European Commission

# Study to assess socio-economic impact of substitution of certain mercury-based lamps currently benefitting of RoHS 2 exemptions in Annex III

*Under the Framework Contract: Assistance to the Commission on technical, socio-economic and cost-benefit assessments related to the implementation and further development of EU waste legislation*

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*Disclaimer*

Oeko-Institut and Fraunhofer IZM have taken due care in the preparation of this report to ensure that all facts and analysis presented are as accurate as possible within the scope of the project. However, no guarantee is provided in respect of the information presented, and Oeko-Institut and Fraunhofer IZM are not responsible for decisions or actions taken on the basis of the content of this report.

**EUROPEAN COMMISSION**

Directorate-General for Environment

Directorate B — Circular Economy and Green Growth

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# Acronyms and definitions:

| | |
|---|---|
| BAU | Business as usual scenario (see also Section 3.1); |
| CFL | Compact fluorescent lamp; |
| CFLi | Compact fluorescent lamp with integrated ballast |
| CFLni | Compact fluorescent lamp with non-integrated ballast |
| CCFL | Cold cathode fluorescent lamps |
| EEE | Electrical and electronic equipment |
| EEFL | External electrode fluorescent lamps |
| EoL | End of life |
| HID | High intensity discharge lamp; |
| HPS | High pressure sodium lamp; |
| LED | Light emitting diode; |
| LFL | Linear fluorescent lamp; |
| MH | Metal halide |
| MELISA | The VHK Model for European LIght Sources Analysis (MELISA) model (VHK 2016); |
| MS | Member State |
| Plug & Play lamp | A lamp that can be used as a "drop-in" replacement, through its insertion into a luminaire (plugging in, screwing in), without requiring the performance of any technical changes to the luminaire aimed at establishing the compatibility of the luminaire with the replacement lamp. |
| Retrofit lamp | A lamp that can be used to replace a lamp used in a luminaire. This term is referred to in this study when a discharge lamp, associated with one of the RoHS exemptions) can be replaced with another lamp (discharge of a different type or other technology) as a Plug & Play substitute or through conversion and/or rewiring of the luminaire aimed at establishing the compatibility of the luminaire with the replacement lamp. |
| RoHS | Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment; |
| SUB | Substitution scenario (see also Section 3.1); |
| ToR | Terms of reference |

# 1. Executive summary – English

Under Framework Contract no. ENV.A.2/FRA/2015/0008, a consortium led by Oeko-Institut was commissioned by DG Environment of the European Commission to assess socio-economic impacts of substitution of certain mercury-based lamps currently benefitting of exemptions in Annex III to Directive 2011/65/EU of the European Parliament and of the Council on the restriction of the use of certain hazardous substances in electrical and electronic equipment ("the RoHS Directive"). The work has been undertaken by the Oeko-Institut and has been peer reviewed by Fraunhofer Institute IZM.

## 1.1. Background and objectives

By January 2015, in line with Article 5 of the RoHS Directive, the European Commission received applications for the renewal of various exemptions listed in Annex III of the Directive, which were due for expiration in July 2016. Several of these exemptions (exemptions no. 1 - 4) were related to the use of mercury in lamps.

On behalf of the European Commission, in 2015 and 2016, the evaluation of the requests was carried out by Oeko-Institut. The evaluation was performed as required according to the criteria in Article 5(1)(a) of the Directive, which states that at least one of the three main criteria[1] must be fulfilled to justify an exemption. A report concluding this evaluation, presenting the assessment and recommendations for each of the requested exemptions, was published in June 2016[2] (Gensch et al. 2016).

The evaluation report includes assessments of a large number of electrical and electronic equipment (EEE) applications, including several groups of discharge lamps where mercury provides fundamental functions. In the evaluations of the latter, special focus was given to the various groups, types and subtypes of discharge lamps as the availability of substitutes strongly varies from case to case. Furthermore, the market for the mercury free LED technology is developing dynamically. Against this picture, the evaluation report recommended certain exemptions to be renewed for a further duration of 5 years, others to be renewed for shorter periods and in many cases, the report suggested amendment to the exemption wording, limiting the scope of the exemption. In a few cases, the report recommended to revoke an exemption, granting the industry a transition period of 18 months as per Article 5(6) to allow for the phase out of relevant lamps.

1 The three Article 5(1)(a) criteria:
— their elimination or substitution via design changes or materials and components which do not require any of the materials or substances listed in Annex II is scientifically or technically impracticable,
— the reliability of substitutes is not ensured,
— the total negative environmental, health and consumer safety impacts caused by substitution are likely to outweigh the total environmental, health and consumer safety benefits thereof.

2 Report available on the Commissions website under: https://publications.europa.eu/en/publication-detail/-/publication/a3fdcc8c-4273-11e6-af30-01aa75ed71a1

On 1 September 2016, the evaluation and recommendations for some of the exemptions (particularly those recommended to be revoked) were presented at a meeting of the Commission Expert Group for RoHS 2 adaptation and enforcement. At the meeting, representatives of LightingEurope, who submitted many of the renewal requests for the lamp exemptions, and other representatives of lamp manufacturers also presented their views and concerns in relation to the evaluation and recommendations. The lighting industry stakeholders stated that the revocation of the exemptions as recommended would lead to significant socio-economic costs for industry and subsequently for the European Union, among others relating to the early closing of manufacturing facilities, loss of employment opportunities, and high investments in conversion of existing luminaires or purchase of new ones, where the existing ones were not compatible with available LED substitutes.

Article 5(1)(a) of the Directive specifies that next to the availability of substitutes, socio-economic impacts should be considered in taking decisions regarding exemption requests, including on the duration of any exemption granted. Though it could not be excluded at the time of the evaluation that the proposed changes to the lamp exemptions (Ex. 1-4) could create various socio-economic impacts, it had then not been possible on the basis of available data to quantify such impacts or to demonstrate their magnitude, and in this respect also to assess the benefits of a mercury reduction against the possible costs of the changes.

Against this background, the European Commission requested technical and scientific support in the preparation of a further detailed evaluation of the socio-economic impact of the substitution of mercury in certain lamps.

## 1.2. Scope and Scenarios

The terms of reference of the current study require the assessment of socio-economic impacts related to mercury-based lamps covered by exemptions 1-4 of Annex III of the RoHS Directive. The assessment considers two scenarios:

- BAU - Business as usual, where the lamp substitution is governed by market forces (RoHS Annex III exemptions 1-4 are renewed without changes to wording);
- SUB - Substitution according to the scenario recommended in the assessment report provided to the Commission by external consultants, with effect as of mid-2018;

The recommendations in the previous evaluation report took into account the differences in substitute availability pertaining to Plug & Play[3] replacement lamps, substitute lamps that require a rewiring or conversion of the lighting equipment and substitutes that comprise of a replacement of the lighting equipment (luminaire). On the basis of a first analysis of expected impacts, it was concluded that the main

[3] A Plug & Play lamps is a lamp that can be used as a “drop-in” replacement, through its insertion into a luminaire (plugging in, screwing in), without requiring any technical changes to the luminaire aimed at establishing the compatibility of the luminaire with the replacement lamp.

differences between the scenarios are related to a sub-set of the lamps covered by Annex III exemptions 1-4, which are detailed in the following[4]. The lamps addressed in this sub-set are the focus of the detailed analysis performed in this study:

- Compact fluorescent lamps below a wattage rating of 50 W (Annex III exemptions 1(a)-(b)); 325 million lamps directly affected. Spillover effects[5] related to other CFL lamps are discussed;
- Linear fluorescent lamps with normal lifetime and with tube diameter ≥ 9 mm and ≤ 28 mm (T5 and T8, Annex III exemptions 2(a)(2)-(a)(3)); 323 million lamps directly affected. Spillover effects related to other LFL lamps are discussed;
- Non-linear tri-band phosphor lamps with tube diameter > 17 mm (e.g. T9, Annex III exemption 2(b)(3)); between 6 to 18 million lamps directly affected[6]. Discussed together with LFL lamps;
- Mercury in High Pressure Sodium (vapour) lamps for general lighting purposes with a colour rendering index Ra <60 (Annex III exemption 4(c)); this sub-group addresses 23 million lamps, however only some of these lamps with a power rating between 155 W < P ≤ 405 W are expected to be affected differently under the two scenarios. Spillover effects related to other HPS lamps are discussed;
- Special purpose lamps covered by exemptions 1(f), 2(b)(4), 4(a) and 4(f) (number of lamps affected: 400,000 lamps for Ex. 1(f); 18 million lamps for Ex. 2(b)(3)[7], 2(b)(4) and 4(a) and not clear for Ex. 4(f)).

## 1.3. Methodology and Data Sources

According to its Specific terms of reference, the study should demonstrate the socio-economic impacts of lamp substitution under different options, in terms of:

- *Impact on employment;*
- *additional costs (money expenditure) for different user categories due to lamp substitution;*
- *impacts on consumers (private and public);*
- *quantified generation of additional waste as a consequence of the lamp substitution before the end of the regular lifetime; and*
- *reduction in the amount of mercury placed on the EU market.*

4 All numbers stated below refer to the 2013 annual market volume in Europe of the various lamp types

5 Spillover effects may occur where the share of lamps affected from the common discharge technology is relatively significant, and thus expected to have a larger impact on the production of lamps of the same technology. For example, where a facility manufactures both general purpose (90%) and special purpose lamps (10%) of a specific technology, it can be expected that a phase-out of the general purpose lamps may affect the economic feasibility of continuing manufacture of the special purpose ones.

6 Estimated number of lamps relates to the exemptions 2(b)(3), 2(b)(4) and 4(a). If no additional data is made available, for the sake of further discussion, it shall be assumed that at worst, 18 million lamps were placed on the market in 2013, and at best 6 million.

7 As detailed in Table 1, stakeholder data indicates that in 2013, 18.6 million lamps were placed on the market for Ex. 2(b)(3), Ex. 2(b)(4) and Ex. 4(a). Though only two of these exemption are included in the sub-group "special purpose lamps" data is not available as to how this quantity is divided between the lamps covered by these three exemptions.

Various data was used at the initial stage to prepare a first estimation of impacts expected to be associated with the two scenarios. For the purpose of the initial and the later estimations, data was used from the following sources where possible:

- Data from the VHK Model for European LIght Sources Analysis (MELISA) (VHK 2016) has been used as a source for market data and market forecasts. Though the version of this model used, dated 13 July 2016, is not published at the time of writing, it is understood that it represents a consensus model, discussed with various stakeholders and developed as a commonly accepted forecast of the lighting market of the coming years.
- In relation to specific exemptions, information and data from the initial exemption requests submitted by LightingEurope in January 2015 has been used. This is relevant for example in cases of lamps not covered by the MELISA model (special lamps) and where additional information is needed to bridge the gap between the data in the MELISA model (related to specific lamp technologies for general purpose lighting) and the RoHS exemptions (where classification is related to power supply, dimensions, etc.).

Where the above sources did not allow sufficient substantiation of estimations with data and information, assumptions were made on the basis of expert judgement, so as to provide a first estimation for reference. For example, such assumptions were made in relation to the weight of scrap generated through a regulatory driven substitution or in relation to the availability of substitutes for a certain technology.

To validate such assumptions (confirm or adjust on the basis of data provided by stakeholders and/or expert judgement of the lighting sector), a targeted stakeholder meeting was held on 22.2.2017 with LightingEurope (LE) and with representatives of some of its members. During the meeting, the various assumptions were discussed to determine what data was relevant for allowing a more precise estimation. Some of the assumptions made were confirmed through the discussion held during the stakeholder meeting and are specified as such within this document. For other assumptions, following the meeting, LE provided additional data in relevant areas (where this did not breach proprietary issues) and the estimation was carried out again after a revision of the related assumptions.

## 1.4. Key findings – Overview of the assessment results

### 1.4.1. Preliminary remark

Due to the complexity of the assessment (various lamp types as well as different substitution routes, best and worst case scenario, etc.), the presentation of all findings would exceed the scope of this summary. Against this background, the next section summarises relevant general findings, followed by a section where we detail the most relevant findings for the lamp groups defined, including cross references to the detailed findings.

### 1.4.2. General findings

In general, the current study shows that for most of the exemptions reviewed in relation to mercury used the recommendations do not create new impacts per se, but only accelerate processes already underway in the lighting sector. For the predominant part, the implementation of the recommendations specified in the 2016 technical and scientific assessment (Gensch et al. 2016)[8] results in costs and benefits incurring earlier than otherwise expected. There are, however, differences between the exemptions as regards the time that would be needed for various processes to take place naturally. While substitution is currently already underway for some technologies, for others, it is only expected in the future. This affects the ratio between substitutions to take place naturally in any scenario and between substitutions that may be associated with the implementation of the recommendations of the 2016 technical and scientific assessment. How significant the impacts of an early substitution are expected to depend on this ratio, as follows.

The amount of replacement costs furthermore depends on the available replacement options, i.e. on the share of lamps that can be replaced with Plug & Play alternatives, that require rewiring, or, in cases where such alternatives are not compatible with the lamp fixture, on the share of luminaires to be replaced. The distribution of these options varies from case to case. Energy savings expected from the shift to LEDs have been subtracted from the costs of replacement. In some cases, this may set-off costs significantly already within the period investigated in the assessment whereas in other cases, this shall occur at a later stage.

In relation to labour, in the various cases, a regulatory driven phase-out occurring earlier than the natural phase-out can be expected to lead to a loss of jobs related to the manufacture of discharge lamps (in the EU and beyond - see 3.4). The lighting industry has estimated that in the EU, around 20,000 employees could, as a consequence of the above, lose jobs in the lighting sector (i.e. decrease in discharge lamp manufacture in the EU). However, it needs to be kept in mind that some of the employees may be shifted towards development and manufacture of mercury-free lamps. Additionally, as for some types of lamps, the regulatory driven phase-out shall result in luminaires needing to be rewired or replaced, an increase in the employment of electricians is also expected as a positive result of the SUB scenario. For example, for compact fluorescent lamps (CFL), the increase in electrician jobs in the EU is expected to be in the range of 10.800 and 27.500 jobs, depending on the year. For linear fluorescent lamps (LFL), an increase in the range of 37,000 to 55,000 electrician jobs is expected in the EU. For further details, see the sections related to "Expected impacts on employment" (4.3, 5.36.3 and 7.3). Overall, the loss of jobs in the lighting sector is expected to occur independently from the measures covered by this assessment by reason of the shift to LED technologies. It would extend over a longer period where the recommendations are not implemented.

[8] See footnote 2.

### 1.4.3. Specific findings

Further key findings are highlighted below for the four lamp sub-groups investigated in the course of this study: compact fluorescent lamps, linear fluorescent lamps, high pressure sodium lamps and special purpose lamps.

For **compact fluorescent lamps** (CFL), the current natural market development shows a general reduction in the stock of these lamps, suggesting that the natural shift away from CFL is already taking place: Despite the fact that there is currently no phase-out for any of the CFL lamps as a consequence of the RoHS restrictions, the natural phase-out is expected to lead to a reduction of the total stock of lamps in 2025 to only 40% of the total 2018 stock.

For ***CFL with integrated ballast*** *(hereafter CFLi),* the natural phase-out is more significant (the 2025 stock comprises 35 % and 38 % of the 2018 stock for residential and non-residential CFLi respectively). In other words, for these sub-groups, around two thirds of the stock should be phased-out by 2025 regardless of the implementation of the recommendations of the 2016 scientific and technical assessment.

For ***CFL with non-integrated ballast*** *(hereafter CFLni)* the natural phase-out is more moderate with the 2025 stock comprising of 66 % and 56 % of the 2018 stock for residential and non-residential CFLni, respectively. The slower natural phase-out of residential CFLni is expected to be related to the longer service life of such lamps.

In regard to this reduction in stocks, it is important to note that substitution is ongoing despite the lack of Plug & Play substitutes. Such substitutes are common for CFLi lamps (particularly for lamps in the lower wattage groups), however, in the CFLni groups and for the higher wattage groups of CFLi, available information suggests that the lack of Plug & Play substitutes would make rewiring and conversion of luminaires or the replacement of luminaires necessary, leading to higher replacement costs. The indication that 60 % of the stock of all 2018 CFL lamps will be substituted in the BAU scenario by 2025 suggests that such costs are acceptable in most cases.

According to the analysis of the SUB scenario, the additional substitution costs for consumers shall amount to a total of approximately 38,800 million EUR for the 7 year period 2019-2025 (actual costs only begin to incur in 2019), or an average of 42 EUR per lamp (18 EUR per CFLi and 89 EUR per CFLni). The annual costs vary and start at ~7,900 million EUR in 2019, decreasing to ~3,300 million EUR in 2025. In both cases, the expected energy savings have been subtracted from the lamp substitution costs, as LED substitutes consume less energy than their CFL counterparts. It is noted that the analysis only covers the years between 2016 and 2025, however, lamps purchased as substitutes for restricted CFLs in the SUB scenario shall continue to provide energy savings after this period due to their longer lifetime. The per capita total costs of substitution amount to ~75 EUR per EU resident, distributed over the 7 years investigated, meaning that per annum, between 6.4 and 15.5 EUR per capita costs shall incur for the CFL phase-out in the observed period assuming the recommendations in the 2016 study are implemented. In 2025, the annual cost would have already decreased to ~6.4 EUR per capita, meaning that the annual costs related to the regulatory driven substitution are decreasing from year to year. When comparing the respective costs for CFLi and CFLni, it is further observed that costs of the regulatory driven CFLni phase out shall be higher than for CFLi (ranging from 1.2-6.1 EUR per capita for CFLi and 5.3-9.3 EUR per capita for CFLni and per annum).

For further details on the analysis, please see chapter 4.

In the case of **linear fluorescent lamps** (LFL), a distinction has to be made between T5 lamps and T8 lamps in relation to impacts of a regulatory driven substitution.

***LFL T8 lamps*** are lamps covered by Ex. 2(a)(3) of RoHS Annex III: Tri-band phosphor LFL with normal lifetime and a tube diameter > 17 mm and ≤ 28 mm. A natural phase-out is expected to be underway for T8 lamps by the time the implementation of the recommendations would apply. Current forecasts of the development of T8 lamps show that a decrease in their sales is expected to begin in 2017, and in 2025, new sales are expected to be only 56% of the 2018 sales. For such lamps, sales expected in 2019 are already expected to decrease by 5 % in relation to 2018 sales and in 2021, 80 % of the 2018 sales are still to be placed on the market. Thus, here too, the regulatory driven substitution is only expected to accelerate the incurrence of impacts by a few years. This trend towards natural phase-out is understood to be a result of the growing availability of substitutes for T8 lamps, which enable both direct replacement as well as the conversion of luminaires.

***LFL T5 lamps*** are lamps covered by Ex. 2(a)(2) of RoHS Annex III: Tri-band phosphor LFL with normal lifetime and a tube diameter ≥ 9 mm and ≤ 17 mm. For T5 lamps, though a decrease in sales also begins in 2017, it is much more moderate in nature. 2025 sales are expected to represent 65 % of the 2018 sales. This is mainly a result of the decrease in sales of T5 non-residential lamps, however, the stock remains very similar to that of 2018. For T5 lamps, the natural phase-out is developing much slower, meaning that the implementation of the recommendations would result in impacts being accelerated more significantly. This difference stems from the development of substitutes which also influences the range of possible impacts of early substitution. If for T8 lamps some Plug & Play lamps are already available, for T5 lamps, such alternatives are only starting to develop, meaning that an early phase-out would require a larger number of lamps to be replaced together with their luminaire. The price of luminaire replacements contributes largely to the total costs of an early replacement. Therefore, the lower availability of replacement LEDs for T5 LFL lamps results in higher replacement costs and longer period being required for the energy cost savings to start covering the replacement costs.

In total, a regulatory driven substitution of LFL would result in annual costs in the range of ~48,900 and ~33,000 million EUR over the period 2019-2025 (i.e. per capita cost between 96 and 64 EUR for this period). In the scenario that assumes the highest costs for replacements of luminaires (250 EUR per item), the total costs of regulatory driven substitution for lamp users are estimated to amount to ~160,000 million EUR for T8, while for T5, they amount to ~83,600million EUR. Looking at the numbers and the costs per lamp type (i.e. taking into account the number of T5 and

T8 lamps to be replaced), the average cost per T8 lamp replacement is estimated at 186 EUR per lamp, for T5 lamp at 231 EUR per lamp.

For further details on the analysis, please see chapter 5.

The case of **high pressure sodium** (HPS) lamps differs from CFL and LFL lamps in so far that the 2016 scientific and technical evaluation did not recommend a phase-out of a corresponding sub-group of lamps, but rather an adaptation leading to lower mercury thresholds of some of the respective exemptions. The aim of this change was to better reflect the mercury content of lamps currently sold on the market. However, in one case (Ex. 4(c)(II)), industry communicated that the threshold recommended is too low for some of the lamps covered by the exemption and that this shall result in a regulatory driven phase-out of lamps exceeding the recommended threshold. Though the share of such lamps from the total group of HPS lamps is relatively small (~10%), for users of such lamps, the lack of LED replacement lamps shall result in a replacement of HPS luminaires. The total costs of this process are estimated to amount to ~927 million EUR for the period between 2019 and 2025 (or 1.8 EUR per capita for the complete period), assuming that 50 % of lamps do not comply with the recommended new threshold. This translates to an average cost of 288 EUR per lamp. The cost of the replacement per lamp is significantly higher than for the CFL and for the LFL lamps, particularly of the T8 type (see above). This is mainly a result of the lack of retrofit substitutes (Plug and Play LED alternatives or LEDs requiring a luminaire conversion), leading to the need to replace each luminaire in which the lamp has reached its end-of-life. Furthermore, as the 2016 recommendations did not recommend an early phase-out in this case, it is noted that adjusting the mercury threshold slightly would avoid such costs. For further details on the analysis, please see chapter 6.

The case of **special purpose lamps** also differs from the first two lamp groups. Here too, the purpose of the recommendations from the 2016 scientific and technical assessment has been to adapt the exemption wording to reflect the actual applications on the market. The approach aimed to introduce application specific exemptions in cases where it was possible to identify lamps for which technical substitutes were not available, not reliable or resulted in higher impacts on environment and health. Where such sub-groups could be identified, application specific exemptions were formulated and 5 year exemptions were recommended. Impacts on these lamps are hence currently not expected.

In some cases, information from stakeholders provided technical justification only for a part of the lamp types covered by the original exemption. In consequence, recommending exemptions was only possible for those lamp types for which it had been shown that at least one of the Article 5(1)(a) criteria was fulfilled, whereas for other lamp types, a recommendation was not possible. For such lamps, two cases are apparent:

- Applications covered by recommended general short term exemptions, where application specific exemptions shall need to be applied for in the form of exemption renewals. In such cases, the main costs expected are related to the effort of requesting such application specific exemptions and are mainly administrative in nature.

- Applications, which are not covered by the recommended exemptions and for which only a transition period is currently proposed: In this case, new exemptions would need to be applied for and costs would depend on the length of the exemption evaluation process and on its results:
  - Where such new exemptions are granted within the transition period, costs would be mainly administrative in nature;
  - Where exemptions would not be granted, aside from administrative costs, additional costs are expected as lamps could no longer be placed on the market. Though this would affect the lighting industry in the form of lost revenue and loss of employment, users of such lamps could be expected to have even more significant costs, where these lamps are used in the manufacture of other sectors, or in the provision of various services.

As the types of costs vary from case to case and also in relation to specific exemptions, an estimation of total costs was not possible for the special purpose exemptions, however, some indicative examples are presented and discussed within the report. For further details on the analysis, please see chapter 57.

# 2. Sommaire exécutif - Français

En vertu du Contrat-cadre n° ENV.A.2/FRA/2015/0008, un consortium mené par l'Oeko-Institut a été chargé par la Direction Générale de l'Environnement de la Commission européenne d'évaluer les impacts socio-économiques du remplacement de certaines lampes au mercure bénéficiant actuellement des exemptions prévues à l'annexe III de la Directive 2011/65/UE du Parlement européen et du Conseil relative à la limitation de l'utilisation de certaines substances dangereuses dans les équipements électriques et électroniques (« la Directive RoHS »). Les travaux ont été menés par l'Oeko-Institut et ont fait l'objet d'un examen par les pairs de l'Institut Fraunhofer IZM.

## 2.1. Contexte et objectifs

En janvier 2015, conformément à l'Article 5 de la Directive RoHS, la Commission européenne a reçu des demandes de renouvellement pour diverses exemptions énumérées à l'annexe III de la Directive, dont l'expiration était prévue en juillet 2016. Plusieurs de ces exemptions (exemptions n°1 à 4) étaient liées à l'utilisation du mercure dans les lampes.

En 2015 et 2016, l'évaluation des demandes de renouvellement a été réalisée par l'Oeko-Institut pour le compte de la Commission européenne. L'évaluation a été effectuée conformément aux critères listés à l'Article 5(1)(a) de la Directive qui stipule qu'au moins un des trois critères principaux[9] doit être rempli pour justifier d'une dérogation. Un rapport concluant cette évaluation, présentant l'évaluation et les recommandations pour chacune des exemptions demandées, a été publié en juin 2016[10] (Gensch et al. 2016).

Le rapport d'évaluation inclut des évaluations d'un grand nombre d'applications d'équipements électriques et électroniques (EEE), dont plusieurs groupes de lampes à décharge où le mercure remplit des fonctions essentielles. Dans les évaluations de ces lampes, une attention particulière a été accordée aux différents groupes, types et sous-types de lampes à décharge car la disponibilité de substituts varie fortement d'un cas à l'autre. Par ailleurs, le marché de la technologie LED sans mercure connaît un développement dynamique. Dans ce contexte, le rapport d'évaluation a recommandé que certaines exemptions soient renouvelées pour une nouvelle durée de 5 ans, d'autres pour des périodes plus courtes et, dans de nombreux cas, le rapport a suggéré de modifier la formulation de l'exemption, limitant ainsi sa portée. Dans quelques cas, le rapport recommandait de révoquer une exemption, accordant à l'industrie une période de transition de 18 mois conformément à l'Article 5(6), pour permettre l'élimination progressive des lampes concernées.

L'évaluation et les recommandations concernant certaines des exemptions (en particulier celles dont l'abrogation est recommandée) ont été présentées le 1er septembre 2016, lors d'une réunion du groupe d'experts de la Commission sur l'adaptation et l'exécution de la Directive RoHS 2. Lors de cette réunion, des représentants de LightingEurope, qui ont soumis bon nombre des demandes de renouvellement pour les exemptions de lampes, ainsi que d'autres représentants de fabricants de lampes ont également présenté leurs points de vue et préoccupations concernant l'évaluation et ses recommandations. Les parties prenantes de l'industrie de l'éclairage ont déclaré que la révocation des exemptions, telle que recommandée, entraînerait des coûts socio-économiques importants pour l'industrie et, par la suite, pour l'Union européenne, notamment en relation avec la fermeture anticipée d'usines de fabrication, la perte d'emplois et des investissements importants dans la conversion des luminaires existants ou dans l'achat de nouveaux luminaires lorsque les luminaires existants ne sont pas compatibles avec des substituts LED disponibles.

L'Article 5(1)(a) de la Directive précise qu'en plus de la disponibilité de substituts, il convient de tenir compte des impacts socio-économiques lors de la prise de décisions concernant les demandes d'exemptions, y compris concernant la durée de toute

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9 Les trois critères de l'Article 5(1)(a) :

- leur élimination ou leur substitution par des modifications de conception ou des matériaux et composants ne nécessitant aucun des matériaux ou substances énumérés à l'annexe II est scientifiquement ou techniquement impraticable,
- la fiabilité des produits de substitution n'est pas garantie,
- le total des incidences négatives sur l'environnement, la santé et la sécurité des consommateurs causées par la substitution est susceptible de l'emporter sur le total des avantages qui en découlent pour l'environnement, la santé et la sécurité des consommateurs.

10 Rapport disponible sur le site Internet de la Commission à l'adresse suivante : https://publications.europa.eu/en/publication-detail/-/publication/a3fdcc8c-4273-11e6-af30-01aa75ed71a1

exemption accordée. Bien qu'il ne pouvait être exclu au moment de l'évaluation que les modifications proposées aux exemptions relatives aux lampes (Exemptions 1 à 4) pourraient avoir des impacts socio-économiques divers, il n'avait pas été possible sur la base des données disponibles, de quantifier ces impacts ou de démontrer leur ampleur et, dans ce contexte d'évaluer également les avantages d'une réduction de mercure par rapport aux coûts potentiels des modifications.

Dans ce contexte, la Commission européenne a sollicité un soutien technique et scientifique pour la préparation d'une nouvelle évaluation détaillée de l'impact socio-économique de la substitution du mercure dans certaines lampes.

## 2.2. Portée et scénarios

Les termes de référence de la présente étude exige l'évaluation des impacts socio-économiques liés aux lampes à base de mercure couvertes par les exemptions n°1 à 4 de l'annexe III de la Directive RoHS. L'évaluation tient compte de deux scénarios :

- BAU (« *Business As Usual* ») - Maintien de la situation actuelle où la substitution des lampes est régie par les forces du marché (les Exemptions 1 à 4 de l'annexe III de la Directive RoHS sont renouvelées sans modification de formulation) ;
- SUB - Substitution conformément au scénario recommandé dans le rapport d'évaluation fourni à la Commission par des consultants externes, avec effet à la mi-2018 ;

Les recommandations formulées dans le précédent rapport d'évaluation tenaient compte des différences dans la disponibilité des substituts afférente aux lampes de remplacement Plug & Play[11], les lampes de substitution nécessitant un recâblage ou nécessitant une conversion de l'équipement d'éclairage, et les substituts nécessitant un remplacement de l'équipement d'éclairage (luminaire). Sur la base d'une première analyse des impacts escomptés, il a été conclu que les principales différences entre les scénarios sont liées à un sous-ensemble de lampes couvertes par les Exemptions 1 à 4 de l'annexe III, qui sont détaillées dans les paragraphes suivants[12]. Les lampes abordées dans ce sous-groupe font l'objet de l'analyse détaillée réalisée dans le cadre de cette étude :

- Lampes fluorescentes à simple culot (compactes) (LFC) d'une puissance inférieure à 50 W (annexe III, Exemptions 1(a) à (b)) ; 325 millions de lampes directement affectées. Les effets secondaires[13] liés à d'autres lampes LFC sont abordés ;

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[11] Une lampe Plug & Play est une lampe qui peut être utilisée comme lampe de remplacement " prête à poser ", au travers de son insertion dans un luminaire (par branchement ou vissage) sans nécessiter aucune modification technique du luminaire pour établir la compatibilité du luminaire avec la lampe de remplacement.

[12] Tous les chiffres mentionnés ci-dessous se réfèrent au volume annuel du marché en Europe en 2013 pour les différents types de lampes.

[13] Des effets secondaires peuvent se produire lorsque la part des lampes concernées par la technologie commune de décharge est relativement importante et de ce fait, on peut s'attendre à ce qu'elle ait un impact plus important sur la production des lampes de la même technologie. Par exemple, lorsqu'une usine fabrique à la fois des lampes d'usage général (90%) et des lampes à usage spécial (10%) d'une

- Lampes fluorescentes linéaires (LFL) à durée de vie normale et avec un diamètre de tube ≥ 9 mm et ≤ 28 mm (T5 et T8, annexe III, Exemptions 2(a)(2)-(a)(3)) ; 323 millions de lampes directement affectées. Les effets secondaires liés à d'autres lampes LFL sont traités ;
- Lampes fluorescentes non linéaires triphosphore avec un diamètre de tube > 17 mm [par exemple T9, annexe III, Exemption 2(b)(3)] ; entre 6 et 18 millions de lampes directement affectées[14]. Traité conjointement avec les lampes LFL.
- Mercure dans les lampes (à vapeur) de sodium haute pression destinées à l'éclairage général avec un indice de rendu des couleurs Ra < 60 (annexe III, Exemption 4(c)) ; ce sous-groupe concerne 23 millions de lampes, or, seules certaines de ces lampes dont la puissance P est comprise entre 155 W et ≤ 405 W devraient être affectées différemment pour chacun des deux scénarios. Les effets secondaires liés à d'autres lampes HPS (Haute Pression Sodium) sont évoqués ;
- Lampes à usage spécial couvertes par les Exemptions 1(f), 2(b)(4), 4(a) et 4(f) (nombre de lampes concernées : 400 000 lampes pour l'Exemption 1(f) ; 18 millions de lampes pour l'Exemption 2(b)(3)[15], 2(b)(4) et 4(a) et indéterminé pour l'Exemption 4(f)).

## 2.3. Méthodologie et sources de données

Conformément aux termes de référence spécifiques, l'étude devrait démontrer les impacts socio-économiques du remplacement des lampes en fonction de différentes options, en termes de :

- *Impact sur l'emploi ;*
- *coûts supplémentaires (dépenses financières) pour différentes catégories d'utilisateurs, causés par le remplacement des lampes ;*
- *impacts sur les consommateurs (privés et publics) ;*
- *production quantifiée de déchets supplémentaires générés par le remplacement des lampes avant la fin de leur durée de vie normale ; et*
- *réduction de la quantité de mercure mise sur le marché de l'UE.*

technologie particulière, on peut s'attendre à ce qu'une disparition progressive des lampes d'usage général ait une influence sur la faisabilité économique de poursuivre la fabrication des lampes à usage spécial.

14 L'estimation du nombre de lampes se réfère aux Exemptions 2(b)(3), 2(b)(4) et 4(a). Si aucune donnée supplémentaire n'est mise à disposition, il peut pour la suite des discussions être supposé que dans le pire des cas, 18 millions de lampes ont été mises sur le marché en 2013, et dans le meilleur des cas, 6 millions.

15 Comme détaillé dans le tableau 1, les données fournies par les parties prenantes indiquent qu'en 2013, 18,6 millions de lampes ont été mises sur le marché pour les Exemptions 2(b)(3), 2(b)(4) et 4(a). Bien que seulement deux de ces exemptions soient incluses dans le sous-groupe "lampes à usage spécial", aucunes données ne sont disponibles concernant la répartition de cette quantité par lampes à usage spécial couvertes par ces trois exemptions.

Diverses données ont été utilisées en phase initiale pour préparer une première estimation des impacts escomptés associés aux deux scénarios. Aux fins de l'estimation initiale et des estimations ultérieures, les données ont été utilisées dans la mesure du possible à partir des sources suivantes :

- Les données issues du modèle VHK, modèle reconnu d’analyse des sources d’éclairage en Europe (MELISA[16]) (VHK 2016) ont été utilisées comme source de données et de prévisions de marché. Bien que la version du modèle utilisée, datée du 13 juillet 2016, ne soit pas encore publiée au moment de la rédaction du présent document, il est entendu qu'il représente un modèle consensuel, discuté avec divers intervenants et accepté communément comme outil de prévision du marché de l'éclairage pour les années à venir.
- En relation avec les exemptions spécifiques, les informations et données issues des demandes d'exemptions initiales soumises par LightingEurope en janvier 2015 ont été utilisées. Ceci est pertinent par exemple dans le cas des lampes non couvertes par le modèle MELISA (lampes spéciales) et lorsque des informations supplémentaires sont nécessaires pour combler l'écart entre les données du modèle MELISA (concernant des technologies de lampes spécifiques pour l'éclairage général) et les exemptions RoHS (lorsque la classification concerne l'alimentation électrique, les dimensions, etc.).

Lorsque les sources susmentionnées n'ont pas permis une corroboration suffisante des estimations sur la base des données et des informations, des hypothèses ont alors été formulées sur la base de l'avis d'experts, de manière à fournir une première estimation à titre de référence. De telles hypothèses ont par exemple été formulées concernant le poids de résidus et déchets générés par une substitution réglementaire ou concernant la disponibilité de substituts pour une technologie en particulier.

Pour valider ces hypothèses (confirmer ou ajuster sur la base des données fournies par les parties prenantes et/ou par l'avis d'experts du secteur de l'éclairage), une réunion ciblée des parties prenantes a été tenue en date du 22 février 2017 avec l’association LightingEurope (LE) et des représentants de certains de ses membres. Lors de cette réunion, les différentes hypothèses ont été discutées afin de déterminer quelles données étaient pertinentes pour permettre une estimation plus précise. Certaines des hypothèses formulées ont été confirmées au travers de la discussion en réunion des parties prenantes, et sont précisées comme telles dans le présent document. Pour d'autres hypothèses, et suite à la réunion, LightingEurope a fourni des données supplémentaires dans les domaines pertinents (dès lors que cela ne contrevenait pas aux aspects de propriété intellectuelle et protection de données confidentielles). L'estimation a été effectuée une nouvelle fois après une révision des hypothèses y afférant.

16 MELISA correspond à l’abréviation en anglais du modèle analytique VHK « Model for European Light Sources Analysis ».

## 2.4. Principales conclusions - Aperçu général des résultats de l'évaluation

### 2.4.1. Remarque préliminaire

En raison de la complexité de l'évaluation (divers types de lampes ainsi que différentes voies de substitution, scénario du meilleur et pire des cas, etc.), la présentation de tous les résultats dépasserait l'étendue du présent résumé. Dans ce contexte, la section suivante résume les conclusions générales pertinentes, suivies d'une section où nous détaillons les conclusions les plus pertinentes pour les groupes de lampes définis, avec des renvois vers les conclusions détaillées.

### 2.4.2. Résultats généraux

De manière générale, la présente étude montre que pour la plupart des exemptions examinées liées au mercure utilisé, les recommandations ne génèrent pas de nouveaux impacts en soi, mais seulement accélèrent les processus déjà en cours dans le secteur de l'éclairage. Pour la majeure partie, la mise en œuvre des recommandations précisées dans l'évaluation technique et scientifique de 2016 (Gensch et al. 2016)[17] engendre des coûts et des avantages plus rapides que prévu. Il existe toutefois des différences entre les exemptions au vu du temps qui serait nécessaire pour que les différents processus se déroulent naturellement. Bien qu'une substitution soit déjà en cours pour certaines technologies, pour d'autres, elle n'est escomptée que dans le futur. Ceci influe sur le ratio entre les substitutions qui doivent avoir lieu naturellement quel que soit le scénario et entre les substitutions qui peuvent être associées à la mise en œuvre des recommandations de l'évaluation technique et scientifique de 2016. L'importance des impacts d'une substitution anticipée devrait dépendre de ce taux de répartition, comme présenté ci-après.

Le montant des coûts de remplacement dépend en outre des options de substitution disponibles, c'est-à-dire de la part de lampes qui peuvent être remplacées par des solutions Plug & Play, qui nécessitent un nouveau câblage, ou de la part des luminaires à remplacer lorsque les solutions de substitution ne sont pas compatibles avec le support de la lampe. La répartition de ces options varie d'un cas à l'autre. Les économies d'énergie escomptées provenant du passage aux lampes LED ont été soustraites des coûts de remplacement. Dans certains cas, les économies d’énergie peuvent compenser les coûts liés à la substitution de manière significative, et ce dès la période examinée dans l'évaluation, tandis que dans d'autres cas, cela se fera à un stade ultérieur.

S’agissant de l’emploi, on peut s'attendre dans les différents cas à ce qu'une suppression progressive incitée par la réglementation, intervenant plus tôt que la disparition naturelle, conduise à une perte d'emplois liés à la fabrication de lampes à décharge (dans l'UE et au-delà - voir Section 3.4). L'industrie de l'éclairage a estimé qu’environ 20 000 salariés au sein de l'UE pourraient en conséquence de ce qui précède, perdre leur emploi dans le secteur de l'éclairage (c'est-à-dire une diminution

[17] Voir la note en bas de page 1.

de la fabrication de lampes à décharge dans l'UE). Cependant, il faut garder à l'esprit que certains employés pourront être transférés vers le développement et la fabrication de lampes sans mercure. En outre, comme pour certains types de lampes, l'élimination progressive imposée par la réglementation doit entraîner la nécessité de recâbler ou de remplacer les luminaires, auquel cas une augmentation de l'emploi d'électriciens est également attendue comme un résultat positif du scénario « SUB ». Par exemple, pour les lampes fluorescentes compactes (LFC), l'augmentation du nombre d'emplois d'électriciens au sein de l'UE devrait être de l'ordre de 10 800 à 27 500 emplois, en fonction de l'année. S'agissant des lampes fluorescentes linéaires (LFL), une augmentation de l'emploi de l'ordre de 37 000 à 55 000 postes d'électriciens est escomptée au sein de l'UE. Pour plus de détails, voir les sections relatives aux « Impacts escomptés sur l'emploi » (4.3, 5.3, 6.3 et 7.3). Dans l'ensemble, les pertes d'emplois dans le secteur de l'éclairage devraient se produire indépendamment des mesures abordées dans la présente évaluation, en raison du passage aux technologies LED. Les pertes d'emplois s'étendraient sur une période plus longue dans le cas où les recommandations ne sont pas mises en œuvre.

### 2.4.3. Résultats spécifiques

D'autres résultats-clé sont présentés ci-dessous pour les quatre sous-groupes de lampes étudiés dans le cadre de la présente étude : lampes fluorescentes compactes, lampes fluorescentes linéaires, lampes à vapeur de sodium haute pression et lampes à usage spécial.

