http://www.mercuryconvention.org/Convention last accessed 4.3.2016

"Article 4(1): Each Party shall not allow, by taking appropriate measures, the manufacture, import or export of mercury-added products listed in Part I of Annex A after the phase-out date specified for those products, except where an exclusion is specified in Annex A or the Party has a registered exemption pursuant to Article 6…"

Annex A specifies the following products relevant to the Hg discharge lamp exemptions dealt with in this report:

"*Mercury-added products*

The following products are excluded from this Annex:

… (c) Where no feasible mercury-free alternative for replacement is available, switches and relays, cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for electronic displays, and measuring devices;

Part I: Products subject to Article 4, paragraph 1

Mercury-added products	***Date after which the manufacture, import or export of the product shall not be allowed (phase-out date)***	**Consultants comments**
Compact fluorescent lamps (CFLs) for general lighting purposes that are ≤ 30 watts with a mercury content exceeding 5 mg per lamp burner	*2020*	Covers lamps falling under Ex. 1(a)
Linear fluorescent lamps (LFLs) for general lighting purposes: *(a) Triband phosphor < 60 watts with a mercury content exceeding 5 mg per lamp;* *(b) Halophosphate phosphor ≤ 40 watts with a mercury content exceeding 10 mg per lamp*	*2020*	Covers lamps falling under Ex. Covers lamps falling under Ex. 2a
High pressure mercury vapour lamps (HPMV) for general lighting purposes	*2020*	Covers lamps falling under Ex. 4(d), which has expired
Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for electronic displays: *(a) short length (≤ 500 mm) with mercury content exceeding 3.5 mg per lamp* *(b) medium length (> 500 mm and ≤ 1 500 mm) with mercury content exceeding 5 mg per lamp* *(c) long length (> 1 500 mm) with mercury content exceeding 13 mg per lamp*	*2020*	Covers lamps falling under Ex. 3(a-c)

The restrictions above apply to all countries who have signed the convention, however it is also mentioned that "*nothing in this Convention prevents a Party from taking additional domestic measures consistent with the provisions of this Convention in an effort to protect human health and the environment from exposure to mercury in accordance with that Party's other obligations under applicable international law.*"

4.4 Stakeholder Contributions

A number of contributions have been made by stakeholders with general comments regarding the lamp exemption (Annex III Ex. 1-4) as well as with comments specific to a certain exemption. The latter shall be discussed in the exemption specific chapters to follow, whereas the former are summarised below.

Ministry of Environment and Food of the Danish Environmental Protection Agency (DEPA)

DEPA[32] has sent a few documents as reference to the lamp exemptions. Though some of these documents were in Danish, a summary in English was provided:

- The first reference provides results of a web based survey performed in October 2014 with 1152 consumers (age 18 years or above).
- The second reference regards data on LED and Hg containing lamps (Baggrundspapir, kviksølv og sparepærer …) with relevant references in English that could be consulted. Furthermore, a first calculation of the possible energy, CO_2 and Hg saved if all energy saving lamps in Denmark are replaced with LEDs is made. The calculation is made on the assumption that the LED lamps use approx. 25% less energy compared to CFLs. For Denmark the result is 46.8 GWh, 16983 tons CO_2 and 0.4 kg Hg. This corresponds all in all to approximately €15 million.

[32] Danish EPA (2015a), Ministry of Environment and Food of the Danish Environmental Protection Agency, Contribution to RoHS Stakeholder Consultation Regarding 29 Exemptions, submitted 8.9.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Contribution_Exemption_1-4/Stakeholder_consultation_RoHS_-_29_exemption_in_Annex_III.pdf, links to referenced document: Tabbelraport in Danish: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Contribution_Exemption_1-4/Tabelrapport_med_kryds_-_Kampagneevaluering_elsparepaerekampagne_-_Praetest.pdf
Baggrundspapir vedr. kampagne om sparepærer og kviksølv in Danish: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Contribution_Exemption_1-4/Baggrundspapir__kviksoelv_og_sparepaerer_5.2.12_GODKENDT.pdf
Survey and health assessment of mercury in compact fluorescent lamps and straight fluorescent lamps: http://mst.dk/service/publikationer/publikationsarkiv/2010/jul/survey-and-health-assessment-of-mercury-in-compact-fluorescent-lamps-and-straight-fluorescent-lamps/
Commission Regulation implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for nondirectional household lamps: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Contribution_Exemption_1-4/sec_2009_327_impact_assesment_en.pdf

- The third reference is to a Danish survey and health assessment of mercury in compact fluorescent lamps and straight fluorescent lamps. The report presents methodology and results of an assessment of the health risk associated with breakage of these kinds of lamps in a private home.
- A last reference is to a Commission impact assessment regarding possible measures considered for implementation under the EcoDesign Directive. DEPA explains that in this assessment from 2009, a large share of the energy consumption was from fossil fuels. DEPA requests that the validity of this argumentation be revised, as it is understood that the share of energy produced from alternative energy sources (e.g. windmills) in the EU has increased. Thus the balance between Hg used in lamps to reduce energy consumption and Hg emissions associated with energy production is expected to have changed and this argumentation may no longer be valid.

In later correspondence DEPA[33] submitted the following revised table from the EPINION survey with data as to how Danish people have disposed of lamps in the past, highlighting which methods are understood to be correct (marked in yellow) and which are not (marked in red).

Table 4-4: Survey of Danish households on bulb disposal

Responses of Danish households to the question *"Think of the last time you had to discard one of the following worn out bulbs. How did you discard the bulb?"*	Energy saving bulb (i.e. CFLs)	LED bulb	Fluorescent tube	Special bulb (halogens or incandescent bulbs)
I delivered it at the recycling station	38%	26%	39%	31%
I delivered it as bulky waste	4%	3%	4%	3%
I put it into the bin for domestic waste	18%	10%	6%	19%
I delivered it as hazardous waste	11%	6%	9%	8%
I delivered it as small electronic waste	9%	7%	7%	8%
I delivered it as glass	3%	2%	3%	4%
Other	2%	2%	2%	2%
I never put a bulb like that to waste	5%	36%	15%	7%
I do not remember/I do not know	10%	17%	15%	17%
Correct disposal behavior total	**38%**	**33%**	**39%**	
Incorrect disposal behavior total	**30%**	**10%**	**16%**	

Source: Provided by DEPA (2016a), referencing data from the EPINION 2014 survey.
Note: In the table the clearly correct and incorrect way of discarding worn out bulbs is marked with yellow and red respectively. For special bulbs it is not possible to indicate correct way of discarding them since this headline covers different bulbs. In some area a special box for collecting bulbs is put up in the bulky waste area. It is therefore not possible to say if this way of discarding the lamps is correct or incorrect, unless the numbers are crossed with the municipalities and their collection system is checked. Bulbs can be delivered as hazardous waste, then the staff will always make sure the lamp is handled correctly, however this is not always the recommendation by the local authorities.

[33] Danish EPA (2016a), Ministry of Environment and Food of the Danish Environmental Protection Agency, Answers to Clarification Questions as to Contributed Documents, Prepared Towards Meeting at Oeko-Institut e.V., Berlin, Friday 5th February 2016, submitted per email 4.2.2016

Further information regarded the amount of light bulbs placed on the market in various years and collected through the various collection mechanisms:[34]

- "In Denmark DPA-system administers the mandatory producer responsibility system. According to the **2014 statistics of the DPA-system** 1547 tons of bulbs (the various types of bulbs are not specified) were put on the market for consumers and 199 tons for professionals, for a total of 1746 tons of bulbs[35]. Concerning collection 765 tons of bulbs were collected from consumers and 12 tons from professionals, amounting to 777 tons and corresponding to a collection percentage of 45%. [36]. According to **statistical data from the DPA system for 2006,** in 2006 Denmark achieved an overall collection rate of 36%[37]. Data from 2010 shows an overall collection rate of 43%.
- In a Ph.D.-thesis from 2014 based on waste composition analysis, it has been estimated that every household in Denmark delivers 1 gram of energy saving bulbs (containing mercury)/week as domestic waste. This number is based on statistics from 3129 households[38]. 1 gram/week corresponds to approximately 50 gram/year[39]. Having 2.775 million households this corresponds to ca. 140 tons of bulbs/year.

DEPA[40] refers to an assessment made in 2015 by FORCE Technology commissioned by the Danish EPA, which among others looked into the influence of the mixture of bulbs and the influence on energy consumption using numbers from the Danish Energy Agency[41].

[34] Op. cit. DEPA (2016a)
[35] DEPA (2016a) refers to DPA system (Danish Producer responsibility), WEEE, BAT og ELV Statistik 2014 (https://www.dpa-system.dk/da/DPA/Dokumenter?id=7854eb59-7b8d-4fcc-b58a-221f6d0b9ad5 - available in English for 2013 file:///C:/Users/doble/Downloads/UK_WEEE%20%20BAT%20og%20ELV%20Statistik%202013.pdf)
[36] Ibid.
[37] DEPA (2016a) refers to DPA system (Danish Producer responsibility), Data og statistik for 2006 (file:///C:/Users/doble/Downloads/WEEE-Statistik%202006.pdf)
[38] DEPA (2016a) refers to Bigum 2014, Life cycle assessment of special waste types: WEEE and batteries, Ph.D. Thesis, Danish Technical University
[39] Ibid.
[40] Op. cit. DEPA (2016a)
[41] DEPA (2016a) refers to Danish Energy Agency, ELMODELBOLIG Statistik, http://statistic.electric-demand.dk/TekniskRap/Resultater?AppGrTek=60&AppTek=61&SpmTek=1&SubSpmTek=1&disp=1&res1ser=4&App=61&ExtraDevice=0&CheckExtradevice=False&Spm=1&Sub=0&QuestId=0

Table 4-5: Energy consumption totals by bulbs type in 1998 and 2012

Bulbs	1998 (GWh)	2012 (GWh)
Incandescent bulbs	1200.5	236.2
Energy Saving bulbs	50.1	197.8
Fluorescent tubes	155.5	148.8
Halogen bulbs	112.4	382.5
Total consumption for lighting	**1518.5**	**963.3**

Source: DEPA (2016a) refers to Danish Energy Agency, ELMODELBOLIG Statistik, See footnote 41

Polish Association of Lighting Industry

The Polish Association of Lighting Industry (PZPO)[42] have submitted general comments concerning the lamp exemptions.

- PZPO reiterates the impracticability of reducing Hg quantities besides a certain point, in light of the negative impacts that this could have on lamp life and subsequently increasing the replacement frequency and waste generation: "*Although technological advances facilitated reduction in the quantity of mercury in fluorescent light sources, there is a certain threshold value responsible for a significant drop in lamp's lifespan*."
- PZPO further raises concern as to the possible influence that fluorescent light source availability could have on the further development of LEDs: *"This is due mainly to the possibility of changing one lighting system to another as well as to the possibility to increase the energy savings... The demand for higher energy savings triggered the development of LED sources, with fluorescent lamps continuing to be the main points of reference. Imposing restrictions on fluorescent sources may lead to a halt in the development of LED sources."*

Belgian Federal Public Services for Health, Food Chain Safety and Environment

The Belgian Federal Public Services for Health, Food Chain Safety and Environment (Health FGOV)[43], submitted comments regarding Hg in lamps, explained to specifically target lamps falling under Ex. 1 (compact fluorescent lamps). However the points raised are of a general nature and may thus be of relevance to Hg lamps in general. In this respect, a main concern regards the collection and treatment of lamps at EoL. The lack of

[42] PZPO (2015a), Polish Association of Lighting Industry, Comments to Annexes III and IV Directive 2011/65/EU (RoHS), submitted 5.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_1_a-e_/Directive_RoHs_-_PZPO_comments_05_10_15_eng.pdf

[43] Health FGOV (2015a), The Belgish Federal Public Services for Health, Food Chain Safety and Environment, Belgian communication for the public consultation on the renewal of the ROHS exemptions on the Mercury containing lamps, submitted 16.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Contribution_Exemption_1-4/Ex_1-4_FPS_Health__Food_chain_safety_and_Environment_Be_position_Hg_lamps_20151016.pdf

information as to the actual collection and treatment rates throughout Europe does not allow understanding the efficacy of the mechanism in place to handle this type of WEEE. Two concerns are mentioned in this respect, the one related to the possible need to evaluate the loss of mercury where lamps are not collected and treated properly (i.e. potentially emitted to the environment). The other questions the fate of Hg in the short and medium term, explaining that there are decreasing options for future use of recycled Hg. This could result in the long term in environmental impacts which should be assessed, related to the continued marketing of Hg lamps and their EoL.

