Response To Öko-Institut

regarding the

1st Questionnaire Exemption No. 4c(I-III) (renewal request)

Exemption for "Mercury in other High Pressure Sodium (vapour) lamps for general lighting purposes not exceeding (per burner):
I) P ≤ 155 W: 25 mg per burner
II) 155 W < P ≤ 405 W: 30 mg per burner
III) P > 405 W: 40 mg per burner"

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Name and contact details

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Abbreviations and Definitions

CMH	Ceramic metal halide
Hg	Mercury
HPS	High pressure sodium (vapour) lamps
LEU	LightingEurope
Na	Sodium

Background

The Oeko-Institut and Fraunhofer IZM have been appointed within a framework contract[1] for the evaluation of applications for the renewal of exemptions currently listed in Annexes III of the new RoHS Directive 2011/65/EU (RoHS 2) by the European Commission.[1]

LightingEurope has submitted a request for the renewal of the above mentioned exemption, which has been subject to a first evaluation. The information you have referred has been reviewed and as a result we have identified that there is some information missing and have formulated a few questions to clarify some aspects concerning your request.

Questions

1. Page 6 details various uses of HPS lamps, which all appear not to be private-consumer uses. On pg. 11 however it is detailed that "*Some manufacturers of electrical equipment in other RoHS categories may install HPS lamps with improved colour rendering into their equipment for general illumination purposes and so they will need to use lamps that comply with the RoHS directive. However the products that they place on the market are not category 5 but may be household appliances, medical devices or potentially in any RoHS category 1 - 11*". Please provide a few examples of such products using HPS lamps for consumer /medical /monitoring and control purposes if relevant and estimate what share of the market such cases represent.

   Answer of LightingEurope: The remark was made in all LightingEurope exemption renewal requests since the lamp manufacturer does not control where the lamps are used, hence the text can be considered as a standardized formulation across all papers. HPS lamps in particular are used in professional lighting applications, there might be a small number of lamps that are used in private applications for outdoor lighting. We have no examples of medical monitoring or control usage.

2. Pg. 12-13 explains the function of sodium and Hg in the lamp, clarifying that the sodium reacts with the lamp components, resulting in the rise of the ratio of Hg/Na vapour in the lamp, until the point where the Hg ratio is too high and the lamp extinguishes (end-of-life). It is explained that "*For a given sodium consumption, a certain amalgam dose is required to reach the specified life*". However it is understood that the Na share decreases whereas the Hg share remains the same. Please explain why the amount of sodium used determines the minimal amount of Hg needed and why more sodium cannot be used alternatively in order to prolong the lamp life.

   Answer of LightingEurope: The ratio of sodium to mercury in the dosed amalgam is what determines the vapour pressures of both these substances. These absolute vapour pressures in turn define the electrical and photometrical properties of the HPS lamps. If, in an attempt to accommodate for a loss of sodium over life, more sodium is dosed for a given mercury content, the discharge plasma will be richer in sodium initially. Since the luminous efficacy peaks at a given sodium pressure, the consequence of this is that the lamp will have lower efficacy than rated (and also a higher colour rendering index) and will be out of

[1] Contract is implemented through Framework Contract No. ENV.C.2/FRA/2011/0020 led by Eunomia.

specification. Furthermore, excessively high sodium content can negatively affect system reliability (e.g. a worse extinction characteristic leads to “drop outs/cycling” from minor line voltage dips).

3. Additional factors are mentioned in section 4.2.3 of the application that govern the use of Hg in HPS lamps. Please estimate how much each of these factors, as well as the amount of sodium used per lamp, determines the amount of Hg needed per lamp?