Pour les **lampes fluorescentes compactes** (LFC), l'évolution naturelle actuelle du marché montre une réduction générale du stock de ces lampes, ce qui suggère que la disparition naturelle des LFC est déjà en cours : Bien qu'il n'y ait actuellement aucune disparition progressive des lampes CFL en conséquence des restrictions RoHS, la disparition naturelle devrait entraîner une réduction du stock total de lampes en 2025 de seulement 40% par rapport au stock total de 2018.

Pour les ***lampes LFC à ballast intégré*** *(ci-après LFCi)*, la disparition naturelle est plus importante (en 2025, le stock de LFCi résidentielles représentera 35% du stock de 2018 et le stock de LFCi non résidentielles 38% du stock de 2018). En d'autres termes, pour ces sous-groupes, environ deux tiers du stock devraient disparaitre progressivement d'ici 2025, indépendamment de la mise en œuvre des recommandations de l'évaluation scientifique et technique de 2016.

Pour les ***lampes LFC à ballast non intégré*** *(ci-après LFCni)*, la disparition naturelle est plus modérée, le stock de 2025 représentant 66% du stock de lampes LFCni résidentielles de 2018 et 56% du stock de lampes LFCni non résidentielles de 2018. La disparition naturelle plus lente des lampes LFCni résidentielles devant être liée à la durée de vie plus longue de ces lampes.

S'agissant de cette réduction des stocks, il est important de noter que la substitution se poursuit malgré l'absence de substituts Plug & Play. De tels substituts sont courants pour les lampes LFCi (en particulier pour les lampes des groupes de puissance inférieure) ; cependant, dans les groupes de lampes LFCni ainsi que pour les groupes de lampes LFCi de puissance supérieure, les informations disponibles suggèrent que le manque de substituts Plug & Play rendrait nécessaire le recâblage et la conversion des luminaires ou leur remplacement, conduisant à des coûts de remplacement plus élevés. L'indication selon laquelle 60% du stock de 2018 de toutes les lampes LFC seront remplacés dans le scénario « »BAU » d'ici 2025 suggère que ces coûts sont acceptables dans la plupart des cas.

Selon l'analyse du scénario « SUB », les coûts de substitution supplémentaires pour les consommateurs s'élèveront à un total d'environ 38 800 millions d'euros pour la période septennale 2019-2025 (les coûts réels ne commencent à survenir qu'en 2019), soit en moyenne 42 euros par lampe (18 euros par LFCi et 89 euros par LFCni). Les coûts annuels varient et s'élèvent à ~7 900 millions d'euros en 2019, baissant à ~3 300 millions d'euros en 2025. Pour les deux types de lampes, à ballast intégré (LFCi), et à ballast non intégré (LFCni), les économies d'énergie escomptées ont été déduites des coûts de substitution des lampes, étant donné que les substituts LED consomment moins d'énergie que leurs homologues LFC. Il convient ici de préciser que l'analyse couvre seulement les années allant de 2016 à 2025 ; toutefois, les lampes de substitution achetées pour remplacer les LFC, restreintes dans le scénario « SUB », continueront à générer des économies d'énergie au-delà de cette période, en raison de leur durée de vie plus longue. Les coûts totaux de la substitution par habitant s'élèvent à environ 75 euros par résident de l'UE, répartis sur les sept années étudiées, ce qui signifie que chaque année, entre 6,40 et 15,50 euros par habitant seront engagés pour la disparition progressive des lampes LCF pendant la période observée, supposant que les recommandations énoncées dans l'étude de 2016 soient appliquées. En 2025, les coûts annuels auraient déjà baissé à ~6,40 euros par habitant, ce qui signifie que les coûts annuels liés à la substitution incitée par la réglementation diminuent d'année en année. En comparant les coûts respectifs pour les lampes LFCi et LFCni, on constate en outre que les coûts de la disparition progressive des LFCni entraînée par la réglementation seront plus élevés que pour les LFCi (allant pour les LFCi de 1,20 à 6,10 euros par habitant par an et pour les LFCni de 5,30 à 9,30 euros par habitant par an).

Pour plus de détails sur l'analyse, voir le chapitre 4.

Dans le cas des **lampes fluorescentes linéaires** (LFL), il convient de distinguer entre les lampes de type T5 et les lampes de type T8 en fonction des impacts d'une substitution réglementaire.

***Les lampes LFL de type T8*** sont des lampes couvertes par l'Exemption 2(a)(3) de l'annexe III de la Directive RoHS : LFL triphosphore, avec une durée de vie normale et un diamètre de tube > 17 mm et ≤ 28 mm. On s'attend à ce qu'une disparition progressive naturelle soit en cours pour les lampes T8 d'ici la mise en œuvre des recommandations. Les prévisions actuelles concernant le développement des lampes de type T8 montrent qu'une baisse de leurs ventes devrait commencer en 2017 et qu'en 2025, les nouvelles ventes ne devraient représenter que seulement 56% des ventes de 2018. Pour ces lampes, les ventes attendues pour l'année 2019 devraient déjà diminuer de 5% par rapport aux ventes de 2018 et en 2021, ce seront 80% des ventes de 2018 qui devront encore être mises sur le marché. Ainsi, là encore, on s'attend à ce que la substitution réglementaire n'accélère la disparition des lampes de type T8 que de quelques années seulement. Cette tendance vers une disparition naturelle des lampes de type T8 s'explique par la disponibilité croissante de substituts aux lampes T8, qui permettent à la fois le remplacement direct et la conversion des luminaires.

***Les lampes LFL de type T5*** sont des lampes couvertes par l'Exemption 2(a)(2) de l'annexe III de la Directive RoHS : LFL triphosphore avec une durée de vie normale et un diamètre de tube ≥ 9 mm et ≤ 17 mm. Pour les lampes T5, bien qu'une baisse des ventes commence également en 2017, elle est beaucoup plus modérée dans sa nature. En 2025, les ventes de LFL de type T5 devraient représenter 65% des ventes de 2018. Ceci est essentiellement dû à la baisse des ventes de lampes LFL de type T5 non résidentielles. Cependant, le stock reste très similaire à celui de 2018. Pour les lampes de type T5, leur disparition naturelle progressive se développe beaucoup plus lentement, ce qui signifie que la mise en œuvre des recommandations entraînerait une accélération plus marquée de leur substitution. Cette différence entre les lampes de type T5 et de type T8 dans le déroulement et la vitesse de leur substitution découle de la mise au point de substituts qui influe également sur l'éventail des impacts possibles d'une substitution précoce. Si certaines lampes Plug & Play sont déjà disponibles pour les lampes de type T8, ces alternatives ne font que commencer à se développer pour les lampes de type T5, ce qui signifie qu'une disparition précoce nécessiterait le remplacement d'un plus grand nombre de lampes et de leur luminaire. Le prix de remplacement des luminaires contribue largement aux coûts totaux d'une substitution précoce. Par conséquent, la disponibilité limitée des LED de remplacement pour les lampes LFL de type T5 engendre des coûts de substitution plus élevés, et une période plus longue s'avère nécessaire avant que les économies d'énergie commencent à compenser les coûts de substitution.

Au total, une substitution réglementaire des lampes LFL engendrerait des coûts annuels de l'ordre de ~48 900 à ~33 000 millions d'euros sur la période 2019-2025 (soit un coût par habitant entre 96 et 64 euros pour cette même période). Dans le scénario qui suppose les coûts les plus élevés pour le remplacement des luminaires (250 euros par élément), les coûts totaux de la substitution réglementaire pour les utilisateurs de lampes sont estimés à environ 160 000 millions d'euros pour les lampes de type T8 et à environ 83 600 millions d'euros pour les lampes de type T5. En prenant en compte le nombre de lampes (c'est-à-dire le nombre de lampes de types T5 et T8 devant être remplacées) et les coûts par type de lampe, le coût moyen de substitution d’une lampe de type T8 est estimé à 186 euros par lampe, tandis que le coût moyen de substitution d’une lampe de type T5 est estimé à 231 euros.

Pour plus de détails sur cette analyse, veuillez-vous référer au chapitre 5.

Le cas des **lampes à vapeur de sodium haute pression** (HPS) diffère de celui des lampes LFC et LFL, dans la mesure où l'évaluation scientifique et technique de 2016 ne recommandait pas une disparation progressive d'un sous-groupe correspondant de lampes, mais plutôt une adaptation de la formulation de l’exemption conduisant à des seuils de mercure plus bas pour certaines des exemptions respectives. L'objectif de ce changement était de mieux refléter la teneur en mercure des lampes actuellement vendues sur le marché. Toutefois, dans un cas (Exemption 4(c)(II)), l'industrie a fait savoir que pour certaines des lampes visées par l'exemption, le seuil recommandé était trop bas et que par conséquent, pour les lampes dépassant le seuil recommandé, cela reviendrait à les faire disparaitre par voie d'incitation réglementaire. Bien que la part de ces lampes dans le groupe total des lampes HPS soit relativement faible (~10%), pour les utilisateurs de telles lampes, l'absence de lampes de substitution à technologie LED doit conduire au remplacement des luminaires HPS. Les coûts totaux de ce processus sont estimés à environ 927 millions d'euros pour la période comprise entre 2019 et 2025 (soit 1,80 euro par habitant pour l'ensemble de la période), en supposant que 50% des lampes ne sont pas conformes au nouveau seuil recommandé. Cela correspond à un coût moyen de 288 euros par lampe. Le coût de remplacement par lampe est significativement plus élevé pour les lampes HPS que pour les lampes LFC et les lampes LFL, notamment pour les lampes LFL de type T8 (voir ci-dessus). Ceci s'explique principalement par l'absence de substituts adaptés (solutions alternatives LED Plug & Play ou LEDs nécessitant une conversion de luminaire), ce qui conduit à la nécessité de remplacer chaque luminaire dès lors que la lampe dans le luminaire a atteint sa fin de vie et ne peut être remplacée par un substitut. Par ailleurs, étant donné que les recommandations (de l'évaluation scientifique et technique) de 2016 ne préconisaient pas une disparition précoce des lampes HPS, il est à noter qu'un léger ajustement du seuil de mercure permettrait d'éviter de tels coûts. Pour plus de détails sur cette analyse, voir le chapitre 6.

Le cas **des lampes à usage spécial** diffère également des deux premiers groupes de lampes. Là encore, les recommandations issues de l'évaluation scientifique et technique de 2016 avaient pour objectif d'adapter la formulation de l'exemption afin de refléter les demandes réelles sur le marché. L'approche visait à introduire des exemptions spécifiques pour des applications particulières, pour les cas où il était possible d'identifier des lampes pour lesquelles des substituts techniques n'étaient soit pas disponibles, soit pas fiables, ou avaient un impact plus important sur l'environnement et la santé. Lorsque de tels sous-groupes ont pu être identifiés, des exemptions spécifiques ont été formulées, et des exemptions d'une durée de 5 ans préconisées. De ce fait, les effets d'une substitution réglementaire sur ces lampes ne sont donc pas prévus présentement.

Dans certains cas, l'information fournie par les parties prenantes a apporté une justification technique uniquement pour une partie des types de lampes visés par l'exemption initiale. Par conséquent, il a été possible de recommander des exemptions seulement pour les types de lampes pour lesquels il avait été démontré qu'au moins un des critères de l'Article 5(1)(a) était rempli, tandis que pour les autres types de lampes, une recommandation était impossible. Pour ces autres types de lampes, deux cas se présentent :

- Demandes couvertes par des exemptions générales recommandées à court terme, pour lesquelles des exemptions spécifiques doivent être demandées sous la forme de renouvellements d'exemption. Dans de tels cas, les principaux coûts attendus sont liés aux efforts déployés pour faire la demande de telles exemptions spécifiques et sont principalement de nature administrative.

- Les demandes non couvertes par les exemptions recommandées et pour lesquelles seule une période de transition est actuellement proposée : Dans ce cas, des demandes de nouvelles exemptions seraient à faire, et les coûts dépendront de la durée du processus d'évaluation des exemptions et de ses résultats :
  - Lorsque de telles nouvelles exemptions sont accordées durant la période de transition, les coûts seraient principalement de nature administrative ;
  - Dans les cas où des exemptions ne seraient pas accordées, des coûts supplémentaires sont à prévoir en plus des coûts administratifs car les lampes ne pourraient plus être mises sur le marché. Bien que cela impacterait l'industrie de l'éclairage, sous la forme de perte de revenus et de perte d'emplois, les utilisateurs de ces lampes pourraient subir des coûts encore plus importants, lorsque ces lampes sont utilisées dans la fabrication d'autres secteurs ou dans la prestation de divers services.

Étant donné que les types de coûts varient d'un cas à l'autre et également en relation avec des exemptions spécifiques, il n'a pas été possible d'estimer les coûts totaux pour les exemptions relatives aux lampes à usage spécial ; toutefois, quelques exemples indicatifs sont présentés et examinés dans le présent rapport. Pour plus de détails sur l'analyse, voir le chapitre 7.

# 3. Introduction

## 3.1. Background and objectives

Towards the end of 2014, the Commission started receiving applications for the renewal of various exemptions listed in Annex III of the Directive. A large number of exemptions that had been listed in the Directive annex at the time that the RoHS recast came into force were to become due for expiration in July 2016. In line with the Directive stipulations, stakeholders interested in the renewal of such exemptions had begun submitting requests for their renewal, many of which were related to the use of mercury in lamps.

The evaluation of the requests was carried out by Oeko-Institut in 2015 and 2016 and a report including the evaluations of each of the requested exemptions was published in June 2016 (Gensch et al. 2016), providing recommendations as to the fate of each of the exemptions. The evaluation was carried out as required according to the criteria stipulated in Article 5(1)(a) of the Directive, from which it can be understood that at least one of three main criteria[18] must be fulfilled to justify an exemption.

Though some of the exemptions were recommended for renewal for a further duration of 5 years, others were recommended for shorter periods and in many cases the report suggested amendment to the exemption formulations, targeted at limiting the scope of applicability. In a few cases the report recommended a revoke of the exemptions, granting industry a transition period of 18 months to allow for the phase out of relevant lamps.

On 1 September 2016, the evaluation and recommendations for some of the exemptions (particularly those recommended to be revoked) were presented by Oeko-Institut at a Delegated Act Expert Group meeting, to provide insight to the Commission and to the Member State representatives involved in the delegated act process and to allow discussion of various aspects. Representatives of LightingEurope, who had submitted many of the renewal requests for the lamp exemptions, and a few representatives of lamp manufacturers, were also allowed to present their views and concerns at this meeting in relation to the recommendations. As had already been argued in their exemption request applications, LightingEurope claimed that the withdrawal of the exemptions recommended for revoke would lead to extreme socio-economic costs for industry and subsequently for the European Union, among others in light of loss of employment opportunities, in light of the early closing of manufacturing facilities and in light of high investments in the conversion of existing luminaires or the purchase of new ones where the existing ones were not compatible with available LED substitutes. At that time, though it could not be excluded that the proposed changes to the lamp exemptions (Ex. 1-4) could create various socio-economic impacts, it had not been possible on the basis of available data to quantify such impacts or to demonstrate their magnitude, and

[18] The three Article 5(1)(a) criteria:
— their elimination or substitution via design changes or materials and components which do not require any of the materials or substances listed in Annex II is scientifically or technically impracticable,
— the reliability of substitutes is not ensured,
— the total negative environmental, health and consumer safety impacts caused by substitution are likely to outweigh the total environmental, health and consumer safety benefits thereof.

in this respect also to present the benefits of a mercury reduction against the possible costs and benefits thereof.

As Article 5(1)(a) also specifies various aspects that should be considered in the evaluation process, including possible socio-economic impacts, it is the consultants understanding that with this study request, the Commission is seeking support in understanding the appearance and the magnitude of impacts that could incur should the recommended changes to the exemptions be implemented.

Against this background the European Commission requested technical and scientific support in the preparation of a further detailed evaluation of the socio-economic impact of early substitution of mercury in certain lamps. Among others, it was emphasized that the study should demonstrate the socio economic impacts of lamp substitution under different options, in terms of:

- "*impact on employment;*
- *additional costs (money expenditure) for different user categories due to lamp substitution;*
- *impacts on consumers (private and public); and*
- *quantified generation of additional waste as a consequence of the lamp substitution before the end of the regular lifetime*".

This study has been performed by the Oeko-Institut and has been peer reviewed by Fraunhofer IZM. The overall project has been led by Yifaat Baron.

## 3.2. Project scope

On the basis of the study terms of reference (ToR), the analysis presented here is aimed at assessing and evaluating socio-economic impacts resulting from two possible scenarios. The scenarios relate to various types of mercury-based discharge lamps listed in RoHS Annex III exemptions, no. 1(a to e - lighting purpose), no. 1(f - special purpose), no. 2(a), no. 2(b)(3), no. 2(b)(4), no. 3, no. 4(a), no. 4(b), no. 4(c), no. 4(e), and no. 4(f) and to the fate of these exemptions:

- **The Substitution Scenario (SUB)**: Recommendations from the Oeko-Institut 2016 (Gensch et al. 2016) evaluation are followed, leading to a regulatory driven substitution of certain lamps no longer allowed on the market.
- **The Business As Usual scenario (BAU)**: The validity of all current exemptions is extended for a further 5 year duration[19].

The Oeko-Institut recommendations of 2016 do not prescribe changes for all of the above mentioned exemptions. It can be concluded that the scenarios shall mainly be expected to differ where recommended changes are to be applied. Though the differences in impacts shall be a result of inconsistencies in relation to the regulation of a certain type of lamp in the different scenarios (the inconsistence between lamps covered by the exemption recommended to be changed in one scenario in comparison to a scenario

[19] The maximum validity that may be granted for exemptions available to products falling under categories 1-7, 10 and 11.

where the exemption remains unchanged), this is not to say that other lamp groups could not be affected in certain cases. On the one side, such impacts may be relevant in relation to other discharge lamps (for example, lamps covered by different exemption but produced in the same facility) and on the other hand they can be expected to impact the sales of alternative lamp technologies (for example LED).

It can be understood that production lines, and often also production facilities, are specific to a certain discharge technology. Thus **discharge lamps affected indirectly** are expected to be of the same (production and assembly) technology, however covered by a different exemption – see Section 3.4 in this respect). Such impacts are mainly expected, where the share of lamps affected from the common discharge technology is relatively significant, and thus expected to have a larger impact on the production of lamps of the same technology. For example, where a facility manufactures both general purpose (90%) and special purpose lamps (10%) of a specific technology, it can be expected that a phase-out of the general purpose lamps may affect the economic feasibility of continuing manufacture of the special purpose ones. Where a facility however only manufactures special purpose lamps (100%) of the same technology, the fate of general purpose ones would not be expected to subsequently result in a risk to the activities of that facility. In contrast - it is possible that where a general purpose phase-out results in the closure of a facility that manufactured both types, that facilities specializing in special purpose lamps may subsequently benefit from increased business. As data has not been fully available as to the distribution of the manufacture of various technologies and their sub-groups among different facilities, conclusions as to the range of impacts in such cases are difficult, however where such a risk of indirect impacts may be relevant, it will be noted in the relevant chapters below. Such impacts shall be termed spillover impacts throughout this document.

To clarify in relation to which exemptions the scenarios can be expected to differ, the two scenarios are compared below in relation to the various exemptions. Impacts specified under the "Summary of differences" column are expected as direct impacts. The "Further aspects that may impact scenarios" column specifies areas where indirect (or spillover) affects could be expected as well as additional factors that may influence impacts.

**Table 1 Presentation of the exemption formulations to prevail in each scenario and the expected differences between the scenarios**

| Scenario / exemption no. | Business as usual: where lamp substitution is governed by market forces (RoHS Annex III exemptions 1-4 remain valid) | Substitution Scenario: according to the recommendations made in the assessment report provided to the Commission by external consultants , with effect as of mid-2018. | Lamps (in millions) placed on the market in 2013, covered by the Ex. (LEU 2015) | Amount of Hg (kg) placed on the market in 2013 for lamps covered by the Ex. (LEU 2015) | Summary of differences | Further aspects that may impact scenarios |
|---|---|---|---|---|---|---|
| 1(a-e) | Mercury in single capped (compact) fluorescent lamps not exceeding (per burner):<br>(a) For general lighting purposes < 30 W: 2,5 mg may be used after 31.12.2012<br>(b) For general lighting purposes ≥ 30 W and < 50 W: 3,5 mg may be used after 31.12.2011<br>(c) For general lighting purposes ≥ 50 W and < 150 W: 5 mg<br>(d) For general lighting purposes ≥ 150 W: 15 mg<br>(e) For general lighting purposes with circular or square structural shape and tube diameter ≤ 17 mm: 7 mg may be used after 31.12.2011 | Mercury in single-capped (compact) fluorescent lamps not exceeding (per burner):<br>(a) For general lighting purposes < 30 W: 2.5 mg – denied, 18 months transition recommended;<br>(b) For general lighting purposes ≥ 30 W and < 50 W: 3.5 mg – denied, 18 months transition recommended;<br>(c) For general lighting purposes ≥ 50 W and < 150 W: 5 mg – renewal for Cat. 5 until 21.07.2019;<br>(d) For general lighting purposes ≥ 150 W: 15 mg – renewal for Cat. 5 until 21.07.2019;<br>(e) For general lighting purposes with circular or square structural shape and tube diameter ≤ 17 mm – renewal until 21.07.2021, 7 mg may be used per burner until 31.12.2019, 5 mg may be used per burner after 31.12.2019. | (a): 291<br>(b): 34<br>(c): 10<br>(d): 2<br>(e): 3 | (a): 727<br>(b): 120<br>(c): 51<br>(d): 26<br>(e): 21 | A) Compact fluorescent lamps below a wattage rating of 50 w shall be prohibited on the market after mid-2018;<br>B) The Hg threshold for lamps covered by item (e) shall be reduced from 7 mg per burner to 5 mg per burner after 31.12.2019. | A) The share of lamps covered by Ex. 1(a) and 1(b) is significant (~95%) and may result in impacts to CFL lamps covered by other exemptions).<br>B) Halogen lamps shall gradually be phased out between September 2016 and September 2018 in light of the EcoDesign Regulations. Changing market shares of CFL/ halogen/ and LED lamps should thus be estimated in relation to this expected change and not only in relation to differences in RoHS exemptions.<br>C) The amendment of item (e) is a direct result of complying with the requirements of the Minamata Convention, which the EU has ratified. |

| Scenario / exemption no. | Business as usual: where lamp substitution is governed by market forces (RoHS Annex III exemptions 1-4 remain valid) | Substitution Scenario: according to the recommendations made in the assessment report provided to the Commission by external consultants , with effect as of mid-2018. | Lamps (in millions) placed on the market in 2013, covered by the Ex. (LEU 2015) | Amount of Hg (kg) placed on the market in 2013 for lamps covered by the Ex. (LEU 2015) | Summary of differences | Further aspects that may impact scenarios |
|---|---|---|---|---|---|---|
| 1(f) | Mercury in single capped (compact) fluorescent lamps not exceeding (per burner): (f) For special purposes: 5 mg | (f) -I For lamps designed to emit light in the ultra -violet spectrum: 5 mg – renewal until 21.07.2021;<br>(f) -II For special purposes: 5 mg – renewal until 21.07.2019. | 0.4 | 2 | The exemption duration has been limited for a period of three years for lamps of relevance that do not emit in the UV spectrum. | The evaluation report clarifies that the shorter validity has been granted in light of lacking information to justify the exemption for lamps that do not emit in the UV spectrum. The renewal should allow industry to prepare more detailed information to justify the exemption for other types of lamps that are understood to be covered by the term special purpose. It is possible that once this part of the exemption were to be revaluated, that it would be concluded that the exemption were justified for further technologies. It is also possible that for some technologies the availability of substitutes shall become clear or their being covered by other exemptions and thus not by exemption 1(f). |

| Scenario / exemption no. | Business as usual: where lamp substitution is governed by market forces (RoHS Annex III exemptions 1-4 remain valid) | Substitution Scenario: according to the recommendations made in the assessment report provided to the Commission by external consultants , with effect as of mid-2018. | Lamps (in millions) placed on the market in 2013, covered by the Ex. (LEU 2015) | Amount of Hg (kg) placed on the market in 2013 for lamps covered by the Ex. (LEU 2015) | Summary of differences | Further aspects that may impact scenarios |
|---|---|---|---|---|---|---|
| 2(a) | Mercury in double-capped linear fluorescent lamps for general lighting purposes not exceeding (per lamp): (1) Tri-band phosphor with normal lifetime and a tube diameter < 9 mm (e.g. T2): 4 mg may be used after 31.12.2011 (2) Tri-band phosphor with normal lifetime and a tube diameter ≥ 9 mm and ≤ 17 mm (e.g. T5): 3 mg may be used after 31.12.2011<br>(3) Tri-band phosphor with normal lifetime and a tube diameter > 17 mm and ≤ 28 mm (e.g. T8): 3,5 mg may be used after 31.12.2011<br>(4) Tri-band phosphor with normal lifetime and a tube diameter > 28 mm (e.g. T12): 3,5 mg may be used after 31.12.2012<br>(5) Tri-band phosphor with long lifetime (≥ 25 000 h): 5 mg may be used after 31.12.2011 | 1) Tri-band phosphor with normal lifetime and a tube diameter < 9 mm (e.g. T2): 4mg – renewal until 21.07.2021;<br>(2) Tri-band phosphor with normal lifetime and a tube diameter ≥ 9 mm and ≤ 17 mm (e.g. T5): 3 mg – denied, 18 months transition recommended;<br>(3) Tri-band phosphor with normal lifetime and a tube diameter > 17 mm and ≤ 28 mm (e.g. T8): 3.5 mg – denied, 18 months transition recommended;<br>(4) Tri-band phosphor with normal lifetime and a tube diameter > 28 mm (e.g. T12): 3.5 mg – denied, 18 months transition recommended;<br>(5) Tri-band phosphor with long lifetime (≥ 25 000 h): 5mg – renewal until 21.07.2021. | (1): 0.4<br>(2): 76<br>(3): 247<br>(4): No data; entry not applied for and lamps in phase out in light of Ecodesign Directive.<br>(5):8-10 in 2014 | (1): 1-1.2<br>(2): 190<br>(3): 751<br>(4): No data; entry not applied for and lamps in phase out in light of Ecodesign Directive.<br>(5):40 in 2014 | Linear fluorescent lamps with a tube diameter ≥ 9 mm and > 28 mm (e.g. T5, T8, T12) and with a normal lifetime shall be prohibited on the market after mid-2018; | T12 lamps are understood to be in phase out in light of the Ecodesign Directive. Item 5 of this exemption allows further placing on the market of lamps with a tube diameter ≥ 9 mm and > 28 mm (e.g. T5, T8, T12) provided that they have a long lifetime. It is assumed that this item may be used to allow further placing on the market of some lamps (mainly T5 and T8); however from initial information from industry it is assumed that the total number of T5 and T8 lamps would nonetheless decrease in comparison to the business as usual scenario. |

| Scenario / exemption no. | Business as usual: where lamp substitution is governed by market forces (RoHS Annex III exemptions 1-4 remain valid) | Substitution Scenario: according to the recommendations made in the assessment report provided to the Commission by external consultants , with effect as of mid-2018. | Lamps (in millions) placed on the market in 2013, covered by the Ex. (LEU 2015) | Amount of Hg (kg) placed on the market in 2013 for lamps covered by the Ex. (LEU 2015) | Summary of differences | Further aspects that may impact scenarios |
|---|---|---|---|---|---|---|
| 2(b)(3) | Mercury in other fluorescent lamps not exceeding (per lamp): (3) Non-linear tri-band phosphor lamps with tube diameter > 15 mm (e.g. T9): 15 mg may be used after 31.12.2011 | 2(b) Mercury in other fluorescent lamps not exceeding (per lamp): (3) Non -linear tri-band phosphor lamps with tube diameter > 17 mm (e.g. T9) – renewal until 21.07.2019. | 18.6*<br>*divided between Ex. 2(b)(3), Ex. 2(b)(4) and Ex. 4(a). | 188*<br>*divided between Ex. 2(b)(3), Ex. 2(b)(4) and Ex. 4(a). | The renewal of the exemption is limited to three years. | Industry may request a further extension, but for the purpose of the study it is proposed to assume that a second extension would not be granted. |
| 2(b)(4) | Mercury in other fluorescent lamps not exceeding (per lamp): (4) Lamps for other general lighting and special purposes (e.g. induction lamps): 15 mg may be used after 31.12.2011 | (II) Lamps emitting light in the non-visible spectrum: 15 mg per lamp – renewal until 21.07.2021;<br>(III) Emergency lamps: 15 mg per lamp – renewal until 21.07.2021;<br>(IV) Mercury in other fluorescent special purpose lamps not specifically mentioned in this Annex: 15mg per lamp – renewal until 21.07.2019. | 18.6*<br>*divided between Ex. 2(b)(3), Ex. 2(b)(4) and Ex. 4(a). | 188*<br>*divided between Ex. 2(b)(3), Ex. 2(b)(4) and Ex. 4(a). | The exemption duration has been limited for a period of three years for lamps of relevance that do not emit in the UV spectrum and that are not emergency lamps. | See comments to Ex. 1(f). |

| Scenario / exemption no. | Business as usual: where lamp substitution is governed by market forces (RoHS Annex III exemptions 1-4 remain valid) | Substitution Scenario: according to the recommendations made in the assessment report provided to the Commission by external consultants , with effect as of mid-2018. | Lamps (in millions) placed on the market in 2013, covered by the Ex. (LEU 2015) | Amount of Hg (kg) placed on the market in 2013 for lamps covered by the Ex. (LEU 2015) | Summary of differences | Further aspects that may impact scenarios |
|---|---|---|---|---|---|---|
| 3 | Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for special purposes not exceeding (per lamp): (a) Short length (≤ 500 mm): 3,5 mg may be used after 31.12.2011<br>(b) Medium length (> 500 mm and ≤ 1 500 mm): 5 mg may be used after 31.12.2011<br>(c) Long length (> 1 500 mm): 13 mg may be used after 31.12.2011 | Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for special purposes not exceeding (per lamp):<br>(d) Short length (≤ 500 mm), 3,5 mg may be used per lamp in EEE placed on the market before 22 July 2016<br>(e) Medium length (> 500 mm and ≤ 1 500 mm),<br>5 mg may be used per lamp in EEE placed on the market before 22 July 2016<br>(f) Long length (> 1 500 mm) 13 mg may be used per lamp in EEE placed on the market before 2 2 July 2016 | No data provided. | Less than 2 | The exemptions are provided for 5 years for use of lamps in equipment placed on the market before 22.7.2016. | Industry has stated that lamps are only needed for older equipment and has agreed to the formulation, thus it is assumed that the scenarios shall be similar in relation to this exemption. |
| 4(a) | Mercury in other low pressure discharge lamps (per lamp): 15 mg may be used after 31.12.2011 | 4(a)-I: Mercury in low pressure non-phosphor coated discharge lamps, where the application requires the main range of the lamp-spectral output to be in the UV spectrum; up to 15 mg mercury may be used per lamp – renewal until 21.07.2021. | 18.6*<br>*divided between Ex. 2(b)(3), Ex. 2(b)(4) and Ex. 4(a). | 188*<br>*divided between Ex. 2(b)(3), Ex. 2(b)(4) and Ex. 4(a). | The exemption wording has been amended to better address lamps actually under the scope of the exemption. | Industry was consulted in relation to the new formulation and it is understood that it better reflects the actual lamps placed on the market through this exemption. Thus it is assumed that the scenarios shall be similar in relation to this exemption. |

| Scenario / exemption no. | Business as usual: where lamp substitution is governed by market forces (RoHS Annex III exemptions 1-4 remain valid) | Substitution Scenario: according to the recommendations made in the assessment report provided to the Commission by external consultants , with effect as of mid-2018. | Lamps (in millions) placed on the market in 2013, covered by the Ex. (LEU 2015) | Amount of Hg (kg) placed on the market in 2013 for lamps covered by the Ex. (LEU 2015) | Summary of differences | Further aspects that may impact scenarios |
|---|---|---|---|---|---|---|
| 4(b) | Mercury in High Pressure Sodium (vapour) lamps for general lighting purposes not exceeding (per burner) in lamps with improved colour rendering index Ra > 60:<br>I) P ≤ 155 W: 30 mg may be used per burner after 31.12.2011<br>II) 155 W < P ≤ 405 W: 40 mg may be used per burner after 31.12.2011<br>III) P > 405 W: 40 mg may be used per burner after 31.12.2011 | Mercury in High Pressure Sodium (vapour) lamps for general lighting purposes not exceeding (per burner) in lamps with improved colour rendering index Ra > 60:<br>(I) P ≤ 155 W; 30 mg may be used per burner – renewal until 21.07.2021;<br>(II) 155 W < P ≤ 405 W; 40 mg may be used per burner – renewal until 21.07.2021. | Not detailed | 5-10 | The exemption items have been reformulated, excluding lamps where P > 405 W, for which a transition period shall be given. | The change is a result of the understanding from industry that such lamps have become obsolete. Thus it is assumed that the scenarios shall be similar in relation to this exemption. |

| Scenario / exemption no. | Business as usual: where lamp substitution is governed by market forces (RoHS Annex III exemptions 1-4 remain valid) | Substitution Scenario: according to the recommendations made in the assessment report provided to the Commission by external consultants , with effect as of mid-2018. | Lamps (in millions) placed on the market in 2013, covered by the Ex. (LEU 2015) | Amount of Hg (kg) placed on the market in 2013 for lamps covered by the Ex. (LEU 2015) | Summary of differences | Further aspects that may impact scenarios |
|---|---|---|---|---|---|---|
| 4(c) | Mercury in other High Pressure Sodium (vapour) lamps for general lighting purposes not exceeding (per burner):<br>I) P ≤ 155 W: 25 mg may be used per burner after 31.12.2011<br>II) 155 W < P ≤ 405 W: 30 mg may be used per burner after 31.12.2011<br>III) P > 405 W: 40 mg may be used per burner after 31.12.2011 | Mercury in other High Pressure Sodium (vapour) lamps for general lighting purposes not exceeding (per burner):<br>(I) P ≤ 155 W; 25 mg may be used per burner after 31 December 2011 – renewal until 31.08.2018;<br>(II) 155 W < P ≤ 405 W; 30 mg may be used per burner after 31 December 2011 – renewal until 31.08.2018;<br>(III) P > 405 W; 40 mg may be used per burner after 31 December 2011 – renewal until 31.08.2018;<br>(IV) P ≤ 405 W; 20 mg may be used per burner – renewal from 1.9.2018 until 21.07.2021;<br>(V) P > 405 W; 25 mg may be used per burner – renewal from 1.9.2018 until 21.07.2021. | 23 | 345 | It has been recommended to decrease the mercury thresholds after August 2018. | It shall be necessary to understand what portion of lamps complies with the stricter thresholds in order to understand market changes and possible socio-economic impacts of such changes. |
| 4(e) | Mercury in metal halide lamps (MH) | Mercury in metal halide lamps (MH) – renewal until 21.07.2021. | 16 | 176 | Changes have not been recommended so differences are not expected. | |

| Scenario / exemption no. | Business as usual: where lamp substitution is governed by market forces (RoHS Annex III exemptions 1-4 remain valid) | Substitution Scenario: according to the recommendations made in the assessment report provided to the Commission by external consultants , with effect as of mid-2018. | Lamps (in millions) placed on the market in 2013, covered by the Ex. (LEU 2015) | Amount of Hg (kg) placed on the market in 2013 for lamps covered by the Ex. (LEU 2015) | Summary of differences | Further aspects that may impact scenarios |
|---|---|---|---|---|---|---|
| 4(f) | Mercury in other discharge lamps for special purposes not specifically mentioned in this Annex | (II) Mercury in high pressure mercury vapour lamps used in projectors where an output ≥2000 lumen ANSI is required – renewal until 21.07.2021;<br>(III) Mercury in high pressure sodium vapour lamps used for horticulture lighting – renewal until 21.07.2021;<br>(IV) Mercury in lamps emitting light in the ultraviolet spectrum for curing and disinfection – renewal until 21.07.2021. | Projection lamps: 3;<br>UV short arc mercury: not detailed;<br>UV curing: 0.13;<br>UV disinfection: 0.18 | Projection lamps: 45;<br>UV short arc mercury: 20;<br>UV curing: 75;<br>UV disinfection: 81 | The exemption duration has been limited for a period of three years for all lamps of relevance other than certain projection lamps, horticulture lamps and lamps emitting light in the ultraviolet spectrum for curing and disinfection. | See comments to Ex. 1(f). |

On the basis of this comparison, of the number of lamps directly affected by each exemption and of the outlined differences, the consultants conclude that the main differences between the scenarios are related to a smaller sub-set of lamps, which are detailed in the following. All numbers stated below refer to the 2013 annual market volume in Europe of the various lamp types:

- Compact fluorescent lamps below a wattage rating of 50 W (325 million lamps directly affected). Spillover effects related to other CFL lamps are discussed;
- Linear fluorescent lamps with normal lifetime and with tube diameter ≥ 9 mm and ≤ 28 mm (T5 and T8) (323 million lamps directly affected). Spillover effects related to other LFL lamps are discussed;
- Non-linear tri-band phosphor lamps with tube diameter > 15 mm (e.g. T9) (between 6 to 18 million lamps directly affected[20]); Discussed along with LFL lamps;
- Mercury in other High Pressure Sodium (vapour) lamps for general lighting purposes (23 million lamps directly affected by the exemption, though only lamps between 155 W < P ≤ 405 W expected to be affected). Spillover effects related to other HPS lamps are discussed;
- Special purpose lamps covered by exemptions 1(f), 2(b)(4), 4(a) and 4(f) (number of lamps: 400,000 lamps for Ex. 1(f); 18 million lamps for Ex. 2(b)(3), 2(b)(4) and 4(a) and not completely clear for Ex. 4(f)).

The current assessment shall focus on these above cases, also detailing possible "spillover" effects on other types of lamps where these can be expected (e.g. mutual manufacturing at the same production site) as an indirect result of exemption amendments.

In contrast, for the following lamps and exemptions it has been assumed that the scenarios are not expected to differ. In a stakeholder meeting that took place with LightingEurope and some of its members from industry on the 22nd of February, these assumptions were confirmed by the participants (LightingEurope 2017a).

- Cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) covered by Ex. 3. For such lamps, the renewed exemption (SUB scenario) has been limited to lamps to be used in electrical and electronic equipment (EEE) placed on the market before the 22.7.2016. This formulation was proposed to LE and its members during the initial evaluation as it was understood that such lamps are only in use in older equipment. It was understood that the formulation was suitable and should not result in the early phase-out of lamps and in the respective early end of life of equipment in which they are in use. Thus the scenarios are not expected to differ in terms of impacts.
- For metal halide lamps (MH) covered by Ex. 4e, it has been recommended to renew the exemption with its current wording. Thus a regulatory driven substitution of lamps in the SUB scenario is not expected (BAU and SUB scenarios are equivalent).
- Though a change to the mercury threshold of exemption 1(e) is also recommended, it is related to the Minamata Convention and thus the market and subsequent impacts

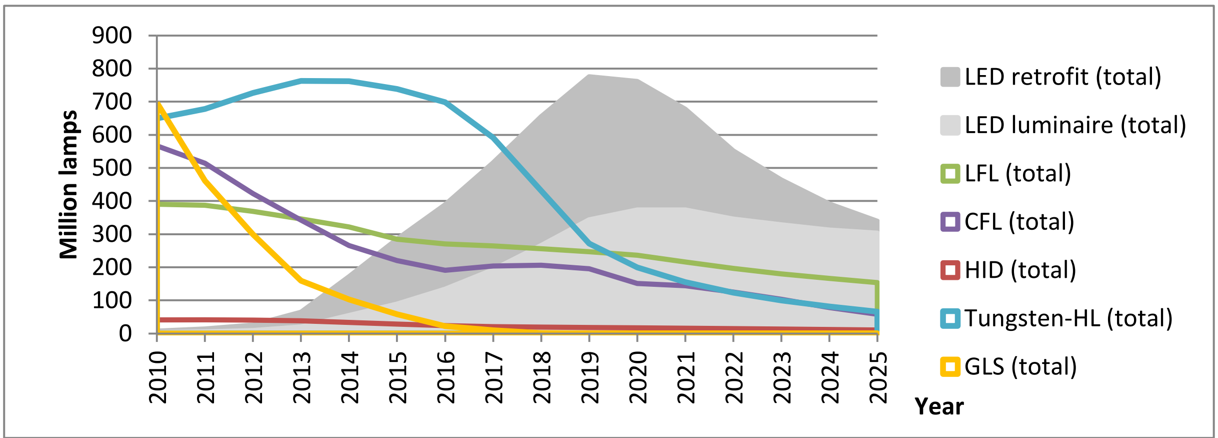
20 Estimated number of lamps relates to the exemptions 2(b)(3), 2(b)(4) and 4(a). If no additional data is made available, for the sake of further discussion, it shall be assumed that at worst case 18 million lamps were placed on the market in 2013 and at best 6 million.

are not expected to differ between the scenarios, in this respect. Against this background impacts of this change are also excluded from the scope of discussion.

