Exemption Request Form – Exemption #4(f)

Date of submission: **17 January 2020**

1. Name and contact details

(A) Name and contact details of applicant:

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On behalf of the Company/Business organisations/Business associations listed below participants in the **RoHS Umbrella Industry Project ("the Umbrella Project")**:

American Chamber of Commerce to the European Union (AmCham EU) EU Transparency Register ID number: 5265780509-97	ANIE Federation EU Transparency Register ID number: 74070773644-23	Communications and Information Network Association of Japan (CIAJ)	DIGITALEUROPE (DE) EU Transparency Register ID number: 64270747023-20
European Association of Internal Combustion Engine Manufacturers (EUROMOT) EU Transparency Register ID number: 6284937371-73	European Coordination Committee of the Radiological, Electromedical and Healthcare IT Industry (COCIR) EU Transparency Register ID number: 05366537746-69	Deutsche Theatertechnische Gesellschaft (DTHG)	European Garden Machinery Industry Federation (EGMF) EU Transparency Register ID number: 82669082072-33
European Partnership for Energy and the Environment (EPEE) EU Transparency Register ID number: 22276738915-67	European Passive Components Industry Association (EPCIA) EU Transparency Register ID number: 22092908193-23	European Power Tool Association (EPTA)	The European Semiconductor Industry Association (ESIA) is an industry association working under the umbrella and legal entity of the European Electronic Component Manufacturers Association (EECA) EU Transparency Register ID number: 22092908193-23
European Special Glass Association (ESGA) EU Transparency Register ID number: 053892115799-18	The European Steel Association (EUROFER) EU Transparency Register ID number: 93038071152-83	GAMBICA - The UK Association for Instrumentation, Control, Automation & Laboratory Technology	International Association of Lighting Designers (IALD) EU Transparency Register ID number: 017514515406-70
Information Technology Industry Council (ITI) EU Transparency Register ID number: 061601915428-87	Interconnect Technology Suppliers Association (ITSA)	IPC – Association Connecting Electronics Industries EU Transparency Register ID number: 390331424747-18	Japan Analytical Instruments Manufacturers' Association (JAIMA)

Japan Business Council in Europe (JBCE) EU Transparency Register ID number: 68368571120-55	Japan Business Machine and Information System Industries Association (JBMIA)	Japan Electric Measuring Instruments Manufacturers' Association (JEMIMA)	Japan Electrical Manufacturers' Association (JEMA)
Japan Electronics and Information Technology Industries Association (JEITA)	Japan Federation of Medical Devices Associations (JFMDA)	Japan Inspection Instruments Manufacturers' Association (JIMA)	Japan Lighting Manufacturers Association (JLMA)
Japan Measuring Instruments Federation (JMIF)	Japan Medical Imaging and Radiological Systems Industries Association (JIRA)	Korea Electronics Association (KEA)	LightingEurope (LE) EU Transparency Register ID number: 29789243712-03
MedTech Europe EU Transparency Register ID number: 433743725252-26	Nippon Electric Control Equipment Industries Association (NECA)	National Electrical Manufacturers Association (NEMA)	Österreichische Theatertechnische Gesellschaft (OETHG)
Live Performance Europe (PEARLE) EU Transparency Register ID number: 4817795559-48	RadTech Europe	ROBE Lighting	The Association of Lighting Designers (ALD)
The Professional Lighting and Sound Association (PLASA)	SEMI EU Transparency Register ID number: 402302029423-14	SPECTARIS - German Hightech Industry Association EU Transparency Register ID number: 55587639351-53	VPLT · The German Entertainment Technology Association EU Transparency Register ID number: 819880923782-49

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2. Reason for application:

Please indicate where relevant:

- ☐ Request for new exemption in
- ☐ Request for amendment of existing exemption in
- ☒ Request for extension of existing exemption in
- ☐ Request for deletion of existing exemption in
- ☐ Provision of information referring to an existing specific exemption in:

☒ Annex III ☐ Annex IV

No. of exemption in Annex III or IV where applicable: **4(f)**

Proposed or existing wording: existing wording below

We submit this application to request an extension of the existing exemption no. 4(f) of Annex III and propose to use the existing wording:

4(f) Mercury in other discharge lamps for special purpose not specifically mentioned in this annex

Duration where applicable:

We apply for renewal of this exemption for the categories marked in section 4 below for the respective maximum validity periods foreseen in the RoHS2 Directive, as amended. For these categories, the validity of this exemption may be required beyond those timeframes. Although applications in this exemption renewal request may be relevant to other categories not marked in section 4 further below, this renewal request does not address those categories.

☐ Other: _____

3. Summary of the exemption request / revocation request

The scope of exemption 4(f) currently covers all lamps used for special lighting purposes that do not belong to any of the groups identified in exemptions 1(a)-4(e) by technology and application in Annex III of RoHS Directive 2011/65/EU (4g is not considered as it has expired).

Discharge lamps need mercury for the generation of high power light in the visual and non-visual range. Only some projector lamps are used in households. The mercury in both of these lamps cannot be substituted and replacement lamps that use a different technology are not available. Thus, the exemptions for the use of mercury in these lamps are essential to facilitating a wide variety of commercial, public, and professional applications – many of which are essential to the EU community.

There are currently efforts to develop mercury-free technologies for some applications (e.g. low power projectors, stage lighting, horticultural lighting, UV applications). However, the new light sources used in these technologies do not replace the mercury containing lamp but instead involve the design of new equipment. Although these new applications could someday cover and even replace some existing solutions, that future is still sometime away. In the meantime, a high number of applications will remain dependent on the mercury containing lamps covered by exemption 4(f).

If 4(f) lamps were no longer allowed, many uses would cease. This is especially true of those who use higher wattage lamps, such as the European semiconductor industry. The European semiconductor industry relies on 4f lamps and any prohibition against their use would have far reaching effects. That iss because so many sectors and technologies depend on semiconductors. From communications to computing, health care, defense, transportation, and clean energy – all these sectors use applications that rely on semiconductors.

Semiconductors also enable many emerging technologies, including virtual reality, the Internet of Things, energy-efficient sensing, automated devices, robotics, and artificial intelligencem and the role semiconductors play in sustainability, including in efficient lighting, electric vehicles, and smart grids.

Beyond semiconductors, without 4(f) lamps we would not be able to produce medicines or clean drinking water and wastewater, harden the coatings that make our products last longer, and project images in our offices. In addition, valuable electrical and electronic equipment would become premature waste, and many jobs all over the EU that are dependent on the availability of these products would disappear.

Clearly, the prohibition of 4(f) lamps would have far-reaching and long-lasting consequences.

Lamps covered by this exemption renewal request:
Exemption 4(f) so far covers a group of lamps that have not been further specified like exemptions 1 a-g, 2a-b, 3a-c, and 4a-e, g of Annex III but which could be uniquely identified.

Following an exclusion principle, lamps covered by 4(f) do not belong to the family of Low Pressure Discharge lamps for general and special lighting purposes, which are covered by exemptions 1-4(a). These include:

- Compact fluorescent lamps (CFLi and CFLni),
- Fluorescent lamps (linear and non-linear FL),
- Cold cathode fluorescent lamps, and
- Low pressure UV lamps without phosphor coating operating at the same pressure as FL and CFL lamps.

Within the High Pressure discharge lamps (i.e. other than low pressure lamps) category, the following lamp families are defined in exemptions 4(b, c, e):

- High Pressure Sodium (vapour) lamps (HPS) for general lighting, and
- Metal Halide lamps (MH).

The lamps and UV light sources contained in exemption 4(f) are:

- High Pressure Sodium (vapour) lamps (HPS) for horticulture lighting,
- High pressure lamps for projection, studio, and stage lighting, and
- Medium and high-pressure UV lamps.

OEKO report Pack 9 (2016) proposes to split exemption 4(f) further and identify the most important lamp types in this group[1]. However, because several uses and applications would

[1] https://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/RoHS-Pack_9_Part_LAMPS_06-2016.pdf

not be covered by this wording, such a split would have a substantial negative socio-economic impact one those using these lamps within the EU.

Instead, we propose keeping this diverse group of lamps together in exemption 4(f), but with the addition of a more accurate description of the technical type of lamps and a summary of their applications. The more accurate technical description will allow for surveillance authorities to check whether the claimed 4(f) exemption is justified using objective measurements.

The description below is essentially in line with the approach taken in the EU Ecodesign Regulation 2019/2020[2]. It should be noted that the below definitions are only a reference to the definitions in the Ecodesign Regulation 2019/2020 and are not valid for category 8 and 9 products, as they are exempted from the Regulation.

The light sources of exemption 4(f) can only be handled by professionals because they emit dangerous UV light, are in many cases too bright for human eyes, and require special control gear to operate them.

The light sources covered by exemption 4(f) are:

High pressure sodium lamps[3]:

Specified as: "*light sources with a photosynthetic efficacy >1.2 µmol/J, and/or emitting 25 % or more of total radiation power of the range 250-800 nm in the range of 700-800 nm, and intended for use in horticulture"*

Application:

- Used in greenhouses for stimulating plant growth

Short arc mercury lamps[4]:

Specified as: "*high pressure mercury lamps with a luminous flux > 500 lumen per mm² of projected light-emitting surface area defined as the area of the largest circle that fits between the electrodes of the high pressure lamp*"

Applications:

- Lamps for projection purposes (being part of projectors)
- Lamps for entertainment, cultural, and stage lighting purposes
- Short-arc lamps for microlithography (essential for semiconductor production), boroscopy, and microscopy, along with fiber-optic lighting

[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.)
[3] Page 25, Ibid
[4] Page 4, see footnote 4

Medium and high pressure mercury lamps[5]:

Specified as *"light sources with specific effective ultraviolet power >2 mW/klm and intended for use in applications requiring high UV-content"*

Applications:

- Medium and high-pressure UV lamps for curing, disinfection, sterilization, and other photochemical and photobiological purposes
- High Pressure Electrodeless UV Light Sources for various applications
- High pressure lamps for the treatment of zoo mammals and birds, daylight simulation and other applications
- Curing of inks in printing systems and the hardening of adhesives and silicones
- Disinfecting surfaces, water, and air
- UV curing of composites, automotive coatings, glass, and plastic decoration
- Wood treatment
- Production of electronic components and printed board
- Medical, industrial, research and development applications, including testing, inspection, measurements, qualitative and quantitative analysis, and utilising specific wavelength

Figure 1 describes the lamp technologies covered by RoHS Annex III exemptions 1-4 as valid in January 2020.

[5] Page 25, see footnote 4

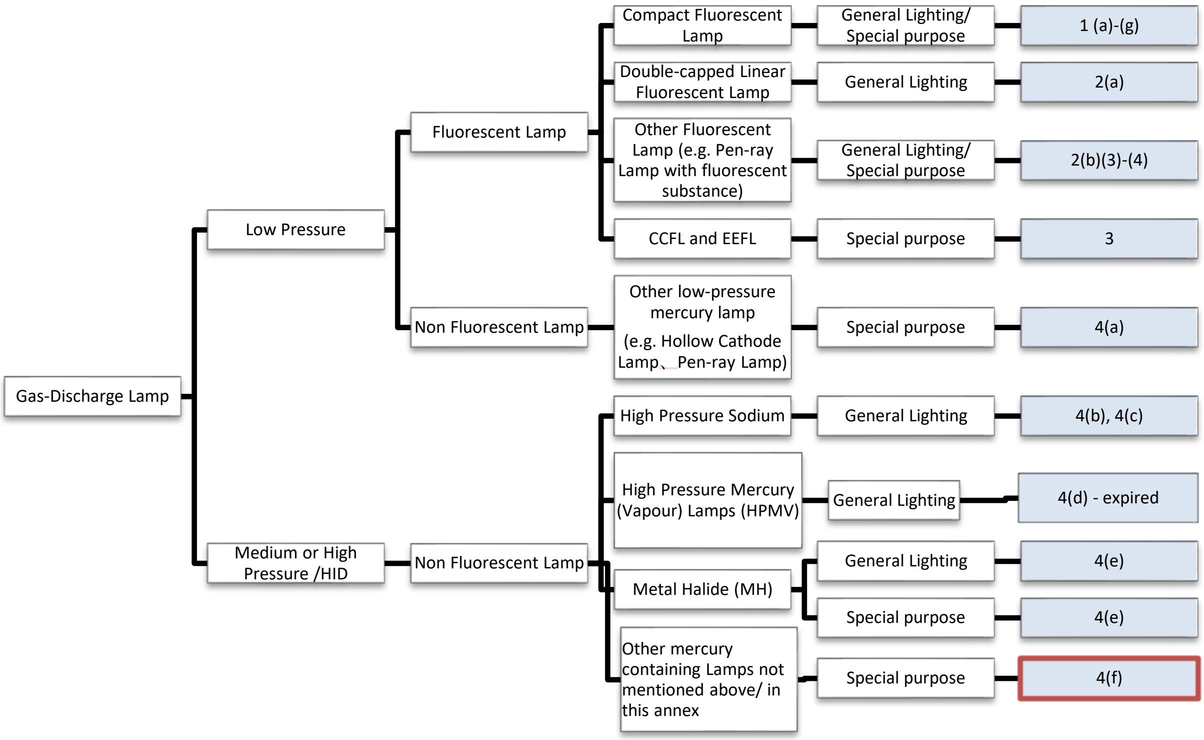

Figure 1: Chart on the hierarchy of lamps and exemptions

We would like to stress that Exemption 4(f) and the belonging lamp types represent a small market share and are responsible for only a small part of mercury use compared to the other lighting exemptions.

Replacement of mercury and mercury containing lamps is impracticable:

The lamps covered by exemption 4(f) must remain available on the EU market:

- For new equipment for certain applications where no functionally suitable alternatives are available
- As spare parts for in-use equipment as replacing end-of-life lamps avoids having equipment become electronic waste before due time

The requirements of RoHS Art. 5(a) are met:

- Substitution of mercury in the lamps is not possible.
- There are no or nearly no mercury-free replacement lamps available for the electrical and electronic equipment in which they are used in.
- In those cases where a different technical solution is already available or will be in the future (e.g. for smaller wattage projector lamps, certain UV applications), a complete redesign of the equipment is required for such light source to be used.

- These alternative solutions require, like all electrical and electronic equipment, additional use of lead in materials and electronic components currently exempted according to Annex III of RoHS Directive.
- It is impossible to calculate the negative socio-economic impact that banning 4(f) lamps would have. Such a move would have huge consequences on commercial and industrial processes, the health of people, availability of clean drinking water, availability of electrical and electronic equipment for cultural and entertainment purposes – to name only a few.
- The accidental prohibition of certain lamps could have a high socio-economic impact on the customer and user of the lamp, as well as for the producer of the equipment in which the lamp is used. For example, the 4(f) proposal of the OEKO report (2016) does not cover certain stage lighting lamps or the UV lamps used for microlithography and which are essential for semiconductor production in the EU.
- Potential misuse and difficult market surveillance, as argued in the OEKO report (2016) [6] as the main reasons for excluding important lamps from the scope of 4(f), is in practice very unlikely and easy to detect by market players. Market surveillance is in the best interest of lamp producers as well as the manufacturers of potential Hg-free alternatives and authorities would be immediately notified of any misuse.

Table 1, below, provides a summary of why exemption 4(f) is still needed:

6 Assistance to the Commission on Technological Socio-Economic and Cost-Benefit Assessment Related to Exemptions from the Substance Restrictions in Electrical and Electronic Equipment, :2016 (OER)

Requirement according RoHS Article 5(a)	Status for mercury in other discharge lamps for special purposes not specifically mentioned in this Annex
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,	Substitution of mercury in the lamps covered by this exemption is scientifically and technically impracticable. In addition, retrofit replacement lamps using a different technology, such as Light Emitting Diodes (LED), are not available. In those cases where a different technical solution is available, a complete redesign of the equipment in which the lamp is used is required. These solutions require the use of lead in materials and electronic components currently exempted according to Annex III of RoHS Directive.
the reliability of substitutes is not ensured,	In those cases where a different technical solution based on LED, laser or other technology is available, the reliability of the products must be ensured and documented in the CE Declaration of Conformity. Although enough experience on the reliability of existing technologies is available, for new product technologies, long-term reliability needs to be demonstrated in practice.
the total negative environmental, health and consumer safety impacts caused by substitution are likely to outweigh the total environmental, health and consumer safety benefits thereof.	LED-based replacement lamps are currently not available for lamps covered by this exemption. The existing technologies have a negative impact coming from mercury use. In those cases where alternative technologies are available, they are usually less material efficient. Example: HPS lamp for horticulture lighting need far less material compared to the batteries used by horticulture LED modules for lighting the same plant area. The conventional lamp is also highly energy efficient. In cases where the lamps would no longer be available, even for existing equipment, a high amount of waste would be generated. Detailed information on the environmental impact of this can only be evaluated by the producers and users of the equipment in which the lamps are used.

