**INFORMATION RELEVANT TO THE REVIEW OF ANNEXES A AND B**
**15 May 2020**

## Background

Article 4 of the Minamata Convention states that no later than five years after the date of entry into force of the Convention, the Conference of the Parties shall review Annex A and may consider amendments to that Annex in accordance with Article 27.
In accordance with Decision MC-3/16: *Review of Annexes A and B*, the Minamata Convention Secretariat requested information that could be used for the revision of Annex A, Part I to the Minamata Convention. In a letter dated 13 December (MC/COP3/2019/15), the Secretariat called for submissions from Parties (with the revised deadline of 15 April) including:

a) Information on mercury-added products and on the availability, technical and economic feasibility, and environmental and health risks and benefits of non-mercury alternatives to mercury-added products, pursuant to paragraph 4 of article 4 of the Convention;
b) Information on processes that use mercury or mercury compounds and on the availability, technical and economic feasibility and environmental and health risks and benefits of mercury-free alternatives to manufacturing processes in which mercury or mercury compounds are used, pursuant to paragraph 4 of article 5 of the Convention.

The Secretariat has invited non-parties and others to provide further information on the use of mercury or non-mercury alternatives referred to in the submissions by the Parties.

In this document we provide further information related to:

## Products

### 1. Batteries and button cells

**EU**

EU Directive 2006/66/EC on batteries and accumulators and waste batteries and accumulators, prohibits the placing on the market all batteries or accumulators, whether or not incorporated into appliances, that contain more than 0,0005 % of mercury by weight. The directive was adopted in 2006 and has been subject to a number of revisions. Last amendments were incorporated in November 2013, including a ban on cadmium from cordless power tools by the end of 2016 and on mercury from button cell batteries by 1 October 2015.

The prohibition of the manufacture, export and import of Batteries or accumulators that contain more than 0,0005 % of mercury by weight, after 31.12.2020, is covered by the **Mercury Regulation (EU) 2017/852** which complements a large body of existing EU environmental law on mercury.

**India**

A recent 2019 market study conducted by Toxics Link, in New Delhi (Jungpura and Kalkaji) markets showed that no mercury containing button cell batteries could be found. The interviewed retailers asserted "They no longer *sell mercury-added button cell battery; it used to be available before but now most of the shop sells mercury free batteries as the cost of both the batteries is almost the same*" (as per retailer from Kalkaji). In these markets mostly Alkaline and Lithium button cell batteries were available. The previous study of Toxics Link[1] also reiterated that in India there is no inventory on the use of mercury in button cell batteries in India. What emerged during the discussions with end users in India was that mercury-free button cell batteries are used in key application areas, such as watches, hearing aids, healthcare instruments, children's toys, etc. The cell batteries are mainly composed of common materials—steel, zinc and manganese – that do not pose a health or environmental risk in normal use or disposal.

### 2. Mercury containing lamps

Among many uses, mercury is currently also present in different types of lamps, widely used in residential and commercial buildings. The Minamata Convention has set maximum limits for the mercury content allowed in Compact fluorescent lamps (CFL), linear fluorescent lamps (LFL), high pressure mercury lamps and cold cathode fluorescent lamps (Annex ), after 2020.

**EU**

The European Union has developed and adopted legislation regulating the content of electrical and electronic equipment (EEE); Directive 2011/65/EC or Restriction of Hazardous Substances (RoHS) bans the use of certain hazardous chemicals in EEE – including mercury or any components containing mercury – in new equipment marketed after 1 July 2006.

[1] Mercury free India; Right Choice by Toxics, https://www.zeromercury.org/mercury-added-skin-lightening-creams-campaign/

Lighting sources are part of this directive. Given mercury was necessary for many lighting technologies, specific lamps have been exempted from the ban; the EU has specifically permitted continued use of fluorescent lamps with a generally low mercury content, as well as all specialty mercury lamps (more details on this are contained in the RoHS Directive).

The maximum allowed limits of mercury under the RoHS are lower or equal to those indicated by Annex A of the Minamata Convention.

However, as mercury free and more energy-efficient alternatives are becoming widely available, such as LEDs, the EU is currently revising these exemptions.

The prohibition of the manufacture, export and import of the above lamp categories as listed under the global section, after 31.12.2020, is covered by the Mercury Regulation (EU) 2017/852 which complements a large body of existing EU environmental law on mercury.

However, under the EU Ecodesign directive, which looks mainly at the energy efficiency of products including lighting, **Commission Regulation 2019/2020 of 1st October 2019[2] agreed,** via an energy efficiency formula, **to ban Linear fluorescent Lamps (LFLs) T2 and T12 and Compact Fluorescent Lamps (CFLs) with integrated ballast (CFLi) by 1st September 2021, and certain lengths (2-foot, 4-foot and 5-foot) of T8 linear fluorescent lamps by 1st September 2023.**

New evidence[3] published by the Swedish Energy Agency (SEA) and CLASP (as also submitted by Norway) highlights the fact that mercury-free drop-in (direct retrofit) alternatives to fluorescent lamps exist today for over 90% of the fluorescent sockets in Europe, therefore the RoHS exemption for fluorescent lighting is no longer justified. We invite you to thoroughly review the full report.

The report provides links to, and information from manufacturer websites that confirms there are cost effective direct retrofit LED replacements on the market today which operate on the existing fluorescent ballast (magnetic or electronic) and are the same size and base type. These LED retrofit lamps not only eliminate mercury from lighting, but they also will save the end users money on their energy bills and to the LED lamps last longer, meaning fewer replacement lamps. LED retrofit lamps are on average twice as efficient as the fluorescent lamps and last at minimum 2-3 times longer.

Beyond health benefits, climate and consumers would also benefit from ending the fluorescent lamp use examined in the SEA/CLASP report, providing them with lower running costs for businesses and households, and a reduction in $CO_2$ emissions.

The SEA-CLASP report further quantifies the following benefits[4] for Europe from removing these exemptions (for **CFL ni, T5 LFL and all lengths of T8 LFL**) by 2021:

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[2] 2 Commission Regulation (EU) 2019/2020 of 1 October 2019 laying down ecodesign requirements for light sources and separate control gears pursuant to Directive 2009/125/EC of the European Parliament and of the Council and repealing Commission Regulations (EC) No 244/2009, (EC) No 245/2009 and (EU) No 1194/2012 (Text with EEA relevance.) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2019.315.01.0209.01.ENG&toc=OJ:L:2019:315:TOC

[3] "Evidence of the availability of mercury-free alternative products to certain fluorescent lamps", revision v.2 published by the Swedish Energy Agency and CLASP Europe. 12 December 2019. Link: https://meta.eeb.org/wp-content/uploads/2019/11/SEA-and-CLASP-analysis-of-RoHS-exemptions-for-fluorescent-lamps-v2-1.pdf

[4] Benefits in this modelling were calculated for Sweden and CLASP by VHK, the consultants who conducted the lighting market analysis for DG ENER. The estimates were calculated using the same European lighting market model.

- 4.8 metric tonnes of mercury are avoided; 2.6 metric tonnes from the lighting supply chain and 2.2 metric tonnes avoided emissions from power stations (coal);
- €12.5 billion in energy and replacement lamp savings for businesses and consumers across Europe;
- 138.3 TWh of electricity savings; and
- 40.9 million metric tonnes of $CO_2$ emission savings.

Additional evidence concerning these lamps, **non-linear lamps**, **Cold Cathode Fluorescent Lamps (CCFLs) and High Intensity Discharge (HID) lamps - High Pressure Sodium vapour (HPS) and Metal Halide (MH) lamps-** was submitted by the European Environmental Bureau, Mercury Policy Project and the Responsible Purchasing Network in February 2020[5] to the European Commission. Some of this evidence is explained below and more information can be found in the full document in the Annex to this document.

- **LED U-shaped T8 lamps,** which have a higher energy efficiency and longer rated life than U-shaped fluorescent T8s, are available in the European marketplace. For example: Osram's SubstiTUBE U-Shaped LED Lamps[6] are a direct replacement for U-Shaped T8 Fluorescent Lamps.
- **LED circular T9 lamps**, which have a higher energy efficiency and longer rated life than circular fluorescent T9s, are available in the European marketplace. For example, Philips CorePro LEDtube Circular Lamp has an A+ Energy Efficiency Label and a 30.000 hour rated life[7] compared to an A Energy Efficiency Label and a 13.000 hour rated life for the T9 circular lamp it can replace.
- **Cold cathode fluorescent lamps (CCFL)** are rapidly being replaced by LEDs in the marketplace and there is an expectation that this trend will continue[8]. LEDs have practically replaced CCFLs in LCD backlight applications used for panels in small devices including smartphones and tablets as well as large appliances and electronics such as TVs, PC monitors, and notebooks. Thanks to their higher luminous efficiency and far smaller form factor, LEDs enable more effective positioning of the light sources behind the panel. Furthermore, there is an urgency for ending this exemption and hastening the complete transition to LEDs since CCFLs create health and environmental hazards when products containing them are recycled at the end of their useful life. [9]
- LED lamps can replace many types of **High Intensity Discharge lamps (HIDs)** including both high-pressure sodium (HPS) and metal halide lamps, which contain a

[5] https://eeb.org/library/mercury-containing-lamp-exemptions-to-rohs-directive/
[6] Osram, LED SubstiTUBE U-Shaped Lamps, 12 February 2020, https://www.osram.com/ecat/SubstiTUBE%20U-Shape-SubstiTUBE%20T8%20EM-LED%20tubes-Lamps-Digital%20Systems/com/en/GPS01_3234358/PP_EUROPE_Europe_eCat/

[7] Philips Data Sheet for CorePro LEDtube Circular Lamp, 24 January 2020, https://www.assets.signify.com/is/content/PhilipsLighting/comf7342442-pss-en_gb
[8] 2019 *Waste Electronic and Electrical Equipment (WEEE) Handbook,* https://books.google.be/books?id=fvKiDwAAQBAJ&pg=PA349&lpg=PA349&dq=LEDs+replacing+CCFLs+in+europe&source=bl&ots=GqzkoG3vQ6&sig=ACfU3U3M9tWXT_S_CxzxAla8fqG9UyaGMQ&hl=en&sa=X&redir_esc=y#v=onepage&q=LEDs%20replacing%20CCFLs%20in%20europe&f=false
[9] See also "Evaporation of Mercury from CCFLs during Recycling of LCD Television Sets," 2013 December, https://www.researchgate.net/publication/260246422_Evaporation_of_Mercury_from_CCFLs_during_Recycling_of_LCD_Television_Sets

significant amount of mercury. LED lamps are now available in a wide array of sizes, wattages and lumen outputs and with a variety of commonly used HID bases (e.g., E27, E40). Suitable applications – both indoor and outdoor – include, but are not limited to: High-bay Lighting, Street lights, Garages, Parking Lots, Area lighting, Pedestrian zones, Parks, Industry, Retail and Museums.

The benefits of LEDs over **High Pressure Sodium (HPS) lamps** are many:

- LED lamps are much more energy efficient than HPS lamps.
- LEDs also have a longer rated life, which reduces their replacement and installation costs as well as their lifecycle environmental impacts.
- LEDs emit a higher quality of light, which is white rather than the yellow light that is emitted from HPS lamps.
- LED lamps do not cycle on and off.
- LEDs are mercury-free unlike HPS lamps.

High-pressure sodium lamps (HPS) are primarily used for street lighting and other exterior lighting applications, although they are rapidly becoming replaced by other technologies including, notably, LEDs because:

- of their poor color quality – many HPS lamps appear yellow because their CRI is typically in the 20s;
- they cycle on and off, which causes maintenance and safety problems; and
- their relatively short life.

Over the past few years, there has been a significant increase in the number of LED replacements for high-intensity discharge (HID) lamps – particularly LEDs that can replace high-pressure sodium (HPS) lamps up to 400 watts[10].

According to the International Dark Sky Association, "Early LEDs were energy-inefficient and emitted little light, but due to technological advances, LED efficiency and light output have doubled about every three years. Because of their improved quality and falling prices, LEDs are now replacing conventional high-intensity discharge (HID) lamp types for outdoor lighting in communities around the world."[11]

**Quartz metal halide lamps** – particularly low-wattage models – can be readily replaced with **more energy-efficient ceramic metal halide (CMH) lamps**, which have a longer rated life and typically have less or the same amount of mercury. Since quartz and ceramic MH lamps are very often available in the same shape and type of lamps and bases, they are almost always interchangeable. Therefore, preference should be given to Ceramic MH drop-in replacements with multiple environmental benefits, including significant mercury reduction as well as energy savings.

Since some metal halides have a similar base, bulb shape and lumen output as the HPS

[10]Global Industry Analysts, "High Intensity Discharge (HID) Lighting: Market Analysis, Trends and Forecasts, 2018 May, https://www.strategyr.com/market-report-high-intensity-discharge-hid-lighting-forecasts-global-industry-analysts-inc.asp

[11] International Dark Sky Association, *LED Practical Guide*, https://www.darksky.org/our-work/lighting/lighting-for-citizens/led-guide/

lamps up to 400 watts, there are manufacturers offering LED replacement lamps for some types of metal halide lamps. Examples are provided in the full paper.

Furthermore, because of the submission of these above updated figures concerning mainly CFLs and LFLs (T5 and T8) , the European Commission requested a revision of the socioeconomic assessment that had been published in 2019 but based on 2013-2017 data.

The **updated socioeconomic assessment on phasing out CFLni, LFL T5 and T8** in Europe was published on 11 May 2020[12] – while the previous study had shown high costs, the updated version shows that there are actually €13.5 billion Euros of net savings for European consumers and businesses in addition to the tonnes of mercury removed from our homes, offices and the environment. The report states that 2,882 kg of mercury is removed by ending the exemption for fluorescent lamps in 2021. However, in addition to these benefits there are also additional mercury and CO2 emissions saved at the power station because the LED retrofit lamps are so much more efficient than fluorescent (i.e. avoids the need to burn coal, a fossil fuel which contains mercury).

LED technology has become increasingly more competitive and easier to retrofit, to the point that there is now no economic or technical justification to keep fluorescent lamps on the European market.

**India**

As a start it is important to bring to the notice of the Convention Secretariat that the mercury limits set in the Convention are higher than what is currently achievable and practiced in a developing country like India. India is one of the largest global users of mercury containing lamps, with almost 28 million pieces of CFL lamps and 132 million pieces of LFL sold annually (2018).

The Industry had voluntarily reduced mercury content to 3.5 mg for CFLs of less than 26 watts by the end of 2014, as has been stated by ELCOMA, the lighting association in India (http://www.elcomaindia.com/). This was lower than Bureau of Indian Standards mercury limit of 5 mgs for the same category of lamp, applicable at that point.

Mercury containing lamps were brought under the ambit of E-waste management Rules in India in 2016[13], which prescribes the mercury content for different kinds of lamps based on the rationale of ROHS limits for metals as prescribed by the EU. These limits have been in force since October 2016 and have been followed by all lighting companies registered in India. The allowed limits, listed below, are much lower than the maximum mercury content limits set by Minamata Convention.

[12] https://rohs.exemptions.oeko.info/fileadmin/user_upload/reports/RoHS_SEA_Lamps_2020_Revision_Final_08052020.pdf
[13] Indian 2016 E-waste rules
http://cpcb.nic.in/displaypdf.php?id=UHJvamVjdHMvRS1XYXN0ZS9FLVdhc3RlTV9SdWxlc18yMDE2LnBkZg==

**Table 1: Allowed mercury limits in lamps, India**

| | |
|---|---|
| *1* | *Mercury in single capped (compact) fluorescent lamps not exceeding (per burner):* |
| 1(a) | For general lighting purposes <30 W : 2.5 mg |
| 1(b) | For general lighting purposes = 30 W and <50 W : 3.5mg |
| 1(c) | For general lighting purposes = 50 W and <150 W : 5mg |
| 1(d) | For general lighting purposes =150 W : 15 mg |
| 1(e) | For general lighting purposes with circular or square structural shape and tube diameter =17 mm : 7mg |
| 1(f) | For special purposes:5 mg |
| *2(a)* | *Mercury in double-capped linear fluorescent lamps for general lighting purposes not exceeding (per lamp)* |
| 2(a)(1) | Tri-band phosphor with normal life time and a tube diameter < 9mm (e.g.T2): 4mg |
| 2(a)(2) | Tri-band phosphor with normal life time and a tube diameter = 9 mm and = 17 mm (e.g. T5): 3 mg |
| 2(a)(3) | Tri- band phosphor with normal life time and a tube diameter >17 mm and = 28 mm(e.g. T8): 3.5 mg |
| 2(a)(4) | Tri-band phosphor with normal life time and a tube diameter >28 mm (e.g. T12):3.5 mg |
| 2(a)(5) | Tri-band phosphor with long life time (=25000 h):5mg |
| *2(b)* | *Mercury in other fluorescent lamps not exceeding(per lamp):* |
| 2(b)(1) | Linear halophosphate lamps with tube >28 mm (e.g. T 10 and T12):10 mg |
| 2(b)(2) | Non-linear halophosphate lamps(all diameters):15mg |
| 2(b)(3) | Non-linear tri-band phosphor lamps with tube diameter >17 mm(e.g.T9):15 mg |
| 2(b)(4) | Lamps for other general lighting and special purposes (e.g. induction lamps):15mg |
| *3* | *Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL)for special purposes not exceeding (per lamp):* |
| 3(a) | Short length( < 500 mm):3.5mg |
| 3(b) | Medium length(>500 mm and<1500 mm): 5mg |
| 3(c) | Long length(>1500 mm): 13mg |
| *4(a)* | *Mercury in other low pressure discharge lamps (per lamp): 15mg* |
| *4(b)* | *Mercury in High Pressure Sodium(vapour) lamps for general lighting purposes not exceeding (per burner)in lamps with improved colour rendering index Ra>60:* |
| 4(b)-I | P =155 W : 30 mg |
| 4(b)-II | 155 W < P <405 W : 40 mg |
| 4(b)-III | P >405 W: 40 mg |
| *4(c)* | *Mercury in other High Pressure Sodium(vapour)lamps for general lighting purposes not exceeding (per burner):* |
| 4(c)-I | P<155 W:25mg |
| 4(c)-II | 155 W < P < 405 W:30 mg |
| 4(c)-III | P >405 W:40 mg |

In the table below, the Minamata convention and the Indian standards have been compared for select types of lamps.