In relation to **lamp technologies affected indirectly**, it is useful to understand the developments expected in the lighting sector in the BAU scenario in terms of changing market shares of various lamps. Though LED lamps are an important and increasing alternative for the various discharge lamp technologies, it is worth mentioning that in some cases other alternatives may be of relevance. Incandescent and halogen lamps for example are an alternative for some CFL lamps, in terms of the lamp fixture and in terms of the quality of light they provide. However incandescent lamps have been phased-out (aside from special purpose applications) and halogen lamps are to be phased out in September 2018 (in both cases a result of lamp regulation through the Ecodesign directive). As the overlap between halogen phase-out and between the potential phase-out of discharge lamps in the SUB scenario is expected to be short termed (for example between January and September 2018 for CFL lamps of Ex. 1(a) and 1(b)), such impacts are not further discussed in this study. In contrast, as the development of LED technologies overlaps and is also indirectly affected by the fate of the RoHS discharge lamp exemptions, its development in the BAU scenario provides an important context for any additional sales expected in the SUB scenario. Development of the various conventional lamp technologies (CFL, LFL and HID discharge technologies, but also halogen and incandescent) in comparison with development of LED retrofit lamps and luminaires[21], is presented below to provide the context for potential development in the SUB scenario. Within the lamp type specific chapters, data shall be presented to provide a context of the technology being discussed and the development of the relevant types of LED lamps.

**Figure 1 Development of lamp sales (2014-2025), based on VHK data**

*The development of conventional lamp technologies (empty line) can be seen on the background of the development of LED retrofit (replacement) lamps and LED (replacement) luminaires. Data is absolute and not stacked.*




*Source of data: MELISA model, data for VHK BAU scenario (VHK 2016)*

The data presented above is taken from the business as usual scenario (BAU) of the VHK MELISA model (VHK 2016), developed in the context of the Ecodesign preparatory study for lighting. In their estimations for the BAU scenario, it is understood that VHK

[21] Where a LED lamp cannot be used as a replacement within a luminaire previously using a conventional lamp, the luminaire can no longer be used and thus shall need to be replaced with an LED luminaire.

estimated how the market of various lamp types shall develop in the case that the Ecodesign Regulation of lamps remains unchanged. This means that only the Ecodesign Regulations in force at the time the model was developed (last update in 2016) are considered in terms to possible changes to lamps that can be placed on the market. This includes for example the phase-out of the incandescent lamp and of T4 and T12 linear fluorescent lamps that had already taken place by 2016 as well as the phase out of halogen lamps that in part was only required starting 2016 and 2018 (depending on lamp socket type). In contrast, in relation to Figure 1, it should be noted that the MELISA model did not take into consideration changes to the market of CFL and LFL Lamps as a result of changes to the corresponding exemptions of Annex III of the RoHS Directive. In this sense, the significant decrease in the trend of sales of CFLs observed in 2016 and the more moderate decreases for CFLs in 2019 and 2021 and for LFLs in 2015 and in 2020 are not a result of RoHS restrictions of lamps proposed in the 2016 Oeko study, but of other trends present in the market. Against this background, it shall later be discussed in the comparison of the two scenarios, to what degree the exemption creates new impacts (i.e., additional costs for industry and society) and alternatively, to what degree such costs are more or less equal and only accelerated and expected to incur earlier in the SUB scenario than in the BAU scenario.

For all exemptions it has been recommended to limit the exemptions to category 5. LE has raised concerns in its exemption application documents and throughout the evaluation process that limiting exemptions to category 5 could create uncertainty whether lamps may be used in equipment of other categories. In the consultants understanding, the use of lamps in equipment of all categories is not limited by the association of a lamp with Cat. 5, unless the exemption wording specifically limits the use to certain EEE or EEE categories. However this aspect is understood to be of legal nature and would thus require a legal interpretation to provide clarity and certainty for stakeholders. In this context we recommend to clarify this aspect in future guidance (such as in the frequently asked questions document) so as to avoid uncertainties and subsequent impacts. If limitation of the exemptions to category 5 is perceived as a source of legal uncertainty, extending the exemptions to all categories (as is currently the practice in exemptions 1-4) is estimated to relieve such uncertainties and to avoid subsequent impacts. The availability of the exemption to different categories is not further discussed in this report.

## 3.3. Project set-up, data sources and methodology

Assignment of project tasks to Oeko-Institut, started 22 December 2016. Various data was used at this initial stage to prepare a first estimation of impacts expected to be associated with the two scenarios. For the purpose of this initial as well as the later estimations, data was used from the following sources where possible:

- Data from the VHK Model for European Light Sources Analysis (MELISA) (VHK 2016) has been used as a source for market data and market forecasts. This model was developed by VHK as part of a Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements (‘Lot 8/9/19’), prepared for the European Commission during 2014-2016. The last version of the model, dated 13 July 2016 has been used as a source for various data in the present study. Though this version has not been published at the time of writing, it is understood that it represents a consensus model, discussed with various stakeholders and developed as a commonly accepted forecast of the lighting market of the coming years for the various actors involved, including Member State representatives and regulatory organisations, industry, consumer and environmental non-governmental organisations, etc. Data is used from this model from the "business as usual" scenario developed by VHK and represents the market as expected to develop without further measures enacted through the Ecodesign Directive. In relation to costs data from the MELISA model, it is noted that a distinction is made between costs for residential applications (where VAT is included) and non-residential applications (where VAT has been excluded). The data has been used as is (i.e. with VAT where included and vice versa) and is also summed as is where relevant (costs with and without VAT are summed). This is based on the understanding that the costs in this form reflect the price that the relevant consumer perceives (with VAT in the private sector and without in the commercial sector).

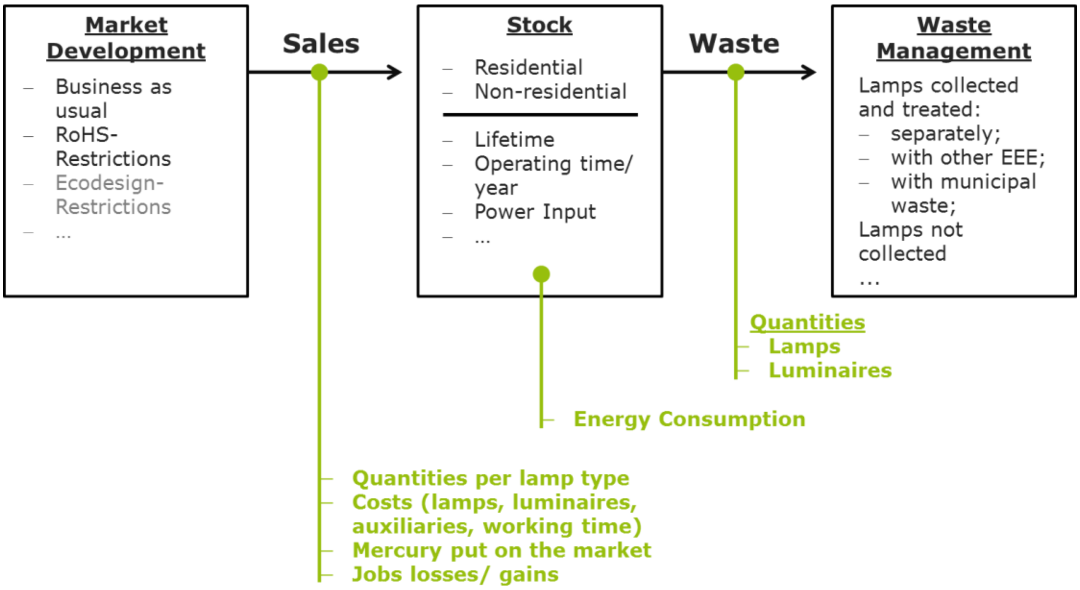
- In relation to specific exemptions, information and data from the initial exemption requests submitted by LightingEurope in January 2015 is used. This is relevant for example in cases of lamps not covered by the MELISA model (special lamps) as well as where additional information is needed to bridge the gap between the data in the MELISA model (related to specific lamp technologies for general purpose lighting) and the RoHS exemption (where classification is related to power supply, dimensions, etc.).

Where the above sources did not allow substantiating the estimation with data and information, assumptions were made on the basis of expert judgement, so as to provide a first estimation for reference. For example, such assumptions were made in relation to the weight of scrap generated through the regulatory driven substitution or in relation to the availability of substitutes to a certain technology.

To validate such assumptions (confirm or adjust on the basis of data provided by and/or expert judgement of the lighting sector) a targeted stakeholder meeting was held on 22.2.2017 with LightingEurope and with representatives of a few of its members. During this meeting, Oeko-Institut presented results of a first estimation of impacts in the two scenarios for exemptions 1(a-e), 2(a)(1-5), 2(b)(3), 4(b) and 4(c). Initial assumptions were also discussed relating to the special purpose lamps covered by exemptions 1(f), 2(b)(4), 4(a) and 4(f) and in relation to exemptions where impacts were not expected to differ between the scenarios (3, 4(e)). During the meeting the various assumptions were discussed to determine what data was relevant for allowing a more precise estimation. Some of the assumptions made were confirmed through the discussion held during the stakeholder meeting and are specified as such within this document. For other assumptions, following the meeting, LE provided additional data in relevant areas (where this did not breach propriety issues) and the estimation was carried out again after a revision of the related assumptions in such cases.

In the following chapters, results of the estimation are presented and discussed for each of the lamp types in the scope of this study. The following figure provides context to the various market stages of lamps (sales, stock, end-of-life) as well as parameters affecting the number of lamps and relevant impacts (for example emissions, production of waste) in each stage.

**Figure 2 Relation between market stages of lamps, number of lamps at each stage and socio-economic impacts**




*Source: Own illustration*

Where data and/or information have been available to allow a comparison (quantitative and/or qualitative), differences presented for the two scenarios are detailed for:

- The expected market development in each scenario (sales and stock); here data is presented for the development of the lamp technology of relevance for the exemptions being discussed, while also providing data on the parallel development of LED substitutes for that lamp technology (retrofit lamps and luminaires).
- The sales and stock data allow understanding the number of lamps reaching end-of-life (EoL) in a specific scenario, which represents the number of lamps that need to be replaced. Data from the MELISA model related to the number of lamps reaching EoL is used for the BAU scenario. Natural phase-out (related to consumer preference of other lamp technologies) is assumed to be reflected in the initial BAU scenario and is thus disregarded as the discharge lamp data already reflects this natural shift to other technologies (e.g. LED). For the SUB scenario the differences in lamp sales (once exemption changes are implemented) are used to derive the number of lamps reaching EoL. By calculating the difference between the estimated lamp sales of each of the scenarios, the number of additional lamps reaching end of life (EoL) and thus requiring a replacement in the SUB scenario is derived. These estimations are the basis on the one hand for deriving some of the impacts related to early phase-out (for example costs of replacement) and on the other hand also for deriving some of the environmental impacts (for example additional waste or avoided amounts of mercury placed on the market).
- The differences in sales also affect the stock of lamps, i.e. the number of lamps in stock or understood to be in operation in a certain year. The various lamp types have different lifetime expectancies, which are reflected in the stock. A lamp sold in a specific year is added to the stock and remains part of the stock throughout its expected lifetime. The lifetime in years is calculated in relation to the total expected

operative hours and the average expected hours of operation per year (the second value differs depending on the purpose of use: residential or non-residential purposes). Once a lamp reaches its end-of-life it is removed from the stock. In the BAU scenario, natural phase-out represents such lamps that are replaced with an alternative technology, whereas other lamps reaching end-of-life shall be replaced by the same type of lamp. In the SUB scenario in contrast, once the RoHS restrictions come into force, all lamps reaching end-of-life shall be replaced with an alternative technology. In most cases, in the period after which RoHS restrictions come in to force in the SUB scenario, the lifetime of lamps replacing a product that has reached its end-of-life extends beyond the analysis period (2016-2025) and thus impacts related to operation such as energy consumption are only partially reflected in the analysis.

- Within the various chapters, results for the number of lamps to be replaced are presented in the "Expected market development in each of the scenarios" section, whereas results for impacts calculated on the basis of this data are presented in the sections following thereafter (e.g., Possible costs for users related to lamp substitution; Impacts on the generation of waste, etc.). The method for quantifying various impacts is often shortly explained in proximity to results as additional data is used for impact estimations (e.g., costs of substituting lamps, Hg contents per lamp, etc.). It is noted that in line with the first changes to market sales occurring in a certain year (depending on exemption recommendations for phase-out/amendment), impacts for the scenarios are expected to differ starting the relevant year (usually 2019).
- Expected impacts on employment (also discussed separately in Section 3.4 in light of the lack of data to enable a demonstration of such impacts in relation to specific lamp technologies and/or exemption);
- Possible costs for users related to substitution;
- (Other) Expected impacts on consumers;
- Expected impacts on the generation of waste;
- Expected impacts on the amounts of mercury to be placed on the market;

The ToR has specified that the assessment is to be carried out for the period between 2016 and 2021, also requiring that some data be specified since 2014 (e.g., volume of lamps). It is furthermore clear that some impacts shall only become evident at the end of this period or possibly even after this period, as expiration dates shall result in a transition period and in some cases amendments of exemptions are recommended for a later time. To allow a better understanding of the possible consequences of each of the scenarios, the consultants thus look at the period between 2014 and 2025. This allows a differentiation between benefits and costs within the short term (1-3 years) and the mid-term (4-10 years). In some cases impacts relevant for the long term (10 years and above) may be mentioned.

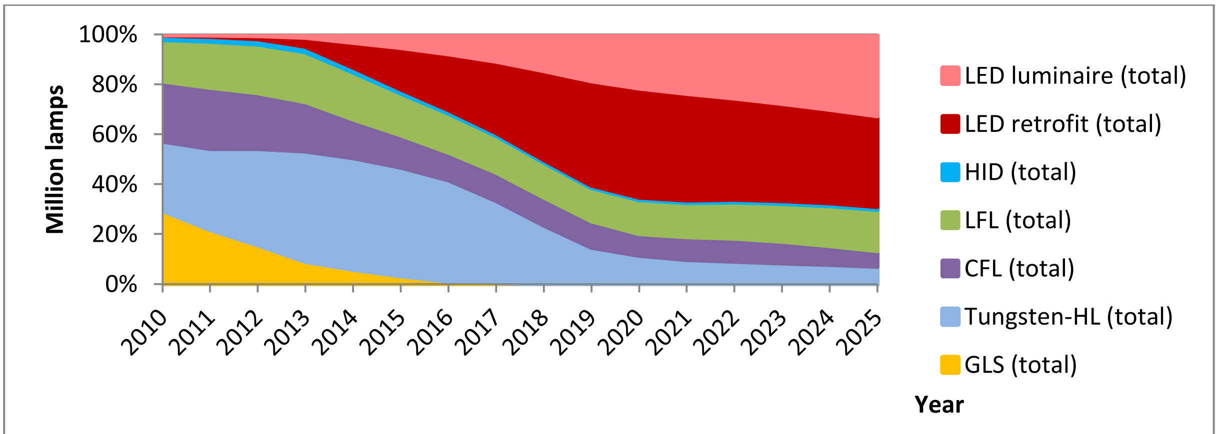
## 3.4. Impacts on employment

### 3.4.1. General Considerations

The Terms of Reference for this study require among others an estimation for the two scenarios of impacts related to the manufacture of lamps and employment. The availability of information related to these issues is limited and furthermore does not allow an understanding of what part of the lamp sector (i.e., number of employees or number of manufacturing facilities) is associated with the manufacture of a specific lamp technology of relevance for the RoHS exemptions (i.e., discharge lamps). The following summary of the production and employment situation is based on information provided by LE as well as information that was collected in this analysis on the basis of publicly available sources. It does not allow a full understanding of the state of employment and production of the lighting sector (in general and specifically in the EU), but should serve to provide some insight on this topic and on possible impacts that could be expected in relation to a specific discharge technology in the SUB scenario.

LE (LightingEurope 2016) specifies that it represents an industry of over 1,000 companies in Europe, with more than 100,000 employees. This industry is understood to produce not just discharge lamps but also lamps of other technologies as well as other lighting equipment (luminaires and parts thereof). In this sense the consultants understand that only a share of these numbers can be directly associated with discharge lamps and with the fate of those lamps in relation to decisions in relation to RoHS exemptions covered in this analysis. Data is not available to allow understanding what share of employees is associated with the development and production of a certain lamp technology. To provide some insight on this aspect, the changing share of the volume of lamps sold on the EU market per annum is presented in Figure 3. Though it is assumed that the manufacture of some technologies is not evenly distributed between EU and non-EU countries, other data is not available to provide data on the corresponding shares of lamp technology manufacture, neither in the EU nor globally.

**Figure 3 Development of lamp share sales in the EU 28 between 2010 and 2025, millions of lamps, based on VHK data**




*Notes: LED – light emitting diodes; HID – high intensity discharge lamps; LFL – linear fluorescent lamps; CFL – compact fluorescent lamps; Tungsten-HL – halogen lamps; GLS – Incandescent lamps*

As an outcome of the implementation of the SUB scenario, LE estimates that "the current Oeko proposal will lead to a ban of 80% of the conventional energy efficient discharge lamps. The reduced load for the European factories will force early closure and loss of 20.000 European jobs in lamp factories and supporting sectors."

The consultants assume that the 20,000 jobs refer to jobs within the lighting sector associated with the development and manufacture of discharge lamps to be phased-out in the SUB scenario. Though a certain impact could be said to be relevant for example to lamp sales (i.e. jobs in the retail sector or in logistics) these are assumed to shift from one technology (the lamp being phased-out) to another (lamps considered to provide a retrofit replacement). In this sense, the 20,000 jobs are assumed to be distributed between discharge lamp technologies that are to phase-out as a consequence of the SUB scenario. Such technologies include CFL, LFL, HPS lamps falling under Ex. 4(c)II and special lamps not provided with a 5 year exemption renewal. Though the distribution of market shares of these technologies may provide some insight as to how these jobs may be distributed between the different technologies, it can only be assumed as indicative. This has various reasons:

- Though special lamps are produced in small volumes, their variation in terms of types of application is expected to be much larger and thus to demand a larger share of jobs in the development stage, and vice versa in relation to general purpose lamps;
- The 20,000 jobs are understood to be related with the EU lighting industry. From other statements, it is expected that the manufacture of some lamps marketed in the EU is more concentrated in the EU than others. For example, for CFL lamps with non-integrated ballast, it can be understood that most lamps sold in the EU are also manufactured in the EU, whereas for CFLi lamps, significant shares of sold lamps are manufactured outside the EU.
- For some lamp technologies the SUB scenario envisions a significant phase-out of lamps of that technology (e.g., ~95% of CFL), whereas for others the significance of the phase-out is relatively small (~10% for Ex. 4(c)II HPS lamps) or not clear (special lamps).

Data as to the volume of lamps understood to have been placed on the market in 2016 for the various lamp technologies is specified in Table 2 as well as the resulting sale shares for 2016. These shares can only be assumed indicative in relation to the distribution of jobs between technologies. As specified above, there are various reasons why the actual distribution of jobs to be lost in the SUB scenario shall be different and thus these numbers should be considered with caution.

**Table 2 Lamp sales of discharge technologies to be phased out in the SUB scenario and their respective sales share**

| Lamp type | 2016 sales volume | 2016 sales share | Source: |
|---|---|---|---|
| CFLi | 127 | 27.7% | Based on MELISA model (VHK 2016) |
| CFLni | 64 | 13.8% | |
| LFL T5 | 66 | 14.3% | |
| LFL T8 | 185 | 40.2% | |
| HPS Ex. 4c | 2 | 0.5% | Estimated share covered by the exemption item in relation to data from MELISA model (VHK 2016) – see Chapter 6 for detail. |
| Special lamps | 16 | 3.5% | Based on LE estimations for sales volume in 2013, see Chapter 0 for detail. |
| Total | 460 | 100% | |

In relation to the number of facilities manufacturing lamps of a specific technology in the EU and beyond, LE has specified that it "*cannot disclose such information, as it may compromise the position of its members*." The same has been said in relation to specifying the number of employees associated with the production of a specific lamp technology. LE explains that "*in view of the sensitive nature of some of the questions raised concerning job losses, factory production sites and capacity, such numbers cannot be disclosed, as mentioned previously in meetings with Oeko and the European Commission, as it may breach competition laws and compromise the position of LightingEurope members*."

### 3.4.2. Additional information

In the following, information is presented as to the number of employees and facilities of some of the lighting manufacturers based on own research of publicly available data sources. Detail does not always allow determining the share of business related to specific lamp types or the location of all manufacturing facilities of discharge lamps, but allows an initial overview.

Information[22] from 2010 specifies that **General Electric** had a total of 33 sites and 16,000 employees at the time. 10 sites were located in the EU with 7,500 employees. 14 sites were located in North America with 4,800 employees and the rest in South America and Asia. It is further understood[23] that a large number of manufacturing facilities are located in Hungary, some manufacturing components of lamps and others manufacturing various types of lamps:

- "GE Hungary" manufacture of metal, ceramics and glass components, as well as wires and filaments;
- "Light Source Factory Budapest" - manufactures high pressure sodium (HPS); quartz metal halide (QMH); ceramic metal halide (CMH); full range of automotive halogen and discharge headlights";
- "GE Hungary Light Source Factory Kisvárda" - produces halogen & automotive lamps;
- "GE Hungary Light Source Factory Nagykanizsa" – manufactures traditional incandescent products; incandescent lamps; halogen lamps; non-integrated compact lamps; fixtures; plastics and metal parts; glass production;
- "GE Hungary Hajdúböszörmény Component Factory" – manufactures tungsten and molybdenum wires; coils (for incandescent lamps, vacuum evaporation and fluorescent lamps); CMH, HID, and automotive lamp cathodes, lead in wires for all lamp types;
- "GE Hungary Component Factory Zalaegerszeg - produces various lamp bases; electrical and mechanical metal components.

Neonlite International Holdings Limited is the owner of the trademark **MEGAMAN®**. It is understood that the majority of its sales revenue was generated in 2013 and 2014 from LED products (74% and 80% sales revenue respectively) whereas CFL and other goods (including components and luminaires) generated 26% and 20% sales revenue in 2013

[22] See: https://www.ge.com/sites/default/files/ge_bank_america_merrill_lynch_presentation_12162010_0.pdf

[23] See: http://www.gelighting.com/LightingWeb/emea/resources/world-of-ge-lighting/our-factories/

and 2014 respectively. The decreasing demand for CFL lamps and a persistent shortage of labour in the industry has lead the company to gradually phase out one of the CFL producing factories (resulting in 400 redundancies), which was expected to cease total production in September 2014. In 2014 80% of Megaman's manufacture was related to LED and only 20% to CFL and other products[24]. 1,200 people are employed in Hong Kong and mainland China. Headquartered in Hong Kong, the Company has two LED manufacturing plants (December 2014) in Xiamen, China[25].

Towards the end of 2016, **NARVA**, a former East Germany company, announced that it would reduce its activities in the discharge lamp manufacturing area to special purpose lamps. Manufacture of (general lighting) CFL and LFL is to be ceased. The company shall depart from 250 of the former 370 employees. The reasons for this change have been stated to be the surplus of such lamps supplied from Asia (at dumping prices) as well as the growing market share of LED. According to NARVA, the market for (mass market types of) discharge lamps has shrunk over the last years by 10% annually. It can be understood that until recently, NARVA facilities manufactured the following lamp types: LFL T5, LFL T8, FL-PL, FL U-shape, LED, special discharge lamps; whereas following the change manufacture shall focus on LED, LED luminaires, special discharge lamps and glass parts (assumed to be further processed by other manufacturers).[26]

**Philips Lighting** manufactures and distributes interior lighting as well as exterior lighting, lighting electronics and ballasts, automotive and special lamps, light-emitting diodes and lighting solutions based on them. Production is carried among others in the main branch in Hamburg, in the branches Goch and Ulm (U-L-M-Photonics) and above all in Aachen, which is also the central production and research centre for organic light-emitting diodes (OLED). In 2016 the Philips Lighting division employed approximately 34,250 individuals worldwide.[27]

It can be understood that in 2015, **OSRAM** employed approximately 33,100 individuals, 10,100 of which worked in the lamps business unit. The Lamps Business Unit comprises OSRAM's general lighting lamps business. This includes both traditional offerings and LED retrofit lamps (LEDr-classic-format LED-based lamps that are used as a direct replacement for traditional products with standardized sockets). [28] A 2016 press release state that Osram has parted from it general lighting business[29], which was purchased by three Chinese companies including a LED manufacturer.

An OSRAM document describes the market for traditional lamps as relatively highly concentrated, in so far that it is associated with three leading companies: Philips, OSRAM, and General Electric are explained to have a combined market share of over 50%. The consultants understands traditional lamps to mean discharge lamps, but also

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24 See https://www.megamanuk.com/assets/files/pdf/Sustainability%20Report%202013-14-EN-FINAL.pdf

25 See http://www.megaman.cc/worldwide

26 Summarized from press announcements: http://www.mdr.de/sachsen/chemnitz/narva-schutzschirmverfahren-100.html; http://www.mdr.de/sachsen/chemnitz/narva-brand-erbisdorf-entlaesst-zwei-drittel-seiner-belegschaft100.html

27 Summarized and translated from: www.results.philips.com/#!/downloads

28 See: http://www.osram-group.de/~/media/Files/O/Osram/documents/en/fiscal-year-2015/osram-annual-report-screen.pdf

29 See: https://www.osram.com/osram_com/press/press-releases/_business_financial_press/2016/osram-announces-name-of-lamps-business-ledvance/ and http://www.ledsmagazine.com/articles/2016/07/osram-sells-ledvance-ssl-business-to-chinese-trio-including-mls.html

halogen and incandescent as far as these are still manufactured. Where LED lamps are concerned, the document explains that a large number of medium-sized and small-sized producers make up for the rest of the market share (not clear what share this represents), including low-cost suppliers from Asia. [30]

To summarize, though it is not possible to specify the number of individuals relying on the manufacture of discharge lamps for their livelihood, nor their distribution in the EU nor globally, it is apparent that changes to the RoHS exemptions could be expected to have impacts on manufacture and on employment all over the world. Nonetheless, in the consultants' opinion, regardless of the RoHS exemptions, two parallel trends are underway that significantly influence the future manufacture and sale of discharge lamps. The surplus of discharge lamps supplied from Asia (at significantly lower prices), as well as the growing market share of LED are understood to play a heavier role in the shift of European lamp manufacturers away from the manufacture of discharge lamps (at least in relation to general purpose lamps). There is evidence that a number of facilities manufacturing CFLs or LFLs have already been closed in some cases and it can be assumed that the volume of production in other facilities is also decreasing. This process is understood to be a result of the general development of the lighting sector and not directly related to the RoHS Directive and the unclear fate of exemptions, as facilities have been closed as early as 2014. Though the impact of a change in availability of RoHS exemptions cannot be denied, it is perceived mainly to influence the timeframe of this shift already underway (i.e. to accelerate a process that is already taking place).

30 See: http://www.osram-group.de/~/media/Files/O/Osram/documents/en/fiscal-year-2015/osram-annual-report-screen.pdf

# 4. Compact fluorescent lamps (CFL) – General purpose lighting

## 4.1. Exemptions in the scope of this section

The current chapter covers impacts related to exemptions 1(a-e) specified below for the use of mercury in compact fluorescent lamps (CFL).

*Ex. 1: Mercury in single capped (compact) fluorescent lamps not exceeding (per burner):*

*a. For general lighting purposes < 30 W: 2,5 mg may be used after 31.12.2012*

*b. For general lighting purposes ≥ 30 W and < 50 W: 3,5 mg may be used after 31.12.2011*

*c. For general lighting purposes ≥ 50 W and < 150 W: 5 mg*

*d. For general lighting purposes ≥ 150 W: 15 mg*

*e. For general lighting purposes with circular or square structural shape and tube diameter ≤ 17 mm: 7 mg may be used after 31.12.2011*

Most impacts related to a possible change to these exemptions are expected to incur in relation to lamps covered by the exemptions themselves, and are detailed in the sections to follow.

Though spillover effects may be relevant for special purpose lamps, covered under Ex. 1(f) (special purpose lamps), such effects are discussed in chapter 7 and thus not specified here in detail. It is also noted that a further exemption, Ex. 1(g) is listed in Annex III of the Directive for long-life CFL lamps. In reference to this exemption, some qualitative statements are made throughout the next sections.

## 4.2. Expected market development in each of the scenarios

In the following chapter, estimations are made as to the expected differences between the BAU scenario and the SUB scenario (see Section 3.1 for detail) in relation to the lamp market situation and subsequent impacts.

To understand the differences in sales and subsequently of the European stock of CFL lamps over the years 2014-2025, MELISA sales and stock data have been used as a source for data for the BAU scenario. The SUB scenario is developed on the basis of these data, assuming that exemptions 1(a) and 1(b) are revoked in 22 July 2016, and that a transition period of 18 months, until 21 January 2018, is provided to ease the phase out of relevant lamps. For the purpose of this study, it is assumed that stock already placed on the market at retailers throughout the transition period shall still be circulated until the end of the calendar year 2018. In this sense, the share of lamps falling under these exemptions is subtracted from the SUB scenario starting 2019. Similarly, it is expected that following the recommended three year renewal of exemptions 1(c), 1(d) and 1(e), that the exemptions shall later be revoked in 22 July 2019 and provided a transition period until 21 January 2021. As of January 2022, it is expected that lamps falling under exemptions 1(a-e) could no longer be placed on the EU market.

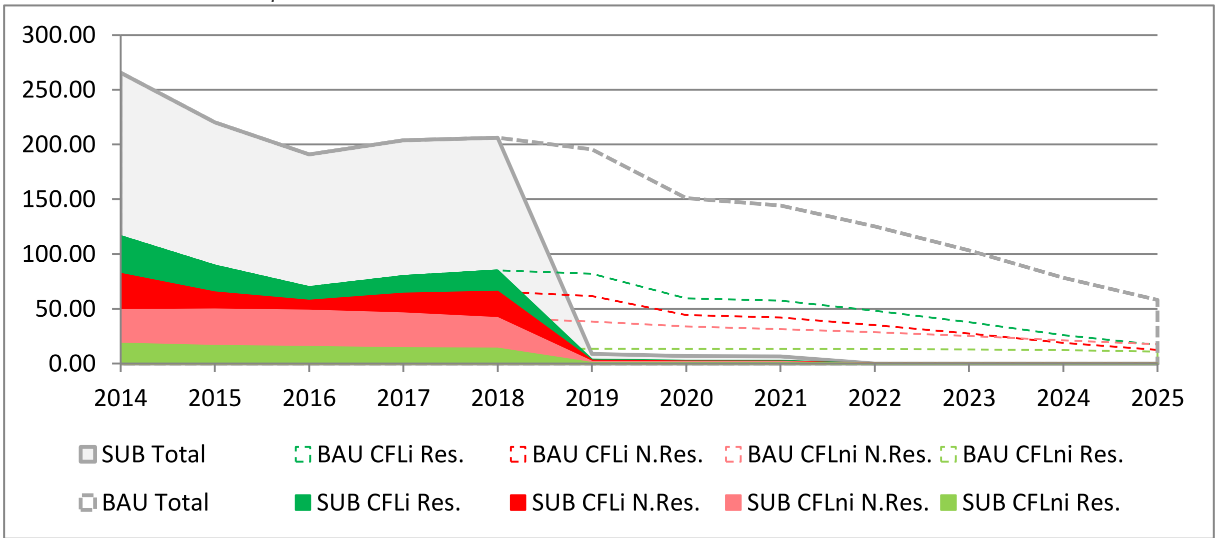
It is noted that the scenarios are expected to be identical until 2018, after which the change to exemptions is to be reflected in market sales and thus expected to result in various impacts. Though in the phase out of the incandescent lamp, sales increased dramatically shortly before its implementation, LE (LightingEurope 2017a) have confirmed that such a trend is not expected in the case of CFLi, as most consumers will not prefer CFL over LED replacements, which are considered to have better functionality. It is understood from LE that this general assumption has been considered in the MEILSA model.

Figure 4 and Figure 5 thus show the development of the sales and stock of lamps in the EU 28 over the period 2014-2025 on this basis. The scenarios are identical until 2018, with differences apparent starting 2019. The development of the BAU scenario after this year is portrayed with a dotted line, in comparison to the solid line and "filled" surface of the SUB scenario trends. The diagrams provide both the total CFL lamps sold in each year for each scenario as well as the breakdown to CFL with integrated (CFLi) and with non-integrated (CFLni) ballast and the break-down to residential and non-residential lamps.

Ex. 1g is listed in Annex III of the Directive for long-life CFL lamps. LE (LightingEurope 21.03.2017) estimate such lamps to have a total share of 2-3% of all CFL lamps, however data for CFL-long life are not addressed separately in the MELISA model and thus also not addressed separately in Figure 4 and Figure 5 below. LE (LightingEurope 2017d) also mention that lamps covered by Ex. 1g include both CFLni and CFLi lamps, and are only available in a few types (understood to be in relation to power supply in wattage and other technical parameters) and not in the entire standard life product range.

**Figure 4 Development of CFL sales in the EU 28, in millions of lamps**

*The SUB development (filled line) can be seen on the background of the BAU development (dotted line) for the total lamps, as well as the breakdown to integrated and non-integrated CFL lamps and to residential and non-residential lamps. Data is absolute and not stacked.*

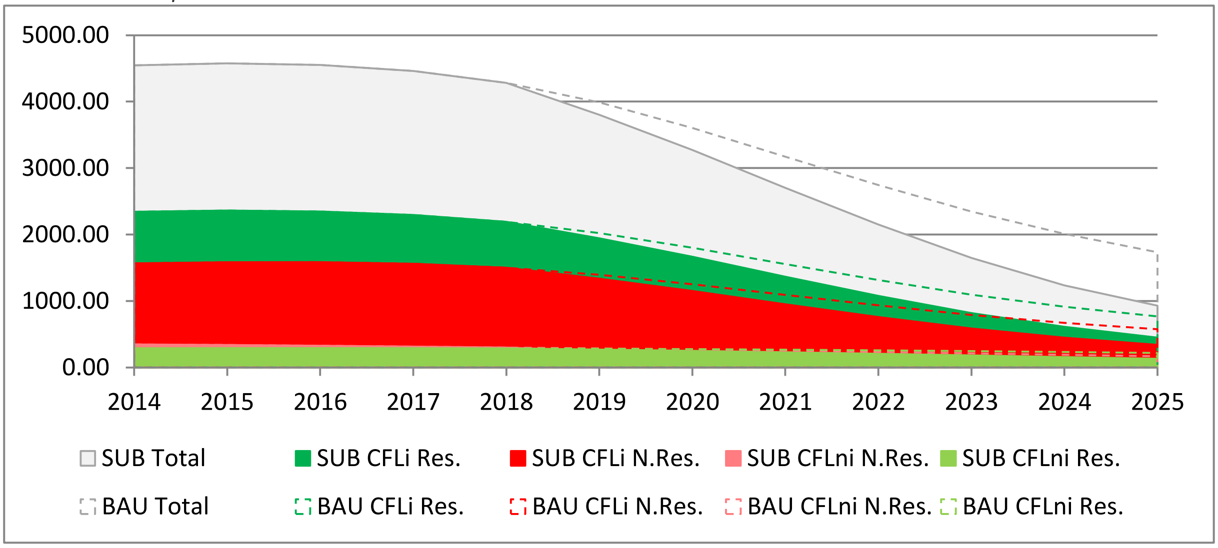



*Own compilation based on data from (VHK 2016)*

Though changes to the exemptions to be implemented in the SUB scenario have a near to immediate impact on the trend in sales of lamps, this impact is more moderate in relation to the stock of lamps in use in the EU at a certain point in time, as suggested from comparing the diagrams below. Figure 5 shows how the stock of CFLs develops throughout the observed period, while Figure 6 shows the estimated additional CFLs expected to reach EoL in the SUB scenario. Though the lamps may no longer be sold shortly after the revoke of an exemption, their service lives vary (VHK 2016) from 6.25 years for non-residential CFLni to 14.4 years for residential CFLni. Actual phase out from the stock of lamps in use is thus expected to begin in the years to come and thus only relevant after 2025 for the various CFL lamp types, in light of the long service lives.

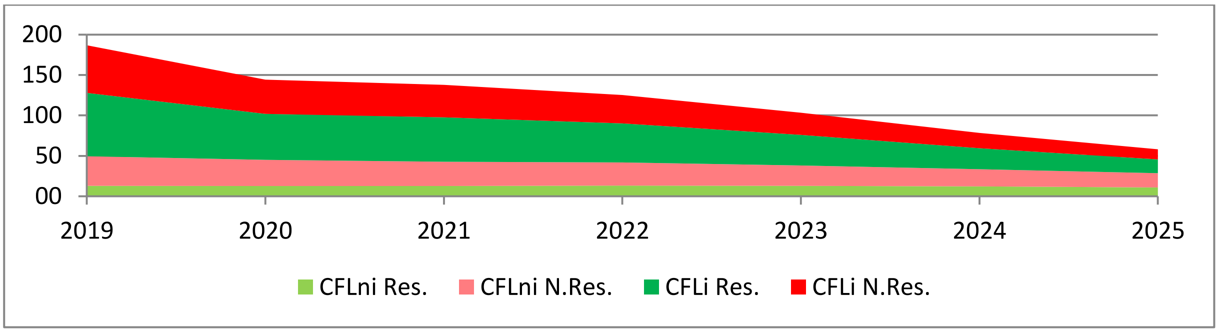
**Figure 5 Stock development of CFL Lamps. BAU, millions of lamps**

*The SUB development (filled line) can be seen on the background of the BAU development (dotted line) for the total lamps, the breakdown to integrated and non-integrated CFL lamps and to residential and non-residential lamps. Data is absolute and not stacked.*




*Own compilation based on data from (VHK 2016)*

**Figure 6 Estimation of additional CFL lamps reaching EoL (i.e. lamps to be replaced) in the SUB scenario, millions of lamps**




*Own compilation based on data from (VHK 2016)*

In cases where a lamp reaches its end of life, it is expected that the consumer shall seek a replacement lamp or in some cases a replacement luminaire. The MELISA model (VHK 2016) makes assumptions as to the share of EoL lamps for which the consumer has shifted to LED retrofit lamps or to an LED luminaire. For the SUB scenario, in which certain lamps become unavailable for consumers, assumptions have been made as to the number of EoL lamps for which one of three substitution routes have been chosen:

- Replacement with an LED Plug & Play lamp;
- Replacement with an LED lamp requiring rewiring /conversion;
- Replacement of the luminaire with an LED luminaire (including lamp).

LE (LightingEurope 2017b) provide assumptions as to the availability of Plug and Play substitutes for CFL lamps, reproduced in Table 3 below. The ranges specified for each product group in the table have been generated as a compilation of LE member data. LE asked each of its members to specify the availability of substitutes in relation to its CFL product portfolio. Values submitted by the different members were then compared and LE specified the ranges by taking the lowest value stated and the highest one. The range does not reflect possible overlaps between LE member data and thus it is difficult to use this as a basis for estimating the actual availability of substitutes for estimating impacts. The reference to substitute availability is in relation to the share (%) of products within a product group for which a suitable substitute exists. It does not reflect if substitute availability is higher in a certain part of the product group than in others (e.g., higher for lamps with lower power rating than for lamps with a higher power rating in a specific product group) or if substitute availability is spread evenly.

LE expects that for CFLi below 12W, close to 100% suitable LED retrofit lamps are available, though some geometric constraints may still apply in certain cases. The availability is understood to decrease in relation to the increase in power rating (wattage). For CFLni the status of substitute availability is different. LE explains that after 5 years of intensive research and development, one first reliable type (assumed to be a series of lamps with the same lamp holder and differing power ratings) of CFLni safe retrofit lamp has been introduced this year, which is a "Plug and Play". As this is a complex family with various types (lamp holders, lamp control gear etc.) it will take time to produce LED retrofit lamps in an economically feasible way. LE state that VHK predicts that in the long run for CFLni, replacement of the luminaire as a whole, is a better solution for the environment (the consultant assumes this is a result of energy consumption). Furthermore, as some CFL luminaires contain more than a single lamp, it is estimated that on average 1.5 lamps are used in a CFLni luminaire in comparison to close to 1 in a CFLi luminaire.

