Assessing Annex III Fluorescent Lamp Exemptions in the Light of Scientific and Technical Progress

Report to the Committee on the Regulation of Hazardous Substances

Preface

This report provides a technical assessment of the exemptions provided in Annex III of the 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 (RoHS) in electrical and electronic equipment[1] for the following fluorescent lamp types:

- compact fluorescent lamps which are not integrally ballasted (CFLni),
- linear fluorescent lamps of with tube diameter ≥ 9 mm and ≤ 17 mm (e.g. T5), and
- linear fluorescent lamps of with tube diameter > 17 mm and ≤ 28 mm (e.g. T8).

This assessment does not address T12 linear fluorescent lamps or integrally ballasted compact fluorescent lamps (CFLi) as both are phased out on 1 September 2021 under the recent ecodesign lighting regulation, Commission Regulation EU 2019/2020[2]

This report has been developed jointly by the Swedish Energy Agency and CLASP.

[1] 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)Text with EEA relevance: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02011L0065-20190722

[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

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1 Annex III Categories Reviewed

The Swedish Energy Agency and CLASP conducted a review of the criteria associated with the exemptions for fluorescent lighting products in Annex III of the restriction of the use of certain hazardous substances (RoHS) in electrical and electronic equipment (RoHS Directive).[3] These lamp categories were prioritised in part because they constitute the largest share of mercury in the lighting exemption categories – see Figure 1.

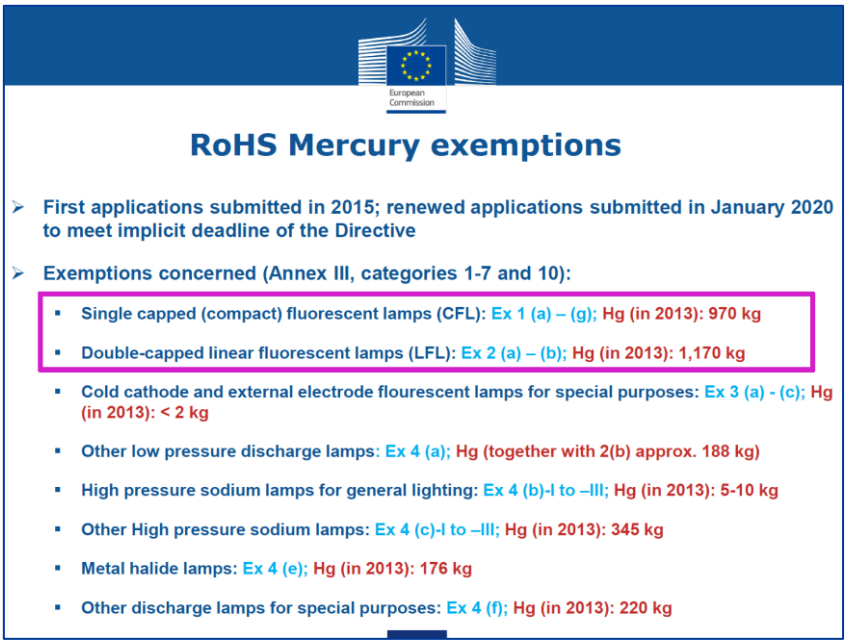


Figure 1. Estimated quantities of mercury by Lamp Exemption Category, 2013

In this section, we present the Annex III subcategories that were individually assessed and the criteria used in that assessment, which were derived from Article 5(1)(a) of the RoHS Directive.

The following tables provide an overview of all of the current and expired exemptions in Annex III that relate to fluorescent lighting. The majority of the exemptions presented here were granted for a 5-year-period of renewal to July 2016. Since no decision has been taken as regards the exemptions, they are still valid. Table 1 presents the exclusions for single-capped compact fluorescent lamps (CFLs), which encompasses two sub-categories of single-capped CFLs: integrally-ballasted compact fluorescent lamps (CFLi) and non-integrally ballasted compact fluorescent lamps (CFLni). This difference is important because CFLi are being phased out by Ecodesign[4] on 1 September 2021, but CFLni are not and have no terminal date.

[3] 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

[4] 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/PDF/?uri=CELEX:32019R2020&from=EN

	
Single-capped, compact fluorescent lamp which contains the ballast integral to the lamp (CFLi). This lamp operates on mains volltage (230V, 50Hz), and will be phased-out by Ecodesign on 1 September 2021.	Single-capped, compact fluorescent lamp which does not contain an integral ballast (CFLni). Instead, for these lamps, the ballast is contained within the fixture the lamp is inserted into. These lamps are not phased-out by Ecodesign.

Figure 2. Two types of single-capped compact fluorescent lamps

Table 1 presents all the different categories for single-capped CFLi and CFLni. They are grouped according to wattage, shape and long life.

Table 1. RoHS Annex III exemptions for single capped (compact) fluorescent lamps*

Category #	Category Description	Limit	RoHS Date	Status / Notes
III.1(a)	For general lighting purposes < 30 W	2,5 mg	Valid – requested for renewal	CFLi: Ecodesign phases out on 1 Sept 2021. [5] CFLni: no phase-out date.
III.1(b)	For general lighting purposes ≥ 30 W and < 50 W	3,5 mg	Valid – requested for renewal	
III.1(c)	For general lighting purposes ≥ 50 W and < 150 W	5 mg	Valid – requested for renewal	
III.1(d)	For general lighting purposes ≥ 150 W	15 mg	Valid – requested for renewal	
III.1(e)	For general lighting purposes with circular or square structural shape and tube diameter ≤ 17 mm	7 mg	Valid – requested for renewal	These are all CFLni lamps; there is no phase-out date for these lamps.
III.1(f)	For special purposes	5 mg	Valid – requested for renewal	Exempted from Ecodesign. No phase-out date
III.1(g)	For general lighting purposes < 30 W with a lifetime equal or above 20 000 h	3,5 mg	Valid – requested for renewal	Application pending; thus still exempted and no phase-out date.

*Note: The exemptions in this category apply to both integrally-ballasted compact fluorescent lamps (CFLi) and non-integrally ballasted compact fluorescent lamps (CFLni).

[5] 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/PDF/?uri=CELEX:32019R2020&from=EN

Table 2. RoHS Annex III exemptions for double capped linear fluorescent lamps for general lighting purposes and other fluorescent lamps

Category #	Category Description	Limit	RoHS Date	Status / Notes[6]
III.2(a)(1)	Tri-band phosphor with normal lifetime and a tube diameter < 9 mm (e.g. T2)	4 mg	Valid – requested for renewal	Ecodesign phases out these lamps on 1 Sept 2021
III.2(a)(2)	Tri-band phosphor with normal lifetime and a tube diameter ≥ 9 mm and ≤ 17 mm (e.g. T5)	3 mg	Valid – requested for renewal	Exempted from Ecodesign. No phase-out date
III.2(a)(3)	Tri-band phosphor with normal lifetime and a tube diameter > 17 mm and ≤ 28 mm (e.g. T8)	3,5 mg	Valid – requested for renewal	Ecodesign phases out certain lengths of T8 on 1 Sept 2023
III.2(a)(4)	Tri-band phosphor with normal lifetime and a tube diameter > 28 mm (e.g. T12)	3,5 mg	Valid – requested for renewal	Ecodesign phases out these lamps on 1 Sept 2021
III.2(a)(5)	Tri-band phosphor with long lifetime (≥ 25 000 h)	8 mg	Valid – requested for renewal	
~~III.2(b)(1)~~	~~Linear halophosphate lamps with tube > 28 mm (e.g. T10 and T12)~~	~~10 mg~~	Expired on 13 April 2012	No longer allowed on the market.
~~III.2(b)(2)~~	~~Non-linear halophosphate lamps (all diameters)~~	~~15 mg~~	Expired on 13 April 2016	No longer allowed on the market.
III.2(b)(3)	Non-linear tri-band phosphor lamps with tube diameter > 17 mm (e.g. T9)	15 mg	Valid – requested for renewal	
III.2(b)(4)	Lamps for other general lighting and special purposes (e.g. induction lamps)	15 mg	Valid – requested for renewal	

Table 3. Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for special purposes

Category #	Category Description	Limit	RoHS Date	Status / Notes
III.3(a)	Short length (≤ 500 mm)	3,5 mg	Valid – requested for renewal	Ecodesign phases out these lamps on 1 Sept 2021
III.3(b)	Medium length (> 500 mm and ≤ 1 500 mm)	5 mg	Valid – requested for renewal	Ecodesign phases out these lamps on 1 Sept 2021
III.3(c)	Long length (> 1 500 mm)	13 mg	Valid – requested for renewal	Ecodesign phases out these lamps on 1 Sept 2021

While Tables 1 through 3 present all of the categories of fluorescent lamps included in Annex III, we focus our assessment of the Article 5(1)(a) criteria on CFLni, T5 and T8.

[6] 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/PDF/?uri=CELEX:32019R2020&from=EN

2 RoHS Directive Article 5(1)(a) criteria

The report takes into consideration the scientific and technical progress of mercury-free LED retrofits for various categories of fluorescent lamps listed in Annex III. The authors analyse whether the criteria in Article 5(1)(a) of the RoHS Directive justify maintaining fluorescent lamp exemptions in Annex III, or if those exemptions should be withdrawn.

This chapter presents the criteria under Article 5(1)(a) and our assessment of each of the exempted fluorescent lamp types. Figure 3 presents a screen capture of the relevant text from Article 5 of the RoHS Directive.

Article 5

Adaptation of the Annexes to scientific and technical progress

1. For the purposes of adapting Annexes III and IV to scientific and technical progress, and in order to achieve the objectives set out in Article 1, the Commission shall adopt by means of individual delegated acts in accordance with Article 20 and subject to the conditions laid down in Articles 21 and 22, the following measures:

(a) inclusion of materials and components of EEE for specific applications in the lists in Annexes III and IV, provided that such inclusion does not weaken the environmental and health protection afforded by Regulation (EC) No 1907/2006 and where any of the following conditions is fulfilled:

— their elimination or substitution via design changes or materials and components which do not require any of the materials or substances listed in Annex II is scientifically or technically impracticable,

— the reliability of substitutes is not ensured,

— the total negative environmental, health and consumer safety impacts caused by substitution are likely to outweigh the total environmental, health and consumer safety benefits thereof.

Decisions on the inclusion of materials and components of EEE in the lists in Annexes III and IV and on the duration of any exemptions shall take into account the availability of substitutes and the socioeconomic impact of substitution. Decisions on the duration of any exemptions shall take into account any potential adverse impacts on innovation. Life-cycle thinking on the overall impacts of the exemption shall apply, where relevant;

(b) deletion of materials and components of EEE from the lists in Annexes III and IV where the conditions set out in point (a) are no longer fulfilled.

2. Measures adopted in accordance with point (a) of paragraph 1 shall, for categories 1 to 7, 10 and 11 of Annex I, have a validity period of up to 5 years and, for categories 8 and 9 of Annex I, a validity period of up to 7 years. The validity periods are to be decided on a case-by-case basis and may be renewed.

For the exemptions listed in Annex III as at 21 July 2011, the maximum validity period, which may be renewed, shall, for categories 1 to 7 and 10 of Annex I, be 5 years from 21 July 2011 and, for categories 8 and 9 of Annex I, 7 years from the relevant dates laid down in Article 4(3), unless a shorter period is specified.

For the exemptions listed in Annex IV as at 21 July 2011, the maximum validity period, which may be renewed, shall be 7 years from the relevant dates laid down in Article 4(3), unless a shorter period is specified.

Figure 3. Screen Capture of Article 5(1)(a) Criteria from the RoHS Directive

Included in Article 5(1)(a) are six criteria which will form the basis of our assessment for each of the exempted fluorescent lamp types. However, the actual criteria in Article 5(1)(a) are not easy to cite because some of the criteria are in a bulleted list with narrative text after the bullet points, and other criteria are contained in the paragraph at the end of 5(1)(a). In addition, it is not clear how subparagraph one relates to subparagraph two in Article 5(1)(a). For clarity, we have assigned each of the criteria an identifiable number and given them brief descriptive titles. However, exactly how the criteria should be applied requires further analysis.

Table 4. Assigning Numbers and Descriptive Titles to the Criteria from Article 5(1)(a)

Text from Article 5(1)(a)	Our assigned criterion number and descriptive title
Their elimination or substitution via design changes or materials and components which do not require any of the materials or substances listed in Annex II is scientifically or technically impracticable;	(i) Annex II Materials or Substances
The reliability of substitutes is not ensured;	(ii) Reliability of Substitutes
The total negative environmental, health and consumer safety impacts caused by substitution are likely to outweigh the total environmental, health and consumer safety benefits thereof;	(iii) Environment, Health and Safety
Decisions on the inclusion of materials and components of EEE in the lists in Annexes III and IV and on the duration of any exemptions shall take into account the availability of substitutes….	(iv) Availability of Substitutes
… and the socioeconomic impact of substitution.	(v) Socioeconomic Impact
Decisions on the duration of any exemptions shall take into account any potential adverse impacts on innovation.	(vi) Impact on Innovation

2.1 (i) Annex II Materials or Substances

This first criterion seeks to clarity whether the replacement product contains any RoHS Annex II materials or substances, which are: lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB), polybrominated diphenyl ethers (PBDE) and the four classified phthalates (DEHP, BBP, DBP and DIBP).

In their presentation to DG Environment on 12 February 2020, on slide 7 LightingEurope stated that LED replacement lamps do contain Annex II substances:

> "Alternatives, like all electronics, contain other Annex II substances"

They also made this statement on slide 11 of their presentation on 22 October 2019:

> "The main alternative for mercury lamps is LED technology which, like all electronics, contains Annex 2 restricted substances (e g lead)"

Thus, LightingEurope has twice stated that they believe LED replacement lamps contain banned Annex II substances and therefore fail this requirement of Article 5(1)(a). We feel it is important that the RoHS Committee is informed that these statements are not true, as LED products do not contain lead, mercury, cadmium, hexavalent chromium, nor they contain bromine flame retardants. RoHS compliant means RoHS compliant, so any product that carries this label will use alternative flame retardants.

LED retrofit tubes and replacements for pin-based fluorescent lamps (CFLni) are sold and installed today. We understand that the RoHS requirements are strictly enforced, so the components and parts used in LED lamps are already RoHS compliant and not only do not contain mercury, but do not contain any other Annex II materials or substances. In fact, the electronics contained in LED drivers are no different on a materials basis than the ballast contained in a CFLi lamp. The only difference between the two lighting technologies is that there is mercury in the fluorescent tube and no mercury in the LED lamp.

We checked the website of two of LightingEurope's leading members to see if their LED retrofit tubes were RoHS compliant or not. The following screen captures from their websites show that these companies are declaring their products as compliant with RoHS, meaning there are no Annex II materials or substances in their LED retrofit products.[7]

Figure 4 is the "Eco Passport" that Philips/Signify issues for their portfolio of products as part of their Sustainable Design process. In the box marked "Substances", it states that "EU RoHS compliant: Yes" and "EU RoHS phthalates compliant: Yes".

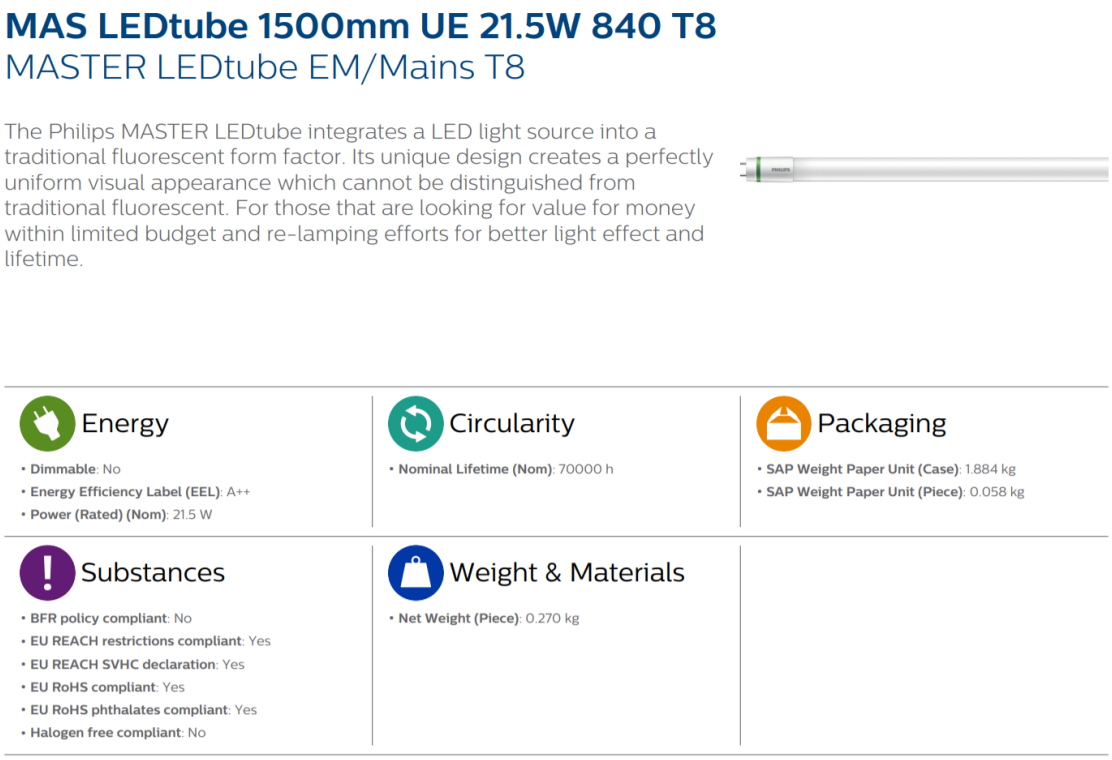


Figure 4. Screen Capture of Philips declaration of RoHS Compliance for their LEDtube[8]

The following figure presents the Safety Data Sheet from LEDvance which was published on 4 April 2018 and addresses all LED lamp types, base types and wattages. We have just extracted section I (identification) and section III (Composition – Information on Ingredients), which clearly states that "There are no known health hazards from exposure to lamps that are intact." They also note in their report that the solder used in the circuit boards is not a lead-based solder, but rather an alloy of Antimony (Sb) and Tin (Sn).

[7] It is, of course, always possible for an unscrupulous company not to follow RoHS and use a banned bromine flame retardant or a solder that contains lead – but they could do the same for fluorescent lamps, just as well as well as for LED. Fundamentally, the difference between LED and fluorescent is simply the lack of mercury – otherwise, from an Annex II perspective, there is no difference between them.

[8] https://www.assets.signify.com/is/content/PhilipsLighting/fp929001377002-gis-global

SAFETY DATA SHEET
LED Lamps & Replacements

LEDVANCE

SYLVANIA brand LED lamps, manufactured by LEDVANCE, LLC, are exempted from the requirements of the OSHA Hazard Communication Standard (29 CFR 1910.1200) because they are "articles." The following information is provided by LEDVANCE, LLC as a courtesy to its customers.

I. IDENTIFICATION

Trade Name (as labeled): **SYLVANIA LED**

This data sheet covers all LED lamp types, base types and wattages.

Manufacturer: LEDVANCE, LLC
200 Ballardvale Street
Wilmington, MA 01887
978-570-3000

Emergency Contact: EH&S Specialist 978-570-3000

III. COMPOSITION – INFORMATION ON INGREDIENTS

THERE ARE NO KNOWN HEALTH HAZARDS FROM EXPOSURE TO LAMPS THAT ARE INTACT.

LEDVANCE LED lamps are lighting equipment with standardised sockets and bases so that they can replace less efficient lamps without changing the fixture ("retrofit"). These lamps are available in many different designs such as reflector, classic, pin-based or tubular shaped lamps.

Composition:

Glass/Plastic/Metal Enclosure:
LED lamps are available in various bulb types and shapes that may be constructed of glass, plastic or aluminum or a combination of these materials. The glass enclosure used in some of the LED lamps is manufactured from soda-lime glass and is essentially similar but not identical to that used throughout the glass industry for incandescent lamps, bottles and other common consumer items. Some of the glass enclosures may contain a thin coating of clay and silca inside the surface of the glass.

