LIGHTINGEUROPE
THE VOICE OF THE LIGHTING INDUSTRY

Request to renew Exemption 1(a)

under the RoHS Directive 2011/65/EU

Mercury in single-capped (compact) fluorescent lamps below 30 W

Date: January 15, 2015

Contents

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2 Reason for application

LightingEurope submits this application to:	*request for an extension of existing exemption* ***no. 1(a) in Annex III***
LightingEurope proposes to continue using the existing wording which is:	*Mercury in single capped (compact) fluorescent lamps not exceeding (per burner):* *1(a) For general lighting purposes < 30 W: 5 mg* *Expires on 31 December 2011; 3,5 mg may be used per burner after 31 December 2011 until 31 December 2012; 2,5 mg shall be used per burner after 31 December 2012*
LightingEurope requests a duration of	*Maximum validity period required*

3 Summary of the exemption request

The validity period of DIRECTIVE 2011/65/EU Article 5(2) Annex III Exemption 1(a) will end automatically per 21/07/2016, unless an application for renewal has been made to the Commission in accordance with Annex V.

With reference to the above, this request concerns the extension of the current Annex III exemption: 1(a) of Directive 2011/65/EU Article 5(2) regarding mercury in single-capped (compact) fluorescent lamps for general lighting purposes < 30 W.

Over the last decade CFL lamps have strongly contributed to the achieved energy savings and to the reduction of CO2 emissions in Europe, being the direct replacement for incandescent lamps (Figure 1)[1]. As such CFL lamps have also contributed to reduce mercury emission from fossil fuel operated power plants.

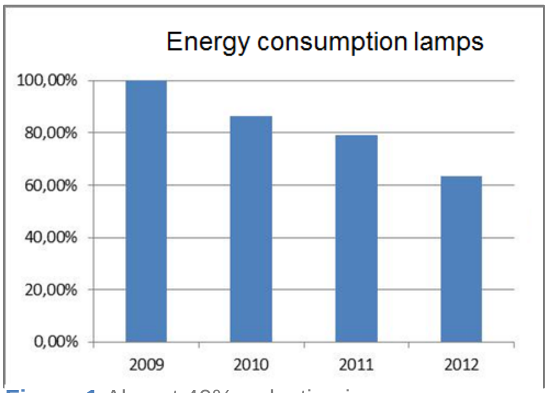

Figure 1 Almost 40% reduction in energy consumption in Europe by consumer lamps. Source : LightingEurope

At the same time the level of mercury dosed per compact fluorescent lamp has decreased considerably during the last years driven by the industry and formalized under the RoHS directive of max 5 mg to max 3,5 mg to max 2,5 mg/lamp (2006 - 2011). Figure 2 shows the achieved mercury reduction of the total fluorescent family.
Nevertheless, the fluorescent technology inherently needs a minimal amount of mercury in order to function through the full indicated lifetime and to deliver the energy efficiency benefits.

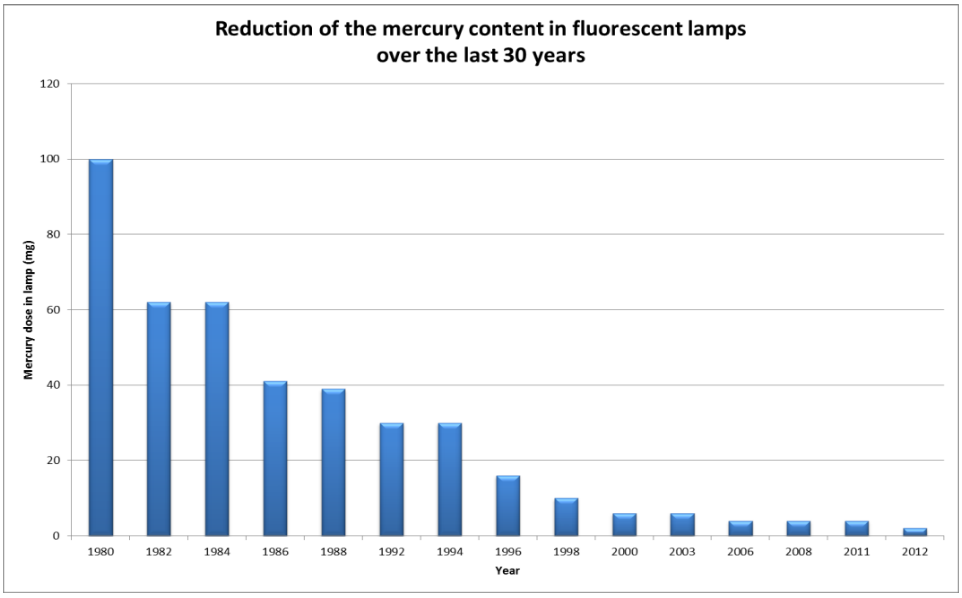

Figure 2: Mercury content of fluorescent lamps

[1] Source: LightingEurope
[2] http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_VI/Request_7/Request_No7_1st_Clarification_Questions_20120622_final.pdf

Waste management (WEEE) measures by EU authorities and industry together have resulted in still increasing collection & recycling rates (2013 rates already surpassing 45% target set for 2016), reducing the environmental impact of mercury even further.
More and more LED solutions come to the market; however they cannot always serve as a fully compatible replacement for the huge variety of CFL lamps < 30 W for consumers and professional end users. The following replacement issues in existing luminaires will not be solved by the LED technology on short notice: size, form factor, light distribution, light output, weight and heat management. Next to these issues lamps operated on separate ballasts can face problems with electrical compatibility, because many different types of gears (both conventional ballast and electronic control gear) are installed in the European market. Examples of these issues are reduced performance in dimmed mode and flickering. The person installing a LED based solution on ballasts originally designed for CFL is in most cases executing the rewiring and will as such be responsible to check if the new combination fulfils all requirements.

Based on above arguments LightingEurope is of the opinion that suitable LED replacement lamps are not available for many CFL lamp types in many applications. Removing CFL lamps from the market would therefor force early refurbishment of the lighting system or even new luminaire investments, which would unnecessarily and dramatically increase the waste.
Furthermore, in the residential area, due to the higher product price of the LED alternative, giving the same energy efficiency, the consumer has to invest more to achieve the same amount of energy savings

It is widely expected that, even without legislative policy measures, LED adoption will increase naturally during the coming years when LEDs will become more affordable and availability will increase. This will reduce the number of CFL lamps sold in the European market as will be described in section 5.2. Already with the threshold value as set in the current RoHS directive, the total amount of mercury brought into the EU market will reduce by half by 2020 (Figure 3).

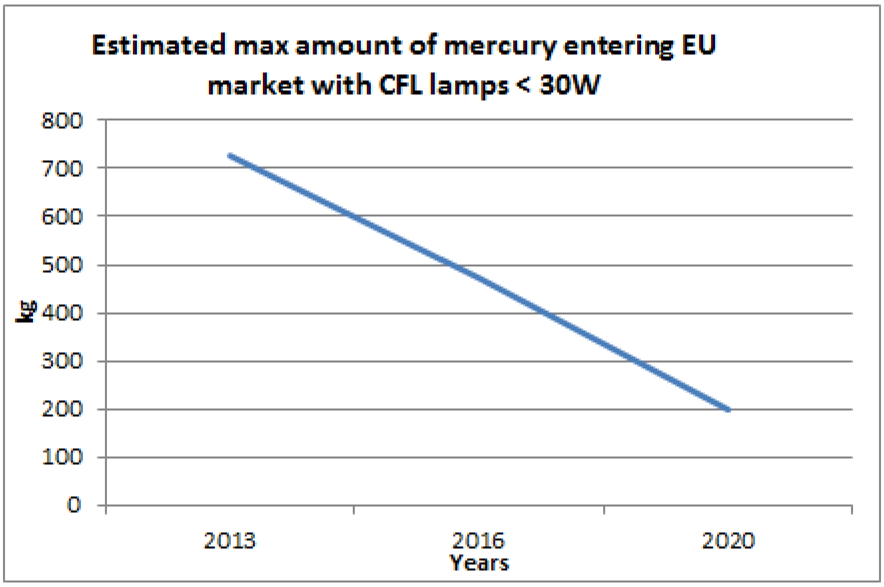

Figure 3: Estimated maximum amount of Hg entering EU by CFL < 30 W, using the current RoHS limits.