**Table 3 The availability of Plug and Play substitutes in terms of coverage of the relevant product range (%) according to LightingEurope**

| | P < 12W | 12 W <= P < 30 W | 30 W <= P < 50 W | P >= 50 W |
|---|---|---|---|---|
| CFLi plug and play | 98 – 100 % | 61 – 100% | 20 – 100% | 0 – 57% |
| CFLni plug and play | 0% | 0 - 55% | 0% | 0% |
| CFLni limited | 0 - 29% | 0 – 44% | 0 – 13% | 0% |

*Note: It is borne in mind that the figures above are ranges from LightingEurope members whereby the lowest and highest values are taken. Furthermore, Plug and Play is used when neither safety nor functionality (dimmability, light distribution) is compromised. Limited is used (replaceability) when safety is not compromised but one or more functionality parameters are.*

*Source: (LightingEurope 2017b)*

It can be understood that the actual availability of substitutes for each relevant product range is within the specified range. On this basis, Oeko-Institut has developed the assumptions for use in the estimation of impacts in the SUB scenario, specified in Table 4. In some cases the average is chosen (for example 12 W ≤ P < 30 W CFLi), in others a more conservative approach is taken (for example P ≥ 50 W CFLi).

**Table 4 Assumptions as to the chosen route for replacing a CFL lamp at EoL.**

*The shares are related to the total number of additional CFLs reaching end-of-life in the SUB scenario, i.e. the share of lamps reflects the number of lamps to be replaced through a certain route.*

| Lamp and route | | P >12 W | 12 W ≤ P < 30 W | 30 W ≤ P < 50 W | P ≥ 50 W |
|---|---|---|---|---|---|
| CFLi | LED Plug & Play | 100% | 80% | 50% | 10% |
| | LED + rewiring | 0% | 6% | 15% | 27% |
| | LED Luminaire | 0% | 14% | 35% | 63% |
| CFLni | LED Plug & Play | 0% | 20% | 0% | 0% |
| | LED + rewiring | 30% | 24% | 30% | 30% |
| | LED Luminaire | 70% | 56% | 70% | 70% |

Despite the fact that the share of lamps, for which replacements become available, can be expected to change from year to year in light of development in alternative technologies (i.e. LEDs), for simplicity it has been assumed that this share remains constant throughout the analysed period. As the availability, for example, of Plug & Play alternatives can be expected to increase, this means that the estimation is conservative in nature.

Based on information provided by LightingEurope it can be understood that the CFLi and CFLni lamps are distributed unevenly between different power supply ranges. As it has been generally explained that most lamps in the lower power supply ranges are used for residential applications and expected to be CFLi and vice versa, the following assumptions are later used to differentiate between lamps to be replaced through the different routes. In this respect, LE stated the following:

- 0-12W: lamps are used for residential applications.
- 12-30W: lamps are used in both residential and non-residential applications
- 30-50W: lamps are used mainly in the non-residential applications.

**Table 5 Distribution of CFL lamps in relation to power supply ranges and CFLi/CFLni**

*The shares are related to the total number of CFL lamps placed on the EU market annually.*

| Power supply | CFLi – expected share | CFLni – expected share |
|---|---|---|
| 0-12 w | 50% | 0% |
| 12-30 w | 30% | 20% |
| 30 - 50 w | 15% | 30% |
| 50 w and up | 5% | 50% |

On the basis of these assumptions and the number of additional lamps (and if necessary luminaires) requiring replacement in the SUB scenario, an estimation of the amount of lamps to be replaced through each of the three routes is calculated (LED Plug & Play, LED + rewiring or LED luminaire). The results are specified in

Table 6 and have been used for quantifying the various socio-economic impacts in the following sections.

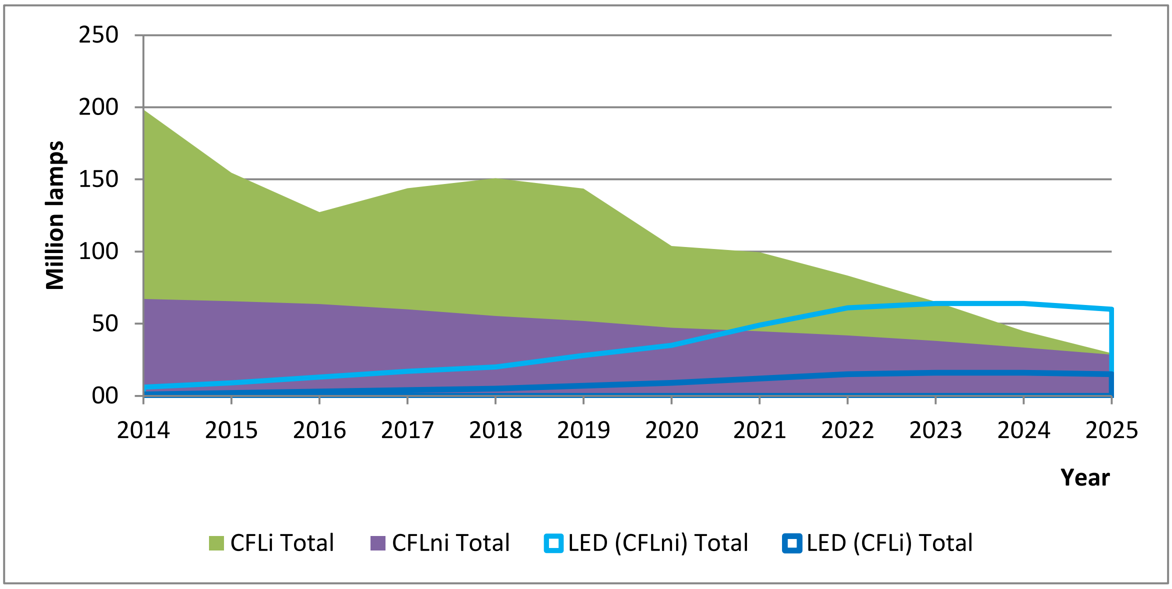
**Table 6 Distribution of CFL lamps to be replaced in the SUB scenario according to the replacement route assumed**

| Lamps substituted with Plug & Play LED, millions of lamps | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Lamp** | **Sub-group** | **2019** | **2020** | **2021** | **2022** | **2023** | **2024** | **2025** |
| CFLi | ≤12 w | 68.6 | 49.6 | 47.5 | 41.7 | 32.6 | 22.4 | 14.8 |
| | 12-30 w | 32.9 | 23.8 | 22.8 | 20.0 | 15.7 | 10.8 | 7.1 |
| | 30 - 50 w | 10.3 | 7.4 | 7.1 | 6.3 | 4.9 | 3.4 | 2.2 |
| | ≥50 w | 0.7 | 0.5 | 0.5 | 0.4 | 0.3 | 0.2 | 0.1 |
| CFLni | ≤12 w | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 12-30 w | 2.0 | 1.8 | 1.7 | 1.7 | 1.5 | 1.3 | 1.1 |
| | 30 - 50 w | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | ≥50 w | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Lamps substituted with LED + Rewiring, millions of lamps** | | | | | | | | |
| **Lamp** | **Sub-group** | **2019** | **2020** | **2021** | **2022** | **2023** | **2024** | **2025** |
| CFLi | ≤12 w | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 12-30 w | 2.5 | 1.8 | 1.7 | 1.5 | 1.2 | 0.8 | 0.5 |
| | 30 - 50 w | 3.1 | 2.2 | 2.1 | 1.9 | 1.5 | 1.0 | 0.7 |
| | ≥50 w | 1.9 | 1.3 | 1.3 | 1.1 | 0.9 | 0.6 | 0.4 |
| CFLni | ≤12 w | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 12-30 w | 2.4 | 2.2 | 2.1 | 2.0 | 1.8 | 1.6 | 1.4 |
| | 30 - 50 w | 4.5 | 4.1 | 3.8 | 3.8 | 3.4 | 3.0 | 2.6 |
| | ≥50 w | 7.4 | 6.8 | 6.4 | 6.3 | 5.7 | 5.0 | 4.3 |
| **Lamps substituted through luminaire substitution, millions of lamps** | | | | | | | | |
| **Lamp** | **Sub-group** | **2019** | **2020** | **2021** | **2022** | **2023** | **2024** | **2025** |
| CFLi | ≤12 w | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 12-30 w | 5.8 | 4.2 | 4.0 | 3.5 | 2.7 | 1.9 | 1.2 |
| | 30 - 50 w | 7.2 | 5.2 | 5.0 | 4.4 | 3.4 | 2.4 | 1.6 |
| | ≥50 w | 4.3 | 3.1 | 3.0 | 2.6 | 2.1 | 1.4 | 0.9 |
| CFLni | ≤12 w | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | 12-30 w | 5.5 | 5.0 | 4.8 | 4.7 | 4.3 | 3.7 | 3.2 |
| | 30 - 50 w | 10.4 | 9.5 | 9.0 | 8.8 | 8.0 | 7.0 | 6.0 |
| | ≥50 w | 17.3 | 15.8 | 15.0 | 14.7 | 13.3 | 11.7 | 10.0 |

To provide additional context for the various changes related to lamps that may be denied market access in the SUB scenario, it is useful to observe the general shift (driven by the market development which is independent from the RoHS regulation) expected from the use of CFL lamps in luminaires to the use of LED replacements for luminaires (either as replacement for a CFL lamp or in a new LED replacement luminaire). The following figure shows the development of CFL lamp sales in relation to the development of the sales of LED lamp replacements sold for CFL applications. In both cases, a break-down of data is provided in relation to CFLi and CFLni.

**Figure 7 Development of sales of CFL lamps and LED CFL alternatives (lamps and luminaires for the CFL application range) (2014-2025)**

*The CFL sales development (CFLi, CFLni filled lines) can be seen in the background of the LED sales development (LED-CFLi lamps and LED-CFLni lamps - empty lines). The rise in CFLi sales observed starting in 2016 is expected to be related to the partial phase-out of halogen lamps as a result of the Ecodesign Regulation and under the understanding that halogen users, shifted, for the most part to CFL lamps. Data is absolute and not stacked.*




*Source: Own compilation based on data from the MELISA model (VHK 2016)*

## 4.3. Expected impacts on employment

In relation to the manufacture of CFL Lamps, it is understood that manufacturing facilities (e.g., equipment) producing CFL lamps are specific to the production of CFL lamps (see also Section 3.4). LE (LightingEurope 2017b) explains that the facilities of the larger lamp manufacturers produce general lighting lamps and special lamps on the same lamp lines in the same factories. The European lamp production lines manufacture many lamps for general lighting while most of them are non-integrated lamps (i.e., CFLni), intended for professional use with separately installed control gear. The same CFL lines produce specialty lamps, though there are also a few specialty lamp producers with dedicated lines for their special lamps (Lighttech, Narva, Dr. Fischer).

For the larger companies, producing both general lighting lamps and special lamps, some of the product types may be very high volume and some may also be specialty niche products, which tend to have much smaller batch sizes and production volumes. The Specialty Lamp manufacturers do not produce high volume general lighting lamps. They produce almost exclusively specialty lamps which may be used for special equipment as demonstrated in the applications.

LE have estimated that a total of 20,000 jobs are at risk of loss in the EU lighting industry if the recommendations of Oeko-Institut (Gensch et al. 2016) are to be implemented (SUB scenario). Using the 2016 sales volume and share of lamp technologies to be affected as an indicative basis (please see Section 3.4 in this regard – estimation should be interpreted with caution), a rough estimation of jobs related to CFL manufacture, to be lost in the EU in the SUB scenario can be made:

- The CFLi share 27.7 % would correspond to ~ 5,500 jobs:

- The CFLni share 13.8 % would correspond to ~2,800 jobs;
- The special purpose share 3.5 % would correspond to ~700 jobs, but only a fraction of this group is associated with CFL special purpose lamps (less than 20 jobs).

However, from the information detailed above, it appears that CFL manufacture in the EU is more focused on CFLni lamps, for both general lighting and special purposes. Thus CFLi sales volumes are not expected to suitably reflect the share of corresponding possible job losses in the EU, which are probably much lower, whereas for CFLni it would be difficult to say if the estimated job losses are higher or lower. A further difficulty is estimating jobs related to general purpose CFL and special purpose CFL. The share corresponding to CFL special lamps is very low, though it is also understood that there are companies that manufacture only specialty lamps. It is assumed that for specialty CFL, job losses would be relatively higher.

In relation to costs of substitution, estimations have been made in relation to the hours of labour required for performing replacements in the LED rewiring route and in the LED luminaire replacement route. An estimation was performed based on the number of additional lamps to be replaced in the SUB scenario (

Table 6 ) for each of these segments. It was assumed that one working hour is required for rewiring or replacing a CFLi luminaire, as most of these are assumed to be residential and for most replacements a single luminaire would be handled during a visit of a technician. For CFLni it was assumed that more than a single luminaire would be rewired or replaced per visit as most luminaires are non-residential, thus only half an hour was calculated per lamp (see also Section 4.4 for additional detail). On the basis of these estimations, Table 7 presents the aggregated hours of labour expected in relation to the additional substitution expected in the SUB scenario.

**Table 7 Annual hours of labour associated with the additional CFL substitution in the SUB scenario and the electrician jobs created respectively in that year**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| CFLi: Million hours of labour | 24.7 | 17.8 | 17.1 | 15.0 | 11.7 | 8.1 | 5.3 |
| CFLi: Jobs | 14,025 | 10,139 | 9,719 | 8,524 | 6,670 | 4,591 | 3,021 |
| CFLni: Million hours of labour | 23.8 | 21.6 | 20.5 | 20.1 | 18.3 | 16.1 | 13.7 |
| CFLni: Jobs | 13,513 | 12,290 | 11,653 | 11,419 | 10,390 | 9,128 | 7,789 |
| CFL: Million hours of labour | 48.5 | 39.5 | 37.6 | 35.1 | 30.0 | 24.1 | 19.0 |
| CFL: Jobs | **27,538** | **22,429** | **21,371** | **19,943** | **17,061** | **13,719** | **10,811** |

It should be noted that on the basis of an 8 hour day, and 220 work days per year, the total amount of hours translates into between around 11 and 27.5 thousand jobs (technical employees), depending on the year observed and decreases throughout the period. To provide context to this number, according to an EU Skills Panorama Document (ICF and Cedfop 2014), in 2013 there were over 11 million jobs across the EU-28 in metal and electrical trades[31] (the share of electrical trades is not clear). Though it is expected that some of these jobs may have been pre-existing, it is expected that some of them are new jobs, expected to support the phase-out process from LFL to LED alternatives.

## 4.4. Possible costs for users related to lamp substitution

As explained in Section 4.2, additional lamps reaching EoL in the SUB scenario starting 2019 are expected to be replaced with LED lamps either with a Plug & Play lamp, with an LED requiring a rewiring of the luminaire or with a LED luminaire. For each of these routes, the results of a quantification of expected costs due to a regulatory driven substitution are presented below.

On the basis of purchase prices specified in the MELISA model (VHK 2016) for CFL and for alternative LED, an estimation has been made as to the costs of substitution with Plug & Play LED (see Table 8 below). Purchase prices detailed in MELISA are given for both CFL and LED[32] in prices relevant for 2010, including VAT. Discounting has not been

[31] Electricians, electronic mechanics and other workers in electrical trades are required to install, maintain and repair electrical wiring systems, electrical transmission cables, telecommunications systems and perform other similar activities

[32] For CFLi and CFLni the price is consistent along the period of the calculation. For LED, the MELISA model provides price estimations that decrease from year to year, understood to represent the change in price as the technology develops.

applied in the current estimation and thus the estimation is in relation to 2010 prices. Though at the beginning of the period of relevance, costs of LED are still higher than the typical cost given for CFL in MELISA, this tendency reverses within a few years (2022 for CFLi and 2024 for CFLni) and quickly leads to negative costs (that is lower expenses) for consumers. In other words, in such cases where substitute with a Plug & Play LED is possible, consumers are expected to have lower costs for purchasing a replacement lamp in comparison with an alternative purchase of a CFL lamp.

In some cases where a Plug & Play substitute is not available, costs for rewiring or for luminaire replacement have been estimated. In this respect for 2018, LE (LightingEurope 2017b) had estimated the following parameters for non-residential lamps:

- Price per CFLni 12.50 EUR and (on average) 1.5 lamps per luminaire
- 25 EUR labor costs per replacement of luminaire
- Product price of 75 EUR estimate

The consultants have developed the following cost assumptions for CFL residential and non-residential rewiring and replacement. These costs may be somewhat higher than the LE estimations above for CFLni (which are understood to be used mainly by non-residential consumers). In this sense the cost assumptions used are considered to be more conservative. The more conservative values were used as LE (LightingEurope 2017b) with which the assumptions were shared, expects the cost estimations for lamps to be in the range of current average market prices. LE notes that labour costs might be different if the luminaires are for example built into the ceiling (i.e., higher). In such cases the customer might decide to replace the ceiling as a whole if the new luminaires do not fit exactly, or when the ceiling is damaged during the removal of the old luminaires. Though the consultants agree that such cases are plausible, cost estimations have been restricted to costs related directly to the lamp and its installation.

- Residential lamps:
  - The cost of an LED replacement lamp for residential purposes has been estimated based on VHK estimations as to the development of CFLi LED retrofit market prices - costs include VAT;
  - The cost for auxiliary parts (for example replacement ballast, dimmer, etc.) is assumed to be 10 EUR in such cases;
  - Labour costs for replacement are based on 1 hour labour / luminaire amounting to 50 EUR
  - Average LED luminaire (as replacement) costs are assumed to be 100 EUR;
- Non-residential lamps:
  - The cost of an LED replacement lamp for non-residential purposes has been estimated based on VHK estimations as to the development of CFLi LED retrofit market prices - costs do not include VAT;
  - The cost of auxiliary parts is assumed to be 20 EUR in such cases;
  - Labour costs for replacement are based on ½ hour labour / luminaire, amounting to 25 EUR, as it is assumed that often more than one luminaire is handled;
  - Average LED luminaire (as replacement) costs are assumed to be 100 EUR.

Table 8 presents the estimated annual costs for lamps to be replaced according to each of the three scenarios.

**Table 8 Annual costs of CFL substitution according to the various routes, million EUR, including VAT for residential and excluding for non-residential**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| **Costs related to substitution with Plug & Play LED, millions of EUR** | | | | | | | |
| CFLi | 160 | 67 | 27 | -0 | -13 | -19 | -20 |
| CFLni | 12 | 9 | 7 | 6 | 4 | 3 | 2 |
| **All CFL** | **171** | **75** | **34** | **6** | **-9** | **-16** | **-17** |
| **Costs related to substitution with LED + rewiring, millions of EUR** | | | | | | | |
| CFLi | 451 | 323 | 307 | 268 | 209 | 143 | 95 |
| CFLni | 732 | 653 | 610 | 590 | 530 | 461 | 390 |
| **All CFL** | **1,184** | **976** | **917** | **858** | **739** | **605** | **484** |
| **Costs related to substitution with a LED luminaire, millions of EUR** | | | | | | | |
| CFLi | 2,500 | 1,808 | 1,733 | 1,520 | 1,189 | 819 | 539 |
| CFLni | 4,016 | 3,652 | 3,463 | 3,394 | 3,088 | 2,713 | 2,315 |
| **All CFL** | **6,517** | **5,460** | **5,196** | **4,913** | **4,277** | **3,531** | **2,854** |

*Note: Negative costs specified for substitution with Plug & Play mean that the price of LED has decreased below the price for CFL, giving a negative difference.*

It should be noted that the number of lamps to be replaced has been used to derive the number of luminaires to be replaced. Though it can be understood from LE that usually a single lamp is used in CFLi luminaires, it has been stated that for CFLni the average is 1.5 lamps. The consultants assume that this would mean that for luminaires with multiple lamps, in some cases, due to the EoL of a single lamp the complete luminaire would be replaced. In contrast, in others, the luminaire may remain in operation until all other lamps require replacement or, particularly where a group of identical luminaires is in use, lamps may be shifted from other luminaires to allow gradual replacement of the luminaire group (in this case once a share of all identical luminaires require replacement of all lamps). Though it is difficult to estimate how this would affect the replacement of luminaires during the observed period, it can be assumed that for CFLni, that the numbers above (a total of 257 million luminaires replaced) can be considered conservative in the sense of an upper limit. Assuming that CFLni luminaires have in average 1.5 lamps, the number of luminaries to be replaced would be expected to be 171 million luminaires (assumed an over-estimation). In reality the number of CFLni luminaires to be replaced is expected to be in the range of these two cases, i.e., between 171 and 257 million additional luminaires can be expected to be replaced over the period between 2019 and 2025 in the SUB scenario. The costs estimated above for luminaire replacement of CFLni, may vary respectively.

The shift from CFL to LED may be associated with certain costs for consumers, who need to change equipment; however, it is also estimated to result in a certain benefit related to the costs of energy consumption. To estimate the savings, for each lamp to be replaced, the difference between an average CFL (used in the BAU scenario) and average LED CFL alternative is calculated and summed for each lamp in relation to the hours the lamp is expected to be operated annually. The yearly operation hours for CFL are used in both cases in order to compare the difference in relation to the same use pattern. In this respect, for each lamp sub-group, Table 9 specifies the annual savings related to lamps newly replaced in that year. In parallel, each lamp is expected to remain in use over its typical service life. As lamps to be replaced are only observed in the period between 2019 and 2025, a cumulative calculation has been carried out only for this duration, in which the savings of each years lamps are summed with the savings related to lamps from earlier years (theoretically the savings would be taken into consideration for 12.5-28.6 years, according to the MELISA model, however this is beyond the timeframe of the analysis). The results are specified in Table 9 below.

**Table 9 Annual and cumulated energy savings related to substitution of CFL with LED**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| **CFLi Res.** | | | | | | | |
| Number of CFLi Res. substituted (millions) | 78.3 | 56.8 | 54.9 | 48.3 | 37.8 | 26.0 | 17.0 |
| Annual savings per lamp (Wh) | 2,711 | 2,902 | 2,896 | 2,851 | 2,825 | 2,824 | 2,821 |
| Annual savings for newly replaced lamps (GWh) | 212.3 | 164.9 | 158.9 | 137.6 | 106.8 | 73.3 | 48.1 |
| Cumulative savings for replaced lamps (GWh) | 0.0 | 212.3 | 377.2 | 536.1 | 673.7 | 780.5 | 853.8 |
| **Sub-total (GWh)** | **212.3** | **377.2** | **536.1** | **673.7** | **780.5** | **853.8** | **901.9** |
| **CFLi Non-Res.** | | | | | | | |
| Number of CFLi Non-Res. substituted (millions) | 58.8 | 42.3 | 40.2 | 35.1 | 27.4 | 18.9 | 12.5 |
| Annual savings per lamp (Wh) | 3,253 | 3,355 | 3,464 | 3,551 | 3,600 | 3,647 | 3,691 |
| Annual savings for newly replaced lamps (GWh) | 191.4 | 141.9 | 139.1 | 124.6 | 98.7 | 69.0 | 46.2 |
| Cumulative savings for replaced lamps (GWh) | 0.0 | 191.4 | 333.3 | 472.5 | 597.1 | 695.8 | 764.8 |
| **Sub-total (GWh)** | **191.4** | **333.3** | **472.5** | **597.1** | **695.8** | **764.8** | **810.9** |
| **CFLni Res.** | | | | | | | |
| Number of CFLni Res. substituted (millions) | 12.9 | 49.6 | 47.5 | 41.7 | 32.6 | 22.4 | 14.8 |
| Annual savings per lamp (Wh) | 2,798 | 2,993 | 3,009 | 3,026 | 3,042 | 3,057 | 3,073 |
| Annual savings for newly replaced lamps (GWh) | 36.2 | 38.0 | 38.3 | 40.1 | 39.3 | 37.5 | 33.6 |
| Cumulative savings for replaced lamps (GWh) | 0.0 | 36.2 | 74.2 | 112.6 | 152.6 | 191.9 | 229.4 |
| **Sub-total (GWh)** | **36.2** | **74.2** | **112.6** | **152.6** | **191.9** | **229.4** | **262.9** |
| **CFLni Non-Res.** | | | | | | | |
| Number of CFLni Non-Res. substituted (millions) | 36.6 | 23.8 | 22.8 | 20.0 | 15.7 | 10.8 | 7.1 |
| Annual savings per lamp (Wh) | 10,096 | 10,408 | 10,741 | 11,008 | 11,158 | 11,300 | 11,434 |
| Annual savings for newly replaced lamps (GWh) | 369.6 | 336.8 | 322.1 | 315.2 | 281.1 | 239.7 | 201.7 |
| Cumulative savings for replaced lamps (GWh) | 0.0 | 369.6 | 706.3 | 1028.4 | 1343.6 | 1624.7 | 1864.3 |
| **Sub-total (GWh)** | 369.6 | 706.3 | 1,028.4 | 1,343.6 | 1,624.7 | 1,864.3 | 2,066.0 |
| **CFL total GWh** | **809.5** | **1,491.1** | **2,149.6** | **2,767.0** | **3,292.8** | **3,712.3** | **4,041.7** |

*It is noted that the savings per CFLni non-residential lamps are significantly larger than those of the other sub-groups. This is related to the significantly longer annual operation (1600 hours per annum in comparison with 700 h/a for CFLni residential and 500 h/a for both types of CFLi)*

Based on the electricity prices given in the MELISA model for the years of the analysis (see

Table 10), the monetary benefits related to costs saved have been calculated and are presented in relation to the accumulated costs in Table 11 below.

**Table 10 Electricity rate (2010 prices, including VAT for residential and excluding for non-residential) per kWh**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| Residential | 0,24 EUR | 0,25 EUR | 0,26 EUR | 0,27 EUR | 0,28 EUR | 0,29 EUR | 0,31 EUR |
| Non-residential | 0,15 EUR | 0,16 EUR | 0,16 EUR | 0,17 EUR | 0,18 EUR | 0,18 EUR | 0,19 EUR |

*Source: MELISA model (VHK 2016)*

**Table 11 Cost savings related to cumulated energy consumption of CFL substituted with LED, million EUR, including VAT for residential and excluding for non-residential**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| **CFLi Res.** | 51 | 95 | 140 | 183 | 221 | 251 | 276 |
| **CFLi Non-Res.** | 29 | 52 | 77 | 101 | 123 | 140 | 154 |
| **CFLni Res.** | 9 | 19 | 29 | 41 | 54 | 67 | 80 |
| **CFLni Non-Res** | 56 | 111 | 167 | 228 | 286 | 342 | 394 |
| **CFL Total** | **145** | **276** | **414** | **553** | **684** | **800** | **904** |

To summarise, the total costs and benefits (where quantified as monetary costs) are presented in Table 12 below.

**Table 12 Summary of annual monetary costs/benefits related to CFL regulatory driven substitution in SUB, millions of EUR, including VAT for residential and excluding for non-residential**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | Remarks |
|---|---|---|---|---|---|---|---|---|
| Additional purchase costs for LED | 171 | 75 | 34 | 6 | -9 | -16 | -17 | See Table 8 for detail |
| Additional purchase costs for LED + rewiring | 1,184 | 976 | 917 | 858 | 739 | 605 | 484 | |
| Additional purchase costs for LED + luminaire replacement | 6,517 | 5,460 | 5,196 | 4,913 | 4,277 | 3,531 | 2,854 | |
| Energy cost savings | -145 | -276 | -414 | -553 | -684 | -800 | -904 | See Table 11 for detail |
| **Total** | **7,727** | **6,235** | **5,734** | **5,224** | **4,324** | **3,320** | **2,416** | |

It should be noted that the total annual costs (net benefit) decrease from year to year. This tendency is expected to continue; in part due to the growing relevance of the price savings related to lamp purchase (Prices for both CFLi and CFLni remain constant, and at a certain point in time are higher than the comparable LED price). However the main factor assumed to further support this tendency is related to the estimated energy costs of LED in comparison with CFL which are represented here in a relatively conservative way. This has two reasons, the first being that energy savings are expected to rise as the LED technology develops in comparison with the no longer developing CFL technology. The second reason, being that LED service life is higher in comparison with CFL service life, meaning that when comparing an LED to a CFL lamp, more than one CFL lamp would be needed to allow for a comparison throughout the LED service life. The last and most significant reason is related to the fact that the costs have only been estimated for the period between 2019 and 2025 (7 years) which are understood to represent a small portion of the LED total service life. While costs for replacement of lamps and luminaires are one-time costs, the influence of energy savings is expected to extend across the full service life and is an operative cost with a heavier influence on the net benefit. Based on the VHK data, the LED service life is 12 years for residential CFLi alternatives and 28.6 years for residential CFLni alternatives in comparison with 12 and 14.3 years for CFLi and CFLni. In the non-residential segment the LED service life is 12 and 12.5 years for CFLi and CFLni alternatives respectively, similar to the comparable CFLi (12 years) but significantly longer than the comparable CFLni (6.25 years). Though the total net benefit for the 2019-2025 period may be perceived as significant (approximately 35 billion EUR), the annual sum decreases from year to year. The net benefit in 2025 is only around 31 % of that of 2019 and is expected to continue decreasing significantly in the years to follow. Though this means that a large investment would be made by various consumers for the CFL substitution within a 7 year period, this investment should be seen in perspective with the estimated energy savings to incur in this period and beyond.

Upon comparing the net benefit between CFLi and CFLni lamps (see Table 13 below), it is observed that costs related to CFLni are significantly higher than for CFLi, representing approximately 70 % of the total costs for the period between 2019 and 2025. As the initial sales of CFLni lamps on the market are much lower than those of CFLi lamps, this is understood to mainly be a result of the lower Plug & Play availability, resulting in higher substitution costs. This is also reflected in the average per lamp replacement costs which account for an average of 18 EUR for CFLi and an average of 89 EUR for CFLni.

**Table 13 Summary of monetary costs/benefits related to CFLi and CFLni regulatory driven substitution in SUB, millions of EUR unless otherwise noted, including VAT for residential and excluding for non-residential**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| **Calculation for CFLi lamps** | | | | | | | |
| Additional purchase costs for LED | 160 | 67 | 27 | -0 | -13 | -19 | -20 |
| Additional purchase costs for LED + rewiring | 452 | 323 | 307 | 268 | 209 | 143 | 94 |
| Additional purchase costs for LED + luminaire replacement | 2,501 | 1,808 | 1,733 | 1,520 | 1,189 | 819 | 539 |
| Energy cost savings | -80 | -147 | -217 | -284 | -343 | -391 | -430 |
| Total | **3,032** | **2,051** | **1,851** | **1,504** | **1,042** | **552** | **183** |
| Cost per lamp (EUR/lamp) | 22.11 | 20.68 | 19.47 | 18.04 | 15.98 | 12.29 | 6.18 |
| **Calculation for CFLni lamps** | | | | | | | |
| Additional purchase costs for LED | 12 | 9 | 7 | 6 | 4 | 3 | 2 |
| Additional purchase costs for LED + rewiring | 732 | 653 | 610 | 590 | 530 | 461 | 390 |
| Additional purchase costs for LED + luminaire replacement | 4,016 | 3,652 | 3,463 | 3,394 | 3,088 | 2,713 | 2,315 |
| Energy cost savings | -64 | -129 | -197 | -269 | -340 | -409 | -474 |
| Total | **4,695** | **4,185** | **3,883** | **3,720** | **3,282** | **2,769** | **2,233** |
| Cost per lamp (EUR/lamp) | 94.76 | 92.86 | 90.88 | 88.85 | 86.15 | 82.72 | 78.19 |

## 4.5. Other Impacts on consumers (public and private)

To set the various impacts discussed above in perspective, it is worth understanding what the more common uses of CFL lamps are. Where CFLi lamps are in use, a large part of consumers are private consumers using lamps for residential purposes, i.e. in the lighting of homes. The sale volumes of CFLi lamps in the last years already show a significant reduction in their market, a tendency expected to continue as particularly in the residential market, users are understood to prefer alternatives for functionality reasons. Though in some cases this may still include a preference towards the warm light provided by halogen lamps, the consultants assume that in an increasing share of cases, this preference is already established in relation to LED alternatives for CFL. For CFLni, mainly used in non-residential uses, the preference related to functionality in terms of light colour is less relevant. Common uses here include for example office lighting, in which it is understood that lamp arrays are required to comply with standards related to lighting and its distribution. Nonetheless, here too a decrease in sales is underway, which LE (LightingEurope 2017b) explains in part to be related to the sales of CFLni luminaires which have almost ceased. LE estimates that CFLni sales will probably decrease by 50% in the period 2015-2020, and further estimate this decrease to be "*even faster*" for CFLi. "*This decline is already happening as a result of the further development and growing affordability of the LED lamps. The CFLi below 12W has a good fraction of LED retrofit lamps that are already available at an affordable price. For CFLi > 12W and for CFLni the fraction of available, adequate replacement lamps is much lower*." Though this data suggests that consumers view LED as acceptable substitutes, there are still application areas where a regulatory driven substitution could be more burdensome to certain users than to others. Where CFLni is used in the lighting of offices or of commercial spaces, multiple luminaires of the same type are often owned by the same consumer. A regulatory driven phase-out may have heavier impacts on such users as where Plug & Play alternatives are lacking, substitution costs shall be higher not only per luminaire, but also for such consumers who need to replace multiple luminaires at the same time. Though some creativity could be expected where maintenance departments "concentrate" CFLni luminaires in certain office spaces and thus manage the CFLni luminaire replacement more gradually, it is expected that such consumers shall be more burdened than others. As explained in Section 4.4 some luminaire replacements may include the replacement of ceiling (or walls), especially where installations are built into these building elements. In certain cases, luminaires may also be built into other equipment. Though this is common for special purpose lamps, the production of which may be impacted indirectly by an early decrease in the manufacture of other CFL as described in chapter 7, standard consumer equipment may also be relevant in some cases. LE has provided examples (LightingEurope 2017a) for such equipment such as in the lighting of oven hoods, though data is not available to suggest whether such equipment is common. It is also noted that in the case of oven hood lighting, it is assumed that in most cases, consumers would not replace the oven hood in light of a non-replaceable lamp, but rather opt to use other lighting fixtures outside the oven to compensate for the lack of its light.

A further aspect which has been raised, however not supported by data, relates to the possible differences in costs for consumers in different EU Member States (MS). Though costs may be similar nominally, the purchasing power of consumers is not similar in all countries, possibly having an effect on private consumers. Though data suggests that natural phase out of CFLi in residential uses is naturally underway in the BAU scenario, this aspect could result in different burdens of substitution for consumers of different MS. A short research for orientation purposes suggests that in some MS of the EU the market supply is already dominated by LEDs, with other technologies offered in small amounts of low variation if at all. This suggests that the aspect of the economic burden for end users due to lack of alternatives to LED has become obsolete. Though conducting a current market study to this end is out of the scope of this study, it would be recommended, for example, to conduct such studies at the level of single Member States.

## 4.6. Impacts on the generation of waste

A further impact of the regulatory driven phase-out that is expected in the SUB scenario in relation to the additional lamps requiring replacement is related to the amount of waste that could be expected where a Plug & Play substitute is not available. Such cases shall “force” either a rewiring of the luminaire (which may result in the early scrapping of certain components such as ballasts, dimmers, etc.) or a complete replacement of the luminaire (scrapping the CFL luminaire, probably before the end of its service life). On the basis of such cases, an estimation of the additional waste to be generated as a consequence of early substitution was performed. For this purpose the following assumptions have been developed in relation to the average weight of auxiliary parts and luminaires:

- Best case scenario: 1 kg per luminaire (scrapped); 0.25 kg for auxiliary parts (rewired)
- Worst case scenario: 2 kg per luminaire (scrapped); 0.5 kg for auxiliary parts (rewired).

LightingEurope did not provide specific data related to the average weights of auxiliary parts and luminaires for this estimation. It was however specified (LightingEurope 2017a) that it is difficult to make an average of the weight of luminaires as they can differ greatly depending on the type of luminaire.

In relation to the number of additional luminaries expected to be replaced in the SUB scenario, the following amounts of waste can be expected:

**Table 14 Amounts of additional waste to be generated in the SUB scenario where CFL are substituted with a LED substitute requiring rewiring or where the luminaire is replaced, Thousands of tons**

| Lamp | Sub-group | | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|---|
| CFLi | Auxiliary waste | Best | 1.9 | 1.3 | 1.3 | 1.1 | 0.9 | 0.6 | 0.4 |
| | | Worst | 3.7 | 2.7 | 2.6 | 2.3 | 1.8 | 1.2 | 0.8 |
| | Luminaire waste | Best | 17.3 | 12.5 | 12.0 | 10.5 | 8.2 | 5.7 | 3.7 |
| | | Worst | 34.6 | 25.0 | 23.9 | 21.0 | 16.4 | 11.3 | 7.4 |
| | **Total** | **Best** | **19.1** | **13.8** | **13.3** | **11.6** | **9.1** | **6.3** | **4.1** |
| | | **Worst** | **38.3** | **27.7** | **26.5** | **23.3** | **18.2** | **12.5** | **8.2** |
| CFLni A (1 lamp per luminaire) | Auxiliary waste | Best | 3.6 | 3.2 | 3.1 | 3.0 | 2.7 | 2.4 | 2.1 |
| | | Worst | 7.1 | 6.5 | 6.2 | 6.0 | 5.5 | 4.8 | 4.1 |
| | Luminaire waste | Best | 33.3 | 30.3 | 28.7 | 28.1 | 25.6 | 22.5 | 19.2 |
| | | Worst | 66.6 | 60.6 | 57.4 | 56.3 | 51.2 | 45.0 | 38.4 |
| | **Total** | **Best** | **36.9** | **33.5** | **31.8** | **31.2** | **28.3** | **24.9** | **21.2** |
| | | **Worst** | **73.7** | **67.1** | **63.6** | **62.3** | **56.7** | **49.8** | **42.5** |
| CFLni B (1.5 lamps per luminaire) | Auxiliary waste | Best | 2.4 | 2.2 | 2.1 | 2.0 | 1.8 | 1.6 | 1.4 |
| | | Worst | 4.8 | 4.3 | 4.1 | 4.0 | 3.7 | 3.2 | 2.7 |
| | Luminaire waste | Best | 22.2 | 20.2 | 19.1 | 18.8 | 17.1 | 15.0 | 12.8 |
| | | Worst | 44.4 | 40.4 | 38.3 | 37.5 | 34.1 | 30.0 | 25.6 |
| | **Total** | **Best** | **24.6** | **22.4** | **21.2** | **20.8** | **18.9** | **16.6** | **14.2** |
| | | **Worst** | **49.1** | **44.7** | **42.4** | **41.5** | **37.8** | **33.2** | **28.3** |

To summarize, the SUB scenario can be expected to generate an additional amount of waste related to the rewiring of CFL luminaires and to their replacement. Over the period between 2019 and 2025, this waste is estimated to amount to between 77-155 thousand tons for CFLi. For CFLni the expected waste is estimated to be in the range of about 208-416 thousand tons if only one single lamp is assumed per luminaire or in the range of 139-277 thousand tons if on average 1.5 lamps are calculated per luminaire. This also depends on consumers' decision whether to replace once a single lamp malfunctions or when all lamps require replacement. In cases where a luminaire contains multiple lamps and is scrapped once the first lamp reaches EoL, some additional waste is associated to lamps scrapped early (depending on the remaining service life). While considering the amount of waste generated, it should be taken into account that certain components of EoL luminaires (steel, aluminium, copper, etc.) could serve as a source of secondary materials, if properly collected and recycled.

## 4.7. Impacts on the amounts of mercury to be placed on the EU market

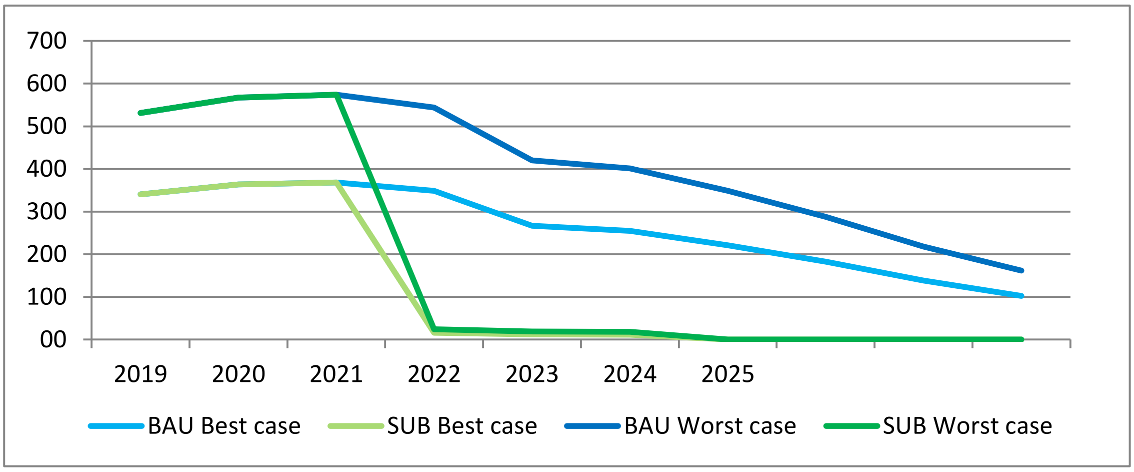
Based on the expected sales forecasted in the MELISA model (VHK 2016) in the period between 2015-2025, an estimation has been made as to the amount of mercury to be placed on the market in each scenario over this period.