Base:
All lamps are fitted with a metal base or pins for installation in appropriate lighting fixtures. Bases are generally constructed with aluminum, nickel-plated tin, nickel-plated brass, plastic or a combination of these. None of these materials would present a hazard in the event of breakage of the lamp, aside from the obvious ones due to broken glass.

Light Emitting Diode Package:
LED lamps contain solid-state light emitting diodes (LEDs) as the light-generating source. The LED's composition consists of metals, phosphor, plastics and InGaN (Indium Gallium Nitride) semiconductor chip. Due to their insolubility and inertness, these materials do not present a significant hazard.

Electronic Driver:
LED lamps also contain circuitry to energize the LEDs. The electronic LED driver is built into the lamp housing. The driver consists of parts that are essentially similar, but not identical, to those used throughout the electronics industry for other common consumer electronic equipment. The plastic housing is typically made of PBT (Polybutylene-terephthalate) and is not considered hazardous.

Figure 5. Screen Capture of LEDvance's Safety Data Sheet (SDS) filing in the USA

2.2 (ii) Reliability of Substitutes

The second criterion – (ii) relates to whether the reliability of the substitute LED products is ensured or not. In other words, the Directive doesn't want a situation where the alternative product being installed is less reliable than the fluorescent lamp that it is replacing.

There are tens of thousands of LED retrofit lamps that are available on the market today, some are of better quality than others, but these products do offer some information relating to the

reliability of the products. There are two good proxy indicators that are available in the market to verify whether this criterion has been met:

1) Manufacturer declared lifetime (usually in hours) of the lamps
2) Warranty period offered with the LED replacement lamps

Manufacturers declare the lifetime of products in hours, and base this declaration on the expected service life of a product. The typical lifetime of a linear fluorescent lamp (including both T5 and T8) is around 15,000 to 24,000 hours – which corresponds to 2.3 to 2.8 years of service, if the lamp is operated 24 hours per day. The typical lifetime of an LED retrofit lamp is 30,000 to 70,000 hours – 3.4 to 8.0 years of service at 24 hours per day. Detailed examples of these lamps are given in Section 3 of this report.

Warranty periods vary across the industry. Standard fluorescent tubes have a warranty period up to 2 years, but for LED replacements, the typical warranty period for LED fluorescent tubes is more than twice as long: 5 years. This longer warranty period is due to the expected service life of the lamps, specifically the reliability of the substitutes.

Thus, the reliability of LED retrofit lamps is actually better than the fluorescent lamps they are replacing. The LED lamp typically has a service life that is 2-3 times longer than the service life of the fluorescent lamp would replace.

2.3 (iii) Environment, Health and Safety

The third criterion – (iii) relates to whether the total negative environmental, health and consumer safety impacts caused by substitution are likely to outweigh the total environmental, health and consumer safety benefits thereof. In other words, are the impacts of the LED substitute products likely to create problems in the area of environment, health or consumer safety? Let's discuss each of these individually.

2.3.1 Environment

Fluorescent lamps contain 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.[9] 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.

In addition to eliminating the mercury, LED replacement lamps also offer an environmental benefit in the form of a reduction in greenhouse gas emissions due to their higher energy-efficiency. These energy savings translate into further reductions in the release of mercury by avoiding emissions from coal-fired power plants in Europe which release mercury trapped in the coal they burn. We calculated that if the RoHS exemptions for CFLni, T5 and T8 lamp types were to all end in 2021, then mercury reductions would be 2574 kilograms from the lamps and

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

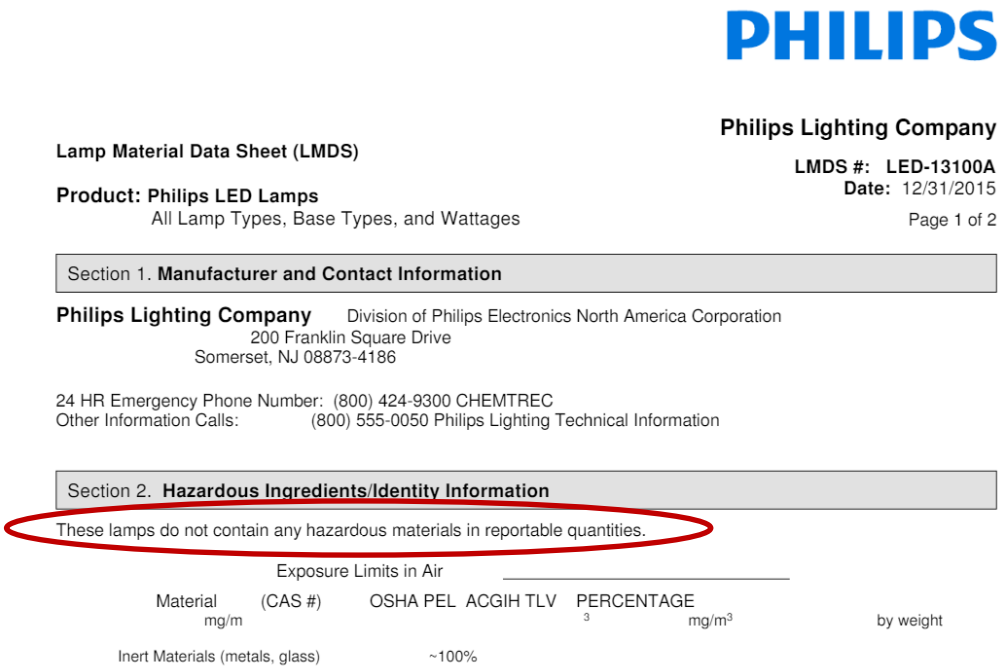
2213 kilograms of mercury emissions avoided at the power station from the electricity savings[10]. In total then, the avoided mercury emissions associated with lamp disposal and avoided electricity consumption would be 4787 kg. In addition, due to the lower consumption of power from the more energy-efficient LED replacements for fluorescent lamps, an additional environmental benefit of 40.9 million metric tonnes of carbon dioxide is avoided. These benefits are presented in Table 5 below.

Table 5. Environmental Benefits from Phase-Out of T8, T5 and CFLni Lamps in September 2021

Savings	Cumulative (2015-2030) Savings for:			
	T8	T5	CFLni	Sum
CO_2 Savings (*million metric tonnes*)	18.9	17.8	4.2	**40.9 MMT**
Mercury savings lamps (kg Hg)	808.5	1173	592.5	**4787 kg**
Mercury savings at powerplant (kg Hg)	1024	963.2	225.6	

2.3.2 Health

LED retrofit lamps do not contain any mercury; thus, they are better for human health than fluorescent lamps by the simple fact that they remove mercury from the living space, and the ever present risk of breakage. Figure 6 below, a material data sheet filing in the United States for Philips Lighting for their LED lamps – including all lamp types, base types and wattages – clearly states "[t]hese lamps do not contain any hazardous materials in reportable quantities."



PHILIPS

Philips Lighting Company

Lamp Material Data Sheet (LMDS)

LMDS #: LED-13100A
Date: 12/31/2015

Product: Philips LED Lamps
All Lamp Types, Base Types, and Wattages

Page 1 of 2

Section 1. **Manufacturer and Contact Information**

Philips Lighting Company Division of Philips Electronics North America Corporation
200 Franklin Square Drive
Somerset, NJ 08873-4186

24 HR Emergency Phone Number: (800) 424-9300 CHEMTREC
Other Information Calls: (800) 555-0050 Philips Lighting Technical Information

Section 2. **Hazardous Ingredients/Identity Information**

These lamps do not contain any hazardous materials in reportable quantities.

Material	(CAS #)	Exposure Limits in Air OSHA PEL	ACGIH TLV	PERCENTAGE
		mg/m^3	mg/m^3	by weight
Inert Materials (metals, glass)				~100%

Figure 6. Screen Capture of Philips' Lamp Material Data Sheet (LMDS) in the USA

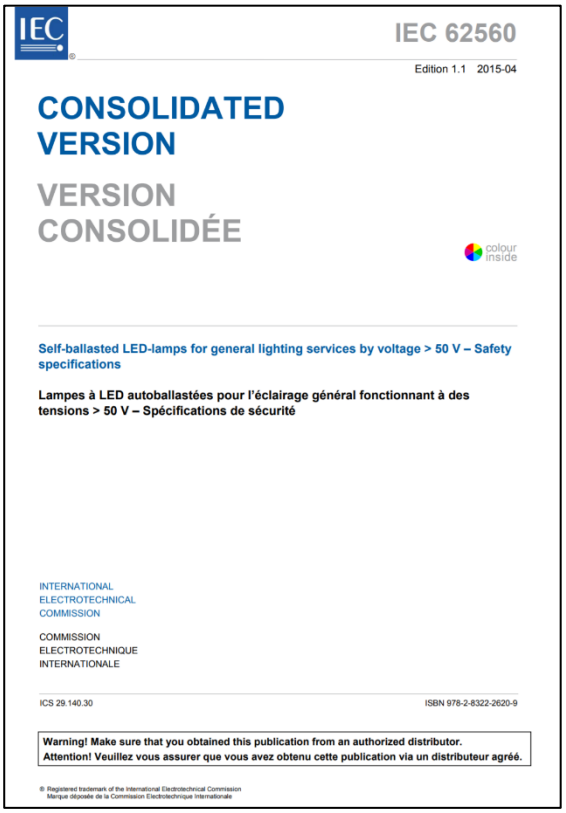
[10] According to the Commission's Joint Research Centre, mercury is released into the air when coal is burned at the power station. The JRC estimates that with the current generation mix of 31% of EU power derived from coal, each kilowatt-hour releases 0.016 mg of mercury into the air. Electricity savings from LED lamps will therefore reduce power station mercury emissions when compared with less efficient fluorescent lamps.

Thus, there are no hazardous substances in LED lighting, and thus there is no increase in health hazard associated with LED lighting.

2.3.3 Safety

Industry has worked hard to help ensure that LED retrofit lamps are safe to install and do not pose any safety concerns while in use. LED retrofit lamps have safety standards which they must comply with, like any electrical product placed on the market. These safety standards have been in place for years and have been updated by the standardisation community as the technology has progressed. As an example, the following is an IEC safety standard for certain LED retrofit lamps:

IEC 62560:2011+AMD1:2015 CSV: Self-ballasted LED-lamps for general lighting services by voltage >50 V - Safety specifications Specifies the safety and interchangeability requirements, test methods and conditions required for integrally ballasted LED-lamps


IEC 62560

Edition 1.1 2015-04

CONSOLIDATED VERSION

VERSION CONSOLIDÉE

colour inside

Self-ballasted LED-lamps for general lighting services by voltage > 50 V – Safety specifications

Lampes à LED autoballastées pour l'éclairage général fonctionnant à des tensions > 50 V – Spécifications de sécurité

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 29.140.30

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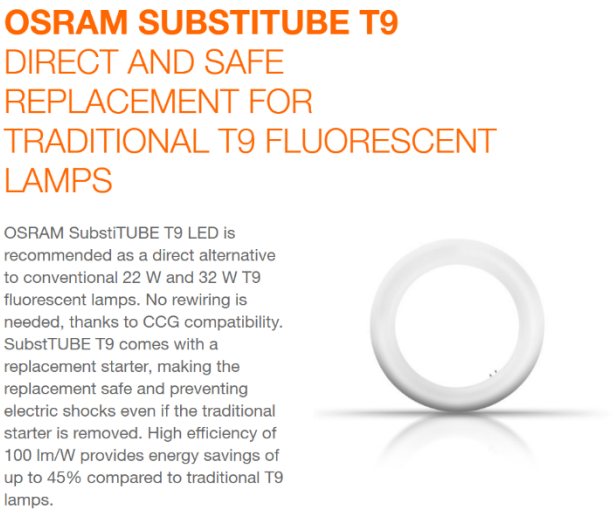
In this standard, safety requirements are set-out for all products that fall within the scope of this regulation:

- General requirements, test conditions and marking
- Interchangeability – cap, bending moment and mass of lamp
- Protection against accidental contact with live parts
- Insulation resistance and electric strength after humidity treatment
- Mechanical strength – axial strength
- Cap temperature rise
- Resistance to heat, and resistance to flame and ignition
- Fault conditions
- Creepage distances and clearances
- Abnormal operation
- Test conditions for dimmable lamps
- Photobiological safety
- Ingress protection
- Information for luminaire design

And the manufacturer's literature and websites confirm that there are no safety hazards, as indicated by this OSRAM product[11], which notes that no rewiring is needed and that the LED lamp is supplied with a replacement starter so the replacement is safe and there is no risk of electrical shock.

For all these reasons, there do not appear to be any safety concerns associated with LED replacement lamps.



2.4 (iv) Availability of Substitutes

This fourth criterion relates to the availability of substitutes for linear fluorescent lamps. This term – availability – can take on two interpretations. One relates to whether there are LED product types available on the market to fit into the existing luminaires; and the other relates to whether the LED industry is prepared to ramp-up its production to meet the volume of demand created from the phase-out. This section addresses both issues.

2.4.1 Model Availability

There are literally 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[12] 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[13] 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."[14] 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."[15]

In the main body of this report, we address the specifics relating to base type and lamp length; however in this overview section we will address two important cross-cutting issues that apply to all LED lamps, namely correlated colour temperature (CCT) and colour rendering index (CRI).

[11] https://www.ledvance.com/professional/products/product-stories/led-tubes-online-special/osram-substitube-t9/index.jsp
[12] https://www.lighting.philips.com/main/support/support/tools/ledtube-selectortool
[13] https://www.ledvance.com/professional/products/product-stories/led-tubes-online-special/index.jsp
[14] https://assets2.sylvania.com/media/bin/asset-1377974/asset-1377974
[15] https://tungsram.com/en/products/led-retrofit/led-tubes

A question was raised by LightingEurope about the range of available CCT and CRI for LED lamps, and whether they are able to provide equivalent light service compared to the range offered by linear fluorescent lamps. The tables below present our findings for these questions, which we developed by using the on-line search catalogues for these lamps.

Colour Rendering Index - A specific concern was raised by LightingEurope as to the availability of T8 lamps which have a very high CRI. We searched online for these and found a range of products that match the highest CRI of fluorescent lamps. The fluorescent and LED alternatives are presented in the table below. Hyperlinks are provided for verification purposes.

Table 6. Comparison of Very High CRI Values – Best Fluorescent Tubes and Best LED Tubes

Technology	Manufacturer	# Models	CRI Value	Link
Fluorescent	Philips/Signify Master TL-D Super 80	59 products	78 to 85	Link
	Philips/Signify Master TL-D 90 Graphica	3 products	95 to 98	Link
	Osram/LEDvance LUMILUX T8	33 products	77 to 90	Link
	Osram/LEDvance Lumilux De Luxe T8	10 products	≥ 90	Link
LED	Philips/Signify Master LEDtube EM/Mains T8	77 products	80 to 83	Link
	General Electric – Refit Solutions High CRI with reveal TriGain Tech.	9 products	90+	Link
	YujiLights High CRI Lamps (95+ BC series; 98 VTC series)	5 products	95-98 CRI	Link
	Waveform Lighting (T5 and T8)	15 products	≥ 95	Link

From these models already available on the market, LED retrofit lamps that match all the same CRI values that are achieved by fluorescent tubes. The CRI value of the LED tubes is just a function of the LEDs that are selected by the product designer, choosing LEDs or a combination of LEDs that have a high CRI or a very high CRI.

Thus, we conclude that there is no technical issue from a product availability perspective for LED lamps being made with very high CRI values – it is simply a matter of market demand.

Correlated Colour Temperature – the CCT is a measure of the color 'shade' of white light emitted by a lamp, relating to the color of light emitted by an ideal blackbody radiator when heated to a particular temperature, measured in Kelvin. Spectrally, 'warm' shades contain more yellowish/red light content and are at lower Kelvin (2700 -3500K), while 'cool' shades contain more blue (greater than 5000K) to create their overall white 'color' appearance.

Figure 7 depicts the range of color temperatures which are experienced as the light source moves along the Planckian black body radiator curve. In the x,y chromaticity plot, when following the Planckian black body radiator in the direction of the yellow arrow, the white-light appearance will change from warm to cool white. This variation is then shown in the

figure below, with the light sources illuminating numbers that correspond to the approximate color temperature they represent.

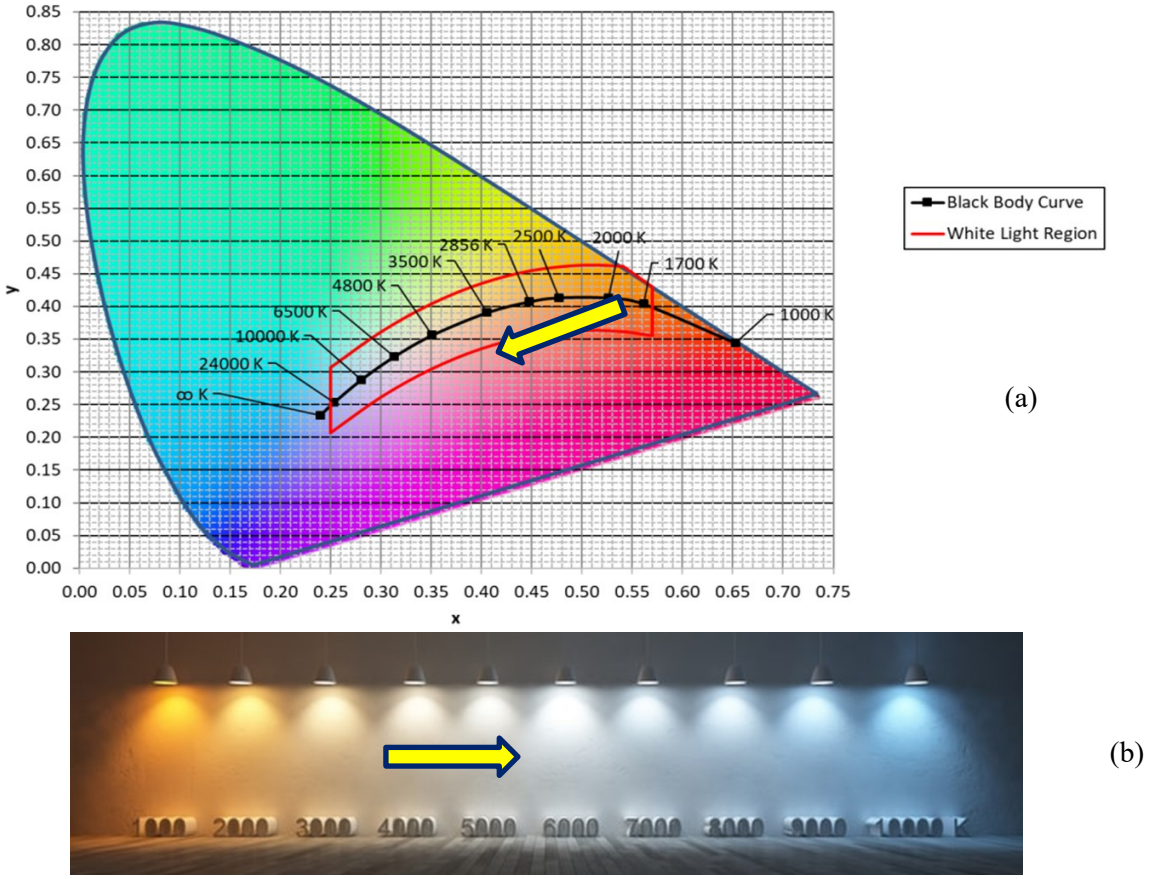


Figure 7. Movement along the curve in (a) results in changes in the CCT of white light in (b)

The CIE defines Correlated Color Temperature as follows:

> *CIE eILV 17-258 correlated color temperature [Tcp] ; temperature of the Planckian radiator having the chromaticity nearest the chromaticity associated with the given spectral distribution on a diagram where the (CIE 1931 standard observer based) u', ⅔v' coordinates of the Planckian locus and the test stimulus are depicted; Unit: K*

Thus, the CCT describes the color appearance of a white light source with respect to the closest matched Planckian radiator. As with colour rendering index, there is no technical barrier to LED lamps producing all of the same CCT values as those of fluorescent lamps – it is simply a product design decision that is made when selecting the LEDs for the lamp. Indeed, we find that already on the market today, we have a full range of CCT values for the linear lamps – please see the table below. Philips and Osram make the most popular CCT values for linear LED lamps – 2700K to 6500K; and other companies are offering 10000K and 20000K CCT. The resultant light output from the LED lamps is simply a function of the choice of LED chips used in the product, thus on a practical level, any CCT is achievable.

