LIGHTINGEUROPE
THE VOICE OF THE LIGHTING INDUSTRY

Request to renew Exemption 2(a)(3)

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

2(a) Mercury in double-capped linear fluorescent lamps for general lighting purposes not exceeding (per lamp):
2(a)(3) Tri-band phosphor with normal lifetime and a tube diameter > 17 mm and ≤ 28 mm (e.g. T8): 3.5 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(a)(3) of Annex III***
LightingEurope proposes to continue using the existing wording which is:	*2(a) Mercury in double-capped linear fluorescent lamps for general lighting purposes not exceeding (per lamp):* *2(a)(3) Tri-band phosphor with normal lifetime and a tube diameter > 17 mm and ≤ 28 mm (e.g. T8): 3.5 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

The validity period of DIRECTIVE 2011/65/EU Article 5(2) Annex III Exemption 2(a)(3) 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:

2(a) Mercury in double-capped linear fluorescent lamps for general lighting purposes not exceeding (per lamp):

2(a)(3) Tri-band phosphor with normal lifetime and a tube diameter > 17 mm and ≤ 28 mm (e.g. T8): 3.5 mg may be used per lamp after 31 December 2011

Linear T8 lamps for general lighting as covered by exemption 2(a) 3 is a very big segment of all linear fluorescent lamps. They are among the most energy efficient lamps, reaching levels up to 100 lumens per watt and a lifetime of 20khrs for the regular lamps. They are widely used in offices, schools and industrial buildings as well as residential homes, with hundreds of millions of installed light points in many configurations. T8 contains 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.

The T8 market demand is still very high, in 2013 ca 247 Mio T8 lamps have been marketed in EU-28, sales for all lamp (triband phosphor and halophosphate) decreased slightly from 2009 to 2013, ca 14% (see chapter 4.2.4).

The overall estimated yearly mercury input decreased from 2009 to 2013 from ca 1604 kg to 751 kg (-53%, decrease per lamp: -45%), due to mercury reduction measures and the phase-out of halophosphate lamps.

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. WEEE for LED based lamps is not in place.

There is a growing market for mercury-free T8 lamps based on LED technology with features such as energy efficiency and design flexibility. However, based on numerous performance criteria LED tubes are not fully equivalent to T8 lamps; hence cannot generally replace them in their broad usage base. 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 is essential to know which kind of control gear, electronic or conventional, is present in the luminaire. It can require technical changes to the luminaire (rewiring), especially in luminaires equipped with an electronic control gear (acc. LightingEurope rough estimation: ca 40%). Full compatibility with all installed conventional or electronic control gears is not possible.
2) Different light distribution: due to the LED tubes changed optical characteristics vs. the existing T8, the light plan could be no longer optimized for the application. Expert knowledge is needed to get a good result.

3) Applicable legal and compliance requirements like conformity assessments, declaration, and labelling of the changed luminaire are needed. The person installing the LED based solution is responsible to perform testing and measures to ensure the new system fulfils these requirements including when the original lamp type is installed again. It is inevitable that linear T8 LED replacement lamps will also be installed by people who are not qualified professionals if T8 fluorescent lamps 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. This, in combination with the electrical compatibility and light distribution effects limits straight-forward and hassle-free market entrance of the LED alternatives.
4) Restricted choice in the LED based lamps, only a fraction of the existing lengths are available, not all colours and for example no direct replacement in emergency lighting.
5) 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. With a conservative assumption of the replacement of 400 million luminaires 200 billion € would be needed (500€ per luminaire incl. installation) creating 4 Mio tons WEEE (10 kg each) of still functional and energy efficient equipment.

In the absence of public funding and support programs as they characterize other global regions, conventional technologies such as fluorescent support the investment of new LED development almost exclusively. Thousands of FTE's are employed in the manufacturing and supplies of fluorescent lamps today in Europe.

In the desired situation, end-users, customers and consumers should be allowed to replace one-to-one an existing T8 lamp with any available on the market LED tube themselves. As this is not the case LightingEurope asks for an extension of the existing exemption.

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 tri-band phosphor linear fluorescent T8 lamps for general lighting not exceeding 3.5 mg per lamp as summarized in Table 1:

Requirement according RoHS Article 5(a)	**Status for mercury in linear fluorescent T8 lamps for general lighting not exceeding 3.5 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 T8 linear fluorescent lamps is scientifically and technically impracticable. In some cases T8 lamps can be replaced by LED based alternatives. Alternatively installed luminaires can be replaced with very high socioeconomic impact by mercury-free fixtures. Both LED based solutions require lead in materials and electronic applications currently exempted according Annex III of the RoHS Directive.
the reliability of substitutes is not ensured,	Substitution of fluorescent lamps or the corresponding fixtures with LED-based solutions require in most cases qualified professionals to perform the installation. This can inevitably not be assured. Correctly installed LED based lamps and 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.	Consumer safety is given if LED-based lamps are installed according the manufacturers advise. In most cases qualified professionals have to do this. Based on recent studies[1] LED based lamps show comparable energy efficiency, hence cannot be considered as more beneficial to environment in all situations. It has to be analyzed case by case whether a fluorescent lamp can be technically replaced and whether the substitute LED based lamp can fully fulfill all required functionalities.

Table 1: Requirements according RoHS Article 5/a) and their fulfilment for mercury in T8 linear fluorescent lamps for general lighting not exceeding 3.5 mg per lamp

For this reason an exemption for mercury in lamps covered by this exemption is required with a maximum validity period and with no expiry date.

[1] CALiPER, “Application Summary Report 21: Linear (T8) LED Lamps”, p.6

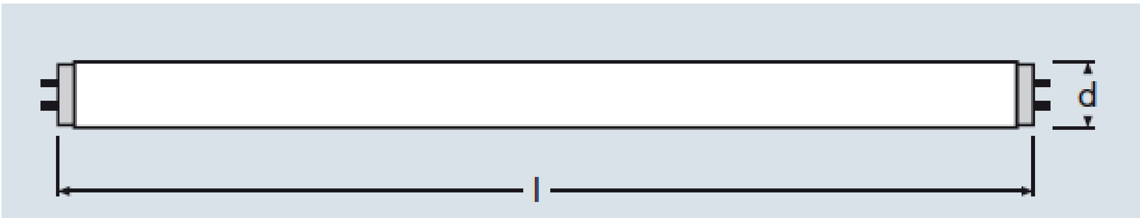
4 Technical description of the exemption request

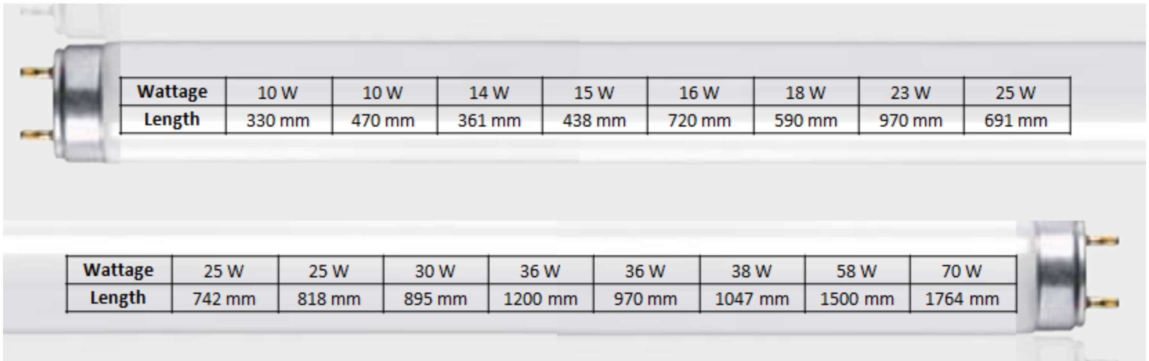
4.1 Description of the lamps and their applications

4.1.1 *Lamps covered by this exemption*

This exemption covers Mercury in double-capped linear fluorescent tri-band phosphor lamps for general lighting purposes with normal lifetime and a tube diameter > *17 mm and* ≤ *28* mm (e.g. T8). The maximum allowed mercury dose is currently 3.5 mg per lamp.

All lamps currently put on the EU market by members of LightingEurope are T8 lamps with standardised dimensions and base. These T8 lamps with a diameter (d) of usually ca. 26 mm and 16 lengths (l) are very economical, offer a good quality of light having and very good luminous flux. They have a good average lifetime operated on a suitable electronic control gear. Regarding the main applications (see 4.1.2) the lamps are in use mainly in professional areas but quite often also in private homes.





Wattage	10 W	10 W	14 W	15 W	16 W	18 W	23 W	25 W
Length	330 mm	470 mm	361 mm	438 mm	720 mm	590 mm	970 mm	691 mm

Wattage	25 W	25 W	30 W	36 W	36 W	38 W	58 W	70 W
Length	742 mm	818 mm	895 mm	1200 mm	970 mm	1047 mm	1500 mm	1764 mm

Figure 1: Drawing/picture of T8 lamps indicating different types, lengths and wattages. There is a high variety of lumen outputs available.

Further description

- Available types and wattages (main types used in EU): 10 - 70 W
- Available Colour Temperatures: 2.700K up to > 6.500K
- Typical Colour Rendering Index (Ra): 80- >90
- Average Lifetime[2]: Typically 15.000 -20.000hrs on an electronic control gear,
- Base (standard designation): G13 (bi-pin), IEC/EN60061),
- Dimmable (with special electronic control gear)

Figure 2: Picture of a T8 lamp base G13 (bi-pin)

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 mains voltage. Conventional control gears (CCG) have traditionally been used to limit the current. T8 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..