Table 1: summary justifying renewal of exemption 4(f)

4. Technical description of the exemption request / revocation request

(A) Description of the concerned application:

1. To which EEE is the exemption request/information relevant?

   Name of applications or products:

The scope of exemption 4(f) covers those lamps that

- are non-fluorescent, and
- have higher internal pressure compared to fluorescent lamps, and
- are not covered by exemptions 4(b), 4(c) and 4(e), and
- are used for special purposes.

These lamps are used in a wide area of applications as described below.

a. List of relevant categories: (mark more than one where applicable)

☒ 1	☒ 7
☒ 2	☒ 8
☒ 3	☒ 9
☒ 4	☒ 10
☒ 5	☐ 11
☒ 6	

b. Please specify if application is in use in other categories to which the exemption request does not refer:

Applications in this exemption renewal request may be relevant to categories not marked above or below.

We are of the opinion that lamps in general are category 5 because the majority are used for general illumination. However, they have some of the characteristics of components (used in luminaires), consumables (finite lifetime and regularly replaced), and spare parts (lamps in luminaires have to be replaced when they cease functioning). Because some manufacturers of electrical equipment in other RoHS categories may install fluorescent lamps into their equipment for general illumination purposes, they will need to use lamps that comply with the RoHS Directive. However, the products that they place on the market are not category 5 but may be household appliances, medical devices, or potentially in any RoHS category.

c. Please specify for equipment of category 8 and 9:

The requested exemption will be applied in

☐ monitoring and control instruments in industry

☐ in-vitro diagnostics

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

2. Which of the six substances is in use in the application/product?

   (Indicate more than one where applicable)

   ☐ Pb ☐ Cd ☒ Hg ☐ Cr-VI ☐ PBB ☐ PBDE

3. Function of the substance:

The function of Hg in gas discharge lamps lies within the light generating process of converting electricity into light. Electrons are emitted from a heated electrode that collides with mercury atoms, a collision that elevates their electrons to an excited state. When these fall back to their original energy state, they emit photons either in the ultraviolet (UVC, UVB, UVA & UVV) or visible light wavelength range, depending on the technology.

By using a mix of different element atoms in the hot gas plasma, each emitting at specific wavelengths, the spectral distribution of the lamp as a whole and the quality of its colour rendition properties can be controlled.

The use of mercury allows these needed properties to be achieved.

Because of its unique combination of properties that no alternative can provide, mercury has been used for many decades. Mercury has a relatively low boiling temperature, meaning it is readily able to produce a vapour of suitable pressure. The heavy mercury atom slows down the fast electrons as they make their way though the plasma. When the electrons collide with the mercury atom, UV light is generated very efficiently.

Mercury vapour is essential: all mercury is evaporated and the resulting pressure is chosen in such a way that:

- the system can provide the exact power to the lamp
- the discharge radiates as effective as possible
- it generates the required wavelengths for the desired application and with a brightness that allows for the most effective collection of the light

Since the applications for 4(f) lamps differ, the designs and amount of mercury used also differs widely. For example, very high power lamps need a certain lamp volume to prevent the heat generated in the discharge from melting the wall of the discharge vessel. If the same high power lamp is used for projection, the arc must be very compact. This requires a very high mercury pressure. The combination of very high pressure and a large discharge requires a large amount of mercury (up to 100 gram), e.g. in short arc mercury lamps. Other lamps, such as those used for water purification, require very efficient UV generation. Here the generated UV must escape from the discharge without trapping the radiation. These lamps have a medium mercury pressure (below 1 bar).

Mercury in High Pressure Sodium lamps:

The main role of mercury is different in HPS lamps, where it is used to tune the resistance of the plasma in such a way that the efficiency of the combination lamp and driver functions in an optimal way.

High Intensity Discharge lamps generate light in a compact plasma arc with high brightness. After the lamp is started by a voltage pulse, the initial noble gas discharge heats the lamp and evaporates part of the sodium/mercury amalgam pill. At first it is mainly the mercury that goes into the vapour phase. The increasing mercury vapour pressure increases the electrical resistance in the discharge, which allows more power to be put into the discharge. As a consequence of more power coupled into the discharge, the discharge tube wall heats up and sodium and mercury evaporate further until a state of thermal equilibrium is established between the electrical power supplied to the discharge, the heat conducted to the surroundings, and the radiation emitted from the discharge. The lamps are designed in such a way that the optimal efficiency is reached at this equilibrium.

Although the mercury is not consumed over life, the sodium in the discharge tube does chemically react with the PCA wall (Polycrystalline alumina, ceramic discharge tube) and the electrode emitter [7,8]. As a result, the fraction of mercury in the amalgam becomes higher, which raises the lamp's voltage. At a certain point in time, the lamp voltage becomes so high that the mains voltage can no longer sustain the arc and the lamp extinguishes. This is the end of the lamp's life. For a given sodium consumption, a certain amalgam dose is required to reach the specified life. If the dose is too small, the ratio of mercury in the amalgam rises rapidly, as does the lamp's voltage, leading to a premature end of life.

The main role of mercury is to tune the resistance of the plasma in such a way that the efficiency of the combination lamp and driver is optimised. However, the mercury also has several additional essential functions to fulfil:

1. The mercury in the plasma of a High Pressure Sodium lamp does not directly contribute to the spectrum of the lamp because the arc temperature is too low to excite

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[7] Luijks G.M.J.F., Sodium-PCA interaction in unsaturated HPS lamps, paper submitted for the LS6 conference in Budapest, Sept. 1992

8 Itoh, A. and Okamura, K., Evaluations of the sodium reduction in HPS lamps, paper submitted for the LS6 conference in Budapest, Sept. 1992

the interesting (optical) energy levels of the mercury atom. However, there is a very significant indirect contribution of the mercury atoms: the proximity of mercury atoms shifts the energy levels of sodium and allows for a substantial broadening of the sodium resonance line[9,10]. This broadening shifts the emission of the lamp to the red and, by tuning the amalgam composition, the optimum radiation for growing plants can be obtained.

2. The presence of the mercury vapor also greatly reduces the thermal conduction of the sodium-mercury-xenon plasma[11] . Therefore, there is less heat loss from the plasma to the discharge tube wall. The efficiency of the lamp is thereby greatly improved by the presence of mercury[12].
3. The high pressure of mercury limits evaporation of the hot tungsten electrode. The low evaporation helps maintain the light flux over the lamp's lifetime. A high evaporation rate of tungsten would lead to a blackening of the arc tube, reducing the transmission of light and thus lowering lumen maintenance.

The use of a high Xenon pressure further improves the efficiency of these lamps. This makes them even more distinct from ordinary high-pressure sodium lamps. As the broadening of the spectrum towards the red is essential, there are no mercury-free alternatives for these lamps.

4. Content of substance in homogeneous material (%weight):

The RoHS Directive (2011/65/EU) defines homogenous material as a material that cannot be further mechanically disjointed. In the case of lamps, mercury is inserted or dosed into the burner in various forms (typically as liquid mercury in medium- or high-pressure discharge lamps). However, other forms are also in use. For example, high-pressure sodium lamps use a Mercury-Sodium amalgam.

Mercury is present in the so-called discharge tube or burner. In nearly all mercury discharge lamps used for special purposes, a very specific amount of mercury is needed. Below, the most common dosing technologies are listed for lamps covered by this exemption:

- Manual pipetting or needle injection of liquid mercury (100% Hg)
- Semi- or fully-automatic dosing, disc needle injection of liquid mercury (100% Hg)
- Mercury-Sodium amalgams Na-Hg (ca. 20% Hg)
- Amalgam sticks (ca. 20-50% Hg)

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[9] Woerdman, J.P, Schleyen, J., Korving, J., Van Hemert, M.C, De Groot. J.J. and Van Hal, R.P.M., Analysis of satellite and undulation structure in the spectrum of Na+Hg continuum emission, J. Phys. B : At.Mol.Phys.,vol.18, pp4204-4221 (1985)

[10] J.de Groot and J. Van Vliet, The High Pressure sodium lamp, Kluwer Techische Boeken B.V. Deventer, ISBN 9020119028 (1986), p. 141 to 145

[11] J.de Groot and J. Van Vliet, The High Pressure sodium lamp, Kluwer Techische Boeken B.V. Deventer, ISBN 9020119028 (1986), p. 130 to 131

[12] J.de Groot and J. Van Vliet, The High Pressure sodium lamp, Kluwer Techische Boeken B.V. Deventer, ISBN 9020119028 (1986), p. 149 to 153

5. Amount of substance entering the EU market annually through application for which the exemption is requested:
   Please supply information and calculations to support stated figure.

There is no single database or reliable evaluation that provides accurate data. The figures below come from different market studies and from the input of individual companies. The amount of mercury is LightingEurope's best estimation.

Lamp type	***Mercury range per lamp***	***Mercury put on EU market***
High pressure sodium lamps for horticulture lighting	*19-40 mg, depending on type, Wattage*	*Data can be shared in confidentiality as part of a future consultation[13].*
Lamps for projection purposes	*10-48 mg, depending on Wattage, average 20mg*	• *Ca. 22 kg maximum in new projector lamps* • *6 kg maximum in replacement/spare part lamps*
Lamps for studio and stage lighting	*10-40 mg, depending on Wattage, average 30 mg*	*6 kg maximum*
Short arc mercury lamps	*20 mg – 8 g per lamp in EU (50 – 6.500 Watt)* *Medical, curing: 20 mg average* *Semiconductor production: 720mg average*	***6.1 kg total EU:*** *1.1 kg total EU medical* *5.0 kg total semiconductor production*
Medium pressure UV lamps	*Typical range of 10-3000 mg*	• *Curing: 2018 - 108 kg; 2021 - 158 kg* • *Disinfection: less than 100kg per year* • *Detailed data can be shared in confidentiality as part of a future consultation.[14]*
Other high pressure	*No information available*	*No information available*

Table 2: Estimation of the amount of mercury put on the market per year in lamps covered by exemption 4(f) of RoHS Annex III.

[13] Due to competition law, data can only be supplied under confidentiality as part of a future review of this exemption dossier.
[14] Ibid.

High Pressure Sodium lamps:

Although the Melisa model established for the Ecodesign Regulation 2019/2020[15] provides a good estimate of the total number of HPS lamps entering the market annually, the amount used for horticulture applications is narrow and has only a few players. Revealing the number of lamps put on the market is confidential competitive information and is not allowed within LightingEurope due to Competition Law. Thus, LightingEurope can only estimate the amount of mercury. Using the Melisa model, it is estimated that 7.1 million HPS lamps were put on the market in 2019. With approximately 10% of these lamps being used for horticulture applications and thus containing less than 40 mg of mercury, we can roughly estimate that HPS lamps are responsible for putting 30 kg of mercury on the market in 2019. The Melisa model estimates a general decline of 6% per year for all HPS lamps, leading to the amount of mercury put on the market by this application being reduced to 22 kg per year after five years.

Lamps for projection purposes:

According to LightingEurope estimates, in 2019, of the approximately 6.2 million new projectors placed on to the market, 5.3 million contain mercury. In addition, around 1.5 million lamps are marketed separately for replacement (aftermarket lamps). Lamps for projection purposes are mainly marketed by lamp manufacturers to projector manufacturers located outside the EU. Lamps are then reimported, contained within a projector, as a projector spare part. Calculating a market share of 20% for Europe leads to approximately 1.36 million lamps (1.06 million in new projectors, 0.3 million replacement) containing around 28 kg of mercury. Taking into account the annual expected market decline, the amount of mercury put on the market by this application will be reduced to 13 kg by 2023.

Lamps for stage lighting, studios, and entertainment

LightingEurope estimates around 1 million entertainment lamps are marketed worldwide every year. Around 80% of them are used for new equipment, and 20% as replacement lamps. Using a market share of 20% for Europe, we calculate 200,000 lamps containing a total of about 6 kg of mercury.

Medium Pressure UV lamps

Our estimate on the quantities of mercury used annually in Europe for producing lamps used in the areas of curing and disinfection is based on publicly available figures from Yole Development. As to curing application, we arrive at a quantity of 108 kg in 2018 and 158 kg for 2021. However, as to disinfection applications, we see a total of less than 100 kg per year. From our point of view, approximately 200 kg of mercury are used in UV lamps for disinfection and curing annually in Europe. In addition, lamps from other regions are supplied to the European market.

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15 Page 85 of “Melisa Model” Impact assessment - SWD(2019)357/996485 - Part 2 -available for download at the following link here: https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2018-476175_en.

A big portion of UV lamp manufacturers are smaller producers, not members of LightingEurope, and often located outside the EU. Their lamps are mainly imported as part of the system in which they are used, as well as related spare parts.

High Pressure Short Arc mercury lamps:

The EU market for High Pressure Short Arc mercury lamps can be separated into the following applications:

- Medical, Microscopy, Curing etc.: Ca. 55,000 lamps (mainly 50-200 Watt) per year;
- Industrial (Integrated Circuits) Ca. 7,000 lamps, (mainly 200-6.500 Watt) per year.

The total mercury content of these lamps is around 6 kg per year. Semiconductor production includes production of LED chips, and other IC, memory, MEMs, sensors, ASICs, etc.

6. Environmental Assessment:

☐ Yes

☒ No

An LCA was compiled or the production, use, and disposal of short arc mercury lamps. The Cumulative Energy Demand of this lamp, OSRAM HBO 12000 W/Chl, has been published under www.osram.com/lca.

(B) In which material and/or component is the RoHS-regulated substance used, for which you request the exemption or its revocation? What is the function of this material or component?

Mercury is inserted into the discharge tube or burner used for converting electrical energy into light.

(C) **What are the particular characteristics and functions of the RoHS-regulated substance that require its use in this material or component?**

Lamps emitting light in the visible wavelength range

High-pressure mercury gas discharge lamps can emit radiation directly as visible light. It is the use of mercury that allows the needed properties for creating visible light to be achieved.

Lamps for projection

Exemption 4(f) lamps are essential to the projection market, including those used for commercial, medical, and scientific purposes. It can even be found in small quantities in projection lamps for private use. These lamps are typically used in equipment having a much longer life-time than the lamps themselves.

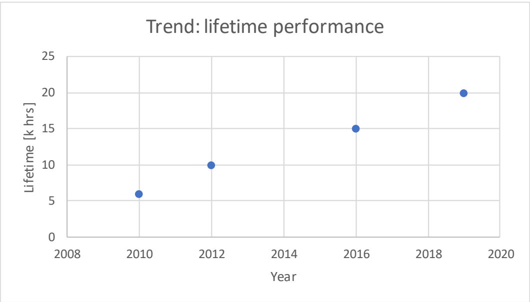
- For new equipment: only limited alternatives to mercury lamps exist in the projection market, and only for specific applications. The vast majority of projectors still need mercury-based lamps (*see section on alternatives to mercury containing lamps for projection, p. xx*).
- Existing equipment in the European market: The mercury containing lamps used for projection are tailor-made to the application/projector in terms of form, fit, and function. Consequently, no other replacement light source – aside from mercury-based lamps – can fit in the projector. This is different than the general lighting sector, where LED replacement bulbs are widely available. (*For more information, see section on alternatives to mercury lamps, p. xx*). Out of pooling data on projector sales provided by the consultancy firm Futuresource (based on 2018 data), an average of 7 mpcs projectors are sold worldwide every year, of which approximately 25% are sold in Europe. Assuming that the average life of a projector is 10 years, the installed base in Europe is estimated to be 17 million projectors. The continuation of mercury-based lamps are needed to serve this base of existing projectors with spare parts and to avoid turning it into electronic waste before necessary.

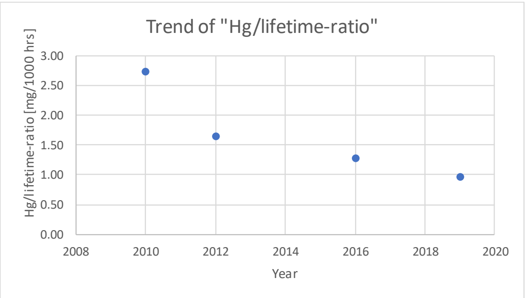
Based on the above, it should be concluded that for both the initial market and for the existing installed base of projectors, the continuation of mercury-based lamps is needed. That’s because projection applications are very demanding about the light source. To reach sufficient brightness, the light of the lamp has to be efficiently collected onto the imaging display. This can only be achieved with a lamp that resembles a point source (i.e., a lamp with a high luminance and a short arc).

For these UHP (Ultra High Pressure) lamps, the high luminance of the plasma is reached using pure mercury (1) at a very high pressure (2).

(1) Using only mercury results in the best luminance arc. Compared to lamps with spectrum additives (high-performance metal halides), the luminance in a mercury-based lamp is higher by a factor of two[16]. Furthermore, in a pure mercury gas it is possible to design a halogen cycle that keeps the wall clean. This is necessary to obtain a long lifespan small lamps. Mainstream projector lamps currently have a lifespan of 5 000 to 20 000 hours, whereas typical high-performance metal halide lamps (with lower pressure and less mercury) typically expire around 1 000 hours.

