LIGHTINGEUROPE
THE VOICE OF THE LIGHTING INDUSTRY

Request to renew Exemption 2(b)(3)

under Annex III of the RoHS Directive 2011/65/EU

2(b) Mercury in other fluorescent lamps not exceeding:
2(b)(3) Non-linear tri-band phosphor lamps with tube diameter > 17 mm (e.g. T9): 15 mg may be used per lamp after 31 December 2011

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1 Name and contact details

Industry Association:	LightingEurope	Tel.:	+32 2 706 86 07
Name:	Attila Morotz	E-Mail: attila.morotz@lightingeurope.org	
Function:	Policy Director	Address: Diamant Building Boulevard Auguste Reyers 80 1030 Brussels, Belgium	

2 Reason for application

LightingEurope submits this application to:	*request for extension of existing exemption* ***no. 2(b)(3) of Annex III***
LightingEurope proposes to continue using the existing wording which is:	*2(b) Mercury in other fluorescent lamps not exceeding:* *2(b)(3) Non-linear tri-band phosphor lamps with tube diameter > 17 mm (e.g. T9): 15 mg may be used per lamp after 31 December 2011*
LightingEurope requests a duration of	*Maximum validity period required*

3 Summary of the exemption request

Per DIRECTIVE 2011/65/EU Article 5(2) Annex III Exemption 2(a)(2) will expire 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

2(b) Mercury in other fluorescent lamps not exceeding:

2(b)(3) Non-linear tri-band phosphor lamps with tube diameter > 17 mm (e.g. T9): 15 mg may be used per lamp after 31 December 2011

Non-linear triband phosphor fluorescent lamps for general lighting covered by this exemption are a small group of energy- and resource-efficient lamps required in the EU market.

They are widely used in public buildings, restaurants, industry, shops, supermarkets and department stores as well as for street and city lighting.

Non-linear triband phosphor lamps contain a small amount of intentionally added mercury in the discharge tube, which is essential to convert electrical energy in light. Mercury consumption of fluorescent tubes dropped approximately 90% in the past 20 years by implementing energy efficiency regulations, RoHS requirements and innovation programs.

There are no specific market data available for the lamps covered by this exemption. Considering EU-28 sales data for lamps covered by the exemption 1(e), 2(b)(2), 2(b3), 2(b)(4) and 4(a) of Annex III, RoHS Directive marketed in EU-28 there is a decreasing market from 2009 to 2013. In 2013 ca. 19 Mio non-linear and special purpose lamps have been marketed[1]. The overall roughly estimated yearly mercury input decreased from 2009 to 2013 from ca 510 kg to 190 kg (-63%, decrease per lamp: -33%).

With its limited sets of components, fluorescent tubes are very resource efficient. There are systems in place for efficient recycling (WEEE), resulting in reduced impact of mercury and other materials on the environment.

There are relatively few nonlinear LED based replacement lamps, none of which could be considered as fully compatible and direct replacement for conventional lamps in existing applications. It must be decided case by case, if the LED based solution can be an effective replacement for the existing fixture and situation. It mostly requires involvement of people with professional expertise due to the following issues:

1) Electrical compatibility: A LED tube has to operate on the installed control gear without any problems. It can require technical changes to the luminaire (rewiring), especially in luminaires equipped with electronic control gears.
2) Applicable legal and compliance requirements like conformity assessments, declaration, and labelling of the changed luminaire are needed.
3) Different light distribution: due to the LED tubes changed optical characteristics vs. the existing fluorescent lamps.

[1] Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements (‘Lot 8/9/19) Draft Interim Report, Task 2, Nov.2014, VITO, VHK

4) LED lamps do contain electronic components as well as materials which like nearly all other electronic equipment use the RoHS regulated substance lead in applications exempted by Annex III of the Directive.

Another growing market approach is the use of integrated LED luminaires, but this requires full luminaire replacement including the additional high investment and negative environmental impact. There are no data available about number of luminaires, equipment and fixtures using non-linear lamps. With a conservative assumption 500€ per luminaire incl. installation would be needed for replacement creating 5-10 kg WEEE for each still functional and energy efficient equipment.

In the absence of public funding and support programs, conventional technologies such as fluorescent support the investment of new LED development almost exclusively. The requirements mentioned in Article 5(a) of the RoHS Directive for the inclusion of materials and components of EEE for specific applications in the list in Annex III are met for mercury in non-linear tri-band phosphor lamps for general lighting covered by this exemption and not exceeding 15 mg per lamp as summarized in Table 1:

Requirement according RoHS Article 5(a)	**Status for mercury in non-linear triband phosphor fluorescent lamps for general lighting not exceeding 15 mg per lamp**
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 replacement of Mercury in non-linear fluorescent lamps is scientifically and technically impracticable. Currently there are no significant LED retrofit lamps available in the market. Alternatively installed luminaires can be replaced with very high socioeconomic impact by mercury-free fixtures. This solution requires lead in materials and electronic applications currently exempted according Annex III of the RoHS Directive.
the reliability of substitutes is not ensured,	Only few nonlinear LED replacements are available, hence reliability cannot judged, Correctly installed LED based luminaires are considered to be reliable.
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.	LED based luminaires so far do not reveal a clear general environmental benefit e.g. due to higher energy efficiency during the use phase.

Table 1: Requirements according RoHS Article 5/a) and their fulfilment for mercury in non-linear triband phosphor lamps for general lighting with a diameter >17 mm not exceeding 15 mg per lamp.

For this reason an exemption for mercury in lamps covered by the exemption is required with a maximum validity period and with 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 mercury in non-linear fluorescent tri-band phosphor lamps for general lighting purposes with normal lifetime and a tube diameter > *17 mm* (e.g. circular T9 or T12 lamps or U-shaped T8 lamps, see figure 1). The maximum allowed mercury dose is currently 15 mg per lamp.

The majority of lamps currently put on the EU market by members of LightingEurope are T9 circular or T8 U-shaped lamps with standardised dimensions and base. These lamps with a diameter of ca. 26 mm (T8) or 29 mm (T9) are very economical, offer a good quality of light having a very good luminous flux. They are compact with good average lifetime with suitable electronic control gear. Regarding the main applications (see 4.1.2) the lamps are in use mainly in professional areas but sometimes also in private homes.

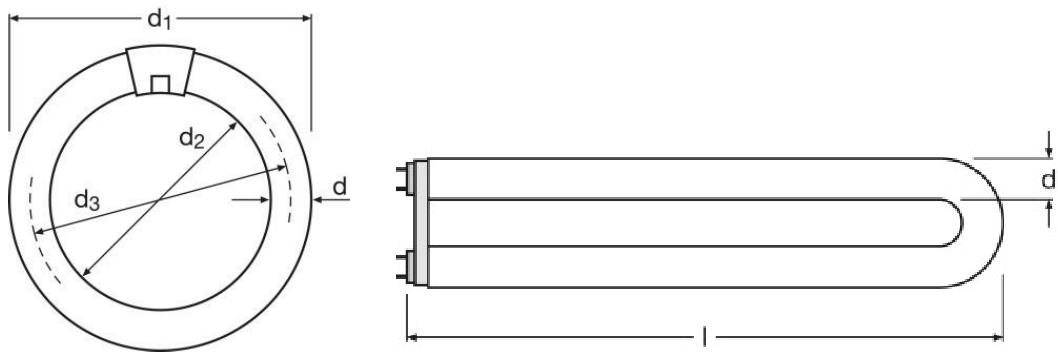

Figure 1: Drawing/picture of a T9 circular and a T8 U-shaped lamp.

Double capped fluorescent lamps are always components of a lighting system. Because of the physics of gas discharge, fluorescent lamps cannot be operated directly on ac line voltage. Conventional control gears (CCG) have traditionally been used to limit the current. T8/9/12 lamps in a luminaire with a CCG usually need a so-called starter, an electronic component which is replaced together with the lamp due to a limited life time. The introduction of electronic control gears (ECG) brought several advantages compared to CCG regarding power consumption, lifetime, maintenance costs, temperature behaviour, switching, flicker, dimming etc..