T8 lamps 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 the customers/users requirements, such as dimming, temperature range, light management systems, emergency lighting, single or multi lamp drive, stand-alone

[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 a sample population of lamps have failed.

luminaire vs. multi-luminaire lighting system etc.. LightingEurope roughly estimates that ca. 60% of the installed T8 luminaires are using a CCG, there are no statistical data available. 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.

4.1.2 *Applications covered by this exemption*

T8 fluorescent lamps are designed for operation in luminaires and to operate on conventional or on electronic control gear in nearly all areas of public and private life, e.g.

offices, public buildings, industry, shops, supermarkets and department stores, restaurants, tunnels and many more as shown below.

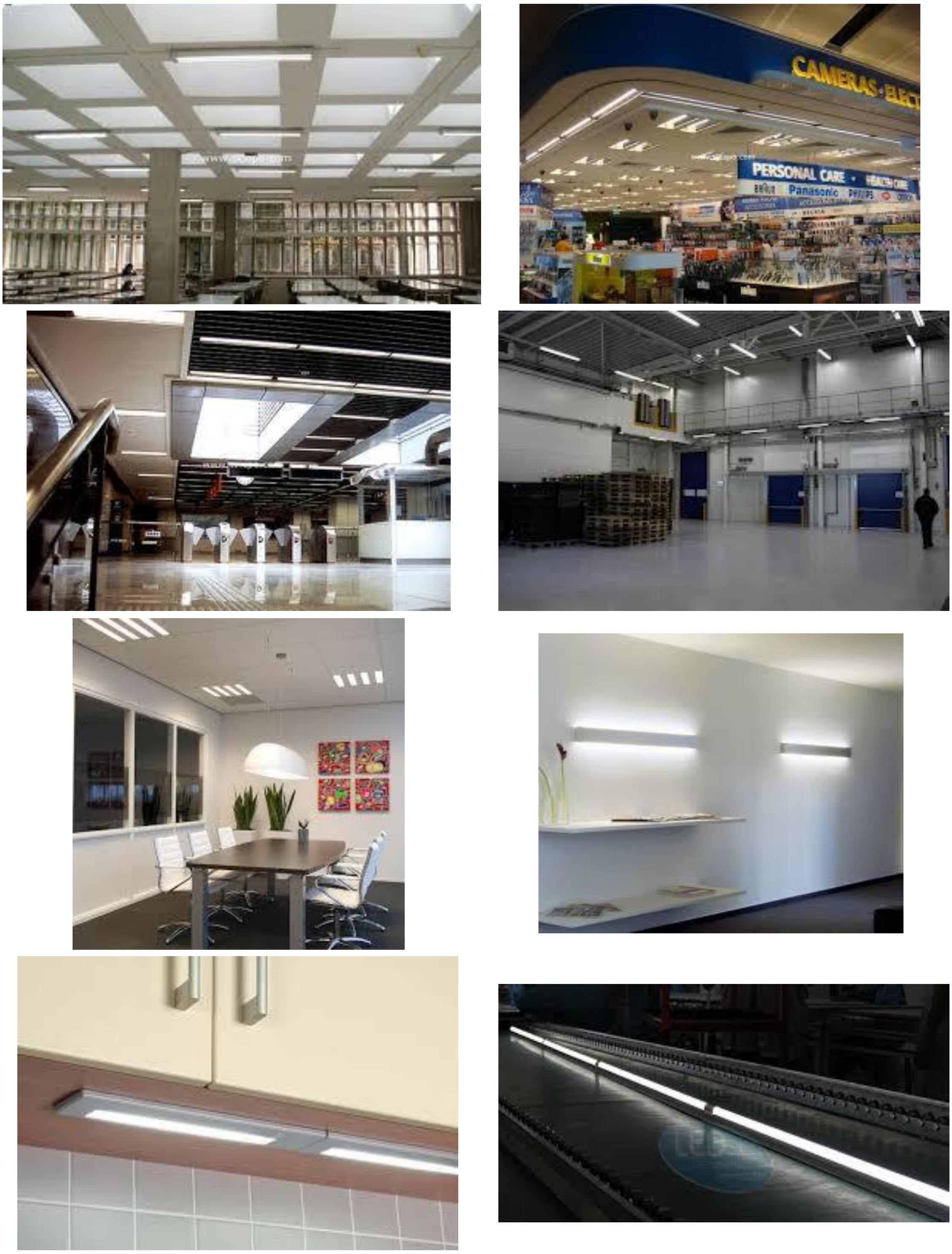


Figure 3: T8 linear fluorescent lamps are used in nearly all areas of private, economical or public life

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(a)(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 below). The composition of the coating determines light colour and colour rendering.

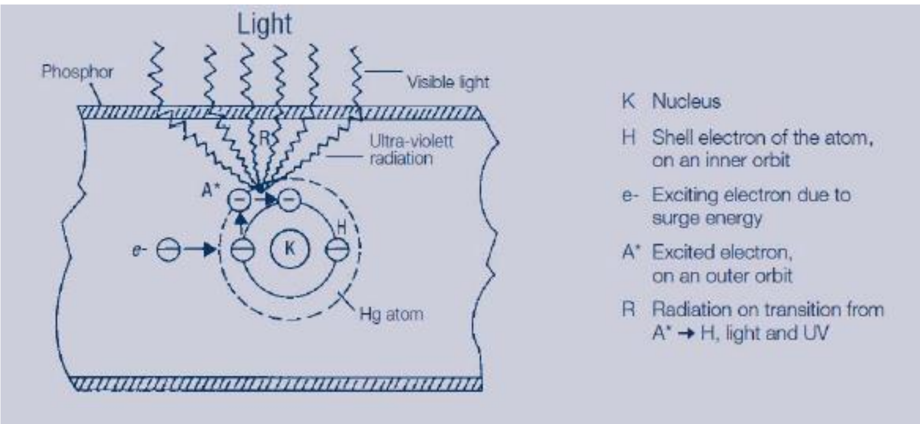


Figure 4: Electrical current is passed via the two filament electrodes through the tube which is filled with partially ionized gas. The electrons excite mercury atoms to emit short-wave ultra-violet light, which is converted into visible light in the phosphor layer on the inside of the tube. Different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

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

last decennia the dosing techniques became much more accurate, so less mercury can 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

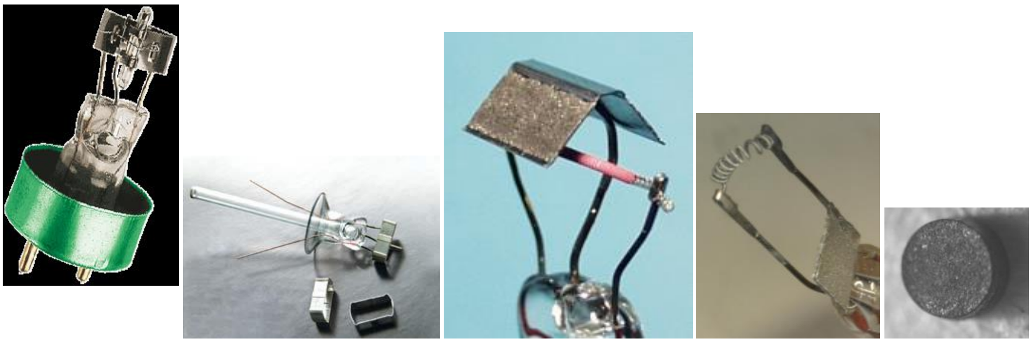


Figure 5: Mercury dosing technologies
From left: Hg-capsule; metal-alloy[4], metal alloy "roof", metal alloy "flag", HgFe pill

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

[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*

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 of 3.5 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 T8 lamps had to be reduced from 5 mg to 3.5 mg per burner as of 1st Jan 2012.

In order to be able to dose the required amounts of mercury well below 5 mg, 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 2.5 mg can vary between 1.5-3.5 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 2.5 mg, the needed RoHS value in this example may be as high as 3.5 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

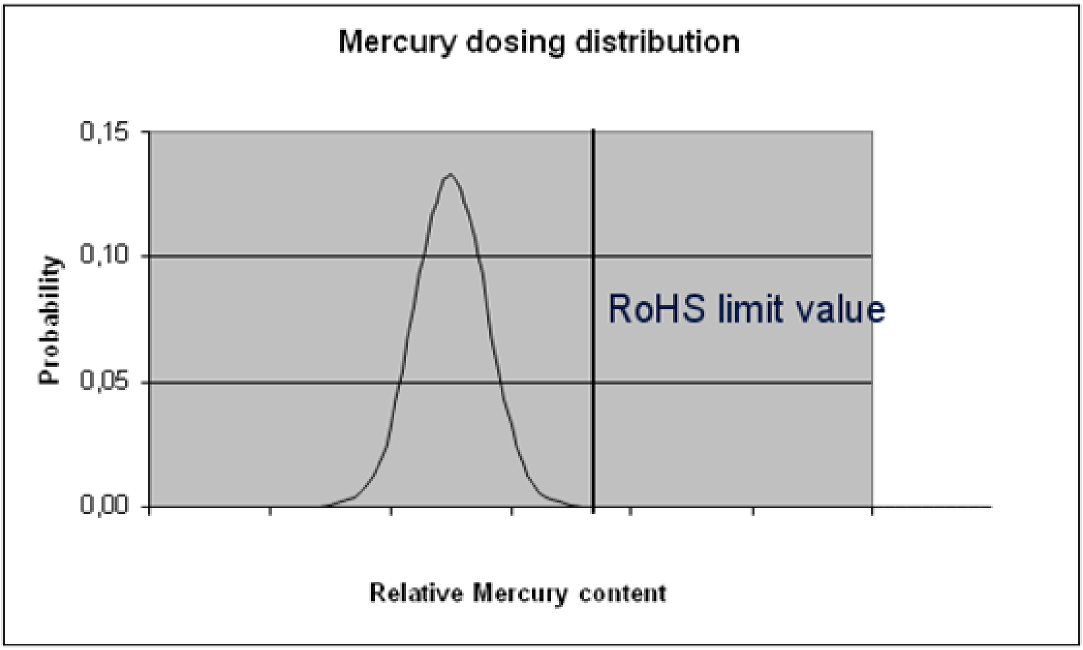

Figure 6: Simplified illustration (example only) of the effect of mercury dosing variance, where average value needs to be chosen lower than the RoHS limit value. The graph displays measurements of the mercury content in dosing units performed as quality control during their production, here FeHg pill.