Evolution of UHP lamps: UHP lamps are constantly being improved to increase their lifespan and decrease Hg consumption, as shown in graphs below:





(2) By reducing the current, the high-pressure reduces the load on the electrodes and serves as a buffer gas to insulate the arc from heat loss. The high-pressure also limits the diffusion of tungsten atoms away from the hot electrode. In addition to the halogen cycle, these properties are also enable the long lifespan of UHP lamps compared to other high luminance lamps. The high-pressure also improves the lamp's spectrum, allowing it match the required output spectrum for quality picture imaging (according REC709 standards). The good colour quality

[16] New UHP Lamp Technologies for Video Projection, Holger Mönch, 2001, *SID-ME Meeting on display Materials and Components Fall 2001* LightingEurope

is due to the extreme pressure and the *Bremsstrahlung* (i.e., deceleration radiation) generated by the collision of electrons with mercury atoms[17].

Special application of projection lamps (rear projection)

The projection lighting domain can be split into two technologies, both of which use the same lamp solution:

- Front Projection Applications
- Rear Projection Applications

As discussed above, front projection applications, also called projectors or beamers, predominantly require high-pressure mercury short arc lamps. This is true for both new applications and the replacement market.

Rear projection (solutions with integrated screens) differ from front projection applications. The rear projection market can be split into two market segments:

- RP-TV: Rear Projection Television
- Video wall application (stacking of multiple RPTV engines)

Rear projection TV

Video wall

Difference between front and rear projection

Front projection is typically used to project content onto a separate screen. To do this, the projector is typically positioned in front of the screen (hence the name). Rear projection

[17] Bremsstrahlung radiation from electron–atom collisions in high pressure mercury lamps, J E Lawler 2004 *J. Phys. D: Appl. Phys.* **37** 1532
Infrared continuum radiation from high and ultra-high pressure mercury lamps, J E Lawler, A Koerber and U Weichmann ,2005 *J. Phys. D: Appl. Phys.* **38** 3071

applications, on the other hand, typically project onto a built-in screen (within the application, comparable to televisions) and the projection device is located behind the screen (i.e., rear).

Currently, the vast majority of rear projection systems have transitioned to LED based TVs. However, existing applications still require replacement lamps. As with the front projection aftermarket, there is no retrofit solution available for LED. This means that if you want or have to upgrade your system to an SSL solution, the entire application must be replaced with a new equipment. Doing so has a significant socioeconomic impact, as unnecessary waste is created and new equipment is produced. Furthermore, oftentimes this new equipment contains small amounts of hazardous substances – even RoHS regulated substances in exempted applications (for technical reasons, see front projection).

As rear projection is more comparable with a television system, brightness is also specified in a different way than it is with front projection. The luminance of the application is used to specify the brightness output as candela per square metre (symbol: cd/m2). Most of the times nit (symbol: nt) is a non-SI name also used for this unit (1 nt = 1 cd/m2).

Example of control room.

Lamps for stage lighting and other cultural and entertainment purposes:

Lamps for projection under exemption 4(f) include not only lamps used in projectors, but also those used for studio and stage lighting. These lamps are essential to concerts, shows, theater, studios, and film sets. Discharge lamps are used by the entertainment industry for high-powered, automated fixtures (moving lights) and follow spots (high-powered lights specifically used for 'following' a performer from a long distance away and operated by a human operator). For theatrical performances, there is an artistic requirement to have a very bright light source, and touring shows tend to use a lot of small discharge lamps, which are very efficient.

An illustration of this lamp is shown in the picture below.

The lamp power of these kinds of lamps varies between 100W and 650W. Luminous flux goes up to 33 000 lm (depending on lamp wattage and the aperture size of the measurement device). The very small arc distance of 0.7mm towards 1.5mm enables a very high beam intensity.

The lamps are used in equipment that have a much longer lifespan than the lamps themselves have. Thus, the lamps must remain available on the market as spare parts:

- For new equipment, as there are no or nearly no alternatives available on the EU market.
- For equipment in use, to replace extinguished lamps and thus avoiding equipment unnecessarily turning into electronic waste before due time. The typical weight of an entertainment fixture varies between 20 and 35kg.

LightingEurope is aware of the difficulty of unambiguously classifying certain lamps in the category set out by RoHS legislation. However, for lamp manufacturers, it is essential to have legal certainty regarding the possibility of putting products on the market irrespective of the planned application as we are not able to control the use of the lamps in products. While for general lighting it is more understandable that they cannot be considered as "spare parts of a luminaire", application-specific and special-purpose lamps can also be considered as a spare part (or consumable) in certain applications (i.e., entertainment fixtures).

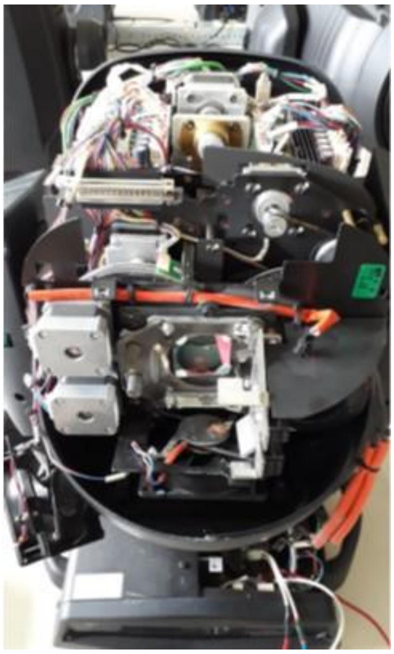
The compact and lightweight design of the lamps provides OEMs the freedom to create small and lightweight fixtures that can be used at any location on a stage. But even though these lamps are small and light, they can create powerful light beams. That's because the combination of the short arc, dedicated reflector, and high-color temperature produces a sparkling, high beam intensity. The lamps also offer a long and reliable lifetime, high efficacy, and fast replacement times.

The lamps are used in dedicated fixtures that are developed specifically for these lamps.

The fixtures for these lamps are complexi, combining a dedicated lamp holder and dedicated cooling and optical systems.

- Lamp holder: to get the best performance, it is very important that the lamp is aligned well in the fixture. This is achieved via a dedicated lamp holder (depending on the reflector type used).
- Cooling: cooling is essential to reaching optimal performance over the lamp's lifespan. The requirements for the cooling design depend on the lamp's design (lamp power, burner design, reflector).
- Optical system: in combination with the lamp design, the optical system is designed to achieve optimal optical performance. Optical components such as color wheels, gobo's, etc. are used to create the desired optical effects.

An example of the complex inner design of a typical entertainment fixture is shown in the picture below. Because of the high complexity, these entertainment fixtures are quite expensive, with typical prices up to €14 000.



Within the entertainment sector, three different fixture types can be distinguished: beam, spot, and wash. The difference between these fixture types is in the beam angle:

- Beam: < 4°
- Spot: between 5° and 50°
- Wash: > 50°

In reality, most OEMs produce a combination of two or three types, the so-called hybrid fixtures: beam/wash (2-in-1) or beam/spot/wash (3-in-1).

The brightness level is extremely important for beam applications,. This high brightness (up to 28 000 lm/mm²) can only be achieved using lamps with a very short arc.

In the most recent developments, there is a trend towards higher spans (up to 6 000 hours), resulting in a decrease in Hg-consumption in the market (as lamps do not need to be replaced as often).

Lamps for horticulture applications (High-Pressure Sodium lamps):

In lamps used for horticulture applications, mercury broadens the sodium radiation from yellow light towards the red part of the spectrum. It also increases the efficiency of the lamp to stimulate the growth of plants. Currently, there is no available substitute technology that meets all the functional requirements of lamps used in this application.

This exemption covers the High-Pressure Sodium (HPS) lamps used in horticulture, a member of the High Intensity Discharge (HID) lamps group. HPS lamps for horticulture are designed to stimulate plant growth (examples include tomatoes, cucumbers, and flowers) and are illustrated below:

The efficiency of the lamps is not expressed in lumens/W, as plant growth responds to the photons almost universally (i.e., each photon above a certain minimal energy is of about the same efficiency). Research by universities and applied agricultural research stations has demonstrated that the rate of photosynthesis is related to the number of photons (typically between 400– 700 nm). This photosynthetic flux (Photosynthetic Photon Flux, or PPF) measures the total stream of light available for the plants. This is expressed as the micromole of photons per second (μmol / s)[18].

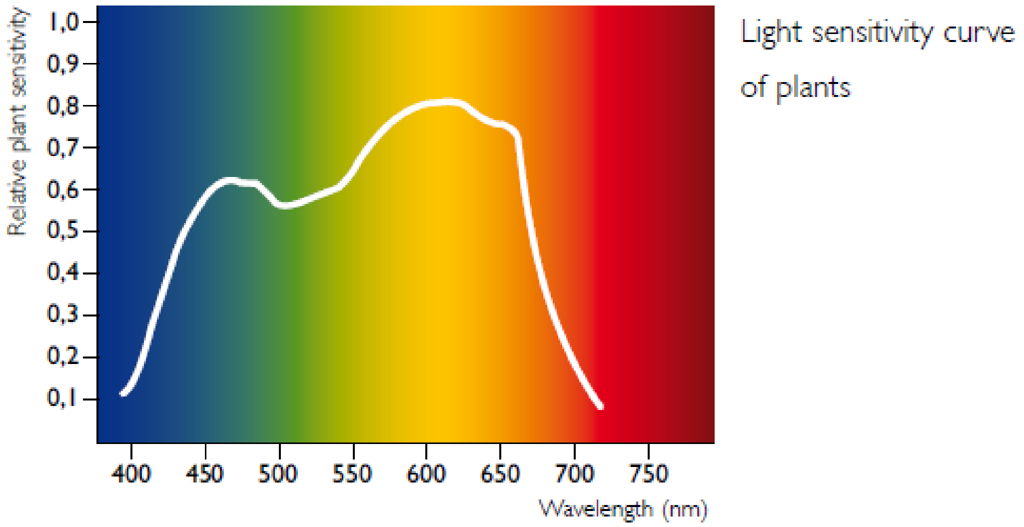


Figure 2: Light sensitivity curve of plants defining PPF.

A system's efficiency is measured as micromoles of photons per Joule electrical energy, which ranges from 2.1 (micromole photons/Joule), for the most efficient 1 000W lamp, to 1.6 (micromole photons/Joule) for 250W lamps.

Since plants are used to receiving light from above, these lamps are mounted above the plants and should be as compact as possible (their small size helps ensure that they don't block useful sunlight). The lamps are handled by technically skilled installers and sold by specialised distributors or as part of lighting equipment.

A recently discovered secondary effect of these lamps is their ability to provide irradiation with infra-red light. Many crops benefit from infrared radiation from above (from the direction of the sun), especially during the winter. The flux depends on the plant, but for tomatoes it is about 25-30 W/m^2, which is easily provided by HPS lighting. In LED lighting, this radiation is absent. Modern greenhouses typically combine HPS and LED lamps so as to benefit from both[19].

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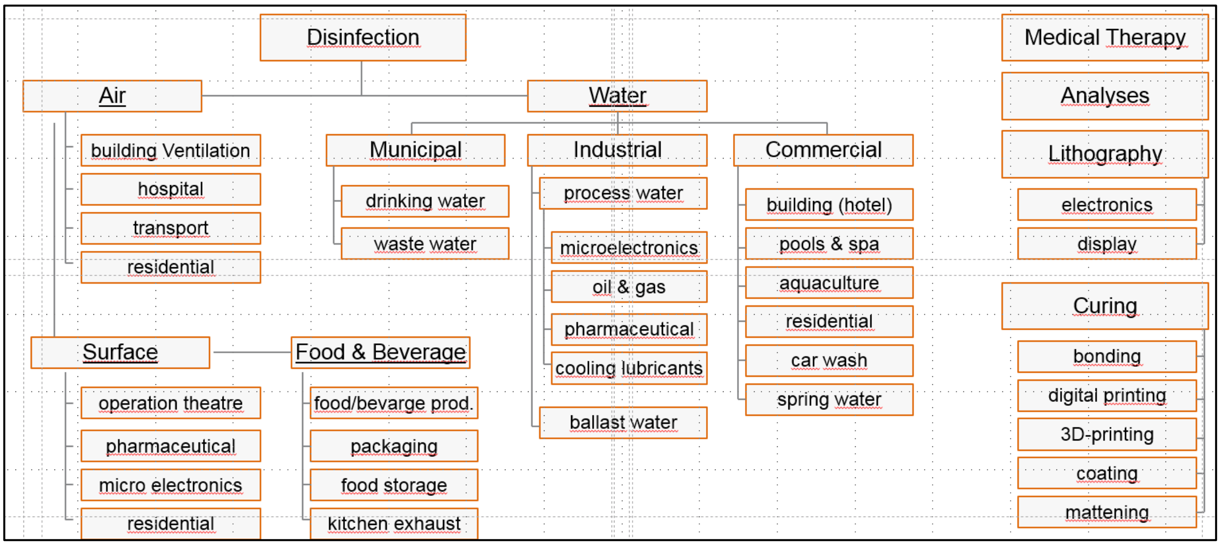
[18] Accuracy of quantum sensors measuring yield photon flux and photosynthetic photon flux. Barnes C[1], Tibbitts T, Sager J, Deitzer G, Bubenheim D, Koerner G, Bugbee B, HortScience. 1993 Dec 28 (12):1197-200.
[19] http://www.energiek2020.nu/fileadmin/user_upload/energiek2020/onderzoek/licht/docs/Warmtevraagstuk_led_in_tomaat.pdf http://www.energiek2020.nu/uploads/media/Stralingswarmte_en_led.pdf

HPS lamp customers are farmers with greenhouses, especially greenhouses equipped with cogeneration equipment for generating their own electricity and that use the CO_2 and heat produced in this process to stimulate crop growth.
De Groot and Van Vliet[20] give a comprehensive review of the operation principles of the HPS lamp. Further developments are discussed in a paper by Geens and Wyner[21].

HPS lamps are characterised by a very long lifespan (30,000 to 50,000 hours) and a very high luminous efficiency (from 80 lm/W to 150 lm/W). HPS lamps can only operate on designated drivers that switch the lamp on and regulate the power. These drivers can be a combination of an electro-magnetic ballast (inductive/capacitive load) used to stabilise the lamp's current and a high voltage pulse generator (ignitor) used to ignite the lamp. Today, electronic drivers are also used to stabilise the lamp at the correct power.