European Environmental Bureau (EEB) the Mercury Policy Project, and the Responsible Purchasing Network

The European Environmental Bureau (EEB), the Mercury Policy Project, and the Responsible Purchasing Network[44] submitted general comments while also including specific conclusions and recommendations for some of the specific exemptions, to be detailed in chapters to follow. EEB et al. are concerned about LEU's request to renew several RoHS exemptions for continued use of mercury for the maximum validity period and with the present maximum mercury limits. This concern is mainly associated with their understanding that equivalent products with no or less mercury are widely available. Some of which (LEDs), are also more energy-efficient and have a longer rated life than Compact Fluorescent Lamps (CFLs). Such alternatives are expected to rapidly become more cost competitive, especially when their long life and ability to cut energy, replacement, and waste disposal costs are considered. EEB et al. do not favour the length of many of the requested mercury exemptions mainly based on the statement that equivalent LED lamps are not a practical replacement today for every application. They request definite, near-term expiry dates in certain categories of lamps on the basis that LEDs are environmentally preferable and practical for most applications. To support this opinion they support this view with various sources – including the EC and its consultants – that are predicting the availability, performance and price of LED lamps to continue to quickly improve. In some other lamp categories[45], they propose lower Hg limits, that they expect can be achieved when the present expiry dates go into effect – or shortly thereafter (within the next 2 years).

KEMI Kemikalieinspektionen, Swedish Chemicals Agency

KEMI Kemikalieinspektionen, Swedish Chemicals Agency (KEMI)[46], submitted comments for two exemptions[47], explaining that the comments are the same in nature. Aspects of

[44] EEB et al. (2015a),The European Environmental Bureau, the Mercury Policy Project, and the Responsible Purchasing Network, Environmental NGOs Response to Stakeholder consultation 2015 #2 on mercury-containing lamps – Exemption 1-4 (Review of Annex to the RoHS directive), submitted 19.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_1_a-e_/Ex_1-4_EEP-RPN-MPP_Comments_on_RoHS_Request-final_20151016.pdf

[45] EEB et al. have suggested reductions in the thresholds set for Ex. 1(b), Ex. 1(d), 2(b)(3) and 4(c). Recommendations are also made for Ex. 1(a); Ex. 2(a)(2-5), Ex. 4(b), Ex. 4(e).

[46] KEMI (2015a), Kemikalieinspektionen, Swedish Chemicals Agency, Contribution to Stakeholder

general relevance to all Hg exemptions are shortly summarised here. KEMI mention voluntary business initiatives such as that of IKEA who has communicated that it shall switch to selling only LED lamps in various EU countries throughout 2015 and 2016[48]. Further reference is made to an effective phase-out of mercury vapour lamps in the US mentioned in a study for the update of Ecodesign requirements for light sources prepared by VHK, in cooperation with VITO and JeffCott Associates[49]. The study is cited as follows (pg. 131): "*There is value in highlighting the mechanism used by the US to phase-out mercury vapour lamps, i.e. through prohibiting sale of the ballast rather than the lamp itself*." KEMI conclude that a phase-out of mercury in lamps is possible, even if the mechanism to achieve it may vary.

4.5 Critical Review

General note: Lamps are generally understood to be a product, which undergoes relatively short design cycles (in comparison with for example medical devices (average design cycles of 7 years). Currently the lamp sector is in the midst of a transformation from conventional technologies such as incandescent, halogen and discharge lamps towards LED technologies. Within this transition, development is understood to be quick, with some products coming onto the market only for short periods. VHK & VITO for example write in this regard "*The technology is still evolving rapidly and therefore the methods and materials used today could be outdated and outperformed in the (nearby) future*."[50]

Against this background, the study team has consciously attempted to limit the review of existing literature (studies forecasting developments of the lighting sector, available reports of comparative studies, etc.) to more recent reports, where such documents were available. In this respect, it should also be kept in mind that such studies are usually based in the best case on data collected at least half a year before the study was published and in some cases on data collected a year or two prior to publication. Thus where more recent literature was available, studies published before 2013 have not been revisited, with the understanding that results based on earlier data shall be limited in their applicability to products available on the market in 2016.

Consultation 2015-2 Request for extension of exemption 1(a-e), submitted 19.10.2015, available under http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_1_a-e_/Ex_1a-e_KEMI_Answer_to_SC_RoHS_20151016.pdf

[47] Ex. 1(a-e) and Ex. 2(a)(1-5)

[48] See provided reference http://www.ikea.com/gb/en/catalog/categories/departments/lighting/

[49] Reference provided by KEMI: Reference: http://ecodesign-lightsources.eu/sites/ecodesign-lightsources.eu/files/attachments/LightSources%20Task1_Main%20Final%2020151031.pdf See page 140 as report version has been updated.

[50] VITO & VHK (2015), Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements ('Lot 8/9/19'), Final report, Task 4, Technologies, Prepared for the European Commission, DG ENER.C.3, pg. 26, available under http://ecodesign-lightsources.eu/sites/ecodesign-lightsources.eu/files/attachments/LightSources%20Task4%20Final%2020151031.pdf

4.5.1 REACH Compliance – Relation to the REACH Regulation

Appendix A.1.0 of this report lists Entry 18 of Annex XVII of the REACH Regulation, which restricts the use of mercury. According to this entry, mercury and its compounds shall not be placed on the market or used as substances or in mixtures where the substance or mixture is intended for use:

- to prevent fouling;
- in the preservation of wood;
- in the impregnation of heavy-duty industrial textiles and yarn; and
- in the treatment of industrial waters.

Entry 18a is also listed, not allowing mercury to be placed on the market:

- In fever thermometers;
- In other measurement devices intended for sale to the general public;
- In specified measuring devices intended for industrial and professional uses;

None of the above restrictions apply to the use of mercury in CFL lamps falling under the scope of Ex. 1(a-e).

Annex XVII of the REACH Regulation also lists Entry 30 in Annex XVII of the REACH Regulation, stipulating that Hg and its compounds shall not be placed on the market, or used, as substances, constituents of other substances, or in mixtures for supply to the general public.

In the consultants' understanding, the restriction for substances under entry 30 of Annex XVII does not apply to the use of mercury in this application. Hg is used in lamps, which in the consultants' opinion is not a supply of mercury as a substance, mixture or constituent of other mixtures to the general public. Hg is part of an article and as such, Entry 30 of Annex XVII of the REACH Regulation would not apply.

No other entries, relevant for the use of mercury in the requested exemption could be identified in Annex XIV and Annex XVII (status February 2015).

Based on the current status of Annexes XIV and XVII of the REACH Regulation, the requested exemption would not weaken the environmental and health protection afforded by the REACH Regulation. An exemption could therefore be granted if other criteria of Art. 5(1)(a) apply.

4.5.2 Scientific and Technical Practicability of Substitution

From the information available it can be followed that substance substitutes for Hg in discharge lamps have not become available in products on the market. Various research of such alternatives have not resulted in technologies with comparable performance to that of the various discharge lamps to be discussed in the next chapters and research has been discontinued.

Regarding mercury reduction, as shall be presented in some of the chapters to follow, it is observed that progress has been made in the reduction of the amounts of Hg used in various lamps. Though it is possible that in some cases further reductions are possible, it

can be followed that this could require further research into dosing optimisation technologies and use of various materials and components that affect the "consumption" of mercury throughout lamp life and thus the need to preserve a minimal presence of mercury. As it is understood that for some discharge lamp types, a technology alternative in the form of LED is either in development or to some degree already available, it can be followed that the industry is focusing research efforts in this direction. However, as the development stage of LED alternatives differs between technologies, abandoning the reduction strategy shall need to be discussed in the context of specific technologies and sub-groups of exemptions in the following chapters. These discussions relate to the expected availability of LED alternatives and how this could affect the need for exemptions for Hg in discharge lamps in the decades to come. If exemptions are to be considered relevant despite the availability of LED substitutes (i.e. for replacement lamps) over the next few decades, the consultants cannot follow that abandoning further research in to Hg reductions is to be accepted as justified. In this respect, the consultants differentiate between the following cases:

- Cases where it is observed that implementation of LED substitutes is already widespread (or could be widespread, where obstacles such as conformity with standards or price based competition with conventional technologies could be removed). Here achieving further reductions of mercury should be dismissed in favour of adapting measures that shall facilitate the shift to LED, such as limiting exemption validity and exemption revoke.
- Cases where substitutes are still scarce and/or where available retrofit-lamps still provide inferior performance (e.g. in relation to light quality, energy efficiency, electrical compatibility, compatibility with existing luminaires in terms of dimensions, etc.). In such cases it may be relevant to further require a reduction strategy:
    - In some cases this could be accomplished through a shift to long-life lamps, for which it can be followed that in total, a lower Hg amount shall be needed to establish a certain functional life time, as compared to "normal life" lamps.
    - In other cases, though reduction should be promoted, this reduction strategy should not go so far as to create a situation in which the lack of mercury affects the functionality of the lamps (i.e., resulting in premature failures, shifts in spectral output, etc.).

Though in some cases, other Hg-free alternatives may exist, it can be understood that for the most part industry is focusing on LED technologies to deliver alternatives for the various Hg-based discharge lamp technologies. LEU mentions various aspects that need to be considered when evaluating the applicability of LED alternatives, however the relevance of such aspects is case specific and is thus discussed in relation to the various exemptions.

4.5.3 Environmental Arguments

4.5.3.1 Use of Materials and Hazardous Substances

From the information provided it can be understood that both types of lamps use similar electrical components, including the RoHS restricted substance lead, permitted in certain applications through various exemptions. Though differences may be of relevance, available information does not allow a comprehensive comparison in this respect and it can be expected that such a comparison would in any case be case specific. Where information is available to allow a more detailed discussion in relation to specific technologies, it is detailed in the chapters of relevance.

4.5.3.2 Early End of Life and Waste Management

LEU's main concern in relation to LED replacement lamps is that where they are not fully compatible as substitutes, that the early phase-out of Hg-based discharge lamps could cause an early end-of-life of installations, as once a lamp shall malfunction the luminaire shall be useless. The consultants can understand that this aspect is of concern, in light of luminaires which would need to be scrapped early, meaning that the resources used in their making shall have not served their planned product-life potential. However, this aspect needs to be observed against the types of waste that shall be created under different scenarios.

To begin with, as long as discharge lamps containing mercury are to be placed on the market, mercury shall be an aspect of concern in the waste stream, only to be resolved years after the last lamp has been placed on the market. As shortly shown in information provided by stakeholders, and as discussed below and in Section 4.5.6, it is apparent that less than the half of lamps put on the market are properly collected and subsequently disposed of and it is thus to be concluded that possible mercury emissions from such lamps are to some degree not sufficiently controlled. Regardless of the compliance of collection and recycling mechanisms with WEEE targets, the understanding that many lamps are not collected separately raises concern as to the fate of such lamps and the potential for Hg emissions. Where collection is not carried out properly, it is assumed that at least part of the mercury available in such lamps shall end up as diffuse emissions in the environment.

As for the possible early EoL of luminaires, for which replacement lamps shall not be available and the waste resulting in such cases, this argumentation should be observed with caution. To begin with, as shall be discussed in some of the exemptions, it is observed that when carried out by trained personnel, in many cases luminaires can be converted so that LED replacements can be used once modifications are applied. In such cases, though certain components may become waste (for example drivers, dimmers and reflectors) this would not apply to the whole luminaire. In a similar fashion, it can also be expected that conversion-kits shall become quickly available on the market for some luminaires, as is already the case in the USA, where conversion-kits for linear

fluorescent luminaires are addressed in studies dealing with the comparability of LFL and LED technologies[51]. Where such conversions support a shift towards more efficient and Hg-free lamps, such waste would be acceptable as it allows for other environmental benefits. It should be noted in this respect that as compact discharge lamps came onto the market, similar problems occurred as to their incompatibility with luminaires of other technologies (incandescent, halogen) in terms of weight and dimensions. This incompatibility was however accepted, as it was understood that the shift would create environmental benefits in terms of energy savings. In the shift from discharge technologies to LED technologies, in some cases energy savings can also already be observed, whereas in others they are expected in the future under the assumption of further developments of LED technologies. Furthermore, LED technology enables the elimination of mercury, which also needs to be considered as an environmental benefit to be weighed against environmental impacts of early-end-of-life of luminaires (further discussed below). It also needs to be kept in mind that early EoL of luminaires shall in any case be expected to some degree, as consumers decide to change their installations as a result of changing fashion and as a result of additional technical capabilities of new luminaires (for example in the case of LED applications: adjustable colour, or smart applications that can be controlled through the internet and through cellular applications etc.).