LightingEurope believes that above arguments justify the request for extension of the exemption for CFL lamps < 30 W with a maximum validity period and no expiry date.

4 Technical description of the exemption request

4.1 Description of the lamps and their applications

4.1.1 Lamps covered by this exemption

This exemption covers single capped (compact) fluorescent lamps < 30 W.

Compact fluorescent lamps (< 30 W) include lamps for residential and professional use. They can have the electronic control gear integrated in the product (self-ballasted CFLs or CFLi-s) or their control gear is separated from the lamp (plug-in CFLs or CFLni-s). Both types are mostly used for general lighting applications. A large proportion of CFL lamps can be found in people's homes and gardens. Most of the lamps for professional applications are used in offices, public buildings, shops and street lighting. CFL lamps in general have a colour rendering index (CRI) above 80 and are available in a wide range of colour temperatures from extra warm white (2200K) to cool daylight (6500K). Lamps used in different applications have light output, energy efficiency and lifetimes in the ranges 150-2500 lm, 50-80 lm/W and 6000-20000 hours.

There is a huge variety in product designs because of their specific purpose, technology, wattage, size and compactness, life time, internal phosphor coating, production process etc. Below a few examples of the various lamp types are shown.

4.1.2 Applications covered by this exemption

CFL lamps in professional applications are used as energy saving solutions and are found in many down lighters providing general lighting in for example shops, banks, schools, malls, hotels (reception, restaurants, bars, lobby, corridors, rest areas, conference rooms), galleries, offices (reception, lobby, meeting rooms, corridors, rest areas) and sporting facilities (gyms). Many luminaires have been specifically designed for the use of the CFL lamps. Below some pictures of a few applications are shown:

Compact fluorescent lamps (< 30 W) used in residential environments can be found in applications where they act as an energy saving solution for the now banned incandescent lamps. The pictures below give an indication of the wide variety of applications used in and around homes.

4.1.3 Annex I category covered by this exemption

List of relevant Annex I categories for this exemption

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☒ 5

☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11

Application in other categories, which the exemption request does not refer to: N/A

Equipment of category 8 and 9: N/A

The requested exemption will be applied in

☐ monitoring and control instruments in industry

☐ in-vitro diagnostics

☐ other medical devices or other monitoring and control instruments than those in industry

LightingEurope is of the opinion that lamps in general are category 5, because the majority is used for general illumination. However, they have some of the characteristics of components (used in luminaires), consumables (finite lifetime and regularly replaced) or 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 6 but may be household appliances, medical devices or potentially in any RoHS category 1 - 11.

LightingEurope is aware of the difficulty to classify certain lamps unambiguously in the category set out by RoHS legislation. For lamp producers it is essential to have legal certainty regarding the possibility to put the products on the market irrespective of the planned application as we are not able to control the use of the lamps in products falling in other categories 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 in all other RoHS categories. The way that lamps are used has no effect on lamp design so will not affect this exemption request.

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4.2 Description of the substance

4.2.1 Substance covered by this exemption

LightingEurope is asking for exempting

☐ Pb ☐ Cd ☒ Hg ☐ Cr-VI ☐ PBB ☐ PBDE

4.2.2 Function of mercury in lamps

A small amount of mercury is intentionally dosed in all fluorescent lamps as it is essential for the low-pressure gas discharge. When electric current flows through the lamp bulb (=burner), the mercury atoms inside are excited and produce UV radiation. This UV light is then converted into visible light by the fluorescent coating on the lamp bulb with a high degree of energy efficiency.

4.2.3 Location of mercury in lamps

Mercury is present in the so-called burner.

The mercury is instrumental in the conversion of electrical energy into the UV radiation, which is converted subsequently by a phosphor into the emitted visible light.

4.2.4 Amount of mercury

Mercury is dosed in the burner during lamp manufacturing as 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. This is reflected in the current individual RoHS exemptions 1a till 1f. During lamp life, mercury is consumed inside the burner itself. It is bound principally to the phosphor layer and the glass.[3] Once the mercury is bound to these elements, it is no longer available to emit ultraviolet light.

One of the principal design rules to create higher lumen packages in fluorescent lamps is to increase the length of the discharge. Consequently higher lamp wattage involves more glass and phosphor surface, thus more mercury consumption during lamp life and therefore a higher initial mercury dose. Coating of phosphors and glass can give a reduction of the Hg consumption over lamp life, but in general it remains a function of the lamp dimensions and the lifetime. Next to this, processing has its influence, for instance because the actual dose per lamp scatters around the nominal dose, while the threshold value as set by RoHS directive sets a maximum limit.

For single capped compact fluorescent lamps in the scope of the Exemptions 1(a), the maximum dosed mercury amount is set at 2,5 mg.

The influence of mercury consumption on the required dose

The amount of mercury which is needed for the low pressure discharge itself is very low, typically below 0,1 mg per lamp. But there are many processes within the burner, which make a large part of the mercury unavailable for the discharge over lifetime. This is called mercury consumption. The mercury consumption is much higher than the mercury amount needed for the discharge, viz. in the order of a milligram. 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. 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.

[3] Reference: I. Snijkers-Hendrickx et al, Low-Mercury Containing Discharge Lamps. Sustainable and Environmental Friendly Lighting Solutions, LS 11