**Table 2: Comparison of allowed mercury limits in lamps under the Indian regulation and the Minamata Convention.**

| Type | Minamata Convention allowed content | Indian Regulation allowed content |
|---|---|---|
| Compact fluorescent lamps (CFLs) for general lighting purposes that are ≤ 30 watts | ≤5 mg per lamp burner | ≤2.5 mg per lamp |
| Linear fluorescent lamps (LFLs) for general lighting purposes: | | |
| (a) Triband phosphor < 60 watts with a mercury content exceeding; | ≤5 mg per lamp | ≤3-3.5 mg per lamp |
| (b) Halophosphate phosphor ≤ 40 watts | ≤10 mg per lamp | ≤10 mg per lamp |
| Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for electronic displays: | | |
| (a) short length (≤ 500 mm) | ≤3.5 mg per lamp | ≤3.5 mg per lamp |
| (b) medium length (> 500 mm and ≤ 1 500 mm) | ≤5 mg per lamp | ≤5 mg per lamp |
| (c) Long length(>1500 mm) | ≤ 13 mg per lamp | ≤13 mg |

Furthermore, in a recent study, further information came to our attention.

The Indian lighting industry has seen a robust growth of 59%, growing from Rs. 8,500 Cr in 2010 to Rs 13,500 Cr in 2013. This has been largely driven by the move from GLS lamps to CFLs and more recently due to the LEDs - Several government initiatives supported this transition, including use of CFLs in government offices, providing consumers with CFLs through Demand Side Management (DSM) schemes, free lamps to Below Poverty Line (BPL) houses and the programme is supported by ongoing government initiatives to promote LED lighting as well as changing consumer preferences (Elecoma vision doc, 2020)[14]. The LED market will grow to INR 21.6k Cr by 2020, an exponential growth of 41% Compound Annual Growth Rate (CAGR) from INR 1,925 Cr in 2013, making the LED market ~60% of the total lighting industry (INR 37.6k Cr) in 2020. The government has decided to change all street lights and lights in public spaces to LED lights, and initiated making all LED specifications mandatory; notifications to commercial buildings to change existing down lights exclusively to LED are in progress (Elecoma vision doc, 2020). All existing government schemes to distribute CFL are being modified with LED lamp distribution. However, data shows that mercury containing tube lights still have a large market share though there is a sharp decline of the CFL use in the country (Elecoma vision doc, 2020).

[14] Elecoma (2019) *Vision Document 2020*, The information is retrieved from http://www.elcomaindia.com/wp-content/uploads/ELCOMA-Vision-2020.pdf

The Indian experience clearly shows that lower mercury limits is being attained by the lighting industry. Precise dosing techniques, required to achieve the same, are low cost, globally available and applicable for automated production lines as well as manual production facilities in emerging countries. Furthermore, the LED market is growing very fast. These developments may be appropriate for consideration in the Annex A review process.

**Cote d'Ivoire**

LED lamps are sold in Côte d'Ivoire as they are representing 62.26% of the lamp market[15]. According to the data collected as part of the CASE study (2017-2018), this was further verified. The following figures give details of the largest importers of LED lamps in Côte d'Ivoire and the different categories of importers during the period.

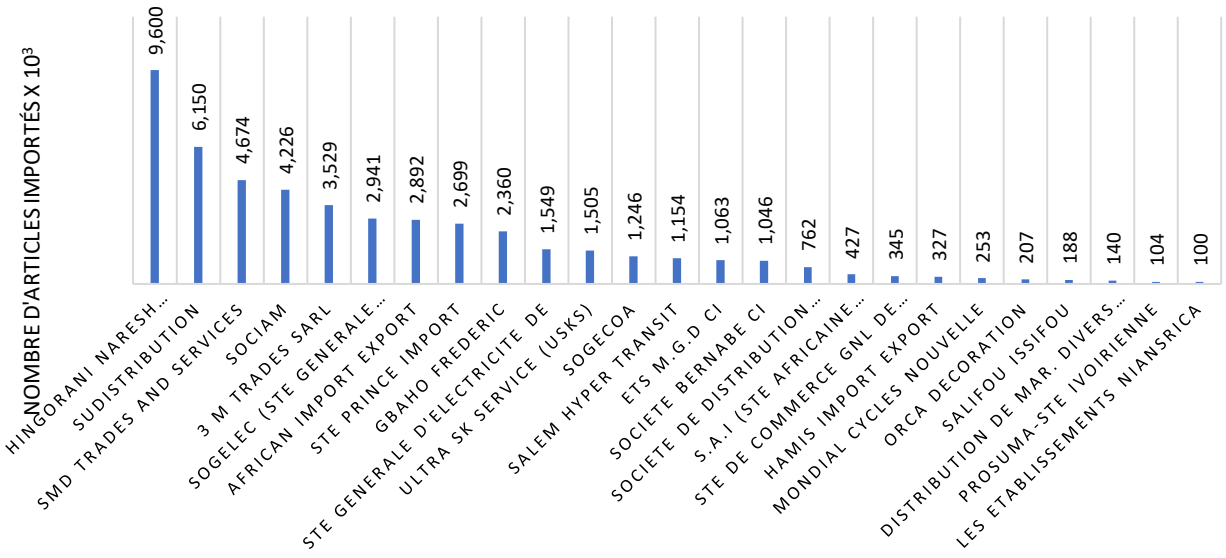


**Figure 1**: Ranking of the 25 major importers of LED lamps in 2018

Small and Medium Enterprises (SMEs) dominate the import of LED lamps with a rate of 90% followed by one-person companies by 6% and large companies by 4%. SMEs were the most important importers of LED bulbs for the year 2018 as indicated by our data illustrated in Figure 1.

Such information may be appropriate for consideration in the Annex A review process.

## 3. Measuring devices

**Serbia**

In Serbia, the national legislation on Chemicals prescribes bans and restrictions of use, placing on the market and production of Mercury and Mercury compounds. The law established the legal basis for adoption of the Rulebook on Bans and Restrictions of Production ("Off. Gazette RS" No. 90/2013, 25/2015, 2/2016 and 44/2017), placing on the Market and Use of Chemicals which has been harmonized with Annex XVII of EU Regulation No. 1907/2006 (REACH). This

[15] Cote d Ivoire MIA report

Rulebook prescribes bans and restrictions of Mercury and their compounds (No. of ban and restriction: 18, 18a). Prescribed provisions of entry 18a for general use came into force in 2011. For professional use these provisions come into force in 2018. In the same Rulebook, bans and restrictions regarding phenyl mercury compounds listed under no. 62 will enter into force on 10th October 2017.

Rulebook introduced among others:

- Ban of placing on the market (including import) of mercury-containing measuring devices, as well as production. The following mercury-added products cannot be placed on the market:

(a) in fever thermometers;

(b) in other measuring devices intended for sale to the general public (such as manometers, barometers, sphygmomanometers, thermometers other than fever thermometers).

The restriction applies to measuring devices that were placed on the market after 5 July 2011.

The following mercury-containing measuring devices intended for industrial and professional uses have not be placed on the market after 1 October 2018:

(a) barometers;

(b) hygrometers;

(c) manometers;

(d) sphygmomanometers;

**(e) strain gauges to be used with plethysmographs;**

**(f) tensiometers;**

(g) thermometers and other non-electrical thermometric applications.

The restriction also applies to measuring devices under points (a) to (g) which are placed on the market empty if intended to be filled with mercury.

The restriction does not apply to: (a) sphygmomanometers to be used: (i) in epidemiological studies which are ongoing on 1 October 2018; (ii) as reference standards in clinical validation studies of mercury-free sphygmomanometers; (b) thermometers exclusively intended to perform tests according to standards that require the use of mercury thermometers until 1 October 2020; (c) mercury triple point cells which are used for the calibration of platinum resistance thermometers.

The following mercury-using measuring devices intended for professional and industrial uses shall not be placed on the market after 1 October 2018: (a) mercury pycnometers; (b) mercury metering devices for determination of the softening point.

The restrictions shall not apply to: (a) measuring devices more than 50 years old on 3 October 2007; (b) measuring devices which are to be displayed in public exhibitions for cultural and historical purposes.

**All information from source**: Minamata Initial Assessment for Serbia, 2018, Available at https://www.researchgate.net/publication/330514455_Mercury_initial_assessment_for_the_Republic_of_Serbia

## 4. Rocket Fuel

Norway, Canada and the EU have referred to the use of mercury in ion engines or ion thrusters in satellites.

ZMWG hereby shares information on the (re-emerging) use of mercury as a propellant in ion engines, in particular the availability, technical and economic feasibility, environmental and health risks and benefits of using mercury or mercury-free alternatives as a propellant in ion engines. This information indicates the propellant use of mercury is likely to cause significant dispersion into the environment, and there are clearly alternatives available.

Name of the product and/or process using mercury: Ion engines, especially for satellites and spacecraft

Alternative names: Ion thruster; mercury ion thruster; mercury bombardment ion thruster, Hall thruster

Purpose of the product/process:

Ion thrusters are used for spacecraft propulsion and produce thrust by ionizing a propellant and accelerating it across an electric field. This is mostly achieved through electron bombardment, where a high-energy electron collides with a propellant atom to release electrons and create a positive ion. For reasons described below, the most commonly used propellant is now xenon; however, in the distant past mercury has been used as a propellant in some ion engines (Fazio et al., 2018)[16].

As cost is a key criterion in the launching of large satellite "swarms" or "constellations" with unprecedented spatial and temporal coverage, a new generation of satellites for Earth observation and telecommunications is being designed and built with off-the-shelf components (Fazio et al., 2018). In-orbit satellite maneuvers are commonly performed using ion thrusters.

Manufacturers:

Apollo Fusion, Inc[17]. (1049 Linda Vista Ave., Mountain View, California, USA) is the only manufacturer identified at this time producing or intending to produce mercury ion thrusters. According to the company's website (accessed 27 April 2020), it expects to have its "first thruster in flight operation in 2020; over 100 thrusters in flight operation by the end of 2022; and over 500 thrusters in flight operation by the end of 2024."

Depending on a client's needs, according to the Apollo Constellation Engine (ACE) datasheet[18], the engine is able to use a range of propellants: It has "multi-propellant capability with Krypton, Xenon, and proprietary propellants." The latter are not specified, although four industry insiders with direct knowledge of Apollo Fusion's technology have confirmed that its propulsion systems are designed to use mercury as a fuel (Bloomberg 2018).[19] This helps to explain the statement

[16] Fazio et al. (2018). N Fazio, SB Gabriel, IO Golosnoy, *Alternative Propellants for Gridded Ion Engines,* Conference Paper, May 2018. Available online at https://www.researchgate.net/publication/326571233_Alternative_propellants_for_gridded_ion_engines

[17] Apollo Fusion Inc. website: http://apollofusion.com/

[18] Apollo Constellation Engine (ACE) datasheet: Available online at https://apollofusion.com/ace.html

[19] Information on the use of mercury as a propellant by Apollo Fusion was revealed to the press by anonymous business insiders. The information has not been validated by the company. Bloomberg (2018). Ben Elgin, This Silicon Valley Space Startup Could Lace the Atmosphere With Mercury, *Bloomberg Businessweek*, 19 November 2018. https://www.bloomberg.com/news/articles/2018-11-

on the company's website that Apollo's proprietary propellant "solves the biggest satellite pain points: mass and volume. … When used with Apollo's proprietary propellant, ACE offers 3x more impulse per mass and volume than other systems."

The propellant tank is described as a composite overwrap pressure vessel (COPV) with aluminum liner. Were mercury to be held in such a propellant tank, the chemical reaction between mercury and the aluminum liner may also be a concern.

Quantity of mercury used: According to the CEO of Apollo Fusion (SatMagazine, February 2018 issue)[20]: "Recently, several companies have filed FCC applications with their goal being the launch of more than 30,000 new satellites during the next five years. By leveraging miniaturization, commercial off-the-shelf technology, and mass-manufacturing techniques, companies are changing the economics of satellite missions…. One of the key components of this new generation of constellations is the satellite propulsion system."

In assessing mercury emissions, Fourie et al. (2019)[21] noted that plans for satellite constellations are expected to increase the number of satellites in Low Earth Orbit (LEO) by a factor of 10 in the next 10-20 years. Assuming a conservative number of satellites using mercury during a 10-year period, they wrote:

> *The potential magnitude of mercury emissions from satellite electric propulsion depends on the propellant mass per satellite and the number of satellites. Satellites in the proposed constellations have masses in the range of 100–500 kg, and propellant typically comprises a large fraction of the mass of satellites due to the large velocity changes required for orbital. As a representative magnitude, 2000 satellites (the average size of two approved constellations) each containing 100 kg of mercury propellant would emit 20 Mg [metric tons] of mercury per year over a 10 year lifetime.*

<u>Environmental and health risks:</u>

There are three key environmental and health risks to be assessed with regard to the use mercury as a satellite propellant:

- the potential impacts on society and future generations of releasing tons of additional mercury into the global environment from low-Earth orbit;
- the risk of launch failure, leading to possible widespread contamination of the natural habitat, as well as human exposure;
- the risk of exposure, emissions, spillage, soil contamination, etc., during production, transport, storage and handling of mercury.

As compared to the estimated 20 metric tons of annual satellite emissions of mercury, North America emits about 50 metric tons of mercury each year (Bloomberg 2018), and the trend is

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19/this-space-startup-could-lace-the-atmosphere-with-toxic-mercury?utm_medium=email&utm_source=newsletter&utm_term=181121&utm_campaign=climatechanged

[20] Longmier (2018). Ben Longmier, An Apollo Fusion Perspective—The trade space will change in 2018 due to new propulsion systems, *SatMagazine*, February 2018 issue: Available online at http://www.satmagazine.com/story.php?number=1976340843

[21] Fourie et al. (2019). D Fourie, IM Hedgecock, F De Simone, EM Sunderland and N Pirrone. Are mercury emissions from satellite electric propulsion an environmental concern?, 2019, *Environ. Res. Lett.* **14** 124021. Available online at https://iopscience.iop.org/article/10.1088/1748-9326/ab4b75

downward as coal-fired power plants and other sources are more stringently controlled or phased out. The environmental and human health implications of mercury releases in orbit have not previously been evaluated because the most common propellants used since the 1980s, for example xenon, are not an environmental concern (Fourie et al. 2019).

Recently a team of researchers used the ECHMERIT model to investigate the fate and global deposition of mercury entering the atmosphere at high altitudes. ECHMERIT simulates the global chemistry and transport of mercury, and is based on the Atmospheric General Circulation Model, ECHAM5, developed at the Max Planck Institute for Meteorology. The following observations were reported, among others (Fourie et al. 2019):

> *All the simulations show that Hg predominantly descends into the stratosphere and troposphere at high latitudes, and that the highest concentrations at ground level occur at around 30°N. The map [below] highlights the geographical regions of highest and lowest potential impact from mercury contamination by satellite emissions. While the simulated deposition fields differ noticeably, it is evident from this ensemble deposition field that some regions are more likely to be impacted by mercury deposition from satellite emissions than others.*

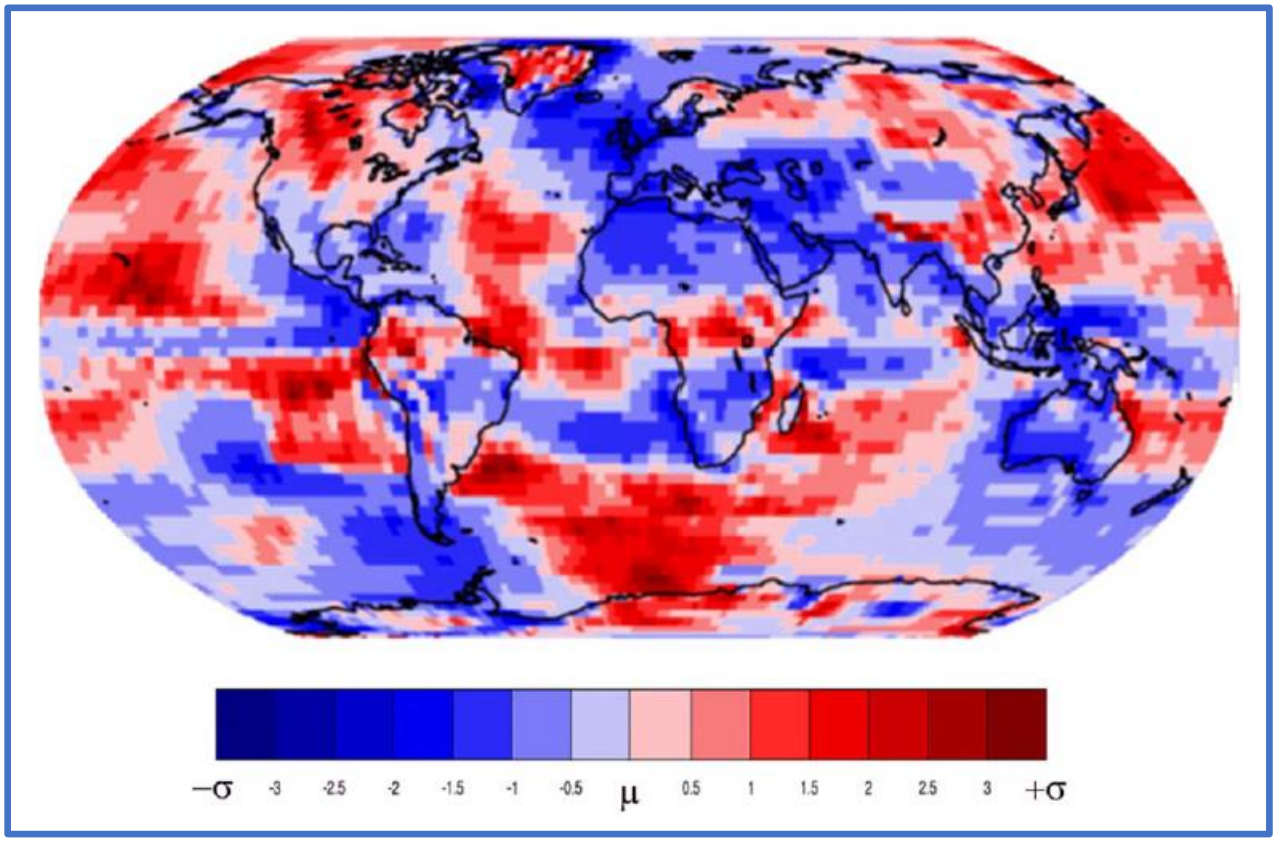


**Figure 2: Geographical distribution of annual mercury deposition from satellite emissions (20 Mg $yr^{-1}$) shown as the probability density function obtained from the ensemble of simulations. Deposition is illustrated in terms of the average (μ = 0.03 $\mu g m^{-2} yr^{-1}$) and standard deviation (σ = 0.02 $\mu g m^{-2} yr^{-1}$) of the ensemble (Fourie et al. 2019).**