A further point of importance in this respect is that the RoHS Directive and its substance restrictions have been in force since 2002. The lighting industry members, which manufacture discharge lamps and, which are in many cases already shifting towards LED technologies, have been aware of these regulations for over a decade as all lamps using mercury needed an exemption from the RoHS restrictions to allow their placement on the market. In this sense, this industry who is leading the development of LED technologies has been aware for many years that a time would come where exemptions for Hg in lamps would expire in light of the development of LED alternatives. Especially as this industry faced similar problems when discharge lamps first came on the market, it is expected that the development of LED technologies be carried out so as to facilitate their uptake on the market and so as to avoid incompatibility of new lamps with old luminaires.

LEU argues that waste from EoL of luminaires is a concern, should exemptions be revoked. However, new luminaires designed for discharge lamps, explained to have life expectancies of 15-20 years or more are continuously placed on the market. The RoHS Directive restricts the use of certain substances, among others mercury, and requires products with such substances to be removed from the market where substitutes available. As lamps and luminaires are usually sold separately, the Directive cannot restrict the further sales of new luminaires designed for discharge lamps. Thus as long as luminaires can be placed on the market, the relevance of the early end-of-life argument is extended indefinitely. If the exemptions should remain available in the long term to

[51] See for example CALiPER studies, some of which are quoted in Section 8.0 of this report.

ensure the availability of replacement lamps for existing luminaires, this could prolong the use of mercury lamps indefinitely. Though one may argue that the market should be allowed to evolve naturally, this argument, principally related to environmental impacts, needs to be seen in context of other environmental aspects of the various lamp technologies, such as energy efficiency and the phase-out of mercury. Against this background, the consultants believe that should exemptions duration be extended, measures beyond the RoHS Directive should be devised to promote the uptake of Hg-free LED technologies, and subsequently the reduction of mercury and the phase-out of mercury using products.

In relation to waste, it can be followed that a recycling mechanism has been developed and is functioning towards the targets for collecting and proper treatment of Hg-based discharge lamps. Though the consultants can follow that these arguments are made to clarify that industry is in compliance with the obligations regarding the end-of life of their products, in lack of specific data relevant for each of the exemptions at hand, this information does not provide a basis for concluding as to the collection rates and the achieved recycling rates of lamps in the EU, neither in general nor in regard to a particular sort of lamp discussed in the requests at hand. Though in some cases argumentation is made against the early application of substitutes, in light of the lack of a developed collection and recycling mechanism for the newer lamp types, the information presented above only clarifies that it is in any case the obligation of industry to elaborate existing mechanisms and to provide for the collection and recycling of new types and models once these are placed on the market.

Information regarding the recycling rates of various lamp types at present is only partially available and does not allow understanding the full effectiveness of such systems. Nonetheless, from other available information it can be understood that the collection and recycling rates are still not as high as is required in general for EEE under the WEEE Directive in all Member States.[52] This, in itself, is of concern in light of the mercury contained in such lamps and the uncertainties as to the fate of such lamps at EoL.

In light of this information the consultants can follow that a further effort is still required to improve the various mechanisms, among others in light of the difficulty to promote consumers to participate in the separate collection of lamps. In any case it is assumed that should new types of lamps come onto the market in the coming years in larger quantities, that industry would be required to further develop existing mechanisms so as to also handle such items at end-of-life to enhance collection and to improve recycling techniques.

[52] For example, information provided by DEPA and by Health FGOV for example cites collection rates below those provided by LEU in relation to specific countries.

The Fate of the RoHS Exemptions for Mercury in Lamps and Subsequent Impacts on the Environment

In general, for a specific application, the provision of an exemption means that RoHS restricted substances are brought on to the European market through that application, while once an exemption expires, the environmental impact related to that substance is avoided. Each of these scenarios, however, results in additional impacts on the environment, related to the use of resources of the application or its substitutes, impacts related to their end-of-life, etc. For the lamp this suggests that it would be necessary to evaluate the two following scenarios in the context of the RoHS Directive and its criteria for exemptions:

- Prolongation of existing exemptions for Hg lamps, resulting in diffuse Hg emissions in the environment in the magnitude of half of the amount of Hg applied in lamp production (i.e. assuming the other half is collected and recycled).
- Revoke of existing exemptions for Hg-lamps, resulting in less diffuse Hg emissions in the environment but additional emissions from waste management procedures due to the early end-of-life of existing installations / luminaires.

Information by LEU in this respect however remains general in nature and does not allow understanding the range of possible impacts nor the various factors that would need to be considered to understand the volume of such impacts. In this respect it is worth noting some of the factors of relevance.

On the component level, various LCAs have been performed (see further details in Section 4.3.3.1 and also Section 5.5.2.2 for the review of such information) between certain discharge technologies and their respective LED alternatives. The most common focus of such studies has been the comparison of CFLs with incandescent lamps and LED alternatives therefor. However, some LCA data or other types of comparative comparisons are also available for example for LFLs as well as for high intensity discharge (HID) lamps. LCA comparisons of single products are complex and do not provide a basis for clear conclusions as to other technologies. However, LEU itself states that "*There is general agreement, that the main environmental impact is created during the use phase, meaning through electricity consumption when burning the lamp. This means that currently the efficacy of the lamp is the determining parameter. Specifically regarding mercury, the biggest amount is released to the environment by power plants when generating energy (especially when coal is the primary power source).*"[53] In this sense it can be concluded that if the efficacy of LED alternatives is comparable to the discharge technology that it is replacing, that from a component perspective that LEDs could be considered at least similar in terms of their environmental impact. The "components" for which this statement needs to be scrutinized more carefully are on the one side the Hg

[53] This statement appears in many of the applications. See for example LEU Ex. 2(b)(3)(2015a)

containing component of discharge lamps (dosed for example as amalgam pills in some cases) and on the other the heat sink of LEDs when it is based on aluminium. During use, however once efficacy is comparable, LEDs would be understood to have an advantage as the Hg emission related to energy consumption would be similar and LEDs do not contain mercury.

If to go a step further, on the system level, the potential for early-end-of life of luminaires needs to be weighed against the actual waste produced and how it is handled. As explained above, even were an exemption for a certain technology to be revoked, it should not be assumed that the respective luminaire stock would be scrapped as a result thereof.

- In some cases luminaires would have been scrapped anyway, in light of natural end-of-life or decisions of consumers to replace luminaires in light of new technological advantages, changing fashions, renovation of buildings, etc. Some of the existing luminaires may indeed be scrapped gradually as last lamps burn-out. For such installations it can be understood that the luminaires would be collected and handled along with other electronic waste. As a large share of such articles is expected to be various metals such as iron, copper and aluminium, it can be expected that such materials would be recycled and would return to the market as secondary materials.
- In others it can be expected that consumers would be able to use available LED alternatives in existing discharge luminaires to enable their further use, even if these would require conversions in some cases. In other words for some of these luminaires early EoL is not expected, while for other early EoL is only relevant for the parts scrapped through conversion (for example electric components such as ballasts). Here too a share of such components can be expected to be recycled and returned to the market as secondary material.

The share of luminaires scrapped as detailed above can be expected to vary for different technologies, depending on the availability of different types of alternatives as well as on the age distribution within the luminaire stock and its respective lifetime. Materials to be recycled would reduce to some degree the expected “cost” of early EoL. In parallel, these impacts would also need to be weighed against the potential of new technologies (such as LED) to save energy and of course to eliminate mercury. On the one side, LED luminaires may in some cases be more resource intensive than discharge ones, for example, where they require measures for dissipating heat such as in lamps with higher lumen output. On the other side, in technologies where larger amounts of mercury need to be dosed, the elimination of Hg from the lamp may balance out the Hg related to energy consumption of luminaire production.

This discussion is only indicative; however it should serve to show the larger context in which the argumentation of early EoL of lamps should be observed.

4.5.4 Safety Aspects

LEU raises concern related to the possible revocation of the exemptions for Hg in discharge lamps, on the basis that where replacement lamps are not available as drop-in substitutes, that adaptation of the installations to accept available alternatives may affect the warranty as well resulting in possible safety impacts. In the consultants view, it needs to be assumed that where such changes should be needed, that they would be carried out (at least for the most part) by technical professionals. Such professionals are expected to have the capability to perform rewiring and conversions without resulting in safety related consequences and in this sense this argumentation cannot be understood to justify an exemption in light of possible future safety issues. Furthermore neither type, nor probability, of the safety issues are described sufficiently in order to assess whether these issues outweigh the benefits from substitution.

4.5.5 Road Map to Substitution

LEU explains that research and development efforts into substitutes for Hg in discharge lamps have ceased, and that all present efforts are directed at the further development of LED technologies. The consultants understand the reference to such research to relate to the possibility of enabling further reductions of Hg doses in discharge lamps as well as to research into possible substance alternatives for Hg in such lamps. There have been cases in the past where exemptions were extended as it became clear that alternatives needed a few more years of development to ensure the applicability of substitutes and their reliability for the respective product range or to ensure the availability of a suitable volume of products on the market. However in contrast to such cases, the case of discharge lamp technology as presented by LEU is not understood to require a grace period of another few years but of a much longer period.

In parallel LEU explains that a full transition to LED in some product groups should only be considered after sufficient time has been provided to resolve the technical issues described and to allow EU users time to make changes without negative safety or socio-economic impacts. The consultants understand from these statements that where LED alternatives shall not enable substitution of discharge lamps within existing installations, that there is no intention of developing other alternatives. LEU, further explains in their documents, that Hg-based discharge lamps could be needed in some cases for over 25 years to avoid possible environmental costs of early EoL of luminaires. LEU was thus asked to clarify if the renewal for some exemptions could be limited to the application of Hg in lamps to be used in installations placed on the market in the past.

LEU explains:

> "*at the moment mercury containing lamps are still used in new installations… Luminaires for general lighting are usually marketed without the lamp. There is no legal ground within the RoHS Directive to prohibit a luminaire or fixture if prohibited substances are not contained exceeding the threshold of RoHS. This would also be very difficult to survey. In every exemption there are many applications where no alternative technology is available, that is fully suitable for the customers' purpose and has comparable or better technical, environmental or*

safety characteristics. Customers must have the option to buy a new luminaire fitting to their existing installation e.g. additional luminaires of exactly the same type to be able to realize the desired solution…".

Though such argumentation may be relevant for phasing out of certain technologies, the consultants are of the opinion that a situation in which a new product using a certain component is still placed on the market cannot be considered a near phase-out situation. This is particularly so given that LEU argues that availability of lamps (i.e. the component) in such products could be relevant for over 25 years in some cases. It also needs to be noted in respect with the last part of the above statement that customers may not always have the chance of purchasing a *"new luminaire fitting to their existing installation"*, regardless of the fate of the discharge lamps, because luminaire models are changed and adapted with time and as a reaction to fashion. In this sense, this argumentation cannot be followed as a justification for extending the Hg exemptions, according to the applicants' requests, for what could be a cumulative period of 15 to 20 years.

4.5.6 The Minamata Convention

LEU rightly claims that lamps allowed on the market through the current exemptions comply with the restrictions of the Minamata convention. However, it is noted that:

> "*nothing in this Convention [i.e. Minamata – consultants addition] prevents a Party from taking additional domestic measures consistent with the provisions of this Convention in an effort to protect human health and the environment from exposure to mercury in accordance with that Party's other obligations under applicable international law*".[54]

The restrictions specified in the Minamata Convention are understood to aim at a global mercury reduction. This is to be accomplished by, inter alia, ensuring that countries where legislation for regulating the use and the emissions of Hg are not as developed or are lacking, are required to apply minimum requirements, which have evolved in some of the other countries.

RoHS restricts the use of mercury in general, and only in some cases are exemptions for further use provided. The fact that products made available on the EU comply with the Minamata restrictions is not understood to contribute to the discussion on the renewal of the remaining exemptions for Hg in lamps. This aspect does not relate to the Article 5(a) criteria for justifying an exemption and is thus not a relevant argument for this purpose.

[54] Op. cit. UNEP, 2016

4.5.7 Stakeholder Contributions

DEPA provides estimations as to the risks associated with lamp breakage, as well as presenting results of surveys where private consumers were asked if they had had to deal with breakage of an Hg lamp in the past and how this was done.

The consultants agree that the information presented justifies concern that emissions of Hg during the use phase of lamps are of relevance and thus cannot be considered to be sufficiently controlled at present.