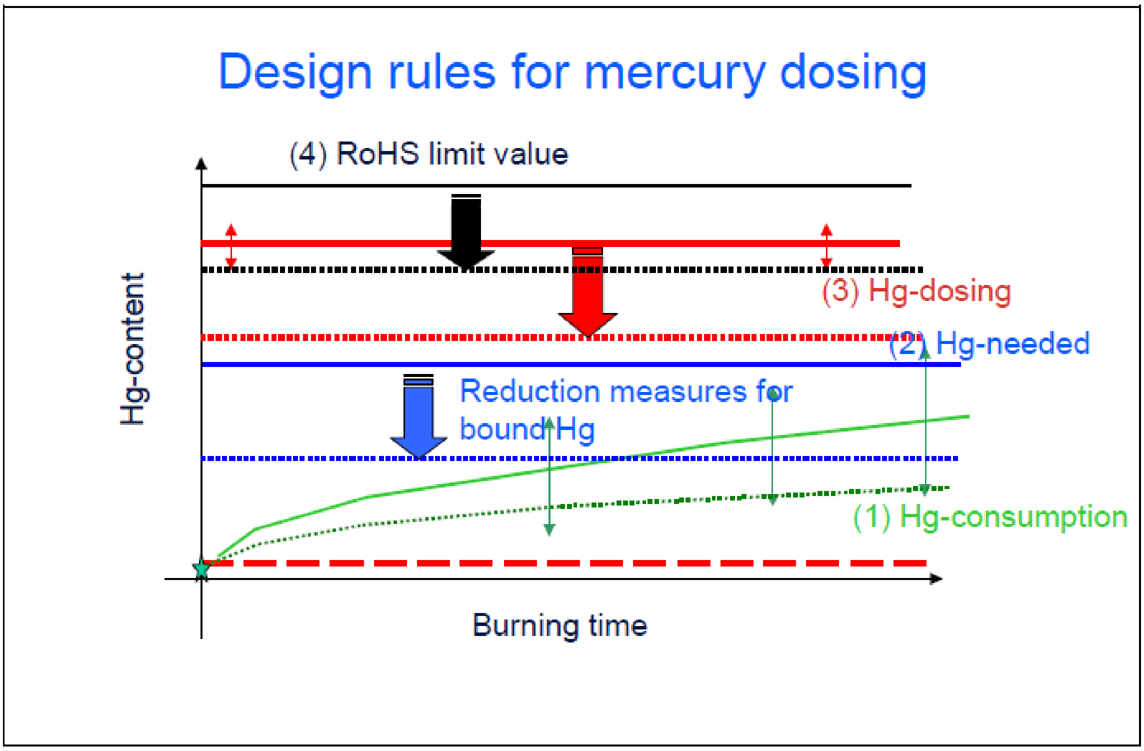

Figure 4 Design rules for mercury dosing in fluorescent lamps, schematically showing the process of setting RoHS limit values based on insights in mercury consumption and mercury dosing.

The lowest (red dashed) line in Figure 4 gives the ideal situation for a low pressure mercury discharge: there is just enough mercury for the discharge to properly function. For a compact fluorescent lamp this is typically in the order of 0,005 to 0,05 mg per lamp (in the gas-phase), depending on the lamp dimensions. However, because of the mercury consumption mechanisms a significantly higher amount must be dosed (which will be explained below). It has not been possible to date to design a lamp with normal functional properties over lifetime using a mercury dose of only 0,005 to 0,05 mg.

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, 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 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 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. The lifetime and performance of CFL lamps in Europe are regulated[4],[5].
Figure 5 shows the dosing variance relatively to the RoHS threshold value.

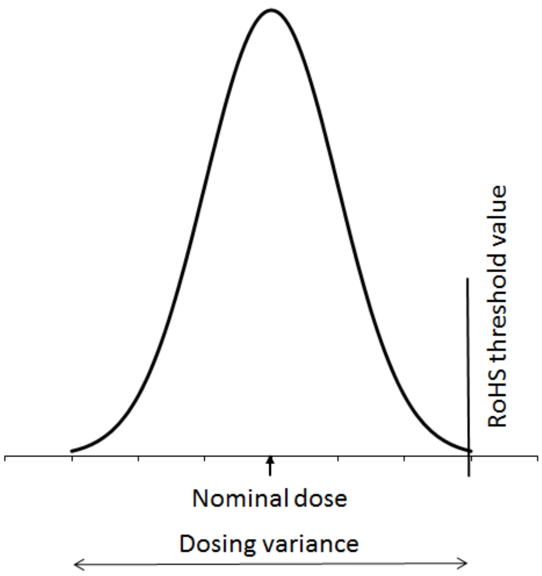

Figure 5: Dosing variance in mercury

Key to the reduction of mercury that has been applied by lamp manufacturers in the previous decades is influencing the factors that determine mercury consumption. These include:

[4] Commission regulation (EC) No. 244/2009, March 18, 2009
[5] Commission regulation (EC) No. 245/2009, March 18, 2009

- Glass type and protective coating
- Type of phosphor material
- Interaction with gasses and impurities
- Lamp processing during manufacturing
- Lamp-ballast interaction during operation

It is also important to take into account the technical capability to reduce both the absolute mercury dose to very low values, and to reduce its variance. Hence, by combining a series of interlinked and complex measures, in a consistent manner, the mercury has been reduced, based on scientific and technical progress in recent years.

4.2.5 Environmental assessments, LCAs

There are several external LCA's performed regarding lighting. There is general agreement, that the main environmental impact is created during the use phase, meaning through electricity consumption when burning the lamp.[6] This means that currently the energy efficiency 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 fossil fuel is the primary power source).[7] Technological advancements in the lighting industry have resulted in a significant reduction in the amount of mercury used in many types of fluorescent lamps over the last two decades.[8] Manufacturers have developed technology that enables a small amount of mercury to be 'dosed' or placed inside a CFL.[9]

For the future however the manufacturing part in the LCA becomes more relevant[10], because the energy consumption by the lamp is already dramatically reduced (higher energy efficiency leads to decreased negative environmental impact).

The total life cycle environmental impact of the light sources is interesting due to the importance of the lighting sector in the total energy consumption. The lighting sector is

[6] see Enlighten report, Section 5, Ch. 3 fig. 4 & 5, p. 111-112 http://www.learning.enlighten-initiative.org/ebook/en_lighten_english_complete.pdf
[7] see Enlighten report, Section 5, Ch. 3 fig.6, p. 111-112 http://www.learning.enlighten-initiative.org/ebook/en_lighten_english_complete.pdf
[8] ENERGY STAR. (2012). Frequently Asked Questions Information on Compact Fluorescent Light Bulbs (CFLs) and Mercury. Retrieved March 29, 2012, from: http://www.energystar.gov/ia/partners/promotions/change_light/downloads/Fact_Sheet_Mercury.pdf
[9] Complete paragraph UNEP toolkit, p.106
[10] Life cycle assessment of light sources – Case studies and review of the analyses Leena Tähkämö, Aalto University publication series DOCTORAL DISSERTATIONS 111/2013

filled with different light sources of different shapes and sizes. The environmental and economic performance comparison of those various types is difficult, due to lack of established rules for the LCA of light sources. As a result, it creates distortion and makes it difficult to numerically compare the results of the LCAs.

Historically the comparison was done with respect to incandescent lamps[11], where it was concluded that the net mercury emission over life cycle is reduced when changing from incandescent to CFL lamps. More recently LCA is done in comparison with LED sources[12], however here it is even more challenging to compare these various-shaped LED light sources to conventional lamps and luminaires. LED technology provides new possibilities for manufacturers to design luminaires, lamps, components and packages containing LED chips, thus the question on which basis those should be compared remains.[13]
In some analyses the current LED alternative comes close to compact fluorescent lamps. Another however concludes that LED lamp product manufacturing uses approximately three times more energy than the manufacturing of a CFL with comparable light output[14]. Thus it needs to be acknowledged that at present no widely accepted consensus exists among experts. However one must consider the improving LED alternative in the right perspective: according to reference[15] LED sources are expected to have a real advantage in the total life cycle over time, at least if energy efficiency keeps improving at the same rate and expected long lifetime is proven.