Table 7. Comparison of CCT Ranges for Fluorescent and LED Tubes

Technology	Manufacturer	# Models	CCT Value	Link
Fluorescent	Philips/Signify T8 lamps	37 products	2700 to 12000K	Link
	Philips/Signify T5 lamps	20 products	2700 to 12000K	Link
LED	Philips/Signify T8 LED lamps	150 products	2700 to 6500K	Link
	MIC Light the World, T5 LED	User specified	10000K	Link
	Laidishine, T8 LED	User specified	20000K	Link
	OSRAM/LEDvance, T8	85 products	3000 to 6500K	Link
	OSRAM/LEDvance, T5	21 products	3000 to 6500K	Link

In addition, there are companies in China which advertise on Alibaba who will make a customized LED lamp of any length, base type, wattage, CRI and CCT. Here are two examples of these companies, which also offer customized logo, customized packaging and give lead times for delivery which can be as short as a month or less.

Shenzhen Wiscoon Technology Corporation
101 – 200 Employees
Certified by TUV SUD for LED Tube manufacturing, also ISO 9001
Specialising in T5 and T8 linear LED tubes
Rated lifetime of 50,000 hours
Click on this link to view the company and their offering

GAOPIN, Guangdong, China
51-100 Employees
Offers a wide range of CCT, from 2700K to 20,000K
Lengths from 300cm to 2400cm
10 Production Lines, ISO 9001 certified; CE mark
Rated lifetime of 50,000 hours
Click on this link to view the company and their offering

2.4.2 Volume Availability

The world's supply of T5 and T8 linear lamps is controlled by 3 to 4 companies, namely Philips/Signify, Osram/LEDvance, Sylvania and General Electric. The manufacturing of tubular lamps requires heavy duty machinery and a glass furnace, which are capital intensive resources – and which forms one of more barriers to entry for newcomers to the conventional TL market. LED retrofit products are made up of electronics + plastic cap parts + a tube made either of plastic or of glass. Establishing and upscaling of the manufacturing of electronics and plastic parts requires little or no tooling and raw materials for manufacturing these lamps are abundantly available. Thus, for mechanical and driver electronics parts supply would be no issue at all.

To the extent glass tubes are used, the existing plant and machinery for manufacturing of glass tubes for conventional tubular lamps would be ideal (also avoiding glass manufacturers having

to lay off workforce). In fact, existing European tubular lamp manufacturers might be said to have an advantage here as they should have the abovementioned glass tube manufacturing available (unless they may already have already shifted to Chinese glass suppliers).

Manufacturing of opto electronics / LED chips for illumination has seen a development of extremely rapid growth manufacturing capacity followed by a very drastic reduction in price over the last decade. LED chips are used in light bulbs, computer screens, televisions, mobile phones, etc. LED production capacity has increased dramatically over the last decade, most notably in China, over the same period of time. Prices indicate overcapacity: mass volume prices for LED's used in retrofit lamps was typically around 4 Euro cents per LED in 2015, it is now around 0,7 Euro cents per LED, a factor of 5 lower in only 5 years. Thus, there is a clear overcapacity in the market, and we do not see any problem with the supply of commodity LED's to prepare for increased demand.

It may be worth noting that non-directional lamps are quietly transitioning from incandescent/halogen/CFLi to LED retrofit lamps around the world, even in countries without regulations mandating the phase-out of the less efficient light sources. This transition, relating to annual sales of literally billions of LED lamps, has happened without any reported supply issues.

Finally, two mitigating factors should be considered in relation to the availability of LED retrofit lamps: (1) stockpiling and (2) longer lifetime. First, on stockpiling, the phase out of incandescent and halogen lamps showed that a significant fraction of the market continued to legally purchase legacy lamps for a year or two after the phase-out date from suppliers that built up inventories prior to the transition phase. This practice softens whatever friction between supply and demand exists. If a T-LED replacement need if a ban on T8 / T5 becomes effective as of 1st September 2121. Second, on lifetime, the lifetime of LED retrofit lamps is 2-3 times longer than fluorescent lamps, thus the unit sales will be lower as those LED Lamps installed in sockets across Europe will last longer and won't need to be replaced as frequently as the fluorescent lamps were. The longer lifetime of LED lamps therefore reduces the unit demand experienced in the market, making the supply easier to achieve.

A report by Navigant Research finds that there will be a 7.6% annual growth rate in Tubular LED lamps from 2018 to 2027. A news item about this report is reproduced below[16]:

> *A new report from Navigant Research examines the commercial market for TLEDs, providing global market forecasts for shipments and revenue, segmented by offering type, building type, and region, through 2027. According its research, Navigant forecasts a 7.6% compound annual growth rate for global TLED shipments from 2018 to 2027.*
>
> *Navigant found that the TLED market is experiencing substantial growth thanks to declining prices, a desire to decrease energy consumption, and building codes and standards that require more efficient lighting solutions.*
>
> *"Price declines and utility incentives have made the initial cost of TLEDs more comparable to that of fluorescent tubes while the above-mentioned benefits have helped justify the higher price point," says Krystal Maxwell, senior research*

[16] https://www.ecmweb.com/lighting-control/article/20904067/global-tubular-leds-to-grow-above-7-annually-through-2027

analyst at Navigant Research, in a release. "They provide a more attractive upfront cost than LED luminaires, as well as increased flexibility and ease of installation, which is helping to drive the TLED market."

According to the report, the form factor of a fluorescent tube provides familiarity to building owners, managers, and tenants and provides a more efficient plug-and-play alternative, depending on the type of lamp. TLEDs also provide quicker retrofit solutions than a retrofit kit or LED luminaire, which incorporates the retrofit of the fixture with a new fixture and integrated light source.

For all the above reasons, we conclude that there will not be any volume availability problems associated with the phase-out of CFLni, T5 and T8 lamps on 1 September 2021.

2.5 (v) Socioeconomic Impact

This fifth criterion relates to whether there are positive socioeconomic impacts associated with mercury-free LED replacements for fluorescent lamps. And indeed, the answer to that is a resounding 'yes'. The phase-out of linear fluorescent lamps is cost-effective today, in many cases with a payback period shorter than one year.

The following screen capture from the OSRAM/LEDVANCE website[17] points to the fact that payback periods can be as short as four months. This is due to the lower sales prices for LED retrofit lamps, the long operating hours for these installations and the fact that direct-replacement LED retrofit tubes are now more than twice as efficient as some mercury-containing fluorescent lamps.

Figure 8. OSRAM/LEDvance Literature Highlighting Benefits of LED Tubular Retrofit Lamps

[17] https://www.ledvance.com/professional/products/product-stories/led-tubes-online-special/index.jsp

We understand that the Commission is working with the Oko Institute to update their socioeconomic analysis based on the new, much higher retrofit potential for LED products than had previously been used, however we still find merit in presenting our findings from this same analysis as this is one of the critical criteria in Article 5(1)(a).

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.

VHK, the consultants who prepared the one-lighting regulation review study and impact assessment for the European Commission conducted runs of the MELISA market model 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:

- 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
- 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
- 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

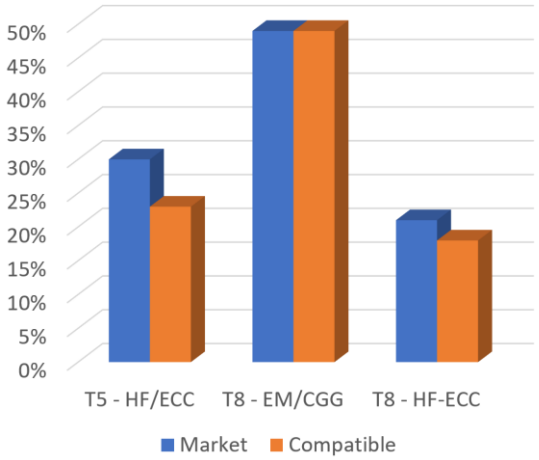
Taken together, phasing out these three lamp types offer significant socioeconomic benefit. If the RoHS exemptions for CFLni, T5 and T8 lamps were limited to 1 September 2021, this would move both of those markets to LED earlier than in the business as usual case, accruing the following benefits across Europe:

Table 8. Net Economic Benefits from Phase-Out of T8, T5 and CFLni Lamps in September 2021

Savings	Cumulative (2015-2030) Savings for:			
	T8	T5	CFLni	Sum
Electricity Savings (*TWh*)	64.0	60.2	14.1	**138.3 TWh**
Energy Bill Savings (*€ billion*)	€5.0	€4.7	€2.8	**€12.5 billion**

Our estimate presented in Table 5 considers a 100% retrofit scenario, and thus may be criticised by some as unrealistic. However, we would point out that our findings are not far from the actual savings in the market today because models available in 2019/2020 are already able to be installed into 90% of existing T5/T8 fluorescent fixtures across Europe. In other words, these luminaires do not need to be changed – simply the lamps will be changed in 90 percent of the cases and the user will experience benefits from day one. And we expect

that percentage to increase over the coming year, particularly if the RoHS exemptions for fluorescent lamps are set to expire. The figure below shows the high rate of compatibility for LED lamps in existing fluorescent fixtures.



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
Philips MASTER LEDtube HF InstantFit HE T5 (9)	60/79 = 76%
Osram Substitube T5 Universal (12)	178/235 = 76%
Sylvania TOLEDO SUPERIA T5 ECG (15)	85/85 = 100%**
Philips MASTER LEDtube EM/Mains T8 (30)	100% (no compatibility issues)
Osram Substitube T8 EM (44)	
Sylvania TOLEDO SUPERIA T8 CCG AND AC (42)	
Philips MASTER LEDtube HF InstantFit T8 (16)	159/197 = 81%
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%
	Overall market compatibility, T5 and T8 LED retrofit tubes:

Figure 9. Illustration of the level of compatibility of LED Tubular Retrofit Lamps

A similarly high level of retrofittable compatibility is available for CFLni lamps, as shown in the figure below. In this diagram, LightingEurope had identified 19 base types but said that only six of them existed in the market. We conducted additional market research and found that 16 of the 19 base types (84%) are already available on the market, including seven new ones made by LightingEurope members that were introduced in the last few months.

There is no technical barrier to producing all CFLni base types, it is just a question of demand. Manufactures have invested and produced these LED retrofit solutions for the higher volume CFLni lamps first because the RoHS exemptions have remained in place, and the LED products have to compete with the incumbent (mercury-containing) fluorescent lamps. Now, if the RoHS exemptions are phased out, the remaining few base types will be produced, as that additional market will now be captured by LED.

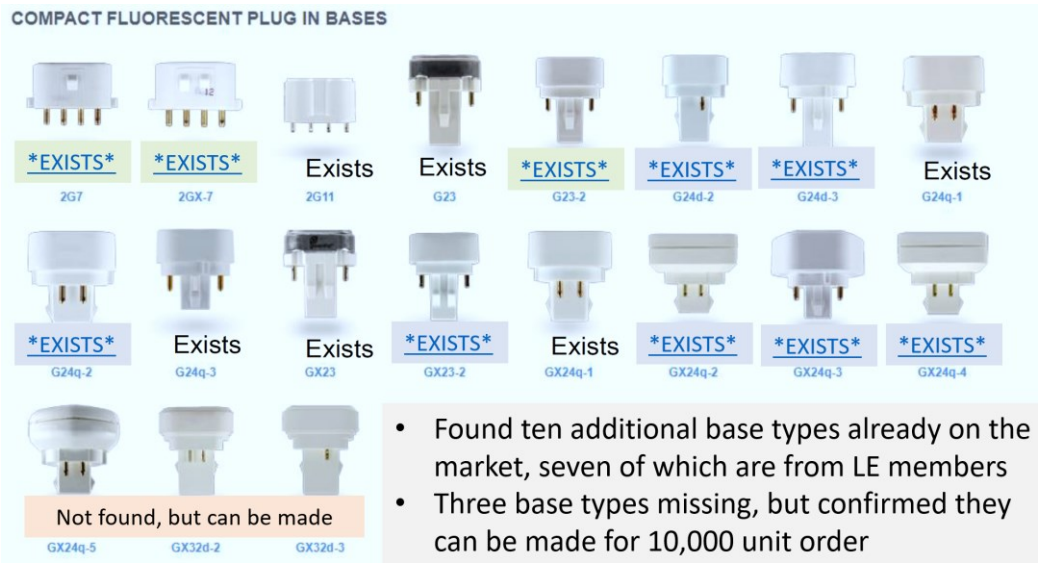


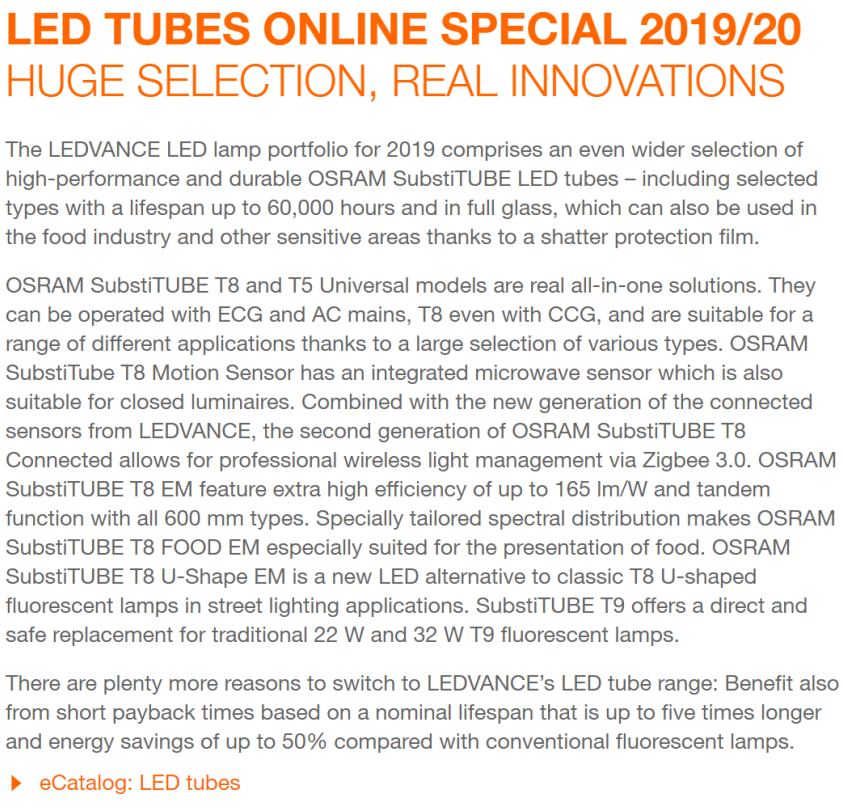
Figure 10. Illustration of the variety of CFLni base types and compatible LED Retrofit Lamps

Thus, overall due to the very high rate of compatibility / ability to directly install LED lamps into existing fluorescent luminaires, we conclude that there are significant socioeconomic benefits that would be realised in Europe if the RoHS exemptions for fluorescent lamps were to be ended in September 2021.

2.6 (vi) Impact on Innovation

There is an on-going effort in the industry to create alternative products to fluorescent lamps. This is not necessarily driven by a desire to remove mercury from the market, but instead because the value proposition of LED technology is greater than fluorescent lamps. LED retrofit lamps tend to last 2-3 times longer, cut power consumption in half, are more easily dimmed, and offer all the same (or in some cases better) light output than fluorescent.

The evidence of these investments can be found on the websites of the companies, who are advertising 'direct drop-in replacements' that operate in the existing fluorescent luminaires without rewiring.



LED TUBES ONLINE SPECIAL 2019/20

HUGE SELECTION, REAL INNOVATIONS

The LEDVANCE LED lamp portfolio for 2019 comprises an even wider selection of high-performance and durable OSRAM SubstiTUBE LED tubes – including selected types with a lifespan up to 60,000 hours and in full glass, which can also be used in the food industry and other sensitive areas thanks to a shatter protection film.

OSRAM SubstiTUBE T8 and T5 Universal models are real all-in-one solutions. They can be operated with ECG and AC mains, T8 even with CCG, and are suitable for a range of different applications thanks to a large selection of various types. OSRAM SubstiTube T8 Motion Sensor has an integrated microwave sensor which is also suitable for closed luminaires. Combined with the new generation of the connected sensors from LEDVANCE, the second generation of OSRAM SubstiTUBE T8 Connected allows for professional wireless light management via Zigbee 3.0. OSRAM SubstiTUBE T8 EM feature extra high efficiency of up to 165 lm/W and tandem function with all 600 mm types. Specially tailored spectral distribution makes OSRAM SubstiTUBE T8 FOOD EM especially suited for the presentation of food. OSRAM SubstiTUBE T8 U-Shape EM is a new LED alternative to classic T8 U-shaped fluorescent lamps in street lighting applications. SubstiTUBE T9 offers a direct and safe replacement for traditional 22 W and 32 W T9 fluorescent lamps.

There are plenty more reasons to switch to LEDVANCE's LED tube range: Benefit also from short payback times based on a nominal lifespan that is up to five times longer and energy savings of up to 50% compared with conventional fluorescent lamps.

▸ eCatalog: LED tubes

Lighting manufacturers around the world have worked hard to develop "plug and play" solutions which enable rapid and easy retrofit of LED lighting into existing linear fluorescent lamps. These alternative products are mercury free and offer easy installation, thereby improving lighting performance, removing mercury, and avoiding energy and CO_2 emissions. Extending the exemptions for fluorescent lamps delays the take-up of new, mercury-free LED lamps by some share of the market, which reduces investment in LED and growth in this new lighting sector.

3 Assessment of Specific Exemptions

3.1 Single capped (compact) fluorescent lamps, III.1(a-g)

This category covers single ended fluorescent lamps which both have an integral ballast (i.e., operates on mains voltage and has an internal ballast) and those that do not have an internal ballast (e.g., pin-based, not integrally ballasted) lamps. The integrally ballasted lamps are abbreviated as "CFLi" and the lamps that are not integrally ballasted are called "CFLni". Since CFLi lamps have been phased-out by the recent Ecodesign regulation[18], this section will focus on the CFLni lamps, examples of which are shown below.

Figure 11. Examples of CFLni Lamps Exempted from RoHS in III.1(a-g)

The following table provides a summary of our findings against the six criteria outlined in Chapter 2 of this report.

Table 9. Summary Table of findings for Single capped (compact) fluorescent lamps, III.1(a-g)

Article 5(1)(a) Criteria	Summary of Finding Discussed below
(i) Annex II Materials or Substances	LED replacements for CFLni lamps are compliant with RoHS and do not contain any Annex II materials or substances.
(ii) Reliability of Substitutes	The LED replacements for single-capped fluorescent lamps are reliable; the LED lamps have rated lifetimes that are between 2.7 and 5.0 times longer than the fluorescent lamps they are replacing.
(iii) Environment, Health and Safety	The LED replacements for CFLni reduce the environmental impact both in terms of CO_2 emissions and mercury released to the environment; they do not present any health hazards and they are designed to comply with the product safety standards and therefore do not introduce any safety concerns.

[18] 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

Article 5(1)(a) Criteria	Summary of Finding Discussed below
(iv) Availability of Substitutes	Yes, there is a vast range and variety of LED replacements for CFLni fluorescent lamps, spanning a wide range of CCT, CRI, wattages, light output and so-on. There are over 880 different models of LED replacements in the US market, which has been found to be similar to the EU market based on sampling. In terms of base types, over 85% of the sockets can be met with an LED replacement.
(v) Socioeconomic Impact	Yes, there is a strong socioeconomic benefit from the installation of LED replacements for CFLni fluorescent lamps, with payback periods from 1.3 to 3.0 years and net cumulative savings through 2030 of €2.8 billion Euro.
(vi) Impact on Innovation	As noted in section 2.6 of this report, continuing to extend the exemption of CFLni lamps from the RoHS Directive is negatively impacting innovation by keeping the legacy technologies on the market and preventing return on investment in the mercury-free alternative LED products.

3.1.1 (i) Annex II Materials or Substances – CFLni, III.1(a-g)

LED replacements for CFLni lamps are compliant with RoHS and do not contain any Annex II materials or substances.