LEU mentions the mechanism for the collection and recycling of discharge lamps and provides general data as to the collection rates estimated for all discharge lamps. Though the consultants do not disregard the effort made to develop this mechanism, information provided by different stakeholders show that its achievements need to be observed in perspective:

- Health FGOV raises concern as to the number of lamps not collected by the mechanism and as to their fate and that of the mercury contained in their burners. It explains that there are indications that less than 50% of CFL lamps have been collected through the mechanism in 2014 in Belgium. It also points out that the WEEE Directive does not require 100% collection, but that industry is merely required to meet certain targets. Concern is also raised as to future uses for recycled mercury from lamps, which can be expected to still enter the waste stream for many years, even after the Hg-lamp exemptions are to expire.
- DEPA raises concern as to the fate of lamps which are not recycled properly and provide information from consumer surveys as to lamp disposal. A study estimating the amount of mercury present in Danish municipal waste is also provided, raising concern as to the possible emissions related to such lamps when not disposed of properly.

As for the contributions of KEMI and EEB et al., the main aspects arising from these documents are discussed in the context of the specific exemptions to which they are related. The reference of KEMI to the possibility of prohibiting the sale of ballasts rather than prohibiting the sales of lamps is an interesting approach. However, developing such a measure under RoHs could only be relevant as long as the RoHS substance, in this case mercury, is present in the component. Ballasts for example can be regulated through the EcoDesign Directive to ensure energy efficiency and this could also be done to promote the uptake of LED alternatives where they provide higher energy efficiency. Nonetheless, under RoHS this proposal would not be feasible as ballasts for example do not contain mercury and can thus not be denied market access as a way of eliminating this RoHS restricted substance.

The consultants can follow that the risk of emissions from Hg lamps during the end-of-life phase are of concern, despite the collection rates stated by LEU. Despite the efforts made and the first achievements, which should not be disregarded, the consultants' are of the opinion that Hg emissions in the end-of-life phase cannot be considered to be sufficiently controlled in light of improper lamp disposal by consumers.

The contribution submitted by TMC raises a legal question as to the availability of the current exemption to category 9 equipment. Regardless of TMCs claims as to the availability of Annex III exemptions to sub-category 9 industrial for 7 years starting in 22.7.2017, in the case of the lamp exemptions the wording formulation limits their applicability to lamps. Though in theory, such lamps could be used in Cat. 9 products, this aspect has not been raised by the applicant or other stakeholders to be an area of application. Furthermore, should such a lamp be used as a component in EEE of Cat. 9, it would still benefit from the exemption as long as it is valid and as long as the wording remains unchanged. Should substitutes become available however, it would be of importance to evaluate their applicability in all possible applications at the same time. In this sense, in the consultants opinion, though some Cat. 9 products could enjoy a validity period of the current exemption up till 2024 (Cat- 9 industrial), it would still be considered beneficial to align the exemption validity of all categories. In contrast, should certain entries of the exemption change, or be revoked, the current formulation would need to remain available to Cat. 9 Articles, which at least from a legal perspective are entitled to benefit from the current exemption for a longer period (until 2021 or 2023, depending on sub-category). This logic is also understood to apply to CFL lamps used in devices falling under Cat. 8.

4.5.8 The Scope of the Exemption

A further aspect that should be considered is the availability of lamps falling under Exemptions 1-4 to EEE in other categories. In general, a lamp is understood to be a component, either used in light equipment that would fall under Cat. 5, or used in other equipment of other categories. As long as an exemption is available, the use of lamps covered by such exemptions as a component in equipment is understood to be possible in equipment of all categories. In this respect, the consultants would generally recommend limiting the exemption entries to category 5.

That said, in the case of Cat. 8 (medical devices) and Cat. 9 (monitoring and control devices) this aspect may need to be handled differently. Only for a few of the entries covered by Exemptions 1-4 is there information that allows concluding that EEE falling under these categories actually makes use of lamps covered by the various entries as components. For example, some of the lamps falling under Ex. 1(f) are used in medical equipment. However where such information is not available, the opposite (i.e. that the exemption is not relevant for such equipment) cannot be concluded at present. In light of Article 5(2), from a legal perspective, excluding EEE falling under Cat. 8 and 9 from the scope of these exemptions may not be possible; however the consultants' are also concerned that extended availability of such lamps for these categories may create a loophole for consumers seeking lamp replacements covered by entries that are due to expire. If possible, the Commission should investigate limiting the sales of such lamps to a business-to-business basis to avoid such misuse.

4.6 References Exemptions 1-4 – General Aspects

Danish EPA (2015a) Ministry of Environment and Food of the Danish Environmental Protection Agency, Contribution to RoHS Stakeholder Consultation Regarding 29 Exemptions, submitted 8.9.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Contribution_Exemption_1-4/Stakeholder_consultation_RoHS_-_29_exemption_in_Annex_III.pdf,

Danish EPA (2016a) Ministry of Environment and Food of the Danish Environmental Protection Agency, Answers to Clarification Questions as to Contributed Documents, Prepared Towards Meeting at Oeko-Institut e.V., Berlin, Friday 5th February 2016, submitted per email 4.2.2016

EEB et al. (2015a) The European Environmental Bureau, the Mercury Policy Project, and the Responsible Purchasing Network, Environmental NGOs Response to Stakeholder consultation 2015 #2 on mercury-containing lamps – Exemption 1-4 (Review of Annex to the RoHS directive), submitted 19.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_1_a-e_/Ex_1-4_EEP-RPN-MPP_Comments_on_RoHS_Request-final_20151016.pdf

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KEMI (2015a) Kemikalieinspektionen, Swedish Chemicals Agency, Contribution to Stakeholder Consultation 2015-2 Request for extension of exemption 1(a-e), submitted 19.10.2015, available under http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_1_a-e_/Ex_1a-e_KEMI_Answer_to_SC_RoHS_20151016.pdf

LEU Ex. 1-4 (2015a) LightingEurope, Response To Oeko-Institut regarding the 1st Questionnaire Exemption No. 1-4 (renewal requests) General Questions for Lamp Exemptions Related to Mercury, submitted 25.9.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Contribution_Exemption_1-4/LE_Ex_1-4_LightingEurope_General_Clarification-Questions_Final.pdf

LEU Ex. 1a (2015a) Lighting Europe, Request to Renew Exemption 1(a) under the RoHS Directive 2011/65/EU Mercury in Single-Capped (Compact) Fluorescent Lamps Below 30 W, submitted 15.1.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_1_a-e_/Lighting_Europe/1a_LE_RoHS_Exemption_Req_Final.pdf

LEU Ex. 2(a)(1)(2015a) Lighting Europe, Request to Renew Exemption 2(a) under the RoHS Directive 2011/65/EU 2(a) Mercury in double-capped linear fluorescent lamps for general lighting purposes not exceeding (per lamp): 2(a)(1) Tri-band phosphor with normal lifetime and a tube diameter < 9 mm (e.g. T2): 4 mg may be used per lamp after 31 December 2011, submitted 15.1.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_2_a__1-5_/Lighting_Europe/2a1_LE_RoHS_Exemption__Req_Final.pdf

NARVA (2014a) NARVA Lichtquellen GmbH + Co. KG, Exemption request for using of mercury in fluorescent lamps, submitted 19.12.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_1_a-e_/NARVA/01_02_a__2b3_4a.pdf

PZPO (2015a) Polish Association of Lighting Industry, Comments to Annexes III and IV Directive 2011/65/EU (RoHS), submitted 5.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_1_a-e_/Directive_RoHs_-_PZPO_comments_05_10_15_eng.pdf

TMC (2015) Test & Measurement Coalition, General comments related to RoHS exemption package 9, submitted 16.10.2015, available under http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_1_a-e_/General_Contribution_Test___Measurement_Coalition_package_9_exemptions_20151016.pdf

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VITO & VHK (2015) Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements ('Lot 8/9/19'), Final report, Task 4, Technologies, Prepared for the European Commission, DG ENER.C.3, pg. 26, available under http://ecodesign-lightsources.eu/sites/ecodesign-lightsources.eu/files/attachments/LightSources%20Task4%20Final%2020151031.pdf

6.0 General Recommendation Regarding Exemptions for Special Purpose Lamps

The current review has investigated four exemptions which permit the use of mercury in special purpose lamps. Through the review of the available information, an attempt was made to clarify differences in applications and in technologies falling under these exemptions, and to understand if overlapping's exist between these exemptions and other exemptions that needed to be considered in the reformulation of certain exemptions.

- **Ex. 1(f)**: "1: Mercury in single capped (compact) fluorescent lamps not exceeding (per burner):
  (f) For special purposes: 5 mg"
- **Ex. 2(b)(4)**: "*Lamps for other general lighting and special purposes (e.g. induction lamps): 15 mg may be used per lamp after 31 December 2011"*
- **Ex. 4(a)**: "*Mercury in other low pressure discharge lamps (per lamp: No limitation of use until 31 December 2011; 15 mg may be used per lamp after 31 December 2011*"
- **Ex. 4(f)**: "*Mercury in other discharge lamps for special purposes not specifically mentioned in this Annex*"

Such differences have been discussed in the various chapters reporting on the evaluation of these exemptions, and taken into consideration in the recommendations therein as far as possible. See Chapters 7.0, 10.0, 12.0 and 16.0 for the individual review reports.

Generally, the consultants view the term "special purposes" as very broad and open to false interpretations, possibly making market surveillance complex and ineffective. In the past, exemptions were provided for Hg for a large range of technologies in light of the absence of sufficient substitutes. At that time, the use of such a general term in the formulation of exemptions could be considered acceptable, as the respective discharge lamps were to come onto the market through one exemption or through another. Possible overlaps could have still been perceived as unconcise regulation; however, the outcome in terms of products that could be placed on the market would have been the same. However, at present it is observed that for many lamp applications alternatives are coming on the market or are already available, usually in the form of light emitting diode (LED) technologies. In light of these developments, recommendations have been made in the course of this evaluation to restrict the scope of some exemptions as far as reasonable. Against this background, it is apparent that avoiding the use of general formulations is pertinent, as these may leave loopholes that could be misinterpreted or misused, leading to restricted articles, containing Hg, being placed on the market.

Towards this purpose an effort has been made to clarify the term “special purposes”. Among others, in each of these exemptions, attempts have been made to understand what types of lamps (applications or technologies) are considered to fall under the specific exemption. As a second stage, other exemptions were reviewed to ensure if certain lamps might be covered by multiple exemptions. Finally, where possible recommendations were developed, proposing adjustments in exemption formulations so as to clearly demarcate technologies and/or applications included in the scope of a particular exemption. In some cases, where available information did not support this exercise, short termed exemptions have been provided to allow industry to provide further clarification before the possible revoke of the exemption for some technologies.

This process has allowed identifying two cases, where exemptions are currently considered justified (see details in respective evaluation reports in Chapters XXXX), and where the consultants believe that further separating these cases from the current exemptions could be beneficial:

- UV Lamps – The justification for the further use of Hg in discharge lamps that emit in the UV range is two-fold. Current substitutes are understood to be limited in terms of their spectral output and thus do not provide a comparable performance in this respect. Furthermore, where alternatives are available that do emit in a limited range of the UV spectrum, their wall-plug-efficiency is currently significantly lower than that of discharge lamps. The early phase-in of such lamps would result in an increase in energy consumption and in other words in a negative environmental impact. Against this background, for all UV lamps it can currently be followed that exemptions are currently justified on the basis of Article 5(1)(a). In parallel however, once substitutes are to become available, their applicability to the full range of UV lamps should be investigated. In this sense, merging all special lamps which emit in the UV range into a separate exemption would be beneficial as it would ensure that future evaluations for such technologies would be carried out at the same time and focussing on comparable technical questions. To this end, and to address the various differences addressed in the various special purpose exemptions for such lamps, the following wording has been suggested as an exemption alternative for UV lamps, and should be considered as an alternative to the separate entries recommended for such lamps in each of the respective exemptions:

  “*Mercury in discharge lamps, emitting mainly in the ultra-violet (UV) spectrum:*

  (I) in single capped (compact) fluorescent lamps, not exceeding 5 mg per burner;

  (II) in other than single capped (compact) fluorescent lamps, not exceeding 15 mg per burner;

  (III) in low pressure non-phosphor coated lamps, not exceeding 15 mg per burner;

  (IV) in medium and high pressure lamps used for curing and disinfection applications;

Valid for Cat. 5 until 21 July 2021"

Entry (II) could alternatively be formulated as "*in fluorescent lamps not covered by entry (I) not exceeding 15 mg per burner*;". However, this would create a dependency between exemption entries (I) and (II), which may lead to legal uncertainties should the entry formulations be adapted with time, without proper consideration of the dependency.