Non-linear tri-band phosphor lamps with tube diameter > 17 mm can be used with CCG as well as with ECG. There are numerous different control gears available on the market offering various functionalities. They are used depending on customer requirements, such as dimming or temperature range. International standards make sure that lamps, control gears and light management systems can be operated in a safe and efficient way and that lamps and control gear can be exchanged while keeping a reliable system. It is essential that only suitable combinations of lamps and luminaires are installed and maintained.

Further description:

	U-shaped T8	Circular T9
Available types and wattages (main types used in EU):	18, 36, 58 Watt	22, 32, 40 Watt
Available Colour Temperatures: 2.700K up to 6.500K	2.700 - 6.500K	
Typical Colour Rendering Index (Ra):	80- >90	
Base (standard designation): G13 (bi-pin), IEC/EN60061),	2G13	G10q
Typical average Lifetime[2]	13.000h	7.500h
Dimmable	yes	

Figure 2: Pictures of a T9 circular (G10q) and a T8 U-shaped lamp (2G13)

[2] Here: **Average rated lamp life (B50)** which is the average value of the life values of individual lamps operated under standardized conditions (50 % failure). In other words, this is the operation time at which for a standardized 3-hour switching cycle (165 minutes on/15 minutes off in accordance with IEC 60081 and IEC 60901) 50 % of asample population of lamps have failed.

4.1.2 Applications covered by this exemption

The most important lamp families falling in this exemption are circular T9 lamps as well as U-shaped T8 lamps.

T9 circular fluorescent lamps are designed for operation in standardised luminaires, operating on conventional or electronic control gear in many areas applications. They are in use in public buildings, hotels, restaurants, shops, industry and can also be found in private households. They are economical, offering good quality of light and excellent uniform illumination with no shadows. The average lifetime is good.

U-shaped T8 lamps are designed for operation in standardised luminaires, operating on conventional or electronic control gear mainly for street and city lighting as well as in industrial facilities. They are economical, offering good quality of light. The average lifetime is good.




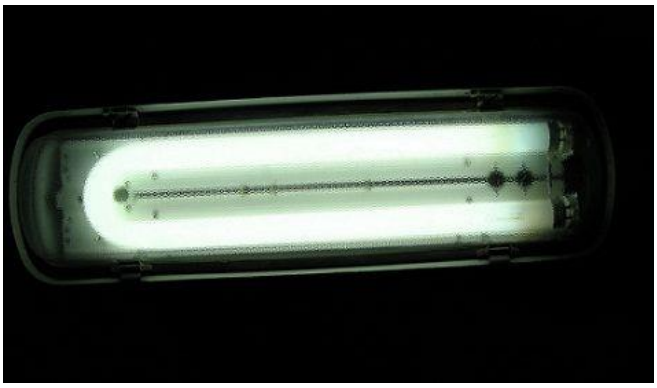

Figure 3: T9 circline and T8 U-bent applications; Source and Copyright:
Row 1, left: http://www.shinlight.com/photo/shinlight/editor/20130929152820_63144.jpg
Row 1, right: http://hi.atgimg.com/img/x/39/8mc200-bk.jpg
Row 2, left: http://i01.i.aliimg.com/img/pb/472/197/746/746197472_648.jpg

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

Lamps covered by exemption 2(b)(3) are considered to be category 5: “Lighting equipment”.

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

Not applicable, see comment below

Equipment of category 8 and 9: Not applicable, see comment below

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 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 in any RoHS category 1 - 11.

LightingEurope 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). The way that lamps are used has no effect on lamp design so will not affect this exemption request.

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

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

Mercury is intentionally applied to fluorescent lamps in homogenous materials exceeding the limit value of 0.1% weight. Fluorescent lamps are low-pressure discharge lamps. When electric current flows through the lamp bulb (=discharge tube), the mercury atoms in a gas phase inside it are excited and produce UV radiation. This UV light is then converted into visible light by the fluorescent coating on the internal surface of the glass tube of the lamp bulb (see figure 4). The composition of the coating determines light colour and colour rendering.

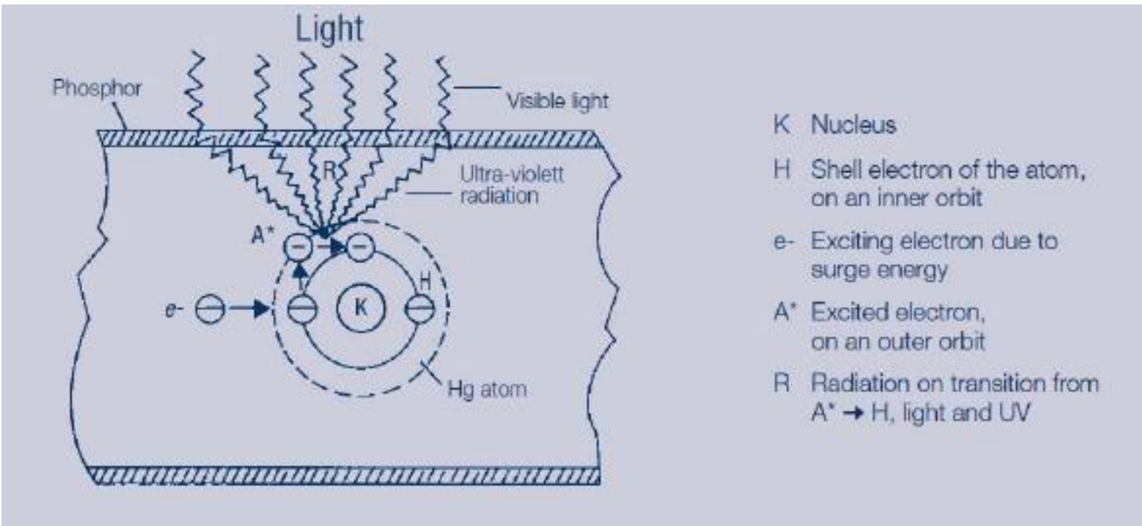

Figure 4:
Electrical current is passed via the two filament electrodes through the tube which is filled with partially ionized gas. The electrons excite mercury atoms to emit short-wave ultra-violet light, which is converted into visible light in the phosphor layer on the inside of the tube. Different light colors are produced depending on the phosphor mix [3].

4.2.3 Location of mercury in lamps

Mercury is present in the so-called discharge tube or burner. There are various technologies to add it to the discharge tube, the so-called dosing techniques. Over the last decennia the dosing techniques became much more accurate, so less mercury can

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[3] http://www.osram.com/media/resource/hires/334404/dulux-fibel.pdf

be applied with a specific variance. This is needed to guarantee both the lifetime of the lamp and to fulfill the ROHS requirements of a maximum mercury dose at the same time. Below the most common dosing technologies for single- and double capped fluorescent lamps are listed and displayed in figure 5.

- Manual pipetting or needle injection of liquid mercury
- Semi- or fully automatic dosing, disc needle injection of liquid mercury
- Glass capsules containing a specified amount of mercury
- Pressed pills containing Fe, Cu with Hg
- Metall alloy shield with Ti_3Hg, an inter-metallic compound
- Dosing amalgams Sn-Hg / Zn-Hg / Bi-Hg/ Bi-In-Hg
- Steering (or control) amalgams Bi-In-Hg / Bi-Sn-In-Hg

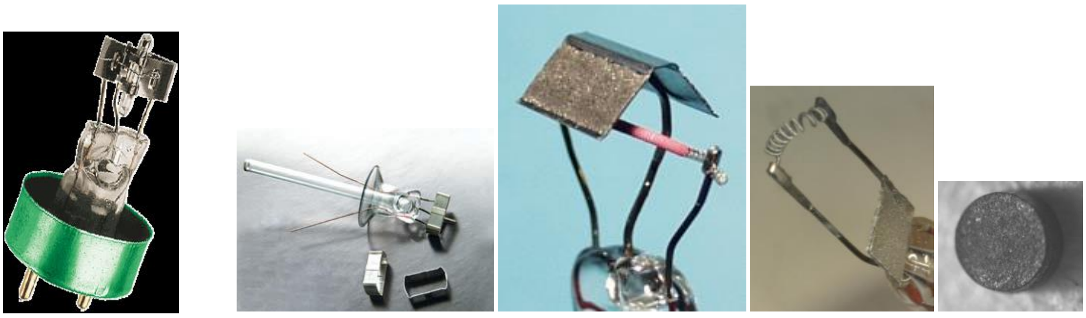

Figure 5: Mercury dosing technologies
From left: Hg-capsule; metal-alloy[4], metal alloy "roof", metal alloy "flag", HgFe pill

4.2.4 Amount of mercury

Mercury is dosed in the discharge tube during lamp manufacturing as homogeneous material (pill, capsule). 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. During lamp life, mercury is consumed inside the discharge tube itself. It is bound amongst others to the phosphor layer and the glass.[5]

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

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[4] I. Snijkers-Hendrickx et. al., Low-mercury containing discharge lamps, 2007,
[5] *Reference: I. Snijkers-Hendrickx et al, Low-Mercury Containing Discharge Lamps. Sustainable and Environmental Friendly Lighting Solutions, LS 11*

scatters around the nominal dose, while the threshold value as set by RoHS Directive sets a maximum limit of 15 mg for the lamps covered by this exemption.