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 that 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 the intended lifetime is not shortened due to a too low available amount of 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.

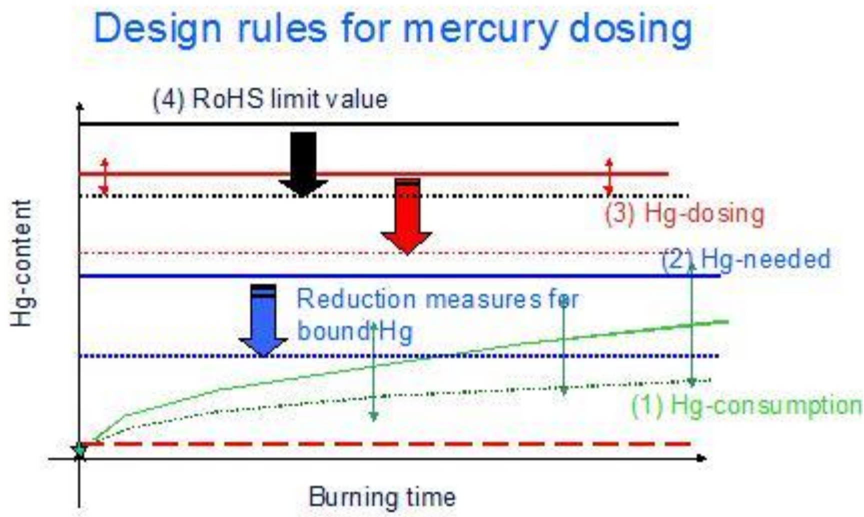

Figure 7: Design rules for mercury dosing in fluorescent lamps, schematically showing the process of setting RoHS limit values based on insights in mercury consumption and mercury dosing.

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

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

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

Path	Mechanism	Main Promoter	Source	Location of bound Hg
Oxidation	Hg+ + x O → HgOx	impurities prematerials	processing coating	coating
Amalgamation	Hg+ + Me → 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 absorption. 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.

In the figure 8 below is the measurement of the Mercury consumption of a certain T8 lamp (36W).

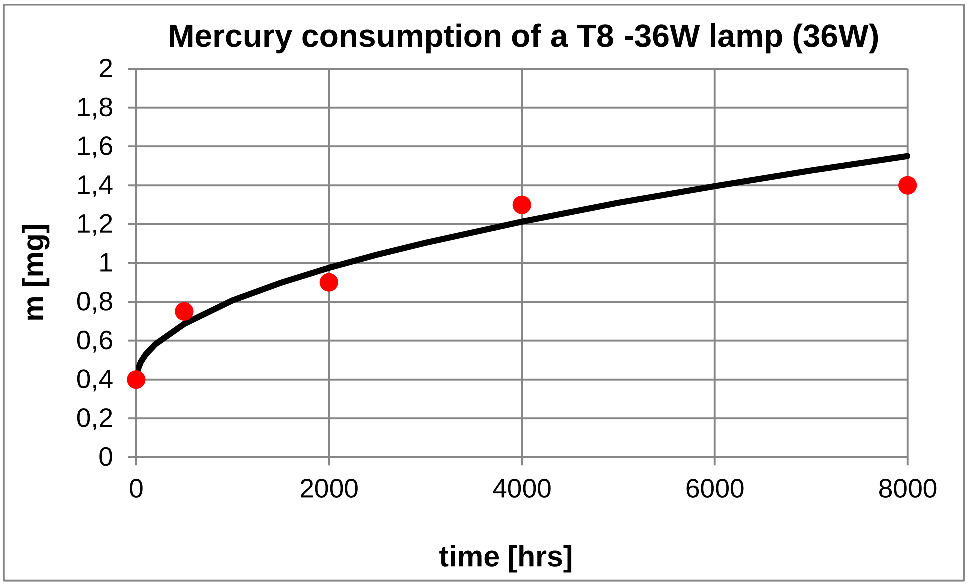

Figure 8: Mercury consumption of a certainT8 lamp 36 Watt with a mercury dosing of 3.0 ± 0.5 mg

Measurements of mercury consumption as displayed in Figure 7 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.

Estimation of the annual Mercury content of T8 lamps marketed in EU-28:
Linear T8 lamps for general lighting as covered by exemption 2(a)(3) cover a very big segment of all linear fluorescent lamps.

In the following table the market (number of produced lamps [Mio pieces], VHK/VITO Study 2014) and the corresponding mercury amount put on the EU-28 market is listed from 2009 to 2014. The average mercury amounts per lamp are estimated by LightingEurope member companies and are also displayed. This can be seen more as a worst case estimation, especially for 2012-2013, where a maximum limit of 3.5 mg was introduced and the estimated 3.0 average is close to the corresponding Max-value. T8 linear halophosphate lamps for general lighting have been phased out in the EU according to ErP Implementing Measure requirement[14] after April 13, 2010. They were replaced by triband phosphor lamps.

The data show that the T8 market demand is still very high, sales for all lamp decreased form 2009 to 2013 ca 14%. In 2013 ca 247 Mio T8 lamps have been marketed.

The overall estimated yearly mercury input decreased from 2009 to 2013 from ca 1604 kg to 751 kg (-53%, decrease per lamp: -45%).

EU-28 Sales	2009	2010	2011	2012	2013
T8 Tri-band [Mio pcs.]	175	216	254	261	245
T8 Halophosphate [Mio pcs.]	113	68	26	4	2
Mercury [kg]	1604	1408	1097	815	751
Average Hg amount per lamp [mg] Tri-band/ Halophosphate	4/8	4/8	3.5/8	3/8	3/8

Table 3: Linear T8 triband phosphor and halophosphate lamp market EU-28 [Mio pcs] and corresponding mercury amount (see text) of all linear T8 lamps, including long life types[15]. Mercury content per lamp was estimated by LightingEurope members, see text.

[14] Regulation (EC) No 245/2009 amended by Regulation (EC) 347/2010
[15] 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

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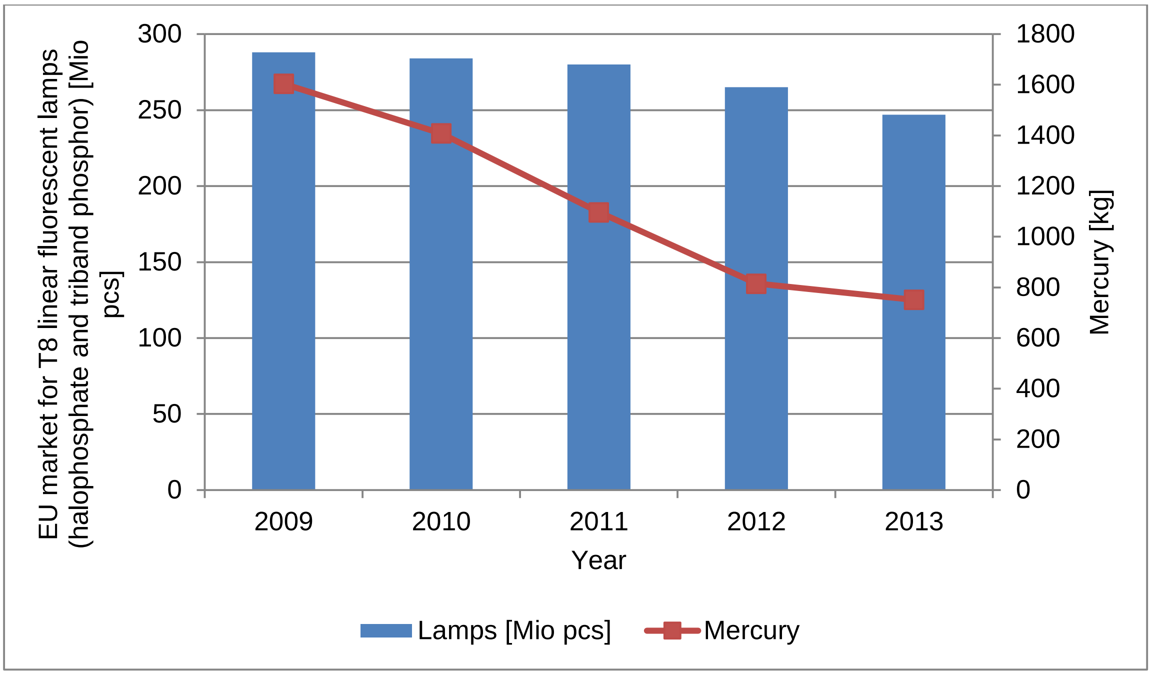

Table 4: Overall market of linear T8 fluorescent lamps [Mio pcs] and overall mercury amount put on the EU market per year, including triband, halophosphate and longlife type.[15]

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.[16] This means that currently the efficacy of the lamp is the main determining parameter. Specifically regarding mercury, the biggest amount of mercury is released to the environment by power plants when generating electrical energy (especially when fossil fuel is the primary power source).[17] 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.[18] Manufacturers have developed technology that enables a small amount of mercury to be 'dosed' or placed inside a fluorescent lamps such as T8.[19]

[16] *(see Enlighten report, Section 5, Ch. 3 fig. 4 & 5)*
[17] *(see Enlighten report, Section 5, Ch. 3 fig.6)*
[18] *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*
[19] *Complete paragraph UNEP toolkit, p.106*

For the future however the manufacturing part in the LCA becomes more relevant[20], 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 relevant due to the importance of the lighting sector in the total energy consumption. The lighting sector contains many 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. The recyclability of TL fluorescent lamps is close to 100% (glass, metal, mercury is reused, tri-band phosphor recycling under investigation).