As discussed in section 2.1, LED retrofits for CFLni lamps do not contain any RoHS Annex II Materials or Substances – they do not contain lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB), polybrominated diphenyl ethers (PBDE) and the four classified phthalates (DEHP, BBP, DBP and DIBP). The LED retrofit products on the market today are declared as RoHS compliant means they are RoHS compliant, so any product that carries this label will use flame retardants that are not banned by Annex II. As noted previously, CFLi integrated drivers are no different on a materials basis than LED drivers, and the same is true for fluorescent electronic ballasts compared with LED drivers. The only difference between the two technologies is that there is mercury in the fluorescent tube and none in the LED lamp.

The screen captures below present the RoHS compliant declarations for different types of CFLni lamps from two large LightingEurope members who both have large portfolios of CFLni products.

PHILIPS
Lighting

CorePro LED PLL

CorePro LED PLL HF 16.5W 865 4P 2G11

Philips CorePro LED PLL is the ideal uplamping solution for downlights & luminaires in a wide range of general lighting applications. It integrates a LED light source into a traditional fluorescent form factor to offer superb energy savings over a lifetime that's twice as long as fluorescent alternatives.

Product data

General Information	
Cap-Base	2G11 [2G11]
EU RoHS compliant	Yes
Nominal Lifetime (Nom)	30000 h
Switching Cycle	50000X

Temperature	
T-Ambient (Max)	45 °C
T-Ambient (Min)	-20 °C
T-Storage (Max)	60 °C
T-Storage (Min)	-40 °C

PRODUCT DATASHEET
ST9-EM 22 123° 12 W/4000K G10q

SubstiTUBE T9 EM | Circular LED tube for electromagnetic control gear and AC mains

AREAS OF APPLICATION

- General illumination within ambient temperatures from −20...+45 °C
- Corridors, stairways, parking garages
- Domestic applications
- Decorative applications

PRODUCT FEATURES

- LED alternative to classic T9 fluorescent lamps in CCG luminaires
- Uniform illumination
- Lifetime: up to 30,000 h
- Mercury-free and RoHS compliant
- Luminous efficacy: up to 100 lm/W

3.1.2 (ii) Reliability of Substitutes – CFLni, III.1(a-g)

The LED replacements for single-capped fluorescent lamps are reliable; the LED lamps have rated lifetimes that are between 2.7 and 5.0 times longer than the fluorescent lamps they are replacing.

It is very important that when an end-user makes a decision to switch lighting technologies that the new light source is viewed as reliable and durable in the lighting application it is replacing. LED light sources – which can be directly retrofitted into an existing luminaire – are more reliable than the fluorescent lamps that they replace. This fact is reflected in the rated lifetime and manufacturer's guarantees that are issued with the products.

The table below shows some examples of fluorescent and direct retrofit (no re-wiring necessary) LED alternatives for those lamps. The rated lifetimes of LED lamps are typically about three times longer than the fluorescent lamps they are replacing. Webpage links are provided as footnotes for verification purposes.

Table 10. Lifetime Comparison for Single capped (compact) fluorescent lamps, III.1(a-g)

Single Capped Fluorescent (CFLni)			LED Direct Retrofits (LED)		
	Philips bulb G10Q CIRCLINE 32w 4000K / 840[19]	9,000 hours		OSRAM/ LEDvance's Substitute T9; 20w 4000K G10q [20]	30,000 hours 3 Year guarantee
	Philips PL-C 10W 830 4P (MASTER) | Warm White - 4-Pin[21]	10,000 hours		Philips CorePro PL-C LED 4.5W 830 | Warm White - 4-Pin[22]	50,000 hours 5 year warranty
	GE 2D Watt-Miser 28W 827 4 pins HomeWhite[23]	15,000 hours		GE 2D Retrofit LED EM GR10q 12.5W 827 Frosted[24]	40,000 hours

The circline product is rated 9000 hours in fluorescent and the LED retrofit is 30,000 hours – which is 3.33 times longer life. The PL-C product is rated 10,000 hours in fluorescent and the LED retrofit is 50,000 hours – so 5 times longer life. And finally, the 2D shaped product is 15,000 hours in fluorescent or 40,000 hours in LED – 2.67 times longer life. Thus, it is safe to conclude that across the range of LED direct retrofits for fluorescent CFLni lamps, the lifetime

[19] Hyperlink to Philips Circline product at Amazon.de
[20] https://www.ledvance.com/professional/products/lamps/led-tubes/substitube-t9-em/index.jsp
[21] https://www.any-lamp.co.uk/philips-pl-c-10w-830-4p-master-warm-white-4-pin
[22] https://www.any-lamp.co.uk/philips-corepro-pl-c-led-4-5w-830-warm-white-4-pin-replaces-10w-13w
[23] https://www.any-lamp.co.uk/ge-2d-watt-miser-28w-827-4-pins-homewhite
[24] https://www.any-lamp.co.uk/ge-2d-retrofit-led-em-gr10q-12-5w-827-frosted-extra-warm-white-4-pin-replaces-28w

is considerably longer – between 2.7 and 5.0 times longer – and thus these are reliable substitutes.

3.1.3 (iii) Environmental, Health and Safety – CFLni, III.1(a-g)

The LED replacements for CFLni reduce the environmental impact both in terms of CO_2 emissions and mercury released to the environment; they do not present any health hazards and they are designed to comply with the product safety standards and therefore do not introduce any safety concerns.

As shown in Table 11, the environmental benefits for phasing out CFLni lamps in September 2021 are significant. Energy bill savings amount to 14.1 TWh of electricity on a cumulative basis if fluorescent CFLni lamps are phased out in September 2021. Using a constant level of carbon intensity (0.296 kg/kWh), the avoided CO_2 emissions would be 4.2 MT of CO_2 for a CFLni phase out in 2021.

The mercury emission reductions from phasing out CFLni fluorescent lamps are two-fold: emissions into the environment from broken and improperly disposed lamps is avoided, and by reducing electricity demand, mercury released to the environment from the burning of coal at European power stations is avoided. We calculate the sum of mercury from avoided lamp shipments and mercury emissions from avoided electricity production that result from retiring the exemption for CFLni fluorescent lamps in 2021, then 818.1 kg Hg is avoided by 2030:

Table 11. Environmental Benefit from Phase-Out of CFLni fluorescent lamps in Europe[25]

Benefits of CFLni phase-out in Sept 2021	Cumulative Savings (2020-2030)
Electricity Savings and Avoided CO2 Emissions	14.1 TWh (4.2 MT CO_2)
Mercury Savings – Lamps and Power Plant Emissions (*kg Hg*)	592.5 kg – lamps 225.6 kg – power plant 818.1 kg - TOTAL

As discussed in section 2.3.3, there are no safety concerns for LED replacements for CFLni lamps. This conclusion is drawn from the fact that LED products have been designed for installation into existing fluorescent luminaires, thus safety issues have been included from the beginning, as indicated in the Osram figure below – note the statement "SubstiTUBE T9 comes with a replacement starter, making the replacement safe and preventing electric shocks even if the traditional starter is removed". Furthermore, all LED products must comply with the requisite international safety standards, which protect for a range of consumer-related safety issues listed in section 2.3.3.

[25] "Personal communication and analysis conducted by VHK using the MELISA lighting market model (which was also used for the Impact Assessment for the Ecodesign one-lighting regulation) --as a one-time courtesy, on a strictly personal title and not assuming any liability for the data or its use-- to provide estimates of the savings potential of various scenarios. Communication on 26 October 2019."

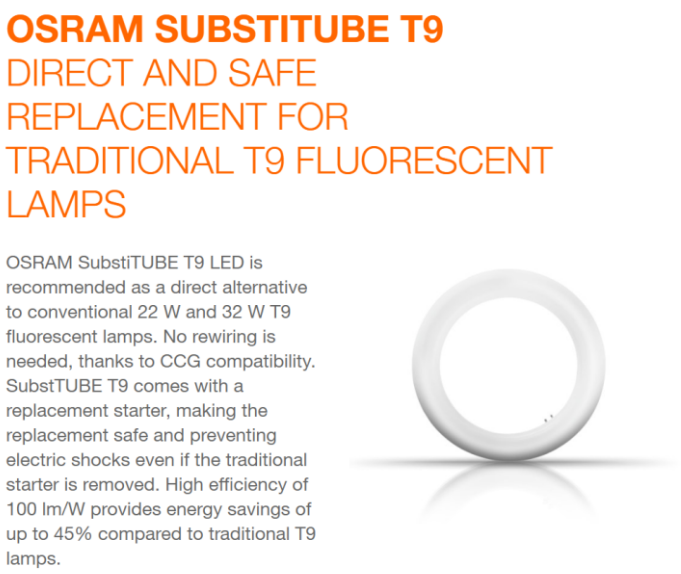


Figure 12. OSRAM advertisement advertising the safety aspect of their CFLni products

3.1.4 (iv) Availability of Substitutes – CFLni, III.1(a-g)

Yes, there is a vast range and variety of LED replacements for CFLni fluorescent lamps, spanning a wide range of CCT, CRI, wattages, light output and so-on. There are over 880 different models of LED replacements in the US market, which has been found to be similar to the EU market based on sampling. In terms of base types, over 85% of the sockets can be met with an LED replacement.

According to the Design Lights Consortium Quality Products List in the US, there are over 880 different models of pin-based compact fluorescent lamps (i.e., not integrally ballasted) CFLni products. [26] Although we don´t have access to a similar database for the EU, sampling on the EU market shows a similar range of products.

In Figure 13, GE/Tungsram highlights the wide range of pin-based LED retrofit products it offers, enabling the end-user to "replace inefficient CFL lighting without the need for tools or a costly upgrade."[27] On the same webpage, GE/Tungsram notes that its LED plug-in 2Pin range is designed with a universal base (G24d) to replace G24d-1, G24d-2, G24d-3 CFL plug-in base types, and that it "easily plugs into existing relevant CFL plug-in sockets." In this way, existing CFL pin-base luminaires can be used while the light source is upgraded to LED, avoiding mercury-containing products.

[26] The Design Lights Consortium (DLC) in the United States maintains a qualified products list database that represents a large percentage of the LED lamps and luminaires offered on the market in North America. For LED replacements for CFLni, on 24 February 2020 the DLC database contained 886 models. While it is recognised that the DLC database does not cover Europe, the European market is expected to have a similarly large sample of models for sale.
[27] https://tungsram.com/en/products/led-retrofit/led-plug-in

Figure 13. GE/Tungsram offers direct retrofit pin-based LED replacements for CFLs with a 4x longer life

LE presented additional evidence in their letter indicating that only 6 out of 19 lamp base types for non-integrally ballasted compact fluorescent lamps (CFLni) have LED retrofits. We checked this finding and were able to find 16 out of 19 base types available in the market today (85% of the base types listed in the LE comment). Please see the screen capture from the LE letter below, where LE have indicated that 2G11, G23, G24q-1, G24q-3, GX23 and GX24q-1 base types are available. SEA/CLASP's analysis found ten additional base types already on the market, over and above the six LightingEurope indicated exist in the market. Of those ten, seven of these base types were recently introduced to the market by LightingEurope members. The table below lists the base types and provides links to the examples we found online.

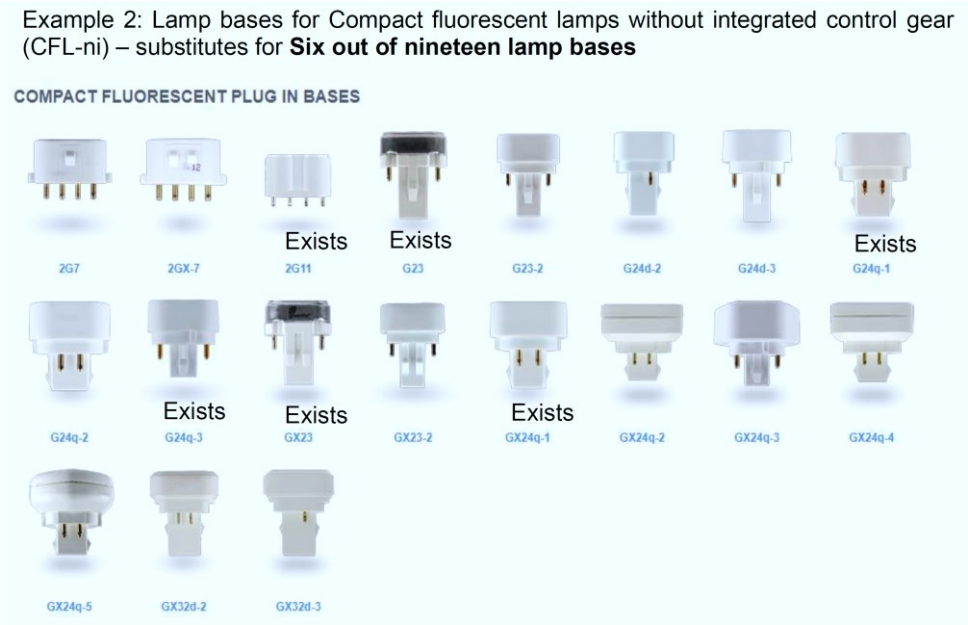


Figure 14. LightingEurope comment claiming only 6 of 19 CFLni base types exist

Table 12. SEA/CLASP research on lamp base types for pin-based compact fluorescent Lamps – 16 out of 19 base types exist

Base Type from LE Comment	Does this Base Type Exist in a Retrofit LED Lamp?	Links to Examples of LED Lamps
2G7	**Yes**	Link to example
2GX-7	**Yes**	Link to example
2G11	**Yes**	Link to example
G23	**Yes**	Link to example
G23-2	**Yes**	Link to example
G24d-2	**Yes**	Link to example
G24d-3	**Yes**	Link to example
G24q-1	**Yes**	Link to example
G24q-2	**Yes**	Link to example
G24q-3	**Yes**	Link to example
GX23	**Yes**	Link to example
GX23-2	**Yes**	Link to example
GX24q-1	**Yes**	Link to example
GX24q-2	**Yes**	Link to example
GX24q-3	**Yes**	Link to example
GX24q-4	**Yes**	Link to example
GX24q-5	**Not found***	
GX32d-2	**Not found***	

Base Type from LE Comment	Does this Base Type Exist in a Retrofit LED Lamp?	Links to Examples of LED Lamps
GX32d-3	**Not found***	

*For these base types, products could not be found at this time, however we did confirm that there is no technical impediment preventing LED retrofit lamps from being made with these base types, as opposed to any other. We contacted Green Electrical Supply https://www.greenelectricalsupply.com/ and consulted with their Sales Team to confirmed the technological feasibility of making LED replacements with any CFLni base type.

3.1.5 (v) Socioeconomic Impact – CFLni, III.1(a-g)

Yes, there is a strong socioeconomic benefit from the installation of LED replacements for CFLni fluorescent lamps, with payback periods from 1.3 to 3.0 years and net cumulative savings through 2030 of €2.8 billion Euro.

Starting from the standpoint of a single CFLni socket, the authors prepared a calculation of the payback period for a CFLni replacement, the payback periods vary with the LED installed but are all positive, allowing end-users to recover their investment. In this calculation, an OSRAM 2D GR10q 28W is compared with a General Electric LED 2D shaped lamp and a Kosnic LED planar retrofit with the same socket (GR10q). Both LED replacements last more than twice as long as the fluorescent lamp, and the payback periods vary from 1.3 to 3.0 years. The results are presented in Table 13 which shows replacement offering European businesses €63.25 with the GE product or €24.02 with the Kosnic retrofit lamp.

Table 13. Life-Cycle Cost Economic Analysis of CFLni Lamp Replacement in Europe

Europe			
	Lamp is on for hours/day:	10	hours/day
	Electricity price:	0.11	EUR/kWh
	Annual change in price of Electricity	4.0%	percent (MEErP)
	Electricity CO2 intensity:	0.296	kg CO2/kWh
	Discount Rate	4.0%	percent

Lamp type	CFLni - GR10q	LED EM-GR10q	GR10q 2D	
Lamp wattage:	28	12.5	18.0	Watts
Rated lamp lifetime:	13000	40000	30000	Hours
Price for one lamp (EUR):	4.08	12.56	16.60	EUR/lamp
Electricity consumption and savings calculations				
Annual electricity consumption for each lamp type:	102	46	66	kWh/year
Annual electricity savings compared to CFLni fluorescent lamp:	---	57	37	kWh/year
Percent electricity savings compared with CFLni fluorescent lamp:	---	55%	36%	percent
Electricity cost for operating the lamps each year:	11.74	5.24	7.55	EUR/year
Financial savings of electricity costs per year vs. fluorescent:		6.50	4.19	EUR/year
Life-Cycle Cost (LCC) of one lamp over analysis period shown				
LCC time period of analysis:	10.0	10.0	10.0	years
LCC of operating lamp for 10 years, discounted to 2019:	128.24	64.98	104.22	EUR (NPV, 2019)
LCC savings of more efficient lamp compared with a fluorescent CFLni:	---	63.25	24.02	EUR (NPV, 2019)
Percent LCC savings compared with a fluorescent CFLni lamps:	---	49%	19%	percent
Payback period and Internal Rate of Return calculations				
Simple Payback period in years, compared with CFLni fluorescent:	---	1.30	2.99	years
Simple Payback period in months, compared with CFLni fluorescent:	---	15.7	35.8	months
Internal Rate of Return (IRR), compared with CFLni fluorescent:	---	90%	38%	percent
CO2 emissions calculations				
CO2 emissions due to electricity for one lamp operating for 10 years:	302.3	135.0	194.3	kg CO2/10 yrs
CO2 savings compared with a CFLni fluorescent lamp:	---	167.3	108.0	kg CO2/10 yrs

VHK prepared an analysis using the MELISA European Lighting market model to estimate the energy and economic impact of a phase-out of CFLni fluorescent lamps. The savings from a CFLni phase-out in September 2021 are significant, saving 14.1 TWh of electricity on a cumulative basis and €2.8 billion Euro.

Table 14. Energy & Financial Savings from Phase-Out of CFLni Lamps in Europe[28]

Benefits of CFLni phase-out	Cumulative Savings (2020-2030)
Electricity Savings	14.1 TWh
Net Financial Savings (taking into account savings on the energy bill and slightly higher lamp costs)	€2.8 billion

3.1.6 (vi) Impact on Innovation – CFLni, III.1(a-g)

As noted in section 2.6 of this report, continuing to extend the exemption of CFLni lamps from the RoHS Directive is negatively impacting innovation by keeping the legacy technologies on the market and preventing return on investment in the mercury-free alternative LED products.

[28] Personal communication and analysis conducted by VHK using the MELISA lighting market model (which was also used for the Impact Assessment for the Ecodesign one-lighting regulation) --as a one-time courtesy, on a strictly personal title and not assuming any liability for the data or its use-- to provide estimates of the savings potential of various scenarios. Communication on 18 October 2019.

With LED retrofits for CFLni lamps, as with all mercury-free LED replacement lamps, maintaining the fluorescent lamp exemption and allowing them to persist in the market slows the uptake of LED and perpetuates the use of mercury-containing fluorescent lamps. These exemptions therefore stifle innovation and prevent (or greatly reduce) the return on investment by small businesses and new start-ups working with LED technology and who are seeking to gain market share.

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

This category covers double ended fluorescent lamps with tube diameter between 9 and 17mm, of which the most popular size is called "T5". T5 lamps are covered in the recent Ecodesign regulation[29] but have an efficacy requirement that still allows fluorescent technology to persist, therefore T5 fluorescent lamps have no phase-out date. For the purposes of this analysis, we consider a phase-out date within the 12-18 month notice period of RoHS, suggesting 1 September 2021 for all lamps in this category.

Figure 15. Examples of T5 Fluorescent Lamps Exempted from RoHS in III.2(a)(2)

The following table provides a summary of our findings against the six criteria outlined in Chapter 2 of this report.