- Emergency lamps – In the application for Ex. 2(b)4, the necessity of retaining an exemption for Hg used in lamps used for emergency lighting was communicated. The given justification was that for emergency lighting, safety regulation and standards specify what lamps can be used as replacement lamps in respective luminaires. Assuming that at least in some cases, such regulation and standards do not specify Hg-free lamps that can be used to replace lamps that have malfunctioned, the consultants agree that an exemption would need to be retained. Though relevant regulation and standards may be updated with time to allow the use of Hg-free lamps (where relevant specifying if and how luminaires must be converted to ensure safety), the consultants can follow that an exemption could be restricted to cases where this is still forthcoming through the following formulation:

  "*Mercury in discharge lamps used in emergency lighting applications, where safety regulation and standards do not permit the use of mercury-free replacement lamps;*

  Valid for Cat. 5 until 21 July 2021"

Should the European Commission choose to follow this recommendation, the suggested entries proposed for UV lamps and emergency lighting lamps under Ex. 1(f), Ex.2(b)(4), Ex. 4(a) and Ex. 4(f) should be omitted.

14.0 Exemption 4(c)(I-III): "Mercury in other High Pressure Sodium (Vapour) Lamps for General Lighting Purposes not Exceeding (Per Burner):"

This review of Annex III exemption 4(c)(I-III) covers the following exemption entries:

I) $P \leq 155$ W
II) $155 \text{ W} < P \leq 405$ W
III) $P > 405$ W

Declaration

In the sections that precede the "Critical Review" the phrasings and wordings of stakeholders' explanations and arguments have been adopted from the documents provided by the stakeholders as far as required and reasonable in the context of the evaluation at hand. Formulations have been altered in cases where it was necessary to maintain the readability and comprehensibility of the text. These sections are based exclusively on information provided by applicants and stakeholders, unless otherwise stated.

Acronyms and Definitions

CRI	Colour rendering index
EEE	Electrical and electronic equipment
EoL	End of life
ErP	The European Directive ErP (Energy related Products) 2009/125/EC also known as EcoDesign
Hg	Mercury
HID	High intensity discharge lamps
HPMV	High Pressure Mercury Vapour
HPS	High pressure sodium (vapour)
LED	Light emitting diode
LEU	LightingEurope
PCA	Poly-crystalline alumina
WEEE	Waste electrical and electronic equipment

14.1 Background

LightingEurope (LEU)[341] has applied for the renewal of Ex 4(c)(I-III) of Annex III of the RoHS Directive. This exemption covers mercury in other high pressure sodium (vapour) lamps (HPS) used for general lighting purposes, i.e. it does not cover HPS with improved colour rendering, which would fall under Ex. 4(b)(I-III).[342]

LEU explains that reduction or omission of mercury in these lamps inevitably leads to loss of efficacy. On the component level (replacement lamps) the applicant further explains that replacing HPS lamps by LED retrofit lamps with conservation of the specification is not possible and is not expected anytime soon due to thermal limitations and compatibility issues. Though on the system level (installations), substitution of HPS installations with LED installations is explained to be underway, this is expected to require another 15-25 years or to result in WEEE prematurely (early end-of-life) if phase-in is forced.[343]

The applicant thus requests the renewal of the exemption with the current wording formulation as listed in Annex III of the RoHS Directive and the maximum available duration allowed (based on Art. 5(2) of the Directive):

	Exemption	Scope and dates of applicability
4(c)	Mercury in other High Pressure Sodium (vapour) lamps for general lighting purposes not exceeding (per burner):	
(I)	P ≤ 155 W	No limitation of use until 31 December 2011; 25 mg may be used per burner after 31 December 2011
(II)	155 W < P ≤ 405 W	No limitation of use until 31 December 2011; 30 mg may be used per burner after 31 December 2011
(III)	P > 405 W	No limitation of use until 31 December 2011; 40 mg may be used per burner after 31 December 2011

14.2 Description of Requested Exemption

High pressure sodium lamps are explained to fall under the High Intensity Discharge Lamps (HID) group. The HPS family includes lamps designed for different purposes in the professional market. HPS lamps are handled by technically skilled installers and sold by specialized distributors or as part of lighting equipment. The customers are for example governments, installers, specialized wholesalers, designers of lighting equipment etc. [344]

[341] LEU Ex. 4(c)(I-III)(2015a), LightingEurope, Request to renew Exemption 4(c) under the RoHS Directive 2011/65/EU: Mercury in High Pressure Sodium lamps, submitted 15.1.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_4_c__I-III_/4c_LE_RoHS_Exemption_Req_Final.pdf

[342] Op. cit. LEU Ex. 4(c)(I-III)(2015a)

[343] Op. cit. LEU Ex. 4(c)(I-III)(2015a)

[344] Op. cit. LEU Ex. 4(c)(I-III)(2015a)

HPS lamps covered by Ex. 4(c)(I-III) are similar in structure and function to those covered by Ex. 4(b)(I-III). A short summary with some specific details is provided here, while additional details can be viewed in Section 13.2 of the Ex. 4(b)(I-III) chapter. HPS lamps consist of a cylindrical discharge tube made of poly-crystalline alumina (PCA), in which two electrode assemblies are mounted at each side (Figure 14-1). The electrodes are made of tungsten (W) and consist of a rod with coiled windings containing a mix of oxides, called the emitter. These oxides reduce the work function of the tungsten and hence reduce also the temperature of the electrodes during operation, thereby greatly improving the life time of the lamps. The tungsten electrodes are welded to niobium (Nb) tubes that serve as the electrical feed-through (Figure 2). The discharge tubes are sealed with a sealing frit which has the same expansion coefficient as PCA and niobium, to prevent thermal stresses during the heating and cooling cycles (start-up / shut-down). Inside the discharge tube xenon is present as a buffer gas, at a pressure of some 20-500 mbar, under room temperature conditions.[345]

Figure 14-1: Construction of a high pressure HPS lamp

Source: LEU Ex. 4(c)(I-III)(2015a)

HPS lamps are characterized by very long life (30,000 to 50,000 hours) and very high luminous efficiency (from 80 lm/W to 150 lm/W). They also typically have a lumen maintenance of more than 80% at end of life (EoL). Their ability to render colours is low (CRI around 20). The majority of HPS lamps are single-capped with Edison screw caps (E27 and E40 for Europe) but there exists also a double-capped range with R7s and Rx7s caps. Figure 14-2 shows different formats. Most manufacturers have both lamps in tubular clear glass format and in ovoid shape with a light diffusing coating. The wattage range is 35W to 1000W. [346]

[345] Op. cit. LEU Ex. 4(c)(I-III)(2015a)
[346] Op. cit. LEU Ex. 4(c)(I-III)(2015a)

Figure 14-2: Different formats of HPS lamps: tubular clear, ovoid coated and clear double-ended

Source: LEU Ex. 4(c)(I-III)(2015a)

HPS lamps can only operate on designated drivers that switch the lamp on and regulate the power. These drivers can be an electro-magnetic ballast (inductive/capacitive load) to stabilize the lamp current in combination with a high voltage pulse generator (ignitor) to ignite the lamp. Nowadays, also electronic drivers are used to stabilize the lamp at the correct power.[347]

LEU states that the product characteristics make HPS lamps a suitable choice for applications that require long life, high efficacy and very good lumen maintenance, but where colour rendering is less important. Typical applications are outdoor lighting: street lighting, parking's, city squares, flood lighting of buildings. Sometimes these lamps are also used indoors, like in warehouses where colour rendering is not important.[348]

14.2.1 Amount of Mercury Used under the Exemption

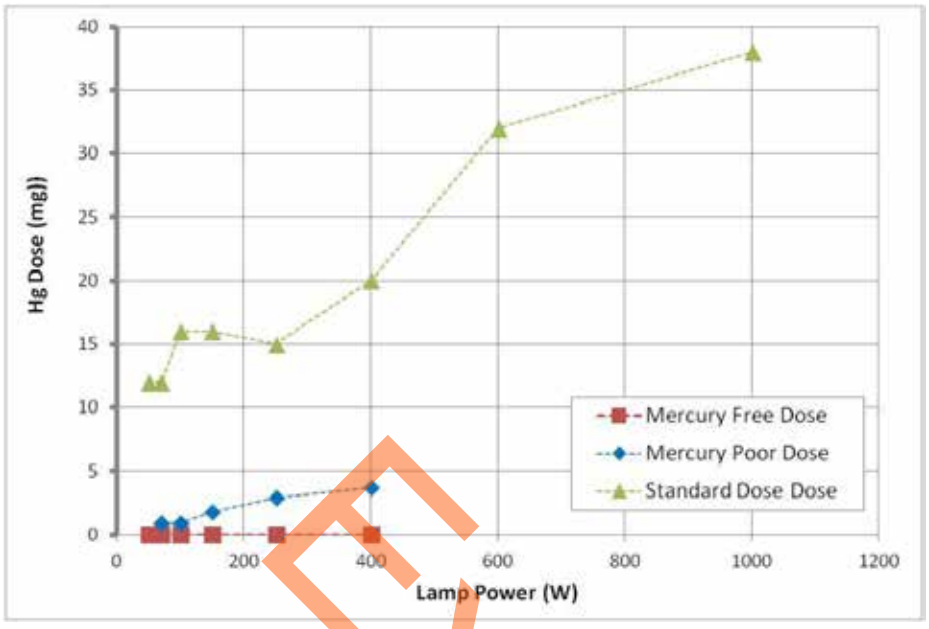
"*Mercury is dosed in the discharge tube during lamp manufacturing as sodium/mercury amalgam with an Hg/Na fraction of 75-97%. The amount of mercury dosed per lamp depends on aspects like lamp power and optical performance. For high pressure sodium lamps in the scope of the Exemptions 4(c) the dosed mercury amounts vary between 1 and 40 mg. There are three types of HPS lamps on the market*".[349]

- Standard dosed: HPS lamps with saturated amalgam dose (i.e. only part of the mercury and sodium is vaporized in the operational lamp) and optimized to yield the highest possible efficacies.
- Mercury poor: Lamps with an unsaturated amalgam dose (i.e. all the mercury and (almost) all the sodium is evaporated in the operational lamp). These lamps are mostly marketed in the USA.
- Mercury Free: Lamps without dosed mercury.

[347] Op. cit. LEU Ex. 4(c)(I-III)(2015a)
[348] Op. cit. LEU Ex. 4(c)(I-III)(2015a)
[349] Op. cit. LEU Ex. 4(c)(I-III)(2015a)

For the first two types listed above, the amalgam dose increases with lamp power (=lamp size). Figure 14-3 shows the dose versus the lamp power.

Figure 14-3: Amalgam doses of different types of HPS lamps on the market



Source: LEU Ex. 4(c)(I-III)(2015a)

The total amount of mercury brought on the European market in HPS lamps is calculated in the following way: an estimated 23 million HPS lamps will be brought onto the European market in 2016. The highest volumes are sold in 70W and 150W Standard dose lamps. The volumes of Mercury Free are low and the Mercury Poor lamps are not on the market in Europe (because of non-compliance with ErP[350] regulation). LEU estimates an average of 15 mg per lamp. Hence, LEU estimates that the total amount of mercury brought on the European market by new lamps of Ex. 4(c) is 345 kg per year. It is estimated that about 46% of the mercury brought onto the European market is recycled. Hence, the net amount brought onto the European market is 186 kg.[351]

LEU[352] mentions the VHK and VITO[353] study, which uses data, available from a report by McKinesy[354], EuroStat Data and LEU statistics (confidential), to develop a self-consistent overview of the EU28 market size and evolution for all lamp technologies. In the

[350] ErP - European Directive ErP (Energy related Products) 2009/125/EC, also known as EcoDesign
[351] Op. cit. LEU Ex. 4(c)(I-III)(2015a)
[352] Op. cit. LEU Ex. 4(c)(I-III)(2015a)
[353] Quoted in LEU Ex. 4(c)(I-III)(2015a) as: Preparatory Study on Light Sources for Ecodesign and/or Energy Labeling Requirements ('Lot 8/9/19'), Prepared by VHK, in cooperation with VITO and JeffCott Associates, 19 November 2014. Available from http://ecodesign-lightsources.eu/documents
[354] Quoted in LEU Ex. 4(c)(I-III)(2015a) as: Lighting the way: Perspectives on the global lighting market, McKinsey 2012 second edition

derivation of this data several assumptions had to be made by the study team and the number of lamps sold are finally tabulated (Table 57 in the report) for two different assumptions for the Average Selling Price (ASP) in the EU28 (low and high ASP). In LEU's application document, these two results are interpreted as confidence intervals and the average of the two is used. Further explanations and results are given in Table 14-1. From the results derived by this procedure it is clear that despite the fact that some new HPS applications are still installed, the installed base is decreasing rapidly in EU28: from 72 million in 2016 to 37 million in 2020. Also the number of HPS replacement lamps will drop drastically between 2016 and 2020: from 23 million to 12 million. The largest part of these lamps is nowadays replacement of lamps for existing luminaires.