   Answer of LightingEurope: The amount of mercury dosed is determined as follows:

   a. A high Pressure Sodium lamp has a cylindrical discharge vessel defined by a length and a diameter. These dimensions and the sodium/mercury ratio in the amalgam are simultaneously optimized so that the maximum efficiency is realized at the desired chromaticity point, at the correct lamp voltage and at a predetermined maximum vessel wall temperature.
   b. The dose (mg’s) of amalgam needed is determined by assessing the sodium loss rate over life. This is done by monitoring the spectrum and the electrical characteristics over the life of the lamp: the lamp voltage increases and the broadening of the sodium D-lines decreases. The minimum dose that guarantees the specified life is chosen.
   c. The additional factors 2 and 3 of section 4.2.3 are secondary, i.e. they are not optimized by themselves but contribute to the quality factors mentioned.

   These effects are the property if the mercury atom itself.

4. Section 4.2.5 details that there are 3 types of HPS lamps. HPS Lamps with Saturated Amalgam Dose are understood to be the typical lamp for which the exemption is needed, whereby Lamps with an Unsaturated Amalgam Dose are explained to be non-compliant with the ErP Regulation 245/2009 and thus not marketed in the EU and Mercury Free HPS Lamps are explained to be marketed in the EU in a low volume.

   a. Please provide an explanation of the term “lumen maintenance” mentioned on pg. 22.

      Answer of LightingEurope: Lumen maintenance is the luminous flux (at a certain point in time) relative to its reference measurement after 100 burning hours. This parameter is regulated in Regulation EC 245/2009, where minimum levels are set (typically 80% at 12000 hours), to ensure the generated light (flux) keeps at acceptable level during product lifetime.

   b. Please explain in more detail why Mercury Free HPS Lamps cannot be used to replace the lamps benefiting from the current exemption 4(c)(I-III) (or to replace certain parts of the application range)?

      Answer of LightingEurope: Although part of the range of saturated HPS lamps can be replaced by Mercury Free alternatives, the overall environmental impact of such replacement would be negative due to the lower efficacy and shorter life of these latter types (Figure 13 in the exemption request), as shown in the Preparatory Study for Eco-Design Requirements of ErP’s for Public Street Lighting (referenced in the exemption request, section 6.1, p. 23).

c. In this respect, please clarify the range of use of Mercury free HPS lamps and of saturated amalgam dose HPS lamps so that it is clear in what cases Hg free alternatives can be applied.

Answer of LightingEurope: *Mercury Free HPS lamps exist in the range 70W-100W-150W-250W-400W. Saturated lamps have the additional wattages 35W-50W and 600W-1000W.*

d. To support your answer please clarify differences in terms of lamp performance and characteristics.

Answer of LightingEurope: See Figure 13 in the Exemption Request.

The mercury free HPS lamps are 5% less efficient than the best mercury containing HPS lamps. The lifetime of the mercury free lamps is one year shorter than the 6 years of the best mercury containing lamps.

Details per wattage (for clear tubular types) are given in the Table below (data from company websites):

Table 1

Wattage	*Mercury Free Technology*		*Mercury Poor Technology*		*Standard Dose Technology*		ERP Efficacy
	Mercury Free Efficacy	Mercury Free Maintenance	Mercury Poor Efficacy	Mercury Poor Maintenance	Standard Dose Efficacy	Standard Dose Maintenance	
50					83	85	80
70	90	83	90	85	95	89	90
100	100	87	100	85	107	90	100
150	114	87	106.7	85	117	91	110
250	125	87	116	85	130	92	125
400	136	87	125	85	142	92	135
600					150	88	135
1000					130	80	-

Values averaged over published values of main European suppliers

5. Regarding information from existing LCAs, three studies are mentioned and it is explained that “Since HPS and ceramic metal halide (CMH) have very similar material usage, production methods and efficacy, the results for CMH can also be extrapolated to HPS.” Please detail the comparison of the two types of lamps to support this statement and to allow understanding to what degree the CMH results can be extrapolated for HPS lamps.