Table 15. Summary Table of findings for Double-capped fluorescent lamps, III.2(a)(2)

Article 5(1)(a) Criteria	Summary of Finding Discussed below
(i) Annex II Materials or Substances	LED replacements for T5 fluorescent lamps are compliant with RoHS and do not contain any Annex II materials or substances.
(ii) Reliability of Substitutes	The LED replacements for double-capped T5 fluorescent lamps are reliable; the LED lamps have rated lifetimes are 2.1 times longer than the fluorescent lamps they are replacing. Furthermore, the product warranty offered on one of the two lamps sampled for this comparison was 5 times longer for the LED retrofit than for the fluorescent lamp it replaces.
(iii) Environment, Health and Safety	The LED replacements for T5 reduce the environmental impact both in terms of CO2 emissions and mercury released to the environment; they do not present any health hazards and they are designed to comply with the product safety standards and therefore do not introduce any safety concerns.

[29] 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

Article 5(1)(a) Criteria	Summary of Finding Discussed below
(iv) Availability of Substitutes	Yes, there is a vast range and variety of LED replacements for T5 fluorescent lamps, spanning a wide range of CCT, CRI, wattages, light output and so-on. There are over 2280 different models of LED replacements in the US market, which has been found to be similar to the EU market based on sampling. In terms of ballast compatibility, 76% of the existing T5 sockets in Europe can be met with an LED replacement today.
(v) Socioeconomic Impact	Yes, there is a strong socioeconomic benefit from the installation of LED replacements for T5 fluorescent lamps, with payback periods from 3.2-3.4 years and net cumulative savings through 2030 of €4.7 billion Euro.
(vi) Impact on Innovation	As noted in section 2.6 of this report, continuing to extend the exemption of T5 fluorescent lamps from the RoHS Directive is negatively impacting innovation by keeping the legacy technologies on the market and preventing return on investment in the mercury-free alternative LED products.

3.2.1 (i) Annex II Materials or Substances – T5, III.2(a)(2)

LED replacements for T5 fluorescent lamps are compliant with RoHS and do not contain any Annex II materials or substances.

As discussed in section 2.1, LED retrofits for T5 fluorescent lamps do not contain any RoHS Annex II materials or substances – they do not contain lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB), polybrominated diphenyl ethers (PBDE) and the four classified phthalates (DEHP, BBP, DBP and DIBP). The T5 LED retrofit products on the market today are declared as RoHS compliant means they are RoHS compliant, so any product that carries this label will use flame retardants that are not banned by Annex II. As noted previously, fluorescent lamp ballasts are no different on a materials basis than LED drivers - the only difference between the two lighting technologies is that there is mercury in the fluorescent tube and none in the LED retrofit lamp.

The screen captures below present the RoHS compliant declarations for two examples of T5 retrofit lamps from OSRAM/LEDvance and from Philips/Signify, both of whom have large portfolios of T5 LED retrofit products.

OSRAM

PRODUCT DATASHEET
ST5HO49-HF 26 W/865 1449 mm HF

SubstiTUBE T5 High Output | LED tubes for electronic high frequency control gears

AREAS OF APPLICATION

- Illumination of production areas
- Supermarkets and department stores
- Public buildings, reception areas, offices, corridors, etc.

PRODUCT BENEFITS

- Quick, simple and safe replacement without rewiring
- Also suitable for operation at low temperatures
- No bending thanks to glass technology

PRODUCT FEATURES

- Compatible with many common electronic control gears (see also compatibility list)
- Lifetime: up to 60,000 h
- Mercury-free and RoHS compliant
- Type of protection: IP20

MASTER LEDtube InstantFit HF T5

MAS LEDtube HF 1500mm HO 26W 830 T5

Philips MASTER LEDtube InstantFit T5 integrates a LED light source into a traditional fluorescent form factor. Its unique design creates a perfectly uniform visual appearance which cannot be distinguished from traditional fluorescents. The Philips MASTER LEDtube InstantFit T5 is the ideal solution for customers who have higher light output requirements and want to maximise value over the lifetime.The full energy savings & longer lifetime result in attractive payback times and TCO benefits.

MASTER LEDtube InstantFit HF T5

Approval and Application	
Energy efficiency label (EEL)	A+
Energy-saving product	Yes
Approval marks	CE marking, RoHS compliance, EMA Keur certificate
Energy Consumption kWh/1000 h	31 kWh

Product Data	
Full product code	871869668552500

Order product name	MAS LEDtube HF 1500mm HO 26W 830 T5
EAN/UPC – product	8718696685525
Order code	68552500
Numerator – quantity per pack	1
Numerator – packs per outer box	10
Material no. (12NC)	929001296102
Net weight (piece)	0.197 kg

3.2.2 (ii) Reliability of Substitutes – T5, III.2(a)(2)

The LED replacements for double-capped T5 fluorescent lamps are reliable; the LED lamps have rated lifetimes are 2.1 times longer than the fluorescent lamps they are replacing. Furthermore, the product warranty offered on one of the two lamps sampled for this comparison was 5 times longer for the LED retrofit than for the fluorescent lamp it replaces.

It is very important that when an end-user makes a decision to switch lighting technologies that the new light source is viewed as reliable and durable in the lighting application it is replacing. LED light sources – which can be directly retrofitted into an existing luminaire – are more reliable than the fluorescent lamps that they replace. This fact is reflected in the rated lifetime and manufacturer's guarantees that are issued with the products.

The table below shows some examples of fluorescent and direct retrofit (no re-wiring necessary) LED alternatives for those lamps. The rated lifetimes of LED lamps are typically about three times longer than the fluorescent lamps they are replacing. Webpage links are provided as footnotes for verification purposes.

Table 16. Lifetime Comparison for Tri-band phosphor with normal lifetime and a tube diameter ≥ 9 mm and ≤ 17 mm (e.g. T5), III.2(a)(2)

T5 Fluorescent Lamps			T5 LED Direct Retrofits		
	Philips TL5 HE 35W 840 (MASTER) | 145cm - Cool White[30]	24,000 hours		Philips LEDtube T5 HF HE 20W 840 145cm (MASTER) | Cool White [31]	50,000 hours 5 Year warranty
	Osram FQ HO 54W 865 G5 Lumilux - 115cm[32]	24,000 hours 1 year warranty		Noxion Avant LEDtube T5 Extreme HO (Direct) 120cm 26W 865 [33]	50,000 hours 5 year warranty

Both T5 fluorescent lamps are rated for 24,000 hours and both LED retrofit T5 lamps are rated for 50,000 hours – which is 2.1 times longer life. The difference between the warranty offered on the two different lamp technologies is markedly different – the fluorescent lamp only offers a 1-year warranty while the LED lamp offers a five year warranty – five times longer. From both a rated lifetime and a warranty perspective, it is safe to conclude that the T5 LED direct retrofits for fluorescent T5 lamps are reliable substitutes.

3.2.3 (iii) Environmental, Health and Safety – T5, III.2(a)(2)

The LED replacements for T5 reduce the environmental impact both in terms of CO_2 emissions and mercury released to the environment; they do not present any health hazards and they are designed to comply with the product safety standards and therefore do not introduce any safety concerns.

As shown in Table 17, the environmental benefits for phasing out T5 fluorescent lamps in September 2021 are significant. Energy bill savings amount to 60.2 TWh of electricity on a cumulative basis if fluorescent T5 fluorescent lamps are phased out in September 2021. Using a constant level of carbon intensity (0.296 kg/kWh), the avoided CO_2 emissions would be 17.8 MT of CO_2 for a T5 fluorescent lamp phase out in 2021.

The mercury emission reductions from phasing out T5 fluorescent lamps are two-fold: emissions into the environment from broken and improperly disposed lamps is avoided, and by reducing electricity demand, mercury released to the environment from the burning of coal at European power stations is avoided. We calculate the sum of mercury from avoided lamp shipments and mercury emissions from avoided electricity production that result from retiring the exemption for T5 fluorescent lamps in 2021, then 2136.2 kg Hg is avoided by 2030:

[30] https://www.any-lamp.co.uk/philips-tl5-he-35w-840-master-145cm-cool-white
[31] https://www.any-lamp.co.uk/philips-ledtube-t5-hf-he-20w-840-145cm-master-cool-white-replaces-35w
[32] https://www.any-lamp.co.uk/osram-fq-ho-54w-865-g5-lumilux-115cm
[33] https://www.any-lamp.co.uk/noxion-avant-ledtube-t5-extreme-ho-direct-120cm-26w-865-daylight-replaces-54w

Table 17. Environmental Benefit from Phase-Out of T5 fluorescent lamps in Europe[34]

Benefits of T5 phase-out in Sept 2021	Cumulative Savings (2020-2030)
Electricity Savings and Avoided CO_2 Emissions	60.2 TWh (17.8 MT CO_2)
Mercury Savings – Lamps and Power Plant Emissions (*kg Hg*)	1173 kg – lamps 963.2 kg – power plant 2136.2 kg - TOTAL

Today, fluorescent lamps are rapidly being replaced across Europe with LED retrofit lamps that are mercury-free, cost-effective, longer-lasting and provides the same or better lighting service compared to fluorescent. Figure 16 is from Philips Lighting/Signify[35] who market LED lighting to businesses as "A green choice", noting that "LED tubes are a mercury-free alternative to traditional fluorescent tubes, a responsible choice that can also contribute towards your green credentials."

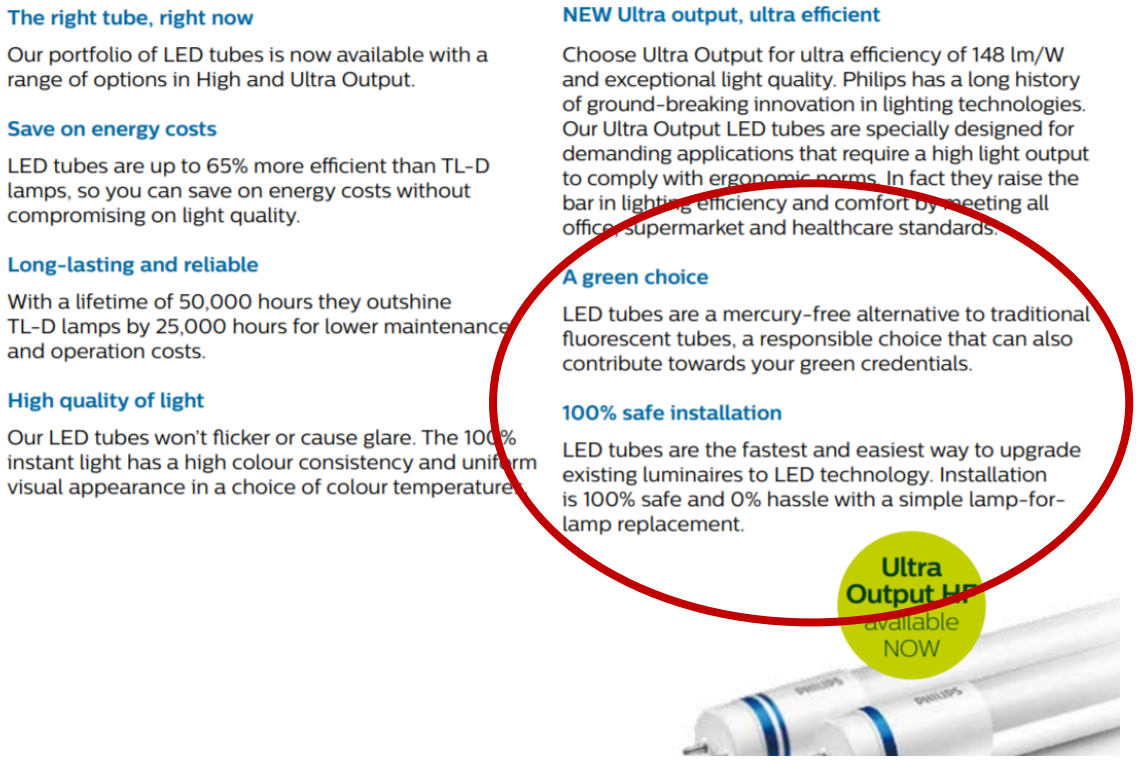


Figure 16. Philips Lighting/Signify highlighting the mercury-free alternative to fluorescent lighting

As discussed in section 2.3.3, there are no safety concerns for LED replacements for T5 fluorescent lamps. This conclusion is drawn from the fact that LED products have been designed for installation into existing fluorescent luminaires, thus safety issues have been included from the beginning, as indicated in the Philips information presented in Figure 16 above. The note reads: "100% safe installation LED tubes are the fastest and easiest way to

[34] "Personal communication and analysis conducted by VHK using the MELISA lighting market model (which was also used for the Impact Assessment for the Ecodesign one-lighting regulation) --as a one-time courtesy, on a strictly personal title and not assuming any liability for the data or its use-- to provide estimates of the savings potential of various scenarios. Communication on 26 October 2019."

upgrade existing luminaires to LED technology. Installation is 100% safe and 0% hassle with a simple lamp-for-lamp replacement". Furthermore, all LED products must comply with the requisite international safety standards, which protect for a range of consumer-related safety issues listed in section 2.3.3.

3.2.4 (iv) Availability of Substitutes – T5, III.2(a)(2)

Yes, there is a vast range and variety of LED replacements for T5 fluorescent lamps, spanning a wide range of CCT, CRI, wattages, light output and so-on. There are over 2280 different models of LED replacements in the US market, which has been found to be similar to the EU market based on sampling. In terms of ballast compatibility, 76% of the existing T5 sockets in Europe can be met with an LED replacement today.

According to the Design Lights Consortium Quality Products List in the US, there are literally thousands of different models of linear LED replacement lamps for T5 installations[36] - 2280 different models. Although we don´t have access to a similar database for the EU, sampling on the EU market shows a similar wide catalogue of products.

In terms of compatibility, the manufacturer catalogues indicate that their direct-replacement T5 LED lamps are compatible with approximately 76% of the T5 fluorescent ballasts installed in Europe today. This is reflected in Table 12 below, and this percentage is expected to increase if the RoHS exemptions for fluorescent lamps are phased out, creating a better market for (mercury-free) T5 LED lamps.

Table 18. T5 Lamp Extract from SEA/CLASP research on LED-Ballast Compatibility for LED lamps

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¤	Average·compatibility·of·lamp-ballast·%¤
Philips·MASTER·LEDtube·HF·InstantFit·HE·T5·(9)¤	60/79·=·76%¤	**76%**¤
Osram·Substitube·T5·Universal·(12)¤	178/235·=·76%¤	
Sylvania·TOLEDO·SUPERIA·T5·ECG·(15)¤	85/85·=·100%**¤	

** Sylvania TOLEDO SUPERIA compatibility claim seems unrealistically high, therefore these models are not included in our calculation of average compatibility %.

3.2.5 (v) Socioeconomic Impact – T5, III.2(a)(2)

Yes, there is a strong socioeconomic benefit from the installation of LED replacements for T5 fluorescent lamps, with payback periods from 3.2-3.4 years and net cumulative savings through 2030 of €4.7 billion Euro.

[36] The Design Lights Consortium (DLC) in the United States maintains a qualified products list database that represents a large percentage of the LED lamps and luminaires offered on the market in North America. In the categories of T5 and T8 LED replacement lamps, the DLC database contains 26,224 models. While it is recognised that the DLC database does not cover Europe, it is presumed that the European market will have a similarly large sample of models for sale.

Starting from the standpoint of a single T5 socket, the authors prepared a calculation for a T5 replacement. The payback periods are longer than T8, however they are still positive, and end-users will easily recover their investment over the 50,000-hour rated life of the LED T5 replacement lamps. In addition, if there were to be a phase-out, T5 LED lamp sales volumes would be expected to rise and prices to fall through competition, yielding shorter payback periods. There isn't an LED entry-level and professional-grade option in T5, thus a single calculation comparison is performed, comparing a 28-Watt linear fluorescent T5 with an LED direct replacement lamp from OSRAM/LEDvance. The results are presented in Table 19, which shows a payback period of between 3.2 and 3.4 years. The net present value of the life-cycle cost savings is still strongly positive, offering European businesses €67.30 with the OSRAM product or €54.93 with the Philips product for each lamp replaced in terms of electricity savings.

Table 19. Life-Cycle Cost Economic Analysis of T5 Lamp Replacement in Europe

Europe			
Lamp is on for hours/day:	10	hours/day	
Electricity price:	0.11	EUR/kWh	
Annual change in price of Electricity	4.0%	percent (MEErP)	
Electricity CO2 intensity:	0.296	kg CO2/kWh	
Discount Rate	4.0%	percent	

Lamp type	T5 LFL	LED T5 - 1	LED T5 - 2	
Lamp wattage:	28	16	16.5	Watts
Rated lamp lifetime:	24000	60000	50000	Hours
Price for one lamp (EUR):	2.83	19.99	18.12	EUR/lamp
Electricity consumption and savings calculations				
Annual electricity consumption for each lamp type:	102	58	60	kWh/year
Annual electricity savings compared to T5 fluorescent lamp:	---	44	42	kWh/year
Percent electricity savings compared with T5 fluorescent lamp:	---	43%	41%	percent
Electricity cost for operating the lamps each year:	11.74	6.71	6.92	EUR/year
Financial savings of electricity costs per year vs. fluorescent:		5.03	4.82	EUR/year
Life-Cycle Cost (LCC) of one lamp over analysis period shown				
LCC time period of analysis:	16.0	16.0	16.0	years
LCC of operating lamp for 16 years, discounted to 2019:	194.65	127.35	139.72	EUR (NPV, 2019)
LCC savings of more efficient lamp compared with a fluorescent T5:	---	67.30	54.93	EUR (NPV, 2019)
Percent LCC savings compared with a fluorescent T5 lamps:	---	35%	28%	percent
Payback period and Internal Rate of Return calculations				
Simple Payback period in years, compared with T5 fluorescent:	---	3.41	3.17	years
Simple Payback period in months, compared with T5 fluorescent:	---	40.9	38.0	months
Internal Rate of Return (IRR), compared with T5 fluorescent:	---	32%	35%	percent
CO2 emissions calculations				
CO2 emissions due to electricity for one lamp operating for 16 years:	483.7	276.4	285.0	kg CO2/16 yrs
CO2 savings compared with a T5 fluorescent lamp:	---	207.3	198.7	kg CO2/16 yrs

Notes: Electricity price of €0.1149/kWh from Eurostat for non-domestic sector[37]. Electricity price escalation rate of 4% is applied (following the MEErP methodology). CO_2 intensity of 295.8 g CO2/kWh from European Environment Agency[38].

VHK prepared an analysis using the MELISA European Lighting market model to estimate the energy and economic impact of a phase-out of T5 fluorescent lamps. The savings from a T5 phase-out in September 2021 are significant, saving up to 60 TWh of electricity on a cumulative basis and €4.7 billion Euro in net savings (including lamp purchase cost).

[37] https://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_price_statistics#Electricity_prices_for_non-household_consumers
[38] Link to European Environment Agency graphic depicting the 2016 CO2 intensity value of 295.8g CO2/kWh.

Table 20. Energy & Financial Savings from Phase-Out of T5 Fluorescent Lamps in Europe [39]

Benefits of T5 phase-out in Sept. 2021	Cumulative Savings (2020-2030)
Electricity Savings	60.2 TWh
Net Financial Savings (taking into account savings on the energy bill and slightly higher lamp costs)	€4.7 billion

3.2.6 (vi) Impact on Innovation – T5, III.2(a)(2)

As noted in section 2.6 of this report, continuing to extend the exemption of T5 fluorescent lamps from the RoHS Directive is negatively impacting innovation by keeping the legacy technologies on the market and preventing return on investment in the mercury-free alternative LED products.

With T5 retrofit lamps, as with all mercury-free LED replacement lamps, maintaining the exemption for fluorescent lamps and allowing them to persist in the market slows the uptake of LED and perpetuates the maintenance of mercury-containing fluorescent lamps. These exemptions therefore stifle innovation and prevent (or greatly reduce) the return on investment by small businesses and new start-ups working with LED technology and who are seeking to gain market share.

[39] Personal communication and analysis conducted by VHK using the MELISA lighting market model (which was also used for the Impact Assessment for the Ecodesign one-lighting regulation) --as a one-time courtesy, on a strictly personal title and not assuming any liability for the data or its use-- to provide estimates of the savings potential of various scenarios. Communication on 18 October 2019.