For this purpose, it was necessary to determine how much mercury is actually placed on the market through the various CFL lamps. The Directive prescribes Hg thresholds which represent the maximum amounts that can be present in a lamp of a specific input power group (wattage) for it to be permitted on the EU market. LE (LightingEurope 2017b) has suggested to use a 0,5-1,0 mg lower value than the maximum allowed RoHS value for this exercise. They explain that the maximum threshold is needed in light of manufacture variation's, however that these lower levels reflect the average amounts of hg applied in typical lamps. The various values are specified below in relation to each of the exemption entries.

**Table 15 Mercury thresholds of related to exemption 1(a-e) and the estimated average value based on the LE suggestion, in mg per lamp.**

| | Ex. 1(a) | Ex. 1(b) | Ex. 1(c) | Ex. 1(d) | Ex. 1(e) |
|---|---|---|---|---|---|
| Max. Threshold | 2.5 | 3.5 | 5 | 15 | 7 (before 1.1.2020)<br>5 (starting 1.1.2020) |
| Estimated average | 1.5 | 2.5 | 4 | 14 | 6 (before 1.1.2020)<br>4 (starting 1.1.2020) |

**Figure 8 Amounts of mercury to be placed on the market through Ex. 1(a-e) in the BAU and the SUB scenarios, calculation based on LE suggestion (best case) and on maximum allowed thresholds (worst case), in kg per annum**




Assuming the average thresholds specified above, the amount of mercury to come onto the market through CFL lamps between 2015 and 2018 in both scenarios is approximately 1,465 kg. Starting in 2019, the recommendations start to have an influence on the amount of mercury to be placed on the market in the SUB scenario (Ex. 1(a) and 1(b)), in which no further lamps are expected on the market after 2022 and thus also no further mercury. In this respect, between 2019 and 2021, approximately 40 kg are expected to come on to the market through CFL in the SUB scenario, in comparison to approximately 870 kg in the BAU scenario. Between 2022 and 2024, no further mercury is expected on the market in the SUB scenario, whereas in the BAU scenario approximately 645 kg shall be placed on the market in this period. In 2025, no further mercury is expected for both scenarios. The total amount of Hg avoided in the SUB scenario amounts to 1476.4 kg. As a sensitivity test, the same calculations were performed in relation to the maximum thresholds, representing the estimated "worst case scenario" and amounting to an amount of 2320 kg of Hg avoided.

To give perspective to the amounts of mercury placed on the market, it should be taken into consideration that based on the data provided by various stakeholders throughout the initial exemption evaluation, it is understood that over half of these amounts are not properly processed as WEEE. Despite an elaborate mechanism for collecting and recycling such lamps, it appears that consumers do not always discard of CFL lamps properly, and in most Member States the amount collected (and thus also recycled) is below this level. Though 50% may be in line with the WEEE Directive targets, the fate of other lamps is not known and is of concern in relation to potentially non-controlled emissions to the environment.

## 4.8. Analysis and discussion of results

Looking at the results of this evaluation the following aspects should be noted:

A first look at the development of CFL **sales** (Figure 4) suggests that a sharp decline is to be expected in the SUB scenario, from which it may be assumed that industry and employment could be subsequently affected from this change. A closer look however shows that in the BAU scenario, though the phase-out is allowed to occur more naturally, it is also underway:

- In BAU (based on the MELISA model) the sales of all lamp groups start to decrease in 2019. Though the 2019 sales are only 5 % lower than those of 2018, this trend continues, and by 2025, sales of new CFL comprise only 28 % of those of 2018.
- In comparison, in the SUB Scenario, the RoHS exemptions are expected to drive a fast reduction in sales already in 2019, at which time already less than 9 million lamps would still be allowed on the market (lamps of Ex. 1(c)-1(e)). Sales then follow a more moderate decrease trend until 2021 (~6 million CFLs placed on the market, and cease completely in 2022.

Stakeholders have claimed that following the changes recommended by the Oeko (2016) report (the SUB scenario) would result in a considerable impact on the lighting industry. However, the above analysis of the BAU scenario, in which no change of the exemptions is undertaken, shows that the impacts are already underway and that the amendment of exemptions to be undertaken in the SUB scenario is not expected to trigger new impacts, but only to accelerate the existing ones, i.e. the impacts shall be realised over a shorter period.

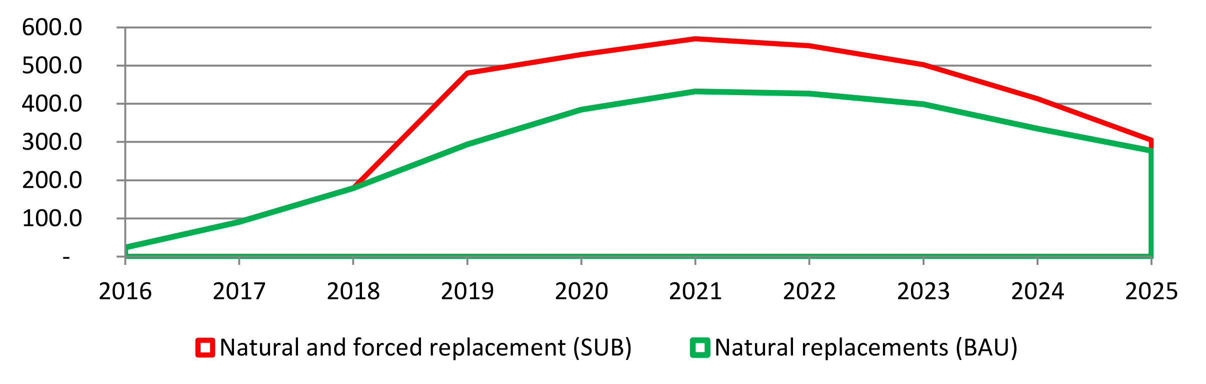
In terms of impacts on **stock** (see Figure 5), this phase-out is more moderate, owing to the CFL service lives that span the range between 6.25 and 14.4 years. In relation to the total stock of the BAU scenario, a decrease is observed in 2016, though already apparent as early as 2014 for the CFLni non-residential sub-group and only starting in 2017 for the sub-groups CFLi non-residential and CFLni residential. Though the 2019 total stock still comprises 93 % of the 2018 total stock, in 2025, only 40 % of the 2018 stock is still in use. This change is more significant for the CFLi sub-groups (only 35 % and 38 % of the 2018 stock for residential and non-residential respectively), which also have larger market shares, than for the CFLni sub-groups (66% and 56 % of the 2018 stock for residential and non-residential respectively).

In comparison, in the SUB scenario, the 2025 stock is only 22% of that of 2018, though here the differences between the various sub-groups are more significant. Though the CFLi sub-group stocks decrease similarly (21 % and 23 % for residential and non-residential respectively), the CFLni stock of the residential sub-group is comparatively high (46 %) while the CFLni non-residential stock is has almost phased-out of stock in 2025 (3 %), probably a result of the lower service life of such lamps in this segment.

The estimation of **additional lamps to reach EoL** in the SUB scenario (see Figure 6) may be misinterpreted to represent lamps that have reached EoL early. However, in fact the number of lamps to reach EoL in both scenarios is not expected to differ before 2025 (for CFLni non-residential with a service life of 6.25 years and later for other sub-groups). Rather this number represents lamps that shall reach EoL and for which a replacement lamp of the CFL kind shall not be available in the SUB scenario, resulting in the need to follow one of the replacement routes.

Natural phase-out in contrast is expected in both scenarios, starting from 2016. Figure 9 below presents a comparison of the lamps to be phased out naturally in both scenarios in comparison with the additional lamps to undergo a regulatory driven phase-out in light of the lack of CFL replacement lamps.

**Figure 9 Comparison of natural phase-out (BAU and SUB) and additional regulatory driven phase-out (SUB) of CFL lamps, millions of units**




As can be seen, the trend of both lamps to naturally phase-out and of the lamps to undergo a regulatory driven phase-out is similar, even though the total lamps to phase-out in the SUB scenario is significantly higher. Though the difference between the two groups is high in 2018 as the SUB phase-out begins, the fact that the two curves start to approach each other starting in 2021, suggests that the natural phase-out expected in the BAU scenario is only a delay in the general phase-out of CFL lamps.

The fact that there is a general reduction in the total stock of CFL lamps in the BAU scenario shows that a natural shift away from CFL lamps is taking place. Though in some cases it could be said that CFLs are replaced with other than LED alternatives, it is assumed that this is the exception, as individuals who have shifted from incandescent and halogen lamps to CFL lamps can be expected to have a preference for an alternative that consumes less energy. In this sense, the difference in stock from year to year in BAU gives indication of the natural volume of CFLs being replaced with LED alternatives, even if this number may be to some degree an overestimation. Table 16 further provides the numbers of lamps being "naturally" replaced in BAU (and SUB) with non-CFL alternatives and between those experiencing a "regulatory driven" phase-out in SUB.

**Table 16 Comparison of CFL "natural" replacements in both scenarios and "regulatory driven" replacements in SUB scenario**

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|
| **Natural BAU and SUB replacements, millions of lamps** | 179 | 294 | 385 | 432 | 427 | 399 | 335 | 277 |
| **Regulatory driven SUB replacements, millions of lamps** | 0 | 187 | 144 | 138 | 125 | 103 | 78 | 28 |
| **Regulatory driven SUB/Total SUB replacements - share** | 0% | 39 % | 27 % | 24 % | 23 % | 21 % | 19 % | 9 % |

The comparison shows that the additional replacements in the SUB scenario are significant. However, at least in the first years the volume of impacts that replacements may have on the lighting industry are higher for natural replacements that are expected to occur in both scenarios than for regulatory driven replacements only occurring in the SUB scenario. It should also be noted that the share of natural replacements in the BAU scenario

- is higher for both types of CFLi lamps - for which substitutes are understood to be more abundant (see Table 3); and
- is higher for CFLni non-residential lamps - which have the shorter service life and need to be changed more often, possibly encouraging non-residential users to replace luminaires earlier, as here there is understood to be a lack in alternatives.

The first two sub-groups have reached a stock level of 38% and below in the BAU scenario in relation to the 2018 stock, despite there being no necessity to replace such lamps with non-CFL alternatives. For the CFLni non-residual group, the level in 2025 is close to 50% that of 2018 (56%) while for CFLni residential it is still close to two thirds (66 %).

Though one could assume that the natural phase-out in the BAU scenario (also in SUB) would differ from the regulatory driven phase-out of the SUB scenario in that CFLs would only be replaced with other lamps where Plug & Play alternatives were available, this information suggests otherwise. Despite the communicated lack of Plug & Play alternatives for CFLni lamps, it seems that users are not deterred from phasing-out CFLni lamps: In both scenarios, almost half of the CFLni users can be expected to naturally replace such lamps either through a rewiring route or through a replacement of the luminaire. In the SUB scenario, by this time all users are expected to have made this shift. Though certain costs can be attributed to this shift, which for some may be more burdensome than for others, it seems that in many cases such costs are already considered acceptable at present.

As for the **costs attributed to replacement of CFL**, it is important to realise which factors contribute to the estimated range of such costs. To begin with, a first split is estimated between lamps to be replaced through rewiring of the original luminaire and between those for which the total luminaire would be replaced. In some cases as much as 70% luminaire replacement has been assumed. Given that it is estimated that rewiring costs are to be lower than luminaire replacement where this route is chosen, it is clear that an overestimation of luminaire replacements would result in an overestimation of costs.

Nonetheless, changing the general ratio of 30:70 between the rewiring and replacement routes chosen to 50:50 or to 20:80 only slightly changes the total costs of these replacements (4 % decrease or 2 % increase respectively). In this sense, though it is clear that these aspects would impact costs to some degree, the sensitivity to these changes is smaller.

**Table 17 Comparison of additional rewiring and luminaire replacement costs in the SUB scenario, assuming differing ratios between the two routes, millions of EUR, including VAT for residential and excluding for non-residential**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| Rewiring 30% | 1,184 | 976 | 917 | 858 | 739 | 605 | 484 |
| Replacement 70% | 6,517 | 5,460 | 5,196 | 4,913 | 4,277 | 3,531 | 2,854 |
| **Total 30:70** | **7,700** | **6,436** | **6,113** | **5,771** | **5,016** | **4,136** | **3,337** |
| Rewiring 50% | 1,973 | 1,626 | 1,529 | 1,430 | 1,232 | 1,008 | 806 |
| Replacement 50% | 4,655 | 3,900 | 3,711 | 3,510 | 3,055 | 2,522 | 2,038 |
| **Total 50:50** | **6,628** | **5,527** | **5,240** | **4,939** | **4,287** | **3,530** | **2,845** |
| Rewiring 20% | 789 | 651 | 612 | 572 | 493 | 403 | 323 |
| Replacement 80% | 7,447 | 6,240 | 5,938 | 5,615 | 4,888 | 4,036 | 3,261 |
| **Total 20:80** | **8,237** | **6,891** | **6,550** | **6,187** | **5,381** | **4,439** | **3,584** |

A further factor that has been tested in this respect relates to the costs of implementing each of these replacement routes. As explained in Section 4.2, the costs used in the estimation (hereafter referred to as the Oeko estimations) were higher than those proposed by LE and the estimation is thus assumed to be more conservative. In a second estimation the LE values (hereafter referred to as the LE estimations), were applied to all cases: 12.5 EUR for the replacement LED lamp needed (assumed to include auxiliary equipment as additional costs not specified), 25 EUR of labour costs in all cases, and 75 EUR in cases where the luminaire must be replaced. The comparison of these two estimations appears in Table 18 below and shows that the LE estimation would result in 28% less costs. A more progressive estimation (hereafter referred to as the Progressive estimation), using the LE estimation as basis (lamp and labour costs) but reducing the luminaire cost to 25 EUR, would result in a 61% decrease of the costs initially estimated.

**Table 18 Comparison of rewiring and luminaire replacement costs in the SUB scenario based on differing equipment and labour costs, millions of EUR, including VAT for residential and excluding for non-residential**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| Oeko Estimation (90-150 EUR per replacement, depending on route + residential/non-residential) | | | | | | | |
| Oeko rewiring | 1,184 | 976 | 917 | 858 | 739 | 605 | 484 |
| Oeko replacement | 6,517 | 5,460 | 5,196 | 4,913 | 4,277 | 3,531 | 2,854 |
| **Oeko Total** | **7,700** | **6,436** | **6,113** | **5,771** | **5,016** | **4,136** | **3,337** |
| LE estimation (112.50 EUR in all cases) | | | | | | | |
| LE rewiring | 639 | 529 | 492 | 459 | 396 | 327 | 263 |
| LE replacement | 4,820 | 4,079 | 3,879 | 3,685 | 3,226 | 2,686 | 2,188 |
| **LE Total** | **5,459** | **4,608** | **4,371** | **4,144** | **3,623** | **3,013** | **2,451** |
| Progressive estimation: Lamp costs of 12.50 EUR + replacement luminaire costs of 25 EUR + labour costs of 25 EUR (62.50 EUR in all cases) | | | | | | | |
| Prog. rewiring | 639 | 529 | 492 | 459 | 396 | 327 | 263 |
| Prog. replacement | 2,291 | 1,940 | 1,845 | 1,753 | 1,535 | 1,279 | 1,042 |
| **Prog. Total** | **2,931** | **2,469** | **2,337** | **2,212** | **1,932** | **1,606** | **1,305** |

On the basis of this comparison it is thus assumed that further differences in the actual costs of replacement could have a significant impact on the actual costs for consumers.

In the consultants view, the comparison shows that the replacement costs have a relatively high sensitivity to changes in the costs of the individual items (costs of: lamp, auxiliary equipment, luminaire and labour). Since the replacement luminaire costs have the highest contribution to the total costs of replacement, the total cost is most sensitive to changes in the price of such items. In this respect it is noted that the price of luminaires can vary widely in range. Though some luminaires may be sold for as little as 20 EUR, others can cost a few hundreds of Euro, depending on the design, the materials used, etc. In this sense luminaire costs used above (100 EUR and 75 EUR) seem to be a good match in terms of representativeness, however costs may vary and could also be adapted to suit budgetary constraints of consumers.

In both, the LE and the Progressive estimation, a half hour of labour is assumed in all cases. Thus in these estimations the total amount of hours of labour decreases from 234 to 184 million hours of labour, translating to a reduction of ca. 133 thousand to 104.5 thousand full time electrician jobs.

To further give significance to the **sensitivity of the analysis to the changes in the costs of replacement elements** (lamps, auxiliary equipment, luminaires and labour), the replacement costs are set into perspective with the other costs and benefits quantified in the model, namely the additional purchase costs for CFL replaced with an

LED Plug & Play lamp and with the benefits to accumulate in the observed period from the reduction in energy consumption of lighting.

**Table 19 Summary of monetary costs/benefits related to CFL regulatory driven substitution in SUB, millions of EUR, including VAT for residential and excluding for non-residential**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| **Calculated on the basis of Oeko estimations** | | | | | | | |
| Additional purchase costs for LED | 171 | 75 | 34 | 6 | -9 | -16 | -17 |
| Additional purchase costs for LED + rewiring | 1,184 | 976 | 917 | 858 | 739 | 605 | 484 |
| Additional purchase costs for LED + luminaire replacement | 6,517 | 5,460 | 5,196 | 4,913 | 4,277 | 3,531 | 2,854 |
| Energy cost savings | -145 | -276 | -414 | -553 | -684 | -800 | -904 |
| **Total** | **7,727** | **6,235** | **5,734** | **5,224** | **4,324** | **3,320** | **2,416** |
| **Calculated on the basis of LE estimations** | | | | | | | |
| Additional purchase costs for LED | 171 | 75 | 34 | 6 | -9 | -16 | -17 |
| Additional purchase costs for LED + rewiring | 639 | 529 | 492 | 459 | 396 | 327 | 263 |
| Additional purchase costs for LED + luminaire replacement | 4,820 | 4,079 | 3,879 | 3,685 | 3,226 | 2,686 | 2,188 |
| Energy cost savings | -145 | -276 | -414 | -553 | -684 | -800 | -904 |
| **Total** | **5,486** | **4,407** | **3,992** | **3,596** | **2,930** | **2,197** | **1,529** |
| **Calculated on the basis of Progressive estimations** | | | | | | | |
| Additional purchase costs for LED | 171 | 75 | 34 | 6 | -9 | -16 | -17 |
| Additional purchase costs for LED + rewiring | 639 | 529 | 492 | 459 | 396 | 327 | 263 |
| Additional purchase costs for LED + luminaire replacement | 2,291 | 1,940 | 1,845 | 1,753 | 1,535 | 1,279 | 1,042 |
| Energy cost savings | -145 | -276 | -414 | -553 | -684 | -800 | -904 |
| **Total** | **2,958** | **2,268** | **1,957** | **1,664** | **1,239** | **790** | **384** |

Here too, the comparison clearly allows concluding that the price of elements related to the replacement costs has a heavy influence on the total net benefit. This is particularly true in relation to the costs used for the estimation of replacement costs of luminaires. In all cases it can be seen that in light of the accumulation of energy savings from year to year, the annual distance between costs and benefits decreases from year to year. Though this difference is still significant where the Oeko estimations for replacement costs are used for the calculation, it decreases significantly when using the other estimations for the replacement costs (LE estimation and Progressive estimation). It is also noted that in both of these estimations, for CFLi lamps, the net benefit shows that the cost of investment is already set-off by the benefits of energy consumption as early as 2025 for the LE estimation and 2024 for the progressive estimation. See Table 20 for detail. This early benefit is expected to be further set-off through the benefits related to amounts of mercury not to be placed on the market through the earlier phase-out.

Once again, these results should be observed against the background that a natural phase-out is already underway accounting for a reduction of two thirds of the CFL stock by 2025. In the natural phase-out, CFLi account for a larger share of lamps being replaced and also have a larger availability of Plug & Play alternatives, corresponding to lower replacement costs. Nonetheless, around a third of CFLni residential lamps and about a half of CFLni non-residential ones are also to be replaced in this period, for which it is understood that in most cases the luminaire replacement route shall be necessary, corresponding to higher costs. It is thus assumed that consumers are voluntarily facing substitution costs of at least a similar order in the period between 2019 and 2025.

To summarise, the various costs and benefits (monetary and non-monetary) are detailed against each other in the table below, also providing detail as to the sensitivity of results where this has been explored.

**Table 20 Summary of lamps affected and costs and benefits related to CFL regulatory driven substitution in SUB (monetary and non-monetary), units noted in the left column**

*Worst case estimations are marked with red, best case estimations with green. Cost benefit estimations are all in relation to regulatory driven phase-out of lamps in SUB scenario. Per capita results appear in blue script.*

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| Lamps to be replaced naturally in BAU and SUB, millions of lamps | 294 | 385 | 432 | 427 | 399 | 335 | 277 |
| Lamps to be replaced naturally in BAU and SUB, lamps per capita | 0.57 | 0.75 | 0.84 | 0.83 | 0.78 | 0.65 | 0.54 |
| Regulatory driven phase-out of lamps in SUB, millions of lamps | 187 | 144 | 138 | 125 | 103 | 78 | 28 |
| Lamps to be replaced naturally in BAU and SUB, lamps per capita | 0.36 | 0.28 | 0.27 | 0.24 | 0.20 | 0.15 | 0.05 |
| Replacement costs (Oeko estimations), millions of EUR | 7,872 | 6,511 | 6,148 | 5,777 | 5,008 | 4,120 | 3,320 |
| Replacement costs (Oeko estimations), EUR per capita | 15.39 | 12.71 | 11.98 | 11.25 | 9.74 | 8.00 | 6.44 |
| **Energy cost savings, millions of EUR** | **145** | **276** | **414** | **553** | **684** | **800** | **904** |
| Energy cost savings, EUR per capita | 0.28 | 0.54 | 0.81 | 1.08 | 1.33 | 1.55 | 1.75 |
| **Net monetary benefit (Oeko), millions of EUR** | **7,727** | **6,235** | **5,734** | **5,224** | **4,324** | **3,320** | **2,416** |
| Net monetary benefit (Oeko), EUR per capita | 15.10 | 12.17 | 11.18 | 10.17 | 8.41 | 6.45 | 4.69 |
| CFLi share thereof, millions of EUR | 3,032 | 2,051 | 1,851 | 1,504 | 1,042 | 552 | 183 |
| CFLi replacement costs per lamp, EUR/lamp | 22.11 | 20.68 | 19.47 | 18.04 | 15.98 | 12.29 | 6.18 |
| CFLni share thereof, millions of EUR | 4,695 | 4,185 | 3,883 | 3,720 | 3,282 | 2,769 | 2,233 |
| CFLni replacement costs per lamp, EUR/lamp | 94.76 | 92.86 | 90.88 | 88.85 | 86.15 | 82.72 | 78.19 |
| Additional WEEE, Worst case, 1 lamp, millions of Kg | 112.0 | 94.7 | 90.1 | 85.6 | 74.9 | 62.3 | 50.7 |
| Additional WEEE, Worst case, 1 lamp, Kg per capita | 0.22 | 0.18 | 0.18 | 0.17 | 0.15 | 0.12 | 0.10 |
| Additional WEEE, Worst case, 1.5 lamps millions of Kg | 87.4 | 72.4 | 68.9 | 64.8 | 56.0 | 45.7 | 36.6 |
| Additional WEEE, Best case, 1 lamp, millions of Kg | 56.0 | 47.4 | 45.0 | 42.8 | 37.4 | 31.2 | 25.4 |
| Additional WEEE, Best case, 1.5 lamps millions of Kg | 43.7 | 36.2 | 34.4 | 32.4 | 28.0 | 22.9 | 18.3 |
| Additional WEEE, Best case, 1.5 lamps, Kg per capita | 0.09 | 0.07 | 0.07 | 0.06 | 0.05 | 0.04 | 0.04 |
| Total Hg placed on the market, BAU, LE estimation, Kg | 349.0 | 266.9 | 255.0 | 221.3 | 182.6 | 138.5 | 102.7 |
| Total Hg placed on the market, SUB, LE estimation, Kg | 15.8 | 12.1 | 11.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Avoided Hg, LE estimation, Kg** | **333.2** | **254.8** | **243.4** | **221.3** | **182.6** | **138.5** | **102.7** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Avoided Hg, LE estimation, mg per capita | 0.65 | 0.50 | 0.47 | 0.43 | 0.35 | 0.27 | 0.20 |
| Total Hg placed on the market, BAU, RoHS threshold estimation, Kg | 544.3 | 420.4 | 401.6 | 348.5 | 287.6 | 218.1 | 161.7 |
| Total Hg placed on the market, SUB, RoHS threshold estimation, Kg | 24.6 | 19.0 | 18.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Avoided Hg, RoHS threshold estimation, Kg** | **519.6** | **401.4** | **383.4** | **348.5** | **287.6** | **218.1** | **161.7** |
| Avoided Hg, RoHS threshold estimation, mg per capita | 1.02 | 0.78 | 0.74 | 0.67 | 0.56 | 0.42 | 0.31 |
| Rough estimation of job losses in the lighting sector CFLi | Estimated by LE as 5,500 jobs in total (for the duration of the phase-out) | | | | | | |
| Rough estimation of job losses in the lighting sector CFLni | Estimated by LE as 2,800 jobs in total (for the duration of the phase-out) | | | | | | |
| Rough estimation additional electrician jobs to support CFL phase-out | 27,538 | 22,429 | 21,371 | 19,943 | 17,061 | 13,719 | 10,811 |

# 5. Linear and non-linear fluorescent lamps – General purpose lighting

## 5.1. Exemptions in the scope of this section

The current chapter covers impacts related to exemptions 2(a)(1-5) and 2(b)(3) specified below for the use of mercury in linear fluorescent lamps (LFL) and non-linear fluorescent lamps.

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

> *(1). Tri-band phosphor with normal lifetime and a tube diameter < 9 mm (e.g. T2): 5 mg; Expires on 31 December 2011; Expires on 31 December 2011; 4 mg may be used per lamp after 31 December 2011;*
>
> *(2). Tri-band phosphor with normal lifetime and a tube diameter ≥ 9 mm and ≤ 17 mm (e.g. T5): 5 mg; Expires on 31 December 2011; 3 mg may be used per lamp after 31 December 2011*
>
> *(3). Tri-band phosphor with normal lifetime and a tube diameter > 17 mm and ≤ 28 mm (e.g. T8): 5 mg; Expires on 31 December 2011; 3.5 mg may be used per lamp after 31 December 2011*
>
> *(4). Tri-band phosphor with normal lifetime and a tube diameter > 28 mm (e.g. T12): 5 mg; Expires on 31 December 2012; 3.5 mg may be used per lamp after 31 December 2012;*
>
> *(5). Tri-band phosphor with long lifetime (≥ 25 000 h): 8 mg; Expires on 31 December 2011; 5 mg may be used per lamp after 31 December 2011*

*Ex. 2(b)(3): Non-linear tri-band phosphor lamps with tube diameter > 17 mm (e.g. T9); No limitation of use until 31 December 2011; 15 mg may be used per lamp after 31 December 2011;*

For convenience, the abbreviations specified in the exemptions above shall be used to differentiate between the various lamps covered by each exemption: T2; T5; T8; T12; Longlife (LL) (either LL T5 or LL T8) and T9 (representing exemptions covered by Ex. 2(b)(3).

It is assumed that T2 and T12 lamps are naturally phasing out. This was confirmed by LE in the stakeholder meeting and has also been conveyed in the correspondence related to the exemption requests. For T2, a renewal of the exemption (Ex. 2(a)(1)) was recommended and impacts are not expected to differ between the scenarios. For T12, such lamps are understood to have been prohibited through the Ecodesign Directive, thus despite the exemption being recommended for revoke, the scenarios are not expected to differ.

Most impacts, related to a possible change of exemptions 2(a)(2), 2(a)(3) and 2(b)(3), are expected to incur in relation to lamps covered by the exemptions themselves (i.e. T5, T8 and T9 lamps respectively), and are detailed in the sections to follow.

Though the exemption for LL lamps was recommended for renewal, such lamps may be used in some cases to substitute normal lifetime T5 and T8 lamps, facing a regulatory driven phase-out in the SUB scenario. Thus, spillover effects can be expected from the revoke of exemptions 2(a)(2) and 2(a)(3) on the further manufacture and use of LL lamps, i.e., lamps covered by Ex. 2(a)(5).

Though spillover effects may also be relevant for special purpose double capped linear lamps, covered under Ex. 2(b)(4), such effects are discussed in chapter 3 and chapter 7 and thus not specified here in detail.

## 5.2. Expected market development in each of the scenarios

In the following chapter, estimations are made as to the expected differences between the BAU scenario and the SUB scenario (see Section 3.1 for detail) in relation to the lamp market situation and subsequent impacts.

To understand the differences in sales and subsequently of the European stock of LFL lamps over the years 2014-2025, MELISA sales and stock data has been used as a source of data for the BAU scenario. The SUB scenario is developed on the basis of these data, assuming that exemptions 2(a)(2-4) are revoked in 21 July 2016, and that a transition period of 18 months, until 21 January 2018, is provided to ease the phase out of relevant lamps. For the purpose of this study, it is assumed that lamps already placed on the market at retailers throughout the transition period shall still be circulated until the end of the calendar year 2018. In this sense, the share of lamps falling under these exemptions is subtracted from the SUB scenario starting 2019. Exemption 2(b)(3) was recommended for renewal for three years. It is assumed that thereafter the exemption shall be revoked (21 July 2019), with an 18 month transition period (21 January 2021). Lamps could still be circulated on the market until the end of 2021. Similarly, it is expected that following the recommended five year renewal of exemption 2(a)(5), that the exemption shall later be revoked in 22 July 2021 and provided a transition period until 21 January 2023. As of January 2024, it is expected that lamps falling under exemptions 2(a)(1-5) could no longer be placed on the EU market.

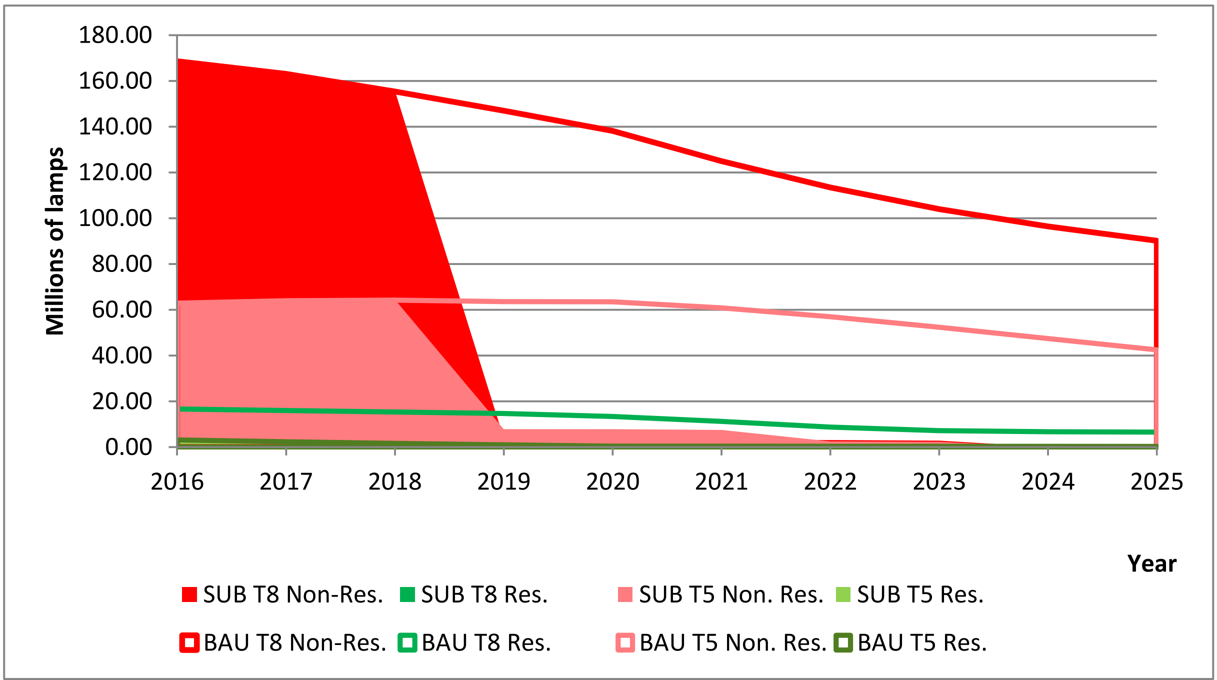
A further aspect contributing to the difference between scenario BAU and scenario SUB is related to the market sales of LL lamps. Theoretically, LL lamps can be produced in different diameters and lengths and in so far provide a possible substitute for other LFL lamps. As it has been understood that LL lamps exist for T5 and T8 lamps, in the SUB scenario, it is assumed that subsequent to the publication of the Oeko-Institut recommendations (Gensch et al. 2016) that sales increase by 10% in relation to BAU sales of the same year, to create a "stock" of LL substitutes for T5 and T8 lamps.

It is noted that the scenarios are expected to be identical until 2016, after which the change to LL lamps is to be reflected in market sales and thus expected to result in various impacts. In 2019 T5- and T8 disappear from the market, with T9 following three years later and LL lamps no longer sold starting 2024.

Figure 10 and Figure 11 thus show the development of the sales and stock of lamps in the EU 28 over the period 2014-2025 on this basis. The scenarios are identical until 2018, with differences apparent starting 2019. The development of the BAU scenario after this year is portrayed with a dotted line, in comparison to the solid line and "filled" surface of the SUB scenario trends. The diagrams provide the annual sales volumes for each lamp type (T5, T8) for each scenario, as well as a breakdown to residential and non-residential lamps. For LL lamps and T9 lamps, a certain market share is assumed on the basis of the number of lamps on the market in 2013/2014. For T9, according to LE data, it is assumed that 6 million lamps were on the market in 2013. On this basis, as T9 lamps are understood to be included in the VHK data for T5, their share is assumed to account for 8% of the total T5 sales volume. As according to LE there were ~9 million LL lamps on the market in 2014, it has been assumed that 6 million were LL T8 and 3 million LLT5 (or a share of 2% or 4% of the total volume respectively). The rest of the market volumes are assumed to be T8 and T5 lamps, 98% and 88% respectively. Though this data has been fed into the calculation and allows estimations of various impacts in the following sections, the data in Figure 10 and Figure 11 has been simplified and shows only the totals, with T8 data representing both T8 and LL T8 and with T5 data representing T5, T9 and LL T5.

**Figure 10 Development of sales in the EU 28, in millions of lamps**

*The SUB development (filled line) can be seen on the background of the BAU development (dotted line) for T8 and T5 lamps, as well as the breakdown to residential and non-residential lamps. Data is absolute and not stacked.*



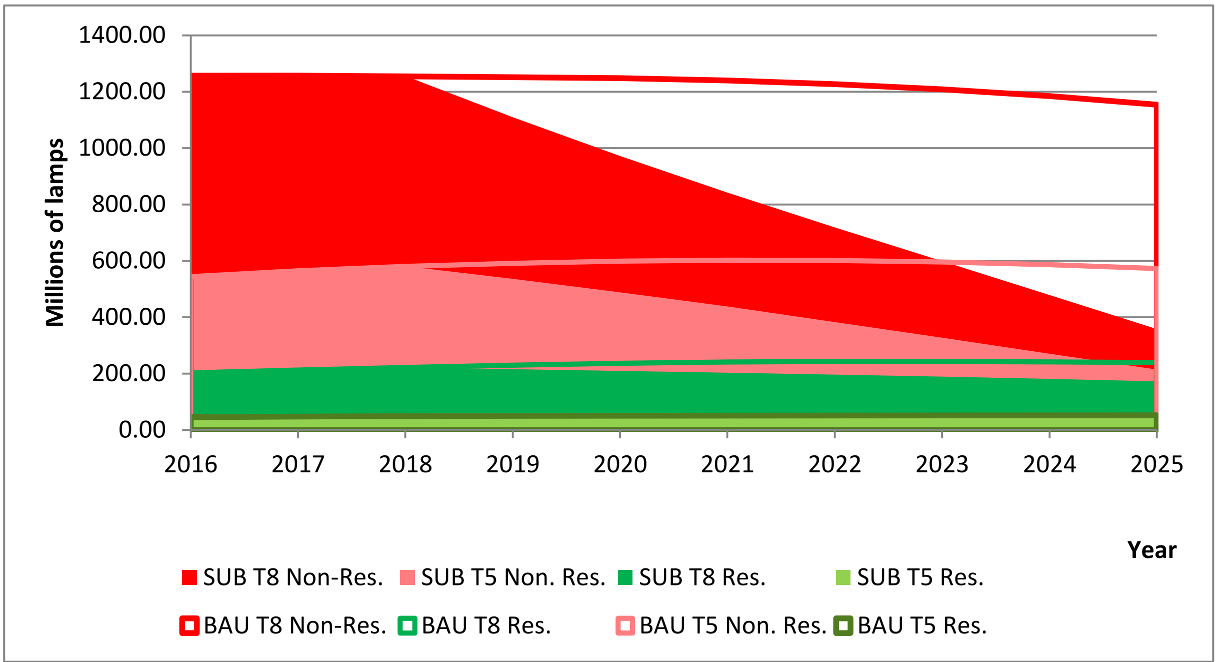

*Own compilation based on data from (VHK 2016)*

The numbers above are expected to be an over estimation. LE (LightingEurope 2017b) explain "*According to the sales numbers collected by LightingEurope, the curve representing the sales of T8 is too high in 2015 when compared with the actual sales accumulated to LightingEurope level. We can surely state this since our companies' together cover over 80% of the linear fluorescent market in Europe. The decline of the T8 sales does not match our expectations. In 2020 our sales estimations for both T8 and T5 are less than half of the numbers indicated in the graph. This is a point where we do not agree with the original VHK report. LightingEurope agrees that the trend will remain a decreasing one. The reason is that LED luminaires overtake the market of new install base. We would like to highlight again that LED retrofit solutions for T5 lamps are currently almost not available at all in the EU market. The reason of the decline in the sales numbers is instead that new LED luminaires are used for renovation and new* *building projects*." As the data basis for this statement is confidential, the current estimation has not been taken into consideration, however on the basis of the LE statement, it should be noted that sales are expected to be significantly lower in the future years and thus also other linked impacts.

Though changes to the exemptions to be implemented in the SUB scenario have a near to immediate impact on the trend in sales of lamps, this impact is more moderate in relation to the stock of lamps in use in the EU at a certain point in time, as suggested from comparing the diagrams. Though the lamps may no longer be sold shortly after the revoke of an exemption, their service lives vary (VHK 2016) from 9.7 years for T8 non-residential (shortest) and to 28.6 years for T5 residential (longest). Actual phase out from the stock of lamps in use is thus expected to begin in the years to come and thus not relevant in the observed period. For T8 non-residential lamps, phase out of lamps placed on the market in 2019 is only expected to start in 2028. For other LFL lamps, actual phase-out only starts much later in light of longer service lives (>10.5 years) and is due to extend over a longer period of time. Furthermore, though a decreasing trend can be observed in the stock development for the use of LFL in non-residential areas (more moderate in BAU than in SUB, but apparent in both), for residential uses this trend is much more moderate. This is probably connected to the longer life of LFL in the residential sector (18.6 and 28.6 years for T8 and T5 respectively) as well to the tendency in non-residential uses to replace groups of luminaires and not just single installations (for example during renovation of offices).

**Figure 11 Stock development in the EU 28, millions of lamps**

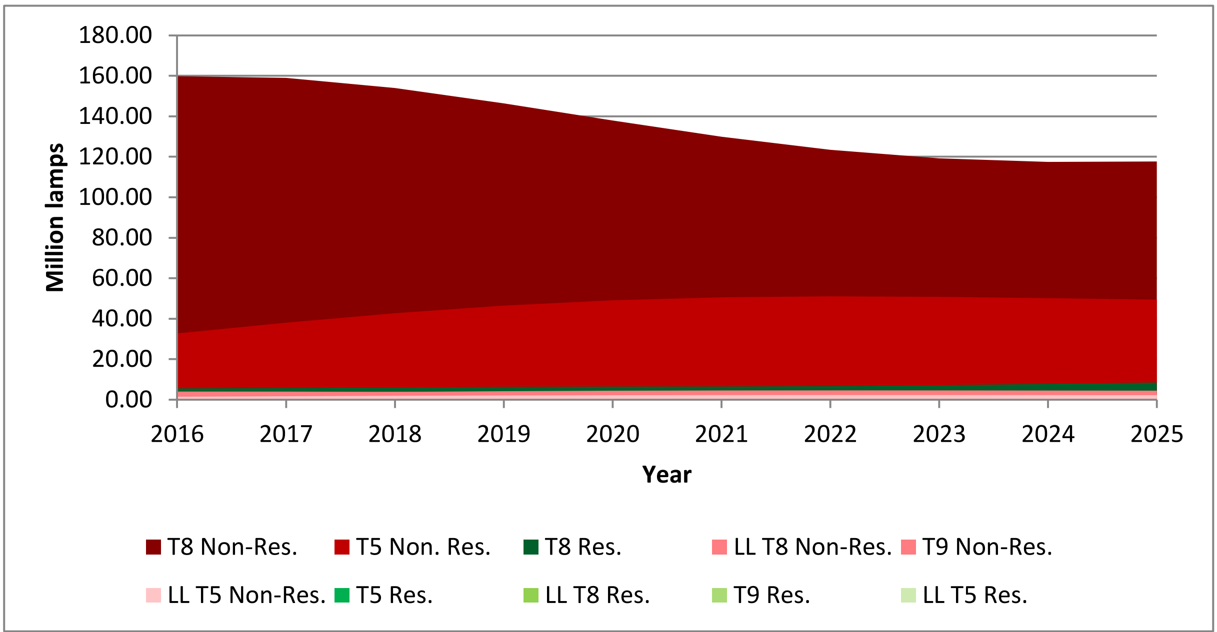
*The SUB development (filled line) can be seen on the background of the BAU development (dotted line) for T5 and T8 lamps, as well as the breakdown to residential and non-residential lamps. Data is absolute and not stacked.*




*Own compilation based on data from (VHK 2016)*

In cases where a lamp reaches its end of life, it is expected that the consumer shall seek a replacement lamp or in some cases a replacement luminaire. Data from the MELISA model (VHK 2016) has been used to determine how many lamps reach EoL per year. As explained above, LFL lamps have relatively long service lives. As the first lamps to be affected in terms of annual sales volume (T8 non-residential) have a service life of almost 10 years (and other lamps even longer), it is concluded that both scenarios are identical in relation to lamps reaching EoL within the period observed for the estimation.