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[11] Pfeifer RP.Comparison between filament lamps and compact fluorescent lamps. International Journal of Life Cycle Assessment 1996; 1: 8—16.; Parsons D. The environmental impact of compact fluorescent lamps and incandescent lamps for Australian conditions. The Environimental Engineer 2006; 7: 8—14; Gydesen A,Maimann D. Life cycle analyses of integral compact fluorescent lamps versus incandescent lamps: RightLight, Stockholm, Sweden, 1991

[12] Department for Environment, Food and Rural Affairs (DEFRA).Life Cycle Assessment of Ultra-Efficient Lamps.Navigant Consulting Europe Ltd. 2009.; Analysis and comparison of incandescent, compact fluorescent lamps and light emitting diode lamps in residential applications, The scientific consulting group inc. (2010) submitted to the U.S. environmental protection agency office of the science advisor; Life-Cycle Assessment of Energy and Environmental Impacts of LED Lighting Products, The U.S. Department of Energy (DOE) building technologies office; Life cycle assessment of light sources – Case studies and review of the analyses, Leena Tähkämö, Aalto University publication series DOCTORAL DISSERTATIONS 111/2013; Life Cycle Assessment of Ultra-Efficient Lamps SPMT08_069, Navigant Consulting Europe, Ltd. A research report completed for the
Department for Environment, Food and Rural Affairs,

[13] Life cycle assessment of light sources – Case studies and review of the analyses Leena Tähkämö, Aalto University publication series DOCTORAL DISSERTATIONS 111/2013, p. 17-18

[14] U.S. Department of Energy. (2012). Life-Cycle Assessment of Energy and Environmental Impacts of LED Lighting Products. Retrieved March 10, 2012 from http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2012_LED_Lifecycle_Report.pdf

[15] Life-Cycle Assessment of Energy and Environmental Impacts of LED Lighting Products,
The U.S. Department of Energy (DOE) building technologies office

5 Waste management

5.1 Waste streams

☒ Article is collected and sent without dismantling for recycling

☐ Article is collected and completely refurbished for reuse

☐ Article is collected and dismantled:

  ☐ The following parts are refurbished for use as spare parts: _____

  ☐ The following parts are subsequently recycled: _____

☐ Article cannot be recycled and is therefore:

  ☐ Sent for energy return

  ☐ Landfilled

Single capped (compact) fluorescent lamps are in the scope of EU Directives 2002/96/EC - WEEE and 2012/19/EU– WEEE Recast. 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. Single capped (compact) fluorescent lamps 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. Figure 6 shows the various steps in the recycling process.

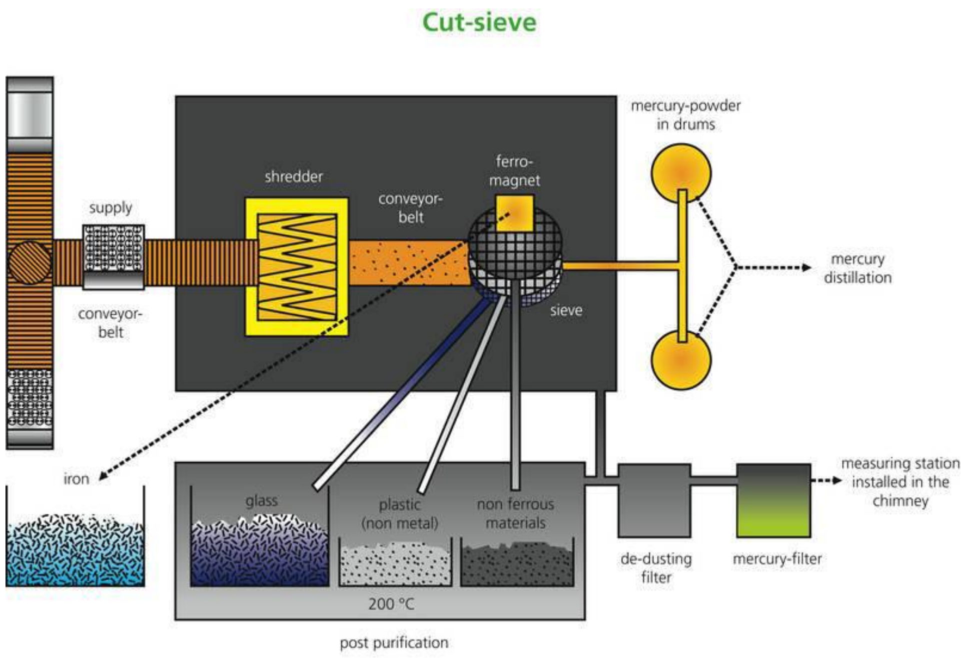

Figure 6: Recycling steps of fluorescent lamps in Indaver (Belgium).
Source:www.indaver.be/waste-treatment/recycling/mercurial-waste.html

Figure 7 illustrates the specifics of recycling the mercury.

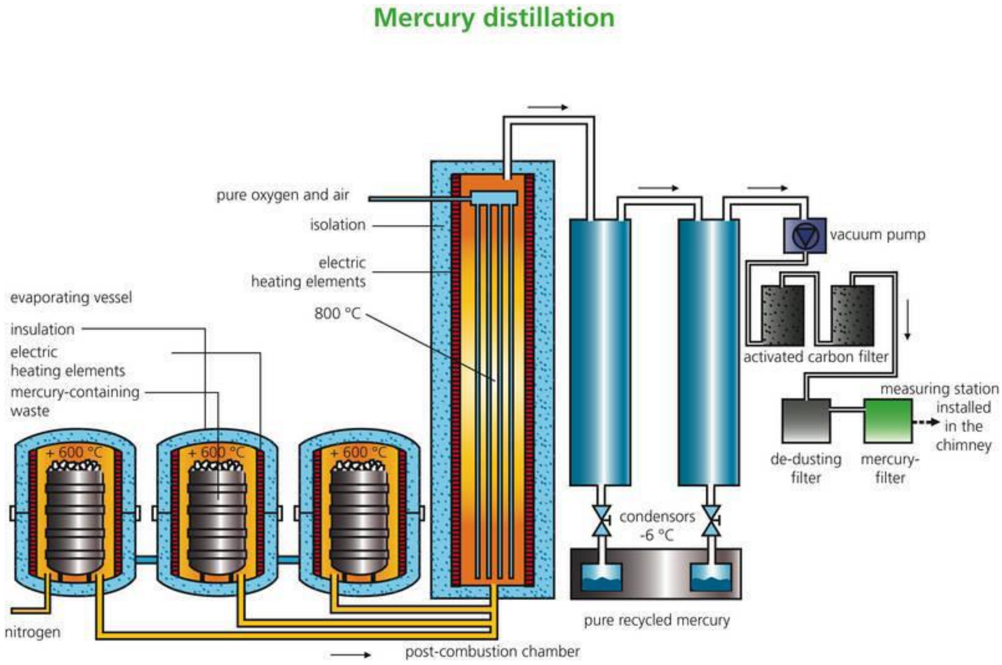

Figure 7: Recycling steps of fluorescent lamps in Indaver (Belgium).
Source:www.indaver.be/waste-treatment/recycling/mercurial-waste.html

European legislation on Waste Electrical and Electronic Equipment (WEEE) makes producers responsible for end of life products within this category as from August 13th, 2005. Target setting as consequence of the present legislation is 45% of Electrical and Electronic Equipment placed in the market by 2016, rising to 65% in 2020 per year for all categories.

European Lamp Companies have founded Collection & Recycling Organizations in the EU Member-States, with the objective to organize the collection and recycling of gas discharge lamps. Goal is to comply with present and probable future EU legislation and meet or exceed national targets.

In general the following channels have been established in the respective member-states providing countrywide coverage:

- Direct collection from large end users: Containers have been made available, ad hoc or permanently, and will be collected upon notification by the end user that the container is full.
- Collection through distribution:

  Wholesalers and Retailers place collection means at their premises respectively in their shops. Collection is done upon notification.
- Collection through municipalities:

  Where infrastructure allows collection means are placed at municipality depots.

Figure 8 'JEKKO' collection container

Figure 9 : ‘Récylum’ collection container

Campaigns are being executed or have been planned to re-enforce the role of the government to educate the population that gas-discharge lamps have to be disposed of in an environmentally friendly way. An example of such a campaign is the distribution of ‘Jekko’ containers to 1 million households in the Netherlands (Figure 8). Another way of organising the take back for consumers is via supermarkets as done by Récylum in France (Figure 9).