3.3 Tri-band phosphor with normal lifetime and a tube diameter > 17 mm and ≤ 28 mm (e.g. T8), III.2(a)(3)

This category covers double ended fluorescent lamps with tube diameter between 17 and 28mm, of which the most popular size is called "T8". Certain (the most popular) lengths of T8 lamps are scheduled to be phased-out by the recent Ecodesign regulation[40] on 1 September 2023, but this date was only agreed after extensive lobbying by the lighting industry as the original proposal was to have them phased out on 1 September 2020. For the purposes of this analysis, we consider a phase-out date within the 12-18-month notice period of RoHS, suggesting 1 September 2021 for all lamps in this category. This represents a two-year acceleration in the phase-out date, which yields significant mercury savings and other stakeholder and environmental benefits.

Figure 17. Examples of T8 Lamps Exempted from RoHS in III.2(a)(3)

The following table provides a summary of our findings against the six criteria outlined in Chapter 2 of this report.

Table 21. Summary Table of findings for Double-capped fluorescent lamps, III.2(a)(3)

Article 5(1)(a) Criteria	Summary of Finding Discussed below
(i) Annex II Materials or Substances	LED replacements for T8 fluorescent lamps are compliant with RoHS and do not contain any Annex II materials or substances.
(ii) Reliability of Substitutes	The LED replacements for double-capped T8 fluorescent lamps are reliable; the LED lamps have rated lifetimes are 2.5 to 3.0 times longer than the fluorescent lamps they are replacing. Furthermore, the product warranty offered on one of the two lamps sampled for this comparison was 5 times longer for the LED retrofit than for the fluorescent lamp it replaces.
(iii) Environment, Health and Safety	The LED replacements for T8 reduce the environmental impact both in terms of CO2 emissions and mercury released to the environment; they do not present any health hazards and they are designed to comply with the product safety standards and therefore do not introduce any safety concerns.

[40] 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

Article 5(1)(a) Criteria	Summary of Finding Discussed below
(iv) Availability of Substitutes	Yes, there is a vast range and variety of LED replacements for T8 fluorescent lamps, spanning a wide range of CCT, CRI, wattages, light output and so-on. There are over 24,000 different models of LED replacements in the US market, which has been found to be similar to the EU market based on sampling. In terms of ballast compatibility, 96.4% of the existing T8 sockets in Europe can be met with an LED replacement today.
(v) Socioeconomic Impact	Yes, there is a strong socioeconomic benefit from the installation of LED replacements for T8 fluorescent lamps, with payback periods from 0.4-0.9 years and net cumulative savings through 2030 of €5.0 billion Euro.
(vi) Impact on Innovation	As noted in section 2.6 of this report, continuing to extend the exemption of T8 fluorescent lamps from the RoHS Directive is negatively impacting innovation by keeping the legacy technologies on the market and preventing return on investment in the mercury-free alternative LED products.

3.3.1 (i) Annex II Materials or Substances – T8, III.2(a)(3)

LED replacements for T8 fluorescent lamps are compliant with RoHS and do not contain any Annex II materials or substances.

As discussed in section 2.1, LED retrofits for T8 fluorescent lamps do not contain any RoHS Annex II materials or substances – they do not contain lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB), polybrominated diphenyl ethers (PBDE) and the four classified phthalates (DEHP, BBP, DBP and DIBP). The T8 LED retrofit products on the market today are declared as RoHS compliant means they are RoHS compliant, so any product that carries this label will use flame retardants that are not banned by Annex II. As noted previously, fluorescent lamp ballasts are no different on a materials basis than LED drivers - the only difference between the two lighting technologies is that there is mercury in the fluorescent tube and none in the LED retrofit lamp.

In Figure 18, Tungsram advertises[41] that its products contain no lead or mercury and are compliant with the material restriction requirements of RoHS.

[41] https://tungsram.com/en/products/led-retrofit/led-tubes

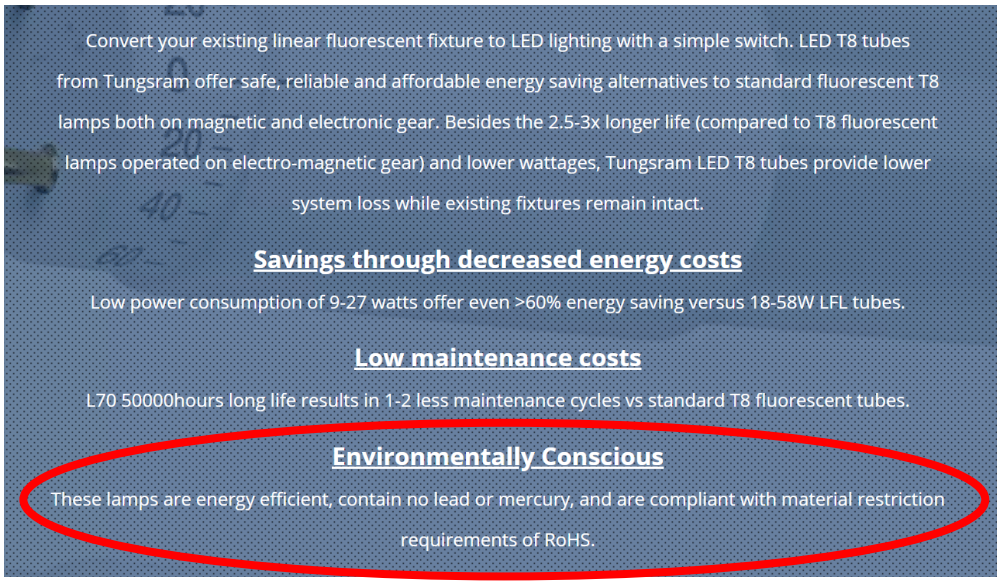


Figure 18. Tungsram advertisement noting the "quick and easy installation" of its LED retrofit lamps

Another example is presented below from OSRAM/LEDvance. This is a 1200mm direct retrofit (SubstiTUBE) T8 lamp, and it clearly states on the product datasheet that this lamp is compliant with the RoHS requirements.

PRODUCT DATASHEET
ST8AU-UN 15 W/6500K 1200 mm

SubstiTUBE Advanced UO UN | LED tubes for electronic and electromagnetic control gears, shatterproof

AREAS OF APPLICATION

- General illumination within ambient temperatures from −25...+50 °C
- Supermarkets and department stores
- Industry
- Illumination of production areas

PRODUCT BENEFITS

- Also suitable for operation at low temperatures
- High luminous flux for sophisticated lighting tasks
- Easy installation
- No bending thanks to glass technology

PRODUCT FEATURES

- Mercury-free and RoHS compliant
- Type of protection: IP20
- Lifetime: up to 60,000 h
- Shatterproof according IEC 61549 AMD 2:2010 -810-1 4.4.1 (Certificate in preperation)
- Compatible with conventional and many common electronic control gears (see also compatibility list) and line voltage
- High color consistency: ≤ 5 SDCM

Figure 19. OSRAM/LEDvance Product Data Sheet for a T8 retrofit lamp

3.3.2 (ii) Reliability of Substitutes – T8, III.2(a)(3)

The LED replacements for double-capped T8 fluorescent lamps are reliable; the LED lamps have rated lifetimes are 2.5 to 3.0 times longer than the fluorescent lamps they are replacing. Furthermore, the product warranty offered on one of the two lamps sampled for this comparison was 5 times longer for the LED retrofit than for the fluorescent lamp it replaces.

It is very important that when an end-user makes a decision to switch lighting technologies that the new light source is viewed as reliable and durable in the lighting application it is replacing. LED light sources – which can be directly retrofitted into an existing luminaire – are

more reliable than the fluorescent lamps that they replace. This fact is reflected in the rated lifetime and manufacturer's guarantees that are issued with the products.

The table below shows some examples of fluorescent and direct retrofit (no re-wiring necessary) LED alternatives for those lamps. The rated lifetimes of LED lamps are typically about three times longer than the fluorescent lamps they are replacing. Webpage links are provided as footnotes for verification purposes.

Table 22. Lifetime Comparison for Tri-band phosphor with normal lifetime and a tube diameter > 17 mm and ≤ 28 mm (e.g. T8), III.2(a)(3)

T8 Fluorescent Lamps			T8 LED Direct Retrofits		
	Philips TL-D 18W 827 Super 80 (MASTER) | 59cm[42]	20,000 hours 1 year warranty		Philips LEDtube HF 8W 830 60cm (MASTER) | Warm White[43]	50,000 hours 5 year warranty
	Osram L 36W 840 Lumilux | 120cm - Cool White[44]	20,000 hours 1 year warranty		Osram SubstiTUBE Advanced HF UO 15.5W 840 120cm | Cool White [45]	60,000 hours 5 year warranty

Both T8 fluorescent lamps are rated for 20,000 hours and the LED retrofit T8 lamps are rated for 50,000 and 60,000 hours – which is 2.5 to 3.0 times longer life. The difference between the warranty offered on the two different lamp technologies is markedly different – the fluorescent lamp only offers a 1 year warranty while the LED lamps both offer a five year warranty – five times longer. From both a rated lifetime and a warranty perspective, it is safe to conclude that the T8 LED direct retrofits for fluorescent T8 lamps are reliable substitutes.

3.3.3 (iii) Environmental, Health and Safety – T8, III.2(a)(3)

The LED replacements for T8 reduce the environmental impact both in terms of CO_2 emissions and mercury released to the environment; they do not present any health hazards and they are designed to comply with the product safety standards and therefore do not introduce any safety concerns.

As shown in **Fel! Hittar inte referenskälla.**, the environmental benefits for phasing out T8 fluorescent lamps in September 2021 are significant – even though it is only a two year acceleration on the phase-out of T8 scheduled under the Ecodesign Directive. Energy bill savings amount to 64 TWh of electricity on a cumulative basis if fluorescent T8 fluorescent lamps are phased out in September 2021. Using a constant level of carbon intensity (0.296

[42] https://www.any-lamp.co.uk/philips-tl-d-18w-827-super-80-master-59cm-extra-warm-white
[43] https://www.any-lamp.co.uk/philips-ledtube-hf-8w-830-60cm-master-warm-white-replaces-18w
[44] https://www.any-lamp.co.uk/osram-l-36w-840-lumilux-120cm-cool-white
[45] https://www.any-lamp.co.uk/osram-substitube-advanced-hf-uo-15-5w-840-120cm-cool-white-replaces-36w

kg/kWh), the avoided CO_2 emissions would be 18.9 MT of CO_2 for a T8 fluorescent lamp phase out in 2021.

The mercury emission reductions from phasing out T8 fluorescent lamps are two-fold: emissions into the environment from broken and improperly disposed lamps is avoided, and by reducing electricity demand, mercury released to the environment from the burning of coal at European power stations is avoided. We calculate the sum of mercury from avoided lamp shipments and mercury emissions from avoided electricity production that result from retiring the exemption for T8 fluorescent lamps in 2021, then 1,832.5 kg Hg is avoided by 2030:

Table 23. Environmental Benefit from Phase-Out of T8 fluorescent lamps in Europe[46]

Benefits of T8 phase-out in Sept 2021	Cumulative Savings (2020-2030)
Electricity Savings and Avoided CO_2 Emissions	64 TWh (18.9 MT CO_2)
Mercury Savings – Lamps and Power Plant Emissions (*kg Hg*)	808.5 kg – lamps 1024 kg – power plant 1832.5 kg - TOTAL

Today, fluorescent lamps are rapidly being replaced across Europe with LED retrofit lamps that are mercury-free, cost-effective, longer-lasting and provides the same or better lighting service compared to fluorescent. Figure 20 is from Philips Lighting/Signify[47] who market LED lighting to businesses as "A green choice", noting that "LED tubes are a mercury-free alternative to traditional fluorescent tubes, a responsible choice that can also contribute towards your green credentials."

[46] "Personal communication and analysis conducted by VHK using the MELISA lighting market model (which was also used for the Impact Assessment for the Ecodesign one-lighting regulation) --as a one-time courtesy, on a strictly personal title and not assuming any liability for the data or its use-- to provide estimates of the savings potential of various scenarios. Communication on 26 October 2019."

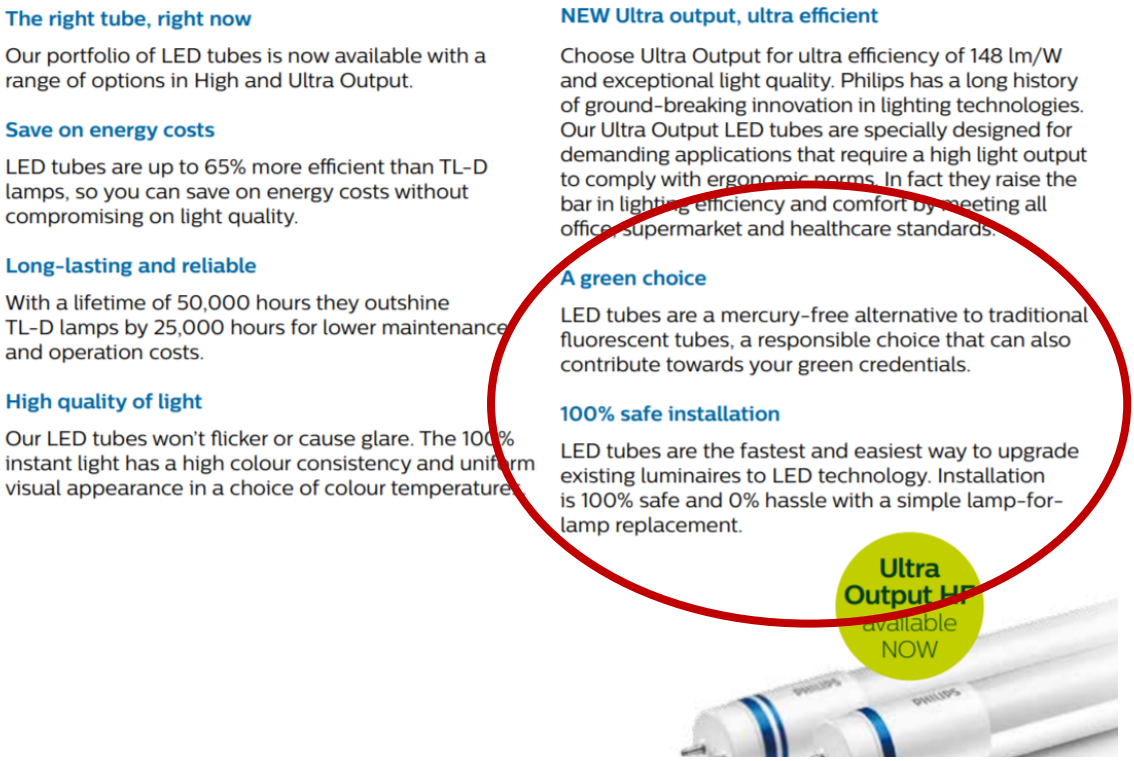


Figure 20. Philips Lighting/Signify highlighting the mercury-free alternative to fluorescent lighting

As discussed in section 2.3.3, there are no safety concerns for LED replacements for T8 fluorescent lamps. This conclusion is drawn from the fact that LED products have been designed for installation into existing fluorescent luminaires, thus safety issues have been included from the beginning, as indicated in the Philips information presented in Figure 20 above. The note reads: "100% safe installation LED tubes are the fastest and easiest way to upgrade existing luminaires to LED technology. Installation is 100% safe and 0% hassle with a simple lamp-for-lamp replacement". Furthermore, all LED products must comply with the requisite international safety standards, which protect for a range of consumer-related safety issues listed in section 2.3.3.

3.3.4 (iv) Availability of Substitutes – T8, III.2(a)(3)

Yes, there is a vast range and variety of LED replacements for T8 fluorescent lamps, spanning a wide range of CCT, CRI, wattages, light output and so-on. There are over 24,000 different models of LED replacements in the US market, which has been found to be similar to the EU market based on sampling. In terms of ballast compatibility, 96.4% of the existing T8 sockets in Europe can be met with an LED replacement today.

According to the Design Lights Consortium Quality Products List in the US, there are literally tens of thousands of different models of linear LED replacement lamps for T8 installations[48] -

[48] The Design Lights Consortium (DLC) in the United States maintains a qualified products list database that represents a large percentage of the LED lamps and luminaires offered on the market in North America. In the categories of T5 and T8 LED replacement lamps, the DLC database contains 26,224 models. While it is recognised that the DLC database does not cover Europe, it is presumed that the European market will have a similarly large sample of models for sale.

24,076 different models. Although we don´t have access to a similar database for the EU, sampling on the EU market shows a similar wide catalogue of products.

In terms of compatibility, the manufacturer catalogues indicate that their direct-replacement T8 LED lamps are compatible with approximately 96.4% of the T8 fluorescent ballasts installed in Europe today. This percentage is calculated based on the estimate that around 70% of the T8 fixtures in Europe have a magnetic ballast and 30% have a high-frequency electronic ballast. The LED lamps designed for magnetic ballasts are 100% compatible, while the LED lamps designed for the T8 high-frequency electronic ballasts are on average 88% compatible. Taken together, with the correct weighting for the different market percentages, a total of 96.4% of T8 fluorescent fixtures in Europe today can use a direct LED replacement.

Table 24. T8 Lamp Extract from SEA/CLASP research on LED-Ballast Compatibility for LED lamps

Ballast type	Percentage of field installations ballast type	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	Average compatibility of lamp-ballast %
EM/CGG	70%	Philips MASTER LEDtube EM/Mains T8 (30)	100% (no compatibility issues)	**100%**
		Osram Substitube T8 EM (44)		
		Sylvania TOLEDO SUPERIA T8 CCG AND AC (42)		
HF/ECC	30%	Philips MASTER LEDtube HF InstantFit T8 (16)	159/197 = 81%	**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%	
			Overall market compatibility, T8 LED retrofit tubes:	**96.4%**

** Sylvania TOLEDO SUPERIA compatibility claim seems unrealistically high, therefore these models are not included in our calculation of average compatibility %.

LED retrofit lamps are designed to fit into existing fluorescent fixtures to minimise inconvenience and avoid the need for rewiring. The types of LED retrofit tubes available now include lamps that can be installed directly into fixtures with the following configurations:

- ✓ Using a magnetic ballast and starter
- ✓ Using a high-frequency electronic ballast
- ✓ Where the old ballast is bypassed, and mains-voltage is wired directly to the G5 (T5) or G13 (T8) sockets
- ✓ Where an LED driver has been retrofitted into an existing fluorescent luminaire

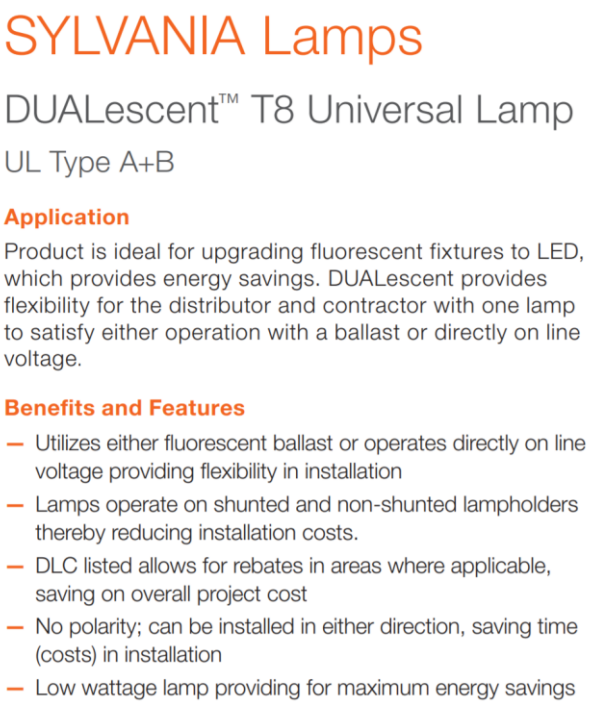
Manufacturers also offer “universal” lamp replacements, which can operate on several of these combinations of power supplies. As OSRAM[49] states in a description of one of its “universal” T8 lamps:

> *OSRAM SUBSTITUBE T8 UNIVERSAL: ONE FOR ALL*
> *With OSRAM SubstiTUBE T8 Universal, you no longer need to give any thought to the driver technology being used. The innovative all-in-one LED tube can be operated with*

[49] https://www.ledvance.com/professional/products/product-stories/led-tubes-online-special/osram-substitube-t8-universal/index.jsp

ECG, CCG and AC mains. It not only makes it much easier for users to operate, but also eliminates the need to keep a double amount of lamps on hand. SubstiTube T8 Universal is suitable for a range of different applications thanks to a selection of three different types: Advanced Ultra Output, Advanced and Value. With a long lifetime up to 60,000 hours and a lumen output up to 3,700 lm, the Advanced Ultra Output and the Advanced models are especially suitable for supermarkets, offices, industrial and public buildings, as well as the illumination of production areas.