**Figure 12 Estimation of additional lamps reaching EoL (i.e. lamps to be replaced) in both scenarios, millions of lamps**




*Own compilation based on data from (VHK 2016)*

It should be noted in relation to T5 that the current technology is a newer and more efficient one (compared to T8) which has not been on the market that long. The fact that the residential T5 have a relatively long service life (28.6 years), explains why T5 lamps are not yet expected to arrive at EoL in the timeframe of the current estimation. As the VHK T5 is also the basis for estimating the volumes for T9 and LL T5, this explains why such lamps are not shown to arrive at EoL. Though it is plausible that LL T5 are only in use for non-residential purposes, it is assumed that this is not the case with T9 lamps, suggesting a certain limitation in relation to the results. As T9 are in any case a very small portion of the market, and as later estimations related to the number of lamps to be replaced are based on the difference between the lamp sales in BAU and SUB, the difference in relation to estimated impacts is assumed to be relatively insignificant.

The MELISA model (VHK 2016) makes assumptions as to the share of EoL lamps for which the consumer has shifted to LED retrofit lamps or to an LED luminaire. In this respect, based on the VHK data, it is concluded that the natural shift to LED (lamps and luminaires) is factored into the data presented above. Though the number of EoL lamps is the same in both scenarios, in the SUB scenario, in which certain lamps become unavailable for consumers, assumptions have been made as to the number of EoL lamps for which one of four substitution routes have been chosen:

- Replacement with a longlife lamp (lamps produced through the increased production volume in SUB);
- Replacement with an LED Plug & Play lamp;
- Replacement with an LED lamp requiring rewiring / conversion;

- Replacement of the luminaire with an LED luminaire (including lamp).

In the period between 2016 and 2023 (including), the number of LL lamps available is based on the difference in LL lamps between the two scenarios. Starting 2024, LL lamps also become unavailable, meaning that from this year, LL are not considered an alternative. It is noted that LL are manufactured in a smaller variety than T5 and T8 lamps, however as the additional volume is relatively small, it is assumed that all lamps are used as substitutes. It shall only be possible to use such lamps as substitutes for T5 and T8 lamps. For T9 lamps and LL lamps, this substitution route is not applicable.

In relation to substitution of T5 lamps, LE (LightingEurope 2017b) state that:

- Replacement with long lifetime T5 lamps is not realistic. This is explained to be related to the very small market of such lamps, to the low variety in relation to the assortment of T5 lamps and therefore also to the limited technical feasibility for some parts of the T5 product portfolio. LE expects that the development of new long-life T5 types, to cover part of the current portfolio, would slow down LED development activities, since it would bind development capacities. In this respect the consultants have only taken into consideration a small increase in LL T5 production, which is assumed to be manufacture of models that already exist.
- As for LED retrofit lamps (understood to mean both Plug & Play and those requiring rewiring), these are explained to nearly not be available for T5 luminaires (understood to reflect the limited variety of existing substitutes). LE states that it is not realistic that LED replacements will be developed in the next 2-3 years for all T5 ballast and luminaire variations (>10.000), nor should it be expected that LED retrofits shall be compatible with the full range of auxiliary equipment (ballasts, dimmers, etc.).
- In relation to LED luminaires, here the volume availability is understood to be restrictive in terms of supporting a regulatory driven phase-out in 2018. For some applications alternatives have not yet been developed (e.g. corrosive environments) and LE estimate the financial impact to EU society due to a regulatory driven luminaire exchange of 660 million luminaires to amount to nearly 200 billion EUR.

In relation to the availability of substitutes for T5 and T8 lamps, LE provided the following table, specifying the ranges of availability in relation to their various members.

**Table 21 The availability of Plug and Play substitutes in terms of coverage of the relevant product range (%) and the range of LFL with no substitute**

| Portfolio coverage | Normal life (i.e. LED) | Portfolio covered by long life | Applications not covered by long life |
|---|---|---|---|
| T5 | 0 - 3.5% | 0 - 17% | 97 – 100% |
| T8 | 0 – 47% | 12 - 100% | 92 – 100% |

On the basis of the information above, the estimations presented in Table 22 have been used to calculate impacts in the following sections, where related to the replacement of LFL and Non-LFL. As the availability of LL lamps for use as replacements depends on the small production increase expected between 2016-2023, these lamps shall first be subtracted from the total volume, after which the shares specified below shall be calculated.

**Table 22 Assumptions as to the chosen route for replacing a LFL lamp at EoL**

| | T8 | T5 | T9 | LL |
|---|---|---|---|---|
| LL replacement | depending on availability of additional lamps in year | | n.a. | n.a. |
| LED Plug & Play replacement | 12% | 1% | 1% | 5% / 1% |
| Rewiring + LED replacement | 10% | 3% | 1% | 5% / 1% |
| LED + Luminaire replacement | 78% | 96% | 98% | 90%/98%* |

*Note: It is assumed that the availability of LED retrofit lamps for T9 is very small, as the market share is small and manufacturers shall have a low interest to invest in the development of LED retrofits. For LL, the situation is estimated to be similar, with the exception that in some cases where T5 or T8 lamps have the same technical specifications (aside from service life), their substitutes may be available for use in LL applications.*

On the basis of these assumptions and the number of additional lamps requiring replacement in the SUB scenario, an estimation of the amount of lamps to be replaced through each of the routes is calculated (longlife replacement, LED Plug & Play, LED + rewiring or LED luminaire). The results are specified in Table 23 and have been used for quantifying the various socio-economic impacts in the following sections. For simplicity, the total for each route is specified per year and the total for the whole period is specified per lamp type.

**Table 23 Distribution of LFL lamps to be replaced in the SUB scenario according to the replacement route assumed and according to total per lamp type, million lamps**

| Route | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| Longlife Replacement | 2.09 | 0.65 | 0.62 | 0.58 | 0.53 | 0.48 | 0.00 |
| Plug & Play Replacement | 19.32 | 18.24 | 16.43 | 14.80 | 13.48 | 12.63 | 12.18 |
| Rewiring + LED | 17.31 | 16.42 | 14.85 | 13.43 | 12.24 | 11.46 | 11.04 |
| Luminaire replacement + LED | 175.74 | 168.69 | 154.78 | 145.34 | 132.73 | 126.18 | 120.58 |
| | **T8 res.** | **T5 res.** | **T8 non-res.** | **T5 non-res.** | **T9** | **LL T8** | **LL T5** |
| Longlife Replacement | 0.25 | 2.72 | 0.04 | 1.94 | | | |
| Plug & Play Replacement | 7.98 | 95.23 | 0.03 | 3.41 | 0.16 | 0.24 | 0.04 |
| Rewiring + LED | 6.65 | 79.36 | 0.08 | 10.22 | 0.16 | 0.24 | 0.04 |
| Luminaire replacement + LED | 51.90 | 618.98 | 2.48 | 327.19 | 15.58 | 4.40 | 3.51 |

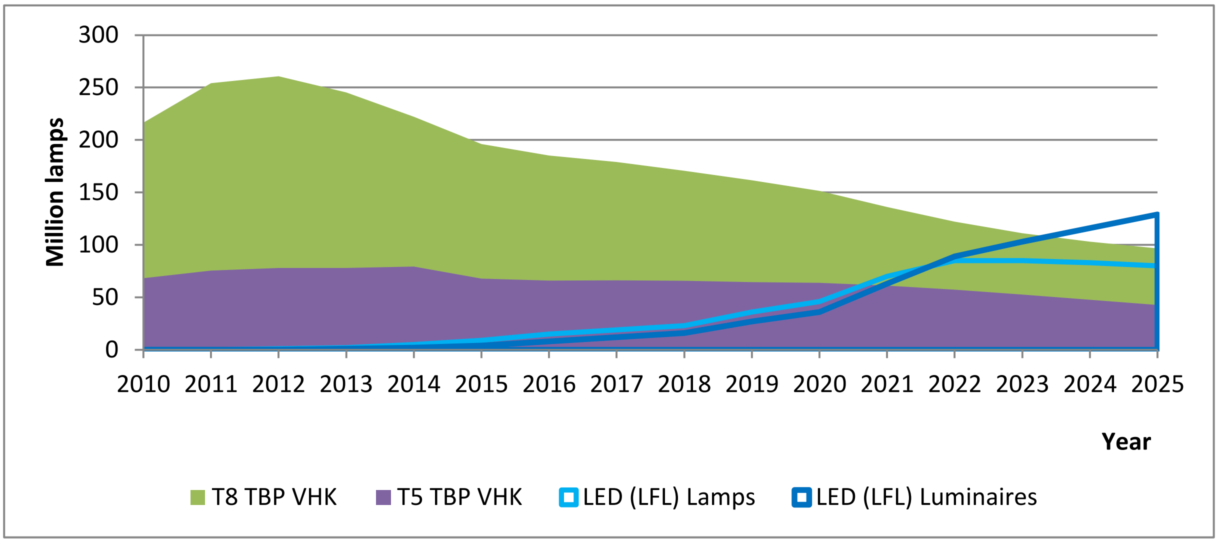
Longlife lamps are no longer placed on the market in 2024, however it has been assumed that the "extra lamps" still in stock from the year before (remaining after standard consumption is subtracted) are available as substitutes each year. Thus the LL replacement route terminates in 2024.

To provide additional context for the various changes related to lamps that may be denied market access in the SUB scenario, it is useful to observe the general shift expected from the use of LFL lamps in luminaires to the use of LED replacements for luminaires (either as replacement for a LFL lamp or in a new LED replacement luminaire).

The following figure shows the development of LFL lamp sales in relation to the development of the sales of LED lamp replacements sold for LFL applications. In both cases, a break-down of data is provided in relation to T5 and T8.

**Figure 13 Development of sales of LFL lamps and LED LFL alternatives in BAU scenario (lamps and luminaires for the LFL application range) (2014-2025)**

*The LFL sales development (T5, T8 filled lines) can be seen in the background of the LED sales development (LED-LFL lamps and LED-LFL luminaires - empty lines). Data is absolute and not stacked.*




*Own compilation based on data from (VHK 2016)*

## 5.3. Expected impacts on employment

In relation to the manufacture of LFL Lamps, it is understood that manufacturing facilities (e.g., equipment) producing LFL lamps are specific to the production of LFL lamps (see also Section 3.4).

In relation to the possible use of longlife lamps as alternatives for T5 and T8, and how this may affect manufacture (and thus subsequently employment) LE (LightingEurope 2017b) claims: "*in a shrinking market, and considering the already limited development resources for traditional lamps, there is only limited possibility seen to extend the long lifetime LFL portfolio without binding additional development resources actually needed to speed up LED innovation. Instead of promoting a larger market share of long lifetime LFL, renewing Ex. 2(a)(5), while not renewing the exemptions for the standard lamps (Ex. 2(a)(2-4)), is more likely to force many suppliers to close LFL factories and phase out all LFL, including also all long lifetime LFL (Ex. 2(a)(5) and lamps for special applications (Ex. 2(b)(4)), since long lifetime LFL production cannot be extended to mass production like standard LFL, and the production volume of long lifetime LFL and lamps for special applications is not high enough to continue a high volume cost-effective LFL production.*".

LE have estimated that a total of 20,000 jobs are at risk of loss in the EU lighting industry if the recommendations of Oeko-Institut (Gensch et al. 2016) are to be implemented (SUB scenario). Using the 2016 sales volume and share of lamp technologies to be affected as an indicative basis (please see Section 3.4 in this regard – estimation should be interpreted with caution), a rough estimation of jobs related to CFL manufacture, to be lost in the EU in the SUB scenario can be made:

- The T5 LFL share 14.3% would correspond to ~ 2,850 jobs.
- The T8 LFL share 40.2 % would correspond to ~ 8,050 jobs.
- It is assumed that around 300 jobs may be relevant for lamps covered by Ex. 2(b)(3), based on the sale volumes of around 6 million. These jobs are presumed to be covered in the jobs specified for T5, as the sales volume of T9 has been estimated from that volume.
- It is assumed that around 450 jobs could be associated to LL lamps, based on the sales volumes of around 9 million. As in the estimation, sales for LL lamps are estimated on the basis of the T5 and T8 sales, it is assumed that these jobs are represented in the numbers above – 150 jobs relevant for the T5 total and 300 for the T8 total.
- The special purpose share 3.5 % would correspond to ~700 jobs, but only part of this group is associated with LFL special purpose lamps (less than 300 jobs).

There is no additional specific information for LFL lamps, neither relating to manufacture nor to employment. In this sense it is difficult to estimate if these values represent a good estimate or not. It is also not possible to estimate whether more jobs would be related to general purpose LFL (T5, T8, T9, LL) or to special purpose ones. The consultants can also not conclude how manufacture and employment are distributed between EU and non-EU countries.

In relation to costs of substitution, estimations have been made in relation to the hours of labour required for performing replacements in the LED rewiring route and in the LED luminaire replacement route. Estimation was performed based on the number of additional lamps to be replaced in the SUB scenario (Table 24) for each of these segments. It was assumed that half an hour is required for rewiring or replacing a LFL luminaire, most of which are assumed to be non-residential (see also Section 4.4 for additional detail). On the basis of these estimations, Table 24 presents the aggregated hours of labour expected in relation to the additional substitution expected in the SUB scenario.

**Table 24 Annual hours of labour and jobs associated with the additional substitution in the SUB scenario**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| T8 rewiring, million hours | 7.82 | 7.37 | 6.62 | 5.94 | 5.40 | 5.01 | 4.84 |
| T8 luminaire, million hours | 60.97 | 57.47 | 51.64 | 46.33 | 42.16 | 39.11 | 37.76 |
| T5 rewiring, million hours | 0.84 | 0.84 | 0.80 | 0.75 | 0.69 | 0.63 | 0.59 |
| T5 luminaire, million hours | 26.90 | 26.88 | 25.74 | 24.11 | 22.16 | 20.07 | 18.98 |
| T9 rewiring, million hours | | | | 0.02 | 0.02 | 0.02 | 0.02 |
| T9 luminaire, million hours | | | | 2.23 | 2.05 | 1.85 | 1.66 |
| LL rewiring, million hours | | | | | | 0.07 | 0.07 |
| LL luminaire, million hours | | | | | | 2.07 | 1.90 |
| Total (jobs) | 54,845 | 52,588 | 48,190 | 45,105 | 41,183 | 39,108 | 37,393 |

It should be noted that on the basis of an 8 hour day, and 220 work days per year, the total amount of hours translates into between 55 and 37 thousand jobs (electricians), depending on the observed year. The number of additional jobs is dynamic and decreases from year to year. To provide context to this number, according to an EU Skills

Panorama Document (ICF and Cedfop 2014), in 2013 there were over 11 million jobs across the EU-28 in metal and electrical trades[33] (the share of electrical trades is not clear). Though it is expected that some of these jobs may have been pre-existing, it is expected that some of them are new jobs, expected to support the phase-out process from LFL to LED alternatives.

## 5.4. Possible costs for users related to lamp substitution

As explained in Section 4.2, additional lamps reaching EoL in the SUB scenario starting 2019 are expected to be replaced with LL Lamps or with LED lamps either with a Plug & Play lamp, with a LED requiring a rewiring of the luminaire or with a LED luminaire. For each of these routes, the results of a quantification of expected costs of substitution are presented below.

The purchase prices of longlife lamps made available on the internet vary and have been assumed to be 20 EUR per lamp in the calculation[34]. It is assumed that lamps shall only be used where technically compatible and not requiring further technical changes to the luminaire. Estimated costs are specified.

**Table 25 Costs of substitution of LFL with longlife lamps (only T5/T8), millions of EUR, including VAT for residential and excluding for non-residential**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| T8 Res. | 1.16 | 0.35 | 0.32 | 0.27 | 0.21 | 0.17 | 0.00 |
| T8 Non-Res. | 13.79 | 4.16 | 3.91 | 3.54 | 3.21 | 2.94 | 0.00 |
| T5 Res. | 0.29 | 0.04 | 0.02 | 0.02 | 0.01 | 0.01 | 0.00 |
| T5 Non-Res. | 9.15 | 3.04 | 3.04 | 2.91 | 2.73 | 2.51 | 0.00 |
| **Total** | **24.39** | **7.60** | **7.29** | **6.74** | **6.17** | **5.64** | **0.00** |

Though longlife lamps are more expensive than the conventional T5 and T8 (a little over twice as expensive), they are also understood to have a longer life. The exemption formulation specifies a minimum of 20,000 Hours, though in reality service life is expected to be significantly higher[35]. According to (VHK 2016), the average T5 service life is between 20,000-21,360 hours and the average T8 between 13,000-21,360. In this respect, assuming that the realistic service lives are at least twice those of conventional LFL, the related costs are concluded to be acceptable as they are comparable to those of conventional LFL from a life cycle cost perspective.

On the basis of purchase prices specified in the MELISA model (VHK 2016) for LFL and for alternative LED, an estimation has been made as to the costs of substitution with Plug

33 Electricians, electronic mechanics and other workers in electrical trades are required to install, maintain and repair electrical wiring systems, electrical transmission cables, telecommunications systems and perform other similar activities

34 See for example: https://www.leuchtmittelmarkt.com/Osram-T5-HO-XT-80W840-Longlife-G5-Lumilux-Cool-White?gclid=CKii3MHH_tICFYgV0wod2-UADA and https://www.beleuchtungdirekt.de/osram-t8-l-58w-840-xxt-g13-kalt-weiss?qcd=1&utm_gst=f1a47da2ad6ca1c3496df3969aed6faff297bbfc&gclid=CP63z9bH_tICFReNGwodOjcEeA

35 For example 90,000 for the following lamp: https://www.beleuchtungdirekt.de/osram-t8-l-58w-840-xxt-g13-kalt-weiss?qcd=1&utm_gst=f1a47da2ad6ca1c3496df3969aed6faff297bbfc&gclid=CP63z9bH_tICFReNGwodOjcEeA

& Play LED. Purchase prices detailed in MELISA are given for both LFL and LED in prices relevant for 2010, including VAT. For T5 and T8 the price is consistent along the period of the calculation. For LED, the MELISA model provides price estimations that decrease from year to year, understood to represent the change in price as the technology develops. Discounting has not been applied in the current estimation and thus the estimation is in relation to 2010 prices. Costs of LED are higher than the typical cost given for LFL in MELISA, though they decrease significantly from almost 80 EUR in 2014 to approximately 15 EUR in 2025.

**Table 26 Costs of substitution with LED Plug & Play, millions of EUR, including VAT for residential and excluding for non-residential**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| T8 Res. | 26.44 | 19.73 | 13.32 | 8.23 | 5.51 | 4.22 | 3.38 |
| LL T8 Res. | | | | | | -0.04 | -0.04 |
| T8 Non-Res. | 705.93 | 585.87 | 474.33 | 384.02 | 316.37 | 267.11 | 233.10 |
| LL T8 Non-Res. | | | | | | 1.43 | 1.10 |
| T5 Res. | 0.13 | 0.05 | 0.03 | 0.03 | 0.02 | 0.02 | 0.01 |
| T9 Res. | | | | 0.00 | 0.00 | 0.00 | 0.00 |
| LL T5 Res. | | | | | | -0.53 | -0.001 |
| T5 Non-Res. | 23.13 | 20.50 | 17.61 | 14.73 | 12.19 | 10.07 | 8.65 |
| T9 Non-Res. | | | | 1.33 | 1.10 | 0.91 | 0.74 |
| LL T5 Non-Res. | | | | | | 0.23 | -0.09 |
| **Total** | **756** | **626** | **505** | **408** | **335** | **283** | **247** |

*It is noted that at the time at which replacement becomes relevant, the costs for LED replacements are lower than those of longlife lamps.*

In relation to the costs of substituting LFL with Plug & Play LED, it is worth mentioning that the service life of LED replacements for LFL are specified as 20,000 for residential purposes, but as 40,000 for non-residential purposes. In this respect, where a Plug & Play alternative is available, from a cost perspective, once the purchase price is below 20 EUR, in 2022, the substitution would be expected to have an added benefit. This applies in cases where the provided light (output, distribution) is comparable to that of the LFL being replaced and may differ for various luminaires.

For calculating costs of rewiring, along with the costs for the LED replacement, it is assumed that 25 EUR shall be required for labour (half an hour). In a similar calculation, LE (LightingEurope 2017b) have assumed that per luminaire the costs would be 50 EUR for T5 and 30 EUR for T8. This depends on the number of lamps and is based on an assumption that a T5 luminaire will on average use 2.5 lamps and a T8 luminaire 2 lamps. Labour costs were assumed to be 20 EUR for T5 and 10 EUR for T8. LE does not calculate auxiliary costs (for additional parts such as dimmer, driver, etc.). As a conservative measure the current calculation assumes 10 EUR for auxiliary costs and higher labour costs, while also referring to the MELISA purchase prices for LED (dynamic).

**Table 27 Costs of substitution with LED + rewiring, millions of EUR, including VAT for residential and excluding for non-residential**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| T8 Res. | 71.65 | 61.89 | 49.27 | 36.50 | 28.97 | 26.28 | 25.66 |
| LL T8 Res. | | | | | | 0.25 | 0.23 |
| T8 Non-Res. | 1085.83 | 958.55 | 820.57 | 706.17 | 617.61 | 550.79 | 510.25 |
| LL T8 Non-Res. | | | | | | 5.56 | 4.95 |
| T5 Res. | 1.27 | 0.49 | 0.44 | 0.40 | 0.36 | 0.32 | 0.30 |
| T9 Res. | | | | 0.01 | 0.01 | 0.01 | 0.01 |
| LL T5 Res. | | | | | | 0.004 | 0.003 |
| T5 Non-Res. | 127.36 | 119.92 | 108.80 | 96.62 | 84.75 | 73.84 | 67.19 |
| T9 Non-Res. | | | | 2.91 | 2.56 | 2.23 | 1.92 |
| LL T5 Non-Res. | | | | | | 0.89 | 0.76 |
| **Total** | **1286** | **1141** | **979** | **843** | **734** | **660** | **611** |

To estimate the costs of replacing luminaires, aside from the LED cost, a labour cost of 25 EUR (half an hour) is calculated per luminaire. Based on the estimation prepared by LE (LightingEurope 2017b), it has been assumed that a luminaire costs 250 EUR. LE's estimation was prepared in relation to residential uses, where such prices may be representative (luminaires usually contain multiple lamps and further equipment such as reflectors). Though it is assumed that for residential uses luminaires would be less expensive (depending on type), the market share of residential uses is relatively small and thus the calculation has been performed with the same price for both cases.

**Table 28 Costs of substitution with LED + replacement luminaire, millions of EUR, including VAT for residential and excluding for non-residential**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| T8 Res. | 2,929 | 2,683 | 2,253 | 1,750 | 1,440 | 1,344 | 1,349 |
| LL T8 Res. | | | | | | 38 | 37 |
| T8 Non-Res. | 29,559 | 27,942 | 25,267 | 22,941 | 21,029 | 19,498 | 18,773 |
| LL T8 Non-Res. | | | | | | 541 | 506 |
| T5 Res. | 210 | 87 | 82 | 77 | 72 | 66 | 64 |
| T9 Res. | | | | 7 | 7 | 6 | 6 |
| LL T5 Res. | | | | | | 3 | 3 |
| T5 Non-Res. | 14,157 | 14,268 | 13,669 | 12,801 | 11,764 | 10,654 | 10,072 |
| T9 Non-Res. | | | | 1,182 | 1,087 | 984 | 882 |
| LL T5 Non-Res. | | | | | | 470 | 421 |
| **Total** | 46,856 | 44,980 | 41,271 | 38,759 | 35,397 | 33,603 | 32,111 |

It should be noted that the number of lamps to be replaced has been used to derive the number of luminaires to be replaced. Though it can be understood from LE that usually a single lamp is used in residential luminaires, it has been stated that for non-residential uses, the T5 average is 2.5 lamps and 2 lamps for T8. The consultants assume that this would mean that for luminaires with multiple lamps, in some cases, due to the EoL of a single lamp the complete luminaire would be replaced. In contrast, in others, the luminaire may remain in operation until all other lamps require replacement or, particularly where a group of identical luminaires is in use, lamps may be shifted from other luminaires to allow gradual replacement of the luminaire group (in this case once a share of all identical luminaires require replacement of all lamps). Though it is difficult to estimate how this would affect the replacement of luminaires during the observed period, it can be assumed for LFL, that the numbers above (a total of 1,024 million luminaires replaced) can be considered as a result of a conservative approach. Assuming that T5 luminaires have in average 2.5 lamps, the number of luminaries to be replaced would be expected to be close to 1 million residential luminaires and around 131 million non-residential ones. Assuming 2 lamps for T8 luminaires, would amount in around 26 million residential luminaires and around 309 million non-residential ones. In reality the number of luminaires to be replaced is expected to be in the range of these two cases, i.e., between a total of 467 and 1,024 million additional luminaires can be expected to be replaced over the period between 2019 and 2025 in the SUB scenario. The costs estimated above for luminaire replacement of LFL, may vary respectively.

The shift from LFL to LED may be associated with certain costs for consumers, who need to change equipment; however it is also estimated to result in a certain benefit related to the costs of energy consumption. To estimate the savings, for each lamp to be replaced, the difference between an average LFL (used in the BAU scenario) and an average LED LFL alternative is calculated and summed for each lamp in relation to the hours the lamp is expected to be operated annually. The yearly operation hours for LFL are used in both cases in order to compare the difference in relation to the same use pattern. In this respect, for each lamp sub-group, Table 29 specifies the annual savings related to lamps newly replaced in that year. In parallel, each lamp is expected to remain in use over its typical service life. As lamps to be replaced are only observed in the period between 2019 and 2025, a cumulative calculation has been carried out only for this duration, in which the savings of each years lamps are summed with the savings related to lamps from earlier years (theoretically the savings would be taken into consideration for 9.7-28.6 years, according to the MELISA model, however this is beyond the timeframe of the analysis). The results are specified in Table 29 below.

**Table 29 Annual and cumulated energy savings related to substitution of LFL with LED**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| **T8 Residential** | | | | | | | |
| Lamps replaced - T8 Res. (millions) | 14.3 | 13.0 | 10.9 | 8.5 | 7.0 | 6.7 | 6.5 |
| Annual savings per lamp (Wh) | 5,129 | 5,842 | 6,122 | 6,371 | 6,677 | 6,857 | 6,963 |
| Annual savings for newly replaced lamps (GWh) | 73.1 | 75.9 | 66.8 | 54.0 | 46.5 | 45.8 | 45.4 |
| Cumulative savings for lamps replaced in earlier years (GWh) | -0.4 | 72.7 | 148.6 | 215.4 | 269.4 | 315.9 | 361.8 |
| | | | | | | | |
| **Sub-total (GWh)** | **72.7** | **148.6** | **215.4** | **269.4** | **315.9** | **361.8** | **407.2** |
| **T8 Non-Residential** | | | | | | | |
| Lamps replaced - T8 Non. Res (millions). | 143.0 | 134.4 | 121.5 | 110.4 | 101.2 | 96.4 | 90.1 |
| Annual savings per lamp (Wh) | 39,785 | 42,143 | 44,894 | 47,089 | 48,438 | 49,703 | 50,790 |
| Annual savings for newly replaced lamps (GWh) | 5,689 | 5,664 | 5,457 | 5,197 | 4,900 | 4,791 | 4,578 |
| Cumulative savings for lamps replaced in earlier years (GWh) | -38 | 5,651 | 11,315 | 16,772 | 21,968 | 26,868 | 31,658 |
| | | | | | | | |
| **Sub-total (GWh)** | **5,651** | **11,315** | **16,772** | **21,969** | **26,868** | **31,659** | **36,237** |
| **T5 Residential** | | | | | | | |
| Lamps replaced T5 Res. (millions) | 0.8 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Annual savings per lamp (Wh) | 1,629 | 2,342 | 2,622 | 2,871 | 3,177 | 3,357 | 3,463 |
| Annual savings for newly replaced lamps (GWh) | 1.4 | 0.8 | 0.8 | 0.9 | 1.0 | 1.0 | 0.9 |
| Cumulative savings for lamps replaced in earlier years (GWh) | 0.0 | 1.4 | 2.2 | 3.0 | 4.0 | 5.0 | 6.0 |
| **Sub-total (GWh)** | **1.4** | **2.2** | **3.0** | **4.0** | **5.0** | **6.0** | **6.9** |
| **T5 Non-Residential** | | | | | | | |
| Lamps replaced T5 Non Res. (millions) | 56 | 56 | 53 | 54 | 50 | 47 | 42 |
| Annual savings per lamp (Wh) | 15,585 | 17,943 | 20,694 | 22,889 | 24,238 | 25,503 | 26,590 |
| Annual savings for newly replaced lamps (GWh) | 868.5 | 998 | 1,103 | 1,247 | 1,213 | 1,209 | 1,129 |
| Cumulative savings for lamps replaced in earlier years (GWh) | -6 | 863 | 1,861 | 2,965 | 4,211 | 5,424 | 6,633 |
| **Sub-total (GWh)** | **863** | **1,861** | **2,965** | **4,211** | **5,424** | **6,633** | **7,762** |
| **LFL total GWh** | **6,588** | **13,327** | **19,955** | **26,453** | **32,614** | **38,660** | **44,413** |

The negative costs in the years 2016 to 2019 are related to the increase in the number of LL lamps in these years (i.e. in these years, the production is assumed to increase slightly in order to allow creating a stock of LL lamps to be used as substitutes in later years).

Based on the electricity prices given in the MELISA model for the years of the analysis (see Table 30), the monetary benefits related to cumulated costs saved have been calculated and are presented in Table 31 below.

**Table 30 Electricity rate (2010 prices) EUR /kWh, including VAT for residential and excluding for non-residential**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| Residential - incl. VAT | 0.24 EUR | 0.25 EUR | 0.26 EUR | 0.27 EUR | 0.28 EUR | 0.29 EUR | 0.31 EUR |
| Non-residential - excl. VAT | 0.15 EUR | 0.16 EUR | 0.16 EUR | 0.17 EUR | 0.18 EUR | 0.18 EUR | 0.19 EUR |

*Source: MELISA model (VHK 2016)*

**Table 31 Cumulated cost savings related to energy consumption of LFL substituted with LED, million EUR, including VAT for residential and excluding for non-residential**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| **T8 Res. Inc. VAT** | 18 | 37 | 56 | 73 | 89 | 106 | 125 |
| **T8 Non-Res. Excl. VAT** | 851 | 1,772 | 2,731 | 3,721 | 4,733 | 5,800 | 6,904 |
| **T5 Res. Inc. VAT** | 0 | 1 | 1 | 1 | 1 | 2 | 2 |
| | | | | | | | |
| **T5 Non-Res Exc. VAT** | 130 | 291 | 483 | 713 | 955 | 1215 | 1479 |
| **LFL Total Res. Inc. VAT** | 18 | 38 | 57 | 74 | 91 | 108 | 127 |
| | | | | | | | |
| **LFL Total Res. Excl .VAT** | 981 | 2063 | 3214 | 4434 | 5688 | 7015 | 8383 |
| **Total** | | | | | | | |
| **LFL Total Res. Excl .VAT** | **999** | **2101** | **3271** | **4509** | **5779** | **7123** | **8509** |

To summarise, the total costs and benefits (where quantified as monetary costs) are presented in Table 32 below.

**Table 32 Summary of monetary costs/benefits related to LFL regulatory driven substitution in SUB, millions of EUR, including VAT for residential and excluding for non-residential**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| Additional purchase costs for LFL | 24 | 8 | 7 | 7 | 6 | 6 | 0 |
| Additional purchase costs for LED | 756 | 626 | 505 | 408 | 335 | 283 | 247 |
| Additional purchase costs for LED + rewiring | 1,286 | 1,141 | 979 | 843 | 734 | 660 | 611 |
| Additional purchase costs for LED + luminaire replacement | 46,856 | 44,980 | 41,271 | 38,759 | 35,397 | 33,603 | 32,111 |
| Sub-total | 48,922 | 46,755 | 42,763 | 40,017 | 36,473 | 34,552 | 32,969 |
| Energy cost savings | -999 | -2,101 | -3,271 | -4,509 | -5,779 | -7,123 | -8,509 |
| **Total** | 47,923 | 44,653 | 39,492 | 35,508 | 30,694 | 27,429 | 24,459 |

Though in the first years after the implementation of the Oeko-Institut recommendations, the substitution costs are considerable, they quickly begin to decrease. In parallel, the energy cost savings related to the replacement of LFL with LED lamps/luminaires used for replacement increase from year to year (here only the first costs accumulating within a 5 year period are taken into consideration). These rising energy costs further set-off the already decreasing substitution costs and their influence on the total costs shall increase from year to year. It is noted that a further contributor to this process is the rising efficacy (lumen/watt efficiency) of LEDs to come on the market. Lamps placed on the market in the later years shall be more efficient than their predecessors and in this sense; energy savings shall increasingly set-off a larger share of the substitution costs as time goes by. In total, the costs throughout the observed period (2019-2025) amount to around 250 billion EUR while the energy savings amount to ca. 32 billion EUR.

## 5.5. Impacts on consumers (public and private)

To set the various impacts discussed above in perspective, it is worth understanding what the more common uses of LFL lamps are. Where LFL lamps are in use, a large part of consumers are commercial/public consumers using lamps for non-residential purposes, i.e. in the lighting of offices, production halls and to some extent streets. The sale volumes of LFL lamps in the last years already show a significant reduction in their market, a tendency expected to continue as particularly in the non-residential market, a trend towards LED is already underway. In office lighting, luminaire arrays are required to comply with standards related to lighting and its distribution. Nonetheless, a decrease is observed here, which LE (LightingEurope 2017b) explains in part to be related to the shift of non-residential users to new LED luminaires when renovating or designing new spaces.

Where LFL is used in the lighting of offices or of commercial spaces, multiple luminaires of the same type are often owned by the same holder. A regulatory driven phase-out may have heavier impacts on such users as where Plug & Play alternatives are lacking, substitution costs shall be heavier not only per luminaire but also for such consumers who need to replace multiple luminaires at the same time. Though some creativity could be expected where maintenance departments “concentrate” LFL luminaires with operative lamps in certain office spaces and thus manage the LFL luminaire replacement more gradually, it is expected that such consumers shall be more burdened than others. As explained in Section 5.4 some luminaire replacements may include the replacement of ceiling (or walls), especially where installations are built into these building elements. In certain cases, luminaires may also be built into other equipment. Though this is common for special purpose lamps, the production of which may be impacted indirectly by an early decrease in the manufacture of other LFL as described in chapter 7, standard consumer equipment may also be relevant in some cases.

A further aspect which has been raised, however not supported by data, relates to the possible differences in costs for consumers in different EU Member States. Though costs may be similar nominally, the purchasing power of consumers is not similar in all countries. In light of the more common non-residential uses, the main burden would fall on organizations and enterprises faced with a large number of replacements ahead of the specified EoL of luminaires, particularly when this concerns multiple luminaires of a certain consumer.

## 5.6. Impacts on the generation of waste

A further impact of the regulatory driven phase-out that is expected in the SUB scenario in relation to the additional lamps requiring replacement, is related to the amount of waste that could be expected where a Plug & Play substitute is not available. Such cases shall "force" either a rewiring of the luminaire or a complete replacement of the luminaire. On the basis of such cases, an estimation of the additional waste to be generated as a consequence of early substitution was performed. For this purpose the following assumptions have been provided by LE (LightingEurope 2017b) in relation to the average weight of auxiliary parts and luminaires:

- Best case scenario:
  - T8: 2.5 kg per luminaire (scrapped); 0.28 kg for auxiliary parts (rewired)
  - T5: 2.25 kg per luminaire (scrapped); 0.24 kg for auxiliary parts (rewired)
- Worst case scenario:
  - T8: 5.5 kg per luminaire (scrapped); 0.5 kg for auxiliary parts (rewired).
  - T8: 2.5 kg per luminaire (scrapped); 0.3 kg for auxiliary parts (rewired)

In relation to the number of additional luminaries expected to be replaced in the SUB scenario, the following amounts of waste can be expected:

**Table 33 Amounts of additional waste to be generated in the SUB scenario where LFL are substituted with a LED substitute requiring rewiring or where the luminaire is replaced, Thousands of tons**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| **T8 LFL and LL T8 – 1 lamp per luminaire** | | | | | | | |
| Sum of luminaires to be rewired | 15.63 | 14.74 | 13.24 | 11.88 | 10.81 | 10.15 | 9.80 |
| Best case scenario | 4.4 | 4.1 | 3.7 | 3.3 | 3.0 | 2.8 | 2.7 |
| Worst case scenario | 7.8 | 7.4 | 6.6 | 5.9 | 5.4 | 5.1 | 4.9 |
| Sum of luminaires to be replaced | 121.94 | 114.94 | 103.29 | 92.66 | 84.32 | 80.48 | 77.64 |
| Best case scenario | 304.9 | 287.4 | 258.2 | 231.7 | 210.8 | 201.2 | 194.1 |
| Worst case scenario | 853.6 | 804.6 | 723.0 | 648.6 | 590.2 | 563.4 | 543.5 |
| **Total sum T8 – best case** | **309.2** | **291.5** | **261.9** | **235.0** | **213.8** | **204.1** | **196.8** |
| **Total sum T8 – worst case** | **861** | **812** | **730** | **655** | **596** | **568** | **548** |
| **T8 LFL and LL T8 - 2 lamps per luminaire** | | | | | | | |
| Sum of luminaires to be rewired | 7.82 | 7.37 | 6.62 | 5.94 | 5.40 | 5.08 | 4.90 |
| Best case scenario | 2.2 | 2.1 | 1.9 | 1.7 | 1.5 | 1.4 | 1.4 |
| Worst case scenario | 3.9 | 3.7 | 3.3 | 3.0 | 2.7 | 2.5 | 2.4 |
| Sum of luminaires to be replaced | 60.97 | 57.47 | 51.64 | 46.33 | 42.16 | 40.24 | 38.82 |
| Best case scenario | 152.4 | 143.7 | 129.1 | 115.8 | 105.4 | 100.6 | 97.1 |
| Worst case scenario | 426.8 | 402.3 | 361.5 | 324.3 | 295.1 | 281.7 | 271.7 |
| **Total sum T8 – best case** | **154.6** | **145.7** | **131.0** | **117.5** | **106.9** | **102.0** | **98.4** |
| **Total sum T8 – worst case** | **430.7** | **406.0** | **364.8** | **327.3** | **297.8** | **284.2** | **274.2** |
| **T5 LFL, T9s and T12 – 1 lamp per luminaire** | | | | | | | |
| Sum of luminaires to be rewired | 1.68 | 1.68 | 1.61 | 1.55 | 1.43 | 1.31 | 1.24 |
| Best case scenario | 0.4 | 0.4 | 0.4 | 0.4 | 0.3 | 0.3 | 0.3 |
| Worst case scenario | 0.6 | 0.6 | 0.6 | 0.6 | 0.5 | 0.5 | 0.5 |
| Sum of luminaires to be replaced | 53.80 | 53.75 | 51.49 | 52.67 | 48.41 | 45.70 | 42.95 |
| Best case scenario | 121.1 | 120.9 | 115.9 | 118.5 | 108.9 | 102.9 | 96.6 |
| Worst case scenario | 295.9 | 295.6 | 283.2 | 289.7 | 266.3 | 251.3 | 236.1 |
| **Total sum T5 – best case** | **121.5** | **121.3** | **116.2** | **118.9** | **109.3** | **103.1** | **96.9** |
| **Total sum T5 – worst case** | **296.5** | **296.2** | **283.8** | **290.3** | **266.8** | **251.8** | **236.6** |
| **T5 LFL, T9s and T12 – 2.5 lamps per luminaire** | | | | | | | |
| Sum of luminaires to be rewired | 1.67 | 3.38 | 4.98 | 6.53 | 7.96 | 9.26 | 10.51 |
| Best case scenario | 0.4 | 0.8 | 1.2 | 1.6 | 1.9 | 2.2 | 2.5 |
| Worst case scenario | 0.6 | 1.2 | 1.8 | 2.4 | 2.9 | 3.4 | 3.9 |
| Sum of luminaires to be replaced | 53.37 | 108.06 | 159.43 | 211.82 | 260.54 | 304.84 | 348.08 |
| Best case scenario | 120.1 | 243.1 | 358.7 | 476.6 | 586.2 | 685.9 | 783.2 |
| Worst case scenario | 293.5 | 594.3 | 876.9 | 1165.0 | 1433.0 | 1676.6 | 1914.4 |
| **Total sum T5 – best case** | **48.6** | **48.5** | **46.5** | **47.6** | **43.7** | **41.3** | **38.8** |
| **Total sum T5 – worst case** | **118.6** | **118.5** | **113.5** | **116.1** | **106.7** | **100.7** | **94.6** |

To summarize, the SUB scenario can be expected to generate an additional amount of waste related to the rewiring of CFL luminaires and to their replacement. Over the period between 2019 and 2025, this waste is estimated to amount to between 315-1,922 thousand tons for T5 and around 856-4,770 thousand tons for T8, depending on the number of lamps per luminaire and on consumers decision whether to replace once a single lamp malfunctions or when all lamps require replacement. In cases where a luminaire contains multiple lamps and it is scrapped once the first lamp reaches EoL, some additional waste is associated with lamps which were scrapped early (depending on the remaining service life).