For fluorescent lamps a high effort was necessary to implement all limit changes coming in force in 2010[6] with effect between 2012 and 2013. The maximum mercury content of non-linear tri-band phosphor lamps with tube diameter > 17 mm had to be reduced to 15 mg per burner as of 1st Jan 2012.

In order to be able to dose the required amounts of mercury precise technologies are necessary and available[7]. But even with accurate technologies there is a certain distribution of the amount of mercury per single dose. The different dosing techniques have different variances. So for example the effective mercury content of lamps with a target or average value of 12 mg can vary between 10.5-13.5 mg (see Figure 6). For manufacturers, an additional "safety margin" (as explained above) is essential to have legal certainty that a product is within the limit. So while in practice the average value may be 12.0 mg, the needed RoHS value in this example may be as high as 14 or higher[8].

Figure 6 also shows that the average value in lamps is clearly much lower than the limit value required per lamp or burner. Manufacturers communicate usually this average lamp mercury content as X.X mg in their product documentation according to ErP Implementing Measure requirement[9].

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[6] Commission Decision 2010/571/EU of 24 September 2010
7 Lamp manufacturers have developed their own proprietary solutions, or have co-developed with independent suppliers, who can offer also solutions to other lamp manufacturers.
8 ELC Exemption request, 2012
http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_VI/Request_7/ELCF_Exemption_Request7_Mercury_long_life_CFL.pdf
9 Regulation (EC) No 245/2009 amended by Regulation (EC) 347/2010

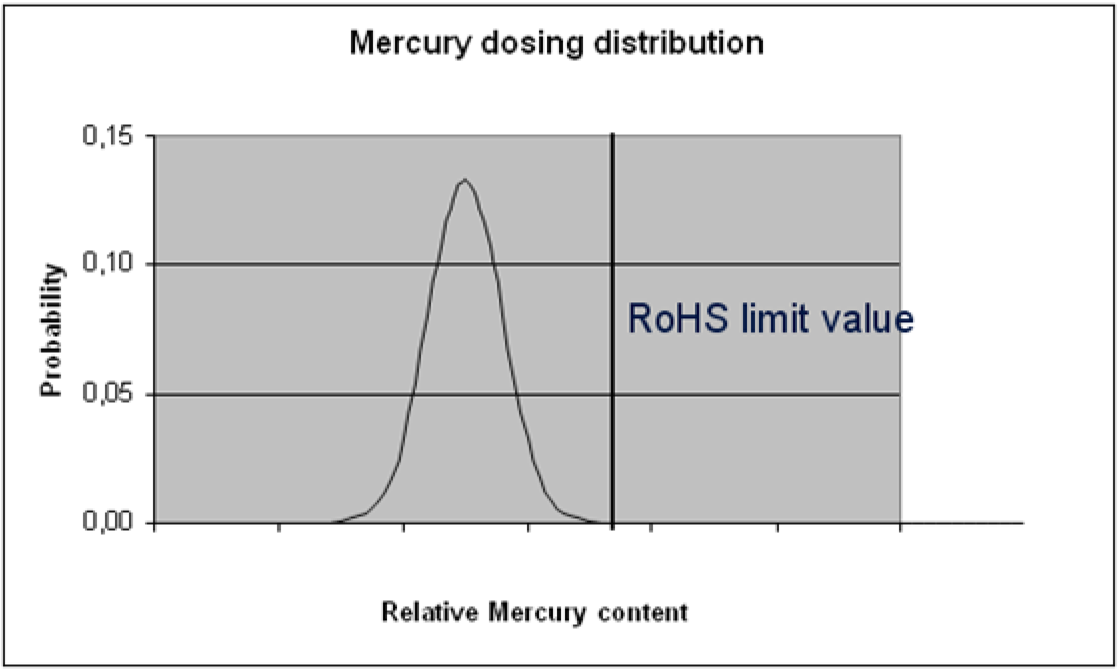

Figure 6: Simplified illustration (example only) of the effect of mercury dosing variance, where average value needs to be chosen lower than the RoHS limit value. The graph displays measurements of the mercury content in dosing units performed as quality control during their production, here FeHg pill.

The most important aspect of Hg content in lamps is the so-called *mercury consumption.*

The amount of mercury which is needed for the low pressure discharge process is very low, significantly below 100 µg per lamp. But there are many processes within the burner, potentially more than 100 have been identified, which make a part of the mercury unavailable for the discharge over lifetime. This is called mercury consumption and is the reason why more mercury has to be dosed, so that the intended lifetime is shortened due to low available mercury. Therefore a balance has to be found taking into account mercury needed over lifetime, mercury variance per dosing unit but also the measurement failure when estimating the amount of mercury in a lamp for market surveillance.

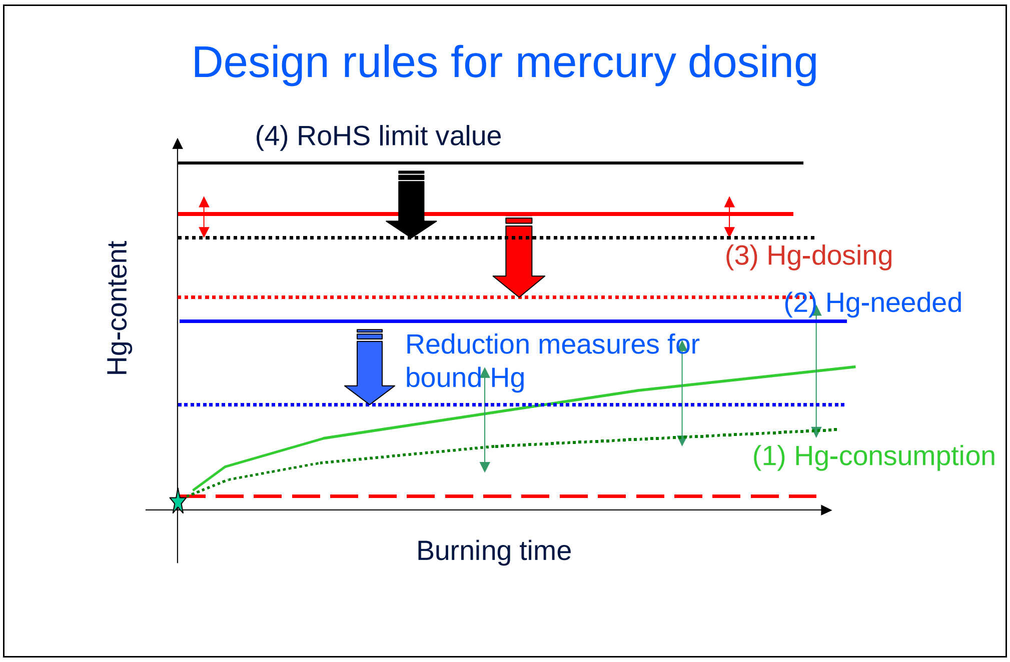

Figure 7: Design rules for mercury dosing in fluorescent lamps, schematically showing the process of setting RoHS limit values based on insights in mercury consumption and mercury dosing.