Based on their modelling, and especially with regard to health implications, Fourie et al. (2019) observed:

> *At 20 Mg $yr^{-1}$, mercury emissions from satellites would represent about 1% of global anthropogenic mercury emissions. While this would already comprise a significant quantity from a single source, it could constitute an even larger fraction in future emissions scenarios as the signatories to the Minamata Convention continue to take steps to reduce their use of mercury and employ abatement measures.*
>
> *… about 75% of the mercury from satellite emissions is deposited in the oceans. This fraction is larger than the magnitude (63%) of land-based anthropogenic emissions that are eventually deposited to the oceans. Marine fish are the predominant vector of methylmercury exposure to human populations in many countries and thus such deposition patterns could potentially affect future human exposure to mercury.*
>
> *Compounding this, mercury deposited to aquatic ecosystems atmospherically may be more readily converted to the bioacccumulative methylmercury species than legacy mercury that has resided in a watershed or strongly bound to organic carbon complexes for an extended period….*

Then focusing especially on the environmental impacts, Fourie et al. (2019) concluded:

> *If launched, satellite electric propulsion using mercury propellant would be a major environmental concern. While beyond the scope of this work, even the possibility of a failure of a launch vehicle carrying a number of satellites would clearly represent a catastrophic risk to local ecosystems. The environmental impact of mercury propellant is not worth the satellite cost savings of moving away from existing non-toxic propellants. The use of mercury as a satellite propellant should be monitored, quantified, and regulated by environmental intergovernmental organizations.*

The bottom line is that if mercury is widely used to propel satellites, the resulting releases would significantly increase the global pool of mercury in the atmosphere and hydrosphere. This flies in the face of global efforts to reduce mercury releases and associated impacts on human health and ecosystems.

<u>Non-mercury alternatives:</u>

According to Fazio et al. (2018), "Xenon is the most common propellant used for space applications, particularly in [the] Gridded Ion Engine (GIE) and Hall Effect Thruster (HET), thanks to its particular physical and chemical properties, such as low first ionization energy, high atomic mass, and chemical inertness. However, this gas costs about $2000/kg due to its currently limited availability and sophisticated production process…." This is more of a factor for satellites requiring significant maneuverability, orbital control, changes in velocity, etc. For efficient orbit raising and orbital station-keeping (maneuvers required to maintain the desired altitude and path), many of these satellites will include electric propulsion systems, predominantly Hall thrusters.

Mercury has been used in the past, but in the 1970s NASA recognized the risks (special handling, contamination on the ground, etc.) related to mercury fuels in satellites and chose other options

- even though mercury was cheaper to use. **Mercury-free alternatives have been available and almost universally used in recent decades (Kieckhafer and King, 2005)[22].**

According to the Apollo Fusion website (accessed 27 April 2020), "In the search for the ideal propellant, Apollo's engineers have tested 15 different options, from standards like Krypton and Xenon to a range of more exotic options."

Fazio et al. (2018) published a comparative overview of the properties of various propellants suitable for electric propulsion, comparing the physical properties and performance of all of the following:

- Xenon (Xe)
- Krypton (Kr)
- Argon (Ar)
- Neon (Ne)
- Helium (He)
- Hydrogen (H2)
- Iodine (I2)
- Buckminsterfullerene (C60)
- Mercury (Hg)
- Adamantane (C10H16)

Fazio et al. (2018) concluded:

> *… the only viable alternative would appear to be Krypton if all of the selected impacts are taken into consideration; however, Iodine and Mercury have the best performance but could be eliminated because of compatibility issues, especially in terms of spacecraft contamination and toxicity. Nevertheless, it should be noted that the former [Iodine] is current [sic] being actively pursued both in Europe and the USA as an alternative propellant despite these issues and that the latter [Mercury] was in the past (up to around 1980) the preferred propellant choice, only being replaced by Xenon due to spacecraft interactions. Additionally, the low storage density of Krypton has important effects on the storage system, i.e. need for a bigger and/or heavier propellant tank system.*

The GMA 2018. Global Mercury Assessment 2018, UNEP, 2019. http://hdl.handle.net/20.500.11822/27579 has also been used as resource.

This use of mercury as a rocket fuel may be appropriate for consideration in the Annex A review process.

[22] Kieckhafer and King (2005). A Kieckhafer and LB King, Energetics of Propellant Options for High-Power Hall Thrusters, Proceedings of the Space Nuclear Conference, San Diego, California, June 5-9, 2005, Paper 1092. Available online at http://aerospace.mtu.edu/__reports/Conference_Proceedings/2005_Kieckhafer_1.pdf

## Processes

### Polyurethanes

### Serbia

In Serbia, the national legislation on Chemicals prescribes bans and restrictions of use, placing on the market and production of Mercury and Mercury compounds. The law established the legal basis for adoption of the Rulebook on Bans and Restrictions of Production ("Off. Gazette RS" No. 90/2013, 25/2015, 2/2016 and 44/2017), placing on the Market and Use of Chemicals which has been harmonized with Annex XVII of EU Regulation No. 1907/2006 (REACH). This Rulebook prescribes bans and restrictions of Mercury and their compounds (No. of ban and restriction: 18, 18a). Prescribed provisions of entry 18a for general use came into force in 2011. For professional use these provisions come into force in 2018. In the same Rulebook, bans and restrictions regarding phenyl mercury compounds listed under no. 62 will enter into force on 10th October 2017.

Rulebook introduced among others:

- Ban of manufacture, placing on the market or use of certain phenyl mercury compounds as substances or in mixtures, as well as in articles or any parts thereof, if phenyl mercury compounds concentration is equal to or greater than 0.01% by weight.

Articles or any parts thereof containing one or more of five phenylmercury compounds that are known to be used especially as catalysts in polyurethane systems shall not be placed on the market after 10 October 2017 if the concentration of mercury in the articles or any part thereof is equal to or greater than 0.01 % by weight.

Rulebook introduces annex XVII of EU REACH Regulation and stipulates that five phenylmercury compounds are known to be used especially as catalysts in polyurethane systems shall not be produced, placed on the market or used as substances or in mixtures after 10 October 2017 if the concentration of mercury in the mixtures is equal to or greater than 0.01% by weight.

**All information from source**: Minamata Initial Assessment for Serbia, 2018, Available at https://www.researchgate.net/publication/330514455_Mercury_initial_assessment_for_the_Republic_of_Serbia

# Annex

**Environmental NGOs Additional input on mercury-containing lamps – Exemptions 1-4**

**(Review of Annex to the RoHS directive)**

**February 2020**

The European Environmental Bureau, the Mercury Policy Project, and the Responsible Purchasing Network[23] would like to submit additional information with respect to the ongoing discussion on Exemptions 1-4 of the RoHS directive, concerning mercury-containing lamps, including compact fluorescent lamps (CFLs), linear fluorescent lamps (LFLs), cold cathode fluorescent (CCFL) and high-intensity discharge lamps (HIDs), given that over 4 years have now passed since our last submission and new evidence documenting that highly efficient LED replacement lamps have become much more widely available and can now replace virtually all types of mercury-containing lamps used for general lighting applications.

As per our letters sent in December 2019 and January 2020[24], we urge DG Environment to carefully review and remove exemptions for virtually all fluorescent and high-intensity discharge (HID) lamps under the Restriction of Hazardous Substances for Electric and Electronic Products (RoHS) Directive, which we conclude are no longer needed or justified. Phase out should take place at the earliest possible date, but no later than 1 September 2021, mainly for the larger categories including compact fluorescent lamps (CFLs), linear fluorescent lamps (LFLs), and low-wattage HID lamps.

Although the validity of the existing exemptions expired in July 2016, the delay in an actual decision by the Commission has led to these lamps still being allowed on the EU market, contributing to mercury pollution, while mercury-free alternatives are available.

[23] NGOs include the **European Environmental Bureau, (EEB)**, www.eeb.org, is a federation of more than 160 environmental citizens' organisations based in all EU Member States and most Accession Countries, as well as in a few neighbouring countries. These organisations range from local and national, to European and international. The aim of the EEB is to protect and improve the environment of Europe and to enable the citizens of Europe to play their part in achieving that goal.
The **Mercury Policy Project (MPP),** a project of the Tides Center, www.mercurypolicy.org, works to promote policies to eliminate mercury uses, reduce the export and trafficking of mercury, and significantly reduce mercury exposures at the local, national, and international levels. We strive to work harmoniously with other groups and individuals who have similar goals and interests.
The **Responsible Purchasing Network,** www.responsiblepurchasing.org, is a non-profit organization based in the United States that helps government agencies, institutions and businesses to specify, evaluate and purchase environmentally preferable goods and services.

[24] https://eeb.org/library/making-the-case-for-a-ban-on-mercury-lamps/

Mercury and its compounds are highly toxic to the developing nervous system as well as harmful to ecosystems and wildlife. Methylmercury, its most toxic form, has the capacity to bioaccumulate and bioconcentrate, especially in the aquatic food chain.

The EU via its 2005 mercury strategy, accompanied measures and as Party to the Minamata Convention on Mercury has as its objective to protect human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds.

Furthermore, most recently, under the European Green Deal, the EC has pledged '*to ensure a toxic-free environment*', to '*help to protect citizens and the environment better against hazardous chemicals and encourage innovation for the development of safe and sustainable alternatives*'.

Taking, rather than avoiding, definitive decisions to end the exemptions for compact and linear fluorescent lamps, will confirm and demonstrate the EU's commitment to the health and environmental objectives described above.

## 1. Introduction

As explained in our comments below, equivalent products with no or less mercury are widely available in the European marketplace and are listed in the online catalogues of multiple large and small lighting manufacturers such as Osram, Tungsram and Philips. Most importantly, drop-in replacement light-emitting diode (LED) *mercury-free* lamps, retrofit kits and fixtures are not only widely available but are also more energy-efficient and have a longer rated life than most types of fluorescent and HID lamps used for general lighting applications. In addition, LEDs are now cost competitive, giving consumers the opportunity to save money when their long life and ability to cut energy, replacement, and waste disposal costs are considered.

We do not favour continuation of mercury exemptions largely on the statement by LightingEurope that equivalent LED lamps are not a practical replacement today for *every* application. Our case is bolstered by many credible sources – including the European Commission and its consultants – that have already requested such phase outs by January 2018, confirming back in 2016 that transition to mercury-free lamps was possible because the availability, performance and price of LED lamps was predicted to fast improve in the coming years.

LightingEurope has also argued the LEDs should not be required because not all fluorescent ballasts are compatible with LEDs. In such cases, the entire luminaire would need to be replaced, which would be costly. The impact of LED ballast incompatibility is significantly overstated by LightingEurope because there are several less-costly options when an existing ballast cannot be paired with an LED lamp. First of all, for most all of the CFLs as well as T5 and T8 fluorescent lamps, 'plug and play' drop-in replacement solutions (that do not require re-wiring) are readily available, as it has been shown in the SEA/CLASP report December 2019[25] and will also be discussed below. Furthermore, many LED lamps have an internal driver that enables the ballast to be bypassed completely, so that ballast compatibility is not an issue. Similarly, many LED lamps can be powered by an external LED driver, which also bypasses the ballast. There are also

[25] SEA/CLASP report Evidence of the availability of mercury-free alternative products to certain fluorescent lamps , 12 December 2019 (Revision, v.2) https://meta.eeb.org/wp-content/uploads/2019/11/SEA-and-CLASP-analysis-of-RoHS-exemptions-for-fluorescent-lamps-v2-1.pdf

a wide array of LED retrofit kits that replace the internal components of a luminaire but enable the housing to be reused.

Moreover, LEDs are more acceptable to consumers than CFLs and other types of mercury-containing lamps because they are more easily dimmable and give off a higher quality of light. They also last longer, which benefits consumers' pocketbooks because LEDs don't have to be replaced as often. In addition, they don't break as easily. As HID replacements, LED lamps are more reliable, so streetlights are down less, causing fewer accidents. They also don't emit UV like some HIDs. According to *Business Matters Magazine*, there are many benefits to using LEDs, including:

1. LED lights last far longer than incandescent or halogen bulbs.
2. They are highly energy-efficient, converting most of their energy into light, rather than heat.
3. They are ecologically sound because they are mercury-free and have a long life, reducing the user's carbon footprint.
4. LEDs are very tough and durable, making them able to "stand up to harsh weather, vibrations, shocks, and abrasions.
5. LEDs are a safe light source, that can offer excellent colour rendering and great quality light; they have almost no UV emissions, making them good options for museums and food pantries,
6. LEDs offer great design flexibility: "LED light arrays can be placed and combined in an infinite number of ways to produce efficient – but also controllable – illumination. The colour, shade, brightness and distribution of light can be controlled to perfection, which makes for not only technically-useful lighting, but also soothing, uplifting or energising mood lighting."
7. They work well in extreme temperatures, including freezers, unlike most fluorescent lamps.
8. They work instantly with no warm-up time and can be turned on an off many times without reducing their performance.
9. They work on low-voltage power, so they can be used outside.[26]

In a few lamp categories, where LED replacement lamps are not yet widely available – such as high-wattage metal halides -- we are proposing lower mercury limits, within the next 18 months. Our research has determined that many lamps in those categories are already meeting the mercury limits that we are proposing based on more accurate dosing methods that are now being widely used.[27]

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[26] "The Top Nine Benefits of Using LED Bulbs," *Business Matters Magazine*, 10 November 2016, https://www.bmmagazine.co.uk/in-business/top-nine-benefits-using-led-bulbs/

[27] Corazza, A., Boffito, C., *Mercury dosing solutions used in Fluorescent Lamps,* Journal of Physics D Applied Physics (Impact Factor: 2.72). 07/2008; 41(14):144007. DOI: 10.1088/0022-3727/41/14/144007 http://www.researchgate.net/publication/230988669_Mercury_dosing_solutions_for_fluorescent_lamps

Due to limited resources, we are addressing some – but not all – of the proposed RoHS exemptions. Our comments and recommendations are focused on the proposed exemptions relating to the allowance of mercury in single-capped (compact) fluorescent lamps without an integrated driver (**CFL-ni**), linear and non-linear fluorescent tubes (**T5, T9),** cold cathode fluorescent lamps (**CCFL**) and mercury-containing high-intensity discharge (**HID**) lamps, including, notably high-pressure sodium (**HPS**) and low-wattage metal halide (**MH**) lamps.

Although limited resources and time do not permit us to provide comments for the remaining categories, we urge the consultant and the Commission to investigate and consider LED applications for these remaining categories and only allow lamps to contain the least amount of mercury that is necessary to ensure reliable lamp performance and only in cases when LED replacements are not available.

Given that for **T2 and T12 Linear Fluorescent Lamps** and **CFLs with integrated ballast**, a phase-out decision for 1 September 2021 is already planned under the Ecodesign-related regulation, these will not be discussed further.

Below is an overview of our comments:

- **Section I** focuses on the **environmental and economic benefits of light-emitting diode (LED) lamps.** This section applies primarily to Exemption 1(a), but also has broader applicability to other exemptions since LED lamps are now considered to be a practical replacement for CFLs as well as many types of tubular fluorescent and HID lamps.
- **Section II** addresses the ***Requests to Renew Exemptions 1(a – e and g),*** which apply to "*Mercury in single capped (compact) fluorescent lamps not exceeding (per burner)" with different wattages.* **Focus is given to CFLs with a non-integrated ballast (CFL-ni).**
- **Section III** addresses the ***Requests to Renew Exemptions 2,*** including:
  - ***Exemption 2(a)(2,3 and 5)***, which apply to *"Mercury in double-capped linear fluorescent lamps for general lighting purposes not exceeding (per lamp), with focus on:*

    *(2) Tri-band phosphor with normal lifetime and a tube diameter ≥ 9 mm and ≤ 17 mm (e.g. T5)*

    *(3) Tri-band phosphor with normal lifetime and a tube diameter > 17 mm and ≤ 28 mm (e.g. T8)*

    *(5) Tri-band phosphor with long lifetime (≥ 25 000 h)*
  - ***Exemption 2(b)(3)***, which applies to *"Mercury in other fluorescent lamps not exceeding (per lamp)*
    *(3) Non-linear tri-band phosphor lamps with tube diameter > 15 mm (e.g. T9)"*
- **Section IV** addresses the **Requests to Renew Exemptions 3(a, b, and c),** concerning cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for special purposes.
- **Section IV** addresses the ***Requests to Renew Exemptions 4(b, c and 3)***, concerning High Pressure Sodium (Vapour) Lamps and Metal Halide Lamps.