Lamps emitting light mainly in the ultraviolet (UV) wavelength range

UV lamps are required for many industrial and commercial processes and markets. The picture below provides an overview of the different uses of low-, medium-, and high-pressure UV lamps:



Medium-pressure UV lamps

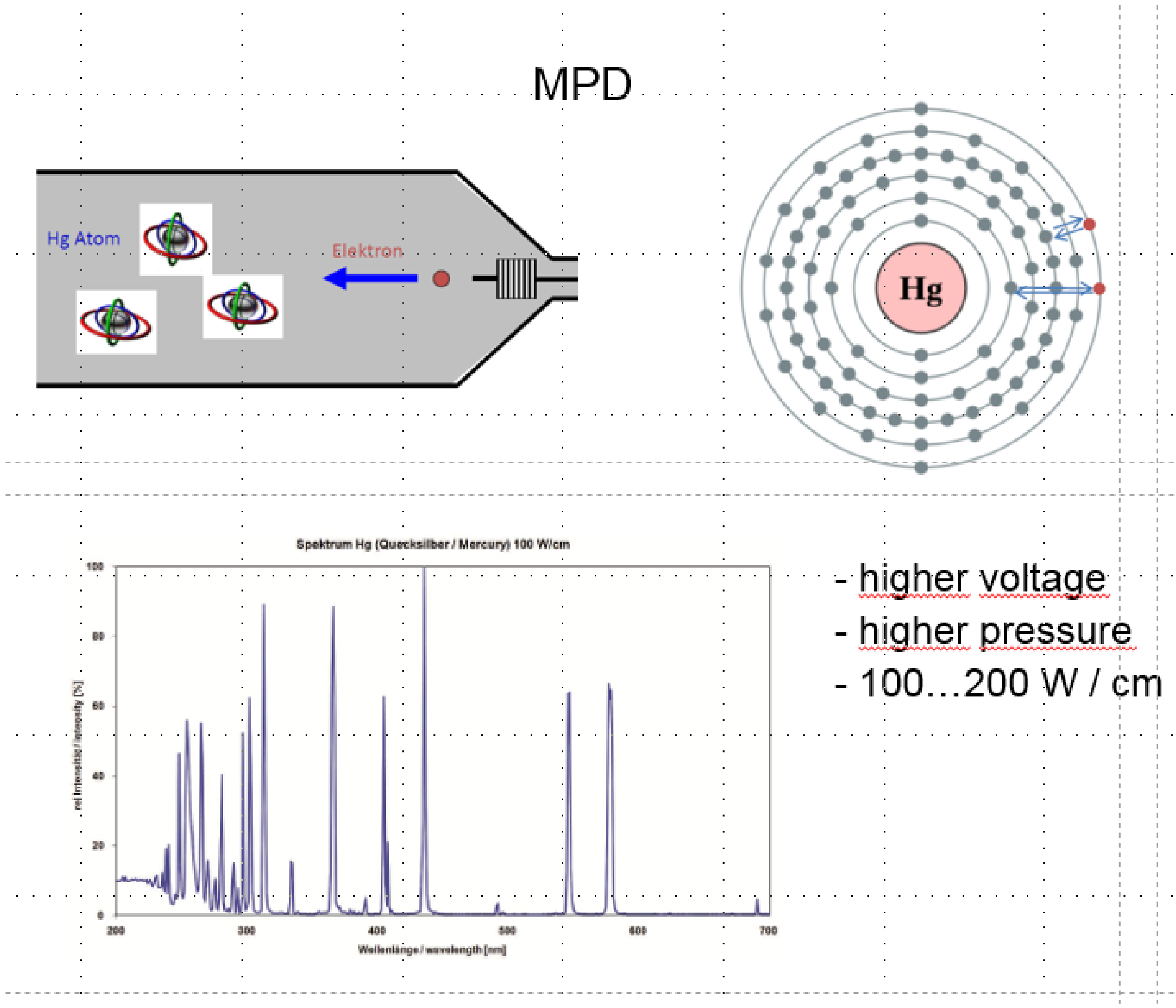
Medium-pressure ultraviolet curing lamps are utilised by special purpose industrial accelerated curing applications and for disinfection and surface modification processes. Typical examples include, but are not limited to, sheet-fed printing, digital inkjet printing, semiconductors, wood

[20] J.de Groot and J. Van Vliet, The High Pressure sodium lamp, Kluwer Techische Boeken B.V. Deventer, ISBN 9020119028 (1986)
[21] R. Geens and E. Wyner, Progress in High Pressure Sodium Lamp Technology", IEE Proceedings-A Vol. 140 No. 6, November 1993

applications, glass and plastic finishing, metal decorating, fibreoptics, CD manufacturing, and electronics. They are also used in water, air, and packaging disinfection processes.

These lamps contain a mixture of mercury and argon gas inside a sealed quartz tube. When in operation, this mixture is heated to create a stable, mercury plasma that emits radiation at specific wavelengths within the UV range (100-400nm) and which are characteristic of mercury. UV curable inks, coatings, and adhesives are formulated to absorb the UV light at specific wavelengths by selecting photo initiators whose absorption profiles match the emission spectrum as closely as possible. In germicidal applications, the spectra must be optimised to match the wavelengths required for cell deactivation.

The use of medium-pressure discharge lamps differs from low-pressure discharge lamps, as illustrated below:



Medium-pressure UV lamps – examples in pictures

<u>Medium-Pressure UV Lamps for Curing</u>

These lamps are favoured where fast and reliable curing of coatings, inks, and adhesives is required and where a durable, scratch-, abrasion-, and/or chemical-resistant surface is required. Examples include:

- Curing of inks and coatings in printing processes
- Curing of coatings on furniture, decor (floor coverings) and wood/MDF
- Curing of coatings for other highly stressed products/components (e.g. lenses, fibre optic cables, automotive parts, plastic housings)
- Microlithography used in manufacturing semiconductors

These lamp types are also used for bonding processes, (e.g. for displays or for such medical products as syringes). Further application examples include the curing of encapsulated casting compounds for electronic components and the curing of silicone papers.

Some of these UV lamps are doped (e.g. with iron) to adapt the radiation spectrum to the process.

<u>Medium-pressure UV lamps for disinfection</u>

These lamp types do not significantly differ in design from lamps used in UV curing. They are used to disinfect water, surfaces, and air. Examples include:

 	• Disinfection of drinking water, process water, wastewater, and ballast water • Disinfection of machine surfaces and packaging materials/products in the pharmaceutical and food industries • Air disinfection in heavily frequented areas such as hospitals and airports

Short Arc mercury lamps

Short-arc lamps contain a mixture of mercury and xenon gas inside a sealed quartz tube. These discharge lamps are available in wattages ranging from 50W to 35000W for DC or AC operation, depending on the type. When high-wattage lamps are at room temperature, the mercury is generally found in the discharge vessel (i.e., bulb) as small metallic droplets. When the lamp is started, the temperature in the bulb rises and heats up in the arc between the electrodes to around 10 000 °C, causing the mercury to vaporise. The temperature on the inside wall of the bulb is around 800 °C. When thermal equilibrium is reached (which may take from 1 to 10 minutes after the lamp is switched on, depending on the type of lamp), the mercury vapour exerts a pressure of about 30 to 70 bar on the bulb (depending on the type of lamp).

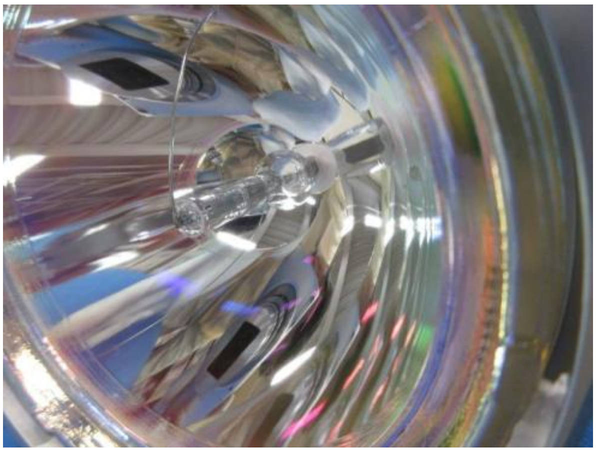
As with all short-arc lamps, material is lost from the tips of the electrodes during normal operation. This not only causes the bulb to blacken but also increases the gap between the electrodes, therefore increasing the lamp's voltage. To avoid overload operation, DC operated short arc lamps may only be used with constant output control gear (mains rectifiers). AC operated lamps, on the other hand, may only be used with suitable reactors.

High-pressure mercury short arc lamps are used in medical and industrial applications, including:

- Microlithography (also known as photolithography) for producing, for example, integrated circuits on silicon wafers, i.e., semiconductors like light emitting diodes (LED), liquid crystal displays (LCDs), and printed circuit boards (PCBs)
- Visual and fluorescence microscopy used in medical, life science, and industrial appliations
- Irradiation for photo polymerisation (used in manufacturing such things as efficient printing ink, reliable adhesives, and effective compound materials)
- Boroscopy (favoured by the aviation industry for performing maintenance work on turbines, engines, and other technical equipment)
- Curing adhesives and composites (e.g. if high a irradiation level is required for short curing times in dental and industrial applications)
- Analytical and diagnostic processes
- Medical fibre optics used to illuminate organs and tissues
- Dental curing

Other high-pressure mercury lamps for special purposes

High-pressure mercury lamp, high-pressure mercury xenon lamp



Lamps and light sources for medical, industrial, and research and development, are used for:

1. Testing and qualitative/quantitative analysis (utilising a specific wavelength)
2. Colour comparison, observation, and inspection (utilising a wavelength ranging from ultraviolet to infrared)

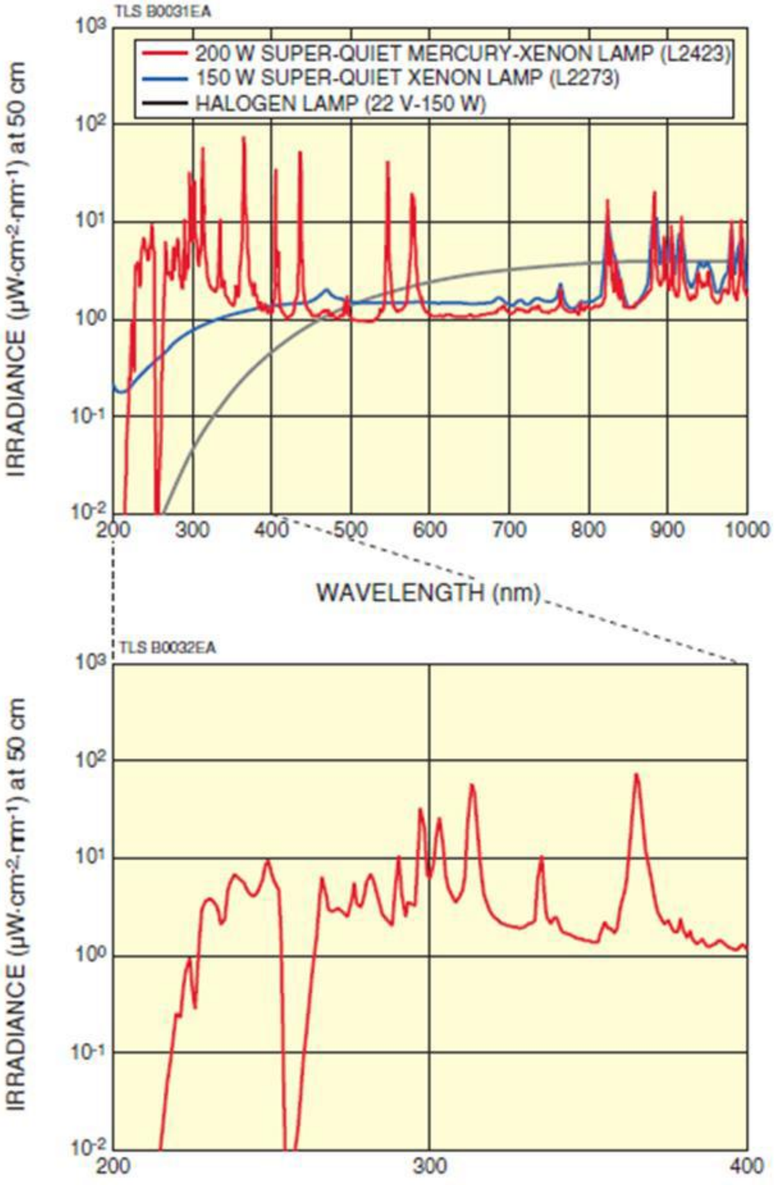
To carry out these applications, multiple specific wavelengths, high-intensity, and a spotlight source are required.

Currently, only mercury (or combinations of mercury and other elements/substances) in a single light source is able to achieve the applications listed above (No.1 and No.2). As these lamps are manufactured in various sizes and power consumptions (corresponding to the equipment used), it is impossible to determine the definite amount of mercury limit value.

Unlike other lamps, a lamp is capable of emitting high-intensity light over a wide wavelength range with a very small bright spot size.

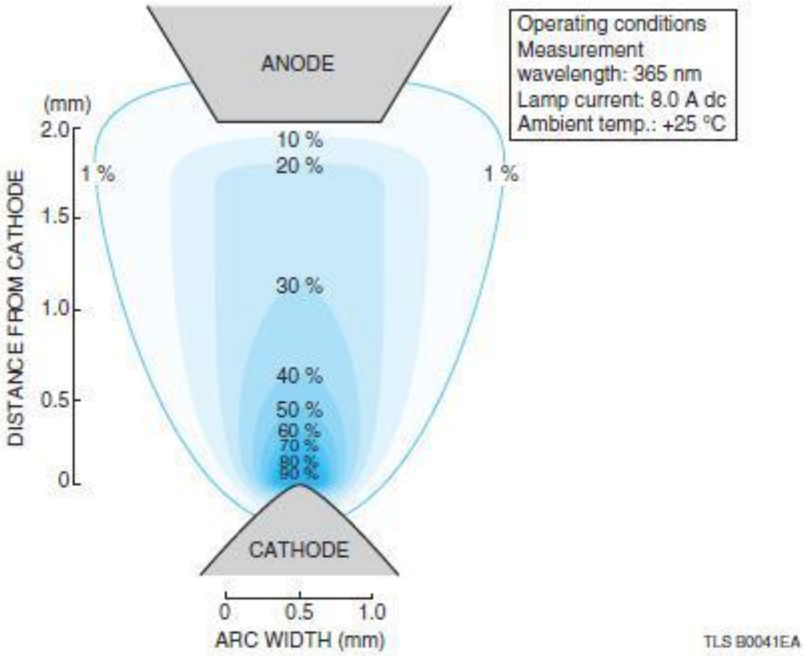
Mercury lamps have several strong bright line spectrums, ranging from ultraviolet to visible light wavelength. In addition, mercury-xenon lamps, which contains xenon gas, have continuous spectrums ranging from ultraviolet to infrared caused. For these reasons, mercury containing lamps can offer the high-intensity and broad wavelengths required by a variety of applications. Moreover, mercury containing lamps feature high-intensity point source. As the laws of physics dictate, the intensity of light from a light source is inversely proportional to the square of the distance from that source. Thus, if the intensity of light needs to be increased, the distance from a light source to the object must be shortened. However, it is impossible to close the distance from the light source to the object in certain applications mentioned above. Thus, the point source of light offered by mercury containing lamp is the best option for such applications.

Spectral irradiance:



Point source of light output distribution

Note: Maximum light output intensity is more intense around the cathode and decreases towards the anode.



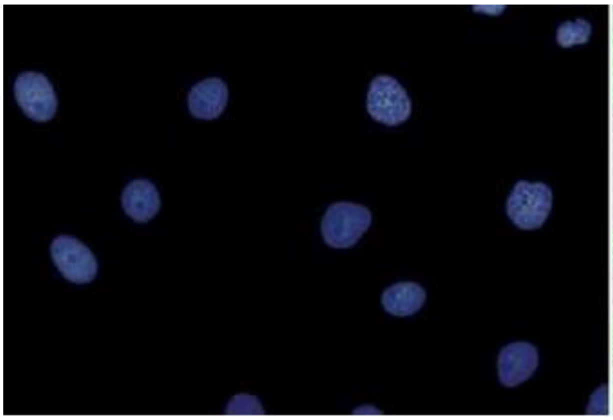
Examples:

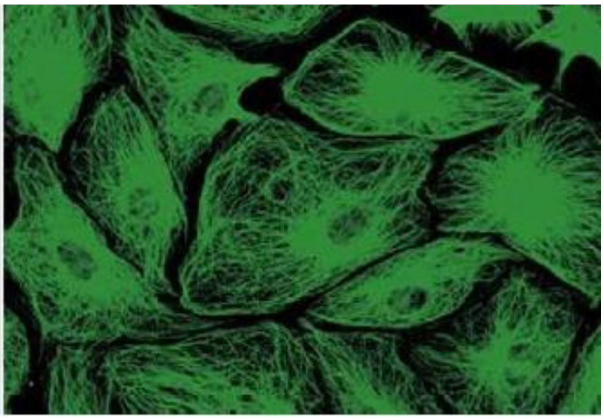
Microscope

Semiconductor inspection devices

Microsurgical systems

Fluorescence microscopy (observation of fluorescence and capturing of image)





Liquid chromatograph detectors

(OR detector, CD detector)

Optical and spectrophotometric products

(Polarimeter)

Genomic research equipment

5. Information on possible preparation for reuse or recycling of waste from EEE and on provisions for appropriate treatment of waste

(A) Please indicate if a closed loop system exist for EEE waste of application exists and provide information of its characteristics (method of collection to ensure closed loop, method of treatment, etc.)

In the EU, all lamps (and equipment in which they are installed) are subject to Directive 2012/19/EU (WEEE) and the respective country-specific implementation of that Directive. According to the Directive, products using mercury-containing lamps must be dismantled and the lamp removed for separate treatment (e.g. projector lamps must be removed from projectors prior to further recycling or shredder processes).

The lamps covered by exemption 4(f) are used in a wide variety of applications, each of which has a different waste route. Most of these lamps are used by professional/commercial customers in industry, municipalities, authorities, etc. Due to its large size, this equipment is usually not disposed of as household waste but instead collected mainly by business-to-business collection schemes set up according to WEEE legislation. Only a small portion could end up in projectors used by private households, as most such projectors have been widely replaced by large TV screens.

Lamp type	Field of use (industrial, commerce, domestic etc.)	Collection scheme
High-pressure short arc mercury lamps	Industry, scientific institutes, hospitals	National collection schemes according to WEEE legislation, contractual recyclers of commercial customers
Lamps for projection, studio and stage lighting purposes	Commercial public and private customers	National collection schemes according to WEEE legislation
High-pressure sodium lamps for horticulture lighting	Industrial, commercial customers	National collection schemes according to WEEE legislation, contractual recyclers of commercial customers
Medium-pressure UV lamps	Industrial, commercial customers	National collection schemes according to WEEE legislation, contractual recyclers of commercial customers
Other medium- and high-pressure lamps for special purposes	Industrial, commercial customers	National collection schemes according to WEEE legislation, contractual recyclers of commercial customers

Table 3: All lamps covered by exemption 4(f) are within the scope of the WEEE Directive 2012/19/EU.