The lowest (red dashed) line in figure 7 gives the ideal situation for a low pressure mercury discharge: there is just enough mercury for the discharge to properly function. For a T8 fluorescent lamp this is typically in the order of 60 micrograms per lamp (in the gas-phase), depending on the lamp dimensions. However, because of the several mercury consumption mechanisms a significantly higher amount must be dosed (which will be explained below). So up to now a lamp with normal functional properties over lifetime, but dosed with only 60 microgram could not be designed.

In practice, mercury from the discharge gets consumed over lamp life. The amount of this consumption is much higher than that what the gas discharge needs for functioning. The mercury gets mostly deposited and effectively bonded to the glass and the phosphor layer. This is reflected by the solid green curve (1) in figure 7, 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 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. In figure 7 solid blue line 2 represents the typical amount that is needed and 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 7 is the line representing the RoHS limit (expressed as mg per lamp), the value of which has to take into account both variances of mercury consumption and of mercury dosing. On the one hand, we 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[10],[11](the lifetime and performance are regulated). 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. Figure 6 shows the dosing variety relatively to the RoHS threshold value.

Next to the important effect the variance in mercury dosing has on setting the average dose lower than the threshold value as prescribed in the RoHS directive, there is another effect on the low end-side of the dosing. The lower the amount that is available in the lamp, the lower the lamp lifetime as mercury is consumed during operation. This can result in too early failure, thus a customer risk as already mentioned, but next to this there are criteria set on lamp lifetime and lamp survival factor in other directives and regulations[12],[13].

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:

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

Once mercury is bound to these, it is no longer available to emit ultraviolet light. The schematic effect is the lowering of the solid curve 1 to the dashed curve in figure 7.

[10] *Commission regulation (EC) No. 244/2009, March 18, 2009*
[11] *Commission regulation (EC) No. 245/2009, March 18, 2009*

Path	Mechanism	Main Promoter	Source	Location of bound Hg
Oxidation	$Hg^{+} + x\,O \rightarrow HgO_x$	impurities prematerials	processing coating	coating
Amalgamation	$Hg^{+} + Me \rightarrow HgMe$ Me: e.g Ba, Na, Sr,...	emitter impurities glass	processing emitter electrode	coating
Adsorption	Hg^{+} - adsorption on surfaces	surface charge, electronegativity	Hg+, e-, Ions, electric potentials.	coating
Absorption	Hg^{+} - diffusion/ incorporation in bulk	prematerials glass	Hg+, e-, Ions, chemical potentials.	glass, coating, components

Table 2: Main mercury consumption mechanisms oxidation, amalgamation, adsorption and absorbtion. Mercury diffuses into the glass tube or can be found as "inactive" mercury compounds in the phosphor coating and is no longer available for the discharge process.

Table 2 shows an overview on the different major paths of mercury consumption which is oxidation, amalgamation, adsorption and absorption. A part of the mercury dosed in a lamp is "consumed" meaning that it is no longer available for the light-producing discharge process. Mercury diffuses into the glass tube or can be found as "inactive" mercury compounds in the phosphor coating. Depending on many different factors such as phosphor composition, lamp chemicals (e.g. getter, emitter), production, use etc. consumption is individual for every lamp.

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 the recent years.

Non-linear fluorescent lamps always need more mercury compared to linear lamps. The main reason for this effect lies in the production process. Lamp production starts with a linear glass tube, to which coatings on glass are applied as well as the phosphor layer. After these processes the tube is brought in a circular, U-form or other non-linear structural shape. This process has influence on the coating and phosphor layers as small cracks are created where the glass is bent. So more mercury diffuses into the glass tube during operational lamp life meaning more mercury is consumed in these lamps.

Measurements of mercury consumption are performed under controlled, optimized laboratory conditions using standardised switching cycles. Operation conditions can significantly increase the consumption (e.g. depending on dimming, switching frequency, high/low temperatures, use as emergency lighting, mains voltage, ballast etc.). This has to be taken into account to find the necessary Hg dosing amount. It is very important that mercury does not reach the limiting factor for the lifetime.

In summary, one has to distinguish between maximum limit value and the mercury content, that on average needs to have a much lower, average or nominal value, to account for variance in lamp manufacturing and operation and to account for market surveillance, with adequate protection of both customer and producer.

Annual Mercury content of non-linear lamps marketed in EU-28:

There are limited statistical data available for non-linear T8 or T9 lamps. T12 lamps are considered to have a niche market only.

In the following table the market (number of produced lamps [Mio pieces]) and the corresponding mercury amount put on the EU-28 market is listed from 2009 to 2013[14]. The lamps in table 3 (“Other FL”) are all lamps covered by the exemption 1(e), 2(b)(2), 2(b3), 2(b)(4) and 4(a) of Annex III, RoHS Directive. The average mercury amounts per lamp are estimated by LightingEurope member companies as displayed in the table. The corresponding average mercury amount per lamp is also displayed. This can be seen more as a worst case estimation, especially for 2012-2013, where a maximum limit of 15 mg was introduced. The data show a decreasing market from 2009 to 2013. In 2013 ca. 19 Mio non-linear and special purpose lamps have been marketed The overall roughly estimated yearly mercury input decreased from 2009 to 2013 from ca. 510 kg to 190 kg (-63%, decrease per lamp: -33%).

[14] Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements (‘Lot 8/9/19) Draft Interim Report, Task 2, Nov.2014, VITO, VHK

EU28	2009	2010	2011	2012	2013
Other FL [Mio pcs.]	34	32	27	23	19
Mercury [kg]	510	480	324	230	190
Average Hg content of lamps [mg]	15,0	15,0	12,0	10,0	10,0

Table 3: Market and mercury content of lamps covered by the exemptions 1(e), 2(b)(2), 2(b)(3), 2(b)(4) and 4(a) of Annex III, RoHS Directive [Mio pcs.]. Data represent sales in EU-28[14].Mercury content has been estimated by LightingEurope.

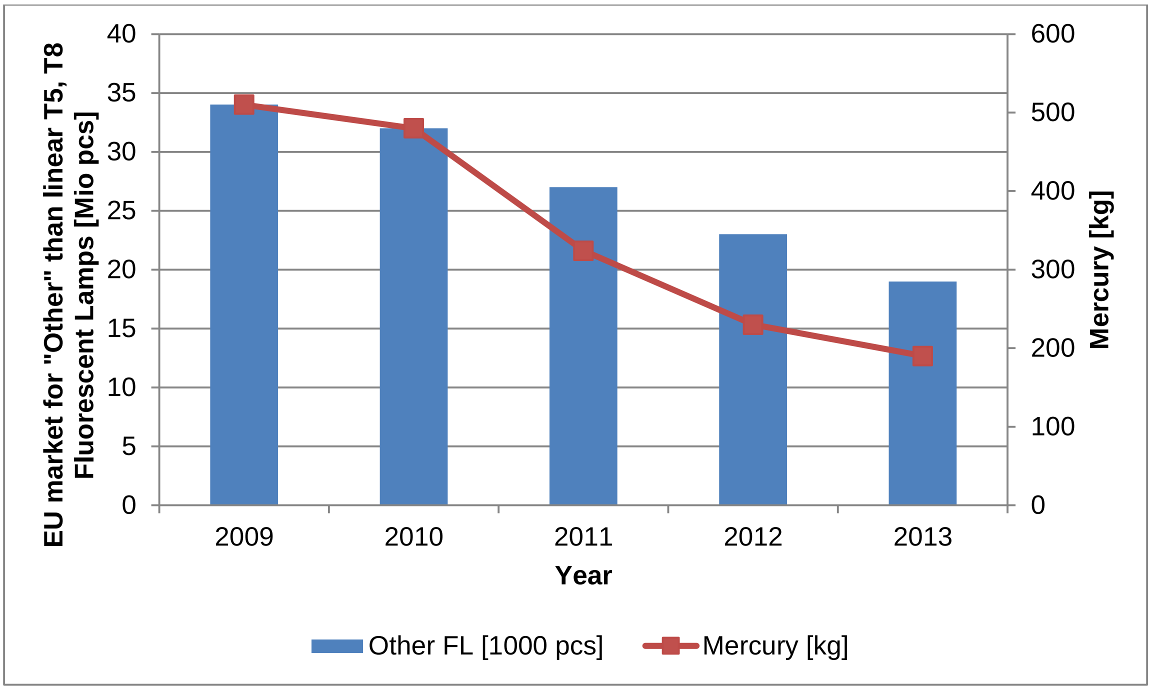

Table 4: The graph displays the lamp sales as well as the total mercury input of table 3

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.[15] 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).[16] 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

[15] *(see Enlighten report, Section 5, Ch. 3 fig. 4 & 5)*
[16] *(see Enlighten report, Section 5, Ch. 3 fig.6)*

decades.[17] Manufacturers have developed technology that enables a small amount of mercury to be 'dosed' or placed inside a fluorescent lamps[18].