Table 14-1: World and European market trend (in million pieces) for HID and HPS lamps according to VHK & VITO report

Source	Category	2011	2012	2016	2020
VHK & VITO	HID TOTAL	54	63	60	30
	LED TOTAL	30	72	407	634
	New	1075	1158	999	878
	Replacement	2817	2572	1399	728
	LAMPS TOTAL	3892	3730	2397	1606
LE Statistics	HPS/HID Ratio	35%	35%	39%	39%
This work	HID NEW	15	19	18	7
	HID Replacement	39	44	42	22
	HPS NEW	5	6	7	3
	HPS REPLACEMENT	14	15	16	9
	HPS TOTAL	**19**	**22**	**23**	**12**
	HPS INSTALLED BASE	**60**	**68**	**72**	**37**

The upper part of the table gives the sales numbers as derived by VHK & VITO for LED and HID as well as the division of all sold lamps over new installations (lamp in a newly installed fixture) and lamp replacements (a new lamp replacing an old one in an existing fixture). Confidential statistical data on lamp sales of LEU members shows that the percentage of HPS lamps in HID sales has been around 35% in the last 4 years and seems to be stable. We assume that this fraction can be extrapolated from LEU members to the whole EU28 sales. Knowing that High Pressure Mercury Vapour lamps will be banned in 2015 and assuming that these lamps will be replaced by a different technology than HID (mainly LED) we obtain that the ratio of HPS to HID sales in the EU28 will be 39% after 2015. The 2nd part in the table gives the projected HPS to HID ratio derived in this way. The division of HID over new and replacement is calculated from the division for all lamps given by VHK & VITO in the following way: assuming that all LED sold until 2020 are new installations and that the new to replacement ratio is the same for all conventional technologies, the total number of HID lamps can be split in new and replacement (third part in table). Using the HPS to HID ratio's obtained the number of new and replacement HPS lamps are then calculated. Finally, assuming a 4-year replacement cycle for HPS lamps, LEU derives the installed base of HPS light points in the EU28.

Source: LEU Ex. 4(c)(I-III)(2015a)

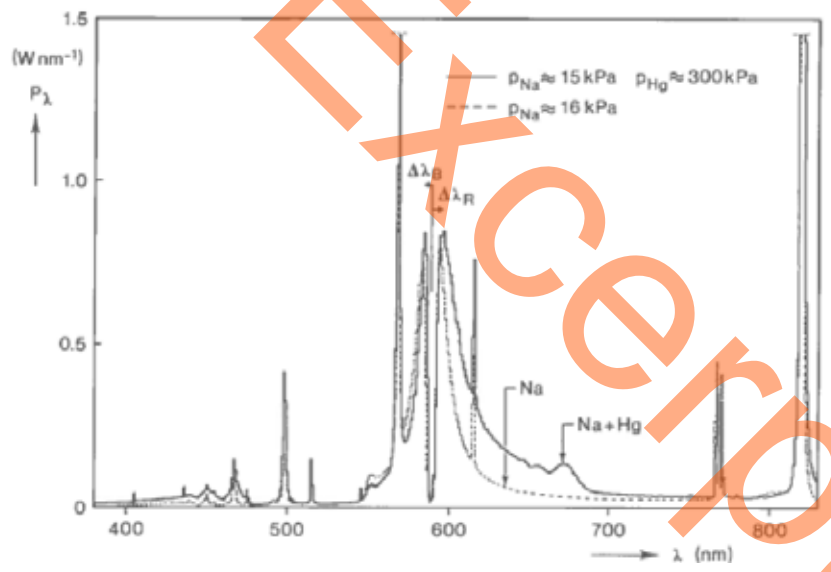
14.3 Applicant's Justification for Exemption

LEU[355] argues that the exemption is still needed as eliminating mercury is not possible and reducing mercury dose per lamp would not allow producing lamps of comparable performance. LEU states that alternatives are becoming more common, but are explained not to be suitable as lamp (component level) replacements in existing installations.

14.3.1 Possible Alternatives for Substituting RoHS Substances

If a sodium discharge lacks mercury, the energy radiated is considerably lower. The lamp with mercury radiates more between 600 and 700 nm and the lamp also produces more light in the blue range (Figure 14-4). The decrease in visible radiation in a lamp without mercury is due to the higher thermal losses of the Na-plasma as compared to an Na-Hg plasma. The loss of luminous efficacy is about 14 lm/W.[356]

Figure 14-4: Spectra of a Hg-containing and a Hg-free HPS lamp



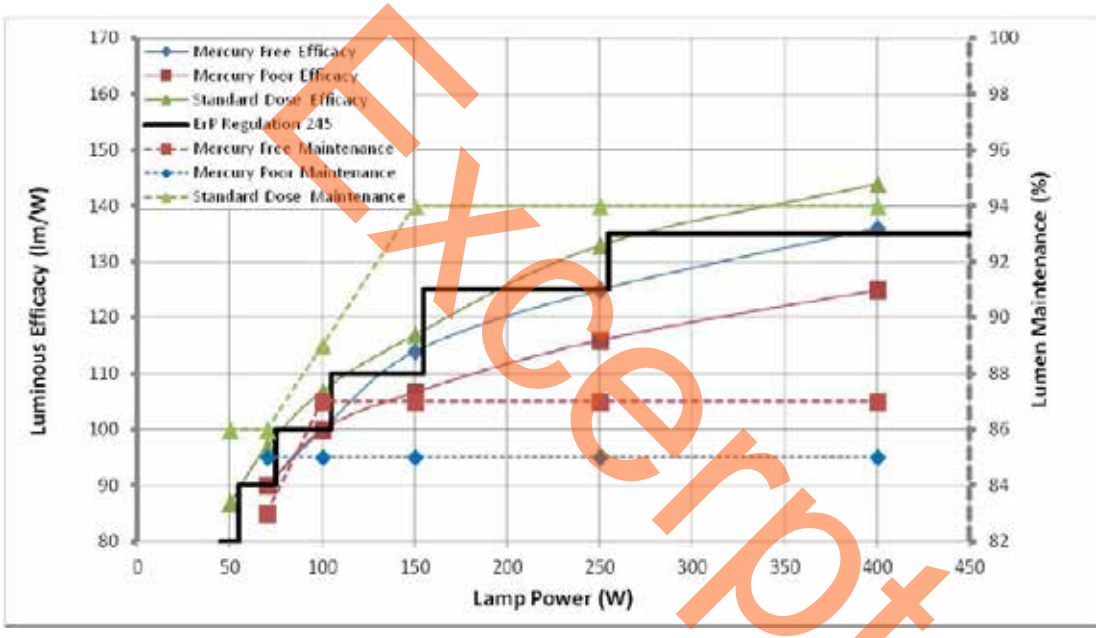
Source: Referred to in LEU Ex. 4(c)(I-III)(2015a) as Department for Environment Food and Rural Affairs (DEFRA), Life Cycle Assessment of Ultra-Efficient Lamps. Navigant Consulting Europe Ltd. 2009

By replacing the mercury pressure with an equivalent xenon pressure, the thermal losses can be kept constant. However, because the electrical conductivity of xenon is higher than that of mercury, a longer and narrower arc tube is required to bring the lamp voltage back to the specified value. The use of this type of tube decreases the luminous efficacy as compared to the standard lamps. Mercury is condensed in the amalgam when

[355] Op. cit. LEU Ex. 4(c)(I-III)(2015a)
[356] Op. cit. LEU Ex. 4(c)(I-III)(2015a)

the lamp is cold. Ignition of this lamp requires a relatively low peak voltage pulse (2 kV). As xenon is not condensed when the lamp is switched on, starting a lamp with a high xenon pressure is more difficult. A higher voltage pulse is needed to cause breakdown in the high pressure xenon and this voltage pulse alone is not enough: a special antenna needs to be provided to enhance the electric field during ignition. Even with the antenna, the pressure of xenon, which can be used, is limited by the requirement that ignition on all installed conventional ballasts is guaranteed.[357] To reach equivalent lumen output a higher sodium pressure would be required but the high temperature needed to evaporate the sodium limits the lifetime of the lamp. In practice the mercury free lamps are approximately 5% less efficient, have a reduced lumen maintenance (-5%) and a shorter lifetime (4 years of operation instead of 6 years), see also Figure 14-5.

Figure 14-5: Luminous efficacy and lumen maintenance of three types of HPS lamps



Source: LEU Ex. 4(c)(I-III)(2015a)

The luminous efficacy and lumen maintenance of mercury free and mercury poor HPS lamps are currently still lacking versus the standard dosed types. Mercury poor lamps are also not compliant with ErP Regulation 245/2009. While progress in efficiency, reliability and lumen maintenance has been made, the mercury containing counterparts have seen the same trend. It is not expected that Hg-free or mercury poor HPS will catch up on the performance of the highest performing Hg-containing HPS products, especially since R&D resources are increasingly dedicated to LED developments.

[357] The consultants understand this to refer to the need for such lamps to be electrically compatible with existing installation to allow their use as replacement lamps.

The Preparatory Study for Eco-Design Requirements of ErP's for Public Street Lighting[358] shows that there is an almost linear relationship between environmental impact and energy efficiency (p. 212) of different lighting scenarios. The authors conclude that due to the lower efficiency of mercury free HPS lamps the studied scenario of replacing all installed HPS lamps with mercury free HPS has a negative overall environmental impact (p. 227) and is therefore not recommended.

14.3.2 Possible Alternatives for Eliminating RoHS Substances

LEU distinguishes in their application between the availability of LED alternatives on the component level (lamp replacement) and on the system level (luminaire/installation replacement.

14.3.2.1 LED Replacement Lamps

LEU explains that numerous LED replacement lamps for HPS are proposed by a large variety of suppliers. However, substitute comparability hinders acceptable retrofitting:

- The lumen output of the substitute is much lower than the HPS lamp it should replace (in the order of 25% of the HPS luminous flux);
- The replacement lamp is much larger than the HPS lamp and will not fit in the vast majority of the luminaires;
- The optical characteristics of the substitute lamp are completely different leading to distorted beam patterns of the luminaires.

A typical example of advertised "retrofit" solutions is given in Figure 14-6.

[358] Quoted in LEU Ex. 4(b)(I-III)(2015a) as Preparatory Study for Eco-Design Requirements of EuP, Lot 9, Public Street Lighting, P. Van Tichelen, T. Geerken, B. Jansen , M. Vanden Bosch (Laborelec), V. Van Hoof, L. Vanhooydonck (Kreios), A. Vercalsteren

Figure 14-6: Typical advertised LED retrofit lamp for HPS lamp replacement

Source: LEU Ex. 4(c)(I-III)(2015a)

In street lighting applications the light levels are strictly regulated and replacement with lamps with much lower luminous flux can cause dangerous situations in traffic. So at least for these regulated applications the use of these LED "retrofits" is not possible.

HID lamps are compact and are in general high power lamps. In the application it is required that HID lamps operate in closed luminaires. Since over 90% of the power supplied to the HID lamp leaves the burner as radiation (visible light, infrared radiation and some UV) the temperature of the luminaire and the lamp is stabilized without the need for heat sinking. The glass surface of the outer bulb of the lamp is heated by conduction of the heat generated in the burner (10% of total supplied power) and by absorption of about half of the infrared radiation from the burner. In total the glass envelope is heated by approximately 40% of the lamp power.

For a currently available 120 lm/W LED lamp the power that is transformed into light is about 40% and there is no IR or UV. So 60% of the power is transformed into heat that has to be removed by convection/radiation to the surrounding air in the closed luminaire. LEU gives an example of a future LED lamp with an efficiency of 150lm/W. To generate the same amount of light this lamp requires only 80% of the power of the 120 lm/W HPS (120/150*100%). For this LED the radiation is now 50% of the input power and the heat generation is the other 50%. So, the heat that needs to be removed by convection/radiation is now 40% of the input wattage to the 120 lm/W HPS.