Figure 21 presents marketing material from Sylvania, which offers a T8 retrofit solution[50] it describes as "ideal for upgrading fluorescent fixtures to LED." That product operates "with a ballast or directly online voltage" for a high degree of flexibility, making these lamps ideal for upgrading fluorescent installations to LED.



SYLVANIA Lamps

DUALescent™ T8 Universal Lamp

UL Type A+B

Application

Product is ideal for upgrading fluorescent fixtures to LED, which provides energy savings. DUALescent provides flexibility for the distributor and contractor with one lamp to satisfy either operation with a ballast or directly on line voltage.

Benefits and Features

- Utilizes either fluorescent ballast or operates directly on line voltage providing flexibility in installation
- Lamps operate on shunted and non-shunted lampholders thereby reducing installation costs.
- DLC listed allows for rebates in areas where applicable, saving on overall project cost
- No polarity; can be installed in either direction, saving time (costs) in installation
- Low wattage lamp providing for maximum energy savings

Figure 21. Sylvania offers products that are ideal for upgrading fluorescent fixtures to LED

On the availability of LED substitutes for all lamp bases, LightingEurope stated that only 3 out of 9 lamp base types are available for linear fluorescent lamps. We checked this finding and do not agree with LE's evidence base. In fact, with a cursory search we were able to find 8 of the 9 base types available in the market today. Please see the screen capture from the LE letter below, where they have indicated only miniature bipin, medium bipin and G10q base types are available. Table 30 lists the base types and provides links to the examples we found online.

Comment from Lighting Europe, claiming only 3 of 9 fluorescent lamp base types exist in the market:

[50] https://assets2.sylvania.com/media/bin/asset-7401814/asset-7401814

Example 1: Lamp bases for Linear Fluorescent lamps – substitutes for **3 out of 9 lamp bases**

Table 25. SEA/CLASP research on lamp base types for Linear Fluorescent Lamps – 8 out of 9 base types exist

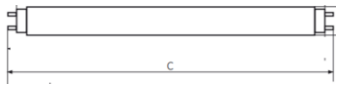
Base Type from LightingEurope Comment	Does this Base Type Exist in a Retrofit LED Lamp?	Links to Examples of LED Lamps
Miniature Bipin	**Yes**	Link to example
Medium Bipin	**Yes**	Link to example
Single Pin	**Yes**	Link to example
Recessed Double Contact	**Yes**	Link to example
4-Pin	**Yes**	Link to example
Single ended, 4-Pin	**Yes**	Link to example
2GX-13	**Yes**	Link to example
Axial	**Not found**	
G10q	**Yes**	Link to example

LightingEurope expressed concern that LED tubes of all different lengths of tube lamps and sockets are not examined, and reviewed Amazon.de to check what lengths of T8 lamps were available. LightingEurope found that only 5 of 16 lengths of T8 lamps were available.

In an effort to verify this finding reported by LightingEurope, SEA/CLASP downloaded all the technical specification sheets for the T8 (TL-D) fluorescent lamps for Philips/Signify, OSRAM and Tungsten/GE Lighting. SEA/CLASP then compiled that data into a spreadsheet and aligned all the model information according to the length of the lamps offered. SEA/CLASP chose these three companies because they have historically been the world's largest three manufacturer of lamps and because they are all members of LightingEurope.

The table below presents all the "C dimensions" (in millimetres) which is the maximum overall length of the fluorescent tubes, including the pins on both ends. SEA/CLASP only found 10 unique lengths of T8 lamps across the complete catalogues of these three global companies, not 16 as claimed by LE. The table below presents the ten lengths of T8 lamps specified by the companies.

Table 26. Maximum overall lengths of T8 lamps offered in Europe by the three largest global lamp manufacturers

 Fluorescent Tube Length (mm)	451.6 mm	484 mm	604 mm	734 mm	908.8 mm	984.2 mm	1061 mm	1213.6 mm	1514.2 mm	1778 mm
Philips/Signify										
MASTER TL-D Eco			x					x	x	
MASTER TL-D Super 80			x			x		x	x	x
MASTER TL-D Secura			x					x		
MASTER TL-D HF Super 80			x					x	x	
MASTER TL-D Xtreme			x					x	x	
MASTER TL-D 90 De Luxe			x					x	x	
MASTER TL-D 90 Graphica			x					x		
MASTER TL-D Food			x					x		
TL-D Coloured								x		
OSRAM										
LUMILUX T8	x	x	x	x	x	x	x	x	x	
LUMILUX XT T8			x					x		
LUMILUX XXT T8								x	x	
LUMILUX DE LUXE T8			x	x				x	x	
Color proof T8			x					x	x	
Coloured T8			x		x			x	x	
OSRAM NATURA T8	x		x		x			x	x	
LUMILUX T8 1 m						x				
LUMILUX CHIP control T8			x					x		
Tungsram/GE Lighting										
T8 Watt-Miser™			x					x	x	
T8 Polylux XLR™ LongLast™			x					x	x	
T8 Polylux XLR™	x		x		x			x	x	x

Next, SEA/CLASP sought to verify whether there were indeed only five lengths of LED lamps available to replace these lengths of T8 lamps. We were able to find direct replacement LED lamps for 9 out of our 10 lengths on Amazon.DE (see Table 27)– although it should be noted that some of the suppliers offering product are not LightingEurope members. When conducting this search, we noted that some suppliers used the overall length (C length) and others used the B length or a nominal length. The figure below illustrates the standardised measurements used for fluorescent tubes.

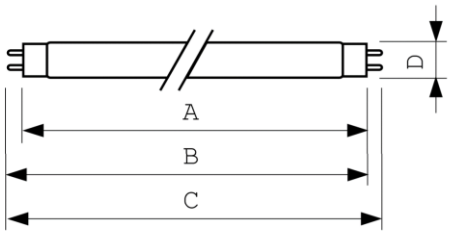


Table 27. Replacement T8 LED lamps on Amazon.DE for lengths identified

C Length	B Length	Product Description on Amazon.DE	Link to Amazon.DE
451.6 mm	438 mm	eLITe PLUS LED Röhre T8 | G13 Sockel | 1040lm | 8W | 4000K Neutralweiß | FWI: 840 | 44cm Lang | ASW: [Energieklasse A++]	Click here
484 mm	470 mm	This length was not available on Amazon.DE, therefore we contacted Zhejiang Boden Electronic Technology Co., Ltd in Zhejiang, China and confirmed that 470mm can be made, but must order 10,000 pieces.[51]	n/a
604 mm	590 mm	Osram LED Substitube Star PC T8 Leuchtstoffröhre, in 60 cm Länge mit G13-Sockel, Ersetzt 18 Watt, Kaltweiß - 4000 Kelvin, 1er-Pack [Energieklasse A+]	Click here
734 mm	720 mm	eLITe PLUS LED Röhre T8 | G13 Sockel | 1300lm | 10W | 4000K Neutralweiß | FWI: 840 | 72cm Lang | ASW: 120° [Energieklasse A++]	Click here
908.8 mm	895 mm	90 cm LED Röhre T8-G13 14 Watt, 300° AUSSTRAHLUNG, 1860 Lumen, Tageslichtweiß/ Kaltweiß 6000 Kelvin, 1:1 Ersatz für 24-30 Watt Leuchtstoffröhren - inclusive LED Starter [Energieklasse A++]	Click here
984.2 mm	970 mm	LED Röhre [kein Starter nötig!] T8 Länge 97,0 cm (!!Sondergröße!!) Leistung 16W Lumen 2240lm Lichtfarbe 4500K Farbreinheit CRI >80 Durchmesser 26mm Sockel G13 [Energieklasse A++]	Click here
1061 mm	1047 mm	Philips Master LEDtube Leuchtstofflampe Value UO T8 1047mm 16 Watt 2300 Lumen 830 3000 Kelvin warmweiß KVG/VVG drehbare Endkappe	Click here
1213.6 mm	1200 mm	Osram LED Substitube Star PC T8 Leuchtstoffröhre, in 120 cm Länge mit G13-Sockel, Ersetzt 36 Watt, Kaltweiß - 4000 Kelvin, 1er-Pack [Energieklasse A+]	Click here
1514.2 mm	1500 mm	Für EVG OHNE Starter, 150 cm LED Röhre T8 / G13, 29 Watt, 330° AUSSTRAHLUNG, 3480 LUMEN, Neutralweiß ~ 4000 Kelvin, ersetzt 58-70 Watt Leuchtstoffröhre. EVG KOMPATIBEL, TÜV zertifiziert [Energieklasse A+]	Click here
1778 mm	1764 mm	Sylvania LED-Tube T8 6Ft = 180cm = 1800mm 3240Lm 840=4000K Sockel G13 für Konventionelle Vorschaltgeräte mit Dummy-Starter [Energieklasse A+]	Click here

3.3.5 (v) Socioeconomic Impact – T8, III.2(a)(3)

Yes, there is a strong socioeconomic benefit from the installation of LED replacements for T8 fluorescent lamps, with payback periods from 0.4-0.9 years and net cumulative savings through 2030 of €5.0 billion Euro.

[51] Personal communication with Penny Tang, Sales Manager at Zhejiang Bodeng Electronic Technology Co., Limited. Located at No F2-13186 District 2, Yiwu International Trade City Zhejiang. Confirmed that it is technologically feasible to make this length (or any length), and she added: "Making 470mm needs customization. The quantities must be 10,000 pcs." Communication on 7 December 2019. Link to manufacturer sales page on Alibaba.

Starting from the standpoint of a single T8 socket, the authors prepared a calculation for a T8 fluorescent lamp with two different LED tubes. The table below presents our findings in relation to this assessment. We compared a €3.68 OSRAM 36W T8 linear fluorescent lamp (20000 hours life) with Philips' CorePro (entry-level, 30000 hours life) LED replacement and Philips' MasterLED (professional-grade, 50000 hours life) LED retrofit models. Assuming operation for 10 hours per day, the entry-level LED offers a payback of 4.9 months compared to the fluorescent (and will last 1.5 times longer than the fluorescent lamp) and the professional grade lamp offers a payback of 11 months (and will last 13 years, which is 2.5 times longer than the linear fluorescent lamp). These calculations reflect energy costs and bulb costs, but do not incorporate labour costs saved over time from reduced frequency of bulb changes.

Table 28. Life-Cycle Economic Analysis of T8 Lamp Replacement in Europe

Europe			
	Lamp is on for hours/day:	10	hours/day
	Electricity price:	0.11	EUR/kWh
	Annual change in price of Electricity	4.0%	percent (MEErP)
	Electricity CO2 intensity:	0.296	kg CO2/kWh
	Discount Rate	4.0%	percent

Lamp type	T8 LFL	LED T8 - 1	LED T8 - 2	
Lamp wattage:	36	18	12.5	Watts
Rated lamp lifetime:	20000	30000	50000	Hours
Price for one lamp (EUR):	3.68	6.77	12.74	EUR/lamp
Electricity consumption and savings calculations				
Annual electricity consumption for each lamp type:	131	66	46	kWh/year
Annual electricity savings compared to T8 fluorescent lamp:	---	66	86	kWh/year
Percent electricity savings compared with T8 fluorescent lamp:	---	50%	65%	percent
Electricity cost for operating the lamps each year:	15.10	7.55	5.24	EUR/year
Financial savings of electricity costs per year vs. fluorescent:		7.55	9.86	EUR/year
Life-Cycle Cost (LCC) of one lamp over analysis period shown				
LCC time period of analysis:	13.0	13.0	13.0	years
LCC of operating lamp for 13 years, discounted to 2019:	205.46	109.85	80.89	EUR (NPV, 2019)
LCC savings of more efficient lamp compared with a fluorescent T8:	---	95.61	124.57	EUR (NPV, 2019)
Percent LCC savings compared with a fluorescent T8 lamps:	---	47%	61%	percent
LCC savings are (X) times larger than LED Tube -1 LCC savings:	---	---	1.3	times greater
Payback period and Internal Rate of Return calculations				
Simple Payback period in years, compared with T8 fluorescent:	---	0.41	0.92	years
Simple Payback period in months, compared with T8 fluorescent:	---	4.9	11.0	months
Internal Rate of Return (IRR), compared with T8 fluorescent:	---	259%	118%	percent
CO2 emissions calculations				
CO2 emissions due to electricity for one lamp operating for 13 years:	505.3	252.6	175.4	kg CO2/13 yrs
CO2 savings compared with a T8 fluorescent lamp:	---	252.6	329.8	kg CO2/13 yrs
CO2 savings is (X) percent more than LED Tube 1 CO2 savings:	---	---	31%	percent

Notes: Electricity price of €0.1149/kWh from Eurostat for non-domestic sector[52]. Electricity price escalation rate of 4% is applied (following the MEErP methodology). CO_2 intensity of 295.8 g CO2/kWh from European Environment Agency[53].

All of the economics presented in this analysis indicate that the replacement of T8 fluorescent lamps is highly cost-effective. On a life-cycle cost basis, discounted to its net present value, end-users will save €95.61 (CorePro) or €124.57 (MasterLED) for each T8 fluorescent lamp replaced.

VHK prepared an analysis using the MELISA European Lighting market model to estimate the energy and economic impact of a phase-out of T8 fluorescent lamps two years earlier (September 2021) than it is currently scheduled to be phased-out under the Ecodesign Directive (September 2023) . The savings from a T8 phase-out in September 2021 are significant, saving up to 60 TWh of electricity on a cumulative basis and €4.7 billion Euro in net savings (including lamp purchase cost).

[52] https://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_price_statistics#Electricity_prices_for_non-household_consumers
[53] Link to European Environment Agency graphic depicting the 2016 CO2 intensity value of 295.8g CO2/kWh.

Table 29. Energy & Financial Savings from Phase-Out of T8 Fluorescent Lamps in Europe [54]

Benefits of T8 phase-out in Sept. 2021	Cumulative Savings (2020-2030)
Electricity Savings	64 TWh
Net Financial Savings (taking into account savings on the energy bill and slightly higher lamp costs)	€5.0 billion

Due to the fact that the majority of T8 lamps are phased-out in 2023 under the Ecodesign, the scenario presented above reflects a slight acceleration in the phase-out date. The initial proposal from the Commission's consultant was to phase-out T8 lamps in 2020, however due to lobbying by industry partners, this was delayed to 2023 in the final regulation published in the OJEU on 5 December 2019. Thus, in terms of lost savings on energy bills, the three-year delay to the phase-out of 2/4/5-foot T8 linear fluorescent lamps wiped out €7 billion Euro of net savings (taking into account lamp purchase cost) for European homes and businesses. If the delay had been held to only one year instead of three and 2/4/5-foot T8 linear fluorescent lamps were phased out in 2021, €5 billion Euro of net savings would thus be recovered by the RoHS Directive for European consumers and businesses.

3.3.6 (vi) Impact on Innovation – T8, III.2(a)(3)

As noted in section 2.6 of this report, continuing to extend the exemption of T8 fluorescent lamps from the RoHS Directive is negatively impacting innovation by keeping the legacy technologies on the market and preventing return on investment in the mercury-free alternative LED products.

With T8 retrofit lamps, as with all mercury-free LED replacement lamps, maintaining the exemption for fluorescent lamps and allowing them to persist in the market slows the uptake of LED and perpetuates the maintenance of mercury-containing fluorescent lamps. These exemptions therefore stifle innovation and prevent (or greatly reduce) the return on investment by small businesses and new start-ups working with LED technology and who are seeking to gain market share.

[54] Personal communication and analysis conducted by VHK using the MELISA lighting market model (which was also used for the Impact Assessment for the Ecodesign one-lighting regulation) --as a one-time courtesy, on a strictly personal title and not assuming any liability for the data or its use-- to provide estimates of the savings potential of various scenarios. Communication on 18 October 2019.

Annex A. Information about the MELISA Model Runs

To understand the magnitude of the savings potential if these exemptions were retired across Europe, the authors contacted Van Holsteijn en Kemna (VHK), the Netherlands-based private consultancy firm that conducted the regulatory analysis for the Commission on the ecodesign one-lighting regulation which was adopted by the Commission on 1 October 2019. VHK built and maintains a European lighting market model called "MELISA" (Model for European Light Sources Analysis) on behalf of the European Commission. We asked VHK to provide us with shipment estimates of the T5 and T8 lamps that would be avoided if certain RoHS exemptions were retired on 1 September 2021. VHK responded that they would conduct these runs as a one-time courtesy, on a strictly personal title and not assuming any liability for the data or its use.

As noted above, on 1 October 2019 the European Commission adopted the one-lighting regulation, which scheduled the phase-out of 90% of the T8 lamps in September 2023[55]. VHK calculated the benefits from accelerating the phase-out of T8 lamps by two years (going from 2023 to 2021) and for phasing-out T5 lamps in 2021 (note: the new ecodesign lighting regulation does not have a phase-out date for T5 fluorescent). In addition, VHK conducted a run that evaluated the phase-out of non-integrally ballasted compact fluorescent lamps (CFLni) which also do not have a phase-out date in the new ecodesign lighting regulation.

VHK provided[56] shipment forecasts in terms of unit sales for T5, T8 and CFLni lamps, as illustrated in the figure below. In the forecasts for T5 and CFLni lamps they mirrored the assumption used by the Commission that adopting a phase-out for a future year triggers a small part of the market (10 to 15%) to move earlier to the mercury-free alternatives. The dark blue line depicts the anticipated shipments of T8 fluorescent lamps under the business as usual scenario, including the new EU lighting regulation (adopted 1 October 2019). The green line depicts shipments of T8 fluorescent lamps if there is a two-year acceleration of the phase-out, with the RoHS exemption for T8 advanced to September 2021 from September 2023. The red line shows projected sales of T5 fluorescent lamps, which have no phase-out date in the new EU ecodesign regulation for lighting. The yellow line depicts shipments if the T5 RoHS exemption is retired in September 2021. The black line projects shipments of CFLni lamps under business as usual with no phase-out date in the new lighting regulation, and the bright blue line shows CFLni lamp shipments if the RoHS exemption is retired in September 2021.

[55] On 1 October 2019, the European Commission adopted a package of regulations, including new requirements on lighting which will phase out 2 foot, 4 foot and 5 foot lengths of T8 linear fluorescent lamps in September 2023. See: 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

[56] Personal communication and analysis conducted by VHK using the MELISA lighting market model (which was also used for the Impact Assessment for the Ecodesign one-lighting regulation) --as a one-time courtesy, on a strictly personal title and not assuming any liability for the data or its use-- to provide estimates of the savings potential of various scenarios. Communication on 16 October 2019."