For the future however the manufacturing part in the LCA becomes more relevant19, because the energy consumption by the lamp is already dramatically reduced (higher efficacy 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 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[20,] 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[21], 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.[22] LED lamp product manufacturing uses considerably more energy than does the manufacturing of a fluorescent lamp with comparable light output[23]. However one

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[17] 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, UNEP toolkit, p.106

[18] Complete paragraph UNEP toolkit, p.106

[19] Life cycle assessment of light sources – Case studies and review of the analyses Leena Tähkämö, Aalto University publication series DOCTORAL DISSERTATIONS 111/2013

[20] 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

[21] 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,

[22] 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

[23] U.S. Department of Energy. (2012). Life-Cycle Assessment of Energy and Environmental Impacts of LED Lighting Products. Retrieved March 10, 2012 from

must consider the improving LED alternative in the right perspective: according to reference[24] the LED sources are expected to have a real advantage in the total life cycle over time, at least if efficiency keeps improving at the same rate and given their relatively long life.

For non-linear T8, T9 and T12 lamps no significant LED retrofit solutions are currently available in the EU market, which can be used in respective fluorescent lamp luminaire. Those lamps which are available often need technically changes in the luminaire. Instead new LED solutions are replacing non-linear fluorescent lamps in new products, such as LED street lighting systems.

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

Double capped linear 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 can bring back the lamps free of charge. Double capped linear 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.

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

Below picture shows the various steps in the recycling process:

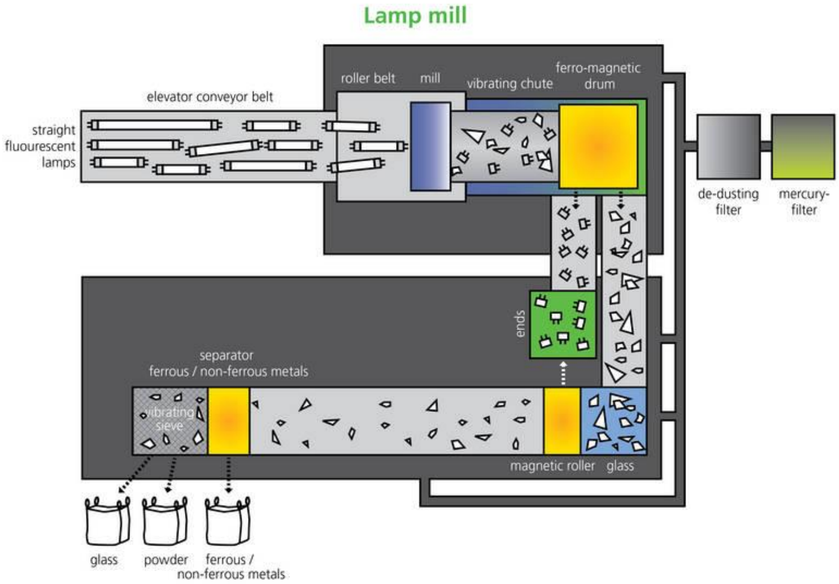

Figure 8a Recycling steps of fluorescent lamps in Indaver (Belgium).
Source: www.indaver.be/waste-treatment/recycling/mercurial-waste.html

The next picture illustrates the specifics of recycling the mercury:

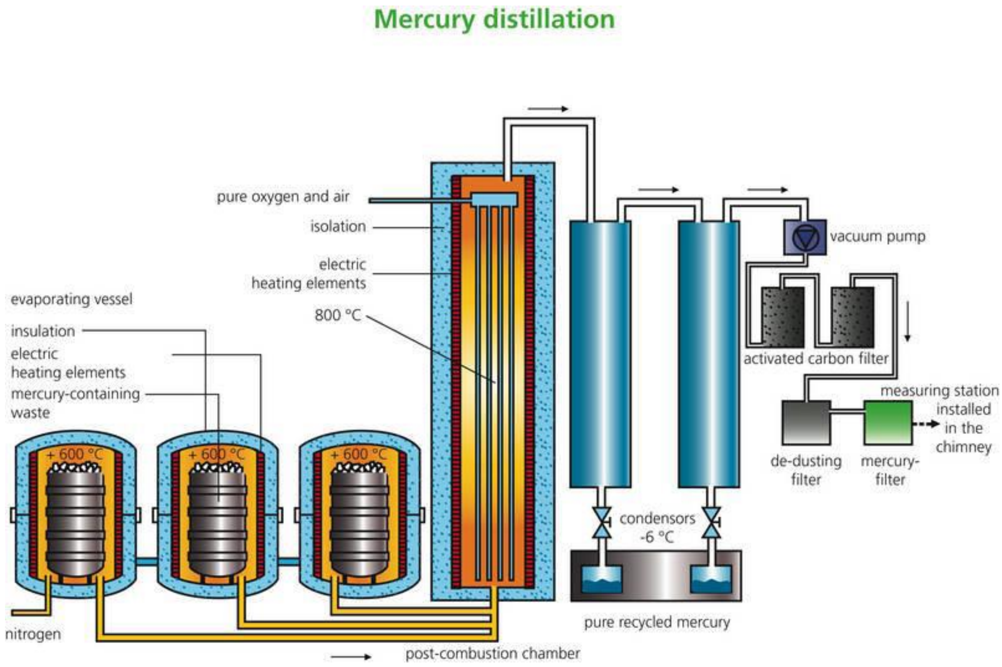

Figure 8b Specific recycling steps of mercury in Indaver (Belgium)

European legislation on Waste Electrical and Electronic Equipment 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 EEE 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 9: Stibat/Wecycle-collection street as present in the Dutch Do-it-yourself shops of Gamma.

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.

Mercury content market:

Non-Linear T8, T9 or T12 lamps for general lighting as covered by exemption 2(b)(3) is a small segment of all fluorescent lamps.

In table 3 of chapter 4.2.4 the market (number of produced lamps [Mio pieces]) and the corresponding mercury amount put on the EU-28 market is listed from 2009 to 2013[25]. The overall roughly estimated yearly mercury input of all lamps covered by the exemptions 1(e), 2(b)(2), 2(b3), 2(b)(4) and 4(a) of Annex III, RoHS Directive decreased from 2009 to 2013 from ca 510 kg to 190 kg (-63%).

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. It also includes the targets set for 2016 and 2019. Please be aware that this graph includes all lamp types, not specific ones.

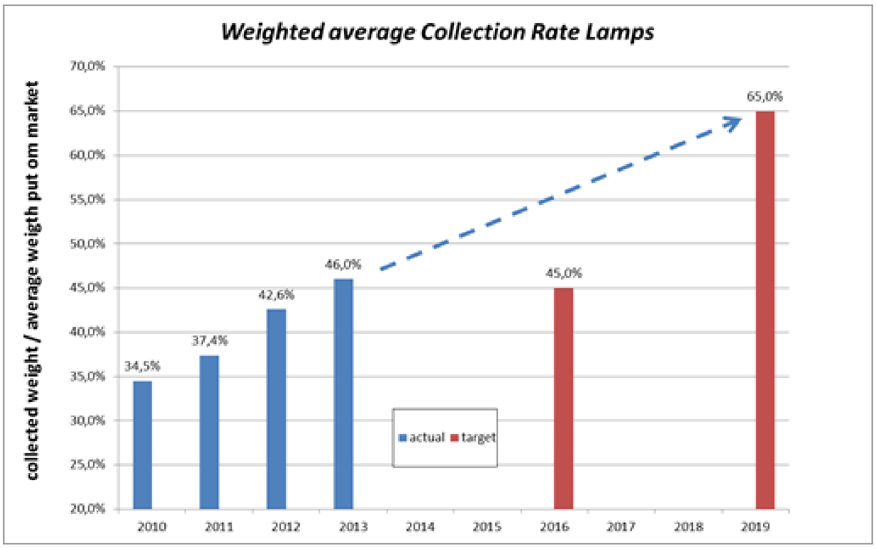

Figure 10: Weighted average Collection Rate Lamps (all lamps): 2010 – 2013 (blue) and targets 2016-2019 (red)

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

[25] Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements ('Lot 8/9/19) Draft Interim Report, Task 2, Nov.2014, VITO, VHK

of CFL lamps is continuously increasing, contributing to the overall mercury reduction program.