Because all lamps are covered by the scope of WEEE, the industry is committed to a closed loop recycling process. Lamp manufacturers within Europe describe the procedure for properly disposing of these lamps within their product manuals and state that only certified organisations have permission for recycling. This helps ensure the recycling process is followed.

<u>Statistics for recycling of lamps used in electronic equipment</u>

With reference to question No. 3 of this section on the quantity of RoHS substance in EEE waste, we would like to note the following:

- Lamp producers have little influence on the actual disposal route that the OEMs of lighting equipment containing lamps promote to their end users. Lamp producers finance and partially steer collection schemes, and such schemes typically contract recyclers to perform the treatment. Alternatively, the equipment producer directly contracts recyclers (e.g. a B2B take-back). This is typically the case when lamps are imported by equipment producers.
- Recyclers are mandated to remove any gas discharge lamps from products (WEEE Annex VII requirement). Recyclers collect such removed lamps, combine them with

other lamps, and hand them over to lamp recyclers. No statistics on the origin of the lamps is made[22].

- Equipment producers are required to provide treatment-relevant information to recyclers (WEEE Art 15 & Annex VII) to facilitate environmentally sound treatment.
- Statistics on the type of equipment collected and treated, partially backed up by sampling, are not detailed enough to break down specific electrical and electronic equipment and estimate this on a European basis[23].
- Therefore, equipment producers do not have European data on end-of-life statistics for electrical and electronic equipment becoming WEEE and, in particular, on lamp treatment and final disposal.
- Lamps that must be replaced become waste and can be brought free of charge to the respective WEEE collection points

(B) Please indicate where relevant:

☒ Article is collected and sent without dismantling for recycling

☐ Article is collected and completely refurbished for reuse

☐ Article is collected and dismantled:

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

☐ Article cannot be recycled and is therefore:

- ☐ Sent for energy return
- ☐ Landfilled

This statement only refers to lamps used in electrical or electronic equipment, not to EEE. Recyclers are mandated to remove any gas discharge lamps from products.

(C) Please provide information concerning the amount (weight) of RoHS substance present in EEE waste accumulates per annum:

☐ In articles which are refurbished

☒ In articles which are recycled < 250 kg

☐ In articles which are sent for energy return

☐ In articles which are landfilled

[22] Information from recyclers on recycled weight of products containing mercury is that the data is not split down by the brand of the product or even the compliance scheme. They recycle mercury in large batches that are mixed from different sources; the majority of mercury comes from public street lighting.

[23] Reports from compliance collections schemes only details the amount of mercury in total collected from WEEE. See example compliance scheme report from Switzerland http://www.google.co.uk/url?url=http://www.swicorecycling.ch/downloads/dokumente/technical-report-swico-sens-slrs-2013.pdf/1400&rct=j&frm=1&q=&esrc=s&sa=U&ei=0kgAVP7uOcjcPYbrgcAH&ved=0CBQQFjAA&usg=AFQjCNGVOdg1ECkVykqDSTAYOAszUgPSAA page 15 showing less than 0.00% mercury collected from all WEEE

As stated above, no suitable statistical data is available. All products fall under WEEE's take back obligations. With reference to Table 2, above, and according to the information and data available to LightingEurope, a total of 240 kg of mercury might be put on the market by lamps falling within this exemption. As the lamps covered by exemption 4(f) are nearly exclusively used in commercial, industrial, and professional applications, a high collection rate for these lamps is assumed.

6. Analysis of possible alternative substances

(A) Please provide information if possible alternative applications or alternatives for use of RoHS substances in application exist. Please elaborate analysis on a life-cycle basis, including where available information about independent research, peer-review studies development activities undertaken

Substitution of mercury in lamps

Alternative chemical elements for mercury either lack the required vapour pressure at a low enough temperature, do not radiate efficiently upon collisions with electrons, or react violently with the transparent quartz wall and block the light when the lamp becomes older.

All single elements, stable combinations of elements, and stable compounds with suitable vapour pressure have been evaluated as possible alternatives to mercury. None provide the same broad UV spectrum or the required wavelengths with enough intensity needed to perform the required functions. Therefore, the only potential future alternative to using mercury would have to come from different technologies. However, the suitability of alternative technologies, as far as those currently available, differs per application. For example, alternatives for horticulture lighting differ from alternatives for water purification or projection lamps.

Application with alternative technology

Equipment using lamps covered by exemption 4(f) are increasingly being replaced by alternative technologies, mainly based on LEDs and laser technology. That being said, for many 4(f) applications, there is no alternative technology offering the same performance characteristics as those provided by mercury-containing lamps. Whenever mercury-free technology is introduced, this is done with completely new or redesigned equipment. Retrofit solutions based on LED or laser technology are currently not possible, as described below.

Horticulture lighting alternatives:

High-intensity discharge lamps are compact and, in general, are high-power lamps. Horticulture applications require that HID lamps operate in closed luminaires. Since over 90% of the power supplied to the HID lamp leaves the burner as radiation (visible light, infrared radiation, and some UV) the temperature of the luminaire and the lamp is stabilised without the need for heat sinking.

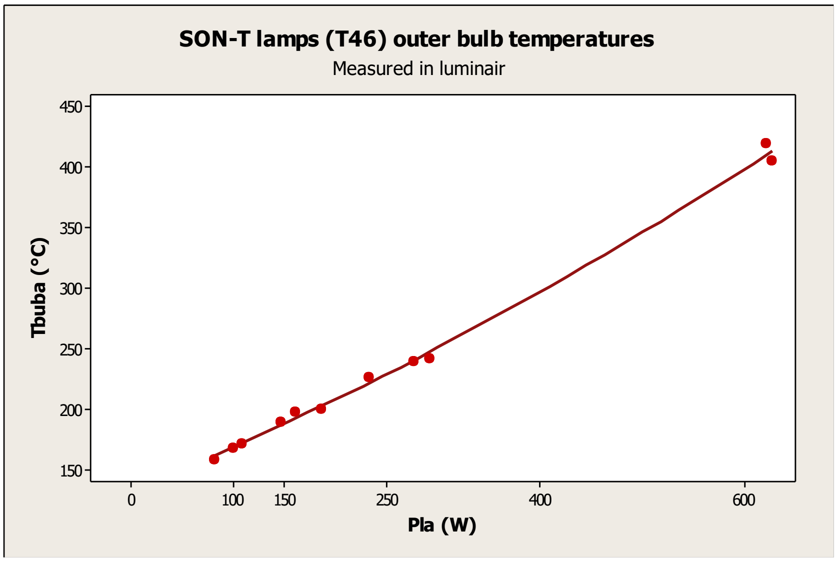


Figure 3: Measured temperatures of the outer bulb of HPS lamps of various power.

The glass surface of the outer bulb of the lamp is heated by conduction of the heat generated in the burner (10% of the supplied power) and by absorption of half of the infrared radiation from the burner. In total, the glass envelope is heated by approximately 40% of the lamp's power[24 25].

As argued in the introduction, the infrared radiation generated by hot HPS lamp is not lost, as it is also beneficial to the plants. For example, the heat stimulates plant growth during the cold winter season.

As to the most efficient LED lamps currently on the market, the power that is transformed into light is about 40%, and there is no IR or UV. 60% of the electrical power is transformed into heat and must be removed by convection/radiation to the surrounding air in the closed luminaire. This makes the design of the luminaire difficult, especially since the environment temperature in the greenhouse is high and the size of the luminaire is limited due to the need to minimize the bulb blocking direct sunlight.

The heat loss of the most efficient LED's is higher than that of HPS lamps. Thus, measuring the envelope temperature of the HPS lamps in a luminaire will predict the temperature of the envelope of a future LED lamp with the same size. Since the transport of heat in a lamp via the lamp base is limited, the only path for the heat to disappear is through conduction to the

24 Jack, A.G. and Koedam, M., "Energy Balances For Some High Pressure Gas Discharge Lamps," Ilium. Eng. Soc., July 1974 (other reference needed: Thesis A. Rijke)

25 Janssen, J.F.J., Rijke, A.J., Nijdam, S., Haverlag, M., Dijk, J. van, Mullen, J.J.A.M. van der & Kroesen, G.M.W. (2012). A comparison between simulated and experimentally determined energy balances for HID lamps. In R. Devonshire & G. Zissis (Eds.), Poster : Poster presented at the 13th International Symposium on the Science and Technology of Lighting (LS-13 2012), june 24-29, 2012, Troy, New York, USA, (pp. CP040-175/176). Sheffield: FAST LS ltd.

air surrounding the lamp. In a closed luminaire, warm air limits this transport, but even if the lamp would operate in open air, the compact size needed for the retrofit lamp to fit in the closed luminaire limits the cooling opportunities.

Figure 3 gives an indication of the measured surface temperature of HPS lamps with different power. The 1000W lamp is even warmer and is measured around 700°C. The LED retrofit lamps will reach at least the same temperature. This surface temperature range of between 400 and 700°C is much higher than the optimal LED junction temperature of 100°C. This means that LED replacement lamps that are the same size as current HPS lamps cannot exist in the coming decades or, if they do that their emitted light flux will be lower and/or their lifespan limited.

Moreover, there is a safety issue of retrofitting an HPS lamp with an LED lamp. HPS lamps are operated on electrical systems that generate high voltage pulses to ignite the lamps. These ignition pulses are typically between 1800V-3300V. These igniters must be removed from the system (if not integrated into the electronic driver) and the luminaire rewired if LED's would be designed to replace HID lamps. The installer needs to take the responsibility for the safe replacement and needs to label the luminaire accordingly. Currently, this replacement scheme is hypothetical as no LED replacements are available for high-power horticulture lamps.

<u>Suitability of alternative technology as spare parts</u>

It is not possible to replace the mercury containing lamps used in existing equipment with alternative technology. Lamps used in greenhouses must be replaced almost every year, and these replacement lamps must fit into the existing fixture and deliver the same performance, safety, and reliability that the equipment was originally designed and tested for.

It should also be noted that these lamps are consumable items mainly utilized in high-value equipment that is already in service. The systems were designed for mercury lamps and there is no alternative chemistry capable of producing a suitable spectral output using the power electronics contained within the existing luminaire.

Hence, even if a new technology becomes available in the future, there will still be a need for sodium/mercury lamps as replacement spare parts for existing installations for a considerable period of time.

As luminaires, LED solutions for top lighting started entering the market in 2019. This demonstrates that the industry is working on alternatives to HPS systems. These systems are in the early stage of development and currently require end users to have adequate budgets.

Figure 4 LED luminaire for horticulture lighting

Mercury-free lamps for projection purposes:

Replacement of mercury

Hg-free discharge technology based on Zn has been developed[26]. However, this technology is not suitable for projection applications – a result of the metal gas pressure being too low and thus producing a low lamp voltage. This results in low energy efficiency. Although efforts have been made to develop a high-pressure Zn discharge lamp capable of achieving reasonable energy efficiency in a projection application, these efforts have been terminated due to a lack of technical solution capable of coping with the required extreme high operating temperatures.

Furthermore, zinc atoms react violently with the quartz, damaging the transparency. The loss in transparency reduces the brightness of the source and makes the lamp unfit for this type of application. This means zinc is not a suitable alternative to mercury.

[26] Patent WO2006046171

Although xenon-lamps can offer the required high luminance needed for projection purposes, they suffer from very low energy efficiency. Because xenon-lamps are about four times less efficient than Ultra High Pressure lamps, they tend to be much larger. As a result, they can only be used in a very limited number of projection applications[27].

Solid state technology

For projectors, the ANSI Lumen (Lm) level on the screen determines the market segments. It is regarded as a basic requirement for a projector to have at least a 2 000 ANSI Lm brightness level. There are multiple other values used to compare screen brightness, but ANSI Lm[28] is considered the standard (eg. LEDlumen[29], marketing lumen, others[30]). For lit environments, a minimum brightness level of 3 000 ANSI Lm is regarded as the standard. All projectors between 2 000 and 5 000 Lm are defined as mainstream projectors.

Several years ago, some projector manufacturers started using solid state light sources within a limited area. These can be categorised as: White LED (1), Scanning Laser (2), RGB LEDs (3), LED/Laser (-phosphor) Hybrid (4), Laser-phosphor (5) or RGB Laser (6), RGBB LEDs (7), or HLD (LED) (8).

White LED (1) and Scanning Laser (2): these technologies will not be able to replace mainstream projectors mounted with mercury containing lamps. The luminance level of White LEDs (1) is too small to reach more than 500 Lm. As to Scanning Lasers, safety requirements limit the scanning beam intensity. Thus, usage of both White LED (1) and Scanning Laser (2) will be limited to the pico projector segment.

RGB LEDs (3) used for projectors are a surface light source and have a limited luminance level. High luminance is required for optical imaging. It does not add value to increase total light flux by increasing the light emitting area, which is a typical design choice for LED illumination. As a result, light intensity is limited when RGB LEDs (3) are used as a light source in projectors. The range of RGB LED projectors currently available on the market only covers lumen levels up to 1 500 ANSI Lm (commercially specified). The measured brightness level is currently still limited to around 800 ANSI Lm[31]. This means RGB LEDs (3) do not play a role in the mainstream segment. To get to higher ANSI lumen levels, RGBB LEDs (7) have been developed. They increase the ANSI Lm by adding an additional blue LED (increase from 800 ANSI lm to 1 050 ANSI lm measured).

[27] Proc. SPIE 5740, Projection Displays XI, April 10 2005

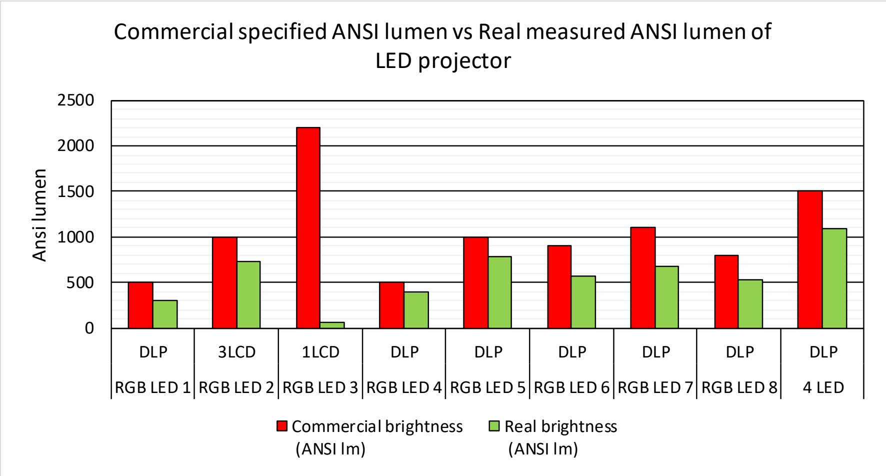
[28] ANSI/NAPM IT7.228-1997 Electronic Projection—Fixed Resolution Projectors (IEC 61947-1)
ANSI/PIMA IT7.227-1998 Electronic Projection—Variable Resolution Projectors (IEC 61947-2)

[29] Are "LED lumens" a Real Thing?, M. David Stone, December 15, 2017, ProjectorCentral.com

[30] 7 Epson Brings Suit Over RCA Projector Claims, Rob Sabin, April 4, 2019 https://www.projectorcentral.com/epson-sues-over-RCA-projector-claims.htm

[31] See product reviews at e.g. www.projectorcentral.com, e.g. projectors HD91, DG-757, LGPF85U, ..

Examples of internal measurements are shown below, proving that no LED projector has been able to reach an ANSI lumen above 1 100.



Although the remaining laser-based technologies (LED/Laser (-phosphor) Hybrid (4), Laser-phosphor (5), and RGB Laser (6)) entered the market some years ago, their market penetration rate is low. For several years now, the level of projectors with hybrid or laser solution is slowly growing (to approximately 7% (2018) of the total market[32]) – a trend that can be explained by the technological difficulties in making laser-based projection systems:

For laser-based (incl. hybrid) projectors, the cooling of the semiconductors requires bulky, heavy, and/or noisy cooling systems, which makes them unsuitable for mobile use.

For RGB Laser (6), a measure for “Laser speckle noise” must be taken for laser illumination without phosphor conversion. “Laser speckle noise” is created by the mutual interference of the laser’s coherent light waves and results in a varying intensity of light spots in the projected image. The suppression of the speckle noise is necessary for laser-based projectors. This is also applied to Scanning Lasers (2), which also requires that safety measurements be taken as the light source is a class 4 laser.

An HLD LED solution (8) consists of HLD LED modules that, in combination with either 1 or 2 direct LEDs, creates white light for projection. The HLD LED modules use a luminescent converter rod to convert blue LED light to green or yellow light with small etendue. This technique enables it to reach a higher ANSI lumen[33]

As a new technology, HLD LED is currently in the exploration phase, with its first application being in the projector market. At this moment, it is manufactured solely by one company.