Answer of LightingEurope:

Materials:

All materials are identical except for:

- Electrode emitters are not present in CMH. These are powders of barium, calcium and strontium oxides applied to the electrodes of HPS lamps. The dose per lamp is in 1-5 mg powder.
- Metal halides are not present in HPS. These are metal-halogen compounds dosed in the range 1-50 mg.
- Fill gas for HPS is Xenon, for CMH it is Argon.

None of these differences have high ecological impact because of the very small amounts used.

The largest material usage in weight is glass, metals and ceramics (poly crystalline aluminium oxide) and these are identical.

Process:

Processes are completely identical. The same equipment can generally be used and power and utility usage is identical.

Very recently (May 2015), a new LCA[2] including all light technologies was drafted in the framework of the MEErP framework of the European Commission**.** The report uses data from 2013**.** Table 16 of this works compares the environmental impact per Mega-lumen-hours for all base case lamp types. The table clearly shows that for all environmental aspects the impact of HPS and MH lamps are very similar. Moreover, in 2013 the HPS (and MH) ecological impact of all studied parameters, including energy use and heavy metals emission to air and water, was still lower than for LED (retrofit lamps).

[2] Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements ('Lot 8/9/19'). Draft report, Task 5 Environment & Economics (base case LCA & LCC), May 2015. http://ecodesign-lightsources.eu/sites/ecodesign-lightsources.eu/files/attachments/LightSources_Task5_may2015_Draft.pdf

Figure 1

HPS Lamp	Ceramic metal halide lamp
	

6. A study "from the Renselaer Polytechnic Institute in Troy, NY, comparing street layouts with several HPS and LED light points" is mentioned explaining that "*LED streetlight layouts on average resulted in a slightly lower power demand than the average HPS streetlight layouts… However, the power demand per kilometre of street for individual layouts varied significantly. Only 2 of the 8 LED luminaires gave a power reduction when compared to the best HPS luminaire… the cost to own and operate the LED installation is still twice as large as an HPS installation*". The studies referenced however are form 2010 and 2011. However it is apparent that the lighting industry is investing a lot of effort in the fast development of solid state lighting and LED applications and thus also anticipated that that the results of these studies may no longer represent the current state of LED development, nor the expected state of development within the coming 5 -10 years. The shift that is already apparent of municipalities towards LED street lighting also supports that the conclusions may no longer be as applicable as they were at the time of the report.

    a. Please provide information and supporting data to clarify the applicability of the report conclusions;

    Answer of LightingEurope: The question refers to a study where HPS lighting is compared with LED luminaires. Hence, the answer below also refers to LED luminaire installations only. LED retrofit lamps are commented in the answers to question 7.

    The feasibility for replacement of the luminaire with LED luminaires has indeed improved over the last years. However, the light plan with the new luminaires on existing poles still has to be adapted to provide the required legal light fluxes.

    The characteristics of replacing an HPS (and more generally an HID) luminaire with an LED luminaire anno 2015 are described in the draft interim Preparatory Study on

Light Sources for Ecodesign and/or Energy Labeling Requirements3 made for the COM by VITO and VHK., see par. 5.17.4. The report states that the LED luminaires nowadays need about 20% less lumen for the same lighting job. However the cost of LED luminaires is still significantly higher than that of an HID luminaire, especially for the higher lumen packages. In par. 5.18.2 the report predicts that, nevertheless, the replacement of HID luminaires with LED lamps will be common practise in the following years: "Considering current trends in street lighting and considering the advantages of LED luminaires over LED retrofit lamps, this is expected to be a frequently used option, in particular for low wattage HPS-lamps at the end of the luminaire life time (30 years)."

b. Please explain how the market shares of lamps falling under Ex. 4(c)(I-III) and of LED lamps have changed over the last 5 years and provide estimations as to further trends expected over the next ten years.

Answer of LightingEurope: The market for HPS lamps consists of a large retrofit market where existing street lighting luminaires are provided with new lamps. A much smaller part of the market is for lamps for new luminaires e.g. for new roads.