## 2. Summary of Recommendations

| Exemption as per Directive 2011/65 | | Directive's [max value][mg] currently | Proposal EEB/ RPN/MPP [Maximum value](mg) | Remarks |
|---|---|---|---|---|
| **1. Mercury in single capped fluorescent lamps not exceeding (per burner):** | | | | |
| **1 (a)** | For general lighting purposes < 30W | 2,5 | 0 | Discontinue exemptions both for CFLi and CFLni. Provide transition period, ending not later than 1 September 2021 |
| **1 (b)** | For general lighting purposes ≥ 30W and < 50W | 3,5 | 0 | Discontinue exemptions both for CFLi and CFLni. Provide transition period, ending not later than 1 September 2021 |
| **1(c)** | For general lighting purposes ≥ 50 W and < 150 W | 5 | 0 | Discontinue exemptions both for CFLi and CFLni. Provide transition period, ending not later than 1 September 2021 |
| **1(d)** | For general lighting purposes ≥ 150 W | 15 | 0 | Discontinue exemptions both for CFLi and CFLni. Provide transition period, ending not later than 1 September 2021 |
| **1(e)** | For general lighting purposes with circular or square structural shape and tube diameter ≤ 17 mm | 7 | 0 | Discontinue exemptions both for CFLi and CFLni. Provide transition period, ending not later than 1 September 2021 |
| **1(f)** | For special purposes: | 5 | | Consider discontinuing exemptions for special-purpose CFLs whenever a determination can be made that LEDs are widely available as replacements. |
| **1 (g)** | For general lighting purposes < 30 W with a lifetime equal or above 20 000 h | 3.5 | 0 | Discontinue exemptions both for CFLi and CFLni. Provide transition period, ending not later than 1 September 2021 |
| **2 (a) Mercury in double-capped linear fluorescent lamps for general purposes not exceeding:** | | | | |
| **2 (a) (1)** | Tri-band phosphor with normal lifetime > 9mm (e.g. T2) | 4 | 0 | Discontinue exemptions. Provide transition period, ending not later than 1 September 2021 |
| **2 (a) (2)** | Tri-band phosphor with normal lifetime > 9mm and ≤ 17 mm (e.g. T5) | 3 | 0 | Discontinue exemptions. Provide transition period, ending not later than 1 September 2021 |
| **2 (a) (3)** | Tri-band phosphor with normal lifetime > 17 mm and ≤ 28 mm (e.g. T8) | 3,5 | 0 | Discontinue exemptions. Provide transition period, ending not later than 1 September 2021 |

| | | | | |
|---|---|---|---|---|
| **2(a)(4)** | *Tri-band phosphor with normal lifetime and a tube diameter > 28 mm (e.g. T12): 5 mg* | 3,5 | 0 | Discontinue exemptions. Provide transition period, ending not later than 1 September 2021 |
| **2 (a) (5)** | Tri-band phosphor with long lifetime (≥ 25 000 h) | 8 | 0 | Discontinue exemptions. Provide transition period, ending not later than 1 September 2021 |
| **2 (b) Mercury in other fluorescent lamps not exceeding:** | | | | |
| **2 (b) (3)** | Non-linear tri-band phosphor lamps > 17 mm (e.g. T9) | 15 | 0 | This category should include both circular T9s and U-shaped T8s. Discontinue exemptions. Provide transition period, ending not later than 1 September 2021. |
| **3** | Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for special purposes not exceeding (per lamp) | 3,5 mg for short length; 5 mg for medium length; and 13 mg for long length | 0 | The exemptions for CCFLs should be discontinued because LED backlighting is a practical alternative that is widely available in the marketplace. Furthermore, CCFLs often break when electronic equipment is recycled. Provide transition period, ending not later than 1 September 2021. |
| **4 Mercury in High Intensity Discharge lamps for general lighting purposes** | | | | |
| **4(a)** | Mercury in other low pressure discharge lamps (per lamp) | 15 | | Consider submission from Typhon Treatment systems – submitted on 4 February 2019 to the Commission- attached separately. |
| **4(b)** | Mercury in High Pressure Sodium (vapour) lamps for general lighting purposes not exceeding (per burner) in lamps with improved colour rendering index Ra > 60: | I) P ≤ 155 W: 30 mg per burner | | Discontinue exemptions. Provide transition period, ending not later than 1 September 2021 |
| | | II) 155 W < P ≤ 405 W: 40 mg per burner | | |
| | | III) P > 405 W: 40 mg per burner | | |
| **4(c)** | Mercury in other High Pressure Sodium (vapour) lamps for general lighting purposes not exceeding | I) P ≤ 155 W: 25 mg per burner | 0 | Discontinue exemptions. Provide transition period, ending not later than 1 September 2021 |
| | | II) 155 W < P ≤ 405 | 0 | |

| | | | | |
|---|---|---|---|---|
| | | W: 30 mg per burner | | |
| | | III) P > 405 W: 40 mg per burner | 0 | |
| **4(e)** | Mercury in Metal Halide (MH) Lamps | | Change to Ceramic metal halides <u>≤250</u> watts and all metal halide lamps over 250 watts | Discontinue exemption for quartz MH lamps, with a transition period. Allow exemption for ceramic metal halide (CMH) lamps, as they have less mercury, a higher efficiency, and a longer rated life than quartz MH lamps. CMH lamps are widely available up to 250 watts.<br><br>Monitor improved availability, performance and price of LED retrofit lamps for metal halide lamps and consider an expiry date for some types of MH lamps as they become practical. |

# 3 Table of Contents

## 4 Analysis and Recommendations

As a start, we would like to refer once more to the SEA-CLASP 2019 study,[28] (key findings in annex) which covered and provided input for the following three main types of fluorescent lamps:

- Single-capped (compact) fluorescent lamps – 1(a-g) - CFL non-integrally ballasted (**CFLni**)
- Double-capped linear fluorescent lamps for general lighting purposes - 2(a)(2)-**T5** and 2(a)(3)-**T8.**

The report provides links to, and information from several manufacturers' websites confirming there are cost-effective direct LED replacement lamps on the market today that operate on the existing fluorescent ballast (magnetic or electronic) and are the same size and base type. In addition, in cases where LEDs are not compatible with an existing fluorescent ballast, there are LED retrofit lamps that by-pass the ballast and, instead, use either an internal or external driver.

We note that all these benefits are aligned with the recently announced European Green Deal, which we are certain you would not wish to undermine.

### 4.1 Section I: The Environmental and Economic Benefits of LED Lamps Compared to CFLs.

The energy efficiency, performance, design, and affordability of LED lamps have all dramatically and consistently improved over the past few years since the previous RoHS Directive's mercury-content limits were established, and since the last consultation in 2015. Moreover, LEDs further promise to keep improving in each of these areas. Today, even without further improvements, LED lamps have many advantages over fluorescent and HID lamps:

- They use less energy to emit the equivalent light output;
- They are dimmable, which facilitates even further energy savings;
- They are considered environmentally preferable to fluorescent and HID lamps from a life-cycle cost perspective; and
- They are mercury-free.

LED retrofit lamps not only eliminate mercury from lighting, but they also save the users of these products money by significantly lowering energy bills and reducing the need to frequently replace lamps. LED retrofit lamps are on average twice as efficient as the fluorescent lamps they are replacing and last at least 2-3 times longer.

The SEA-CLASP report further quantifies the following benefits[29] for Europe from removing these exemptions (for CFL-ni, T5 and T8 lamps) by 2021:

- 4.8 metric tonnes of mercury are avoided; 2.6 metric tonnes from the lighting supply chain and 2.2 metric tonnes avoided emissions from power stations (coal);
- €12.5 billion in energy and replacement lamp savings for businesses and consumers across Europe;
- 138.3 TWh of electricity savings; and

[28] SEA/CLASP report Evidence of the availability of mercury-free alternative products to certain fluorescent lamps , 12 December 2019 (Revision, v.2) https://meta.eeb.org/wp-content/uploads/2019/11/SEA-and-CLASP-analysis-of-RoHS-exemptions-for-fluorescent-lamps-v2-1.pdf

[29] Benefits in this modelling were calculated for Sweden and CLASP by VHK, the consultants who conducted the lighting market analysis for DG ENER. The estimates were calculated using the same European lighting market model.

- 40.9 million metric tonnes of $CO_2$ emission savings.

Numerous credible sources have found LED lighting equipment to be a practical and environmentally preferable alternative to conventional lamps and fixtures. For example, already a 2014 European Commission JRC Science and Policy report[30] stated the following:

> *In just the last few years, LED performance has accelerated quickly and a wave of new commercial, industrial and institutional LED fixtures has been introduced. LED technology is fulfilling its promise of offering the market the most efficient means of converting electrons into photons. LEDs have thus surpassed many conventional lighting technologies in terms of energy efficiency, lifetime, versatility, and colour quality, and due to their increasing cost competitiveness are beginning to successfully compete in a variety of lighting applications. Therefore, LED lighting is no longer "around the corner"; it is here and has a solid market foothold. Performance is improving and costs are coming down.*

More recently, on a global scale, the International Energy Association (IEA)'s May 2019 *Tracking Report on Commercial Buildings/Lighting*[31] noted that LEDs are beginning to dominate global markets and are becoming common replacements for linear fluorescent lamps as well as CFLs. It reported:

> *In 2018, LED sales reached a critical milestone, achieving the same share of global residential sales as less-efficient fluorescent lamps (40%). LED deployment is also progressing for commercial lighting and outdoor applications, especially for linear LEDs to replace fluorescent lamps. As LED costs continue to fall, sales of LEDs are on track with the [Sustainable Development Scenario] SDS, although continued robust growth is needed to make up over 90% of sales by 2030.*
>
> *Global LED uptake has increased substantially in recent years, rising from a market share of 5% in 2013 to 40% of global residential lighting sales in 2018.*
>
> *LED sales now appear to have overtaken fluorescent sales in the residential sector, and that share is expected to continue expanding.*
>
> *Current trends suggest the market is on track to follow the SDS trajectory by 2030. However, to raise the share of LED sales to more than 65% of the residential market by 2025, countries need to take advantage of recent sales trends and update their regulatory policies to keep pace with expected LED performance, which is drastically higher than five years ago.*
>
> *LEDs are now massively produced in many markets, and competition among manufacturers is driving further innovation, wider product choices and lower prices.*

Provided below is further substantiation of the important benefits of LEDs over mercury-containing lamps.

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[30]European Commission Joint Research Centre, JRC Science and Policy Reports: *2014 Update on the State of LED Market*, 2014, http://iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/reqno_jrc92971_jrc92971_online.pdf.pdf

[31]International Energy Association (IEA), *Tracking Report on Commercial Buildings/Lighting*, Mary 2019, www.iea.org/reports/tracking-buildings/lighting

**i. LED light bulbs use less energy than fluorescent lamps and HIDs to create the same amount of light.**

According to the May 2019 International Energy Association Building/Lighting Tracking Report, LED efficacy has improved considerably in recent years and is expected to continue improving in the future due to further technological innovation.

- LEDs typically available on the residential market have an efficacy of over 90 lumens of light per watt of power (lm/W), depending on the model (e.g., directional, non-directional, tubular).
- LED performance is also continuing to improve rapidly. In many markets, the efficacies of LEDs available for residential use already reach 80-120 lm/W. Moreover, they are projected to increase to an average of 160 lm/W by 2030, which corresponds to the [Sustainable Development Scenario] SDS level. In fact, some LED products for commercial uses such as office and street lighting have already reached or exceeded these efficacies – surpassing even the most energy-efficient fluorescent and HID lamps.
- In contrast, efficacies are much lower for compact fluorescent lamps (around 60 lm/W) and halogens (less than 20 lm/W) and will not improve, particularly as industry has shifted focus to LED technology and product innovations.

When LEDs are used instead of fluorescent and HID lamps, power plant-related mercury (and other air pollutant) emissions are typically reduced because LEDs are far more energy efficient. This benefit is expected to be even greater in the future as LED energy efficiency continues to improve.

**ii. LED lamps are more often compatible with dimmers and other lighting controls than CFLs and other types of fluorescent lamps.**

LightingEurope states in its request for many of its RoHS Mercury Exemptions that some LEDs are incompatible with dimmers and, therefore, cannot be used for many general-purpose lighting applications. Ironically, LEDs are *more easily dimmable* than CFLs, LFLs and HIDs, which makes them a more practical alternative for most general lighting applications.

According to Current by GE, one of the advantages of LED lighting is its compatibility with dimmers, "It can take more than a few dollars to make commercial fluorescent lighting systems dimmable, but LEDs, as semiconductor devices, are inherently compatible with controls. Some LEDs can even be dimmed to 10 percent of light output while most fluorescent lights only reach about 30 percent of full brightness. LEDs also offer continuous, opposed to step-level, dimming (where the shift from 100-to-10-percent light output is smooth and seamless, not tiered)."[32]

According to the International Energy Association's May 2019 Tracking Report on Buildings/Lighting, "…LED lamps are twice as efficient as fluorescent ones and are much more

[32]Current by GE, 8 Advantages of LED Lighting, Undated Brochure, https://blog.springfieldelectric.com/ge-led-products/8-advantages-of-led-lighting/.

amenable to lighting controls (i.e., adjustment of light output and even colour using fixture sensors)."[33]

Because they are more easily dimmable, most LED lamps can achieve even higher energy efficiency and further reduce mercury emissions.

iii. **LEDs have been determined to be environmentally preferable from a life-cycle perspective.** Please refer to our 2015 submission[34] as well as the SEA/CLASP study 2019.

iv. **LED light bulbs are mercury-free products, which prevent waste-related issues and mercury exposure during manufacture, use and disposal**, as analysed under the SEA/CLASP 2019 report.

### 4.2 LEDs Can Replace Many CFLs with a Non-Integrated Driver (CFL-ni) (Pin-based LEDs)

Most CFL-ni lamps have 4-pin bases and run on electronic ballasts, which are often compatible with LED replacement lamps. These can also be replaced with LED retrofit kits, which replace the inside of the CFL luminaire with LED lamps and a driver but allow the housing (fixture) to be reused. This eliminates the need for the LED lamps to be compatible with an existing CFL ballast.

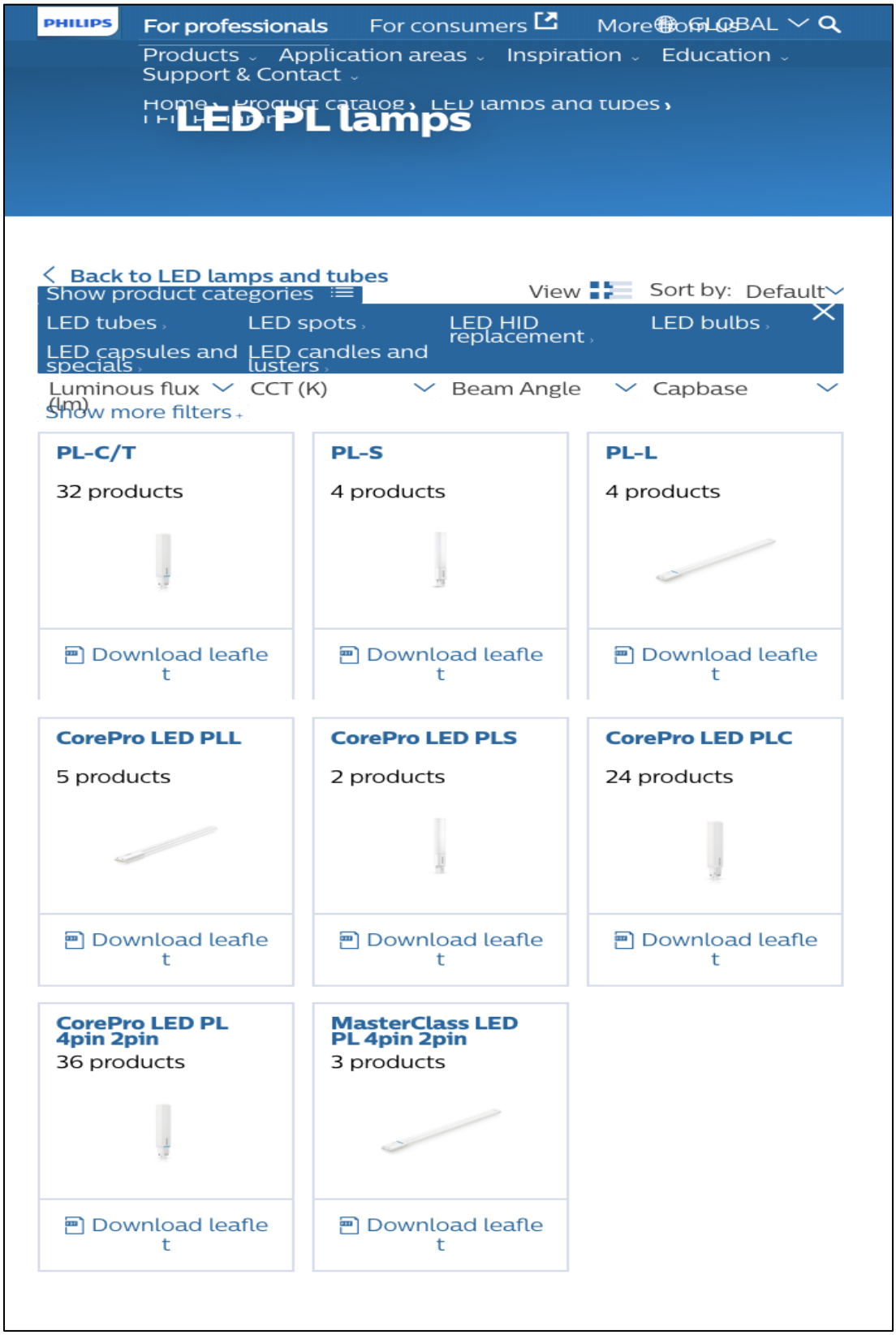
**Availability of LED lamps to replace CFL-ni Lamps:**

Over the past few years, several European lighting manufacturers have begun offering a full line of LED replacement lamps for CFLs with a non-integrated ballast. For example:

- Philips offers 110 models of 2-pin and 4-pin LED PL plug-in compact lamps that can replace CFLs with a non-integrated ballast. (See screenshot of Philips Global e-Catalogue page below showing its wide variety of LED PL Lamps with various types of bases and bulb shapes designed as direct replacement for plug-in CFLs with a non-integrated ballast.)