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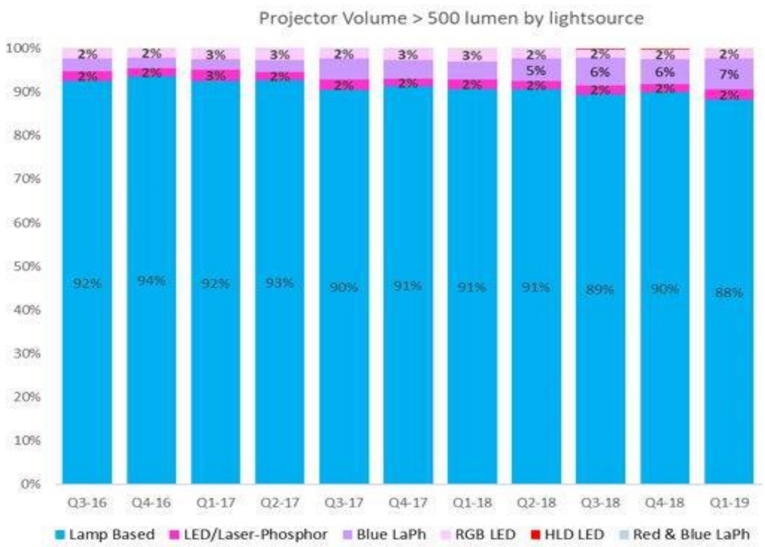
[32] Source: Futuresource-consulting
[33] LED light engine concept with ultra high scalable luminance: Christophe Hoelen

Conclusion: Solid state light sources ((1)-(8)) are not sufficiently mature to be used for mainstream projection purposes. Important remark: LED, Laser/LED Hybrid, and Laser light sources are not backwards compatible with projectors mounted with mercury-containing lamps.

The graph below indicates the market penetration rate of the alternative technologies analysed by FutureSource[34]



Graph with 2019 data

Retrofit solutions are neither possible nor available:

The mercury-containing lamps used for projection in existing equipment (projectors) are tailor-made to an application/projector in terms of form, fit, and function. Consequently, no replacement light source (besides mercury-based lamps) can fit in that projector. This is the opposite of general lighting, where LED replacement bulbs are widely available. There are several reasons for this:

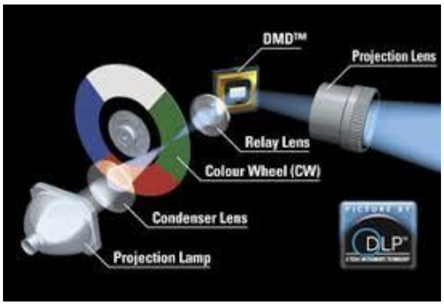
- Difference in projector architecture because mercury lamps emit white light while solid state light needs to combine multiple sources to create white light
- Different cooling requirement
- Different size of light source

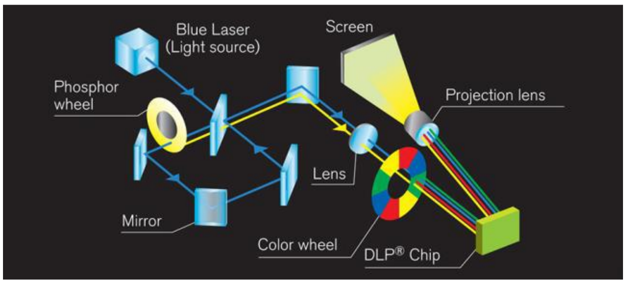
Difference in projector architecture because mercury lamps emit white light while solid state light needs to combine multiple sources to create white light:
A projector using mercury lamps have an architecture that uses white light to project images onto the screen, while projectors using solid state light must have an architecture that allows for the combination of multiple sources. These differences are valid for both projectors based

[34] Source: Futuresource-consulting

on DLP technology, as well as those based on LCD technology. The schematic below outlines these differences.

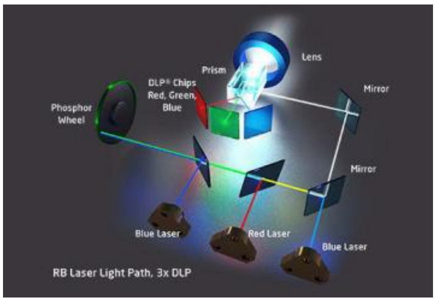
Typical examples of a DLP architecture

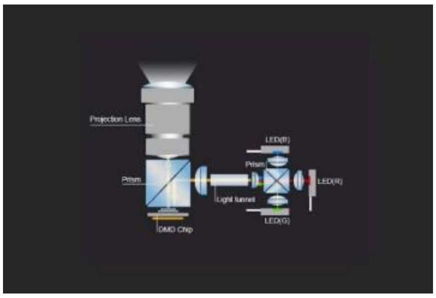




Mercury lamp DLP projector

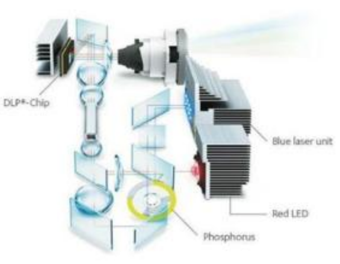
Laser DLP projector

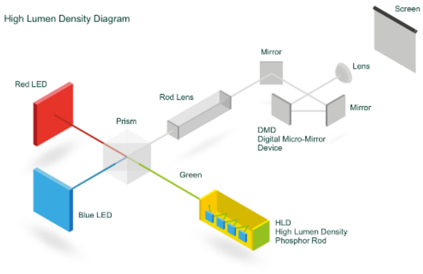




Laser DLP projector

RGB LED DLP projector

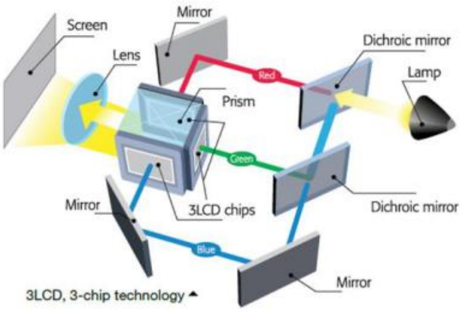


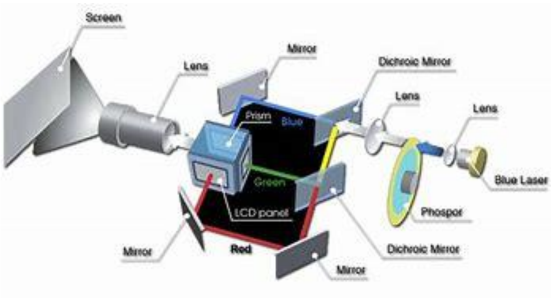


LED/Laser (-phosphor) Hybrid DLP projector

HLD LED DLP projector

Typical examples of an LCD architecture:



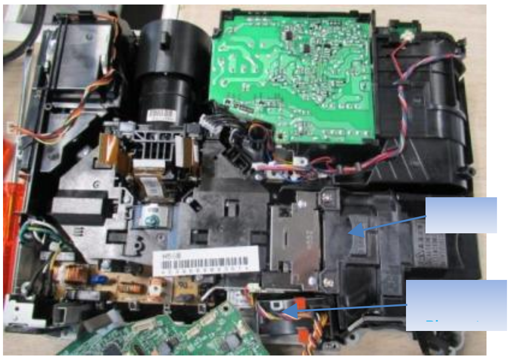


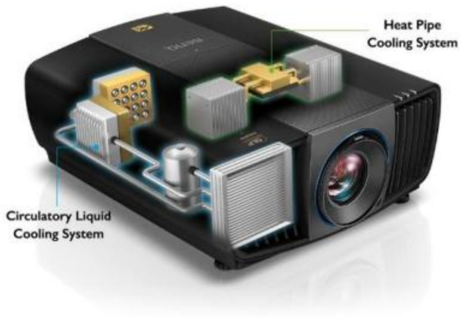
Mercury lamp LCD projector

Laser LCD projector

Different cooling requirements

A mercury-containing lamp requires the lamp bulb be cooled via direct forced cooling, while a laser or LED system is cooled via a heatsink or even using circulatory liquid cooling.



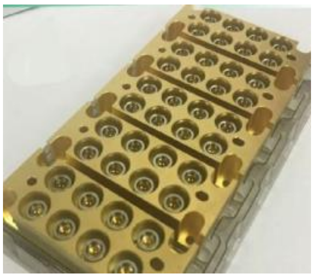


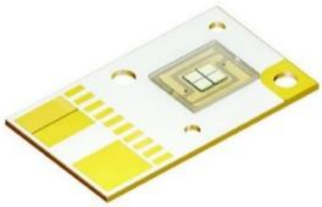
Mercury lamp projector cooling

Laser projector cooling (11)

Different size of light source

A third reason why backward compatibility is not possible is the size of the light source. A laser projector is typically equipped with grids of laser diodes within a flat plane. An LED projector is equipped with three high-power LEDs. A mercury light source, on the other hand, consists of an arc tube with a reflector situated in a large portfolio of different combinations of arc tubes and reflectors. These different technologies all require specific optics to focus the light output on the LCD or DLP panel, making it impossible to be backward compatible.





Laser diode grid High power LED Mercury lamp (bulb inside reflector)

Example of laser projector cooling:
https://businessdisplay.benq.com/en/findproduct/projector/installation-projectors/lk970.html

Alternative technologies for stage lighting, studio, or entertainment

Solid state technology

Within the entertainment sector, three different fixture types can be distinguished: beam, spot, and wash.

The difference between these fixture types is the beam angle:

- beam < 4°
- spot between 5° and 50°
- wash > 50°

In reality, most manufacturers of stage, studio, and entertainment lighting equipment make a combination of two or three types, the so-called hybrid fixtures: beam/wash (2-in-1) or beam/spot/wash (3-in-1).

The brightness level is extremely important, particularly in beam applications. This high brightness (up to 2 8000lm/mm^2) can be achieved using lamps with a very short arc. Even for the lowest power of short arc lamps, the lumen output in beam mode is still higher than that of LED products (2 000lm).

For wash and spot applications, LED is becoming more widely used.

Due to the fact that most of entertainment fixtures are hybrid (beam/wash or beam/spot/wash), the main technology is still the short arc lamp containing mercury.

According to commercial end-users of lamps used for studio and stage lighting, it is generally believed that it will be several years before an alternative light source will be found for the fixtures used in large arena and stadium events, as LED technology is just now reaching its theoretical peak.

This is also true for theatres and other smaller venues. While the general trend is to replace mercury lamps (new moving lights are typically equipped with LED source and bright profile spotlights will most likely be replaced in the course of the next years), there are still applications used to achieve certain artistic design objectives that do not have acceptable replacements.

The biggest reason to switch from discharge to LED technology is the possibility of dimming the source (which is not possible with discharge). But when high intensity and/or low density are required, it is technically not possible to replace discharge with LEDs. It should be noted that, once available, the adoption of alternative light sources will be rapid due to the high costs of current lamps (both in terms of the replacement lamps and the maintenance required due to the high operating temperatures involved). Lower energy LED fittings are generally more reliable due to the lower temperatures and are cheaper to operate due to a lack lamp replacement requirements. As a result of all this, the discharge market is decreasing, but it will still be some time yet before it is replaced.

Conclusion:

Solid state light sources are not sufficiently mature to be used for entertainment purposes in beam and hybrid applications (beam/wash version or beam/spot/wash). Additionally, these LED solutions are not backwards compatible with fixtures mounted with mercury containing lamps, due to following reasons:

- Different cooling requirements
- Different size of light source
- Operation on the existing control gear suited for short arc mercury lamps only
- Mercury lamps emit white light while solid state lamps need to combine multiple sources to create white light

Laser technology

Only very recently (April 2019) was a first fixture based on laser technology been commercially released to the market. However, the technology is still very new within the entertainment sector and market penetration is expected to be rather low (the result of cooling requirements and safety concerns, among other reasons) (see images below).

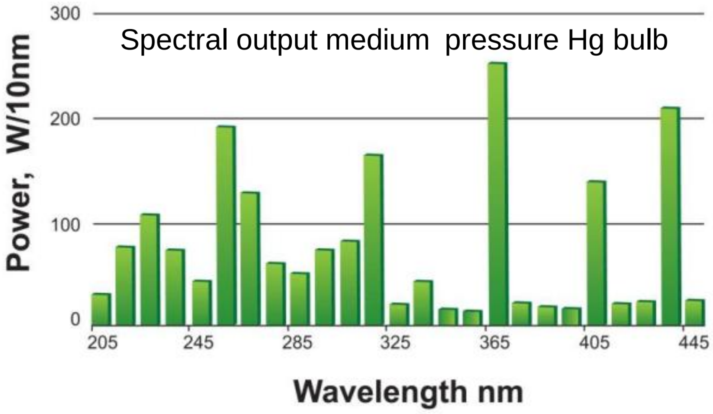
<u>Lamps for UV curing applications</u>

Although UV LED light sources are becoming commercially available as an alternative technology for medium pressure mercury lamps, there are significant limitations due to spectral emissions, cost concerns, and inability to easily replace in the field.

Currently, medium pressure lamps containing mercury are used in a wide range of curing applications, including, amongst others:

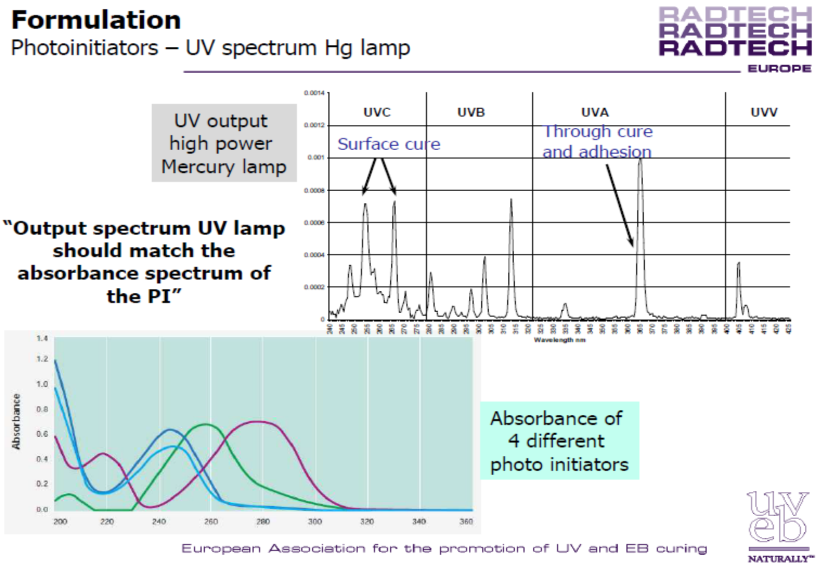
- Curing composites (e.g. glass-fibre)
- Curing paints, inks, and adhesives in the automotive sector
- Glass and plastic decorating (e.g. car interior, cell phones)
- Wood finishing (e.g. curing of inside and surface of parquet, hardwood, wooden furniture)
- Electronic components (e.g. PCB manufacturing, bonding and sealing of displays, semiconductor fabrication, printed and flexible electronics)
- Curing of inks and coatings used in printing processes (sheet-fed offset, web offset, flexo, ink-jet, screen printing) on different substrates (paper, board, cardboard, foils, metal sheets, rigid and flexible materials, even shaped surfaces) for the printing and finishing of a very large variety of products (e.g. books, brochures, ad prints, posters, banknotes, credit cards, packaging materials, labels, signs, direct printed products, panels)

These applications are used in a wide range of well-known markets and industries. The inks, coatings, and adhesives developed for these processes have been designed to respond very efficiently to the broad emission spectrum of medium-pressure mercury lamps (see picture below) to deliver a finished product that meets a wide range of very demanding product specifications.



Spectral output of medium pressure mercury lamps

The broad band emission from the medium-pressure lamps is important because it allows the photo initiator (the component in a UV formulation that absorbs the light) to absorb a wide range of wavelengths and thereby enables the ink, coating, or adhesive to deliver the required combination of properties. For example, in coatings on interior plastic parts for cars, a hard, scratch resistant surface is required. This is achieved utilising shorter wavelengths (280-320nm). Other required properties such as resistance to aggressive solvents or adhesion to plastic surfaces is supported by using longer wavelengths (320-365nm).