Historically the comparison was done with respect to incandescent lamps[21] 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[22], 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.[23]

LED lamp product manufacturing uses considerably more energy than does the manufacturing of a T8 with comparable light output[24]. However one must consider the improving LED alternative in the right perspective: according to reference[25] the LED

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

[21] *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 Environmental Engineer 2006; 7: 8—14; Gydesen A,Maimann D. Life cycle analyses of integral compact fluorescent lamps versus incandescent lamps: RightLight, Stockholm, Sweden, 1991*

[22] *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,*

[23] *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*

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

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

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. Recent DoE research[26] illustrated that luminaires retrofitted with LED lamps performed in the same efficacy range as the fluorescent benchmarks, so it is not clear that they offer guaranteed energy savings when compared to fluorescent troffers equipped with 25 or 28 W high-performance lamps and electronic dimming ballasts. Energy efficiency, or specifically, the total luminaire efficacy and lighting power density of a typical installation are important criteria for choosing a proper LED replacement in existing installation.

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.

[26] http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/caliper_recessed-troffer_2013.pdf

Below picture shows the various steps in the recycling process:

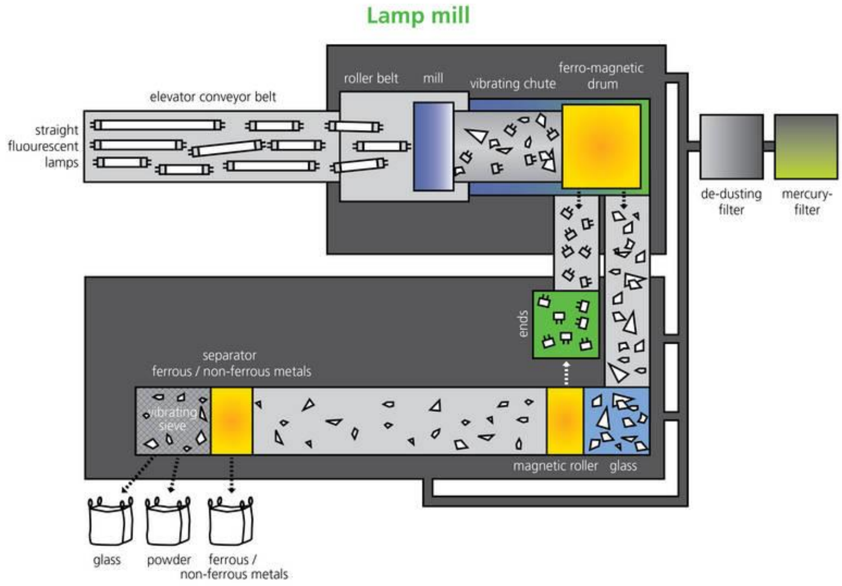

Figure 9a Recycling steps of fluorescent lamps in Indaver (Belgium).
Source: www.indaver.be/waste-treatment/recycling/mercurial-waste.html

The next picture illustrates the specifics of recycling the mercury:

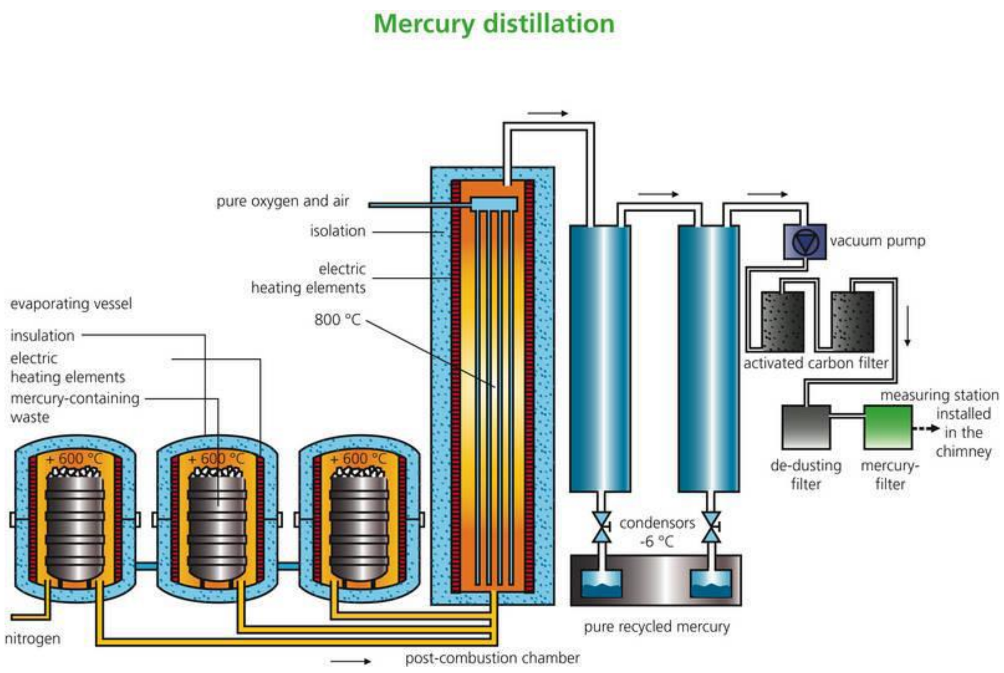

Figure 9b Specific recycling steps of mercury in Indaver (Belgium

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 10: 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:

Linear T8 lamps for general lighting as covered by exemption 2(a)(3) is a very big segment of all linear fluorescent lamps.

The combined data can be found in the table below.

In table 4 of chapter 4.2.4 the number of produced linear T8 lamps (halophosphate and triband phosphor summarized) and the corresponding mercury amount put on the EU-28 market is listed from 2009 to 2013. Sales of these lamps is slightly decreasing from 2009 to 2013 (-14%). In 2013 ca. 247 Mio T8 lamps have been marketed. The overall estimated yearly mercury input decreased from 2009 to 2013 from ca 1604 kg to 751 kg (-53%, decrease per lamp: -45%).

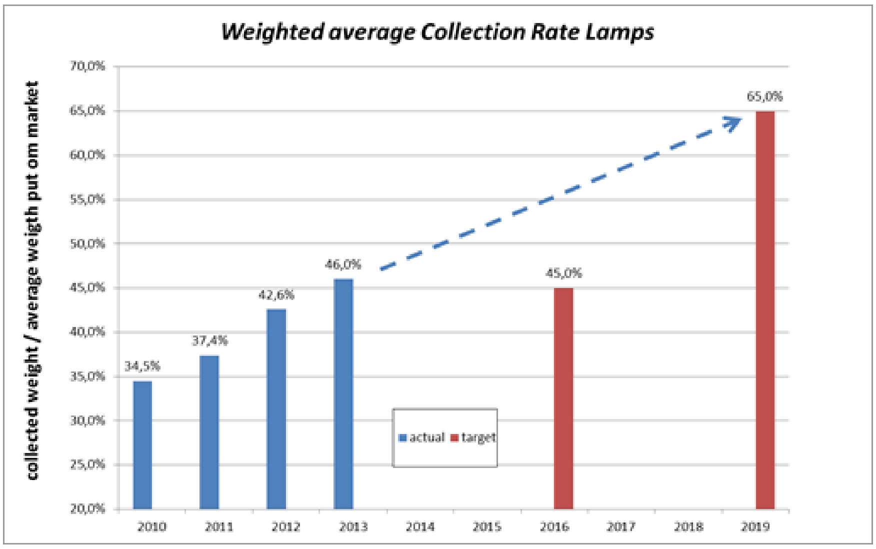

Figure 11 Weighted average Collection Rate Lamps (all lamps): 2010 – 2013 (blue) and targets 2016-2019 (red)

The collection rate of lamps in Europe compared to the average amount of all mercury containing lamps put on the market during 2010 – 2013 is shown in above graph. It also includes the targets set for 2016 and 2019. Please be aware that this graph includes all lamp types, not specific ones. The collection rate for linear fluorescent lamps is much higher, also because a large fraction of the lamps is used by professionals and replaced and collected in bulk.

For these lamps special installations are designed as seen in the figures above and almost all material is recycled (glass, metal and mercury).

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).