5.2 Amount of mercury in WEEE

☐ In articles which are refurbished
☒ In articles which are recycled
☐ In articles which are sent for energy return
☐ In articles which are landfilled

Amount of substance entering the EU market annually (base year 2013) through application for which the exemption is requested:

The report ‘Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling

Requirements (‘Lot 8/9/19’), Draft Interim Report, Task 2 made for the EU indicates a total volume of CFL lamps in EU 28 of 342 Mpcs in 2013. This volume includes all wattages[16].

The collection rate of lamps in Europe compared to the average amount of lamps put on the market during 2010 – 2013 is shown in below graph (Figure 10) based on Collection & Recycling Service Organization (CRSO) data consolidated by Philips Lighting. It also includes the targets set for 2016 and 2019. Please be aware that this graph includes all lamp types, not specifically the CFL < 30W types.

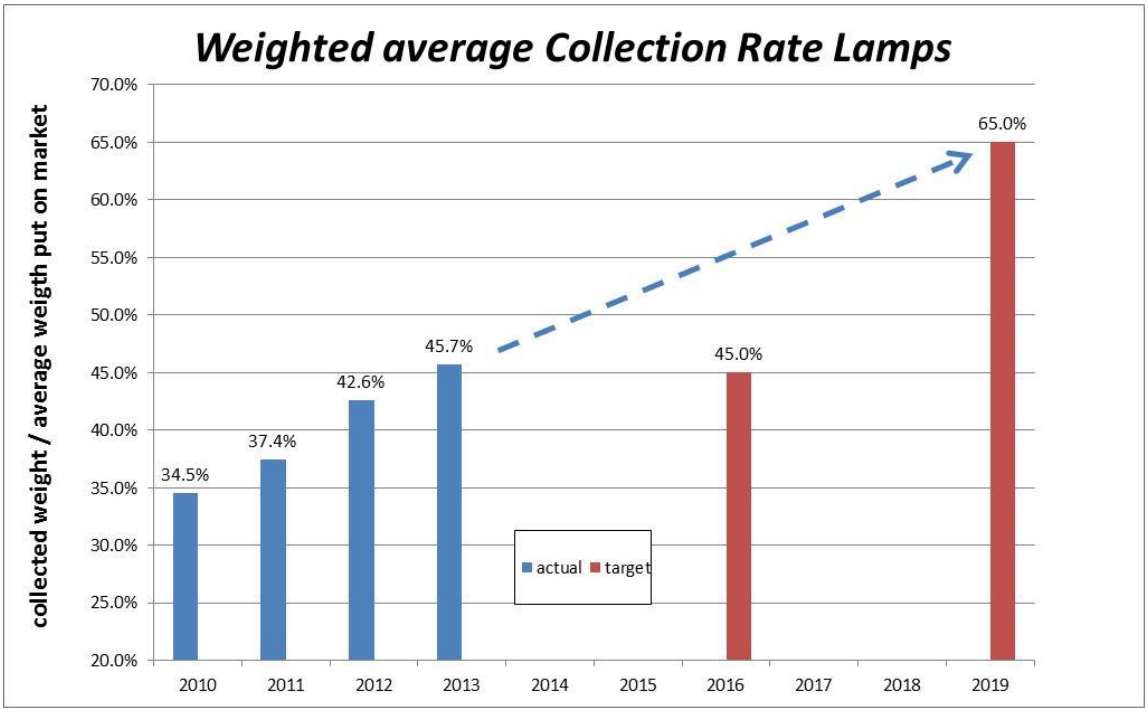

Figure 10: Collection rate of lamps

Reporting on the collection of lamps is available on 2 groups:

- CFL lamps and LED retrofit lamps
- Long CFL lamps without integrated ballast, Fluorescent tubes

This makes it impossible to give specific accurate figures for CFL lamps < 30 W as the available information covers the whole CFL family.

[16] Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements (‘Lot 8/9/19’). Draft Interim Report, Task 2 by Prepared by VHK, in cooperation with VITO and JeffCott Associates Date: 19 November 2014, Table 1.

The amount of mercury entering to EU market with CFLs < 30 W can be estimated with the following algorithm.

The majority of the wattages sold are below 30 W, so are included in exemption 1a. An external report indicating the exact wattage split is not available. Based on experience of the LE members, CFL lamps < 30 W count for 85% of the total CFL volumes in Europe.

The maximum allowed mercury content for CFL lamps < 30 W is 2,5mg.

Combining these numbers indicate that in 2013 (85% * 342Mpcs * 2,5mg) a maximum of 727 kg of mercury has entered the European market (market volume in pieces taken from VHK report for EU) [17].

The McKinsey study as used in the VHK report[18] gives the following rough forecast of volumes in 2016 and 2020. Using these volumes in the calculation of the maximum amount of mercury entering to EU market with CFLs < 30 W gives the following result (illustrated in Figure 11):

2016: (85% * 222Mpcs * 2,5mg) = 472 kg

2020: (85% * 93Mpcs * 2,5mg) = 198 kg

It is emphasized that this is an estimation of the upper limit based on the threshold value of the directive. In reality the amount entering the market will be lower as the average dose per lamp is most often below this threshold value (see 4.2.4). LightingEurope estimates that the average value is roughly 20% below the threshold value.

[17] Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements ('Lot 8/9/19'). Draft Interim Report, Task 2 by Prepared by VHK, in cooperation with VITO and JeffCott Associates Date: 19 November 2014, Table 1.

[18] Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements ('Lot 8/9/19'). Draft Interim Report, Task 2 by Prepared by VHK, in cooperation with VITO and JeffCott Associates Date: 19 November 2014, Table 29.

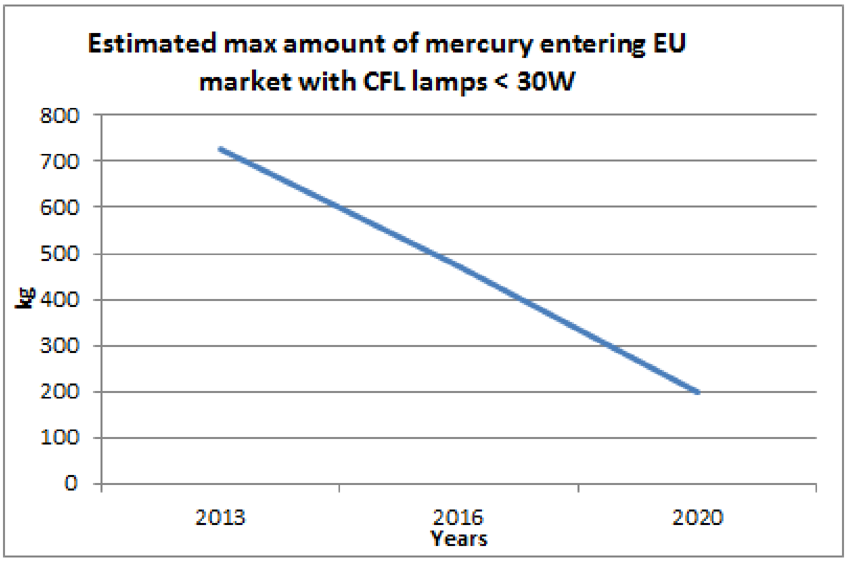

Figure 11: Estimated maximum amount of mercury entering EU market in CFL<30W [kg] using current RoHS limits.

The total amount of mercury entering to the EU market in compact fluorescent lamps covered by this exemption will decrease in the coming years. Main reason for this is the increased penetration of LED alternatives due to their expected decreasing price, improved availability and better replace-ability for the different CFL lamp types.