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

- CFL lamps and other non-linear low- or high pressure lamps as well as LED retrofit lamps
- Fluorescent tubes, long CFL without integrated ballast

Linear fluorescent lamps are recycled separately. It is also important to note that almost every country within EU has a collection and recycling service organisation (figure 12, status per 2009).

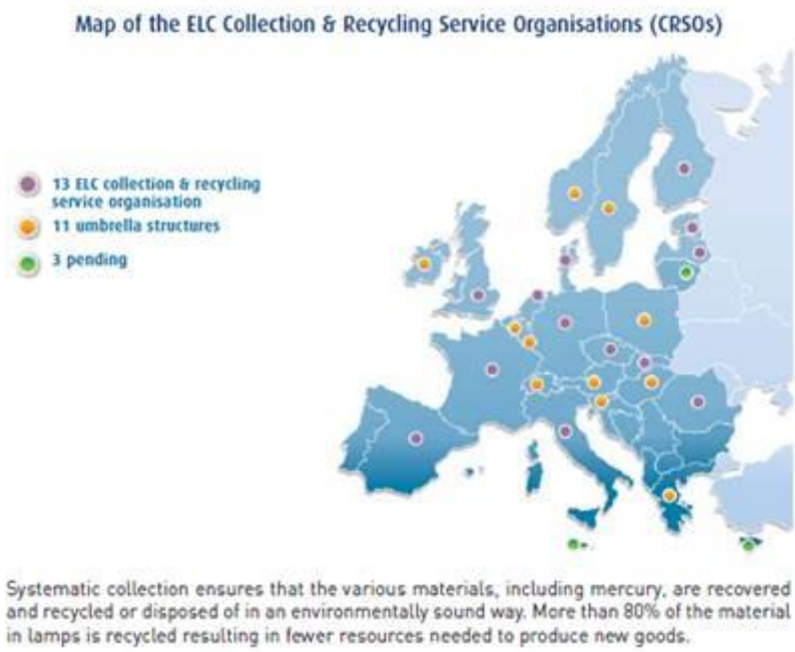

Figure 11: Map of ELC Collection and Recycling Service Organisations (CRSOs). Source: Environmental aspects of lamps[26]

6 Substitution

Can the substance of this exemption be substituted?

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

☒ No

Justification: see in below chapters

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

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. And the average amount of mercury within fluorescent technology per lamp is considerably reduced (see figure 12).

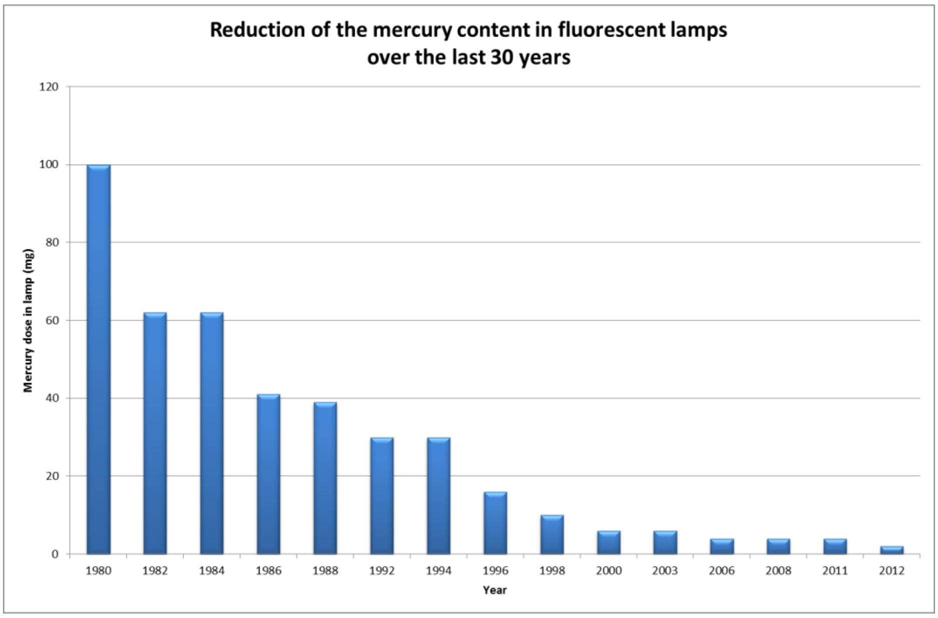

Figure 12: Mercury content of fluorescent lamps

During the last decades several approaches have been made to design low pressure discharge lamps where the light producing element Hg is replaced by a less hazardous material. So far no approach yielded a result with comparable luminous efficacy, product cost and product availability as the still state of the art Hg low pressure discharge lamps.

The mercury discharge is highly efficient in transforming electrical energy into light. There are only two drawbacks: first the generated UV radiation needs to be transformed into visible light, where large losses occur: this is due to the Stokes shift (an energetic UV photon generates, a much lower energy, visible photon) and secondly the discharge contains mercury[27].

Attempts to generate UV with noble gases succeeded partially[28]. However the plasma radiates in the deep UV. At these wavelengths, the Stokes shift is even larger causing

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[27] M Haverlag, Mercury-free discharges for lighting, J. Phys. D: Appl. Phys. 40 (2007)
[28] 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)

lower efficiency. The lack of suitable phosphors[29] prohibited progress in this direction. Other alternatives investigated are low pressure metal halides (for example InI, InBr, GaI3)[30]. Such plasma's generate the visible light directly without the Stokes shift of the phosphor31. There are alternatives from research but the efficiency in prototypes lamps is significantly reduced to approx. 40 lm/W level or below.

One approach has been the dielectric barrier discharge, which uses a Xe excimer as light producing species. It had been developed into a product with an efficacy of about 20 lm/W. As no solution for improvement has been found and regular Hg linear fluorescent lamps operate at up to 120 lm/W these products were not very successful in the market and used only for very special purposes.

Using rare gases instead of mercury leads to a dramatic efficiency drop. Upgrading to similar performance would imply unjustifiable efforts with unknown chance of success (limit of the technology reached) and possibly resulting in a larger negative environmental impact.

Low operating temperature and immediate lumen output could be reached if a light producing species is used which is in gaseous state at room temperature. There had been the theoretical idea that it might be possible to find a suitable operating regime for a nitrogen - rare gas low pressure discharge. In cooperation with the University of Augsburg and the Bayerische Forschungsstiftung (BFS) a project has been started to develop such a light source. The status of research work has been published in a Diploma Thesis and a publication[32]. In 2013 it became quite clear that an efficacy of more than 10lm/W cannot be realized with the approaches followed so far. Therefore the BFS cancelled the project support and in consequence the whole research work has been stopped.

Another approach has been to use metal halide compounds as light source in low pressure discharge. This activity has been carried out in manufacturers laboratories as well as in cooperation with the University of Augsburg. In his PhD thesis "Spectroscopic

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

[30] 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.

[31] 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 looses 67% of the energy when transformed into the same visible photon.

[32] Diploma Thesis "Spektrale Intensität der N2-Strahlung in einer Argon-Niederdruck-Bogenentladung für den Einsatz als Lichtquelle", published 2009 by R. Friedl at the University of Augsburg; „Spectral intensity of the N2 emission in argon low-pressure arc discharges for lighting purposes", R. Friedl, U. Fantz, New J. Phys. 14 043016 ,2012;

Investigation of Indium Halides as Substitutes of Mercury in Low Pressure Discharges for Lighting Applications", published 2011 at the university of Augsburg, S. Briefi shows that currently about 30lm/W might be reached with a potential to get up to 60lm/W. This efficacy is still much lower than Hg containing LPD lamps show. Furthermore, a metal halide LPD lamp needs to be heated up to > 200°C to get the lighting salt evaporated. This causes special issues for safety and very slow run-up behavior.