The latter part of the market, lamps for new installations, is almost completely taken by LED luminaire solutions. Most of the currently produced HPS lamps are used in existing installations. For this market there are no LED solutions (see answers to question 7).

See section 4.1.2 of the exemption request for an estimate of the market trends up to 2020. All available data from market studies have been used there to provide the estimate. In section 6.2.3.3 an attempt to extrapolate this data is made. The conclusion is that it is likely that the installed base of HPS lamps will be replaced by LED in a time frame of 12 years, i.e. by 2027. In view of the uncertainty involved in this extrapolation a period of 10-15 years seems the best estimate.

7. It is stated that "*As explained before, there are no one-to-one true replacement lamps for the HID family available. There are LED lamps that are claimed in advertisements to be retrofits. These lamps are easily available (can be ordered from dozens of websites) but they never supply the required lumen output and are too large to be a universal solution. Moreover, the price for these claimed retrofits presents a problem as they are often priced as high as a full LED luminaire*".

   a. Please provide actual examples and data to support this statement.

[3] Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements ('Lot 8/9/19) Draft Interim Report, Task 4(Technologies), May.2015, VITO, VHK http://ecodesign-lightsources.eu/sites/ecodesign-lightsources.eu/files/attachments/LightSources_Task4_may2015_Draft.pdf

Answer of LightingEurope: Here are 5 examples:

1. http://www.gogreenledinternational.com/led-retrofits/led-post-tops/12w-post-top-street-light.html

   This is a 12W LED lamp claimed to retrofit a 50W HPS lamp. Dimensionally this lamp complies but the lumen output of 1000 lm (max) is only 25% of the lumen output of an HPS 50W lamp (ErP minimum).

   Retail price is $ 87 versus $ 10 for HPS lamp.

2. http://www.gogreenledinternational.com/90w-ul-post-top-light-with-external-ul-power.html

   This is a 90W LED lamp providing 8000 lm. This could replace a 70W HPS lamps lumen-wise but dimensionally there is no match:

   HPS (ovoid) Lmax=165mm x Dmax=72mm

   versus

   LED L=254mm x D=122mm

   Retail price is $ 254 versus $ 10 for HPS lamp.

3. http://www.ledglobalsupply.com/led-commercial-bulbs/400-watt-hid-led-retrofit/

   A 100W-12,000 lm LED lamp claims to retrofit a 400W HID (incl. HPS) lamp. ErP minimum for a 400W HPS lamp is 54,000 lumen, so only 22% of the required luminous flux is provided. Moreover, with 305 mm overall length the lamp is longer than the maximum allowed length in the IEC standard (292 mm).

4. http://www.ledglobalsupply.com/led-commercial-bulbs/120-watt-hid-led-retrofit/

   A 40W LED lamp providing 4200 lm. It is claimed that the lamp replaces a “120W HID lamp”.

   For a 100W HPS replacement an ErP minimum of 10,000 lm is required. So, only 42% is provided. Dimensionally the lamp does not fit either:

   HPS 100W (ovoid) Lmax=186mm x Dmax=78mm

   versus

   LED 40W L=236mm x D=94mm

   Retail price is $ 300 versus $ 10 for HPS lamp.

5. http://www.led-llc.com/products/site-post-top/item/35w-site-roadway-wall-pack-lamp-120-beam-angle

   A 35W LED replacement lamp claimed to replace “up to 100W” HPS. The 2760 lm output is not sufficient to replace 50W (min ErP 4000 lm), 70W (min ErP 6300 lm)

nor 100W (min ErP 10,000 lm). Also dimensionally the lamp does not comply with maximum IEC outlines:

HPS 50-70W (ovoid): Lmax=165mm x Dmax=72mm

HPS 100W (ovoid): Lmax=186mm x Dmax=78mm

versus

LED 40W L=287mm x D=90mm

Retail price is $ 257 versus $ 10 for HPS lamp.

b. In this regard, please clarify if this statement is relevant for all applications of HPS lamps falling under Ex. 4(c)(I-III) or only for the replacement of HPS lamps in existing installations.