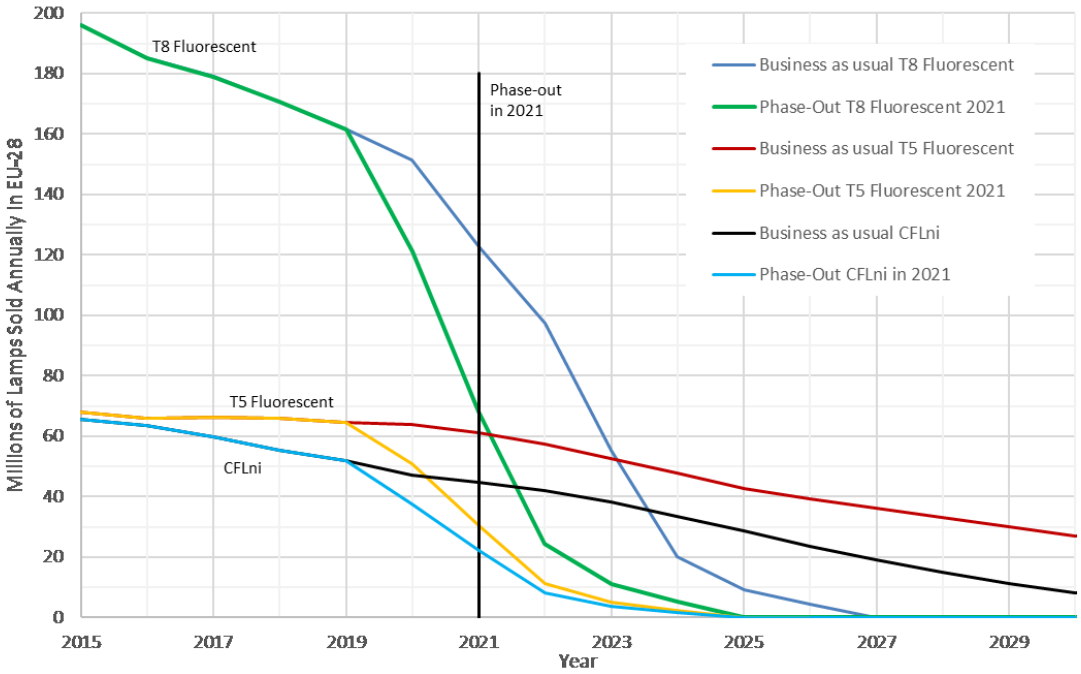


Figure 22. EU-28 shipment forecast T8, T5 and CFLni fluorescent lamps, assuming RoHS phase-out in 2021 (VHK MELISA model)

Annex B. Mercury release to the environment from lamps

The installation of mercury-free alternatives for mercury-containing products will reduce the presence of mercury in our living spaces and landfills. At the end of its useful life there is always a risk that fluorescent lamps will not be recovered and recycled, but instead will simply be discarded into the general waste stream where they go on to contaminate landfills, soil, streams, rivers and ultimately the oceans with mercury. Our research has indicated that more than **half** of the mercury content of T5 and T8 lamps is not collected properly.

The Waste Electrical and Electronic Equipment (WEEE) Directive[57] sets a target for countries across Europe of 80% recycling for gas-discharge lamps. This target is far from sufficient to protect against leaks from lamps into the environment. Indeed, the Directive sets the minimum annual collection rate at "65% of the average weight of EEE placed on the market in the three preceding years in the Member State concerned, or alternatively 85% of WEEE generated on the territory of that Member State" but does not set specific collection targets for individual categories. Based on a 2016 study of the collection rates of WEEE[58], the Commission concluded that it is not appropriate to set individual collection targets in the WEEE Directive at this stage[59], while recognising that the generic collection target of 85% will likely "be reached mostly by increasing the collection of heavy and easily accessible WEEE that has a positive economic value and is less expensive (or more profitable) to treat." Lamps are not heavy compared to other equipment covered under WEEE.

A 2014 European Commission study[60] on WEEE collection found that the collection rate for lamps covered under the WEEE Directive was only 12% in 2010 (see Table 30, where lamps are listed under "Cat 3"). This study projected that the collection rate for lamps would reach 16% in 2019 in the absence of a specific collection target for this category. Collection targets were set by Directive 2012/19/EU and are expected to increase the overall collection rate of WEEE, however the impact on the collection of lamps is expected to be limited. Indeed, their light weight and the fact that they are relatively difficult to collect and transport makes them largely irrelevant for Member States to reach their national collection targets. Furthermore, the small size of lamps makes them easier to dispose of in the general waste than other types of WEEE covered products.

[57] Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE) (recast) (Text with EEA relevance) https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1571396988961&uri=CELEX:02012L0019-20180704

[58] https://www.researchgate.net/profile/Jaco_Huisman/publication/297453161_Study_on_Collection_Rates_of_Waste_Electrical_and_Electronic_Equipment_WEEE_possible_measures_to_be_initiated_by_the_Commission_as_required_by_Article_74_75_76_and_77_of_Directive_201219EU_on_Waste_El/links/56df1cf408aee77a15fcf2c5/Study-on-Collection-Rates-of-Waste-Electrical-and-Electronic-Equipment-WEEE-possible-measures-to-be-initiated-by-the-Commission-as-required-by-Article-74-75-76-and-77-of-Directive-2012-19-EU-on-Was.pdf

[59] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52017DC0171

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

Table 30. Collection Rates in 2019 for the Two Scenarios Analysed[61], Lamps are Cat 3

Categories	Current collection rate	Collection rates to be achieved for the considered general collection target in scenario 1	Collection rates to be achieved for the considered individual targets in scenario 2
Cat 1	38%	95%	85%
Cat 2	47%	95%	85%
Cat 3	12%	16%	85%
Cat 4 exc. PV	38%	95%	85%
Cat 5	26%	70%	85%
Cat 6	49%	70%	85%
PV Panels	3%	85%	85%
Total	37%	85%	85%

Table 13: Collection rates in 2019 for the two scenarios analysed.

A large share of uncollected gas-discharge lamps may be compact fluorescent lamps, which are more common in residential use than T5 and T8 lamps. However, according to the MELISA model developed by VHK for the EC, the share of linear fluorescent lamps in the lamps covered by the WEEE Directive was 38% in 2009.[62] Considering a case in which 16% of those lamps are collected (the projected 2019 collection rate in the 2014 study), then 22% of these 38% would not be collected, which corresponds to 58% of the linear fluorescent lamps not collected. Extractions from Eurostat[63] show that although the situation seems to have improved since 2010, the collection rate of gas-discharge lamps is estimated to be only a third to a half of all gas-discharge lamps reaching their end of life. Thus, it is understood that **at least half** of these mercury-containing lamps (and possibly more) are simply discarded in the general waste stream.

A 2016 Study to assess renewal requests for 29 RoHS 2 Annex III exemptions[64] includes reports from Member States that confirm those concerns. In particular, Belgium and Denmark report that a significant share of mercury-containing lamps are not handled correctly. The following is an extract from the contribution of the Belgian Federal Public Services for Health, Food Chain Safety and Environment[65]:

[61] Source: Study on collection rates of waste electrical and electronic equipment (WEEE) - Possible measures to be initiated by the commission as required by article 7(4), 7(5), 7(6) and 7(7) of Directive 2012/19/EU on waste electrical and electronic equipment (WEEE). Cat 3 represents lamps and scenario 1 represent the actual current situation with no individual target per category. Scenario 2 represents a 85% target for each category.
[62] We selected 2009 because according to the MELISA model it represents the lowest share of T5 and T8 amongst the lamps covered by the WEEE Directive, as we had to use the share of sales as a proxy for the share of waste. Therefore, by considering that all properly collected lamps in 2009 were T5 and T8, we calculated the most optimistic scenario in terms of properly collected and recycled T5 and T8 lamps.
[63] https://ec.europa.eu/eurostat/web/waste/key-waste-streams/weee
[64] https://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/RoHS-Pack_9_Part_LAMPS_06-2016.pdf
[65] https://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Contribution_Exemption_1-4/Ex_1-4_FPS_Health__Food_chain_safety_and_Environment_Be_position_Hg_lamps_20151016.pdf

> In reference to the obligation in the WEEE Directive 2012/19/EU to collect and recycle lamps, including CFL, we note the following in relation to the collection phase of the process: No specific obligation exist to achieve a total (100%) collect ratio of the CFL, therefore we think that the actual ratio of collect achieved by the European operators should be identified to evaluate the level of efficacy of the system in place. Indeed - even if significant efforts have been implemented by the operators - indications that below 50% of CFL lamps was achieved in 2014 in Belgium. We recommend thus a thorough evaluation of these rates around EU to evaluate the mercury lost (i.e. potentially emitted to the environment) and ensuing consequences.

In Denmark, the Danish Environment Protection Agency reported on a survey of Danish household disposal of light bulbs. The table below is an extract from that report.

Table 31. Survey of Danish Households on Bulb Disposal (2016 Study in Denmark)

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

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

Source: Provided by DEPA (2016a), referencing data from the EPINION 2014 survey.

And while these collection rates are low – 38% for CFLs and 39% for fluorescent lamps – the following extract from the report indicates that the estimated rate of collection of lamps in Denmark is significantly higher than the European average reported in the Commission's 2014 study on collection rate:

> "In Denmark DPA-system administers the mandatory producer responsibility system. According to the **2014 statistics of the DPA-system** 1547 tons of bulbs (the various types of bulbs are not specified) were put on the market for consumers and 199 tons for professionals, for a total of 1746 tons of bulbs[35]. Concerning collection 765 tons of bulbs were collected from consumers and 12 tons from professionals, amounting to 777 tons and corresponding to a collection percentage of 45%. [36]. According to **statistical data from the DPA system for 2006,** in 2006 Denmark achieved an overall collection rate of 36%[37]. Data from 2010 shows an overall collection rate of 43%.

All of these data seem to contradict the fact that the majority of Member States report having met the target of 80% for the re-use/recycling of gas-discharge lamps[66], sometimes reporting recycling rates greater than 100%. The reason for these very high reported recovery rates has to do with what is defined as the "recycling rate" in the regulation, which only reflects the share of lamps that are properly handled after being delivered to a recycling centre or similarly specialized facility. Thus, the high recycling rate by definition excludes lamps which are

[66] Cf. pp.189 and 2010-211 of the Implementation report for Directives 2002/96/EC and 2012/19/EU on WEEE - Period 2013-2015 (published in September 2018)

disposed of in the general waste stream. Unfortunately, the majority of fluorescent lamps in Europe are not disposed of correctly and thus the mercury in those lamps ends up not being properly treated, polluting the environment and posing a health risk.

Figure 23 depicts our best estimate of the flow of fluorescent lamps in Europe based on the data sources indicated in this footnote.[67] We estimate that less than half the fluorescent lamps which are installed in Europe are recovered and recycled at the end of life.

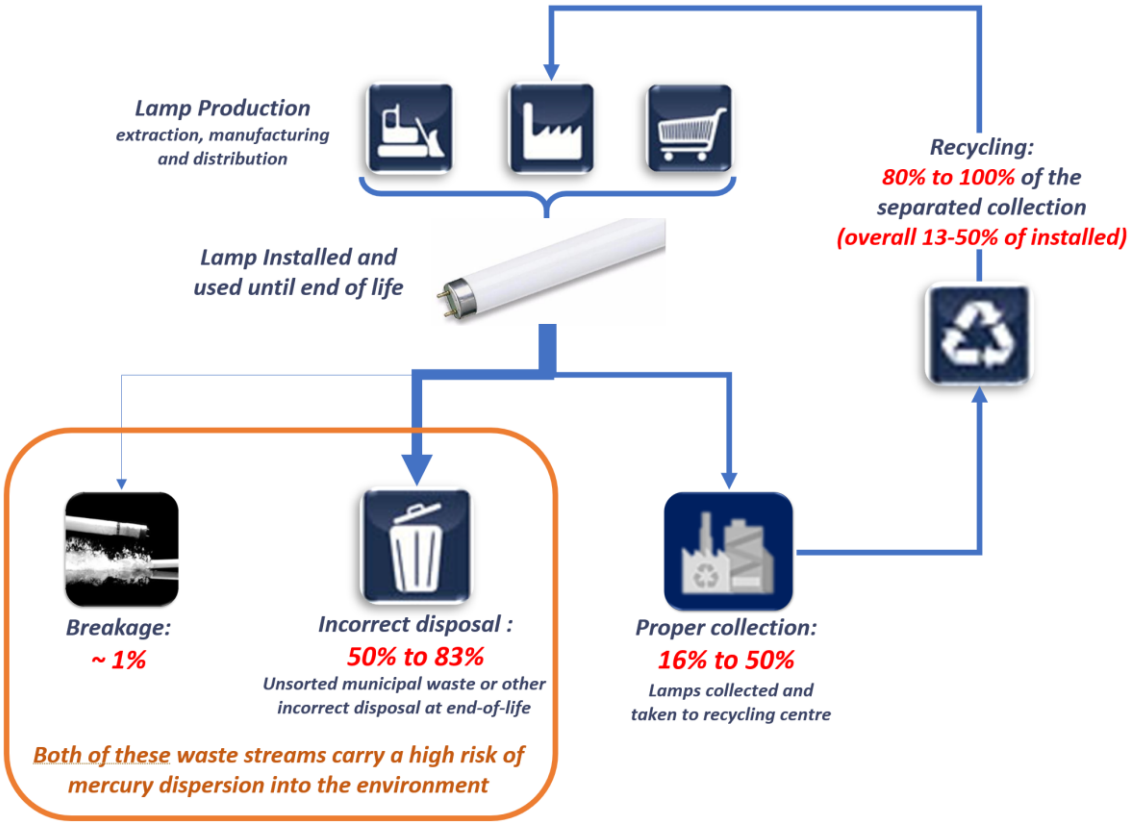


Figure 23. Life-cycle flow diagram of fluorescent lamps in Europe

Following our review of the above-mentioned sources we are concerned that **more than half of the total mercury content of T5 and T8 fluorescent lamps seems to not be appropriately treated**.

[67] Sources: * Danish Ministry of the Environment, Environmental Protection Agency, Survey of Chemical Substances in Consumer Products, No. 104 2010 - *Survey and health assessment of mercury in compact fluorescent lamps and straight fluorescent lamps*, quoting Defra, 2009. Department for Environment, Food and Rural Affairs. http://www.defra.gov.uk/environment/business/products/roadmaps/lightbulbs.htm
** Study on collection rates of waste electrical and electronic equipment (WEEE) - Possible measures to be initiated by the commission as required by article 7(4), 7(5), 7(6) and 7(7) of Directive 2012/19/EU on waste electrical and electronic equipment (WEEE), 2014- https://ec.europa.eu/environment/waste/weee/pdf/Final_Report_Art7_publication.pdf; Eurostat - https://ec.europa.eu/eurostat/web/waste/key-waste-streams/weee; Belgian estimate reported in Assistance to the Commission on Technological *Socio-Economic and Cost-Benefit Assessment Related to Exemptions from the Substance Restrictions in Electrical and Electronic Equipment: Study to assess renewal requests for 29 RoHS 2 Annex III exemptions*, 2016 - https://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/RoHS-Pack_9_Part_LAMPS_06-2016.pdf
*** Final Implementation Report for Directives 2002/96/EC and 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE): 2013 – 2015 - https://ec.europa.eu/environment/archives/waste/reporting/pdf/Final_Implementation_Report_2013_2015_WEEE.pdf

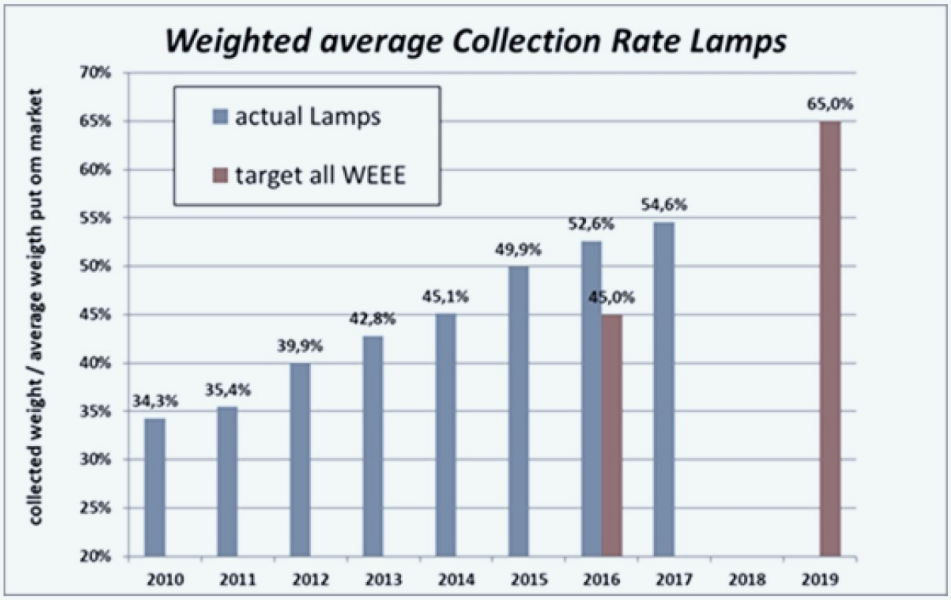
LightingEurope responded to the above estimate by providing the following information (screen captures, shaded in light blue are the LightingEurope letter):

2/ Updated data on collection of waste lamps

LightingEurope is currently collecting recent collection and recycling numbers in cooperation with EucoLight, the European association representing the WEEE schemes for lighting.

The table below contains the data we have received so far and covers both consumer and professional lamps.

The table illustrates that the lighting industry has met the 2016 target for waste collection and is on the way to reach the 2019 target.



Some general remarks about waste lamps:

- As professional lamps have a long lifetime, only a small fraction is replaced each year. Collection rates will increase over the next few years, as the number of lamps placed on the EU market will decrease.
- Professional lamps have higher collection rates compared to consumer lamps (e.g. CLF-I). LightingEurope agrees that the exemption for such consumer lamps should expire on 1 September 2021, the date communicated to the global market under EU ecodesign rules.
- The bulk of the lamps that will need to be recycled over the next few years are already installed and in service. The renewal of the exemptions will not significantly add to the number of lamps on the EU market that will need to be collected and recycled – LightingEurope estimates that the renewal of RoHS exemptions 1 and 2 will result in an 6.6% increase of the total collection and recycling effort *(see Annex 2 for the details of this calculation).*
- The lamps that will be sold in the next years (according to the EU MELISA model) are only a fraction of these installed lamps. This means that the number of lamps arriving to the waste stream will continue to decrease.

SEA/CLASP are concerned that this new data presented is from an industry association of which LightingEurope is an affiliate[68], and has not been published for

[68] https://www.eucolight.org/our-members

expert/independent review or analysis. Our estimate is based on independent sources – i.e., not the regulated entities – and our estimate is far lower than the values published by LE. As stated in Chapter 3 of this report, the 2014 European Commission study found the collection rate for lamps under the WEEE Directive was only 12% in 2010. This Commission estimate is three times lower than the estimate of 34.3% now presented by LightingEurope/EucoLight for that same year (see figure presented above in LE letter).

When there is such disparity in the claimed values – an independent study prepared by the Commission and an industry association which claims the value is three times higher – this call into question the collection rates now being reported in this internal analysis by LE/EucoLight. Everyone agrees that collection rates need to improve, but we can also all agree that adding more mercury-containing fluorescent lamps to the installed stock is not going to accomplish that.

Furthermore, SEA/CLASP call upon EucoLight/LE to improve the transparency around the terminology and numbers used in the recovery and recycling of used fluorescent lamps. We have indeed seen the word "collection" be used in different manners in different documents. This issue of lack of clarity and precision in the use of certain terms contaminated a lot of the discussion on waste. For example, the definition of "recycling rate" in the WEEE regulation only reflects the share of lamps that are properly handled after being delivered to a recycling centre or similarly specialized facility. Thus, the high recycling rate by definition excludes lamps which are disposed of in the general waste stream. Unfortunately, the majority of fluorescent lamps in Europe are not disposed of correctly and thus the mercury in those lamps ends up not being properly treated, polluting the environment and posing a health risk. To ensure that the magnitude of this mercury problem is fully understood, the collection and recycling rate should take into account all fluorescent lamps removed from service every year, and "collection" should only cover separate collection of non-damaged lamps that leads to a proper treatment with no leak of mercury into the environment.

As shown in **Figure 23** in this report, incorrect disposal at the end of life represents 50% to 83% of the fluorescent lamps removed from service at their end of life. SEA/CLASP do not see the logic in allowing the exemption to continue for T8, T5 or CFLni lamps, when drop-in, mercury-free alternatives exist and can start to reduce the waste-collection problem. LE states that the additional mercury put on the market if the exemption is maintained would be relatively small in comparison with what is in the stock of mercury lamps today. However, prolonging the use of mercury-containing lamps requires that the whole collection and recycling chain must be maintained and improved for many more years. Furthermore, we are concerned that as the remaining stock declines, this will lead to less attention and increased unitary costs, and therefore a higher risk of non-optimal treatment.

Given that the fluorescent lamp recovery process has been shown to be ineffective, and that there are mercury-free alternatives to these lighting products already available on the market today (i.e., drop-in replacements that do not need rewiring), we conclude that the RoHS exemptions for fluorescent lighting should be expired. Any

extension is not warranted and would be in violation of the objectives of the RoHS Directive and the Minamata Convention.