While considering the amount of waste generated, it should be taken into account that certain components of EoL luminaires (steel, aluminium, copper, etc.) could serve as a source of secondary materials, if properly collected and recycled.

## 5.7. Impacts on the amounts of mercury to be placed on the EU market

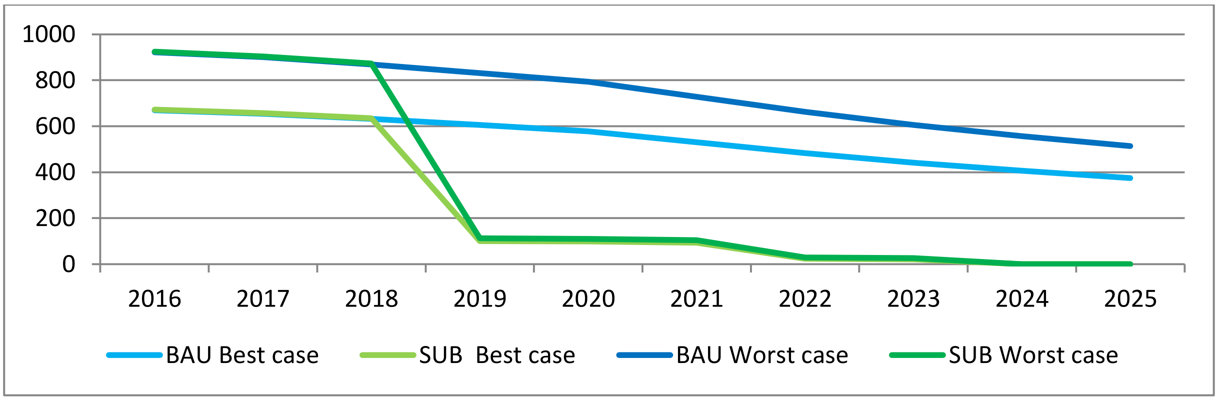
Based on the expected sales forecasted in the MELISA model (VHK 2016) in the period between 2015-2025, an estimation has been made as to the amount of mercury to be placed on the market in each scenario over this period.

For this purpose, it was necessary to determine how much mercury is actually placed on the market through the various CFL lamps. The Directive prescribes Hg thresholds which represent the maximum amounts that can be present in a lamp of a specific input power group (wattage) for it to be permitted on the EU market. LE (LightingEurope 2017b) has suggested to use a 0,5-1,0 mg lower value than the maximum allowed RoHS value for this exercise. They explain that the maximum threshold is needed in light of manufacture variation’s, however that these lower levels reflect the average amounts of hg applied in typical lamps. The various values are specified below in relation to each of the exemption entries.

**Table 34 Mercury thresholds of related to exemption 1(a-e) and the estimated average value based on the LE suggestion, in mg per lamp**

| | Ex. 2(a)(2) – T5 | Ex. 2(a)(3) – T8 | Ex. 2(a)(5) - LL | Ex. 2(b)(3) – T9 |
|---|---|---|---|---|
| Max. Threshold | 3 | 3.5 | 5 | 15 |
| Estimated average | 2 | 2.5 | 4 | 14 |

**Figure 14 Amounts of mercury to be placed on the market through Ex. 2(a)(items 2,3 and 5) and Ex. 2(b)(3) in the BAU and the SUB scenarios, calculation based on LE suggestion (best case) and on maximum allowed thresholds (worst case), in kg per annum**




*Own compilation based on data from (LightingEurope 2017b) (Best case) and on maximum allowed thresholds in the Directive (worst case)*

Assuming the average thresholds specified above, the amount of mercury to come onto the market through LFL lamps in 2015 is around 700 kg. In the period between 2016 and 2018, the increase in sales of LL lamps generates the first difference of 9 kg, in addition to the ~1957 kg Hg placed on the market in both scenarios. This amount is generated in the SUB scenario in light of the additional production. Starting in 2019, the recommendations start to have an influence on the amount of Hg to be placed on the market in the SUB scenario (Ex. 2(a)(2) and 2(a)(3)), in which no further lamps are expected on the market after 2022 and thus also no further mercury. In this respect, between 2019 and 2021, approximately 292 kg are expected to come on to the market through LFL in the SUB scenario, in comparison to approximately 1,714 kg in the BAU scenario. Between 2022 and 2023, the amount of mercury is reduced further in the SUB scenario following the prohibition of lamps covered by Ex. 2(b)(3). In this scenario 44 kg mercury is expected on the market, whereas in the BAU scenario approximately 925 kg shall be placed on the market in this period. Between 2024 and 2025, no further mercury is expected in the SUB scenario in comparison to around 781 kg in the BAU scenario. To summarize, the numbers have been specified in the table below for each of the scenarios. As a sensitivity calculation, results are also provided in relation to the maximum thresholds, representing the estimated "worst case scenario".

To give perspective to the amounts of mercury placed on the market, it should be taken into consideration that based on the data provided by various stakeholders throughout the initial exemption evaluation, it is understood that over half of these amounts are not properly processed as WEEE. Despite an elaborate mechanism for collecting and recycling such lamps, it appears that consumers do not discard off all of LFL lamps properly, and in most Member States the amount collected (and thus also recycled) is below this level. Though 50% may be in line with the WEEE Directive targets, the fate of other lamps is not known and is of concern in relation to potentially non-controlled emissions to the environment.

## 5.8. Analysis and discussion of results

Looking at the results of this evaluation the following aspects should be noted:

In the SUB scenario, the development of **LFL sales** shows a sharp decrease in the sales of T5 and T8 lamps in 2019. Though some sales persist, it is understood that these are sales of LL lamps and of T9 lamps, whereas the T5 and T8 have been phased-out in 2019. To understand this information in context, it is important to compare it with what happens in parallel in the BAU scenario.

Upon looking at T8 lamps, sales are in decrease from the beginning of the observed period (2016). The decrease trend becomes more significant between 2020 and 2022 and then recedes to its initial function. Looking in detail, in 2019, where in the SUB scenario T8 lamps have been phased out – in the BAU scenario T8 sales have also decreased in 5 % in comparison to the year before. In 2021 only 73 % of the residential lamps sold in 2018 and 80 % of the non-residential ones are still to be placed on the market and the trend continues sharply until in 2025, at which time only 42% of the 2018 residential sales and 58% of the non-residential sales are still placed on the market. In this case the development trend is similar for both, residential and non-residential T8 lamps, though more significant for non-residential T8. The T8 restriction appears to accelerate this process of natural phase-out that is already underway.

In the case of T5 the development differs considerably. The sales of T5 still lightly increase until 2020, at which time they also start to decrease, however at a more moderate pace in comparison to the T5. The pace however is mainly a result of the non-residential development. The sales of non-residential T5 in 2019 have only gone down 1 % in relation to 2018. In 2022 the trend has grown somewhat and sales are 89 % of those of 2018. Nonetheless, at the end of the period (2025), the non-residential sales are already down to 66 % of the 2018 sales. In the residential sector the trend is more rapid, though this needs to be observed with caution as the market share of residential T5 is relatively small (only 0.07 % of all LFL in 2018). In 2019, sales comprise of 60 % of those of the year before. At the end of the period, only 17 % of the 2018 sales of T5 are still placed on the residential market.

To summarise, though the SUB phase-out can be considered a partial acceleration of a phase-out already expected for T8 lamps and also for T5 residential lamps, for T5 non-residential lamps this phase-out is developing much more slowly.

The expected change in sales can be expected to reflect also in the **stock** of the different lamp types, though with a certain level of delay which is a result of the long service life time of lamps. Looking at all lamps, only a slight decrease in stock is observed, with the 2025 still accounting for 96 % of the 2018 lamps. Here too however, this trend differs for the various sub-groups. The stock of both the residential sub-groups (T5 and T8) is slightly higher in 2025 than in 2018 (by 6 % and 8 % respectively). In the T8 non-residential sub-group an 8 % reduction can already be observed in 2025, however for T5 non-residential the trend is just beginning, with the 2025 stock accounting for 99% of the 2018 stock. For T5, the trend is assumed to be a result of the current T5 lamps being a relatively new and more efficient technology compared to T8, which also has longer service lives for both segments. Here a natural reduction in stock can only be assumed to begin in the longer term.

In light of the differences in the market development, the comparison of lamps to be replaced is important to understand how the additional costs associated with regulatory driven phase-out in the SUB scenario compare with the inevitable costs of natural phase-out to incur in both scenarios. The number of lamps reaching EoL in both scenarios is a first point of reference. Where consumption remains constant, it can be expected that the number remains more or less the same from year to year. Where a decrease is observed, LFL lamps are being replaced for other lamps, in some cases meaning that the luminaire shall also be replaced. Table 35 shows the development of the number of lamps to be replaced in both scenarios (natural replacement) and additionally in the SUB scenario as well as the share of SUB replacements from all replacements.

**Table 35 Comparison of LFL "natural" replacements in both scenarios and "regulatory driven" replacements in SUB scenario**

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|
| **Natural BAU and SUB replacements - LFL** | 213 | 209 | 204 | 197 | 191 | 187 | 185 | 185 |
| **Regulatory driven SUB replacements – LFL** | -1 | 214 | 203 | 186 | 174 | 158 | 151 | 139 |
| **SUB/(BAU+SUB) replacements - LFL** | 0% | 51% | 50% | 49% | 48% | 46% | 45% | 43% |
| **Natural BAU and SUB replacements – T8** | 164 | 157 | 148 | 140 | 133 | 130 | 128 | 129 |
| **Regulatory driven SUB replacements – T8** | 0 | 157 | 147 | 132 | 119 | 108 | 103 | 97 |
| **SUB/(BAU+SUB) replacements - T8** | 0% | 50% | 50% | 49% | 47% | 45% | 45% | 43% |
| **Natural BAU and SUB replacements – T5** | 48 | 53 | 56 | 57 | 58 | 58 | 57 | 56 |
| **Regulatory driven SUB replacements – T5** | 0 | 57 | 56 | 54 | 55 | 50 | 48 | 43 |
| **SUB/(BAU+SUB) replacements - T5** | -1% | 52% | 50% | 48% | 49% | 47% | 46% | 43% |

The negative numbers in 2018 represent the increase in manufacture of LL lamps. Regardless of the sub-group observed (all LFLs, T8, T5), in the first year after the restriction, the additional replacements in the SUB scenario account for around half of the total replacements (natural + regulatory driven). However as time goes by the share of lamps to be replaced from year to year in the SUB scenario decreases to some degree, where part of the replacement is regulatory driven. In parallel natural phase-outs, understood to be voluntary in both scenarios, show a small increase for all LFL and for T8 lamps, while remaining steady for T5. In other words, natural phase-out for T5 has not yet begun, whereas for T8 there is a steady growth in the number of T8s to undergo replacement naturally. This may suggest that the substitute availability for T8 lamps is larger, as is true in relation to LED replacement lamps (some being Plug & Play and some requiring rewiring) and it can also be expected that some luminaires are to be replaced. However, it is surprising that natural luminaire replacement does not seem to play a role for T5. A possible explanation for this may be that T5 lamps in their newer and more efficient form have only started to come on the market around 2002, partially as a more energy efficient substitute for T8 lamps, steadily increasing in sales in the first five years or so. Though before this period, other, less efficient lamp types than T5, were placed on the market, it is possible that this shift also included a larger replacement of luminaires in some cases (for example where users replaced other lamp types such as T8 with the more efficient T5). If luminaires are still relatively new (in use 15 years and less), this could explain why voluntary replacement is less likely for T5 lamps in general, where Plug & Play alternatives are mostly unavailable and where availability of LED replacements for rewiring is also expected to be significantly smaller than for T8. On this basis, it can be concluded that for T8 a natural phase-out is underway, even though still in earlier stages than the natural phase-out of CFL. For T5 this does not appear to be the case. For various reasons it seems that the phase-out is yet to start here and it is difficult to say when this can be expected at a level understood to be significant (20% and up).

The availability of alternatives to each of the two lamp-subgroups, and particularly of those which are less cost demanding (Plug & Play, LL LFL and rewiring replacements) has a large impact on the total costs of replacement. The mere comparison of lamps to be replaced and the respective costs does not suggest significant differences between T5 and T8 lamps. However, looking at the respective average replacement costs at the per lamp level shows differences.

**Table 36 Comparison of total costs and per lamp costs of replacement between T8 and T5 lamps**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| T8 lamps to be replaced, millions of lamps | 157.25 | 147.39 | 132.46 | 118.83 | 108.13 | 103.07 | 96.66 |
| Total replacement costs, million EUR | 33,525 | 30,446 | 26,094 | 22,036 | 18,618 | 15,787 | 13,866 |
| Costs per T8 lamp, EUR | 213.2 | 206.6 | 197.0 | 185.4 | 172.2 | 153.2 | 143.5 |
| T5 lamps to be replaced, millions of lamps | 56.57 | 55.99 | 53.65 | 54.79 | 50.36 | 47.70 | 42.73 |
| Total replacement costs, million EUR | 14,399 | 14,207 | 13,398 | 12,278 | 10,979 | 9,589 | 8,731 |
| Costs per T5 lamp, EUR | 254.5 | 253.7 | 249.7 | 224.1 | 218.0 | 201.1 | 204.3 |

The total costs of replacement for ca. 864 million lamps over the period between 2019 and 2025 are estimated at ~160, 370 million EUR. For T5, the replacement of ca. 361 million lamps is to cost a total of 83,580 million EUR over the same period. Though the T5 lamps comprise only about 42 % of the T8 lamp volume, their cost of replacement comprises over half the costs related to the T8 lamps (52 %). On the lamp level, the average replacement cost of a T8 lamp amounts to an average of 186 EUR for the period between 2019 and 2025, whereas the parallel cost for T5 is 231 EUR, i.e. replacements shall require almost 25 % higher costs.

In terms of testing the sensitivity of the estimated replacement costs to changes in the choice of substitution route, the following aspects need to be noted:

- The number of T8 and T5 lamps to be replaced with longlife lamps of the same dimensions may seem conservative, based on the manufacture of 10% more LL lamps in relation to the BAU scenario. However without certainty as to the future of the exemption, it is not likely that the lighting industry would decide to invest in the manufacture of additional types of LL lamps to be used as replacement for the larger range of T8 and T5 lamps to be phased-out. The 10% number assumes that manufacture shall increase where lamps may be suitable as replacements in terms of their dimensions and electrical compatibility; however development of further models is excluded and seems quite unlikely in light of the expected developments of LEDs and the resources that have already been directed for its facilitation. Thus no sensitivity testing has been undertaken in relation to this route.
- LED Plug and Play replacements and LED replacements that require rewiring – it can be understood that the development of LED substitutes of this type has focused on the development of T8 alternatives. This strategy has probably been chosen by industry for a number of reasons. First of all T8 lamps are less efficient in terms of energy consumption in comparison to T5 lamps on the one side and their current market volume is also much larger (i.e. the potential for replacement sales). In 2016, ca. 170 million T8 are expected to reach EoL in both scenarios, in comparison to only ca. 37 million T5 lamps. In other words, even if substitute availability were the same, the potential for sales of LED replacements for T8 lamps would be higher.

Furthermore, in relation to efficiency, in 2014, LED replacements were already 15% more efficient in terms of luminous efficacy (lumens/watt) than T8 lamps but more or less equivalent with T5 lamps. Though LED efficiency is rising quickly (see Table 37 below) the difference of energy saving potential between T5 and T8 remains and thus targeting the less efficient lamps is also logical as (commercial) consumers who shift to LED shall usually be looking for a potential to save on energy costs. This also supports a slower development of LED alternatives for T9 and LL lamps. In this respect, the assumptions presented in Table 22 as to the chosen route for replacement are assumed to be adequate for T5, T9 and LL lamps. For T8 lamps, it is possible that the availability assumed for Plug and Play and rewired replacements may be conservative (12 % and 10 %, respectively). Sensitivity testing of this aspect is detailed below.

- The share of lamps to be replaced with LED luminaires in the SUB scenario is a direct result of the share of Plug & Play and rewired replacements available. Thus only the sensitivity of changes to the T8 share has been undertaken.

**Table 37 Comparison of LED LFL replacement lamp luminous efficacy with that of T8 and T5 lamps: values represent the luminous efficacy of replacement LEDs for the specified lamp type in a certain year in relation to the LFL being replaced**

| | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **T8 Res.** | 115% | 125% | 128% | 131% | 137% | 144% | 150% | 151% | 151% | 152% | 152% | 153% |
| **T8 N. Res.** | 111% | 137% | 155% | 174% | 188% | 199% | 208% | 219% | 229% | 235% | 241% | 247% |
| **T5 Res.** | 101% | 110% | 112% | 115% | 121% | 126% | 132% | 132% | 133% | 133% | 134% | 134% |
| **T5 N. Res.** | 101% | 125% | 142% | 159% | 172% | 182% | 190% | 200% | 209% | 215% | 220% | 226% |

*Calculated based on (VHK 2016)*

To test the sensitivity of replacement costs to a change in the share of lamps to be replaced with a Plug & Play LED or with an LED requiring rewiring, it has been assumed that such lamps account for 50% of all lamps to be replaced. The exact changes to the assumptions are as follows:

- It is assumed that a Plug and Play alternative is available for 22% of all lamps to be replaced (in comparison with 12 % in the original estimation);
- It is assumed that a LED alternative requiring rewiring is available for 28% of all lamps to be replaced (in comparison with 10 % in the original estimation).
- It is assumed that 50 % of lamps to be replaced shall result in a replacement of the luminaire (in comparison with 78 % in the original estimation).

Table 38 shows the sensitivity analysis of the replacement costs to changes in the distribution of replacement route. The increased availability of Plug & Play and rewiring substitutes results in a decrease of 32 % in the total costs of replacement within the observed period (2019-2025).

**Table 38 Sensitivity of estimated costs to changes in the share of LED replacements available for substituting T8 lamps, million EUR (costs presented only for T8 segment), including VAT for residential and excluding for non-residential**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| **Initial estimations (12%:10 %:78%)** | | | | | | | |
| **Costs LL replacement** | 15 | 5 | 4 | 4 | 3 | 3 | - |
| **Costs Plug & Play replacement** | 732 | 606 | 488 | 392 | 322 | 271 | 236 |
| **Cost of rewiring replacements** | 1,157 | 1,020 | 870 | 743 | 647 | 577 | 536 |
| **Cost of luminaire replacements** | 32,488 | 30,625 | 27,520 | 24,691 | 22,468 | 20,842 | 20,122 |
| **Total costs of initial estimations** | 34,393 | 32,255 | 28,882 | 25,830 | 23,440 | 21,693 | 20,894 |
| | | | Total for 2019-2025: | | | 187,388 million EUR | |
| **Revised estimations (22%:28%: 50%)** | | | | | | | |
| **Costs LL replacement** | 15 | 5 | 4 | 4 | 3 | 3 | - |
| **Costs Plug & Play replacement** | 1,343 | 1,110 | 894 | 719 | 590 | 497 | 434 |
| **Cost of rewiring replacements** | 3,241 | 2,857 | 2,436 | 2,079 | 1,810 | 1,616 | 1,501 |
| **Cost of luminaire replacements** | 20,826 | 19,631 | 17,641 | 15,828 | 14,403 | 13,360 | 12,899 |
| **Total costs of revised estimations** | 25,424 | 23,603 | 20,975 | 18,630 | 16,807 | 15,477 | 14,833 |
| | | | Total for 2019-2025: | | | 135,749 million EUR | |

*Note: In both cases replacement lamp costs vary from year to year, rewiring costs are estimated at 10 EUR/luminaire and luminaire replacement costs at 250 EUR/luminaire. Labour costs for rewiring or luminaire replacement are estimated to be 25 EUR (half an hour per luminaire.*

The second factor of importance for the estimation of replacement costs is related to the price of LED replacement lamps, of LED lamp rewiring and of LED luminaire replacement (including costs of components as well as of labour). In the initial estimation (hereinafter the “luminaire high” estimation), it was assumed that the cost of auxiliary parts needed for rewiring are 10 EUR per lamp to be replaced; the costs of replacing a luminaire are 250 EUR and the costs of labour (half an hour per lamp) 25 EUR. The cost of LED replacement lamps was based on the dynamic costs given in the MELISA Model (VHK 2016). To test the sensitivity of the replacement costs to the costs of various replacement elements, a further estimation has been performed in relation to the cost of luminaires, which can vary largely. For orientation, prices to be found on the internet for office ceiling lighting in which LED LFL can be used were found between ca. 50 EUR and 200 EUR, though it is plausible that higher prices are also relevant depending on design and quality. Thus reductions of luminaire costs to 150 EUR per luminaire (hereinafter the “luminaire moderate” estimation) and to 75 EUR per luminaire (hereinafter the “luminaire low” estimation) and their impact on the total costs of replacement, have been calculated and are represented below.

Finally, costs specified in the MELISA model (VHK 2016) for LED replacement luminaires were applied to the calculation. These costs are significantly lower than those used in the other calculations and differ for residential and non-residential luminaires. Other costs related to the various substitution routes remain unchanged (lamp prices, auxiliary equipment, labour).

**Table 39 Comparison of rewiring and luminaire replacement costs in the SUB scenario based on differing equipment costs, millions of EUR, including VAT for residential and excluding for non-residential**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | Total |
|---|---|---|---|---|---|---|---|---|
| **Luminaire High Estimation (35-275 EUR per replacement, depending on route)** | | | | | | | | |
| Initial rewiring | 1,286 | 1,141 | 979 | 843 | 734 | 660 | 611 | 6,254 |
| Luminaire High replacement | 46,856 | 44,980 | 41,271 | 38,759 | 35,397 | 33,603 | 32,111 | 272,977 |
| **Initial Total** | **48,922** | **46,755** | **42,763** | **40,017** | **36,473** | **34,552** | **32,969** | **282,450** |
| **Luminaire Moderate estimation (35-200 EUR per replacement, depending on route)** | | | | | | | | |
| Initial rewiring | 1,286 | 1,141 | 979 | 843 | 734 | 660 | 611 | 6,254 |
| Luminaire Moderate replacement | 29,282 | 28,110 | 25,794 | 24,225 | 22,124 | 20,985 | 20,053 | 170,574 |
| **Moderate Total** | **31,348** | **29,885** | **27,285** | **25,483** | **23,200** | **21,934** | **20,911** | **180,047** |
| **Luminaire Low Estimation (35-100 EUR per replacement, depending on route)** | | | | | | | | |
| Initial rewiring | 1,286 | 1,141 | 979 | 843 | 734 | 660 | 611 | 6,254 |
| Luminaire Low replacement | 16,101 | 15,458 | 14,185 | 13,325 | 12,170 | 11,521 | 11,010 | 93,771 |
| **Low Total** | **18,168** | **17,233** | **15,677** | **14,582** | **13,245** | **12,470** | **11,868** | **103,244** |
| **Luminaire (VHK 2016) Estimation for luminaire prices (varying depending on year and residential/non-residential)** | | | | | | | | |
| Initial rewiring | 1,286 | 1,141 | 979 | 843 | 734 | 660 | 611 | 6,254 |
| Luminaire VHK replacement | 10,530 | 9,351 | 8,052 | 7,143 | 6,206 | 5,608 | 5,140 | 52,030 |
| **Low Total** | **12,596** | **11,126** | **9,544** | **8,401** | **7,281** | **6,558** | **5,998** | **61,503** |

It is apparent that the actual cost of luminaires has a very significant impact on the total replacement costs. It should be noted that the initial cost used of 250 EUR per luminaire based on an LE estimation is understood to leave room for additional costs that may be related with luminaire replacement such as ceiling replacement where luminaires have been built into the ceiling. Nonetheless, it needs to be assumed that not all of replacements shall require a replacement of the ceiling, whereas in some cases the user may decide to renovate spaces in which luminaires are to be replaced, in which case not all costs should be attributed to the replacement of lighting. In this respect, though the "Low" estimation is probably an underestimation (total costs decrease to ca. 37 % of the "High" variant), it is plausible that actual costs may be in between the "High" and the "Moderate" estimations (total costs decrease to ca. 64 % of the "High" variant). The application of the (VHK 2016) values results in a 78 % reduction of the costs originally estimated and is in this sense particularly low. Nonetheless, the VHK model and its values were developed in close involvement of stakeholders. Though it can be understood that different stakeholders may have differing views as to various market aspects represented therein, it is also understood that the model and its values have been greeted with a wide acceptance by stakeholders. In this sense, the VHK values are to be considered to be within an acceptable range for most stakeholders, suggesting that the other estimations made in this study are to be viewed as conservative in nature.

To further check the sensitivity of the moderate alternative, moderate luminaire costs are coupled with the revised estimations of the distribution of lamps to be replaced according to their replacement route discussed above (22%:28 %:50% - Plug & Play, rewiring and luminaire replacement respectively). The results thereof (annual costs for each substitution route and in total) are presented in Table 40, compared to the results (only annual totals) for the two scenarios compared for the replacement distribution in Table 38, above.

**Table 40 Sensitivity of estimated costs to changes in the share of LED replacements available for substituting T8 lamps coupled with changes to cost of replacement luminaire, million EUR, Annual costs presented for all substitution routes and total and compared to total annual costs of distribution estimations analysed and detailed above, including VAT for residential and excluding for non-residential**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| **Moderate luminaire price coupled with revised replacement distribution estimations (22%: 28%: 50%)** | | | | | | | |
| **Costs LFL replacement** | 24 | 8 | 7 | 7 | 6 | 6 | 0 |
| **Costs Plug & Play replacement** | 1,366 | 1,131 | 912 | 735 | 603 | 510 | 444 |
| **Cost of rewiring replacements** | 3,370 | 2,978 | 2,545 | 2,179 | 1,898 | 1,699 | 1,576 |
| **Cost of luminaire replacements** | 21,997 | 21,243 | 19,623 | 18,688 | 17,086 | 16,311 | 15,541 |
| **Total costs of initial estimations** | 26,757 | 25,359 | 23,086 | 21,609 | 19,593 | 18,525 | 17,561 |
| | | | | | Total: | 152,490 | million EUR |
| **Initial estimations (12%: 10%: 78)** | | | | | | | |
| **Total costs of revised estimations** | 48,922 | 46,755 | 42,763 | 40,017 | 36,473 | 34,552 | 32,969 |
| | | | | | Total: | 282,450 | million EUR |
| **Revised estimation (12%: 10%: 78)** Revised estimations (22%: 28%: 50%) | | | | | | | |
| **Total costs of revised estimations** | 39,954 | 38,103 | 34,856 | 32,817 | 29,839 | 28,335 | 26,907 |
| | | | | | Total: | 230,811 | million EUR |

An increase in the share of Plug & Play and rewiring replacements coupled with the lower cost of replacement luminaires results in a significant reduction of the total costs of the regulatory driven phase-out. The total costs are only 54 % of the costs expected in the initially calculated SUB scenario. Though the change to the costs of luminaires has a significant impact on the replacement costs of all LFLs (T5, T8, T9 and LL alike) the additional assumption that a larger share of T8 lamps could be replaced with Plug & Play LEDs, retaining the original luminaire, reduces the total costs further. Though this distribution of replacement routes may not represent the actual availability of substitutes in 2017, it can be anticipated that the actual availability of substitutes shall develop over the observed period, reducing the costs of substitution per lamp over time. Though the revised estimations regarding the availability of substitutes may result in an underestimation of costs when used for the complete period, it seems viable that costs of substitution per lamp decrease throughout the observed period.

These results should be observed against the background that a natural phase-out is starting for T8 lamps (by the end of the observed period 6 % of the lamp stock to have been naturally phased out, while sales have gone down in 44 %), whereas for T5 lamps the natural phase-out appears to only begin. Though for T8 lamps the availability of substitutes is constantly developing, for T5 lamps this development could take longer, leading to a larger share of lamps being replaced by new luminaires in the SUB Scenario. For T8 and T5 lamps it is of importance to consider these costs against the comparison of the changing lamp efficacies presented in Table 37. Though in both cases, the improvement of LED LFL lamp efficacies is expected to increase over the next few years, this change is more significant for LED designed as substitute for T8 lamps than for T5 LED substitutes. The LFL phase-out in the SUB scenario can be considered to advance the costs of this phase-out by more than just a few years (such as in the case of CFL). However, it shall also advance benefits related to the improving LED lamp efficacy that should not be disregarded.

For LL lamps it is possible that the availability of substitutes shall be more similar to that of their normal life counterparts – LED modules can generally provide longer service lives and it is usually the quality of the surrounding components that later determines the actual product life time. In this respect, though the assembly of substitute lamps for LL T8 may need to be of higher quality to ensure longer service life, this should be feasible. For LL T5 a lack of available lamp substitutes could be expected, leading to a larger share of luminaire replacements in the SUB scenario. Related costs can be expected to be relevant mainly in the non-residential sector in which the use of such lamps is understood to be more common than in the residential scenario.

As for T9 lamps, here it is difficult to assume what the actual availability of substitute lamps is. A search for such lamps at internet based retailers shows that some LED substitutes are available, however it is not clear how they correspond with the actual variety of lamps covered by Ex. 2(b)(3). In this sense, though the actual availability may be larger than the assumed share (1% for Plug & Play and 1% for lamps to be rewired), it is plausible that a large share of lamps shall still require a luminaire replacement.

To summarise, the various costs and benefits (monetary and non-monetary) are detailed against each other in the table below, also providing detail as to the sensitivity of results where this has been explored. Of interest in this comparison is the understanding that with the decrease in luminaire costs, the time needed for electricity savings to start covering the costs of substitution decreases. In the "Luminaire Low" variant at the end of the observed period (2025), the annual substitution costs (11.868 million EUR) have decreased to a level that is already approaching the annual energy savings (8.453 million EUR in 2025). In this scenario, energy savings can be expected to start setting off substitution costs within the next few years following 2025.

**Table 41 Summary of lamps affected and costs and benefits related to LFL regulatory driven substitution in SUB (monetary and non-monetary), units noted in the left column**

Worst case estimations are marked with red, best case estimations with green. Cost benefit estimations are all in relation to regulatory driven phase-out of lamps in SUB scenario. Per capita results appear in blue script.

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| **Lamps to be replaced naturally in BAU & SUB, millions of lamps** | **209** | **204** | **197** | **191** | **187** | **185** | **185** |
| Lamps to be replaced naturally in BAU and SUB, lamps per capita | 0.41 | 0.40 | 0.38 | 0.37 | 0.36 | 0.36 | 0.36 |
| T8 to be replaced naturally in BAU and SUB, millions of lamps | 157 | 148 | 140 | 133 | 130 | 128 | 129 |
| T5 to be replaced naturally in BAU and SUB, millions of lamps | 53 | 56 | 57 | 58 | 58 | 57 | 56 |
| **Regulatory driven phase-out of lamps in SUB, millions of lamps** | **214** | **203** | **186** | **174** | **158** | **151** | **139** |
| Lamps to be replaced naturally in BAU and SUB, lamps per capita | 0.42 | 0.40 | 0.36 | 0.34 | 0.31 | 0.29 | 0.27 |
| Regulatory driven phase-out of T8 in SUB, millions of lamps | 157 | 147 | 132 | 119 | 108 | 103 | 97 |
| Regulatory driven phase-out of T5 in SUB, millions of lamps | 57 | 56 | 54 | 55 | 50 | 48 | 43 |
| Replacement costs (luminaire high; 12%:10%:78%), millions of EUR | 48,922 | 46,755 | 42,763 | 40,017 | 36,473 | 34,552 | 32,969 |
| Replacement costs (luminaire high; 12%:10%:78%), EUR per capita | 95.62 | 91.23 | 83.35 | 77.90 | 70.92 | 67.11 | 63.96 |
| Replacement costs (luminaire moderate; 12%:10%:78%), millions of EUR | 18,168 | 17,233 | 15,677 | 14,582 | 13,245 | 12,470 | 11,868 |
| Replacement costs (luminaire moderate; 12%:10%:78%), EUR per capita | 35.51 | 33.63 | 30.56 | 28.39 | 25.76 | 24.22 | 23.02 |
| Replacement costs (luminaire low; 12%:10%:78%), millions of EUR | 31,348 | 29,885 | 27,285 | 25,483 | 23,200 | 21,934 | 20,911 |
| Replacement costs (luminaire low; 12%:10%:78%), EUR per capita | 61.27 | 58.32 | 53.18 | 49.61 | 45.11 | 42.60 | 40.57 |
| Replacement costs (luminaire VHK; 12%:10%:78%), millions of EUR | 12,596 | 11,126 | 9,544 | 8,401 | 7,281 | 6,558 | 5,998 |
| Replacement costs (luminaire VHK; 12%:10%:78%), EUR per capita | 24.62 | 21.71 | 18.60 | 16.35 | 14.16 | 12.74 | 11.64 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Replacement costs (luminaire high; 22%:28%:50%), millions of EUR | 39,954 | 38,103 | 34,856 | 32,817 | 29,839 | 28,335 | 26,907 |
| Replacement costs (luminaire high; 22%:28%:50%), EUR per capita | 78.09 | 74.35 | 67.94 | 63.89 | 58.02 | 55.03 | 52.20 |
| Replacement costs (luminaire moderate; 22%:28%:50%), millions of EUR | 26,757 | 25,359 | 23,086 | 21,609 | 19,593 | 18,525 | 17,561 |
| Replacement costs (luminaire moderate; 22%:28%:50%), EUR per capita | 52.30 | 49.48 | 45.00 | 42.07 | 38.10 | 35.98 | 34.07 |
| **Energy cost savings, millions of EUR** | **-994** | **-2,090** | **-3,253** | **-4,481** | **-5,742** | **-7,076** | **-8,453** |
| Energy cost savings, EUR per capita | -1.94 | -4.08 | -6.34 | -8.72 | -11.17 | -13.74 | -16.40 |
| **Net monetary benefit (high; 12%:10%:78%), millions of EUR** | **47,928** | **44,665** | **39,510** | **35,535** | **30,731** | **27,476** | **24,516** |
| **Net monetary benefit (high; 12%:10%:78%), EUR per capita** | **93.68** | **87.15** | **77.01** | **69.18** | **59.75** | **53.36** | **47.56** |
| T8 share thereof, millions of EUR | 33,525 | 30,446 | 26,094 | 22,036 | 18,618 | 15,787 | 13,866 |
| T5 share thereof, millions of EUR | 14,404 | 14,218 | 13,416 | 12,306 | 11,016 | 9,636 | 8,788 |
| **Net monetary benefit (moderate; 12%:10%:78%), millions of EUR** | **30,349** | **27,784** | **24,014** | **20,974** | **17,421** | **14,811** | **12,402** |
| **Net monetary benefit (low; 12%:10%:78%), millions of EUR** | **17,169** | **15,132** | **12,406** | **10,074** | **7,466** | **5,347** | **3,359** |
| **Net monetary benefit (VHK; 12%:10%:78%), millions of EUR** | **11,597** | **9,024** | **6,272** | **3,892** | **1,502** | **-565** | **-2,511** |
| **Net monetary benefit (high; 22%:28%:50%), millions of EUR** | **38,955** | **36,001** | **31,585** | **28,308** | **24,060** | **21,212** | **18,398** |
| **Net monetary benefit (moderate; 22%:28%:50%), millions of EUR** | **25,758** | **23,258** | **19,815** | **17,101** | **13,814** | **11,402** | **9,051** |
| Additional WEEE, T8 Worst case, 1 lamp, millions of Kg | 861 | 812 | 730 | 655 | 596 | 568 | 548 |
| Additional WEEE, T8 Worst case, 1 lamp, Kg per capita | 1.68 | 1.59 | 1.43 | 1.28 | 1.16 | 1.11 | 1.07 |
| Additional WEEE, T5 Worst case, 1 lamp, millions of Kg | 296.5 | 296.2 | 283.8 | 290.3 | 266.8 | 251.9 | 236.6 |
| Additional WEEE, T5 Worst case, 1 lamp, Kg per capita | 0.58 | 0.58 | 0.55 | 0.57 | 0.52 | 0.49 | 0.46 |
| Additional WEEE, T8 Best case, 1 lamp, millions of Kg | 309.2 | 291.5 | 261.9 | 235.0 | 213.8 | 204.1 | 196.8 |
| Additional WEEE, T8 Best case, 1 lamp, Kg per capita | 0.60 | 0.57 | 0.51 | 0.46 | 0.42 | 0.40 | 0.38 |
| Additional WEEE, T5 Best case, 1 lamp, millions of Kg | 121.5 | 121.3 | 116.2 | 118.9 | 109.3 | 103.2 | 96.9 |
| Additional WEEE, T5 Best case, 1 lamp, Kg per capita | 0.24 | 0.24 | 0.23 | 0.23 | 0.21 | 0.20 | 0.19 |
| Additional WEEE, T8 Worst case, 2 lamps, millions of Kg | 430.7 | 406.0 | 364.8 | 327.3 | 297.8 | 284.2 | 274.2 |
| Additional WEEE, T8 Worst case, 2 lamps, Kg per capita | 0.84 | 0.79 | 0.71 | 0.64 | 0.58 | 0.55 | 0.53 |
| Additional WEEE, T5 Worst case, 2.5 lamps millions of Kg | 118.6 | 118.5 | 113.5 | 116.1 | 106.7 | 100.8 | 94.7 |
| Additional WEEE, T5 Worst case, 2.5 lamps, Kg per capita | 0.23 | 0.23 | 0.22 | 0.23 | 0.21 | 0.20 | 0.18 |
| Additional WEEE, T8 Best case, 2 lamps, millions of Kg | 154.6 | 145.7 | 131.0 | 117.5 | 106.9 | 102.0 | 98.4 |
| Additional WEEE, T8 Best case, 2 lamps, Kg per capita | 0.30 | 0.28 | 0.26 | 0.23 | 0.21 | 0.20 | 0.19 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Additional WEEE, T5 Best case, 2.5 lamps millions of Kg | 48.6 | 48.5 | 46.5 | 47.6 | 43.7 | 41.3 | 38.8 |
| Additional WEEE, T5 Best case, 2.5 lamps, Kg per capita | 0.09 | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 | 0.08 |
| Total Hg placed on the market, BAU, LE estimation, Kg | 605 | 578 | 531 | 483 | 441 | 406 | 375 |
| Total Hg placed on the market, SUB, LE estimation, Kg | 100 | 98 | 93 | 23 | 21 | 0 | 0 |
| **Avoided Hg, LE estimation, Kg** | **505** | **479** | **437** | **460** | **420** | **406** | **375** |
| **Avoided Hg, LE estimation, mg per capita** | 0.99 | 0.94 | 0.85 | 0.90 | 0.82 | 0.79 | 0.73 |
| Total Hg placed on the market, BAU, RoHS threshold estimation, Kg | 832 | 793 | 728 | 663 | 605 | 557 | 514 |
| Total Hg placed on the market, SUB, RoHS threshold estimation, Kg | 113 | 110 | 104 | 29 | 26 | 0 | 0 |
| **Avoided Hg, RoHS threshold estimation, Kg** | **719** | **683** | **624** | **634** | **579** | **557** | **514** |
| **Avoided Hg, RoHS threshold estimation, mg per capita** | 1.41 | 1.33 | 1.22 | 1.23 | 1.13 | 1.08 | 1.00 |
| **Rough estimation of job losses in the lighting sector T5** | Estimated by LE as 2,850 jobs in total (for the duration of the phase-out) | | | | | | |
| **Rough estimation of job losses in the lighting sector T8** | Estimated by LE as 8,050 jobs in total (for the duration of the phase-out) | | | | | | |
| **Rough estimation of additional electrician jobs to support LFL phase-out** | 54,845 | 52,588 | 48,190 | 45,105 | 41,183 | 39,104 | 37,390 |

# 6. High pressure sodium lamps – General purpose lighting

## 6.1. Exemptions in the scope of this section

This chapter covers impacts related to exemptions 4(b)(I-III) and 4(c)(III) specified below for the use of mercury in high pressure sodium (HPS) lamps.