[33] International Energy Association (IEA), *Tracking Report on Commercial Buildings/Lighting*, Mary 2019, www.iea.org/reports/tracking-buildings/lighting

[34] EEB. RPN, MPP – Environmental NGOS Response to Stakeholder consultation 2015#2 on mercury-containing lamps – exemption 1-4 (review of Annex to the RoHS Directive), 16 October 2015 https://www.zeromercury.org/download/6/position-paper/1317/151016_eep-rpn-mpp_comments_on_rohs_request-final.pdf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CorePro LED PL 4pin 2pin
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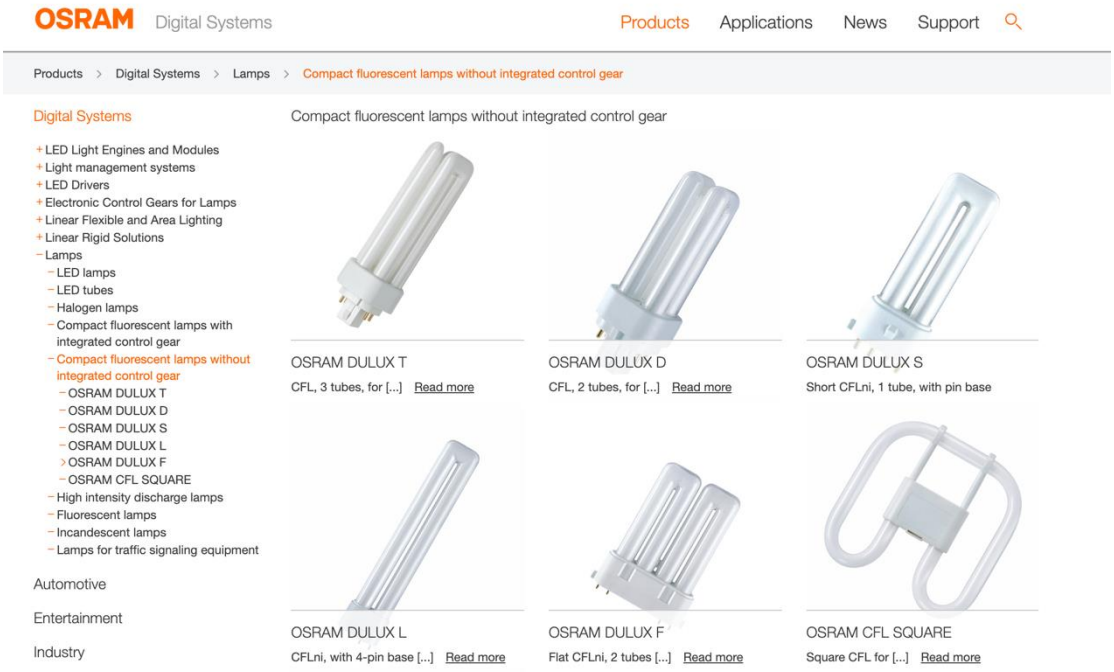
- Osram offers dozens of types of 2-pin and 4-pin LED replacement lamps for plug-in CFLs with a non-integrated driver. (See screenshot below of Osram's landing page for its single-capped compact LED lamps.)




- Tungsram/GE offers several types of Plug-In LED compact lamps that can replace CFLs with a non-integrated ballast. (See screenshot below of its LED Plug-in models.) According to the Tungsram website, accessed in February 2020:

*The new LED Plug-In and LED 2D replacement lamps from GE enable you to replace inefficient CFL lighting without the need for tools or a costly upgrade. GE's LED retrofit lamps provide up to 4x the life of an average CFL and use less than half the energy, delivering a more targeted light that requires less lumens and reduces waste. The result is a dramatic reduction in operating cost, coupled with equally impressive improvements in the quality of light.*

*The current range includes LED replacement lamps for following CFL Plug In lamps:*

- *26/32W CFL 4Pin Plug In with G24-q3 or GX24q-3 base*
- *16W 2D 2Pin with GR8 base*
- *28W 2D 4Pin with GR10q base*
- *18W CFL 4Pin Plug-In with G24q-2 or GX24q-2 base*
- *13/18/26W CFL 2Pin Plug In with G24d-1, 2, 3 base types*

*The relevant LED lamps are compatible with main electronic ballast types.*

**Recommendation for Exemption 1(a – e):**

Discontinue exemptions both for CFLi and CFLni. Provide transition period, ending not later than 1 September 2021

### 4.3 . Exemptions 2(a)(2,3,5) and 2(b)(3) "Mercury in double-capped linear fluorescent lamps for general lighting purposes" [T5, T8, long life LFLs]

As it was already presented and discussed by SEA/CLASP at the Stakeholders' technical meeting with the Commission on the 12 February, on the basis of most recent data – overall market compatibility for T5 and T8 LED retrofit tubes now reaches 90%.

Table 1. Overview of ballast types and compatible LED direct retrofit products using EU T8 and T5 manufacturer lists, December 2019

| RoHS exemption number and standard fluorescent tube type | Percentage of tubes (T5 & T8) in the market | Ballast type | Percentage of field installations ballast type | Estimated proportion of total T5 and T8 market | Ballast type dependent LED tube product name[1,2] (total number of available variants, i.e., CCT, CRI, wattage, length and other parameters) | Claimed percentage of luminaire coverage of available retrofit product according to manufacturers published compatibility lists | Market weighted compatibility (based on average compatibility of lamp-ballast %) |
|---|---|---|---|---|---|---|---|
| 2(a)(2) - T5 | 30% | HF/ECC | 100% | 30% | Philips MASTER LEDtube HF InstantFit HE T5 (9) | 60/79 = 76% | **23%** (76%) |
| | | | | | Osram Substitube T5 Universal (12) | 178/235 = 76% | |
| | | | | | Sylvania TOLEDO SUPERIA T5 ECG (15) | 85/85 = 100%** | |
| 2(a)(3) - T8 | 70% | EM/CGG | 70% | 49% | Philips MASTER LEDtube EM/Mains T8 (30) | 100% (no compatibility issues) | **49%** (49%) |
| | | | | | Osram Substitube T8 EM (44) | | |
| | | | | | Sylvania TOLEDO SUPERIA T8 CCG AND AC (42) | | |
| | | HF/ECC | 30% | 21% | Philips MASTER LEDtube HF InstantFit T8 (16) | 159/197 = 81% | **18%** (88%) |
| | | | | | Osram Substitube T8 Universal (32) | 89/115 = 77 % | |
| | | | | | Sylvania TOLEDO SUPERIA T8 ECG (12) | 103/103 = 100%** | |
| | | | | | Opple Universal LED T8 Tube (6) | 245/254 = 96% | |
| | | | | | LCTW U-Tube T8 (Sengled) (12) | 382/393 = 97% | |
| | | | **Market total:** | **100%** | | **Overall market compatibility, T5 and T8 LED retrofit tubes:** | **90%** |

** Sylvania TOLEDO SUPERIA compatibility claim seems unrealistically high, therefore not included in our calculation of average compatibility %.
1. Manufacturers offer T5 tube lengths 1449, 1149, 849, 549mm. Philips excludes 849mm; Sylvania excludes 849, 549mm.
2. Manufacturers offer T8 tube lengths 1500, 1200, 600mm. Opple excludes 600mm.

Note: T5 and T8 are professional light sources that are normally replaced by qualified installers. In addition to ballast type dedicated drop-in replacements, manufacturers are also marketing tube LED drop-in ("plug & play") products which are not dependent on ballast type (approximately 5% of field installations are consumer applications):

| Manufacturer of available Drop-In / Plug & Play product | T8 ballast type independent LED tube product[1] | Claimed percentage of luminaire coverage according to manufacturers published compatibility list |
|---|---|---|
| Philips | MASTER LEDtube Universal T8 (6) | 116/150 = 77% |
| Osram | Substitube T8 Universal (32) | 89/115 = 77 % |
| Sylvania | TOLEDO SUPERIA T8 UNI (9) | 60/60 = 100%** |
| LEDs Change the World (Sengled) | U-Tube T8 (12) | 382/393 = 97% |
| OPPLE | Universal LED T8 Tube (6) | 245/254 = 96% |

** Sylvania TOLEDO SUPERIA compatibility claim seems unrealistically high, needs checking.
1. Manufacturers offer T8 tube lengths 1500, 1200, 600mm. Philips and Opple exclude 600mm.

Given all comments and research in relation to T8s, under the SEA/CLASP report, these are not further analysed here.

These new figures on compatibility of these lamps, have an important impact on the socio-economic costs as calculated by the Oeko Institute on the 2019 study – where the estimate of compatibility was around 22%, instead of 90%. As a result, the respective costs are far from being as high as reported under this study and this needs to be taken seriously into consideration when decisions are made.

Below, focus is given to the T5s and examples are presented below:

**There is now availability of LED linear T5s, which were not available a few years ago.**

High-performance LED T5 lamps are available from several major EU manufacturers, including, for example:

- GE/Tungsram
- Philips
- Osram


The mercury exemptions for T5 LFLs should be ended because LEDs can replace most models and have significant energy efficiency, toxics reduction, and waste prevention benefits since T5 LEDs often have an equivalent or a higher efficacy (measured in lumens/watt) and a longer rated life, and are mercury-free.

The wide array of LED linear T5s in the European marketplace today were not available a few years ago when the RoHS mercury limits for LFLs were last updated.

T5 fluorescent tube lamps primarily are available in 2-foot (549mm), 4-foot (1149mm), and 5-foot (1449mm) lengths. T5 LED tube lamps are generally offered in the exact same sizes and with the same G5 base); consequently, they are designed to be direct replacements for most models of T5 linear fluorescent lamps (LFLs) currently in use and on the market. See table below showing examples of LED T5 lamps that are direct replacements for common T5 LFLs.

There are many easy and cost-effective options for replacing T5 LFLs with T5 LEDs, including options that do not rely on compatibility with an existing ballast or require replacement of a luminaire. These options include LED T5s that are “Plug and Play” and can run on the existing LFL ballast as well as LED T5s with an internal or external driver that can be used if there is a ballast compatibility issue. Another option that is less costly than replacing the entire luminaire is an LED retrofit kit that re-uses the existing luminaire housing but simply replaces the electrical components (i.e. the LED lamps and driver).

Major European lighting manufacturers such as GE/Tungsram, Philips/Signify, and Osram tout the ease and benefits of replacing T5 LFLs with T5 LEDs. For example:

- Tungsram (GE) offers 16 models of Linear T5 LED Premium Lamps in a variety of sizes (2-foot, 4-foot and 5-foot), wattages (7W-34W), and color temperatures (3000K, 4000K

and 6500K). See screenshots below of an August 2019 data sheet which describes the features and availability of this product line:

*Tungsram [GE] LED T5 Tubes offer more reliable and efficient way to convert existing Fluorescent luminaires to LED technology. This new LED product range offers energy saving replacements for HE 14W-28W-35W and HO 24W-54W-49W-80W Fluorescent tubes. The new LED tubes are designed to operate on 220-240VAC 'Direct-to-Mains' connection to maximise energy efficiency and avoid reliability and compatibility issues relating to HF ballast connection.*[35]

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DATA SHEET

# LED T5 Premium

220-240VAC

## Product information

Tungsram LED T5 Tubes offer more reliable and efficient way to convert existing Fluorescent luminaires to LED technology. This new LED product range offers energy saving replacements for HE 14W-28W-35W and HO 24W-54W-49W-80W Fluorescent tubes. The new LED tubes are designed to operate on 220-240VAC 'Direct-to-Mains' connection to maximise energy efficiency and avoid reliability & compatibility issues relating to HF ballast connection.

## Features

- Outstanding light output, 1100-5100lm
- Excellent efficiency, 150Lm/W
- Extremely long life, 50000H L70/B50
- Wide operating temperature, -20°C/+45°C
- High Power Factor, > 0.9
- Mains Volt operation, 220-240V AC

## Benefits

- Fit & Forget, no ballast reliability concerns and reduced maintenance costs
- Uniform light, suitable for office, retail, education
- Instant-on, full light
- Up to 62% energy saving vs Fluorescent
- Glass tube design, with wide beam angle, 165degrees
- Suitable for low and high ambient temperature operation
- Environmentally friendly, no UV or Hg

[35] Tungsram/GE, *Data Sheet for LED T5 Premium Lamps*, August 2019, https://tungsram.com/en/documents/Tungsram-LED-T5-220-240V-Datasheet-EN.pdf

## Specification summary

| Rated Wattage (W) | Length (mm) | CCT (K) | Cap | Product Description | Rated Luminous flux (lm) | Life L70 (hrs) | CRI (Ra) | Energy Efficiency Class | Pack Qty (pcs) | Product Code |
|---|---|---|---|---|---|---|---|---|---|---|
| 7.5 | 549 | 4000 | G5 | LEDT5 0.6m 7.5W 840 AC220-240V 1/10 | 1100 | 50,000 | 80+ | A++ | 10 | 93115376 |
| 7.5 | 549 | 6500 | G5 | LEDT5 0.6m 7.5W 865 AC220-240V 1/10 | 1100 | 50,000 | 80+ | A++ | 10 | 93115377 |
| 7.5 | 549 | 4000 | G5 | LEDT5 0.6m 7.5W 840 AC220-240V 1/10 DS | 1100 | 50,000 | 80+ | A++ | 10 | 93114779 |
| 7.5 | 549 | 6500 | G5 | LEDT5 0.6m 7.5W 865 AC220-240V 1/10 DS | 1100 | 50,000 | 80+ | A++ | 10 | 93114780 |
| 16 | 1149 | 4000 | G5 | LEDT5 1.2m 16W 840 AC220-240V 1/10 | 2400 | 50,000 | 80+ | A++ | 10 | 93114766 |
| 16 | 1149 | 6500 | G5 | LEDT5 1.2m 16W 865 AC220-240V 1/10 | 2400 | 50,000 | 80+ | A++ | 10 | 93114767 |
| 26 | 1149 | 3000 | G5 | LEDT5 1.2m 26W 830 AC220-240V 1/10 | 3500 | 50,000 | 80+ | A++ | 10 | 93114768 |
| 26 | 1149 | 4000 | G5 | LEDT5 1.2m 26W 840 AC220-240V 1/10 | 3900 | 50,000 | 80+ | A++ | 10 | 93114769 |
| 26 | 1149 | 4000 | G5 | LEDT5 1.2m 26W 840 AC220-240V 1/10 DS | 3900 | 50,000 | 80+ | A++ | 10 | 93114781 |
| 26 | 1149 | 6500 | G5 | LEDT5 1.2m 26W 865 AC220-240V 1/10 | 3900 | 50,000 | 80+ | A++ | 10 | 93114770 |
| 26 | 1149 | 6500 | G5 | LEDT5 1.2m 26W 865 AC220-240V 1/10 DS | 3900 | 50,000 | 80+ | A++ | 10 | 93114782 |
| 26 | 1449 | 3000 | G5 | LEDT5 1.5m 26W 830 AC220-240V 1/10 | 3500 | 50,000 | 80+ | A++ | 10 | 93114771 |
| 26 | 1449 | 4000 | G5 | LEDT5 1.5m 26W 840 AC220-240V 1/10 | 3900 | 50,000 | 80+ | A++ | 10 | 93114772 |
| 26 | 1449 | 6500 | G5 | LEDT5 1.5m 26W 865 AC220-240V 1/10 | 3900 | 50,000 | 80+ | A++ | 10 | 93114773 |
| 34 | 1449 | 4000 | G5 | LEDT5 1.5m 34W 840 AC220-240V 1/10 | 5100 | 50,000 | 80+ | A++ | 10 | 93114774 |
| 34 | 1449 | 6500 | G5 | LEDT5 1.5m 34W 865 AC220-240V 1/10 | 5100 | 50,000 | 80+ | A++ | 10 | 93114775 |

- Philips, which offers over 20 models of linear T5 LED lamps touts the wide availability, versatility and performance benefits (compared to T5 LFLs) of its T5 LED Lamps:

  *Philips T5 LED tubes offer an affordable, energy saving retrofit solution. The T5 lamps have been engineered to withstand the test of time with a 50,000-hour lifetime and a limited 5-year warranty to back it up. The lighting performance effectively replaces conventional fluorescent T5 HO or T5 HE lamps. Available in either InstantFit (Type A or Type C) or MainsFit (Type B / Ballast bypass), Philips T5 TLEDs provide a variety of options for any application.*[36]

  Philips offers several lines of T5 LED lamps in a wide variety of lengths and wattages including:

  - LED T5s (19 products)[37]
  - MASTER LEDtube InstantFit HF T5 (18 models)[38]
  - MASTER LEDtube Mains T5 (6 models)[39]
  - MASTER LEDtube InstantFit T5 (3 models)[40]

[36] Philips Lighting Company, "High Performance LED Replacements for Conventional T5 Lamps," *Online Catalogue*, Accessed 25 February 2020, https://www.lighting.philips.com/main/prof/led-lamps-and-tubes/led-tubes/t5

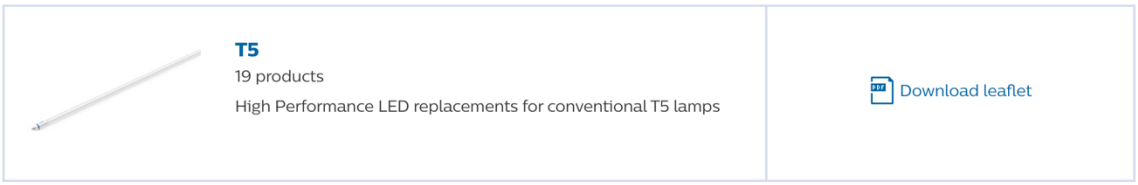
[37] https://www.lighting.philips.com/main/prof/led-lamps-and-tubes/led-tubes/t5

[38] https://www.lighting.philips.com/main/prof/led-lamps-and-tubes/led-tubes/master-ledtube-instantfit-hf-t5