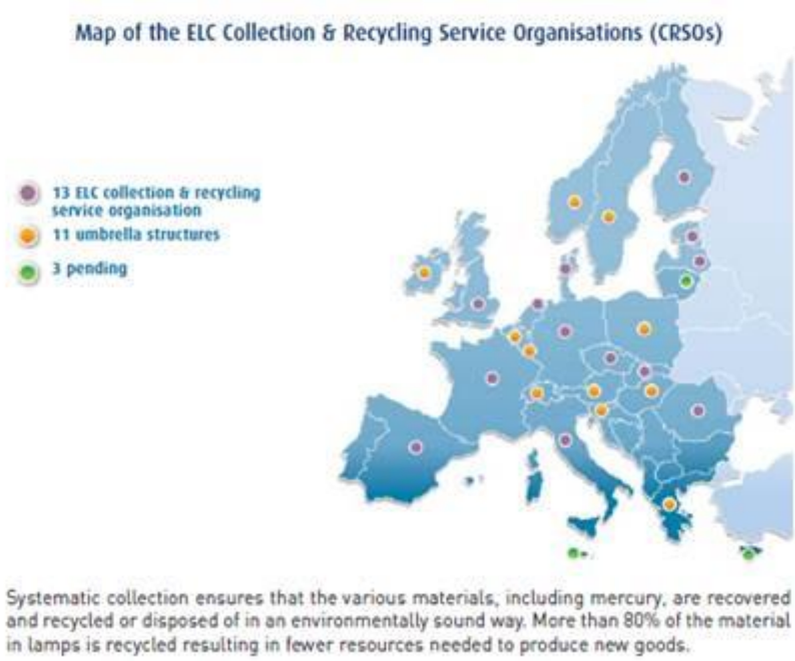

Figure 12: Map of ELC Collection and Recycling Service Organisations (CRSOs). Source: Environmental aspects of lamps[27]

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

6 Substitution

Can the substance of this exemption be substituted?

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

☒ No

Justification: see in below chapters

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 (Figure 13)

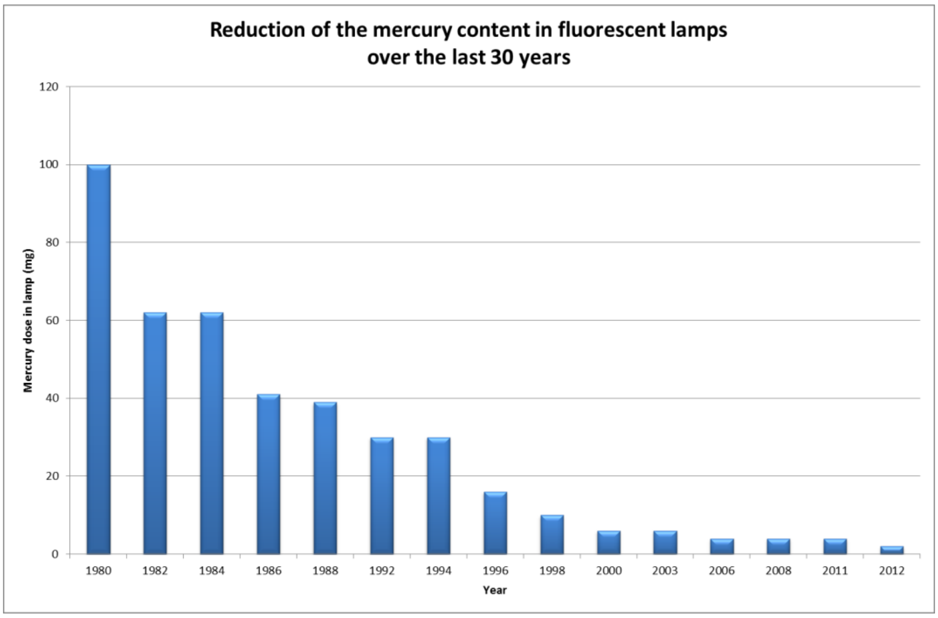

Figure 13: Mercury content of fluorescent lamps

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[28].

Attempts to generate UV with noble gases succeeded partially[29]. However the plasma radiates in the deep UV. At these wavelengths, the Stokes shift is even larger causing lower efficiency. The lack of suitable phosphors[30] prohibited progress in this direction. Other alternatives investigated are low pressure metal halides (for example InI, InBr, GaI3)[31]. Such plasma's generate the visible light directly without the Stokes shift of the phosphor[32]. There are alternatives from research but the efficiency in prototypes lamps is significantly reduced to approx. 40lm/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 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 require a very large R&D effort. As considerable research has already been carried out without success further research is also not likely to develop alternatives to mercury in fluorescent lamps and any alternative will probably be less efficient having 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[33]. In 2013 it became quite clear that an efficacy of more than

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[28] *M Haverlag, Mercury-free discharges for lighting, J. Phys. D: Appl. Phys. 40 (2007)*
[29] *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)*
[30] *J. Dexpert-Ghysa, Re-processing CRT phosphors for mercury-free applications, J. of Luminescence, 129, 1968, (2009)*
[31] *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.*
[32] *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.*
[33] 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

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 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 fluorescent technology by mercury free technology

Considering mercury free lamps, they have been present on the market since years, e.g. incandescent or tungsten halogen lamps. However those cannot be treated as proper replacement for linear fluorescent lamps in existing or new applications. Lamps and luminaires based on LED technology, show much more opportunities and are rapidly entering the market. However they have specific technical and performance characteristics that need to be considered and that prevent immediate change-over. Those will be discussed in this chapter in detail.

6.2.1 *Feasibility of alternatives*

Two key ways to use LED technology in order to substitute T8 lamps can be distinguished: (1) replacement lamps, (2) new installation (either new buildings or refurbished areas). LightingEurope draws special attention towards replacement market of conventional linear fluorescent lamps, due to significant size of the installed park (counted in hundreds of millions light points) and broad complexity built over long time existence of fluorescent tubes. LightingEurope describes four key aspects that need to be considered when evaluating potential LED based replacement for conventional T8

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of the N2 emission in argon low-pressure arc discharges for lighting purposes", R. Friedl, U. Fantz, New J. Phys. 14 043016 ,2012;

based lighting applications: (1) electrical compatibility, (2) Light distribution and lumen output, (3) Portfolio complexity, (4) Lack of standards.

1. Replacement lamps

(1) Electrical compatibility

T8 lamps are uniformly used with all possible lamp drivers designed according to the relevant IEC standards. Safety requirements are standardized in IEC61195. Electrical compatibility requirements are standardized in IEC60081. 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. An IEC standard on electrical compatibility for LED tube does not exist. 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. At present LED tubes are designed and designated to operate either on CCG or ECG (figure 14).

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" [34], by the German associations ZVEI[35] and VDE[36]. 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* as in many cases the lamp replacement requires adaptations to the lighting system (consisting of lamp, control gear and luminaire). This is illustrated in figure 14.

[34] 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

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

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

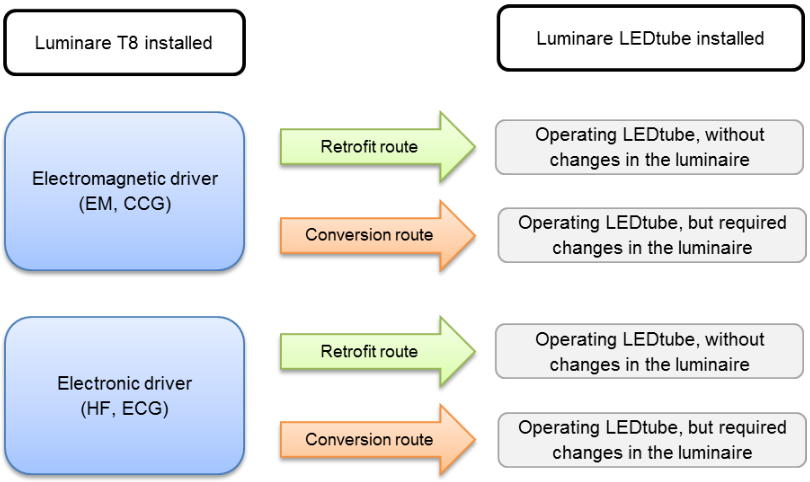

Figure 14: Simplified overview about different routes for using LED tubes in existing luminaires, depending on the ballast used

In the desired situation, an end-user, customer and consumer is able to make a one-to-one replacement of an existing T8 lamp into any available on the market LED tube, but this is not possible. Instead lamp replacement can go two ways:

- Retrofit route: a fluorescent lamp is substituted by a LED tube. The luminaire itself is not rebuilt[37] and the electromagnetic ballast or electronic control gear remains in the installation[38]. Driver compatibility is assumed here.
- Conversion route: both the fluorescent lamp and the starter are replaced, and technical changes also need to be made to the luminaire: ballasts and/or internal wiring may need to be replaced or altered[39].

<u>(1)a Retrofit route</u>

As explained above, for the retrofit route two situations are relevant. Those with respect to compatibility require two types of LED replacement lamps[40]:

1. LED tube compatible with CCG systems (installations with an electromagnetic ballast)
2. LED tube compatible with the many different ECG systems (installations with an electronic driver integrated starter circuit)

[37] Op.cit. ZVEI
[38] 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
[39] Op.cit. ZVEI
[40] Most LED replacement lamps on the market are dedicated to EM systems, but also HF compatible and EM+HF combined LED replacement lamps exist with a limited number of players.

Currently majority of LED tube replacements are designed for CCG systems. LED tube replacements for ECG systems requires different technology to ensure electrical compatibility and are rare on the market (to the best knowledge of LightingEurope members only one of key players on the market offers this solution today).

Typically CCG compatible lamps have single-ended electrical supply, where ECG compatible LED replacements require double ended electrical supply (refer to: figure 15a and 15b). From the outside, the difference between such LED tube replacements cannot be noted. From luminaires perspective difference is not obvious. Though the CCG systems can be recognized by the existence of a starter in the luminaire, it is not easy for a not-skilled customer to recognize the exact installation he has, as often the starter is not visible from the outside and the installation looks the same as an ECG system. A customer needs to have a broad technical knowledge to make a judgment on installed system. Hence it is difficult for unskilled person to exchange conventional T8 in existing luminaire with LED tube.