Since a typical HPS lamp of intermediate power also has an efficacy of 120 lm/W, the power to be removed is now almost equal to the heat loss from the current HPS glass bulb. So for this hypothetical, very efficient LED lamp that might exist in the future, the envelope temperature will be approximately the same as for the current HID lamp. The question is thus whether this efficient LED lamp can operate in the hot lamp envelope? LED lamps can have a long lifetime, above 25000 hrs, as long as the junction temperature of the LED is not above 100°C. As argued above the heat loss to the envelope of 150lm/W LED and for a HPS lamp are the same. So measurement of the envelope temperature of the HPS lamps in a luminaire will predict the temperature of the envelope of the future LED lamp with the same size. Since the transport of heat in a lamp via the lamp base is limited, the only path for the heat to disappear is via conduction to the air surrounding the lamp. In a closed luminaire, warm air limits the transport, but even if the lamp would operate in open air, the compact size needed to fit as a retrofit lamp in the closed luminaire limits the cooling opportunities. On the basis of data concerning the measured surface temperature of HPS lamps of different power, LEU assumes that LED retrofit lamps (reaching at least the same temperature) will have a surface temperature from 160-400°C. This is much higher than the optimal LED junction temperature of 100°C, meaning that LED replacement lamps with the same size as the current HPS lamps cannot exist in the coming decades or that the emitted light flux is lower and/or the lifetime is limited.

It is also explained that should LED lamp replacement alternatives become available, that their use in existing installations would require rewiring of the luminaire.

LEU summarises that LEDs have insufficient performance. Whether it is mostly because of light output or dimensional depends on the approach: more light can be provided by making the lamps bigger, but the HPS specification is never reached and it makes the lamp even more out of dimensional specification. In practise, these lamps are only used in cases where the luminaires are oversized, where there are no requirements on light level and distribution and where it is acceptable to reduce the light level drastically. These conditions represent a very small fraction of the installations as the majority of HPS lamps are used in public lighting conditions where there are strict legal requirements for the lighting provided.[359]

14.3.2.2 LED Replacement Installations

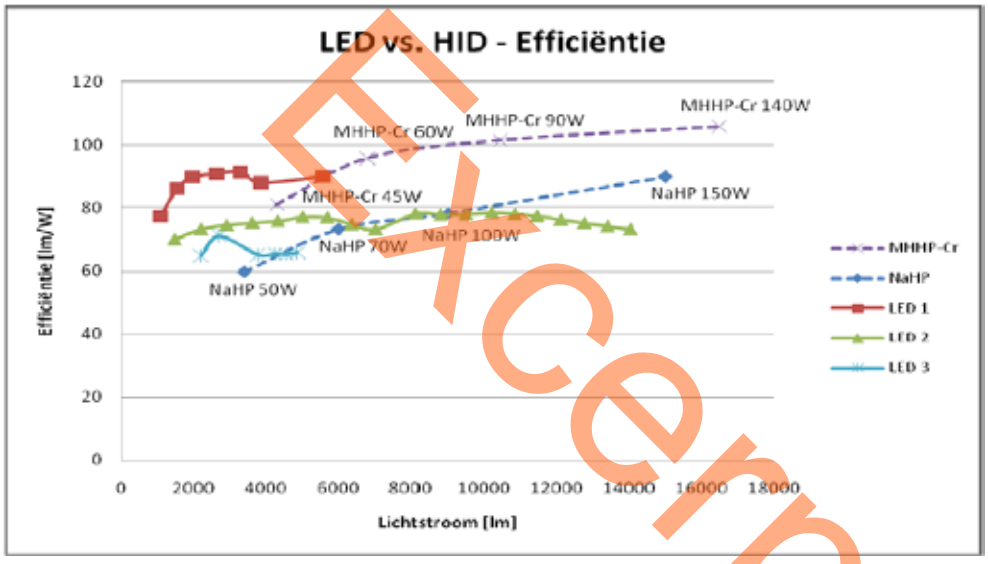
According to LEU[360], LED solutions are entering the market rapidly. McKinsey[361] shows that on the world level LED is competing mainly in the initial market of new luminaires. It is reasonable to state this is also true in Europe.

[359] LEU Ex. 4(c)(I-III)(2015b), Response To Oeko-Institut regarding the 1st Questionnaire Exemption No. 4c(I-III) (renewal request), submitted 15.9.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_4_c__I-III_/Ex_4c_LightingEurope_1st_Clarification-Questions_final.pdf

[360] Op. cit. LEU Ex. 4(c)(I-III)(2015a)

In principle, it is technically possible to replace the complete HPS installation by an LED solution. While this replacement has many advantages there are also significant drawbacks and challenges. A study[362] from the Renselaer Polytechnic Institute in Troy, NY, comparing street layouts with several HPS and LED light points found that, in order to guarantee uniformity and sufficient illuminance levels in accordance with the relevant regulations, the poles on which the fixtures are mounted have to be replaced and the spacing changed (more poles required). The reason for this is basically that LED luminaires are efficient or available below 6000 lumens only. LED streetlight layouts on average resulted in a slightly lower power demand than the average HPS streetlight layouts. The LED layout with the lowest power demand had 81% of the power demand of the HPS layout with the lowest power demand. However, the power demand per kilometre of street for individual layouts varied significantly.[363]

Figure 14-7: Luminaire efficiency of HPS (NaHP), ceramic metal halide (MHHP-Cr) and LED



Note: Efficientie = efficacy, Lichtstroom = Lumen output
Source: Quoted in LEU Ex. 4(c)(I-III)(2015a) as EANDIS presentation at Energiedag VVSG Openbare Verlichting - J. Delandtsheer and K. Putteman, Energiedag VVSG Openbare Verlichting, 19 march 2013. Available from http://www.vvsg.be/Omgeving/Documents/AV%20d4906_VVSG_Energiedag2013_S26_OpenbareVerlichting_JeroenDelandtsheer.pdf

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[361] Quoted by LEU Ex. 4(c)(I-III)(2015b) as: Lighting the way: Perspectives on the global lighting market, McKinsey 2012 second edition
[362] Quoted in LEU Ex. 4(c)(I-III)(2015a) as: [1] National Lighting Product Information Programme. 2010. Streetlights for Collector Roads. Rensselaer Polytechnic Institute. Available from http://www.lrc.rpi.edu/programs/NLPIP/PDF/VIEW/SRStreetlights.pdf (August 2011); and
[2] National Lighting Product Information Programme. 2011. Streetlights for Local Roads. Rensselaer Polytechnic Institute. Available from http://www.lrc.rpi.edu/programs/NLPIP/PDF/VIEW/SR_StreetlightsLocal.pdf (August 2011)
[363] Op. cit. LEU Ex. 4(c)(I-III)(2015a)

In a later communication, LEU confirms however that the feasibility for replacement of the luminaire with LED luminaires has improved over the last years. However, the light plan with the new luminaires on existing poles still has to be adapted to provide the required legal light fluxes. The characteristics of replacing an HPS (and more generally an HID) luminaire with an LED luminaire in 2015 are described in the draft interim Preparatory Study on Light Sources for Ecodesign and/or Energy Labeling Requirements[364] prepared by VITO and VHK, see par. 5.17.4. The report states that the LED luminaires nowadays need about 20% less lumen to provide the same lighting. However the cost of LED luminaires is still significantly higher than that of an HID luminaire, especially for the higher lumen packages. In paragraph 5.18.2 the report predicts that, nevertheless, the replacement of HID luminaires with LED luminaires will be common practise in the following years: "Considering current trends in street lighting and considering the advantages of LED luminaires over LED retrofit lamps, this is expected to be a frequently used option, in particular for low wattage HPS-lamps at the end of the luminaire life time (30 years)."[365]

It is not always commercially feasible for the owners of these professional lighting systems to invest in new LED luminaire solutions when lamps need to be replaced. Such a change requires not only changing the light source but the whole lighting system including luminaire, its optics and magnetic or electronic driver system.[366]

14.3.3 Environmental Arguments

LEU discusses results of three public LCA's published for general HID lamps[367] and makes a comparison between results of these studies related to ceramic metal halide lamps in comparison with LEDs. However, LEU explains that the comparison made is not a suitable comparison for HPS, as according to LEU there would be no retrofit replacements for HPS lamps. A true comparison would need to assume that the luminaire is replaced and not just the lamp.

[364] Referenced in LEU Ex. 4(c)(I-III)(2015a) as Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements ('Lot 8/9/19) Draft Interim Report, Task 4(Technologies), May.2015, VITO, VHK http://ecodesign-lightsources.eu/sites/ecodesign-lightsources.eu/files/attachments/LightSources_Task4_may2015_Draft.pdf

[365] Op. cit. LEU Ex. 4(c)(I-III)(2015b)

[366] Op. cit. LEU Ex. 4(c)(I-III)(2015a)

[367] Referenced in LEU Ex. 4(b)(2015a) as:

- Department for Environment Food and Rural Affairs (DEFRA). Life Cycle Assessment of Ultra-Efficient Lamps. Navigant Consulting Europe Ltd. 2009
- AT. Dale.MM. Bilec,J. Marriott, D. Hartley,C.Jurgens,E. Zatcoff Preliminary comparative life-cycle impacts of streetlight technology. Journal of Infrastructure Systems193— 199,(2011).
- Preparatory Study for Eco-Design Requirements of EuP, Lot 9, Public Street Lighting, P. Van Tichelen, T. Geerken, B. Jansen , M. Vanden Bosch (Laborelec), V. Van Hoof, L. Vanhooydonck (Kreios), A. Vercalsteren

As the referenced studies are from 2009-2011, and it is possible that available LED alternatives have developed (i.e. results are now outdated), the discussed results are not reproduced here and can be viewed in the applicants document.

In the case of a ban on mercury containing replacement lamps a huge investment into LED replacement luminaires will have to be made in the short time span of the replacement cycle of an HPS lamp (4 years). The environmental impact of early end-of-life for millions of still operational HID installations, to LEU's knowledge, has not been quantitatively assessed. However, it is reasonable to assume that the total negative environmental impact caused by this forced substitution is likely to outweigh the total environmental benefits. In view of the natural life of HPS installations, natural replacement of end-of-life installations by LED solutions will take 15 to 25 years.

14.3.4 Road Map to Substitution

LEU explains that, in reference to lamps for new installations, mainly LED luminaires solutions are used. Most of the currently produced HPS lamps are used in existing installations. For this market the LED solutions are not suitable and LEU estimates that the installed base of HPS lamps will be replaced by LED in a time frame of 12 years, i.e. by 2027. In view of the uncertainty involved in this extrapolation a period of 10-15 years seems the best estimate.[368]

14.4 Stakeholder Contributions

A number of contributions have been made by stakeholders raising general points in relation to discharge lamps. Such contributions are summarised in Section 4.4 of the general lamp chapter.

The European Environmental Bureau (EEB), the Mercury Policy Project and the Responsible Purchasing Network[369], submitted comments specifically in relation to Ex. 4(b) and 4(c), explaining that LEDs are increasingly being made to replace HPS lamps and are expected to increase for this application. EEB et al. recommend the Commission to monitor improvements in the availability, performance and price of LED replacements, to consider an expiry date as practical. It is explained that HPS lamps are rapidly being replaced by other technologies because:

- of their poor colour quality – they appear yellow because their CRI is typically in the 20s;
- they cycle on and off, which causes maintenance problems; and

[368] Op. cit. LEU Ex. 4(c)(I-III)(2015b)

[369] EEB et al. (2015a),The European Environmental Bureau, the Mercury Policy Project, and the Responsible Purchasing Network, Environmental NGOs Response to Stakeholder consultation 2015 #2 on mercury- containing lamps – Exemption 1-4 (Review of Annex to the RoHS directive), submitted 19.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_1_a-e_/Ex_1-4_EEP-RPN-MPP_Comments_on_RoHS_Request-final_20151016.pdf

- because of their relatively short life.

EEB et al. explain that some HPS lamps have already been phased out from the market due to energy efficiency under the ErP Directive. For those that remain, HPS lamps with a lower mercury content and more-efficient ceramic metal halide lamps, which also have a lower mercury content than equivalent HPS lamps, are widely available as practical drop-in replacements. A few examples are detailed:

- GE Lighting has a line of low-CRI (<25) Lucalux Standard High Pressure Sodium Lamps (in both tubular and elliptical shapes) in a wide array of common wattages including 70W, 100W, 150W, 250W, 400W and 1000W that can meet the following lower mercury levels through the use of amalgam technology:
  - P < 155 W = 20 mg per burner;
  - >155 W < P < 405 W = 20 mg per burner;
  - P > 405 W = 25 mg per burner.