With the arrival of equally efficient LED light sources, research to alternative discharges has stopped at most companies and universities.

6.2 Substituting florescent technology by mercury free technology

Two key ways to use LED technology in order to substitute fluorescent lamps can be distinguished: (1) replacement lamps, (2) new installation (either new buildings or refurbished areas). Currently LightingEurope is not aware of any relevant nonlinear T8 or T9 LED replacement lamps being available on the EU market.

6.2.1 Feasibility of alternatives

LightingEurope describes three key aspects that need to be considered when evaluating potential LED based replacement for conventional fluorescent based lighting applications: (1) electrical compatibility, (2) Light distribution and lumen output, (3) Lack of standards and especially for this exemption (4) Purpose.

Replacement lamps

The non-linear LED replacement market is in its very initial stage. To the best knowledge of LightingEurope members, only limited examples of such lamps can be found on European market and none of them can be considered as fully compatible with existing applications, due to following issues:.

(1) Electrical compatibility

Non linear fluorescent lamps are uniformly used with all possible lamp drivers designed according to the relevant IEC standards. The key for usage of a LED tube as a replacement lamp in an installed luminaire is its electrical compatibility with the existing control gear. However this is far from comprehensive due to the complexity of the installed park with respect to control gear. Two main driver systems installed in the market are conventional control gears CCG (electromagnetic 50/60Hz) with additional external starter as well as electronic control gear ECG (high frequency) drivers with integrated starter circuits. The ECG drivers are also available in various kinds, ranging from electrode pre -heated to cold start drivers and from current-, power- and voltage-controlled to fixed output and dimming drivers.

For the purpose of this exemption renewal request LightingEurope would like to refer and adapt definitions used in a document "LED lamps as substitutes for fluorescent lamps"[33], by the German associations ZVEI[34] and VDE[35]. This document explains the use of double-capped LED lamps with G13 caps (e.g. LED tubes) in existing luminaires. Two possible situations of replacing a linear fluorescent lamp with G13 cap (e.g. fluorescent T8) are mentioned there being the retrofit and conversion *lamps*. Lighting Europe prefers to refer to the retrofit and conversion *routes.*

- Retrofit route: a fluorescent lamp is substituted by a LED tube. The luminaire itself is not rebuilt[36] and the control gear remains in the installation[37]. Driver compatibility is assumed here.
- Conversion route: the fluorescent 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[38].

As explained in the earlier paragraph retrofit route can be taken if driver compatibility is secured. However unskilled end-user, customer and consumer might be confronted with compatibility issues and wrongly (also unintentionally) chosen LED tube, which will work improperly in existing application. In such situation one will be forced to take out the control gear from his installation and directly connect a LED source to mains voltage (rewiring).

In assessing the suitability of any specific product or installation the user must make his own judgement and/or take appropriate advice[39]. Conversion route can be considered as: (1) complicated, (2) requiring additional compliance and conformity efforts.

Lighting Europe would like to refer to: (1) ZVEI document, where is stated that "*luminaires may only be adapted to accept conversion lamps*[40] *by appropriately trained*

[33] ZVEI and VDE document LA-T 2012-025: "LED lamps as substitutes for fluorescent lamps", 2012 http://www.zvei.org/Publikationen/LED%20tubes%20-%202012-01-26%20english.pdf

[34] ZVEI - Zentralverband Elektrotechnik- und Elektronikindustrie e.V, Eng: German Electrical and Electronic Manufacturers' Association, www.zvei.org;

[35] VDE - Prüf- und Zertifizierungsinstitut, Eng: VDE Testing and Certification Institute, www.vde.com

[36] Op.cit. ZVEI

[37] The replacement of a glow starter compliant with IEC 60155 with other devices does not constitute a modification of the luminaire itself, however the use of such a starter needs to be safe when used in luminaires

[38] Op.cit. ZVEI

[39] CELMA position paper: T5 and T8 Fluorescent Lamp and LED Lamp/Module Adaptors "Retro-fit Conversion Units" for T8, T10 & T12 Luminaires; http://www.valosto.com/tiedostot/CELMA_LED(SM)054C_CELMA_position_paper_on_ADAPTORS_FINAL.pdf

personnel. Conversion of the luminaire shifts the responsibility for the technical and the safety consequences of the conversion to the party carrying out the conversion. There is no separate safety standard for the conversion lamps. Converted luminaires must conform to the basic requirements of the low voltage and EMC directive. A new conformity assessment is required for rebuilt luminaires used with conversion lamps, which needs to be carried on case-by-case basis."; (2) LVD ADCO: "*For a modified luminaire, the manufacturer of the original luminaire will generally no longer be seen as responsible for the safety of the product". Any modifications made to the original luminaire may alter the characteristics of the original product e.g. safety aspects of the original luminaire, and hence risk assessment of hazards posed by the original luminaire may no longer be applicable to the modified luminaire. In this case, the modified luminaire would be considered as a new product"*[41].

The above provided information clearly indicates that replacing nonlinear T8 or T9 fluorescent lamp with LED tubes would be is a complex process. Replacement opportunities with regards to electrical compatibility are far from comprehensive. An end-user, customer and consumer needs to either have a broad technical knowledge or reach out to professionals to ensure the changed luminaire is safe and operates in a proper manner and is compliant with relevant legislation. It requires case-by-case feasibility and measurements.

According to an article "Linear LED tubes versus fluorescent lamps: An evaluation[42]": "the use of LED tubes as replacement lamp for fluorescent lamps is a typical product causing controversy." There is a lack of standardization and inspection to evaluate solid state lighting (SSL) products [43] often resulting in overstated and misleading manufacturer performance claims[44]. The key potential differences that need to be considered when choosing for LED tube replacement will be discussed here.

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[40] Conversion lamps as originally stated in ZVEI document, relate to conversion route adapted by LightingEurope of for the purpose of this exemption renewal request. These concerns lamps, which require modification in the existing luminaire to ensure proper operation

[41] LVD ADCO Recommendation on "Safety of LED T-type replacement tubes and modified luminaires" http://ec.europa.eu/enterprise/sectors/electrical/files/lvd-adco/recomm-led-replac-tubes_en.pdf

[42] "Linear LED tubes versus fluorescent lamps: An evaluation", W.R. Ryckaert K.A.G. Smet, I.A.A. Roelandtsa, M. Van Gils P. Hanselaer

[43] A. Poppe, G. Farkas, G. Molnaacuter, B. Katona, T. Temesvoumllgyyi, J.-W. He, Emerging standard for thermal testing of power LEDs and its possible implementation, in: Proceedings of SPIE - Tenth International Conference on Solid State Lighting, San Diego, CA, USA, August, 2010., per: "Linear LED tubes …" W.R. Ryckaert and others

[44] M.A. Myer, M.L., Paget, R.D. Lingard, CALiPER Benchmark Report–Performance of T12 and T8 Fluorescent Lamps and Troffers and LED Linear Replacement Lamps, Prepared for the U.S. Department of Energy by Pacific Northwest National Laboratory, PNNL-18076, 2009, per: per: "Linear LED tubes …" W.R. Ryckaert and others

(2) Light distribution and lumen output.

The light distribution of a LED tube differs significantly from fluorescent tubes. A fluorescent lamp emits light in all directions, uniformly around the axis of the lamp (360°). This is easily achievable, since the gas discharge responsible for the light emission is omnidirectional. In contrast, LED packages emit light directionally, they are (lambertian) directional light source emitting light in a downward-hemispherical arrangement (Figure 13a and 13b)[45]. It is difficult to achieve an omnidirectional luminous intensity distribution, while also meeting needs for thermal management and electrical regulation. As a result the emitting surface of linear LED lamps often covers only half of the surface area[46].

This is also recognized by the EU regulator in regulation 1194/2014, which includes additional product information requirements for LED lamp replacing fluorescent lamps without integrated ballast (1194 Annex III, art. 32).