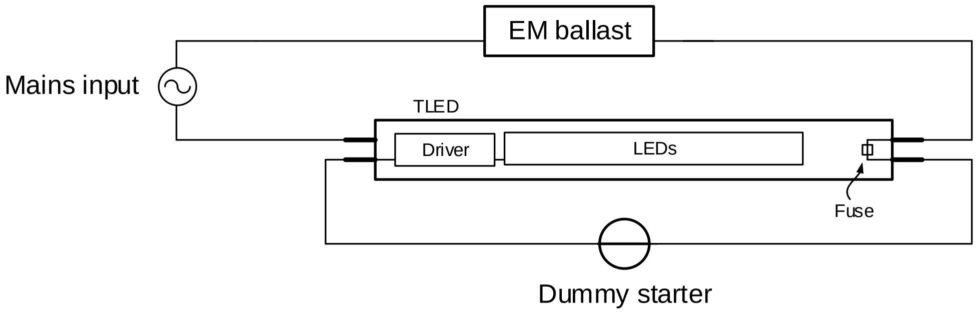

Figure 15a LED replacement lamp for CCG system (EM: electro magnetic)

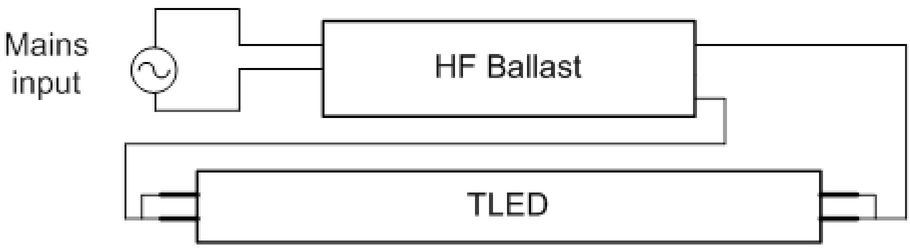

Figure 15b LED replacement for ECG system (HF: high frequency

Considering market transition from CCG to ECG the issue of finding a proper replacement for an existing installation might become more apparent. New installations with ECG drivers have been growing fast in the past decade from around 10% to over 30%[41]. This trend is expected to continue and from April 2017 onwards all new installations will be ECG systems, as CCGs are no longer allowed [EC245/2009]. Next to that the average lifetime of an installed luminaire in office or industrial areas (valid for linear fluorescent lamps) is typically 15 years[42], so it is expected that the replacement market will be completely ECG by 2035-2040. LightingEurope is of opinion that before ECG compatibility is not fully assured and proven; conventional linear lighting still plays a significant role for replacement market of existing luminaires. With present installed base complexity, it is impossible to guarantee a full 100% coverage for both CCG and ECG systems compatibility. This leads to situations where a customer opts for a retrofit lamp assuming driver compatibility but where specific drivers are not specified and supported by the retrofit lamp. The customer is then forced into the conversion route.

(1)b Conversion route

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[43]. 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*[44] *by appropriately trained 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*

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[41] Exact numbers on the existing applications in EU28 are not known to LightingEurope members, but there is historical information available on the new installations based on ZVEI market data.

[42] McKinsey – Lighting the way, http://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/automotive%20and%20assembly/lighting_the_way_perspectives_on_global_lighting_market_2012.ashx

[43] 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

[44] 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

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""*[45].

The above provided information clearly indicates that replacing a conventional T8 lamp with LED tubes 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. With increasing presence of ECG operated systems, the complexity could even increase further.

As explained in earlier paragraphs, when a number of specific precautions involving electrical compatibility are taken into account LED tubes can be used as a replacement of conventional T8 in existing application. However, even then every end-user, customer and consumer needs to be acknowledged about differences that one might be confronted with. According to an article "Linear LED tubes versus fluorescent lamps: An evaluation[46]": "*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[47] often resulting in overstated and misleading manufacturer performance claims[48]. The key potential differences that need to be considered when choosing for LED tube replacement will be discussed here.

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[45] 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

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

[47] 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

[48] 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 16a and 16b)[49]. 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.[50].

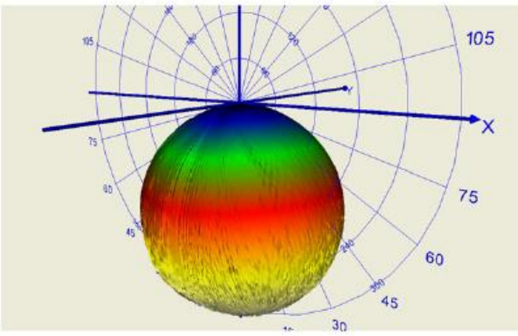

Figure 16a Luminous intensity distribution (3D) – brand K. Source: "Linear LED tubes…" W.R. Ryckaert and others, p. 431

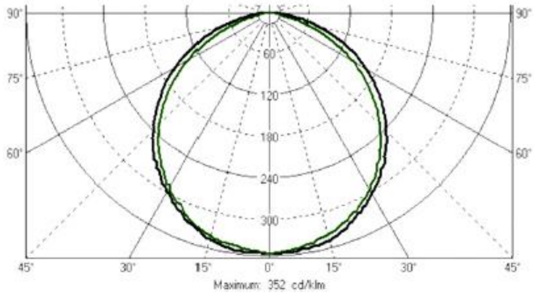

Figure 16b Luminous intensity distribution C0-180 (black) and C90-270 (green) – Brand K. Source: "Linear LED tubes" W.R. Ryckaert and others, p. 431

These differences in construction are typically manifested as differences in luminous intensity distribution—and subsequent in-luminaire performance differences[51]. Two studies comparing LED tubes and conventional T8, i.e. the recent CALiPER[52] study and Belgium study[53], clearly indicate that evaluating the performance of a changed lighting system based on LED tubes requires careful consideration on equivalency of the provided illumination in the new lighting situation as it will not be the same. To keep equivalency, luminous intensity distributions should be tuned to required situation, which may lead to changing the luminaire in which LED tubes are installed. Differences in luminous intensity

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

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

51 CALiPER, "Application Summary Report 21: Linear (T8) LED Lamps", p.6

52 The CALiPER (Commercially Available LED Product Evaluation and Reporting) program was launched by DOE in 2006 to support testing of a representative array of solid-state lighting products for general illumination, using industry-approved test procedures carried out by qualified test labs. The program has evolved right along with the SSL market and serves multiple needs., http://energy.gov/eere/ssl/caliper-testing

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

distribution between LED tubes and conventional T8 are clearly indicated on the figure 17. None of the tested LED tubes provide an omnidirectional light. They offer maximum intensity straight down, and no intensity straight up.

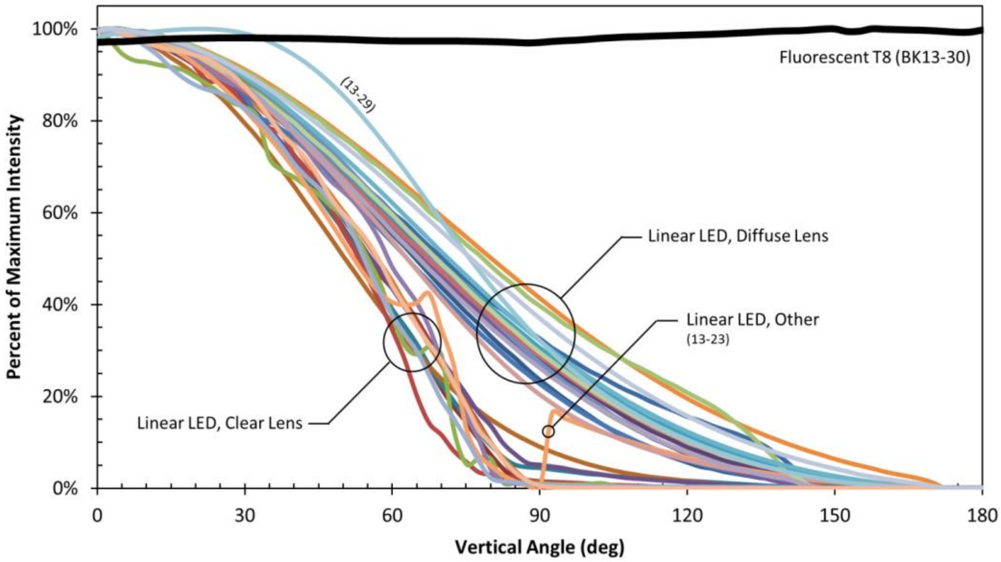

Figure 17: Relative luminous intensity distribution of the Series 21 products (90° horizontal plane)54.

Bare-lamp performance may not translate when the product is operated in a luminaire, thus they should be compared in lamp - luminaire combination. Replacing an omnidirectional fluorescent lamp with a directional LED lamp that has a lower lumen output may not result in reduced illuminance at the work plane but may reduce light on adjacent walls and uniformity ratios on floor, workplace, walls and wall to workplace as well the glare restrictions, for example. Although the lamps included in CALiPER report were tested on several types of optical systems, "none was able to mimic the distribution of light produced by a linear fluorescent lamp"[55]. 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).

In a luminaire without optics (simple fixture, a batten – see figure 18a), LED tubes can offer an efficiency improvement after relamping. The hemispherical radiation of LED linear replacement lamps results in less light losses within the luminaire, as they do not lose as much light upwards. There can be also situations where the light is aimed at the

[54] Although none of the LED products were close to matching the fluorescent benchmark—which had relatively uniform intensity at all vertical angles—the data did reveal a distinct difference between lamps with a clear lens and lamps with a frosted lens. The beam angle is twice the vertical angle at which the intensity is 50% of maximum intensity (ANSI/IES RP-16-10), assuming symmetry.