It is also important to note that almost every country within EU has a collection and recycling service organisation (Figure 12, status per 2009). Collection and recycling rate of CFL lamps is continuously increasing, contributing to the overall mercury reduction program.

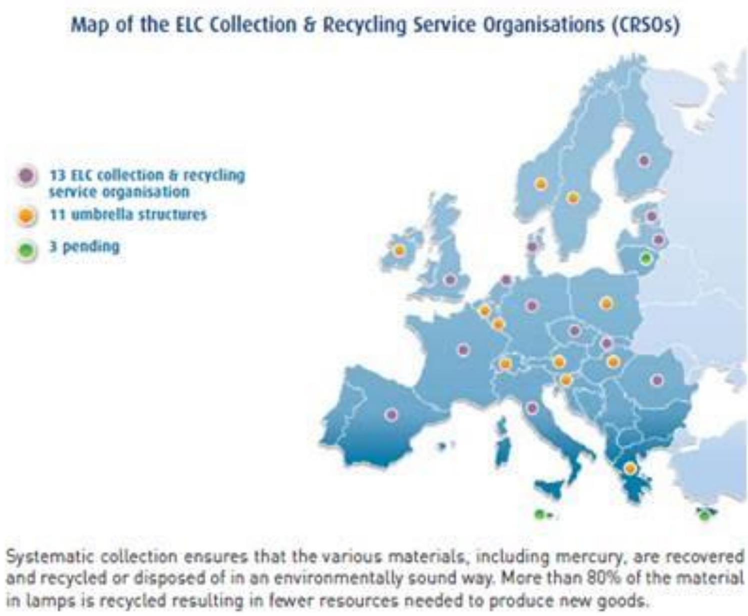

Figure 12: Map of ELC Collection and Recycling Service Organisations (CRSOs). Source: Environmental aspects of lamps[19]

6 Substitution

Can the substance of this exemption be substituted?

☐ Yes, by
- ☐ Design changes:
- ☐ Other materials:
- ☐ Other substance:

☒ No

Justification: see in chapters below

6.1 Substituting mercury in the fluorescent technology

Fluorescent lamps need a certain amount of mercury since it is consumed over life. Technology has evolved over the last decade. The average amount of mercury within fluorescent technology per lamp has been considerably reduced (Fig 13)[20]:

[19] ELC: Environmental aspects of lamps, second edition, APRIL 2009 http://www.elcfed.org/documents/090811_elc_brochure_environmental_aspects_lamps_updated_final.pdf

[20] http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_VI/Request_7/Request_No7_1st_Clarification_Questions_20120622_final.pdf

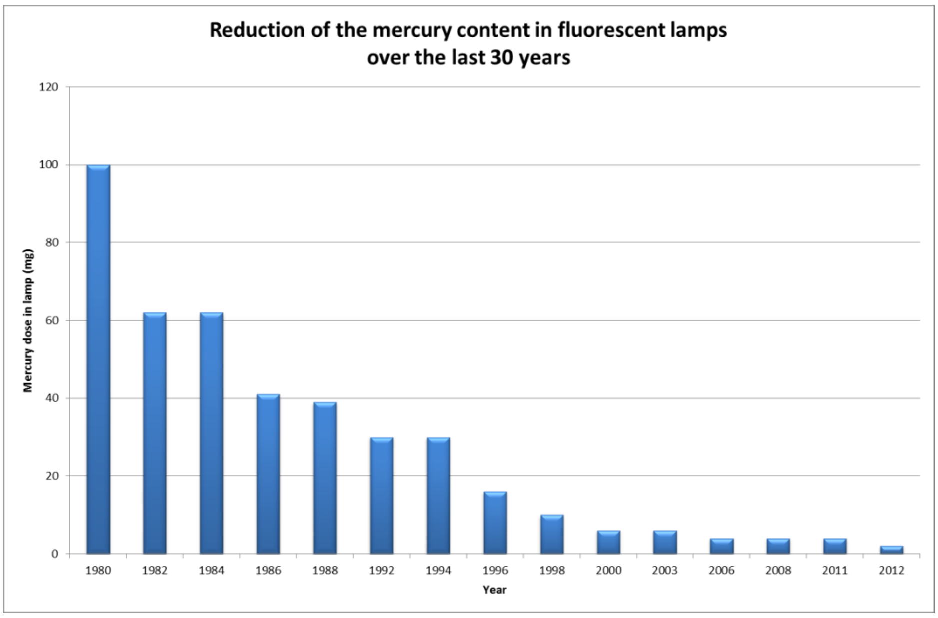

Figure 13: Mercury content of fluorescent lamps. Source: LightingEurope

But low pressure fluorescent lamps without mercury are not possible, despite all the research that has been done on the subject:

The mercury discharge is highly efficient in transforming electrical energy into light. The technology has only two drawbacks: first the generated UV radiation needs to be transformed into visible light, a process for which large losses occur: this is due to the Stokes shift (an energetic UV photon generates a visible photon which has a much lower energy) and secondly the discharge inherently contains mercury as the source to create the UV photons[21].

Attempts to generate UV with noble gases have succeeded partially[22]. However the plasma radiates in the deep UV. At such wavelengths, the Stokes shift is even larger causing lower energy efficiency. The lack of suitable phosphors[23] prohibited progress in this direction. Other alternatives investigated are low pressure metal halides (for example InI, InBr, GaI3)[24]. Such plasma's generate the visible light directly without the Stokes shift

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[21] M Haverlag, Mercury-free discharges for lighting, J. Phys. D: Appl. Phys. 40 (2007)

[22] R Bussiahn, S Gorchakov, H Lange, D Loffhagen and D Uhrlandt, Ac operation of low-pressure He–Xe lamp discharges, J. Phys. D: Appl. Phys. 40, 3882 (2007)

[23] J. Dexpert-Ghysa, Re-processing CRT phosphors for mercury-free applications, J. of Luminescence, 129, 1968, (2009)

[24] D.Smith, J. Michael, V. Midha, G. Cotzas and T. Sommerer D. Smith et al Efficient radiation production in a weakly ionized, low-pressure, nonequilibrium gallium-iodide positive column discharge plasma J. Phys. D: Appl. Phys. 40 3842 (2007). More references can be found in the series: International Symposium on the science and technology of Lighting LS1-14.

of the phosphor[25]. There are alternatives from research but the energy efficiency in prototype lamps is significantly reduced to 40lm/W or below. Mass production is not feasible.

With the arrival of the first energy efficient LED white light sources and the perspective of further improvements, research to alternative gas discharges has stopped at most companies and universities.

6.2 Substituting fluorescent technology by mercury free technology

A mercury free available technology is Halogen. This can be a retrofit solution for some of the applications, but not for all.

Currently, the lighting market is rapidly changing from discharge lamp technology to LED technology, which is mercury free. This change mainly concerns the new installs market, i.e. new luminaires and lighting systems are now frequently based on LED technology. However, for the current installed base of luminaires and lighting systems operating with discharge lamps, a typical refurbishment cycle in shops and offices is on average 7 and 12 years respectively. LEDs in many cases are not suitable drop-in replacements, as will be explained in 6.2.1, so the availability of suitable discharge lamps needs to be secured to prevent a forced, early refurbishment resulting in extra costs and environmental burden.

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 exemption.

Towards discharge lamp technology, no major development efforts have been taking place anymore because innovation efforts in the industry are fully focussing now on LED technology.