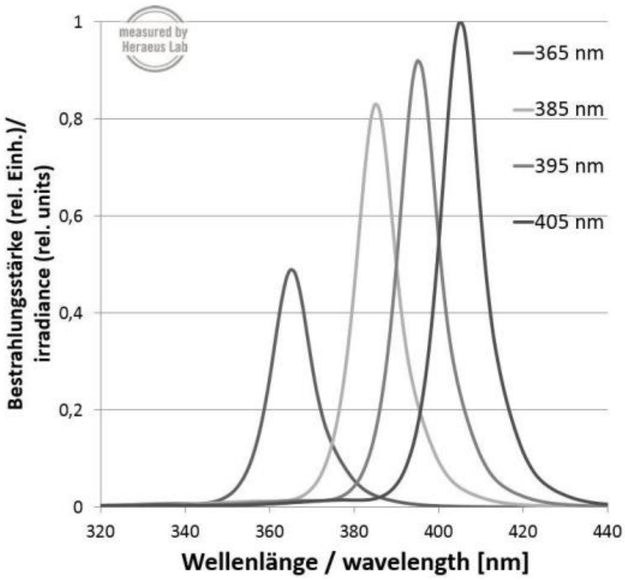


Spectral data of mercury-based UV lamps

UV LEDs are a potential alternative technology that has been introduced into UV curing applications. However, to date, their commercial success has been limited to specific niche applications, such as new inks being developed that are optimized for the emission spectrum of UV LED lamps. Nevertheless, after curing, the ink surfaces are not as robust and scratch resistant as what is achieved with mercury lamp-based systems – the result of a limited availability of photo initiators that can be cured with UV LED.

Examples of where the use UV LEDs is already possible include: adhesives in assembly operations such as PCBs in consumer goods; ink jet printing on labels or in wide format printing for point-of-sale displays; and flexographic printing on heat sensitive films. They can also be used in some coating applications in wood finishing, sometimes in combination with medium-pressure mercury lamps.

One of the drawbacks of UV LED is that the light is only produced in a very narrow band. UV LED lamps delivering 405nm, 395nm, 385nm, and 365nm wavelengths are the most common commercially available products. The most widely-used products deliver 395nm and 385nm and have the highest output and the longest lifespans.



Spectra of 4 different UV LED lamp types

Whilst there has been a growing adoption of UV LED light sources, there are significant limitations due to the lack of viable UVB and UVC LED light sources. Short wavelength UVB and UVC is very important for coatings requiring hard, scratch-resistant surfaces, such as the coatings used on plastic parts for the automotive industry. The highest performing UVC LED light sources currently have a maximum output in the range of 20-60mW. Internal testing with various ink manufacturers indicates that in order for full adoption to be possible, output performance needs to be in excess of 250mW, with similar cost per mW in comparison to a mercury lamp. Considering this, along with the current state of UVC LED development, it is likely to be a number of years (5-10) before viable UVC LEDs are available.

Replacement/retrofit of UV LED lamps is not possible as the mercury lamps are used in special purpose equipment with existing controls, fixtures, and cooling systems that would not be compatible with an LED lamp. Furthermore, the process ink and chemistry are designed to work with the polychromatic mercury light source and would not be compatible with the LED lamp spectrum currently available. In addition, UV curing lamps must be replaced several times over the life of the equipment. Hence, even if a new technology becomes available, there will be a need for UV curing lamps as spare parts for legacy capital equipment for a considerable period.

Lamps for UV disinfection applications

UV energy can be used to disinfect water, surfaces, and air by inactivating microorganisms such as bacteria, viruses, yeasts, fungi, and parasites. The process reduces the pathogen count within seconds and does so in an economic and environmentally friendly way without the use of chemicals. Furthermore, the UV process can be used to eliminate chlorine resistant pathogens such as cryptosporidium.

Applications for water disinfection include municipal water treatment for household drinking water and sewage treatment, industrial water treatment for process water, aquaculture and agriculture needs, and for ballast water for ships. Using UV to disinfect air reduces germs and improves the hygienic and storage conditions in the pharmaceutical and food processing industries, rooms, and such highly frequented areas as airports. Surface disinfection of packaging materials is also carried out by UV, including on filling lines for dairy products and beverages where cups, tops, lids, and packaging foils are exposed to UV to kill germs on the surface. UV sterilisation of packaging is especially important for sensitive food products (e.g. dairy products) as it increases shelf life in terms of consumer protection and food safety. Furthermore, in the food industry, equipment parts and transport containers are disinfected with UV.

UV disinfection is effective at wavelengths between 200-300nm, the spectral region most effective at deactivating the cells of microorganisms (the germicidal action curve has a maximum wavelength of 265nm). UV-C radiation has a strong bactericidal effect. It is absorbed by the microorganism’s DNA, destroys its structure, and inactivates the living cells. Microorganisms are destroyed in just a few seconds with UV radiation. Mercury vapor lamps used in disinfection applications (sometimes referred to as germicidal lamps) are designed to emit a narrow band radiation at a wavelength of 254nm. These mercury lamps have a wall plug efficiency of up to 50% for generating UV-C photons at 254nm. The stronger version, also mercury based, uses an amalgam to enhance the photon flux, but with a lower wall-plug efficiency of ~35%.

A possible mercury-free solution could be an XeBr*- excimer lamp emitting at 282nm or an XeI*- excimer lamp emitting 253nm photons. In both cases, the wall-plug efficiency is below 10%, meaning neither are a realistic alternative given the power consumption comparison with Hg lamps and their poor efficiency. Furthermore, the power supply technology is by far more complex and significantly more expensive compared to conventional ones used to drive Hg-based lamps.

Another alternative might be a Xe2*- excimer lamp emitting 172nm photons with an efficiency of up to 40%. A phosphor might convert the radiation into the germicidal range around 265nm. Assuming a quantum efficiency for the phosphor of 90% and the Stokes shift being ~65%, the total electrical lamp efficiency will come down to ~23%. This low value might only be partly compensated by a larger germicidal action due to the wavelength. However, lifetime values for the Hg-based conventional lamps easily exceed 10 000h – a number that is very hard to achieve using a 172nm based Hg-free version.

Currently, mercury-free solutions such as excimer lamps have only been successful in a few applications in niche markets. In some cases, Flash lamps have already been used for disinfection applications. However, the costs for Flash Systems are more than five times higher compared to systems using Hg containing gas discharge lamps. This is due to the housing and cooling equipment being much more complex. The lifespan of Flash lamps is 2-3 times shorter than medium-pressure lamps, which results in even higher costs and more electrical waste for replacement parts as the lamps have to be replaced more often. Moreover, noise pollution when operating Flash lamps is high at the workplace and handling of photobiological safety is more complex due to the high intensity in UV radiation per flash. Retrofit of Flash lamps into existing applications is not possible.

The development of LEDs emitting in the ultraviolet spectral range is an ongoing trend, but there are still no suitable substitutions available in the UVC range as the current R&D prototypes have a very low power output, low efficiency, low lifespans, and high costs.

With an efficiency of only 3-5%, the UVC LEDs currently on the market simply cannot compete the 50% efficiency offered by conventional mercury vapor lamps. Moreover, with an output of 50mW, a huge number of LEDs are needed to achieve the necessary intensity. Although UVC LED technology might suit small consumer applications like toothbrush disinfection containers, their efficiency/performance to milli Watt ratio is far too low to provide the high-power and high-turnover demanded by the professional market. This results in higher energy consumption compared to what an application using conventional mercury vapor lamps can achieve. With a lifespan that is 30% shorter than that of a mercury vapor lamp, UVC LEDs need to be replaced more often, resulting in higher costs for the operator. Despite what is often advertised by LED manufactures, the performance of UVC LEDs isn't independent of temperature. In fact, increased temperatures and ageing of shortwave LEDs have a negative effect on their performance.

Replacing/retrofitting UVC LED lamps is not possible as mercury lamps are used in special purpose equipment with existing controls, fixtures, and cooling systems not compatible with an LED lamp. Furthermore, disinfection and sterilisation processes only work with shortwave UV spectrum, which cannot be efficiently achieved with the UVC LEDs currently available. In addition, UV curing lamps must be replaced several times over the life of the equipment. Hence, even if a new technology becomes available, UV curing lamps will continue to be needed as spare parts for legacy capital equipment for a considerable period.

An overview on the status of the development of UV LED is given by the *Advanced UV for Life* consortium[35][36].

Alternatives for high-pressure short arc mercury lamps

Short arc mercury lamps are mainly used for microlithography in the semiconductor industry. This industry is fully dependent on the availability of these lamp types. Currently, there is no available alternative for high-pressure short arc mercury lamps.

- Mercury cannot be replaced in short arc lamps

[35] https://www.advanced-uv.de/en/about/welcome/
[36] https://www.advanced-uv.de/fileadmin/user_upload/Infopool/Advanced_UV_for_Life_2018.pdf

- There are no other suitable chemical elements that can be used as a substitute to mercury
- Retrofit solutions are not available

Mercury lamps are used during one of the litho-steps in the semiconductor manufacturing industry. It is used in thousands of systems, with the average lifespan of a litho-tool (a machine that costs several millions) is >25 years. These tools contain optics that are specially designed for the wavelength generated by mercury lamps (365 nm) and there are no alternatives capable of providing the same effective performance. Changing this would be a substantial burden for litho-equipment manufacturers, resist suppliers, and semiconductor manufacturing fabs. For example, litho-equipment manufacturers would have to redesign equipment for a new wavelength, resist suppliers would need to develop a new type of resist, and fabs would have to update the equipment and requalify the processes.

One possible consequence of this might be that fabs decide to move production of “low end” chips (existing products) to other countries where mercury lamps can be used. The lamps themselves are very low risk because mercury is not released to the environment and can be easily recycled.

It is important to stress that specialty UV bulbs containing mercury are critical to the semiconductor process of photostabilization. Photostabilization ensures optimum resist stability and critical dimension (CD) control through etch and implant sequences and is a key enabler of improved device quality. The photostabilization process is a balance of UV energy applied to the top of the wafer and thermal heating applied to the backside of the wafer to remove residual solvents from the photoresist and to further crosslink the resist.

The irradiator is the source of UV radiation for photostabilizer systems. It generates radiation through a process that first converts high voltage DC power into microwave energy using two magnetrons. The microwave energy, generated by the magnetrons, is then used to develop a high-temperature plasma inside a sealed bulb. This plasma then re-radiates the energy in the form of infrared, visible, and ultraviolet radiation. The selected fill and bulb shell materials are tailored to produce high "light" intensities in wavelengths suitable to cure the photo masking materials used in the fabrication of semiconductor components, quartz displays, and disk drives. Other uses include curing low-K dielectrics, SOG, multi-level resist applications, and EPROM erasure.

The UV irradiator is capable of producing UV energy at power levels two orders of magnitude greater than that supplied by an excimer laser. Unlike the laser that covers a spot size of approximately 5mm, the irradiator is capable of supplying full power uniformly over the entire wafer surface.

The bulb consists of a hollow quartz sphere filled with materials, including mercury, selected for their specific emission characteristics under high-energy microwave excitation. When microwaves energize the fill materials, plasma is generated. High-energy plasma causes the bulb temperature to exceed 1 000°C. To extend the life of the bulb, it is constantly rotated within air supplied by pre-aligned quartz cooling jets.

Because these bulbs contain no electrodes, there is no possibility of electrode sputtering and decay. As a result, better spectral consistency, longer useful life, and improved process control and yields are all achieved over other arc bulb assemblies.

Photostabilizers such as those discussed above are in use in many locations within the EU. The specialty UV bulb is necessary for the functionality of these systems. Without a supply of replacement bulbs, this equipment would become obsolete, harming the productivity and efficiency of the semiconductor manufacturers using this technology.

<u>Other high-pressure mercury lamps for special purposes (Cat. 8 & 9 applications)</u>

High-pressure mercury lamp, high-pressure mercury xenon lamp.

Mercury vapor lamps for medical and industrial research and development applications are used for qualitative and quantitative analysis, colour comparison, observation, and inspection. Carrying out these applications requires multiple specific wavelengths, high-intensity, and a spotlight source. At present, only mercury (or combinations of mercury and other elements/substances) in a single light source are able to meet these requirements. As these lamps are manufactured in various sizes and power consumptions corresponding to equipment, it is impossible to determine the definite amount of mercury limit value.

The following table shows simulation data both for mercury xenon lamps and LEDs (for embedding the light source into optical equipment):

Light source	Mercury xenon lamp	LED array
Lamp power rating	100W	100W equivalent
Intensity	3500 mW/cm2	1600 mW/cm2
Operating conditions Wavelength: 365nm, leads light to φ5 bundle fibre, compare intensity from edge of light output		

Table 4: simulation data for both mercury xenon lamps and LEDs

Mercury xenon lamps have a point source of light, which makes it possible to lead light to the optical equipment with high efficiency and maximum intensity on the end of the cathode. On the other hand, because LED has different features, such as surface emission and diffusion light, they are not suitable for the applications mentioned above.

LED must become a larger point source of light than what mercury containing lamp has. As the light emission intensity of a single LED is much lower, it would be necessary to array the LEDs to achieve higher intensity. However, there is a limit to reducing the diameter of the light spot of arrayed LEDs. Point source of high intensity is required for a variety fields, including medical and research and development, and LED is thus not a substitute alternative to a mercury-containing lamp at point source.

Please provide information and data to establish reliability of possible substitutes of application and of RoHS materials in application

Available non-mercury technologies are considered reliable. No alternatives are available for Hg in discharge lamps (see chapter 6(A)).

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7. Proposed actions to develop possible substitutes

(A) Please provide information if actions have been taken to develop further possible alternatives for the application or alternatives for RoHS substances in the application.

See also, above chapter.

Applications with alternative substances

Because of its unique combination of properties that no alternative can offer, mercury has been used for many decades. Mercury has a relatively low boiling temperature, meaning it is readily able to produce a vapour of suitable pressure. The heavy mercury atom slows down fast electrons on their track though the plasma. When the electrons collide with the mercury atom, UV light is generated – a very efficient process for doing so.

Mercury vapour is essential: all of the mercury is evaporated and the resulting pressure is chosen in such a way that:

- the system can provide the exact power to the lamp,
- the discharge radiates as effectively as possible,
- it generates the required wavelengths for the desired application, and
- with a brightness that allows for the most effective collection of the light.

Since the applications for 4(f) vary, the designs and the amount of mercury used differs widely. For example, very high-power lamps need a certain lamp volume to prevent the heat generated in the discharge from melting the discharge vessel wall. At the same time, if the same high-power lamp is used for projection, the arc must be very compact. This requires a very high mercury pressure. This combination of a very high pressure and a large discharge volume results in the need for a large amount of mercury (up to 100 grams). Other lamps require very efficient UV generation, such as those used for water purification. Here the generated UV must escape from the discharge without trapping radiation. As a result, these lamps have a medium mercury pressure (below 1 bar).

Alternative elements for mercury either lack the required vapour pressure at a low enough temperature, do not radiate efficiently upon collision with electrons, or react violently with the transparent quartz wall and block the light when the lamp becomes older.

All single elements, stable combinations of elements, and stable compounds with suitable vapour pressure have been evaluated as possible alternatives to mercury. However, none offer either the same broad UV spectrum or the required wavelengths with sufficient intensity to perform the required functions. Therefore, the only potential future alternatives to the use of mercury would have to come from different technologies.

Applications with alternative technology

There is a wide variety of applications that use special purpose lamps. While for some applications, solutions based on new technology (mainly LED solutions) are either in development or have already entered the market, in other areas, substitution is still not possible. There are good reasons for this, an overview of which can be found under the consortium "Advanced UV for Life". [37][38]

UV LEDs are clearly not as mature as LED technology emitting in the visible region and which are used for general lighting. The development of LED is much more difficult and complex compared to LED in the blue and white spectrum. The market for general lighting is substantially larger than the UV applications market, thus the pull from the market is much higher as are the resources that are put into developing corresponding solutions. Due to the smaller UV applications market, UV LED technology develops slower and the costs of the devices are much higher than what is available in the visible range.

One of the main areas of R&D for UV LED lamps is the development of products that have high output and high efficiency in the UV-C and UV-B regions. This would allow LEDs to work more efficiently with a wider range of formulations and produce the required film properties needed for a range of applications (i.e., produce better surface cure and produce scratch resistant coatings required by many applications, including wood finishing, coatings for plastic components, metal decorating, etc.).

Most UV LED light source system manufacturers do not have such expensive semiconductor production technology in house. As a result, they must absorb the risks of uncertain supply chains, which is difficult as the technology is still developing and in an early stage.

[37] https://www.advanced-uv.de/fileadmin/user_upload/Infopool/Advanced_UV_for_Life_2018.pdf
[38] https://www.advanced-uv.de/en/about/the-consortium-advanced-uv-for-life/

Those UV LEDs currently in development are mainly in the wavelength range of between 340 nm and 220 nm, with an emphasis on 310 nm, 280 nm, and 265 nm wavelengths, which are important for many applications. The manufacturing takes place in a process chain and contains a series of steps: design of the LED hetero-structure and chip layout, growth of the substrate and base layers, epitaxy of the semiconductor heterostructure, processing of LED components at the wafer level, and, finally, dicing the wafers into LED chips and assembling them into housings.