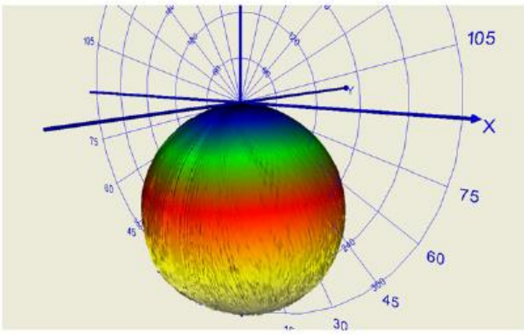

Figure 13a Luminous intensity distribution (3D) – brand K. Source: "Linear LED tubes…" W.R. Ryckaert and others, p. 431

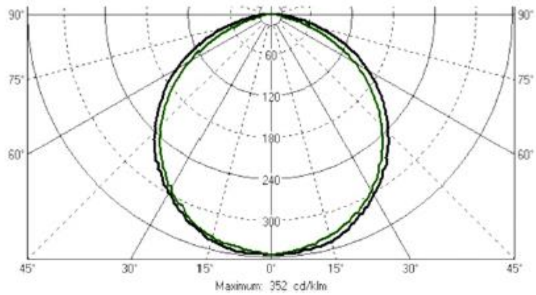

Figure 13b Luminous intensity distribution C0-180 (black) and C90-270 (green) – Brand K. Source: "Linear LED tubes" W.R. Ryckaert and others, p. 431

(3) Lack of standards

A standard covering double capped linear retrofit LED tubes is in preparation (EN62776). As long as this standard is not available manufacturers are recommended to use draft standard 34A/1642/CDV (ZVEI, 2014). For the electromagnetic compatibility of LED retrofit lamps a EMC assessment is in preparation at IEC/CISPR (current draft CISPR/F/628/CDV). For conversion lamps there is no own safety standard available so far. Therefore the requirements of the lamp components must be met, e.g. EN61347-2-13 for the control gear. Also 34A/1642/CDV might be taken into account. After rewiring

[45] "Linear LED tubes versus fluorescent lamps: An evaluation", W.R. Ryckaert K.A.G. Smet, I.A.A. Roelandtsa, M. Van Gils P. Hanselaer

[46] CALiPER, "Application Summary Report 21: Linear (T8) LED Lamps", p.6 http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/caliper_21_t8.pdf

of a luminaire conformity assessment of the luminaire has to be performed (among others: low voltage directive, electromagnetic compatibility). Prior to operation lumen output, energy efficiency, light colour and colour rendering have to be assessed. As long as there is no own standard available EN 62612 „Self-ballasted LED-lamps for general lighting services — Performance requirements“ can be taken into account. So for the subjects glare, flickering, dimming, safety and blue light hazards standards are currently in work.

(4) Purpose

An LED replacement lamp must be able to fulfil all the desired purposes. This can only be decided case by case as the number of lamps as well as the number of application is very high. In certain cases, especially in certain medical applications LED alternatives will require new and very long clinical studies before effectiveness is proven and the operation is safe.

New Installations

LED based luminaires can provide a viable alternative to the applications designed for nonlinear fluorescent lamps. Many conformity and performance related issues are solved. Dedicated designed luminaires directly comply as a system with all safety and standardization legislations is tested and confirmed by the luminaire manufacturer.

If a luminaire is broken in an existing installation or a customer wants to refurbish an existing installation with build in, recessed luminaires in the ceiling, the replacement LED luminaire should be able to fit in the existing space and give the same light distribution. Described earlier challenges that customer might be confronted with (e.g. illuminance), will not be solved in many cases with one-to-one luminaire replacement. A customer will be forced to renovate his ceiling and/or building, make a new lighting design and replace all existing luminaires, while many of them still operating properly.

6.2.2 Availability of substitutes

Currently LightingEurope is not aware of any relevant products of nonlinear T8 or T9 LED retrofit lamps being available in the EU.

LED based luminaires are available on the market and can be used to replace installations based on conventional fluorescent lamps.

6.2.3 Impacts of substitution

As T5 LED replacement lamps are not broadly available the impact of such a substitute cannot be estimated. Also LightingEurope is not aware of comparisons between non-linear fluorescent lighting solutions and new LED based technologies. This kind of comparison could be difficult as these two solutions might not be one to one comparable. Especially the new functionalities of LED solutions (colour changing, flexible form factors, tailor made seizes etc.) could lead to new lighting options and extension of the use of these products. Some aspects of a potential substitution should be mentioned here:

6.2.3.1 Environmental impact of substitutes

LED light sources are a promising technology to improve energy efficiency of a lighting system as a whole.

LCA data of several lighting systems clearly showed, that the system efficacy (use phase) has the highest impact on the environment during the Product Life Cycle. For an optimal system where the LED solution gives exactly the designed light distribution and an acceptable glare level, the LED solution can save energy and have a smaller footprint. Since the LED efficiency as such, is not much higher than that of fluorescent lamps, and the lifetime is comparable, the difference in LCA is small.

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

6.2.3.2 Health and safety impact of substitutes

If in new products or applications a LED based substitute is used it is like in all CE relevant products essential to make sure that the equipment is safe.

As described above special care has to be taken for the use of LED retrofit and conversion solutions in systems which were designed for a fluorescent lamp, including exchange of the lamps by professionals. It is inevitable that LED replacement lamps would also be installed by people who are not qualified professionals if fluorescent lamps covered by this exemption are no longer available. There is a risk that this will not be carried out correctly creating safety risks for consumers or that the lighting will not be suitable.

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:

In case these fluorescent lamps would no longer be available for existing installed lighting solutions, the impact would be by far more than significant. The need to replace or technically change the luminaires, control gears, equipment etc. results in high investments for private, commercial or public customers. The installed equipment can still be used for many years when replacement lamps remain available. As a consequence the environment will be spoiled unnecessarily with additional waste of the discarded luminaires without having an environmental benefit. There are no data available about number of luminaires, equipment and fixtures using non-linear lamps. With a conservative assumption 500€ per luminaire incl. installation would be needed for replacement creating 5-10 kg WEEE for each still functional and energy efficient equipment.

In the absence of public funding and support programs the European industry finances this transformation almost exclusively by its own means.The transformation process in the European lighting industry towards LED is in full course and high investments in the new technology have to be assured.

6.2.3.4 Impact of substitution on innovation

LED lighting is a very innovative technology offering a high variety of new functionalities, high and still increasing energy efficiency and overall performance in nearly all areas.

6.2.4 Future trends of substitution

Non-linear LED based replacement lamps are almost not available in the EU market. At present no significant trend for nonlinear LED based replacement lamps is visible. They are relatively small market, with diverse portfolio, hence LED penetration might be slower (on lamp level).

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.

Mercury cannot be removed from non-linear T8, T9 or T12 fluorescent lamps as described above. No technologies could be developed having similar high efficiencies.

8 Reduction of mercury content of lamps

For fluorescent lamps a high effort was necessary to implement all limit changes coming in force in 2010[47] with effect between 2012 and 2013. The maximum mercury content of non-linear triband-phosphor lamps with a tube diameter of > 17 mm had to be reduced to 15 mg per burner as of 1st Jan 2012.

Further reduction of mercury might technically be possible with high economic effort and R&D resources. The major part of development resources of lighting companies have already been allocated on LED based alternatives. On the other hand the lamps are required for the existing base of fixtures systems and luminaires, which are also highly efficient and have a long life time.

[47] Commission Decision 2010/571/EU of 24 September 2010

9 Other relevant information

During the UNEP Minamata Convention on Mercury end 2013 in Japan agreements have been made on limitation of mercury in various products, including linear fluorescent. This treaty has been agreed upon and signed by 94 countries around the globe. The agreed mercury level for linear fluorescent lamps is 5 mg, for lamps covered by this exemption there is no limit.

Mercury-added products	Date after which the manufacture, import or export of the product shall not be allowed (phase-out date)
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
High pressure mercury vapour lamps (HPMV) for general lighting purposes	2020
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 ≤ 1500 mm) with mercury content exceeding 5 mg per lamp (c) long length (> 1500 mm) with mercury content exceeding 13 mg per lamp	2020

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