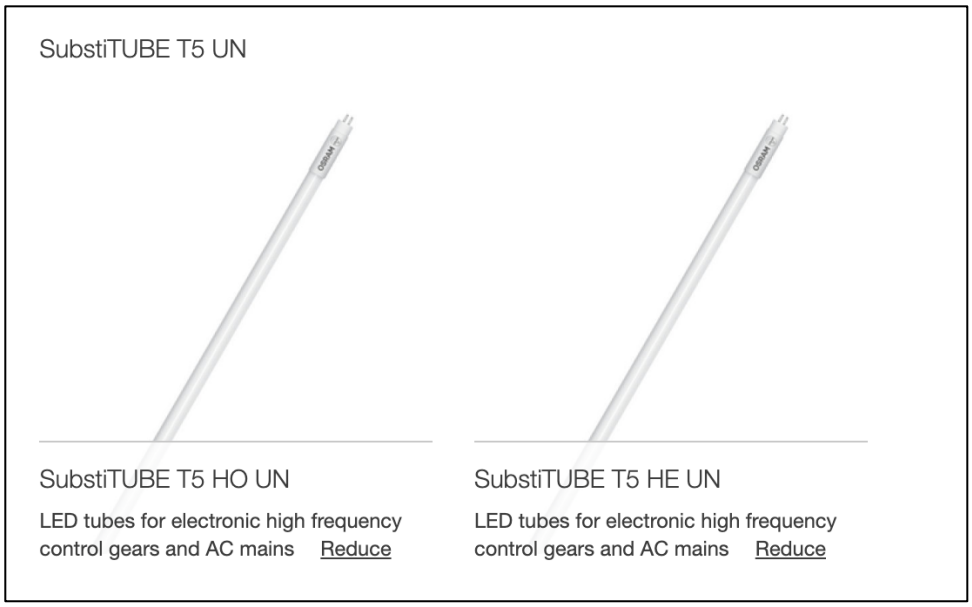
[39] https://www.lighting.philips.com/main/prof/led-lamps-and-tubes/led-tubes/master-ledtube-mains-t5

[40] https://www.lighting.philips.com/main/prof/led-lamps-and-tubes/led-tubes/masterclass-ledtube-instantfit-t5

- ESSENTIAL LEDtubes T5 Mains (10 models)[41]




- Osram offers two lines of LED T5 lamps called T5 SubstiTUBES, which are available in various sizes, wattages and color temperatures. Its T5 LED lamps can replace the most common wattages of T5 fluorescent lamps (14-, 21-, 28- and 35-watt standard output T5 fluorescent lamps as well as 49-, 54- and 80-watt high-output T5 fluorescent lamps. They have a rated life of 60,000 hours. [42]




[41] https://www.lighting.philips.com/main/prof/led-lamps-and-tubes/led-tubes/essential-led-tubes-t5-mains
[42] Osram, SubstiTUBE T5 Lamps, https://www.osram.com/ecat/SubstiTUBE%20T5%20UN-LED%20tubes-Lamps-Digital%20Systems/com/en/GPS01_3234447/PP_EUROPE_Europe_eCat/

## Examples of LED T5 Replacement Lamps from Major European Manufacturers

| T5 LFL Watts | T5 LFL Lumens | T5 LFL Brand | Hg (mg) | T5 LFL Life (Hrs) | T5 Linear Fluorescent Lamp (LFL) Model | T5 LED Watts | T5 LED Lumens | T5 LED Brand | T5 LED Life (Hours) | T5 LED Model |
|---|---|---|---|---|---|---|---|---|---|---|
| **Standard Output T5, 2-Foot (549mm) Length and G5 Base** | | | | | | | | | | |
| 14 | 1200 | Osram | 1,9 | 24.000 | Lumilux T5 14W | 7 | 1000* | Osram | 60.000 | SubstiTUBE T5 High Efficiency 7W (ST5HE14 7W) |
| 13 | 1350 | GE/ Tungsram | 2,5 | 25.000 | FT5/13W/830/GE/WM (LFL Watt-Miser T5) | 8 | 1050* | Philips/ Signify | 50.000 | Master LEDtube HF HE 8W |
| 14 | 1350 | GE/ Tungsram | 2,5 | 30.000 | FT5/14W/835/GE/LL (LFL T5 LongLast) | 7,5 | 1100* | GE/ Tungsram | 50.000 | LEDT5 0.6m 7.5W |
| **Standard Output T5, 4-Foot (1149mm) Length and G5 Base** | | | | | | | | | | |
| 28 | 2600 | Osram | 1,9 | 24.000 | Lumilux T5 HE 28W | 16 | 2400* | Osram | 60.000 | SubstiTUBE T5 High Efficiency 16W (ST5HE28-HF 16W/840 HF) |
| 28 | 2900 | GE/ Tungsram | 2,5 | 30.000 | FT5/28W/840/GE/LL (LFL T5 LongLast) | 16 | 2400* | GE/ Tungsram | 50.000 | LEDT5 Premium 1.2m 16W |
| 26 | 2900 | GE/ Tungsram | 2,5 | 25.000 | FT5/26W/840/GE/WM (Watt-Miser T5) | 16.5 | 2500* | Philips/ Signify | 50.000 | Philips LEDtube T5 HF HE 16.5W 840 115cm |
| **High Output T5, 4-Foot (1149mm) Length and G5 Base** | | | | | | | | | | |
| 54 | 4450 | Osram | 1,9 | 24.000 | Lumilux T5 HO 54 W (High-output, Standard Life, 1149mm) | 25 | 3300* | Philips/ Signify | 50.000 | 25T5HO |
| 54 | 4450 | Osram | 2,5 | 45.000 | Lumilux T5 HO XT 54W (High-output, Long Life, 1149mm) | 26 | 3900* | GE/ Tungsram | 50.000 | LEDT5 1.2m 26W 840 AC220-240V |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 54 | 5000 | GE/ Tungsram | 2,5 | 30.000 | | 26 | 3900* | Philips/ Signify | 50.000 | MASTER LEDtube InstantFit HF1200mm HO 26W T5 (1149mm) |
| **Standard Output T5, 5-Foot (1449mm) Length and G5 Base** | | | | | | | | | | |
| **T5 LFL Watts** | **T5 LFL Lumens** | **T5 LFL Brand** | **Hg (mg)** | **T5 LFL Life (Hrs)** | **T5 Linear Fluorescent Lamp (LFL) Model** | **T5 LED Watts** | **T5 LED Lumens** | **T5 LED Brand** | **T5 LED Life (Hours)** | **T5 LED Model** |
| 35 | 3320 | Osram | 1,2 | 24.000 | Lumilux T5 HE 35W/ | 18 | 2800* | Osram | 60.000 | SubstiTUBE T5 High Efficiency 18W (ST5HE35 18W, 1449mm) |
| 35 | 3650 | GE/ Tungsram | 2,5 | 30.000 | FT5/35W/830/GE/LL (LFL T5 LongLast) | 20 | 3000* | Philips/ Signify | 50.000 | Master LEDtube HF 20W 840 T5 |
| 33 | 3650 | GE/ Tungsram | 2,5 | 25.000 | FT5/33W/830/GE/WM (Watt-Miser, G5 Base) | | | | | |
| **High Output T5, 5-Foot (1449mm) Length and G5 Base** | | | | | | | | | | |
| 49 | 4310 | Osram | 1,7 | 24.000 | Lumilux T5 HO 49W (High Output, 1449mm) | 26 | 3700* | Osram | 60.000 | ST5HO49-HF 26 W (1449 mm HF) High-Output SubstiTUBE |
| 49 | 4310 | Osram | 2,5 | 45.000 | Lumilux T5 HO XT 49W (Energy-Saving, Long Life, 1449mm) | 26 | 3900* | GE/ Tungsram | 50.000 | LED T5 Premium LEDT5 1.5m 26W |
| 80 | 6150 | Osram | 1,7 | 24.000 | Lumilux T5 HO 80W (High Output, 1449mm) | 34 | 5100* | GE/ Tungsram | 50.000 | LED T5 Premium LEDT5 1.5m 34W |
| 80 | 6150 | Osram | 2.5 | 45.000 | Lumilux T5 HO XT 80W (High-Output, Long Life, 1449mm) | 37 | 5600* | Osram | 60.000 | ST5HO 80-HF 37W (SubstiTUBE High Output T5) |
| 80 | 7000 | GE/ Tungsram | 2.5 | 30.000 | FT5/80W/840/GE/LL (LFL T5 LongLast) | | | | | |

*LED Lumens are typically about 10-20% lower than fluorescent lumens because LED lumens are more effectively utilized by human eyes. LED T5 lamps are matched to fluorescent T5 lamps they are designed to replace based on manufacturer information.

**Recommendation for Exemption 2(a) 2, T5, 3 (T8)**

Discontinue exemptions. Provide transition period, ending not later than 1 September 2021

*4.3.4 Exemption 2(a)(5) Tri-band phosphor with long lifetime (≥ 25 000 h)*

We recommend that this Exemption be eliminated as all long lifetime LFLs can meet the mercury limits of the respective "normal life" T5 categories. See table above; unshaded columns show mercury content of various T5 linear fluorescent lamps and their mercury content. No T5 LFL products were found with a mercury content above 2,5, including models with a rated life >25.000 hours.

Moreover, as all of those can anyway be replaced now by LEDs, this exemption should be discontinued.

**Recommendation for Exemption 2(a)(5):**

Discontinue exemptions. Provide transition period, ending not later than 1 September 2021

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

Modern U-bent T8s, which are the most common fluorescent lamps that fall under this exemption for non-linear tri-band phosphor lamps with tube diameter >17 mm (e.g., T9) although they are not specifically called out in the title of this exemption. LED replacements for U-shaped T8 fluorescent lamps as well as circular T9 fluorescent lamps are currently available on the market. See documentation below.

**LED U-Shaped LED Lamps**


LED U-shaped T8 lamps, which have a higher energy efficiency and longer rated life than U-shaped fluorescent T8s, are available in the European marketplace. For example:

- Osram's SubstiTUBE U-Shaped LED Lamps[43] are a direct replacement for U-Shaped T8 Fluorescent Lamps. They come in 8W and 20W models. According to Osram, these products have a rated life of 50.000 hours, which is about twice the rated life of a typical u-shaped fluorescent tube lamp, and offer the following benefits:
  - ✔ Quick, simple and safe replacement without rewiring
  - ✔ Energy savings of up to 65% (compared to T8 fluorescent lamp on CCG)
  - ✔ Instant-on light, therefore ideally suitable in combination with sensor technology
  - ✔ Very high resistance to switching loads

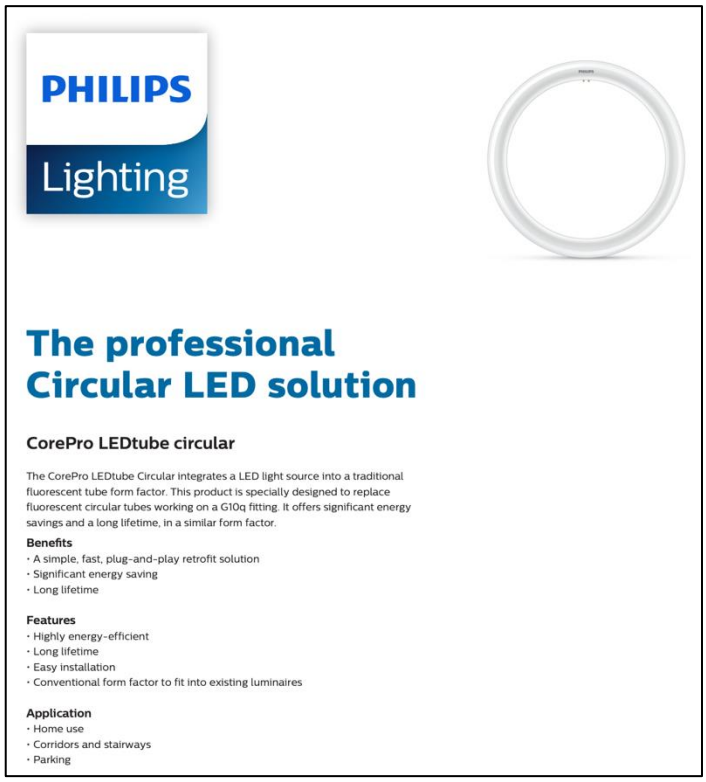
[43] Osram, LED SubstiTUBE U-Shaped Lamps, 12 February 2020, https://www.osram.com/ecat/SubstiTUBE%20U-Shape-SubstiTUBE%20T8%20EM-LED%20tubes-Lamps-Digital%20Systems/com/en/GPS01_3234358/PP_EUROPE_Europe_eCat/

✔ Also suitable for operation at low temperatures

**Circular T9 Fluorescent Lamps**

LED circular T9 lamps, which have a higher energy efficiency and longer rated life than circular fluorescent T9s, are available in the European marketplace. For example:

- Philips CorePro LEDtube Circular Lamp has an A+ Energy Efficiency Label and a 30.000 hour rated life[44] compared to an A Energy Efficiency Label and a 13.000 hour rated life for the T9 circular lamp it can replace. See summary description of the features, benefits and applications this LED product line to the right.




- Osram offers an LED CIRCOLUX 17[45] lamp with the following attributes:

- High luminous flux
- Long lifetime of up to 15.000 hours
- Low energy consumption
- Three-year guarantee
- Good quality of light; color rendering index Ra: ≥ 80; constant chromaticity.

**Recommendation for Exemption 2(b)(3), non-linear tri-band phosphor lamps:**

Discontinue exemptions. Provide transition period, ending not later than 1 September 2021

## 4.4 . Exemptions 3 for Cold Cathode Fluorescent Lamps (CCFLs) and External Electrode Fluorescent Lamps (EEFL)

There is no justification to continue the Exemption for CCFLs since they are rapidly being replaced by LEDs in the marketplace and there is an expectation that this trend will continue. The 2019 *Waste Electronic and Electrical Equipment (WEEE) Handbook* reported:

> *The latest change in display application technology is the rapid move to light-emitting diode (LED) backlight units, replacing mercury containing CCFL. "The forecast for market penetration of LED backlighting is estimated at 66% by 2014. However, given*

[44] Philips Data Sheet for CorePro LEDtube Circular Lamp, 24 January 2020, https://www.assets.signify.com/is/content/PhilipsLighting/comf7342442-pss-en_gb

[45] https://www.osram.com/ecat/CIRCOLUX%20LED%20E27-Professional%20special%20LED%20lamps-LED%20lamps-Lamps-Digital%20Systems/com/en/GPS01_3234797/PP_EUROPE_Europe_eCat/ZMP_3234629/

*the growing environmental issues and legislative direction, this percentage may be achieved sooner as manufacturers head for the high green ground.*

*The drivers for the move to LED backlighting are: (1) power consumption savings; (2) removal of toxic mercury from these products; and (3) enhancement of the contrast ratio of the screen.*

LEDs have practically replaced cold cathode fluorescent lamps (CCFL) in LCD backlight applications used for panels in small devices including smartphones and tablets as well as large appliances and electronics such as TVs, PC monitors, and notebooks. Thanks to their higher luminous efficiency and far smaller form factor, LEDs enable more effective positioning of the light sources behind the panel.

Furthermore, there is an urgency for ending this exemption and hastening the complete transition to LEDs since CCFLs create health and environmental hazards when products containing them are recycled at the end of their useful life. The WEEE Handbook explained this problem:

> *Disassembly studies on LED equipment have shown that CCFL lamps are discovered broken during disassembly. It is clear the fragility of CCFLs in LCDs will lead to breakage during manual disassembly or automated shredding of LCD panels. For both processes, the airborne release of mercury from CCFLs has significant eco-toxicity potential.*[46]

**Recommendation for Exemption 3 -Cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL):**

Discontinue exemptions. Provide transition period, ending not later than 1 September 2021

### 4.5 Exemption concerning other low pressure discharge lamps (per lamp) (4a)

It has come to our attention that there are scientifically and technically practicable and reliable substitutes for certain mercury-based products currently covered by Exemption 4(a), for example for the use of low-pressure discharge lamps for disinfection and advanced oxidation treatment with UV light emitting equipment.

Please see submission and details from Typhon Treatment Systems Ltd. (attached separately)

### 4.6 Exemptions concerning High Pressure Sodium (vapour) lamps (4)(b and c) and Metal Halides (4e)

The benefits of LEDs over HPS lamps are many:

- LED lamps are much more energy efficient than HPS lamps.
- LEDs also have a longer rated life, which reduces their replacement and installation costs as well as their lifecycle environmental impacts.

[46] See also "Evaporation of Mercury from CCFLs during Recycling of LCD Television Sets," 2013 December, https://www.researchgate.net/publication/260246422_Evaporation_of_Mercury_from_CCFLs_during_Recycling_of_LCD_Television_Sets

- LEDs emit a higher quality of light, which is white rather than the yellow light that is emitted from HPS lamps.
- LED lamps do not cycle on and off.
- LEDs are mercury-free unlike HPS lamps.

*4.5.1 There are LED and low-mercury replacement lamps for high-mercury High-Pressure Sodium (HPS) HID lamps (4b and 4c).*

High-pressure sodium lamps (HPS) are primarily used for street lighting and other exterior lighting applications, although they are rapidly becoming replaced by other technologies including, notably, LEDs because:

- of their poor color quality – many HPS lamps appear yellow because their CRI is typically in the 20s;
- they cycle on and off, which causes maintenance and safety problems; and
- their relatively short life.