  The datasheet for this product, which uses ceramic technology, explains that these products are easy drop-in replacements for standard HPS lamps. It states: *"Lucalox™ XO Superlife lamps comprise a sodium discharge system operating at a high pressure within a ceramic arc tube which is mounted in an outer glass bulb. These lamps offer outstanding luminous efficacy, lumen maintenance thus reducing energy and maintenance costs….Easy replacement of standard HPS lamps, fits standard HPS sockets – no new wiring, ballast or fixture are required"*[370]. From the referenced datasheet the consultants observe that lamp dimensions are 156/211/260/283 mm (lengths) by 39/48 mm (diameter) for tubular modules and 156/186 mm (length) by 72/76 for elliptical shapes, depending on wattage.
  Philips MASTER SON-T APIA Plus Xtra High Pressure Sodium Lamps, which contain a ceramic discharge tube, are this manufacturer's most energy-efficient and long-lasting HPS lamps (with rated lifetimes that range from 38.000 to 45.000 hours). It is promoted as *"the longest life, most reliable"* and *"most cost-effective solution in road lighting. All of the HPS lamps in this family of products, which include common HPS wattages of 50W, 70W, 100W, 150W, 250W and 400W) can meet our proposed limits."*[371] From the referenced data sheet the consultants observe that lamp dimensions are 156/210/257/283 mm (lengths) by 36/48 mm (diameter) for tubular modules, depending on wattage.

[370] EEB et al. (2015a) refers to the following data sheet: http://www.gelighting.com/LightingWeb/emea/images/HPS_Lucalox_XO_Superlife_Lamps_Data_sheet_EN_tcm181-12784.pdf

[371] EEB et al. (2015a) refers to the following data sheet: Philips Company, Data Sheet for MASTER SON-T APIA Plus Xtra High Pressure Sodium Lamps, 3 July 2015, http://download.p4c.philips.com/l4bt/3/344247/master_son-t_apia_plus_xtra_344247_ffs_eng.pdf

EEB et al. thus recommend reducing the Hg allowance of lamps with P ≤ 405 W (Ex. 4(c)(I and II)) to 20 mg and lamps with P > 405 W of Ex. 4(c)(III) to 25 mg. They propose these reductions to take affect by 1 September 2018 at the latest

EEB et al. also claim that many companies offer a variety of drop-in LED replacement lamp for HPS lamps, and it is further explained that the benefits of LEDs over HPS lamps are many. For details please see Section 13.4 of chapter 13.0 (Ex. 4(b)).

14.5 Critical Review

14.5.1 Scientific and Technical Practicability of Substitution

From the information that LEU provides it can be followed that eliminating mercury in HPS lamps is not practical. Though HPS lamps without mercury are said to exist, it can be understood that they require a different ignition, and it is thus assumed that such lamps would not be practical as replacements in existing installations. Information also shows that HPS lamps with lower mercury levels exist. Some of these, termed poor-mercury-HPS, are said to have a lower efficacy and not to comply with the ErP regulation. In this respect it is understood that they are not available on the EU market and would thus not be practical as substitutes. However the data comparing such lamps to standard dosed HPS (see Table 14-2) suggests that the efficacy differences are between 5-17 lm/W. Information was not provided as to the difference in Hg dosing, however in the consultants opinion against such efficacy differences (ca. 5-12 % less efficient), it may make sense to integrate the Hg trade-off into considerations whether HPS-Hg-poor lamps should be prohibited on the EU market or not. Arguing as to which lamps should be prohibited under ErP and which should not is however beyond the consultants' mandate. In this context HPS-Hg-poor lamps can at present not be considered as a substitute.

Table 14-2: Comparative data for Hg-free, Hg-poor and standard dosed HPS lamps, related to efficacy and lumen maintenance

Wattage	*Mercury Free Technology*		*Mercury Poor Technology*		*Standard Dose Technology*		ERP Efficacy
	Mercury Free Efficacy	Mercury Free Maintenance	Mercury Poor Efficacy	Mercury Poor Maintenance	Standard Dose Efficacy	Standard Dose Maintenance	
50					83	85	80
70	90	83	90	85	95	89	90
100	100	87	100	85	107	90	100
150	114	87	106.7	85	117	91	110
250	125	87	116	85	130	92	125
400	136	87	125	85	142	92	135
600					150	88	135
1000					130	80	-

Values averaged over published values of main European suppliers

Source: Quoted in LEU Ex. 4(c)(I-III)(2015b)

In contrast, information from EEB et al. shows that there are HPS lamps on the market with significantly lower amounts of Hg, which could support a reduction of Hg allowances specified in Ex. 4(c).

Where LED alternatives are concerned, it can be understood that a distinction must be made between replacement of lamps on the component level (retrofit lamps) and on the system level (installation replacement). LEU explains that on the system level, LED alternatives are numerous; however it is argued that such replacements do not necessarily provide benefits in terms of energy efficiency, particularly for higher lumen output lamps. This argumentation is however substantiated with reports that may be outdated and LEU later confirms that the feasibility for replacement of the luminaire with LED luminaires has improved over the last years. Though current alternatives may show some drawbacks (e.g., lumen output, higher investment costs), LEU admits that the shift towards LED installations has already begun and that HPS lamps are mainly needed to allow lamp replacement in existing HPS installations. The consultants thus conclude that regardless of possible drawbacks, LED alternatives are already perceived on the market as an acceptable alternative.

Where LED alternatives are discussed as replacement lamps in existing HPS installations, it can be understood that alternatives have various limitations. The understanding that most alternatives have dimensions that would prevent their use as alternatives in existing installations clarifies that such lamps would not be practical as retrofit substitutes. Furthermore, as it is explained by LEU that most installations are closed, it can also be followed that the thermal incompatibility of LED alternatives would affect their service life, which would also make substitution with such lamps impractical.

14.5.2 Environmental Arguments

Though LEU mentions LCAs that could be used to provide an indicative comparison of HPS and LED alternatives, this information is explained not to compare the LED in a way that would represent an actual substitution situation. The reports are furthermore outdated and thus this information has not been evaluated.

LEU raises concern that an early phase-out of HPS lamps could result in early-end-of-life of HPS installations which would need to be scrapped, at the latest 4 years after the last HPS replacement was available. Assuming that replacement lamps shall not be available that would be compatible with existing installations, this can be followed in relation to an installed base of 72 million in 2016. In this respect it can be followed that LED alternatives are not a compatible replacement in most cases, supporting this argument. However, it cannot be concluded that other lamps, either Hg-free HPS, HPS-poor HPS, HPS with lower amounts of Hg or metal halide alternatives could not be used as replacements should the Hg allowances be reduced or should the exemption not be renewed. Of the installed stock, it is also assumed that some installations are already approaching EoL and shall be replaced with LED alternatives as a result of the trend in this direction. In this sense, this estimation is considered to be higher than the impacts that could actually be expected.

Further aspects raised are of general nature and are discussed in the general chapter under 4.5.3.

14.5.3 Stakeholder Contributions

For the discussion of general aspects raised by stakeholders, please see Section 4.5.7. As for information provided by EEB et al. specifically for HPS lamps, it concerns both Ex. 4(b) and Ex. 4(c). Thus, not all aspects are understood to be relevant for this exemption. EEB et al. present a few examples of HPS alternatives with lower amounts of mercury, in support of a reduction of the hg allowances of the exemption at hand. As some of these lamps are HPS lamps, their compatibility with current installations is assumed. The differences in Hg doses are understood to be considerable in some cases (for example for entry III the proposal is a reduction of 15 mg). It is also understood that replacement lamps could be needed for existing HPS installations for up to 12 years due to the lack of suitable LED alternatives. In this sense, the consultants agree that a reduction in Hg levels would be beneficial, even if this would mean that replacements are not available for a certain part of the product range (i.e. where Hg doses are above recommended levels). Though EEB et al. also provide examples of LED alternatives, as discussed in Section 13.5.3 of Chapter 13.0 regarding Ex. 4(b), it can be followed that such lamps would not be compatible with current installations due to their dimensions and also because of possible heat dissipation issues.

14.5.4 Conclusions

Article 5(1)(a) provides that an exemption can be justified if at least one of the following criteria is fulfilled:

- their **elimination or substitution** via design changes or materials and components which do not require any of the materials or substances listed in Annex II is scientifically or technically impracticable;
- the **reliability** of substitutes is not ensured;
- the total negative **environmental, health and consumer safety impacts** caused by substitution are likely to outweigh the total environmental, health and consumer safety benefits thereof.

On the luminaire level it can be understood that a trend is already underway towards LED alternatives. Despite arguments raised by LEU that such installations have drawbacks in relation to lamps with higher lumen outputs as well as requiring higher investments, such alternatives are understood to be acceptable as LED installations are being placed on the market, among others to replace HPS ones. This is also supported by LEU's statements that most HPS lamps placed on the market are used as replacements in existing installations.

In contrast, on the level of lamp replacement/retrofit, LED alternatives are understood not to be sufficiently available. Though in some cases it is explained that they could be used (oversized luminaires and where there is acceptability of changes in light level and distribution), in most cases their dimensions would not allow their use. Thermal and

electrical incompatibility with existing HPS installations are also understood to limit their applicability at present.

It can further be followed that though Hg-free HPS lamps are available, that they would not be suitable as retrofit replacements in most HPS installations as their ignition is different and thus lamps would not be electrically compatible. It is also understood that despite the existence of Hg-poor HPS lamps, that these are prohibited by ErP and can thus not be considered as an available substitute in the EU. In contrast, it is observed that there are standard-dosed HPS lamps with lower amounts of Hg that would support a reduction of the Hg allowances currently specified in the exemption entries. In this respect, the proposal submitted by EEB et al. to reduce the Hg allowance of lamps with $P \leq 405$ W (Ex. 4(c)(I and II)) to 20 mg and lamps with $P > 405$ W of Ex. 4(c)(III) to 25 mg, can be followed.

14.6 Recommendation

Though substitutes are understood to be available on the system level (for use in new LED luminaires), such substitutes are too large to allow their application as substitutes in existing HPS luminaires (component replacement). It is assumed that the shift of the luminaire stock from HPS to LED is already underway, but that a phase-out could result in an early end-of-life of existing HPS luminaires (i.e. in waste and potential overall environmental dis-benefit). It is thus recommended to renew the exemption for a further 5 years. However, as proposed by EEB et al., as alternatives with reduced mercury are available in different shapes and for different wattages, it is recommended to reduce that amounts of Hg currently specified in the exemption entries. LEU estimates that the installed base of HPS lamps will be replaced by LED in a time frame of 12 years, i.e. by 2027.[372] Considering the long period understood to be needed to allow the shift from HPS luminaires to LED luminaires, an Hg reduction is perceived as beneficial for the environment.

In light of Article 5(2), from a legal perspective, an exclusion of EEE falling under Cat. 8 and 9 from the scope of this exemption may not be possible.

[372] Op. cit. LEU Ex. 4(c)(I-III)(2015b)

Exemption 4(c)	Scope and dates of applicability
Mercury in other High Pressure Sodium (vapour) lamps for general lighting purposes not exceeding (per burner):	
(I) P ≤ 155 W; 25 mg may be used per burner after 31 December 2011	For Cat. 5: 31 August 2018; For Cat. 8 & 9: 21 July 2021; For Sub-Cat. 8 in-vitro: 21 July 2023; For Sub-Cat. 9 industrial: 21 July 2024;
(II) 155 W < P ≤ 405 W; 30 mg may be used per burner after 31 December 2011	
(III) P > 405 W; 40 mg may be used per burner after 31 December 2011	
(IV) P ≤ 405 W; 20 mg may be used per burner	For Cat. 5: from 1 September 2018 until 21 July 2021
(V) P > 405 W; 25 mg may be used per burner	

Note: As it can be understood that the exemption duration may vary for various categories on the basis of Article 5(2), expiration dates have been specified here for all categories either on the basis of the requested duration in the exemption request which the consultants perceive to be justified, or on the basis of the validity periods specified in Article 5(2) for categories, which are newly in scope.

14.7 References Exemption 4(c)(I-III):

EEB et al. (2015a) The European Environmental Bureau, the Mercury Policy Project, and the Responsible Purchasing Network, Environmental NGOs Response to Stakeholder consultation 2015 #2 on mercury- containing lamps – Exemption 1-4 (Review of Annex to the RoHS directive), submitted 19.10.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_1_a-e_/Ex_1-4_EEP-RPN-MPP_Comments_on_RoHS_Request-final_20151016.pdf

LEU Ex. 4(c)(I-III)(2015a) LightingEurope, Request to renew Exemption 4(c) under the RoHS Directive 2011/65/EU: Mercury in High Pressure Sodium lamps, submitted 15.1.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_4_c__I-III_/4c_LE_RoHS_Exemption_Req_Final.pdf

LEU Ex. 4(c)(I-III)(2015b) Response To Oeko-Institut regarding the 1st Questionnaire Exemption No. 4c(I-III) (renewal request), submitted 15.9.2015, available under: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_4_c__I-III_/Ex_4c_LightingEurope_1st_Clarification-Questions_final.pdf