[55] CALiPER, "Application Summary Report 21: Linear (T8) LED Lamps", p.6

wrong direction after installation. The existing luminaires are not equipped with a possibility to orient the lamp. This design principle of LED tubes has a downside in luminaires with reflectors (see figure 18b). These are used mostly in areas where a high lumen output is required such as offices and schools. As LED tubes do not emit light upwards to the reflector, they don't utilize the reflector's quality of ensuring a good and even light distribution. Therefore, the luminous intensity distribution of the luminaire with an LED tube is considerably different from the luminaire with fluorescent lamp, as per the original lighting design of an installation (Fig. 19a, 19b). This means that conventional T8 still outperforms LED tubes in these applications, while maintain existing lighting plans.

Figure 18a Batten without reflector/optics
http://www.questelectrical.co.uk/fitzgerald-twin-fluorescent-batten-light-fitting-2x70w-t8-1784mm-high-frequency.html

Figure 18b Batten with reflector/optics
Source: http://www.cryselco.co.uk/battent8.shtml

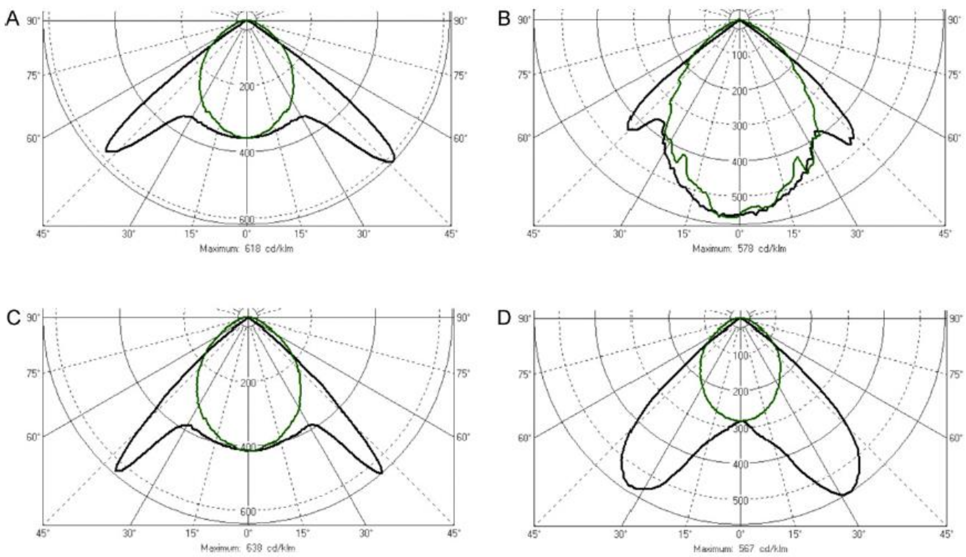

Figure 19a Measured luminous intensity distributions (in cd/klm green: C90–C270 and black C0–C180). (a) Luminaire with a LED tube with diffuser (Brand A). (b) Luminaire with a LED tube with 32 high intensity LEDs (Brand I). (c) Luminaire with a LED tube with 360 SMD LEDs (Brand K). (d) Luminaire with a fluorescent lamp T8–36 W/840. Source: "Linear LED tubes…" W.R. Ryckaert and others, p. 433

Visual differences are also apparent between T8 lamps and LED tubes as presented in the CALiPER.study as displayed figure 19b below.

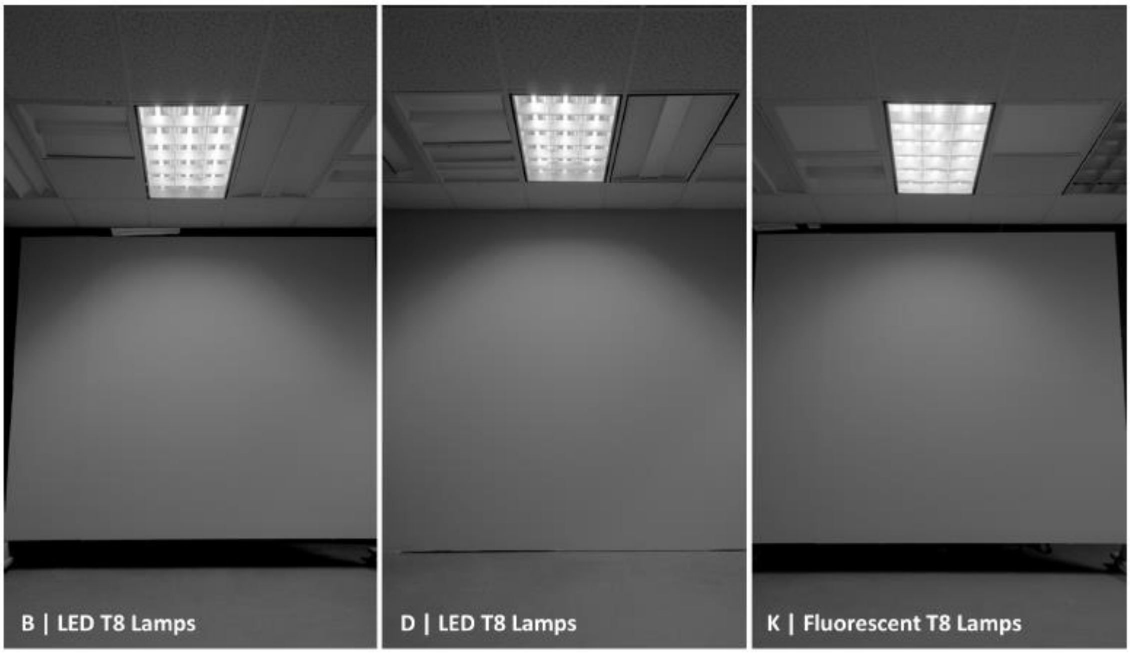

Figure 8. Example comparison of the pattern of light created on the wall by three different troffers with the same parabolic louver. The patterns created by the LED T8 lamps have a more distinct edge that observers did not like.

Figure 19b: Example comparison of the pattern of light created on the wall by three different luminaires with the same parabolic louver. The patterns created by the T8 lamps have a more distinct edge that observers did not like.

(3) Portfolio complexity.

(3)a Portfolio availability

In earlier paragraph two broad studies have been quoted, one originated in United States and second one in Belgium market. Both studies clearly indicate that LED tube portfolio is very complex, with broad characteristics' spread of key parameters, like lumen output, power, colour rendering. Table 5 shows a summary of measurements of twelve LED tubes of brands distributed on the Belgian market (collected in September 2010)[56]. All lamps are intended for replacement of standard T8 36 W fluorescent lamps, they have an integrated driver powered directly from the ac mains power supply. The studied lamps fall under the conversion route classification. Unlike fluorescent tubes, which are standardized within European Energy Efficiency regulation, this is not the case for LED tubes. Hence customer can buy on a market, lamps with variety of lumen outputs, wattages and other characteristics.

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

Brand	Φ (lm)	P (W)	η (lm/W)	CCT (K)	CRI	MCRI	CQS v7.5	PF	THD_I
A	1650	22.8	72.4	4186	90	90	88	0.97	14%
B	1535	23.6	65.0	6876	72	75	72	0.45	192%
C	1595	17.8	89.6	3709	76	83	79	0.82	56%
D	1774	21.2	83.7	4016	69	77	68	0.66	90%
E	754	10.3	73.4	4207	76	85	73	0.48	55%
F	1707	20.9	81.6	3194	65	74	68	0.93	17%
G	1036	15.2	68.2	3307	71	80	68	0.51	162%
H	1437	17.7	81.1	3853	77	85	75	0.96	16%
I	1605	31.6	50.8	3365	88	90	86	0.53	135%
J	920	14.5	63.4	3678	78	87	71	0.84	59%
K	1479	18.3	80.8	4733	65	64	68	0.78	54%
L	1185	17.6	67.3	5329	73	79	72	0.91	22%
Median	1479	17.8	73.4	3853	76	81	72	0.82	55%

Table 5 Initial lamp parameters measured during test, see text.

Figure 20 Examples of LED tubes available on US market, based on CALiPER study. Source: CALiPER, "Application Summary Report 21: Linear (T8) LED Lamps", p.1

At present retrofit and conversion LED tubes (easily) available in markets are in three lengths: 2ft, 4ft, 5ft (replacement for conventional 18, 36 and 58W lamps). However in T8 fluorescent technology more than 10 different lengths between 36 and 180 cm are applied in many different applications. Although most of LED tubes have standardized dimensions to fit existing luminaires, results of CALiPER study, show that there are lamps on the market, which have wider diameter and are heavier (nearly three times more) than their fluorescent counterparts[57]. It will certainly take considerable amount of time before this wide variety of length types will be available in LED as focus of LED retrofit and conversion lamp manufacturers is still focussed on the mass market.

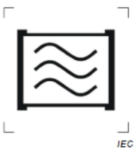
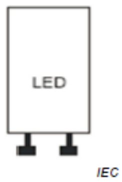
[57] CALiPER, "Application Summary Report 21: Linear (T8) LED Lamps", p.18

(3)b: Emergency lighting

One of the specific, yet very important categories for LED tube compatibility aspects are emergency lighting applications. Though regulation on emergency lighting is not yet detailed beyond safety standards, LED replacement lamps are designated as not suitable for use with emergency lighting installations per IEC62776 (luminaires are designed and certified with conventional fluorescent, LED tube replacement leads to loss of certification on conformity). The safety standard does require LED replacement lamps with adequate marking to differentiate the different application conditions. Next to the compatibility topics addressed, specific marking is required for LED replacement lamps that are not capable to dim, or that are only allowed to use in dry situation.