6.2.1 Feasibility of the alternatives

For CFL lamps replacement by means of LED lamps is not always evident. Specifics to finding alternatives for compact fluorescent lamps include the following issues:

[25] An example if a UV photon of 256 nm from mercury is transformed in a visible photon of 555nm (maximum eye sensitivity) 56% of the energy is lost to heat. In xenon the UV photon is formed around 185 nm this loses 67% of the energy when transformed into the same visible photon.

- As explained in 4.1.1 CFL lamps are installed in a huge variety of types, shapes, sizes, wattages and colours. For just a few of these types LED retrofit solutions are entering the market. It is questionable if LED retrofit solutions will be developed for the total of this complex and scattered landscape with often small series per type.
- In Europe properties of CFL lamps are regulated in various standards like EN60901, EN60969, EN60968 and EN61199, to make compatibility easy for the users. Such standards are currently not available for LEDs which aim to replace CFLs with external ballast, so customers don't have any reassurance that the LED solution fits the existing installation.
- Inherent to the discharge technology, CFL lamps are more of omnidirectional nature, while LEDs by nature emit their light more directionally which can make the one to one replacement difficult. It is difficult for LED based lamps to achieve an omnidirectional luminous intensity distribution, while also meeting needs for thermal management and electrical regulation. When replacing the CFL lamp with a general purpose LED bulb the consumer may notice the light is not distributed in all directions and this could prove to be a disappointment as shown in the picture (Figure 14: Lamp with poor omnidirectional light flux on the left-hand side).

Figure 14: Source http://www.energystar.gov/index.cfm?c=lighting.pr_what_are

- In the application the luminaire might radiate the light in all directions or a reflector is guiding the light into a special direction. Especially in the last case the reflectors are designed for the shape, dimensions and burning position of a CFL lamp to generate the desired light distribution. The more directional light of an LED will give a different light distribution in the same CFL luminaire with reflector. Therefore bare-lamp performance may not translate when the product is operated in a luminaire. The measurement should be performed with a lamp inside the luminaire. Replacing an omnidirectional fluorescent lamp with a directional LED lamp can result in for example reduced illuminance at the work place, changed uniformity ratios on floor and surroundings and even in unwanted glare. The pictures below (Figures 15, 16, 17) also clearly indicate that depending on specification of a luminaire, application performance may differ significantly when directional lamps are installed. In some cases there might be a need for a new light plan design, resulting in renovation and installation of new luminaires.

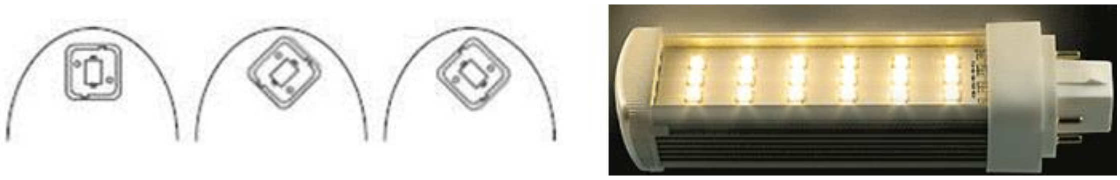

Figure 15: Example of possible burning positions in a luminaire designed for conventional CFL.

Figure 16: Example of a vertical application[26]

Figure 17: Example of a horizontal application[27]

- Some CFL luminaires are designed for 2 lamps. Differences in size of the LED alternatives can cause problems in fitting both lamps in the luminaire. The picture below shows a typical example of LED lamps with the same lumen output, but different size and dimension than the CFL lamps they need to replace.

[26] http://www.amazon.com/Fluorescent-Vertical-Downlight-Lamp-26w/dp/B0040WWUNY, date: 27/11/2014
[27] http://www.globalindustrial.com/p/electrical/lighting-indoor/downlighting/6-cf-downlight-horizontal-frame-in-263242w-1-light, date: 27/11/2014

- The current lamp holders are designed to carry the weight of the existing CFL lamps. Safety standard for CFL lamps (EN60968) prescribes a maximum weight and bending moment to prevent a too high loading of the lamp holder. LED lamps can have a higher weight and bending moment than CFL lamps due to the necessary heat sink which needs to be close to the LEDs to remove the heat from the diodes. As a result the weight of the LED solution often exceeds the values for CFL.
- Luminaires for CFL are designed for the thermal properties of a CFL lamp and not to control the heat as required for dedicated LED fixtures. Direct application of LED replacement lamps instead of CFL can cause thermal problems in closed and/or narrow CFL luminaires.
- The external lamp driver can be a conventional ballast or an electronic control gear. The market for new installations is moving toward electronic control gear due to new functionality (e.g. dimmability) and upcoming energy efficient legislation for the driver. Many CFL lamps used by professional end users are designed to be dimmable. Several modes of dimming (e.g. phase cutting) are present in the market. All modes of operation (EM, HF current controlled, power controlled, voltage controlled, preheat, non-preheat) have in common that the light source is expected to behave electrically as a standardised CFL lamp. The large diversity of drivers is not meant for an electronically ballasted LED lamp. This makes it very difficult for a customer to know which ballast is used and which LED lamp to apply as a retrofit. The usually unskilled end-user might be confronted with compatibility issues and wrongly (also unintentionally) chosen LED based replacements, which will work improperly in the existing application. In such situations one will be forced to take out the control gear from the installation and directly connect a LED source to mains voltage (called rewiring). Currently there is no electrical interface described for LED lamps replacing CFL with external control gear. Standardisation bodies are working on interface standards (related to linear LED based replacement lamps), but it is not expected that these will also become available in the near future for CFL (with external control gear). As a result an end-user, both consumer and professional customer, needs to either have a broad technical knowledge or reach out to professionals to ensure that replacement is safe and the luminaire operates in a proper manner. It requires case-by-case feasibility and measurements. The person installing a LED based solution on ballasts originally designed for CFL is in most cases executing the rewiring and will as such be responsible to check if the new combination fulfils all requirements.
- A regular external driver for a CFL lamp is designed to be used with several subsequent lamps (at least 3 to 4 lamps). In case no suitable LED replacement is

available this would lead to a premature refurbishment of either the ballast or the complete luminaire. This creates additional negative environmental impact through unnecessary waste, when still properly operating components need to be disposed. A typical renovation cycle in the office segment is 12 years and for shops this is 7 years[28].

- Many down-lighter luminaires are built recessed into the ceiling. If no replacement lamp is available, not only the luminaire should be replaced, but because the new LED luminaires will not always fit exactly in the hole in the ceiling, a considerable number of the users will need to replace the whole ceiling to fit the new luminaires.
- For many applications the prices of LED-based alternatives for CFL lamps (especially for increased wattages) are still significantly higher while the system energy efficiency and lifetime in principle are comparable[29] . This means higher investments and a longer payback time.

6.2.2 Availability of substitutes

Looking purely to the capacity to produce LED lamps globally, there will probably be enough capacity to fill the sockets in Europe. But the question is if all sockets can be filled with suitable, replacement LED lamps, fulfilling the requirements of the application and securing proper quality. In that case the conclusion is, as described in 6.2.1, that that is not the case yet in 2016. More time is needed in the development of LED technology to become a true replacement for all CFL lamps in all applications.

6.2.3 Impacts of substitution

As indicated in 6.2.1 LightingEurope is of the opinion that no fully compatible substitutions in LED technology are available for the big variety of CFL lamp types in all types of applications.