In all these steps, it is important that the electrical power be transformed into optical light output power as efficiently as possible as this would allow the manufacturing processes developed for this purpose to be transferrable to industrial production as directly as possible. The wall-plug efficiency (WPE), or radiant efficiency, is particularly relevant as an important parameter for this application. The WPE is given by the ratio of the total optical output power Pout to the input electrical power (i.e., the product of current I and voltage V).
The WPE is determined by the design of the UV LEDs and their material properties, and is largely determined by four processes:

- Contact and layer resistances determine the electrical efficiency.
- The injection efficiency indicates the proportion of charge carriers reaching the light-producing layers. There, the generation of light through radiative recombination competes with processes that produce heat but not light. The ratio is the radiative recombination efficiency.
- Next, the light must escape from the LED (extraction efficiency), which is hindered by reflection on the surfaces.
- The product of the injection, recombination, and extraction efficiencies is the external quantum efficiency (EQE). [39]

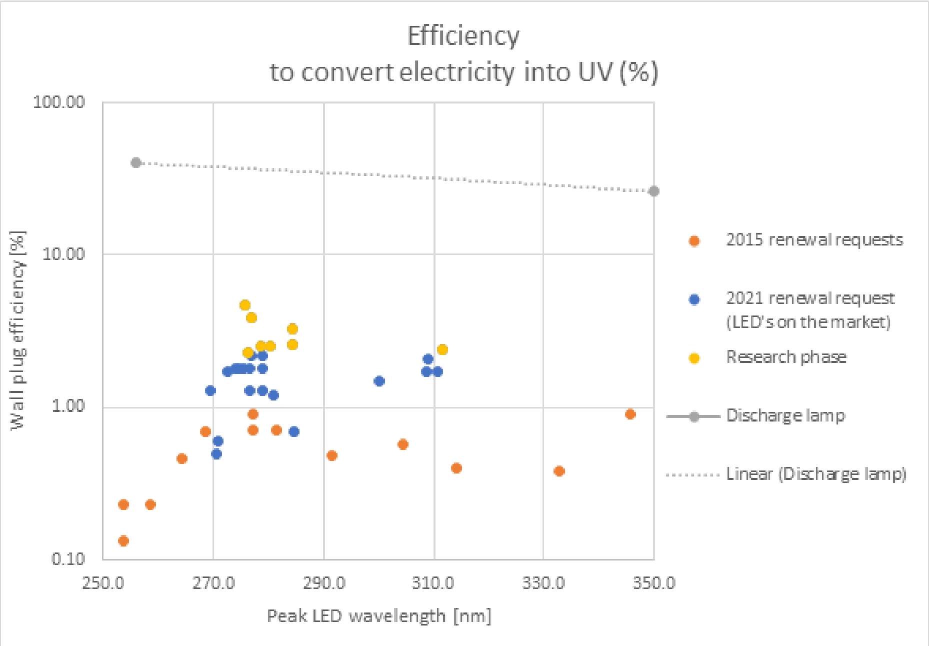
	Blue LED	UVC LED
η_{rad}	96 %	50 %
η_{inj}	98 %	80 %
$\eta_{extraction}$	89 %	16 %
$\eta_{electrical}$	95 %	64 %
η_{EQE}	84 %	6,4 %
WPE (wall plug efficiency)	81 %	4,1 %

Table 5: Comparison of the wall plug efficiency (WPE) or external quantum efficiency (EQE) of blue-emitting LEDs and UVC LEDs [40]

[39] https://www.advanced-uv.de/fileadmin/user_upload/Infopool/Advanced_UV_for_Life_2018.pdf
[40] https://www.advanced-uv.de/fileadmin/user_upload/Infopool/Advanced_UV_for_Life_2018.pdf

The efficiencies of typical blue-emitting LEDs and UVC LEDs are compared in Table 5. While blue-emitting LEDs can now achieve a very high WPE of 81 %, LEDs with emissions in the deep UVB and UVC have a significantly lower WPE of less than five percent. As shown by the comparison in the table, this stark difference in WPE cannot be ascribed to one single cause. Instead, the development of more efficient and more powerful UV LEDs requires improvements in all areas. [41]

The expected timeline for the development work to overcome the current limitations and achieve a secure supply chain is more than five years, with market maturity expected to take 10+ years. Furthermore, the gap between the costs of the mercury-based lamp technology and UV LED technology is high – at least 1-5 orders of magnitude depending on the emission range and complexity of the lamp.



Graph: LEDs (UVC Blue): WPE vs. wavelength (data of several manufacturers)

Since lamps' major impact on the environment happens during the use phase, there has yet to be a more environmentally-friendly alternative to UV LEDs.

(B) Please elaborate what stages are necessary for establishment of possible substitute and respective timeframe needed for completion of such stages.

[41] https://www.advanced-uv.de/fileadmin/user_upload/Infopool/Advanced_UV_for_Life_2018.pdf

Not foreseeable for most applications in new equipment. For existing equipment where the lamps are used, a mercury-free alternative is not possible (see details above).

It should be noted that the few potential long-term solutions for applications in exemption 4(f) contain component materials that use substances regulated in RoHS but exempted in certain exempted applications (e.g. lead in high melting temperature type solders used in diodes, lead in the glass or ceramic found in electronic components, lead in copper alloys, etc.). Furthermore, many of these substitutes would have no beneficial environmental impact, with some even having a negative or impact – a further disincentive to pursuing new technologies that have little prospect of functional success in small markets.

8. Justification according to Article 5(1)(a):

(A) Links to REACH: (substance + substitute)

1) Do any of the following provisions apply to the application described under (A) and (C)?

   Not applicable.

   ☐ Authorisation

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

   ☐ Restriction

   - ☐ Annex XVII ☐ Registry of intentions

   ☐ Registration

2) Provide REACH-relevant information received through the supply chain.
   Name of document:

Based on the current status of Annexes XIV and XVII of the REACH Regulation, the requested exemption would not weaken the environmental and health protection afforded by the REACH Regulation. The requested exemption is therefore justified as other criteria of Art. 5(1)(a) apply.

(B) Elimination/substitution:

1. Can the substance named under 4.(A)1 be eliminated?

   ☐ Yes. Consequences? _____

   ☒ No. Justification:

Mercury-free discharge lamps for the scope of exemption 4(f) are not yet available.

2. Can the substance named under 4.(A)1 be substituted?

☐ Yes.

☐ Design changes:

☐ Other materials:

☐ Other substance:

☒ No.

Justification:

Mercury-free discharge lamps for the scope of exemption 4(f) are not available.

3. Give details on the reliability of substitutes (technical data + information):

In those cases where alternative technologies enter the market, the reliability of the product is assumed. Of course, accumulating long-term information on reliability takes time.

4. Describe environmental assessment of substance from 4.(A)1 and possible substitutes with regard to
   1) Environmental impacts:
   2) Health impacts:
   3) Consumer safety impacts:

⇨ Do impacts of substitution outweigh benefits thereof?
Please provide third-party verified assessment on this:

(C) Availability of substitutes:

Mercury-free retrofit lamps are not available. As described in detail in the chapters above, for certain limited applications, new equipment has been developed that does not use discharge lamps but instead used technologies based on LED or lasers.

a) Describe supply sources for substitutes:

b) Have you encountered problems with the availability? Describe:

c) Do you consider the price of the substitute to be a problem for the availability?

☐ Yes ☐ No

d) What conditions need to be fulfilled to ensure the availability?

(D) Socio-economic impact of substitution:

Mercury free retrofit lamps are not available. As described in detail in the chapters above, for certain limited applications, new equipment has been developed that does not use discharge lamps but instead uses technologies based on LED or lasers.

As described in the chapter above, lamps covered by exemption 4(f) are not suitable for substitution and cannot be substituted

It must be kept in mind that special purpose lamps are used in a variety of equipment installed on the EU market. A premature ban on 4(f) lamps would render this equipment obsolete. This equipment would then become unusable and unnecessary waste well before reaching the end of its service life.

There are no one-to-one substitutes available for the lamps covered by exemption 4(f) due to the wide variety of applications they are used in and the application-specific requirements they must often comply with. For special purpose lamps, no substitute/retrofit lamps are expected for existing equipment. A denial of an exemption renewal for 4(f) lamps would mean these lamps could no longer be placed on the market. The impact of such a denial would therefore be borne not only by the manufacturers of these lamps (i.e., loss of jobs, closing of factories, etc.), but also by the end-users who will no longer have access to lamps to service existing equipment. The lack of lamps for existing equipment will essentially make that installed equipment obsolete, unusable, and unnecessary waste before its end of life (refer to section 5 (A) for the impact on waste).

Granting the exemption as requested and justified in this request will:

- Avoid the high negative socioeconomic impact on applications using (non)-UV spectra that such a ban would have. This impact would be very high for the downstream users who rely on these products to continue functioning and by far exceeds the effects considered by the 2019 Oeko Socio Economic Impact Assessment, which is generally limited to the administrative burden of applying for exemptions.
- Ensure that EEE using these lamps as spare parts will not become unnecessary and avoidable waste.
- Allow commercial and industrial processes to continue, avoiding job losses and a negative impact on the SMEs producing the small amounts of very specific lamps and applications.
- Prevent users from stockpiling lamps.

We have presented an overview of the various applications covered by this exemption within the UV and non-UV range and the potential socio-economic impact that a non-renewal of this exemption would have.

1. ***UV-Lamps:***

As proposed by Oeko in their 2016 report and their 2019 SEIA, all UV applications must be included in exemption 4(f). Doing so avoids dramatic harm to, for example:

Semiconductor manufacturing:

The European semiconductor and LED industries need lamps for microlithography and spectroscopy. According to the 2019 “Study to assess socio-economic impact of substitution of certain mercury-based lamps currently benefitting of RoHS 2 exemptions in Annex III”, carried out by the Oeko Institute, the economic impact on the semiconductor and other IC producing industries, as a user of lamps and equipment, could be in the range of EUR 25-40 billion.[42] Based on information collected for this exemption renewal dossier, the European electronics industry, including semiconductors, directly employs 200-250 000 people and contribute to 1 million indirect jobs across the ICT supply chain (jobs in systems, applications, and services in Europe). Overall, micro- and nano-electronics enable the generation of at least 10 % of GDP in Europe and the world. As a provider of key enabling technologies, the semiconductor industry creates innovative solutions for industrial development, contributing to economic growth and responding to major societal challenges. The European Commission has also ranked it as being one of the most R&D intensive sectors.

UV – curing:

A ban would lead to a loss in business, as several applications that require robust and scratch resistant prints can no longer be served with UV curing printers. An alternative is going back to solvent based inks, which are much more hazardous to human health and the environment.

UV – disinfection (air/water):

A ban will lead to a massive loss in business, applications, and disinfection quality. The existing method for water/air treatment would no longer be possible, resulting in chemicals having to be used to achieve safe water quality. If LED technology is used, more energy would be needed as LED efficiency and output is lower than conventional UV discharge lamps, meaning more LEDs are needed.

UV – disinfection (food):

A ban would also mean a significant number of food filling machines could no longer meet the hygienic requirements for safe food. Instead of UV disinfection lamps, chemicals like H2O2 would be needed for packaging disinfection.

2. *Lamps with visible spectrum:*

Horticultural lighting:

The high power HPS lamps with a power >= 600 W used for horticulture applications require specialised luminaires to provide the right light distribution on crops. There are no direct LED replacement lamps. Changing to an LED solution would require the entire greenhouse to be

[42] Page 144, “Study to assess socio-economic impact of substitution of certain mercury-based lamps currently benefitting of RoHS 2 exemptions in Annex III” , Oeko Institute 2019, available at: https://rohs.exemptions.oeko.info/fileadmin/user_upload/reports/FWCW_RoHS_Lamps_SEA_20190729_Final.pdf

rebuilt as greenhouse roofs are designed to bear the light weight HPS luminaires. Full LED solutions require a different set up of the greenhouse. Banning the horticulture lamps will result in a sudden stop in the production of many vegetables, particularly tomatoes and paprika. The other sector in horticulture is the production of flowers and potted plants. In the Netherlands alone, these sectors use 9 000 hectares and are responsible for 32 000 jobs. (source: central Bureau of statistics the Netherlands)[43]. The economic value of this segment, just for the Netherlands, is around EUR 7.4 billion. (source: University of Wageningen)[44].

Projectors:

The lack of lamps for projectors will render existing equipment non-serviceable and will therefore result in premature waste and will prevent new projectors from being produced. The total projector business has an annual turnover of approx. 6.2 million projectors, which corresponds to a value of $8 billion. The majority of projectors are equipped with a mercury containing lamp (see chapter 6A, reference 29). If projection is not included in this exemption, there will be a direct impact on the projector market and on employment in this sector. Jobs that are affected can vary, including everything from logistics to service, R&D, and manufacturing both projectors and the mercury containing lamps. The projector business itself serves two main market segments:

- Education: focusing on solutions for projecting content in classrooms
- Corporate: focusing on projectors to facilitate the meeting experience

These two market segments together cover +/- 80 % of the total projection market.

The consequence of no exemption being granted, in combination with the lack of equally performing alternatives, will be that new projectors or replacement lamps will no longer be available, resulting in:

- Since the projector is widely used in European classrooms, the level of classroom education will decrease. This is particularly true if the projector cannot be upgraded to the latest models offering higher brightness, higher resolutions, connectivity, which will be he case if the key spare part is no longer available. (as indication: typical replacement cycle for lamps in US schools is said to be every two years)
- In the corporate segment, the projector has a prominent place in meeting rooms and is used to easily share and project content. This is particularly true in the digital world, where interactivity and connectivity are essential to having efficient meetings and cooperation. Poor screen projection could set this trend back, resulting in less productive meetings. To overcome this, presentations will be shared as printed handouts, resulting in more paper consumption and paper waste. Furthermore, less effective meetings might lead to more travel in order to have face-to-face discussions.

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[43] Available at the following link here: https://www.cbs.nl/nl-nl/nieuws/2012/14/tuinbouw-goed-voor-125-duizend-banen

[44] Available at the following link here: https://www.agrimatie.nl/SectorResultaat.aspx?subpubID=2232&sectorID=2240&themaID=2280

Studio, stage, and entertainment lighting:

A mercury ban would have a significant impact on theatres, affecting around 20 % of light sources (of this 20 % there might be replacements for 80 %, but not for the remaining 20 %). A premature mercury ban would have the following consequences:

- Artistic quality: If these lamps are banned before a viable alternative is available, the artistic quality of the event or performance will be compromised (i.e., you won't be able to see the performers).
- Theatres, concert halls, festivals, and other live events would be left to investing in products that artistically cannot replace discharge lamps.
- Carbon footprint: As theatres and events would need to use a much larger quantity of LED fixtures, their carbon footprint will grow. It would significantly affect the logistics for touring companies (i.e., it would require more trucks) and would probably increase the power consumption as the higher-powered LED fixtures are of an equivalent power consumption to existing arc source fixtures.
- Market: The sector is already reducing the quantity of sold arc lamps, as most new moving lights are shipped in LED. However, by banning discharge lamps too quickly, the market will be "killed" as nobody would be able to change inventories so quickly. This also means that the manufacturers currently researching how to replace discharge lamps might not be able to do so anymore.
- Financial burden for cultural institutions: Replacing discharge lamps without giving the market the time to develop new products would result in an enormous financial burden for event companies, theatres, festivals, and other venues.

⇨ What kind of economic effects do you consider related to substitution?

☐ Increase in direct production costs

☐ Increase in fixed costs:

☐ Increase in overhead

☐ Possible social impacts within the EU

☐ Possible social impacts external to the EU

☐ Other: _____

⇨ Provide sufficient evidence (third-party verified) to support your statement:

9. Other relevant information

Please provide additional relevant information to further establish the necessity of your request:

As both the Ecodesign Regulation and RoHS regulate the access of mercury containing lamps to the EU market, LightingEurope expects alignment between these regulations to ensure the confidence of both customers and the industry.

Short arc mercury lamps are exempted from the recently published Ecodesign Regulation[45] because there are no suitable LED replacement lamps.

To quote ANNEX III (exemptions) of the Ecodesign Regulation 2019/2020:
"Any light source or separate control gear within the scope of this Regulation shall be exempt from the requirements of this Regulation, with the exception of the information requirements set out in point 3(e) of Annex II, if they are specifically designed and marketed for their intended use in at least one of the following applications:

(a) signalling (including, but not limited to, road-, railway-, marine- or air traffic-signalling, traffic control or airfield lamps);

(b) image capture and image projection (including, but not limited to, photocopying, printing (directly or in pre-processing), lithography, film and video projection, holography);"

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10. Information that should be regarded as proprietary

Please state clearly whether any of the above information should be regarded to as proprietary information. If so, please provide verifiable justification:

LightingEurope will provide the European Commission, under confidentiality, an overview of the mercury content and lamps placed on the market that are within the scope of this exemption.

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[45] 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.)