(3)c: Marking requirements

LED tubes due to their specific features and being designed mainly around electrical compatibility are complex product category. This is also clearly visible through required marking affixes on lamps and/or packaging.

Lamps suitable for high frequency operation 	Lamps suitable for 50Hz or 60Hz operation 	For lamps that cannot be dimmed. 
“This lamp is not suitable to be used in emergency luminaires designed for double-capped fluorescent lamp(s)” 		If starter needs to be replaced 

(4) 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 an EMC assessment is in preparation at IEC/CISPR (current draft CISPR/F/628/CDV). For conversion lamps also 34A/1642/CDV should be taken into account. After rewiring 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.

New Installations

Linear LED luminaires are providing a viable alternative to the traditional fluorescent tube with such features as: efficacy, energy efficiency, and design flexibility and appearance. But the quality and performance of LED products varies among manufacturers.[58] 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 refurbish 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*

As explained in previous chapter, LED tubes portfolio offered as replacement for conventional T8 in existing applications, have serious availability limitation. Those are:

- Electrical compatibility with ECG systems in a retrofit route is still rare on the market. At the same time European energy efficiency regulation bans electromagnetic ballasts from April 2017 onwards, which will create a natural transition from CCG to ECG based systems.

58 “Replacing the Fluorescent Lamp with Linear LED Luminaires” James Brigagliano, LC, IESNA, November 2012 Downloaded on 7th November 2014: http://continuingeducation.construction.com/article_print.php?L=223&C=947

- No dedicated replacement solutions are available for emergency lighting applications.
- LED tubes are mainly available on the market in only 3 lengths (600, 1200, 1500 mm) and the most common colour temperatures (not available in very cool (12000K) and warm (2700K) colours). Conventional T8 lamps offer more than 10 different lengths and even more wattage equivalents.
- LED tubes in most cases do not allow one-to-one equivalency of lumen output and/or distribution related to a specific wattage. Since these lamps have no performance standard the customer does not know well enough whether the replacing product gives the expected illumination level.

LED tubes offered in new installations, can overcome most of described limitations and good LED based alternatives are available on the market. In these new luminaires the light distribution is optimised for their intended application and the thermal management is optimal for the LED source.

6.2.3 *Impacts of substitution*

A growing number new luminaires based on LED sources, LED retrofit or conversion solutions for T8 linear fluorescent lamps are available in the EU market. Whether these lamps are adequate substitutes is discussed extensively in chapter 6.2. The overall impact of such substitutes in the market and the speed of adaptation is hard to estimate. Some aspects of the 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. The LED lamps use the directional character to optimise light flux in a desired direction. This gives the opportunity to save energy in a selected part of the installed applications, since no light is generated in other directions. This however also requires expertise of the customer to choose the best LED alternative in existing lighting installations.

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.

Energy saving by dimming or switching of the light in the absence of people in the room is both possible for discharge lamps with a suitable controller and for part of the LED tube lamps.

From material composition it is also necessary to have a case by case view. The fluorescent T8 lamps contain glass, metals, phosphors and mercury. These components can be effectively recycled. LED tubes alternatives contain electrical and electronic components such as an integrated control gear and a light engine with mounted LEDs. Material declarations for fluorescent lamps as well as LED replacement lamps (T8) can be found in table 6a and 6b. Like in most other electrical and electronic equipment electronic LED tubes 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, etc.).

Material Declaration Sheet of the unpacked lamp [2) 3)]					
Produktteil / product part	Produktunterteil / product subpart	Materialien / materials	CAS-Nr. [4)]	Masse / mass [5)] (g)	(%)
tube		soda lime glass	-	149,41	94,09%
gas filling		argon	7440-37-1	x	x
		krypton	7439-90-9	x	x
surface coating	phosphor	three band phosphor	-	1,70	1,07%
protective coating		aluminium oxide	1344-28-1	0,38	0,24%
mount	electrode- coil	tungsten	7440-33-7	0,2188	0,14%
	emitter/ emission material	CaSrBaZrO	-	x	x
	lead wire	NiMn	-	x	x
		NiFe47 Cr (Dumet)	-	x	x
		Cu plated steel	-	x	x
	electrode cap 1	Ni plated iron	7439-89-6	0,32	0,20%
	electrode cap 2	Ni plated iron	7439-89-6	0,30	0,19%
		mercury	7439-97-6	0,0033	0,00%
		Titan	7440-32-6	x	x
		Zirconium	7440-67-7	x	x
		Aluminium	7429-90-5	x	x
	spud wire 1	Ni plated steel	-	x	x
	spud wire 2	Ni plated steel	-	x	x
	flare	alkali silicate glass	-	3,24	2,04%
	exhaust tube	alkali silicate glass	-	0,80	0,50%
basing cement		Calciumcarbonate & phenolic resin	-	0,90	0,57%
cap	cap shell	aluminium	7429-90-5	1,52	0,96%
	contact pins	copper	7440-50-8	0,542	0,34%
		zinc	7440-66-6	0,34	0,22%
		lead	7439-92-1	0,0181	0,01%
	insulation plate	hard paper	-	0,62	0,39%
			Gesamt/ Total:	160,32	100,00%

Table 6a: Material declarations of T8 linear fluorescent lamp (1047 mm, 38 Watt)

3. Material Declaration Sheet of the unpacked lamp 2)					
product part	product subpart	materials	CAS-Nr. 3)	mass 4) (g)	(%)
Heat Sink		aluminum alloy		74,90	28,84%
Light Engine		electronic components		34,30	13,21%
Diffuser (Tube)		polycarbonate		114,00	43,90%
End caps		polycarbonate		9,50	3,66%
Driver		electronic components		23,70	9,13%
Starter		plastic, wiring		3,30	1,27%
			Total (rounded):	**260,00**	**100,00%**

Table 6b: Material declaration of a T8 LED lamp (1200 mm, 22 Watt)

6.2.3.2 Health and safety impact of substitutes

With the growing market of LED-T8 lamps, IEC is developing a safety standard [IEC62776] that covers the requirements for safe operation of the LED replacement lamps to the retrofit route (chapter 6.2). This standard is in the process of finalisation.

Upon finishing the standard it will take time to implement its consequences of the standard in real products, in adequate numbers on the market.

The safety standard [IEC62776] does not include the rewiring. This safety is the responsibility of the installer and the luminaire should be appropriately labelled afterwards, with a warning not to replace the LED lamp with a fluorescent lamp anymore. In most cases with an ECG a customer is required to go to the conversion route (rewire). In such a situation the safety and conformity certificates are no longer valid.

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 linear fluorescent T8 lamp, including exchange of the lamps by professionals. It is inevitable that linear T8 LED replacement lamps will also be installed by people who are not qualified professionals if T8 fluorescent lamps 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. As observed during CALiPER study[59] “Most of the LED T8 lamps were sold as a universal product, with no stated requirements in the specification sheets for the types of fluorescent sockets that would work.” They indicate “labeling issues, poor installation instructions, poor mounting or construction, and other complications” could lead to not meet electrical safety standards. Although it “*does not necessarily mean that the luminaires were unsafe, but it could trigger the inspector to require a site inspection*”. Although it is the common view

[59] http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/caliper_recessed-troffer_2013.pdf, p.23 and p.27

that the spectrum from LED light does not cause extra hazards, (for instance blue light hazard, stroboscopic effects), still LED relevant standards are in preparation.

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:

There is a severe change in the lighting market, also covering the production of T8 lamps.

In case T8 fluorescent lamps would no longer be available for existing installed lighting solutions, the impact would be 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. With a conservative assumption of a replacement need of 300 million luminaires 150 billion € would be needed (500€ per luminaire incl. installation) creating 3 Mio tons WEEE (10 kg each) of still functional and energy efficient equipment.

The impact on industrial progress and development of new technology in the LED sector is severely hampered if the lamps at stake are removed from the market too early. 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. In the absence of public funding and support programs as they characterize other global regions, the European industry finances this transformation almost exclusively by its own means.

Thousands of FTE's are employed in the manufacturing and supplies of Fluorescent lamps today in Europe. LED tube alternatives are often not produced in Europe (EU-28) but mostly in Asia.

Material and manufacturing costs on one-to-one basis are significantly higher for LED tubes than conventional T8.

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. 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 could be reduced, based on scientific and technical progress in the recent years.

Allowing this exemption will not affect innovation into new LED technology. Innovative R&D into T8 fluorescent lamps has already ceased as LEDs are seen as the future substitute, but only after sufficient time to resolve the technical issues described here and to allow EU users time to make changes without negative safety or socio-economic impacts.

6.2.4 *Future trends of substitution*

As described above in new products and applications there is a fast increase of the use of LED based technologies. On the other hand the number of T8 lamps sold in EU is still very high, their life time is good and they give very uniform light. T8 lamps are very reliable as they are in the market since decades and do not contain electronic components. The lamps are easily replaceable. Data forecast for 2014 is not yet available, in 2013 ca 247 Mio lamps were marketed in EU-28. Due to the very wide range of applications LightingEurope believes that there is a market need for lamps covered by this exemption for more than 15-20 years.

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 T8 linear 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[60] with effect between 2012 and 2013. The maximum mercury content of T8 lamps had to be reduced from 5 mg to 3.5 mg per burner as of 1st Jan 2012. Also further reductions have been made for certain lamp types, improving mercury consumption as described above in detail.

Further reduction of mercury might technically be possible with high economic effort and R&D resources. But these financial and human resources are needed for the investments and the running transfer to LED technology. 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.

[60] 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 is 5 mg.

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

Table 7: Regulation on mercury added lighting products in Minamata Convention 2013

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