6.2.3.1 Environmental impact of substitutes

The major environmental impact of lighting is the energy consumption in the use phase. As stated before (see 4.2.5), various LCA's show different results and are as such inconclusive regarding the comparison of LED technology versus CFL technology on their

[28] McKinsey, Lighting the way : Perspectives on the global lighting market, July 2011
[29] To prevent infringement of the competition law, specific price levels are not given in this document. Prices per country and brand are differing. More information on current price levels can be gathered through the internet.

total environmental impact. Both CFL and LED lamps for residential applications use an electronic driver of which the environmental impact is the same. The largest differences are the use of mercury in case of CFL and in case of the LED the aluminium based heat sink and the energy to manufacture the product[30]. Comparing the two is difficult. So no conclusion can be drawn on the statement if LED is a full replacement for CFL.

In case no suitable replacement of a CFL lamp can be found and the ballast and/or luminaire also need to be prematurely replaced, this will result in additional waste.

6.2.3.2 Health and safety impact of substitutes

Although the LED technology doesn't contain mercury, it contains other sorts of substances such as lead and plastics. So far researches have not been conclusive in the overall effect of a LED lamp in comparison with a CFL lamp (see section 4.2.5).

The next important aspect of the use of LED based replacements for existing CFL based applications is electrical compatibility. As explained in chapter 6.2.1, the current market situation is far from being comprehensive, due to the big variety of lamp types and gears. Contrary to linear LED based light sources, there is no safety standardization in progress. Safety is the responsibility of the installer and the luminaire should be appropriately labelled afterwards. Special care has to be taken for the use of LED lamps in systems which were designed for a compact fluorescent lamp, including exchange of the lamps by professionals.

6.2.3.3 Socio-economic impact of substitution

Economic effects related to substitution:

☐ Increase in direct production costs

☒ Increase in fixed costs

☐ Increase in overhead

☒ Possible social impacts within the EU

☒ Possible social impacts external to the EU

☒ Other:

[30] U.S. Department of Energy. (2012). Life-Cycle Assessment of Energy and Environmental Impacts of LED Lighting Products. Retrieved March 10, 2012 from http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2012_LED_Lifecycle_Report.pdf.

Banning the energy efficient CFL lamps leads to 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.

Manufacturers offer a wide variety of energy efficient lighting products in their portfolio providing customer choice for professional and residential use. Banning mercury or setting very strict limits on its use will eventually prohibit the use of fluorescent technology for lighting. This means a serious reduction of customer choice for energy efficient lighting solutions.

Some CFL lamp families are still made in Europe. So not granting the exemption will lead to the closing of these factories in the EU with accompanying 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.

6.2.3.4 Impact of substitution on innovation

Focus of the current lighting industry is already on the further development of LED technology (paragraph 6.1). An extension of the exemption will have a positive effect on the efforts to further innovate in LED, as CFL is the benchmark to be outperformed by LED.

6.2.4 Future trends of substitution

LED technology performance is developing, however the balance between cost price, lifetime and energy efficiency and the speed in which it will take place is not yet clear and at least needs time.

6.3 Links to REACH, according to RoHS Directive Article 5(1)(a)

Do any of the following provisions apply to the application described?

no

☐ Authorisation
- ☐ SVHC
- ☐ Candidate list
- ☐ Proposal inclusion Annex XIV

☐ Restriction
- ☐ Annex XIV
- ☐ Annex XVII
- ☐ Registry of intentions

☐ Registration

Provide REACH-relevant information received through the supply chain.

Not Applicable

7 Removal of mercury from lamps

Can mercury be eliminated?

- ☐ Yes.
- ☒ No, as explained in 6.1.

8 Reduction of mercury content of lamps

In paragraph 6.1 is explained that various attempt have been made in the industry to reduce the mercury content in fluorescent technology. These attempts have been successful, because the amount of mercury has been drastically reduced in the last decades. At the same time, the fluorescent technology can only operate when a certain limited amount of mercury is used. As stated before, there is interdependency between the amount of mercury, the light output per wattage (energy efficiency) and the lifetime of the lamp. To be able to keep this fine balance, it is uncertain if the amount of mercury as stated currently in RoHS can be further reduced while keeping the requirements of lifetime and energy efficiency.

9 Other relevant information

During the 2013 UNEP Minamata Convention on Mercury in Japan agreements were made to limit mercury in various products, including compact fluorescent lamps (Figure 18). This treaty has been agreed upon and signed by 94 countries around the globe. The agreed mercury level for CFLs ≤ 30W is 5 mg.

Mercury-added products	**Date after which the manufacture, import or export of the product shall not be allowed (phase-out date)**
Batteries, except for button zinc silver oxide batteries with a mercury content < 2% and button zinc air batteries with a mercury content < 2%	2020
Switches and relays, except very high accuracy capacitance and loss measurement bridges and high frequency radio frequency switches and relays in monitoring and control instruments with a maximum mercury content of 20 mg per bridge, switch or relay	2020
Compact fluorescent lamps (CFLs) for general lighting purposes that are ≤ 30 watts with a mercury content exceeding 5 mg per lamp burner	2020
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

Figure 18: Section in UN-Minamata treaty on mercury limits for CFL. Source: www.mercuryconvention.org.

10 Information that should be regarded as proprietary

LightingEurope provides to the European Commission under confidentiality a comprehensive list of lamps with average mercury content, which are in the scope of the obligation to publish such data according to the ErP Directive Implementing Measures 244/2009, 245/2009, 1194/2012 and produced by LightingEurope member companies.

List of abbreviations

ADCO	Administrative Cooperation Group
BASI	Bioanalytical Systems, Inc
BSP	Barium Synthetic (Pb^{2+}) phosphor
CCG	Conventional Control Gear
CDM	Ceramic Discharge Metal Halide
CDV	Committee Draft for Voting
CFL	Compact fluorescent lamp
CRI	Color rendering index
CRSO	Collection & Recycling Service Organization
DEFRA	Department for Environment Food and Rural Affairs
DOE	Department of Energy
ECG	Electronic Control Gear
EEE	Electrical and Electronic Equipment
ELC	European Lamp Companies Federation
EM	Electromagnetic: lamp control gear based on a magnetic coil (= CCG)
EMC	Electro Magnetic Compatibility
ERP	Energy related Products; Directive 2009/125/EC establishing a framework for the setting of eco design requirements for energy-related products
FTE	Full Time Equivalent, indicates the workload of an employed person
HF	High frequency: lamp control gear based on high frequency (= ECG)
HID	High intensity discharge lamps
HPS	High Pressure Sodium (vapor) lamps
Hz	Hertz
K	Kelvin: Unit of color temperature (2700 K warm color, 5600K cool daylight)
Lm	Lumen
LFL	Linear Fluorescent Lamps
LCA	Life cycle assessment
LED	Light Emitting Diode
LPD	Low Pressure Discharge lamp
LVD	Low Voltage Directive

mg	Milligram
MH	Metal halide lamps
OEM	Original equipment manufacturer
OLED	Organic Light-Emitting Diode
PCA	Poly-crystalline alumina
PLL	Pi shaped Long Length, compact fluorescent lamp
R&D	Research and Development department(s)
REACH	Regulation on Registration, Evaluation, Authorization and Restriction of Chemicals, 1907/2006/EC
RoHS	EU Directive 2011/65/EU on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment
SSL	Solid State Lighting
SVHC	Substances of Very High Concern
TF	Task Force
UMICORE	global materials technology group which focuses on application areas where its expertise in materials science, chemistry and metallurgy makes a real difference.
UNEP	United Nations Environnent Programme
UV	Ultraviolet
VDE	German Association for Electrical, Electronic and Information Technologies
W	Watt unit of (electrical) power
WEEE	Waste Electrical and Electronic Equipment
ZVEI	German Electrical and Electronic Manufacturers´ Association