Over the past few years, there has been a significant increase in the number of LED replacements for high-intensity discharge (HID) lamps – particularly LEDs that can replace high-pressure sodium (HPS) lamps up to 400 watts. According to Global Industry Analysts:

> *The global market for High Intensity Discharge (HID) Bulbs is forecast to decline to US$1.0 billion by 2024, constrained by the growing threat of substitution by light-emitting diode (LEDs) and high efficiency plasma lights. HID bulbs which have been used for years to light streets and factories are today being rapidly replaced by LEDs. Rising energy costs and tighter energy-efficiency standards and regulations are playing major roles in accelerating the phase out of HID lighting technology. Few of the benefits of LED driving its popularity as a replacement for HID include higher energy efficiency due to lower quotient of trapped light; high efficiency at higher operating temperatures; greater effectiveness of LED power drivers over HID ballasts; and longer durability with an operating life over 10 to 12 years.*[47]

According to the International Dark Sky Association, "Early LEDs were energy-inefficient and emitted little light, but due to technological advances, LED efficiency and light output have doubled about every three years. Because of their improved quality and falling prices, LEDs are now replacing conventional high-intensity discharge (HID) lamp types for outdoor lighting in communities around the world."[48]

LED lamps that can replace HIDs are available in a variety of color temperatures (typically ranging from 2700K (warm) to 6500K. Their color quality (typically measured in CRI) is quite high, often 70-90, which makes them more versatile than conventional, low-CRI HPS lamps.

LED lamps can replace many types of HIDs including both high-pressure sodium (HPS) and metal halide lamps, which contain a significant amount of mercury. LED lamps are now available in a

[47]Global Industry Analysts, "High Intensity Discharge (HID) Lighting: Market Analysis, Trends and Forecasts, 2018 May, https://www.strategyr.com/market-report-high-intensity-discharge-hid-lighting-forecasts-global-industry-analysts-inc.asp

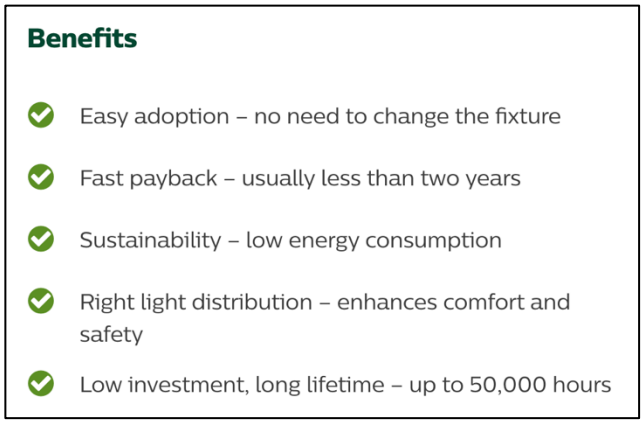
[48] International Dark Sky Association, *LED Practical Guide*, https://www.darksky.org/our-work/lighting/lighting-for-citizens/led-guide/

wide array of sizes, wattages and lumen outputs and with a variety of commonly used HID bases (e.g., E27, E40).

Suitable applications – both indoor and outdoor – include, but are not limited to:

- High-bay Lighting
- Street lights
- Garages
- Parking Lots
- Area lighting
- Pedestrian zones
- Parks
- Industry
- Retail and Museums

Manufacturers tout multiple environmental, safety and health benefits associated with replacing HID lamps with LED lamps. These benefits include significantly improved energy efficiency, longer life (which translates to lower maintenance and replacement costs), instant on (no warm-up time or "cycling"), elimination of mercury, effective thermal management for wide operating temperature range, effective lumen maintenance, and improved visibility, which increases safety. For example:

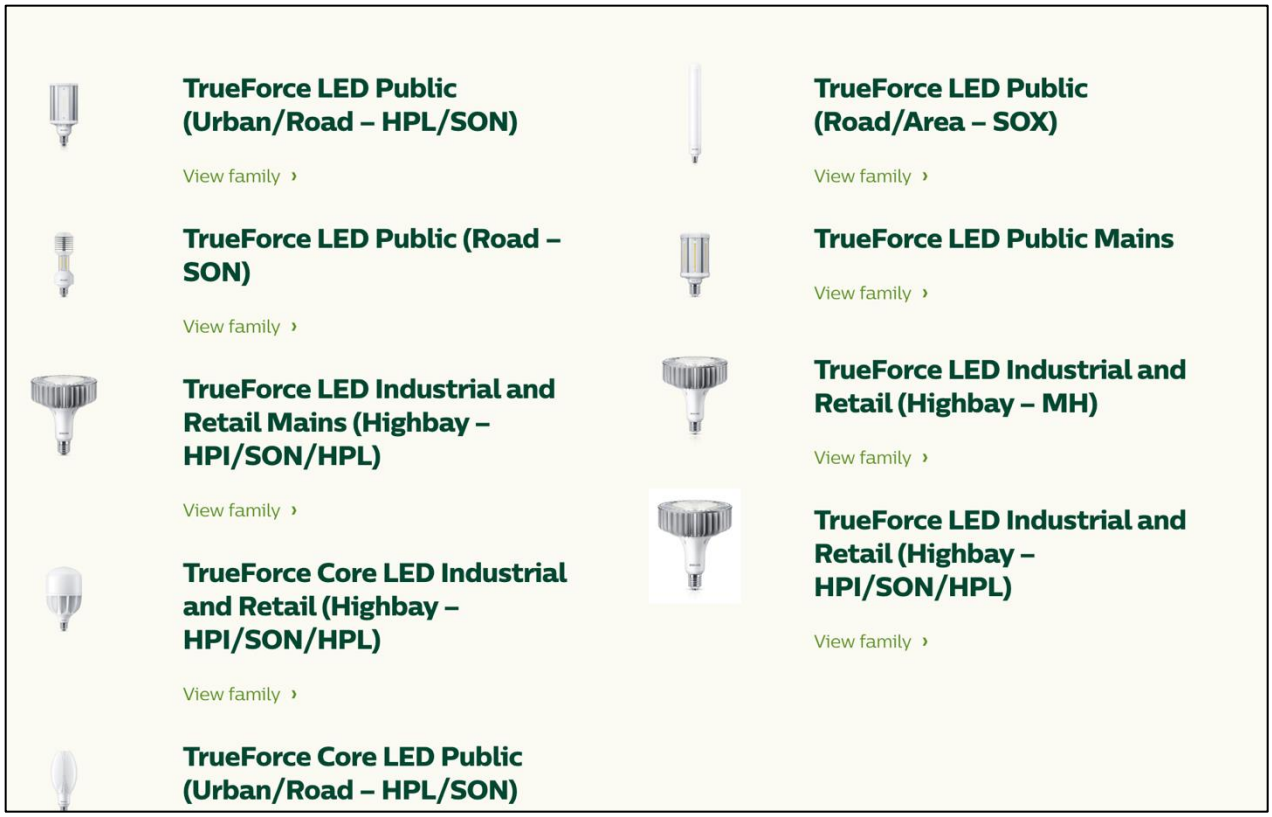



- Philips TrueForce LED lamps offer an easy and short (two-year) payback LED solution to replace High Intensity Discharge (HID) lamps. The products bring the energy efficiency and long lifetime benefits of LED to HID replacement and provide instant saving and low initial investment. With the right lamp size and light distribution, you can easily retrofit TrueForce LED road lamps into the existing systems without changing the luminaire's ballast or reflector while enhancing the lighting quality.[49]

See summary of the benefits of this LED product line and a listing of the various shapes and sizes of Philips TrueForce LED Lamps, below.[50]

[49] Philips Lighting Company, *TrueForce LED Public Road Lamps*, 24 January 2020, https://www.assets.signify.com/is/content/PhilipsLighting/fp929001999402-pss-en_gb

[50] Philips Lighting Global Catalogue, https://www.lighting.philips.com/main/products/trueforce-led-lamps




- Tungsgram/GE offers several LED lamps designed to replace HIDs (such as mercury vapor, high-pressure sodium, or metal halide lamps). This includes 35-, 80- and 150-watt models, which are replacements for 80- and 250-watt metal halide lamps. See screen shots of available products from Tungsram to the right and below.

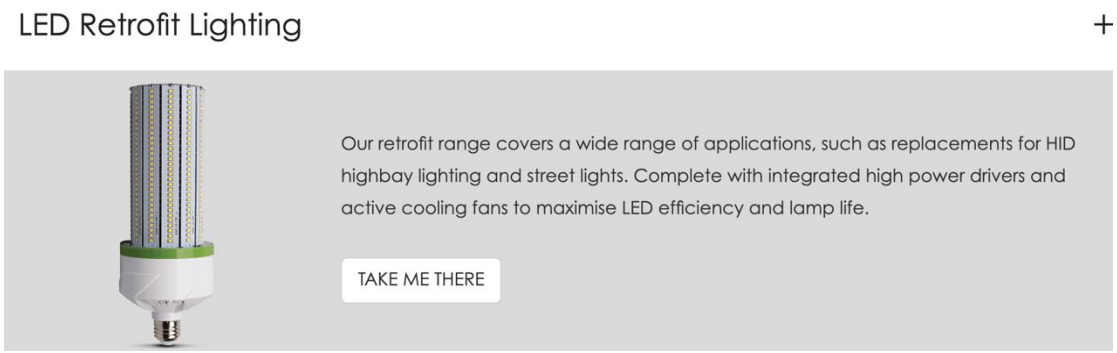

| | Wattage (W) | Burning Position | Cap | Product Description | Tungsram Product Code | Previous Generation Product Code * | Lumen (lm) | CCT (K) | Beam Angle (°) | CRI (Ra) | Rated life L70/B50 (h) | Length (mm) | Diameter (mm) | EEC | Replacement for |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LED HID** | | | | | | | | | | | | | | | |
| 7 | 35 | Universal | E27 | LED 35W/Mercury/730/E27 GE BX1/6 | - | 93038710 | 4 750 | 3000 | 360 | 70+ | 40k | 175 | 76 | A+ | 80/125W HID Mercury |
| | 35 | Universal | E27 | LED 35W/Mercury/740/E27 GE BX1/6 | - | 93038711 | 4 800 | 4000 | 360 | 70+ | 40k | 175 | 76 | A++ | |
| 8 | 80 | Universal | E40 | LED 80W/HID/740/E40 GE | - | 93067075 | 12 000 | 4000 | 360 | 70+ | 50k | 203 | 92.2 | A++ | 250W QMH |
| | 80 | Universal | E40 | LED 80W/HID/750/E40 GE | - | 93067246 | 12 000 | 5000 | 360 | 70+ | 50k | 203 | 92.2 | A++ | |
| 9 | 150 | Universal | E40 | LED 150W/HID/740/E40 TU | 93094721 | - | 23 000 | 4000 | 360 | 70+ | 50k | 211 | 103.9 | - | 250W CMH |
| | 150 | Universal | E40 | LED 150W/HID/750/E40 TU | 93094722 | - | 23 000 | 5000 | 360 | 70+ | 50k | 211 | 103.9 | - | |

- **GE's LED Replacement Lamps for HID lamps are available in** Available in 50W, 70W, 100W, 175W, 250W, 400W, & 1000W replacements. These lamps are available as UL Type A (Plug and Play), which work with the existing ballast and UL B (Ballast Bypass), which "eliminates the need to check ballast compatibility". The manufacturer claims that these LED lamps use

"60-75% less energy, providing similar light output" and last 3.3X longer than an HID (50.000 hours versus 15.000 hours).[51]


According to Current by GE, which is sold under the Tungsram brand in the EU, one of the important benefits of LEDs is that they offer a safety advantage over HIDs and fluorescents because they come on instantly. "Most fluorescent and HID lamps do not provide full brightness the moment they're switched on, with many requiring three minutes or more to reach maximum light output. LEDs come on at 100-percent brightness almost instantly however, and with no re-strike delay. This can be advantageous following a power outage or anytime employees open a building during early morning hours when it is still dark outside."

- **Venture Lighting's Retrofit LEDs,** which come in a variety of wattages that can replace a wide variety of HID lamps and high-wattage CFLs in indoor and outdoor applications. Its 20-watt to 100-watt LEDs can replace 70-watt to 400-watt HIDs including high-pressure sodium and metal halide lamps. With an A+ energy rating, these LED retrofit lamps can reduce energy consumption by 60% and have a rated life of 50.000 hours, which is twice as long as standard HPS lamps.[52]




Below is a table demonstrating that LED lamps can replace most of the commonly used high-pressure sodium (HPS) lamps up to 400 watts without having to replace the entire luminaire (although there are even more LED luminaires that can replace HID luminaires, particularly for street lighting and other outdoor illumination applications. Most HPS lamps are low-CRI models. However, LED lamps and luminaires can replace both high- and low-CRI HPS – and other types of HID – lamps. (LED lamps are in the area of the table below that is shaded green; they can replace HPS lamps in the table without shading.

[51] Currents by GE, *LED Replacement Lamps for HID*, Webpage accessed 10 February 2020, http://www.gelighting.com/LightingWeb/na/solutions/led-lamps-and-modules/led-replacement-for-hid/

[52] Venture Lighting Europe, *LED Retrofit Universal Lamps and LED Corn Lamos* Accessed online on 10 February 2020, https://www.venturelightingeurope.com/products/led-retrofit-lighting/led-retrofit-lamps-universal/ and https://www.venturelightingeurope.com/products/led-retrofit-lighting/retrofit-corn-lamps/

## Examples of LED HPS Replacement Lamps from Major European Manufacturers

| HPS Watts | HPS Lumens | HPS Brand | Hg (mg) | HPS Life (Hours) | HPS Model | LED Watts | LED Lumens | LED Brand | LED Life (Hours) | LED Model |
|---|---|---|---|---|---|---|---|---|---|---|
| 50 | 3500 | GE / Tungsram | 16,6 | 40.000 | LU/50/85/XO/SBY/D/E27 (Standby, long life, dual burner HPS) | 23 | 3000* | Osram | 50.000 | HQL LED 3000 lm 23W840 E27 |
| 50 | 3600 | Osram | 9,8 | 28.000 | NAV-E 50 W/E E27 | 25 | 4000* | Philips | 50.000 | TrueForce LED Public Road – SON 40-25W E27 730 |
| 50 | 3900 | Philips | 9,8 | 30.000 | MASTER SON PIA Plus 50W/E27 | 27 | 3400* | Sylvania | 50.000 | Toledo Performer T60 3400LM 840 E27 SL |
| | | | | | | 30 | 3450* | ProcureLED | 5-yr warranty | COR3040E27 |
| | | | | | | | | | | |
| 70 | 6000 | GE / Tungsram | 10 | 28,500 | LU70/90/MO/T/E27 | 35 | 4800* | Philips | 50.000 | 35E23.5/LED/727/ND 120-277V E49 G2 |
| 70 | 6000 | GE / Tungsram | 19,9 (10/ burner) | 50.000 | LU70/90/X)/SBY/D/E27 (Standby, long life, dual burner HPS) | 35 | 5500* | Philips | 50.000 | TrueForce LED Public Road – SON 55-35W E27 730 |
| 70 | 5900 | Osram | 12 | 24.000 | NAV-E 70 W/I E27 | 36 | 4500* | Sylvania | 50.000 | Toledo Performer T85 4500LM 840 E27 SL |
| 70 | 5900 | Philips | 20 | 30.000 | MASTER SON PIA Plus 70W/E27 | 40 | 4300* | Venture LED | 50.000 | 40W LED Corn Lamp, E27, 840 |
| | | | | | | 40 | 4600* | ProcureLED | 5-yr warranty | COR4040E27 |

| HPS Watts | HPS Lumens | HPS Brand | Hg (mg) | HPS Life (Hours) | HPS Model | LED Watts | LED Lumens | LED Brand | LED Life (Hours) | LED Model |
|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 9600 | GE / Tungsram | 13,3 | 28,500 | LU100/100/MO/T/40 | 46 | 6000* | Osram | 50.000 | HQL LED 6000 lm 46 W/840 E27 |
| 100 | 10.000 | GE / Tungsram | 26.6 (13,3/burner) | 60.000 | LU100/XO/SBY/D/E40 (Standby, long life, dual burner HPS) | 55 | 7500* | Philips | 50.000 | TrueForce LED Public Road – SON 112-68W E40 730 |
| 100 | 10.400 | Osram | 13,1 | 36.000 | NAV-E 100 W Super 4Y | 60 | 6900* | ProcureLED | 5-yr warranty | COR6040E27 |
| 100 | 9700 | Philips | 20 | 36.000 | MASTER SON PIA Plus 100W/220 E40 | 54 | 6800* | Sylvania | 50.000 | Toledo Performer T85 6500LM 840 E40 SL |
| | | | | | | | | | | |
| 150 | 15.300 | GE / Tungsram | 16,4 | 28.500 | LU150/100/100/40 | 85 | 10.000* | Philips | 25.000 | TrueForce HB 100-85W E40 840 120D |
| 150 | 16.100 | Philips | 20 | 36.000 | MASTER SON PIA Plus 150W/220 E40 | 80 | 10.500* | Sylvania | 50.000 | Toledo Performer T85 10500LM 840 E40 SL |
| | | | | | | 80 | 10.800* | ProcureLED | 5-yr warranty | COR8040E40 |
| | | | | | | 80 | 12.000* | Osram | 50.000 | LED HID 80 |
| | | | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 250 | 28.500 | GE / Tungsram | 16,4 | 28,500 | LU250T/40 | 95 | 13.000* | Osram | 50,000 | HQL LED PRO 95 W/840 E40 |
| 250 | 31.600 | Osram | 18,8 | 36.000 | NAV-E 250 W SUPER 4Y | 100 | 13.500* | ProcureLED | 5-yr warranty | COR10040E40 |
| 250 | 30.900 | Philips | 20 | 36,000 | MASTER SON PIA Plus 250W/220/E40 | 110 | 13.000* | Sylvania | 50.000 | Toledo Performer T85 13000LM 840 E40 SL |
| **HPS Watts** | **HPS Lumens** | **HPS Brand** | **Hg (mg)** | **Life (Hours)** | **HPS Model** | **LED Watts** | **LED Lumens** | **LED Brand** | **Life (Hours** | **LED Model** |
| | | | | | | | | | | |
| 400 | 48.000 | GE/ Tungsram | 15,8 | 28.500 | LU400/T/40 | 140 | 20.000* | Osram | 50.000 | HQL LED PRO 140 W/840 E40 |
| 400 | 56.500 | Osram | 18,8 | 36.000 | NAV-E 400 W Super 4Y | 145 | 20.000* | Philips | 50.000 | TrueForce LED HPI/SON/HPL ND 200-145W E40 840 60D |
| 400 | 55.400 | Philips | 20 | 36.000 | MASTER SON PIA Plus 400W/220/E40 | 150 | 23.000* | GE/Tungsram | 50.000 | LED HID 150 |
| | | | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1000 | 130.000 | GE / Tungsram | 24,8 | | LU1000 | | | None found | | |

*Manufacturer states that this is the proper and equivalent replacement despite lower lumens of the LED lamp due to the higher quality of the LED light, which makes the LED lumens more visually available. Only about 55% of the lumens in a low-CRI HPS lamp are visually available. So, the LED replacement lamps needs only about half of the lumens of the HPS lamp it is replacing.