Answer of LightingEurope: The statement is for replacement of HPS lamps in existing installations, i.e. LED retrofits. Installation of new LED systems (LED luminaires) is treated separately (see answers to question 6).

c. In relation to Ex. 4(c)(I-III) applications, please clarify in detail why and in which cases LED substitutes do not provide sufficient performance, when an installation replacement is performed (e.g., energy efficiency, light output and distribution, thermal performance etc.).

Answer of LightingEurope: The scientific explanation of why LED retrofit lamps do not provide sufficient performance is quite basic and is given in section 6.2.1.1.

The lack of performance is in all cases. Whether it is mostly because of light output or dimensional depends on the approach: more light can be provided by making the lamps bigger but the HPS specification is never reached and it makes the lamp even more out of dimensional compliance (see examples above). In practise, these lamps are only used in cases where the luminaires are oversized, where there are no requirements on light level and distribution and where it is acceptable to reduce the light level drastically. These conditions represent a very small fraction of the installations as the majority of HPS lamps are used in public lighting conditions where there are strict legal requirements for the lighting provided.

In the preparatory work[4] for the One lighting regulation, HID retrofit lamps were discussed in reports for task 4, 5 and 6. Specifically in the Task 6 report, par. 3.8, the

[4] Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements ('Lot 8/9/19) Draft Interim Report, Task 4(Technologies), May.2015, VITO, VHK
http://ecodesign-lightsources.eu/sites/ecodesign-lightsources.eu/files/attachments/LightSources_Task4_may2015_Draft.pdf
Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements ('Lot 8/9/19) Draft Interim Report, Task 5(Environemnt and economics), May.2015, VITO, VHK
http://ecodesign-lightsources.eu/sites/ecodesign-lightsources.eu/files/attachments/LightSources_Task5_may2015_Draft.pdf
Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements ('Lot 8/9/19) Draft Interim Report, Task 6(Design options), May.2015, VITO, VHK

replacement of HPS and MH lamps with BAT LED retrofit lamps of 2015 and predicted BAT for 2020 was analysed. The option LED retrofit 2015 is "inspired by a mix of two existing retrofit lamps" and as such not a product that exist on the market in 2015. Moreover, these products are dimensionally not compatible. Even for this imaginary product the electricity usage and the life cycle cost are considerably higher than for the HPS replacement lamp. The prediction for 2020 is more favourable for the LED retrofit as electricity and life cycle cost are both expected to drop below the HPS lamp.

However, severe comments were made on the assumption that these lamps are replacement lamps, for instance by the Danish energy agency.[5]

They state the following: "In Task 6 the LED-option for HID lamps is obviously some kind of LED-retrofit; however such retrofit options are very sparsely available and will probably never be available as a replacement for the very common clear HPS and MH lamps used in road lighting. Therefore it should be clearly explained and shown that the LED-options for HPS and MH lamps are imaginary and only are included only to show that even if a 2020 LED-retrofit option was possible it would not be beneficial."

(Underlining by LightingEurope)

Please note that answers to these questions are to be published as part of the available information relevant for the stakeholder consultation to be carried out as part of the evaluation of this request. If your answers contain confidential information, please provide a version that can be made public along with a confidential version, in which proprietary information is clearly marked.

http://ecodesign-lightsources.eu/sites/ecodesign-lightsources.eu/files/attachments/LightSources_Task6_rev1_june2015_Draft.pdf

[5] The discussion on the existence of LED retrofits for HID lamps is answered by the Danish energy expert in: http://ecodesign-lightsources.eu/sites/ecodesign-lightsources.eu/files/attachments/2nd%20Stakeholder%20comments%20from%20DEA%20%20-%2020150615%20.pdf