Finally, Philips has a line of **MASTER SON-T Mercury-Free HPS Lamps** that are A+ rated for energy efficiency and have a relatively long rated life of 38.000 hours.[53]

LEDs are increasingly being made to replace HPS lamps and are expected to increase for this application. A study cited by the International Energy Agency found [LED and induction lamp] impacts were about 30% lower in global warming potential, respiratory effects and ecotoxicity compared to high pressure sodium and metal halide luminaires [for street lighting and other outdoor lighting applications."[54]

Since LEDs can now replace high-pressure sodium lamps (up to 400 watts) as well as other low-wattage HIDs, we urge the European Commission to consider these findings and work to develop an expiry date for this category of mercury-containing lamps.

**Recommendation for categories 4 b and c:**

Discontinue the exemption for HPS models up to 400 Watts, with transition period ending latest 1 September 2021.

### *4.5.2 Metal Halides*

Due to resource constraints, we were unable to undertake a comprehensive analysis for metal halides lamps; however, also as per our 2015 submission, we consider these comments/examples below sufficient for our recommendation that the Commission allows the mercury exemption to expire for quartz metal halide lamps

Quartz metal halide lamps – particularly low-wattage models – can be readily replaced with more energy-efficient ceramic metal halide (CMH) lamps, which have a longer rated life and typically have less or the same amount of mercury. Below are several examples:


- A review of Osram's 2020 online catalogue revealed that its POWERBALL HCL-ET 70W, is a ceramic metal halide lamp with a mercury content of (7,6 mg), a lumen output of 7500 lumens, an efficacy of 103 lumens/watt (Class A+), and a rated life of 16.000 hours. In comparison, Osram's 70-watt POWERSTAR HQL-ET 70W, which is a less-efficient quartz metal halide lamp, has a lower lumen output of only 5500 lumens, a lower efficacy of only 79 lumens/watt (Class A), and a shorter rated life of only 6000 hours. It also has a slightly higher mercury content (8,0) than its ceramic metal halide counterpart.

[53] Philips Company, *Data Sheet for MASTER SON-T APIA Mercury-Free HPS Lamps*, 26 January 2018, http://www.assets.lighting.philips.com/is/content/PhilipsLighting/comf1609-pss-global

[54] International Energy Agency, *Solid State Lighting Annex: Life Cycle Assessment of Solid State Lighting: Final Report*, 17 September 2014, http://ssl.iea-4e.org/files/otherfiles/0000/0068/IEA_4E_SSL_Report_on_LCA.pdf

- According to GE Lighting (now Tungsgram) there are many benefits to ceramic MH lamps over quartz MH lamps, including their high efficiency and long life:


- *Widest range of wattages from 20W to 400W*
- *Highly controllable point source of light*
- *Wide range of formats for designers flexibility*
- *GU6.5, G8.5, G12, E27/E40 and Rx7s*
- *MR16 and PAR reflectors*
- *Tubular and elliptical versions*
- *High efficacy – up to 111 lm/W*[55]
- *Long life – up to 24,000 hours*
- *Consistent colour over life*
- *Colour temperatures: 3000K & 4200K*
- *UV control*
- *Selection of approved ballasts*

*From bright light and excellent colour rendering to high reliability, a long life and a choice of lamps to suit all kinds of different applications – indoors and outdoors – there are dozens of reasons to choose GE's Ceramic Metal Halide (CMH) lamps, Applications range from accent and spot lighting to flood and area lighting, and they provide an extremely effective replacement for High Pressure Sodium (HPS) and Quartz Metal Halide Lamps.*

More reasons to choose GE's CMH solutions:

According to a 2017 GE Lighting CMH Data Sheet, ceramic metal halide lamps have "up to 24% higher efficacy than quartz metal halide [lamps]." Another benefit of GE's ceramic MH lamps is that they often have a lower mercury content when compared to its equivalent quartz MH lamp. For example:

- GE manufactures both quartz and ceramic double-ended MH lamps in equivalent wattages. Its **150-watt Arcstream Double-Ended Quartz MH Lamp**[56] has a mercury content of 14,5 mg, while its **150-watt ConstantColor Ceramic MH Lamp**[57] has a mercury content of only 10 mg. Moreover, while the quartz MH lamp has a Class A rating and a rated life of 12.000 hours, the equivalent ceramic MH lamp has a Class rating of A+ and a rated life of 15.000

[55]GE Lighting Company (Europe), *Ceramic Metal Halide Lamps*, Accessed 15 October 2015, http://www.gelighting.com/LightingWeb/emea/products/technologies/hid/cmh.jsp

[56] GE Lighting Company (Europe), *Arcstream Double Ended Quartz Metal Halide Lamps with UV Control*, November 2013, http://www.gelighting.com/LightingWeb/emea/images/Metal_Halide_Arcstream_Double_Ended_Lamps_Data_sheet_EN_tcm181-12560.pdf

[57]GE Lighting Company (Europe), *ConstantColor CMH TD Double Ended Ceramic Metal Halide Lamps: 35W, 70W and 150W*, August 2013, http://www.gelighting.com/LightingWeb/emea/images/ConstantColor_CMH_TD_Double_Ended_Lamps_Data_sheet_EN_tcm181-12599.pdf

hours.

- Philips offers a wide array of ceramic MH lamps that are environmentally preferable replacements for quartz MH (and sometimes also HPS) lamps. For example:
    - Its **250-watt MASTER Plus CityWhite Tubular Ceramic Metal Halide** lamp contains only 25,3 mg of mercury and has a Class A+ rating and a rated life of 27.000 hours.[58] In contrast, its equivalent 250-watt quartz MH lamp (MASTER HPI-T Plus Quartz Metal Halide Lamp contains 36 mg of mercury and has a Class A+ rating, also, but a shorter rated life of 20.000 hours.[59]

Since quartz and ceramic MH lamps are very often available in the same shape and type of lamps and bases, they are almost always interchangeable.

Therefore, offering the RoHS Exemption on the ceramic models only would result in use of these easy, drop-in replacements with multiple environmental benefits, including significant mercury reduction as well as energy savings.

Since some metal halides have a similar base, bulb shape and lumen output as the HPS lamps up to 400 watts, there are manufacturers offering LED replacement lamps for some types of metal halide lamps.

One example is ProcureLED which offers a line of LED "Corn Lamps", which are marketed as "Direct Replacement for Metal Halide" that can fit "many different fixtures to replace traditional lamps", which are used to light factories, workshops, warehouses, shipyards, mining, gas stations, streets, etc."[60]

**Recommendation for Exemption 4(e): "Mercury in metal halide lamps"**

Only allow an Exemption for Ceramic Metal Halide Lamps (not for Quartz Metal Halide Lamps) up to and including 250 Watts as well as all metal halides over 250 watts.

Also, monitor improved availability, performance and price of LED retrofit lamps for metal halide lamps and consider an expiry date for some types of MH lamps that are available on the market today.

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For more information please contact:

[58] Philips Company (UK), *MASTER CityWhite Ceramic Metal Halide Lamps*, 28 August 2013, http://download.p4c.philips.com/l4bt/3/322972/master_citywhite_cdo-et_322972_ffs_eng.pdf

[59] Philips Company (UK), *MASTER HPI-T Plus Quartz Metal Halide Lamps, 29 August 2015, http://download.p4c.philips.com/l4b/9/928481300098_eu/928481300098_eu_pss_enggb.pdf*

[60] ProcureLED LED Corn Lamps; March 2019, https://procureled.com/wp-content/uploads/2019/03/Corn-Lamps-ProcureLED.pdf

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# Annex

## SEA-CLASP report – v2- 12 December 2019

The Swedish Energy Agency and CLASP conducted a review of several categories of fluorescent lighting products which are exempted in Annex III of the restriction of the use of certain hazardous substances (RoHS) in electrical and electronic equipment.[61] This review found that there are mercury-free alternative products which can replace these fluorescent lamps, enabling these on-going exemptions from RoHS to be retired.

Through continued investment and on-going breakthroughs in light emitting diode (LED) light sources and drivers alike, the market now enjoys LED retrofit lamps that can be installed directly into existing luminaires without the need for rewiring. These lamps can operate on the existing fluorescent ballast, whether it is magnetic (line frequency) or high frequency. Pictures of examples of some of these lamps can be found in Annex A of this report.

The table below summarises our proposals for consideration based on our findings of the existence of alternative LED replacements for the exempted fluorescent lighting in Annex III of the RoHS Directive. These alternative products are cost-effective and can be installed directly into the fluorescent sockets without the need for rewiring.

**Table 1. Proposals for Consideration on the Exemptions for Certain Fluorescent Lamps**

| RoHS Annex Exemption | Proposals for consideration |
|---|---|
| Mercury in single capped (compact) fluorescent lamps not exceeding (per burner): | |
| 1(a) For general lighting purposes < 30 W: 2,5 mg shall be used per burner after 31 December 2012; | Consider setting the exemption to expire on 1 September 2021 |
| 1(b) For general lighting purposes ≥ 30 W and < 50 W: 3,5 mg may be used per burner after 31 December 2011; | |
| 1(c) For general lighting purposes ≥ 50 W and < 150 W: 5 mg; | |
| 1(d) For general lighting purposes ≥ 150 W: 15 mg; | |
| 2(a) Mercury in double-capped linear fluorescent lamps for general lighting purposes not exceeding (per lamp): | |
| 2(a)(2) Tri-band phosphor with normal lifetime and a tube diameter ≥ 9 mm and ≤ 17 mm (e.g. T5): 3 mg may be used per lamp after 31 December 2011 | Consider setting the exemption to expire on 1 September 2021 |
| 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 | |
| 2(a)(4) Tri-band phosphor with normal lifetime and a tube diameter > 28 mm (e.g. T12): 3,5 mg may be used per lamp after 31 December 2012 | |

[61] DIRECTIVE 2011/65/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast) (Text with EEA relevance) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02011L0065-20190722

| | |
|---|---|
| 2(a)(5) Tri-band phosphor with long lifetime (≥ 25 000 h): 5 mg may be used per lamp after 31 December 2011 | |
| 2(b) Mercury in other fluorescent lamps not exceeding (per lamp): | |
| 2(b)(3) Non-linear tri-band phosphor lamps with tube diameter > 17 mm (e.g. T9): 15 mg may be used per lamp after 31 December 2011 | Consider setting the exemption to expire on 1 September 2021 |

The analysis is based on four key questions which explore the technical and economic feasibility of the alternatives to mercury lighting. These four questions and abbreviated answers are shown in the table below. More detail and information underpinning these answers is provided in the body of this report.

**Table 2. Four Key Questions and Summaries of our Findings**

| Key Question | Summary of Findings |
|---|---|
| Are there alternative mercury-free replacements for fluorescent lamps? | **Yes**. There are thousands of mercury-free LED replacement lamps available today to replace fluorescent lamps – different sizes, lengths, ballast types (i.e., magnetic/starter and high frequency electronic), colour temperatures, and regular, high output and ultra-high light output levels. Lamps are also available which are "universal" and can operate on a variety of input power configurations. Many of these LED products are designed as direct retrofits into existing fluorescent fixtures to avoid the need to rewire. For example, Philips/Signify states[62] that there is "No need to change drivers or rewire", noting that they offer a "plug and play solution that works straight out of the box". OSRAM/LEDvance state[63] that their "SubstiTUBE" product is a "Quick, simple and safe lamp replacement without rewiring." Sylvania lighting advertises that their SubstiTUBE product is "engineered to operate on existing instant start and select programmed rapid start electronic T8 ballasts, these lamps minimise labour and recycling costs."[64] Tungsram reports that in addition to "the 2.5-3x longer life (compared to T8 fluorescent lamps operated on electro-magnetic gear) and lower wattages, Tungsram LED T8 tubes provide lower system loss while existing fixtures remain intact."[65] |

[62] https://www.lighting.philips.com/main/support/support/tools/ledtube-selectortool
[63] https://www.ledvance.com/professional/products/product-stories/led-tubes-online-special/index.jsp
[64] https://assets2.sylvania.com/media/bin/asset-1377974/asset-1377974
[65] https://tungsram.com/en/products/led-retrofit/led-tubes

| Key Question | Summary of Findings |
|---|---|
| Will removing the exemption result in a reduction in mercury in the environment? | **Yes**. Each fluorescent lamp contains several milligrams of mercury and our research has found that more than half of the fluorescent lamps sold in Europe are never recovered and instead end up being discarded with regular municipal waste, contaminating landfill sites and run-off. A 2014 European Commission study on collection rates found that the collection rate was only 12% in 2010 for all lamps under the WEEE Directive.[66] The WEEE Directive sets a target of 80% recycling, however some studies show that the actual rate of separate collection at the end-of-life is less than 50%, thus while reported recycling rates are high, these percentages are not based on total lamps removed from service, but are instead only considering those lamps that are delivered to the correct waste treatment facility. The Minamata Convention encourages the sharing of information around mercury-free alternative products and calls for periodic reviews of the exemptions list. In Europe, by not renewing the exemptions for many of these fluorescent lamps for which there are cost-effective, mercury-free, direct replacement alternatives, RoHS would be aligning with the objective of the Convention and removing 2.6 metric tonnes of mercury from our homes and offices across Europe. |
| Is it cost-effective for LED lamps to replace linear fluorescent lamps? | **Yes**. Economic calculations are presented in section 3 for the most popular lamps. The payback period for replacing a 36W T8 linear fluorescent lamp with an LED retrofit lamp in Europe today is between 5 and 11 months, and the service life of these lamps is 1.5 to 2.5 times longer than fluorescent, saving on replacement costs. LED replacements for T5 fluorescent lamps have longer payback periods of approximately 3 to 3.5 years, however they will operate for approximately 16 years and represent the best option for the end-user, with a net present value life-cycle cost savings of between €55 and €67 for each T5 fluorescent lamp replaced. LED replacements for compact fluorescent lamps not integrally ballasted (CFLni) offer very attractive payback periods of between 1.3 and 3.0 years and will last 2-3 times longer than the fluorescent lamp. For European businesses and households, there is a very strong value proposition in switching to LED, and lighting manufacturers' websites highlight the cost-effectiveness and energy savings potential of LED alternatives to fluorescent lamps. |

[66] https://ec.europa.eu/environment/waste/weee/pdf/Final_Report_Art7_publication.pdf

| Key Question | Summary of Findings |
|---|---|
| Are the societal benefits in terms of energy, $CO_2$ and cost savings significant? | **Yes**. The consultants who prepared the one-lighting regulation review study and impact assessment for the European Commission conducted some new runs of the MELISA market model for this study to help quantify the benefits of phasing out certain fluorescent lamps in 2021. The cumulative benefit through the year 2030 for these specific lamp types are reported as follows:<br>• T8 phase-out: Saves 64 TWh electricity, avoids 18.9 MMT $CO_2$ and has a net saving of €5.0 billion in electricity bills and lamps<br>• T5 phase-out: Saves 60 TWh electricity, avoids 17.8 MMT $CO_2$ and has a net saving of €4.7 billion in electricity bills and lamps<br>• CFLni phase-out: Saves 14 TWh electricity, avoids 4.2 MMT $CO_2$ and has a net saving of €2.8 billion in electricity bills and lamps<br>Taken together, phasing out these three lamp types offers significant societal benefit. In addition, the total electricity savings of 138.3 TWh also avoids the release of mercury from the power stations which burn coal. Using the Commission's estimate of 0.016 mg Hg/kWh of electricity generated in Europe, a further 2.2 metric tonnes of mercury emissions from European power stations would be eliminated. |

**Results Summary**

If the RoHS exemptions for T8, T5 and CFLni lamps were limited to 1 September 2021, this would move both of those markets to LED earlier than in the business as usual case, accruing the following benefits across Europe:

**Table 3. Summary of the Benefits from a Scenario where RoHS exemptions for T8, T5 and CFLni Lamps are Limited to 1 September 2021**

| Metric for T5 and T8 compared to Business as Usual* | Savings from limiting RoHS exemption to 1 September 2021 (cumulative through 2030) |
|---|---|
| **Hg Reduction**: Avoided quantity of mercury put into the lighting supply chain, with the risk of breakage or improper disposal (2.6 metric tonnes) and avoided mercury emitted from power stations due to electricity savings (2.2 metric tonnes). | 4.8 metric tonnes Hg |
| **Energy Bill Savings**: Billions of Euros saved by businesses and consumers on their lighting bills through the use of more energy-efficient LED lamps | €12.5 billion |
| **Energy Reduction**: TWh of cumulative energy reduction | 138.3 TWh electricity |
| **$CO_2$ Reduction**: Metric tonnes of $CO_2$ reduction from the avoided generation of electricity for lighting | 40.9 million metric tonnes $CO_2$ |

*Business as Usual is calculated on the basis of the one-lighting ecodesign regulation adopted by the European Commission on 1 October 2019 becoming law and taking effect. The one-lighting regulation will phase-out T8 fluorescent lamps in September 2023, however it was found to be cost-effective to phase-out T8 fluorescent lamps faster than this, thus this analysis considers a scenario phase-out date of September 2021 for T8 (an acceleration of 2 years). T5 and CFLni do not have a phase-out date in the one-lighting ecodesign regulation, however they are also considered for phase-out in September 2021 through the end of their exemptions in the RoHS Directive.