Ex. 4(b): Mercury in High Pressure Sodium (vapour) lamps for general lighting purposes not exceeding (per burner) in lamps with improved colour rendering index Ra > 60:

I) P ≤ 155 W: 30 mg may be used per burner after 31.12.2011

II) 155 W < P ≤ 405 W: 40 mg may be used per burner after 31.12.2011

III) P > 405 W: 40 mg may be used per burner after 31.12.2011

Ex. 4(c): Mercury in other High Pressure Sodium (vapour) lamps for general lighting purposes not exceeding (per burner):

I) P ≤ 155 W: 25 mg may be used per burner after 31.12.2011

II) 155 W < P ≤ 405 W: 30 mg may be used per burner after 31.12.2011

III) P > 405 W: 40 mg may be used per burner after 31.12.2011

The main impacts are expected in relation to some of the lamps falling under Ex. 4(c). The recommendations for this exemption suggested reducing the mercury thresholds specified for each of the three items. As shall be demonstrated in the next sections, it can be understood that for two of the exemption items, the recommended thresholds are sufficient in relation to the amounts of mercury present in relevant products placed on the market, and shall not result in a regulatory driven substitution of HPS lamps. In contrast, the limit for one of the items is not suitable for all lamps covered by this item and is expected to result in a regulatory driven phase-out for some of the lamps.

As for exemption 4(b), the recommended changes to the formulations are understood to correspond to the actual changes on the market, in which lamps of one of the items have become obsolete. As confirmed by LightingEurope, impacts are not expected in relation to this exemption, neither directly nor in the form of spillover effects.

As for other spillover effects, significant changes to the manufacture of certain lamps can only be expected to affect the manufacture of other lamps of the same technology where the directly affected lamps have a share that is significant enough to change the economic feasibility of manufacture. In this sense, depending on the range of magnitude of possible impacts for lamps of Ex. 4(c), some spillover impacts could be expected for HPS lamps covered by other exemptions (i.e. Ex. 4(f)), however these shall be discussed in chapter 7.

Against this background, the chapter focuses on impacts related to Ex. 4(c) in the two scenarios.

## 6.2. Expected market development in each of the scenarios

As explained above, the recommended changes to Ex. 4(c) concern the mercury thresholds specified for the various exemption items and respectively for the different power supply ranges that each of these items relates to. As the recommended change to this exemption does not restrict the placing on the market of HPS lamps per se, but only the amount of mercury that can be present in such lamps, it is apparent that a regulatory driven phase-out is only to be expected for lamps that would not comply with the new thresholds. Thus, it is important as a first step to understand the differences between the exemptions in each of the scenarios and in the relevant time line in order to understand differences in the subsequent market development. Table 42 thus presents the mercury thresholds relevant to the exemption items and how they correspond to the two scenarios.

**Table 42 Mercury thresholds of Ex. 4(c) items and their correspondence to the two scenarios (Hg-limits per lamp)**

| Hg limits | I: P ≤ 155 W | II: 155 W< P ≤ 405 W | III: P > 405 W | Scenario relevance |
|---|---|---|---|---|
| 4(c) before Sept. 2018 | 25 mg | 30 mg | 40 mg | BAU: 2014-2025<br>SUB 2014-Sept. 2018 |
| 4(c) after Sept. 2018 | 20 mg | 20 mg | 25 mg | SUB Sept. 2018-2025 |

In relation to the thresholds recommended for implementation in September 2018, LE stated (LightingEurope 2017b): "*We agree with the consultants' proposal for the current 4(c)I and 4(c)III categories, which represents the vast majority of the HPS lamps placed on the market in the EU. For the current 4(c)II category (155 W <P<405 W) we ask for a mercury limit of 25 mg*."

In this respect it can be understood that the only area where an expected regulatory driven phase-out is to be expected in the SUB scenario is in relation to lamps in the power supply range of 155 W< P ≤ 405 W. It can also be concluded that lamps that would be affected will have a mercury content in the range of 20 mg ≤ X ≤ 25 mg per burner.

Though information is currently not available as to the share of HPS lamps that would face a regulatory driven phase-out in the SUB scenario, LE specify the following distribution of lamps in relation to the general market share of lamps covered by Ex. 4(c):

- 4(c)I: P <155 W - 74.5% of the total Ex. 4(c) market share;
- 4(c)II: 155 W <P<405 W - 18.4 % of the total Ex. 4(c) market share;
- 4(c)III: P>405 W - 7% of the total Ex. 4(c) market share.

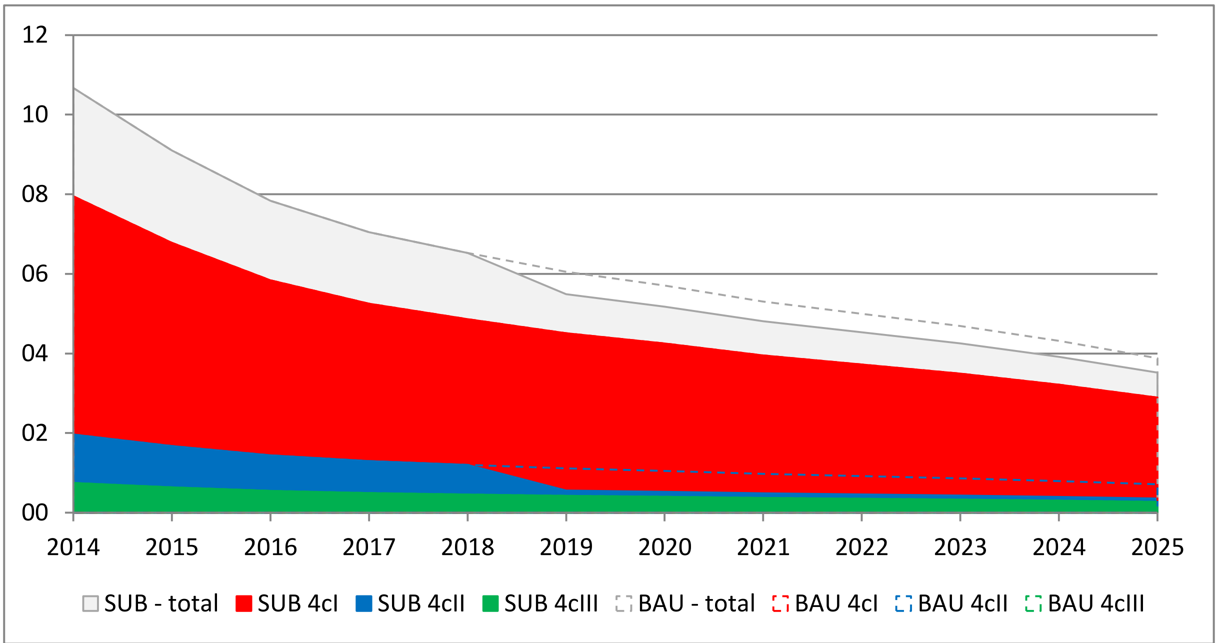
To allow an estimation of the various market developments expected in each of the scenarios, data specified in the MELISA model (VHK 2016) for HPS lamps has been used as a basis for understanding the possible market share of 4(c) lamps in general and of lamps to face a regulatory driven phase-out in scenario SUB. To begin with, it needs to be said that the data available from this source does not make a distinction between HPS lamps which correspond to the different exemptions currently available under the RoHS Directive, but only provides data for HPS lamps in general. In this sense it is noted that the market data given for HPS lamps in the MELISA model is understood to include HPS lamps covered in the RoHS Directive by exemption 4(b), 4(c) and in part 4(f) (special purpose). LEs' statement above, suggests that HPS lamps covered by exemption 4(c) represent the vast majority of the HPS lamps placed on the market in the EU. Thus, in order to allow a conservative quantification, it has been assumed that the HPS market share is distributed between the various exemptions as follows:

- 4(b): 10% of the total market share;
- 4(c): 85% of the total market share;
- 4(f): 5%

These percentages are estimations as no detailed data allowing an estimation of lamps covered by Ex. 4(c) and subsequently of lamps to be affected from the change of the threshold in the SUB scenario were available. Assuming that 85% of the total HPS market share is covered by Ex. 4(c), the following diagram shows the development of the exemption 4(c) power supply ranges in the time frame between 2014 and 2025.

**Figure 15 Development of sales in millions of lamps, millions of lamps**

*The SUB development (filled line) can be seen on the background of the BAU development (dotted line) for the total lamps, as well as the breakdown to the lamps of each exemption item (I-III). Data is absolute and not stacked.*

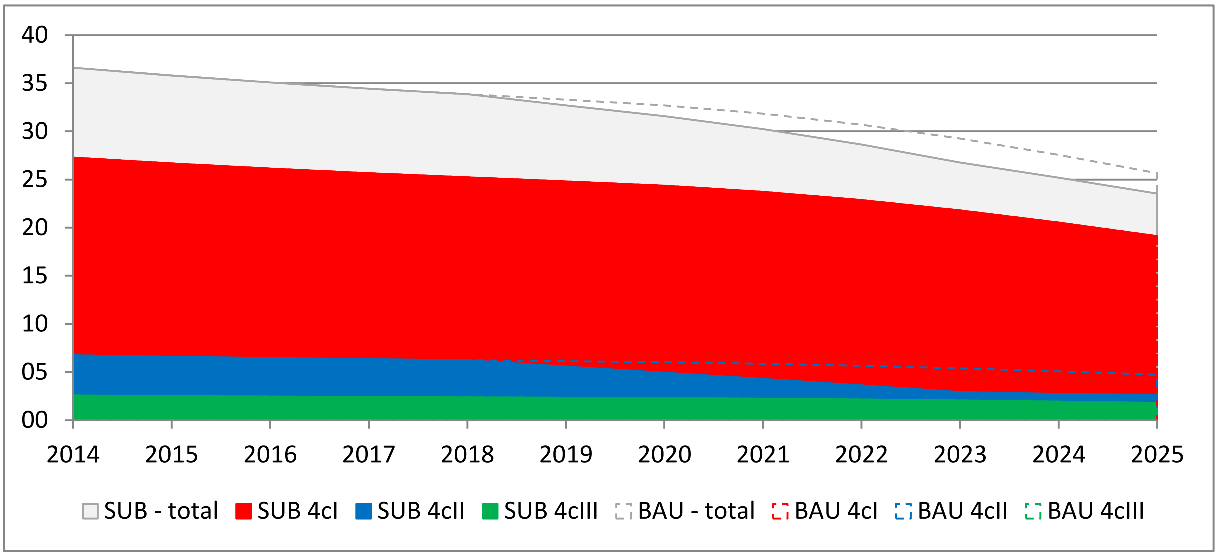



*Own compilation based on data from (VHK 2016)*

It should be noted that only the volume of lamps falling under exemption entry 4(c)II changes (a regulatory driven phase-out of 50% of such lamps is assumed, i.e. assuming that 50% would not comply with the new mercury limit). The abrupt decrease in the volume of sales translates into a somewhat more moderate decrease in the stock development of such lamps.

**Figure 16 Stock development BAU, millions of lamps**

*The SUB development (filled line) can be seen on the background of the BAU development (dotted line) for the total lamps, as well as the breakdown to the lamps of each exemption item (I-III). Data is absolute and not stacked.*




*Own compilation based on data from (VHK 2016)*

Natural phase-out (related to consumer preference of other lamp technologies) is assumed to be reflected in the initial BAU scenario of the MELISA model and is thus disregarded as the HPS data already reflects this natural shift to other technologies. By calculating the difference between the estimated lamp sales of each of the scenarios, the number of additional lamps reaching end of life (EoL) and thus requiring a replacement and the number of luminaires for which a replacement is not available as lamps are no longer sold in the SUB scenario, is derived. These estimations are the basis on the one hand for deriving some of the negative impacts related to early phase-out (for example costs of replacement) and on the other hand also for deriving positive ones (for example avoided amounts of mercury placed on the market). Thus the initial results are presented here and the method for quantifying various impacts is shortly explained either in this section or in the following sections. It is noted that in line with the first changes to market sales occurring in 2019 (lamps placed on the market before September 2018 could be expected to circulate until the end of the calendar year), here too, the scenarios are expected to differ starting 2019.

In the case of HPS lamps, the only difference expected between the scenarios in relation to additional lamps reaching EoL is in relation to Ex. 4cII. Table 43 details the number of additional HPS lamps to require a replacement each year (regulatory driven phase-out as opposed to natural phase-out that occurs in both BAU and SUB).

**Table 43 The amount of lamps for which a replacement shall be needed in the SUB scenario, millions of lamps**

| Lamp type | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| Ex. 4cII | 0.6 | 0.5 | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 |

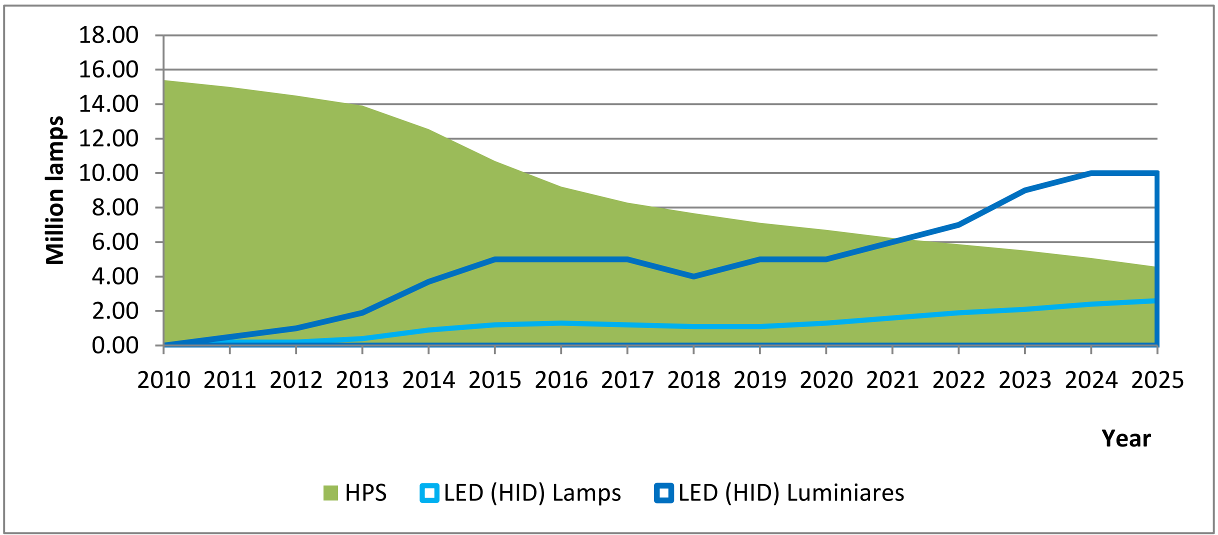
In cases where a lamp reaches its end of life, it is expected that the consumer shall seek a replacement lamp or in some cases a replacement luminaire. From information provided by LE (LightingEurope 2017b) it is understood that there are only limited possibilities for replacing a EoL HPS with another lamp once the specific lamp type is not available. "*Replacing an HPS lamp with a different wattage HPS lamps is not practical because in this case the control gear also has to be replaced. Moreover, the different light output is in most cases unacceptable as most HPS installations are subject to regulation. The industry is working on Plug and Play retrofit lamps. The most likely is that we will succeed first for the low power, ovoid, coated lamps below 150W. These lamps have a larger surface and require less lumen. This package that might be retrofitted with LED alternatives in the coming period, represents about 1% of the total HPS sales… Operating a different wattage HPS lamp on an existing ballast leads to severe quality issues. Substitution with a lower wattage lamp leads to a higher energy consumption (about 10%). Care must be taken with the installed ballast: a higher current might overheat the ballast leading to unsafe situations. Substitution of an HPS lamp with a lower wattage replacement reduces the life time of the lamp dramatically. It can be reduced to less than 10% of its original lifetime and will seriously disappoint the customer. If for example a 250 W lamp is substituted by a 150 W lamp and the driver is not changed we can expect a significant lifetime reduction and no energy saving since the driver will enforce its designed power*."

As it is understood that lamps covered by Ex. 4(c)II have a power supply above 150W, it is concluded that LED Plug & Play alternatives are currently not available for this product segment. It is also concluded that using a different HPS lamp as a Plug & Play substitute would not be practical, as it could be expected to lead to a decrease in the lamp service life and possibly also to safety issues (lower wattage) or to a higher energy consumption (higher wattage). It is understood that the comparability of both HPS and LED replacement lamps is limited, in relation to technical aspects as well as in relation to the room within the luminaire available for possible replacement lamps. It is thus assumed that the availability of substitutes (HPS or LED) that could be used in the existing luminaire would be relatively low. In this respect, it shall be assumed that all additional lamps to require a replacement in the SUB scenario shall require a replacement of the luminaire.

To provide additional context for the various changes related to lamps that may be denied market access in the SUB scenario, it is useful to observe the general shift expected from the use of HPS lamps in luminaires to the use of LED lamps in luminaires (either as replacement or in new LED luminaires). The following figure shows the development of HID lamp sales in relation to the development of the sales of LED lamp replacements and LED luminaire replacements sold for high intensity discharge (HID) applications. It should be noted that HID lamps include HPS lamps as well as high pressure mercury lamps (HPM) and metal halide (MH) lamps. As it has been understood in the course of this project and in the course of the first evaluation that LE replacement lamps for HPS and MH luminaires are only available for a narrow part of the scope of such lamps, it is possible that LED lamp sales are more relevant for HPM applications. In parallel, it is expected that LED luminaire sales specified in the figure are more relevant for the replacement of MH and HPS luminaires.

**Figure 17 Development of sales of HPS lamps and LED HID alternatives (lamps and luminaires for the HID application range) (2010-2025)**

*The HPS sales development (filled line) can be seen in the background of the LED sales development (LED-HID lamps and LED-HID luminaires - empty lines). Data is absolute and not stacked.*




*Source: Own compilation based on data from (VHK 2016)*

## 6.3. Expected impacts on employment

As the recommendations only change the amount of Hg that is permitted in lamps of Ex. 4(c)II, only a certain share of lamps covered by Ex. 4(c) are expected to be impacted directly by the change in the SUB scenario. The estimation of impacts in this study has assumed that 50% of the Ex. 4(c)II share would no longer be allowed on the market after September 2018. This amounts to 9% of the total share of Ex. 4(c) lamps, which is approximately 8% of the total HPS market share. Though 8% is not an insignificant share, it is not a share that would be expected to have a significant impact on the manufacture of other HPS lamps.

In parallel, the replacement of luminaires shall have a small influence on lighting manufacturers who produce LED luminaires that are appropriate replacements for HPS luminaires, as well as on the manufacturers of LED lamp alternatives.

As a cost estimation for the labour associated with the replacement of HPS luminaires was performed (see details in 6.4), it is anticipated that this process shall be associated with an annual addition of between 557 and 357 thousand labour hours in the period between 2019 and 2025, depending on the year (see Table 44below). Based on 8 hours of work per day and 220 days a year, the annual amount of hours translates into between approximately 315 and 200 jobs (technical employees), depending on the year.

**Table 44 Estimated additional hours of labour, respectively jobs, associated with the regulatory driven substitution of HPS in the SUB Scenario**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| Total hours | 556,792 | 524,914 | 487,863 | 459,689 | 431,430 | 397,191 | 357,003 |
| Total jobs | 316 | 298 | 277 | 261 | 245 | 226 | 203 |

Though it is expected that some of these jobs may have been pre-existing, it is expected that at least some of these jobs are new jobs, expected to support the phase-out process from HPS to LED alternatives. In this respect it should also be mentioned that as the HPS phase out is expected to take place over a relatively short period, as long as the exemption is to remain valid for other HPS lamps (i.e., 4(c)I, 50% of 4(c)II and 4(c)III) these additional jobs are at least for the most part assumed to be generated temporarily for the duration of the phase-out (~ 5 years).

## 6.4. Possible costs for users related to lamp substitution

Additional costs directly related with the substitution scenario are expected where a lamp reaching EoL shall result in a regulatory driven substitution of the luminaire. For quantifying such costs, data specified in the MELISA model (VHK 2016) for the purchase price of LED luminaires has been used, starting at around 187 EUR in 2019 and decreasing to 126 EUR in 2025. Additionally, it has been assumed that replacing a luminaire head requires an hour of labour (50 EUR). Estimated costs are specified below. It should also be noted that luminaires may differ in their light dispersion, and thus in some cases it may also be relevant to change the number of lighting sources as well as their array. This could result in the need for additional lighting poles or in some cases in a complete replacement of existing lighting poles and respective construction works, both of these are not quantified here.

**Table 45 Costs of additional luminaire replacement expected in the SUB scenario, in millions of EUR unless otherwise specified, including VAT for residential and excluding for non-residential**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| Total luminaire replacement costs | 175.90 | 145.61 | 119.60 | 101.91 | 87.30 | 74.30 | 61.48 |
| Labour costs | 27.84 | 26.25 | 24.39 | 22.98 | 21.57 | 19.86 | 17.85 |
| Total | 203.74 | 171.86 | 143.99 | 124.90 | 108.88 | 94.16 | 79.33 |
| Per capita (EUR/capita) | 0.40 | 0.34 | 0.28 | 0.24 | 0.21 | 0.18 | 0.15 |
| Per lamp (EUR/lamp) | 365.93 | 327.40 | 295.15 | 271.70 | 252.36 | 237.06 | 222.20 |

Costs amounting to approximately 927 million EUR could be expected as a result of the required replacement of HPS luminaires in the SUB scenario during the observed period. This translates to an average cost of 288 EUR for the replacement of each lamp. As this only takes into consideration the replacement of the luminaire itself, which is expected in many cases to be a street lighting "head", this is expected to be an under estimation, as additional costs could be expected in cases where additional street lighting poles shall be needed (or where all poles shall be replaced.

A calculation of the possible energy savings was not performed. The VHK data is not specific in relation to the relevant group of HPS lamps, but rather provides an average energy consumption value for all HPS. Additionally, energy consumption values are not detailed in the model for HPS alternatives (LED lamps and LED luminaires) but rather are given in general for the HID group. As it is not clear how these values relate to the energy consumption of relevance for lamps under Ex. 4(c)II and of their potential alternatives, the plausibility of estimation on this basis would be uncertain and has thus not been performed.

Though some costs are also expected for the lighting industry, these costs are assumed to be less significant in relation to the full range of income related to HPS lamps covered by Ex. 4(c). This assumption is based on the fact that only a certain share of lamps covered by Ex. 4(c)II could no longer be placed on the market – for the purpose of this study assumed as 50% of Ex. 4(c)II share, which amounts to 9% of the total share of Ex. 4(c) lamps. As 9 % is considered a significant but still small share of the total Ex. 4(c) market share, other HPS lamps are not expected to suffer from a spillover impact. In parallel, it can also be expected that the lighting industry shall incur certain benefits related to the production of substitute LED luminaires which shall be used to replace HPS luminaire that could no longer be used.

## 6.5. Impacts on consumers (public and private)

As it is expected that most costs related to additional replacement of HPS lamps in the SUB scenario shall be for the replacement of street lighting luminaires, it can be respectively assumed that most costs shall be borne by non-residential consumers. Municipalities can be expected to incur a large part of relevant costs. In parallel, commercial consumers can also be expected to operate luminaires for the lighting of external areas such as open spaces in the proximity of facilities, parking areas, etc.

The burden of an early luminaire replacement for such users shall depend on the actual age of luminaires to be replaced, or in other words, whether a replacement would have been considered in any case over the next few years or whether it were only otherwise undertaken in the long run. According to the MELISA model, HPS lamps have an average service life of 21,360 hours (from 2016 and on) and are operated on average 4,000 hours per annum. This would mean an average service life of 5.3 years per lamp. Though LE (LightingEurope 2015) have specified the average service life for lamps falling under Ex. 4(c) to be in the range of 30,000-50,000 hours, the VHK data would mean that lamps reach EoL around 5 years after being placed on the market. This means that a full replacement of luminaires using lamps no longer permitted on the market (50% of the Ex. 4(c)II lamps) would be expected to take place within the five years after lamps can no longer be sold for this segment with more than 20 mg of mercury. First luminaires to be replaced will be of lamps placed on the market from 2014 and on, with last replacements expected for lamps placed on the market shortly before the change of the threshold in Sept. 2018. In this sense, costs for relevant consumers are expected to incur over a relatively short period (five years) and are thus to be interpreted as more burdensome than in cases of lamps with longer service lives.

## 6.6. Impacts on the generation of waste

As has been explained above, it is assumed that all luminaires requiring a lamp replacement shall need to be replaced as a whole, i.e. with a LED luminaire. The luminaires to be replaced shall in such cases be scrapped (in some cases prematurely in relation to the luminaire service life). The range of lamps covered by Ex. 4(c)II is between 155 and 405 Watt. To simplify the estimation of waste to be generated in relation to the SUB scenario, it has been assumed that all lamps covered by Ex. 4(c)II are used as street lighting lamps. Luminaire heads for street lighting for lamps in this range differ in their weight, depending on the wattage of the lamp for which they have been designed. Based on example products[36] it has been assumed that the weight may differ from around 10 kg to around 18 kg per luminaire. As it is understood that luminaires for higher wattages are heavier, and as it is probably the higher wattages for which the proposed threshold for mercury shall not be sufficient, it is possible that the actual expected amounts are closer to the worst case calculation presented in Table 46 below. As explained in Section 6.4 above, it is possible that in some cases additional street luminaire poles would be required to ensure sufficient light distribution or that all luminaire poles would be replaced, however, the impacts of this possible situation will not be quantified here.

**Table 46 The amount of additional waste to be generated in the SUB scenario, in thousands of tons**

| | Luminaire weight | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|
| Best case | 10 kg | 8.4 | 7.2 | 6.5 | 6.0 | 5.6 | 5.2 | 4.9 |
| Worst case | 18 kg | 15.1 | 13.0 | 11.7 | 10.8 | 10.0 | 9.4 | 8.8 |
| Best case | 10 kg | 5.6 | 5.2 | 4.9 | 4.6 | 4.3 | 4.0 | 3.6 |
| Worst case | 18 kg | 10.0 | 9.4 | 8.8 | 8.3 | 7.8 | 7.1 | 6.4 |

The amount of additional waste expected to be generated in the SUB scenario is between approximately 32 and 58 thousands of tonnes. The actual amount is expected to be closer to the worst case estimation.

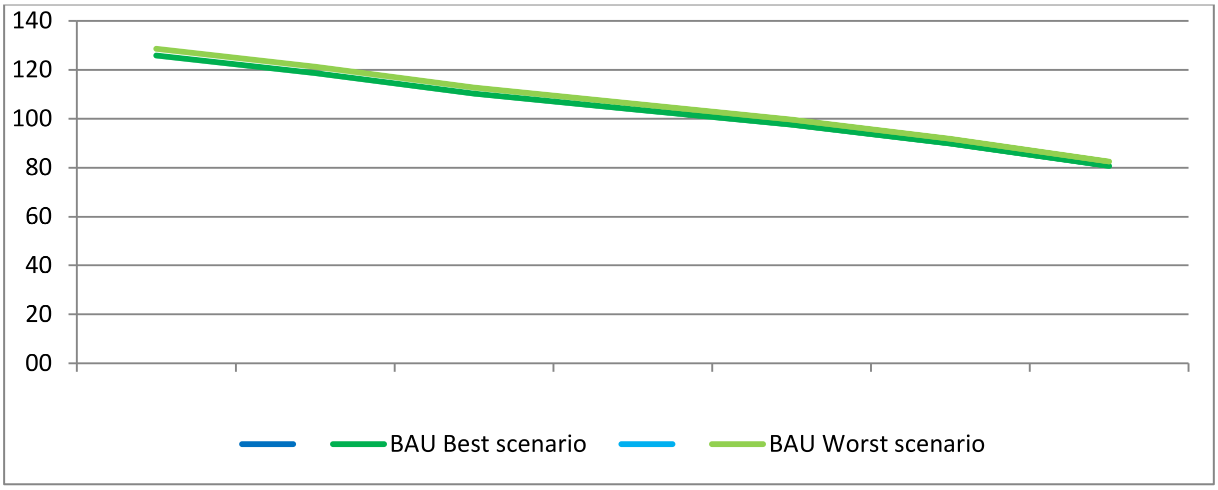
## 6.7. Impacts on the amounts of mercury to be placed on the EU market

On the basis of the differences between the two scenarios in relation to the number of lamps to be placed on the market per year, an estimation of the quantity of Hg to be placed on the market was made for each scenario as well as a comparison.

As only lamps covered by Ex. Item 4(c)II are to be affected, results are shown only for such lamps. As Ex. 4(c)II lamps have a mercury content between 20 to 25 mg per burner, a best case / worst case estimation is provided below based on an average content of Hg between 22.5 mg to 25 mg.

[36] See GE catalogue under the following link: http://www.gelighting.com/LightingWeb/emea/images/Outdoor-Luminaires-Catalogue-EN_tcm181-44489.pdf

**Figure 18 The annual amounts of additional mercury to be placed on the market in the BAU and the SUB scenarios, calculation based a best case value (22.5 mg per burner) and a worst case value (25 mg per burner), in kg per annum**




*Own calculation*

The total amount of Hg not to enter the market in the SUB scenario is expected to be between approximately 72-80 kg (best /worst case).

## 6.8. Analysis and discussion of results

Though the number of lamps to be affected by the regulatory driven phase-out in the SUB scenario is understood to be a relatively small proportion of HPS lamps placed on the market, it is still useful to provide some context for this estimation.

Upon observing the general tendencies of **sales** in the BAU scenario (see Figure 15), it is clear that there is a certain decrease in the number of lamps to be placed on the market from year to year. In the period after which the exemption impacts start to become apparent (2019-2025), a decrease in lamp sales can be observed. Though the decrease from year to year is relatively moderate, the 2025 sales account for only 59% of those of 2018. In the SUB scenario the sales of all lamps decrease only slightly more than in the BAU scenario (in 2025 the sales are 54% of 2018 sales), the sales covered by item 4(c)II in 2025 are only 30% of the 2018 sales. In other words, it is apparent that the general sales of HPS and thus also possible impacts on manufacture are relatively small, whereas the impact on item 4(c)II lamps is more significant as can also be expected in relation to users of such lamps.

The change in sales translates more slowly to a change in **stock** in relation to HPS lamps covered by Ex. 4(c) in general, in 2025 in the BAU scenario, 76% of the 2018 stock is still in use in comparison to the SUB stock where the 2025 stock has decreased to 69% of the 2018 values. Whereas about 8.2 million HPS lamps are phased-out naturally in the BAU scenario (replaced with LED luminaires), around 25 % more lamps (10.3 million) are to be replaced in the SUB scenario.

The total amount of **Hg not to enter the market** in the SUB scenario is expected to be between approximately 72.3 and 80.4 kg (best /worst case) – ~ half the amount estimated in the BAU scenario for Ex. 4(c)II alone which amounts to between 144.7 and 160.7 kg (best /worst case).

In relation to possible sensitivity of the model to changes of assumptions related to the share of HPS to be affected, a few aspects have been investigated.

Though LE have stated that of the HPS lamps, Ex. 4(c) accounts for the majority of HPS lamps placed on the market, it is possible that the assumption used is too high (85%). To test the sensitivity of this assumption, a lower share has been assumed. If this general share were to be reduced to 75% of all lamps, this would result in only a small change in relation to the number of lamps to require replacement in the SUB scenario. In comparison:

- In 2025 sales of the SUB scenario would still remain at around 54 % of the 2018 sales – just a few percent below the BAU value of 59 %.
- Though the HPS lamp stock of ex. 4(c) is lower in this estimation, the decrease in the SUB stock through the amendment of Ex. 4(c)II is of the same order and in 2025 the stock of al Ex. 4(c) lamps accounts for69 % of that of 2018, as is also the case in the SUB scenario using the initial estimations.
- Only 3.2 million HPS lamps would need to be replaced in the SUB scenario (regulatory driven phase-out) in addition to those phasing out naturally. This is only somewhat higher (0.4 million lamps) than in the SUB scenario when using the initial estimations, where a total of 2.8 million lamps would need to be replaced.
- This reduction in the general share of lamps reduces the costs of additional luminaire replacement in some 12 %, from a total of around 927 million EUR to a total of 818 million EUR. The average cost for the replacement of each lamp does not change (288 EUR per lamp).
- The reduction in relation to waste is also relatively small, decreasing the initial 32.1-57.9 thousands of tons (best case: worst case) to a cost range of 48.2-86.8 thousands of tons.
- The total amount of Hg not to enter the market in the SUB scenario is expected to slightly decrease to between approximately 63.8-70.9 Kg (best /worst case) in comparison to the initial 72.3-80.4 kg (best /worst case), with less than 63.8-70.9 Kg (best case/worst case) still to be placed on the market (this is a overestimated value as the threshold in SUB is 20 mg mercury per lamp).

Though the sensitivity of the model could be investigated in relation to the share of item 4(c)II lamps from all Ex. 4(c) lamps, it is assumed that LightingEurope's estimation is based on the number of lamps their members place on the market and the expected share of this in relation to all HPS lamps placed on the market. Though numbers may vary slightly, this estimation is expected to reflect the state of the market and thus was not investigated for sensitivity.

Increasing the share of 4(c)II lamps to be denied market access (i.e. phased-out) in the SUB scenario from 50 % to 75 % (assuming a larger share contains more than 20 mg Hg) results in the following changes:

- In 2025 sales of the SUB scenario would decrease further to around 51 % of the 2018 sales –a few percent further below the SUB value of 54 % when the initial estimations are applied. In both cases the decrease in sales over the period between 2018 and 2025 is only somewhat below the BAU decrease which is 59 % in both cases.
- The HPS lamp stock would also decrease further to 66 % of that of 2018, in comparison to the 69 % of the SUB scenario using the initial estimations.

- A total of 4.8 lamps would need to be replaced (regulatory driven phase-out) in the SUB scenario when assuming that 75 % of Ex. 4(c)II lamps do not comply with the new threshold. This is in addition to lamps being phased out naturally. Under these estimations the number of lamps to be phased out is 50 % higher than under the original estimations in which the estimated regulatory driven phase-out only amounts to 3.2 million lamps over the observed period.
- This increase of the share of 4(c)II lamps to be phased-out increases the costs of additional luminaire replacement from a total of ca. 927 million EUR to a total of 1,390 million EUR. The average cost for the replacement of each lamp does not change (288 EUR per lamp).
- In relation to waste the increase is more significant, increasing the initial 32.1-57.9 thousands of tons (best case: worst case) to a range of 48.2-86.8 thousands of tons.
- The total amount of Hg not to enter the market in the SUB scenario is expected to be between approximately 108.5-120.6 Kg (SUB best /worst case) in comparison to the BAU amounts of Hg to be placed on the market through Ex. 4(c)II of between 144.7-160.7 kg (BAU best /worst case). A total of between36.2-40.2 Kg is still to be placed on the market in the SUB scenario through Ex. 4(c)II (overestimation as 20 mg is the maximum threshold).

To summarise, the various costs and benefits (monetary and non-monetary) are detailed against each other in the table below for the initial scenario evaluated.

**Table 47 Summary of lamps affected and costs and benefits related to HPS regulatory driven substitution in SUB (monetary and non-monetary), units noted in the left column.**

| | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|
| **HPS to be replaced naturally in BAU & SUB, millions of lamps** | **0.6** | **0.6** | **0.9** | **1.1** | **1.4** | **1.7** | **1.9** |
| HPS to be replaced naturally in BAU and SUB, lamps per capita | 0.001 | 0.001 | 0.002 | 0.002 | 0.003 | 0.003 | 0.004 |
| 4(c)II HPS to be replaced naturally in BAU and SUB, millions of lamps | 0.11 | 0.11 | 0.16 | 0.21 | 0.26 | 0.31 | 0.35 |
| **Regulatory driven phase-out of 4(c)II HPS in SUB, millions of lamps** | **0.56** | **0.52** | **0.49** | **0.46** | **0.43** | **-0.12*** | **-0.24*** |
| HPS to be replaced naturally in BAU and SUB, lamps per capita | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | -0.0002* | -0.0005* |
| Replacement costs, initial estimation, millions of EUR | 203.74 | 171.86 | 143.99 | 124.90 | 108.88 | 94.16 | 79.33 |
| Replacement costs (initial estimations), EUR per capita | 0.40 | 0.34 | 0.28 | 0.24 | 0.21 | 0.18 | 0.15 |
| Replacement costs per lamp, EUR per lamp | 365.93 | 327.40 | 295.15 | 271.70 | 252.36 | 237.06 | 222.20 |
| Additional WEEE, initial estimation, Worst case, millions of Kg | 10.0 | 9.4 | 8.8 | 8.3 | 7.8 | 7.1 | 6.4 |
| Additional WEEE, initial estimation, Worst case, Kg per capita | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 |
| Additional WEEE, initial estimation, Best case, millions of Kg | 5.6 | 5.2 | 4.9 | 4.6 | 4.3 | 4.0 | 3.6 |
| Additional WEEE, initial estimation, Best case, Kg per capita | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Total Hg placed on the market, BAU, initial estimation, 22 mg/lamp, Kg | 25.1 | 23.6 | 22.0 | 20.7 | 19.4 | 17.9 | 16.1 |
| Total Hg placed on the market, SUB, initial estimation, 22 mg/lamp, Kg | 12.5 | 11.8 | 11.0 | 10.3 | 9.7 | 8.9 | 8.0 |
| **Avoided Hg, initial estimation, 22 mg/lamp, Kg** | **12.5** | **11.8** | **11.0** | **10.3** | **9.7** | **8.9** | **8.0** |
| Avoided Hg, LE estimation, mg per capita | 0.024 | 0.023 | 0.021 | 0.020 | 0.019 | 0.017 | 0.016 |
| Total Hg placed on the market, BAU, initial estimation, 25 mg/lamp, Kg | 27.8 | 26.2 | 24.4 | 23.0 | 21.6 | 19.9 | 17.9 |
| Total Hg placed on the market, SUB, initial estimation, 25 mg/lamp, Kg | 13.9 | 13.1 | 12.2 | 11.5 | 10.8 | 9.9 | 8.9 |
| **Avoided Hg, initial estimation, 25 mg/lamp, Kg** | **13.9** | **13.1** | **12.2** | **11.5** | **10.8** | **9.9** | **8.9** |
| Avoided Hg, LE estimation, 25 mg/lamp, mg per capita | 0.027 | 0.026 | 0.024 | 0.022 | 0.021 | 0.019 | 0.017 |
| Total Hg placed on the market, BAU, initial estimation, 25 mg/lamp, Kg | 193.4 | 166.5 | 149.8 | 138.7 | 128.6 | 121.2 | 112.7 |
| Total Hg placed on the market, SUB, initial estimation, 25 mg/lamp, Kg | 172.4 | 148.5 | 133.5 | 123.7 | 114.7 | 108.1 | 100.5 |
| **Avoided Hg, initial estimation, 25 mg/lamp, Kg** | **20.9** | **18.0** | **16.2** | **15.0** | **13.9** | **13.1** | **12.2** |
| Avoided Hg, LE estimation, 25 mg/lamp, mg per capita | 0.041 | 0.035 | 0.032 | 0.029 | 0.027 | 0.025 | 0.024 |
| **Rough estimation of job losses in the lighting sector HPS** | Estimated by LE as 99 jobs in total (for the duration of the phase-out) | | | | | | |
| **Rough estimation of additional electrician jobs to support HPS phase-out** | 316 | 298 | 277 | 261 | 245 | 226 | 203 |

*Note: *The negative numbers related to the regulatory driven phase-out in SUB in 2024 and 2025 signify that the annual phase-out in SUB is smaller than in BAU. This means that lamps that would have phased-out naturally without the amended exemption are expected to in part have phased-out earlier in the SUB scenario through the regulatory driven phase-out.*

# 7. Special purpose lighting

## 7.1. Exemptions in the scope of this section

The current chapter covers impacts related to exemptions 1(f), 2(b)(4), 4(a) and 4(f):

- 1: Mercury in single capped (compact) fluorescent lamps not exceeding (per burner): (f) For special purposes: 5 mg;
- 2(b)(4): Mercury in other fluorescent lamps not exceeding (per lamp): (4) Lamps for other general lighting and special purposes (e.g. induction lamps): 15 mg may be used after 31.12.2011
- 4(a): Mercury in other low pressure discharge lamps (per lamp): 15 mg may be used after 31.12.2011
- 4(f): Mercury in other discharge lamps for special purposes not specifically mentioned in this Annex

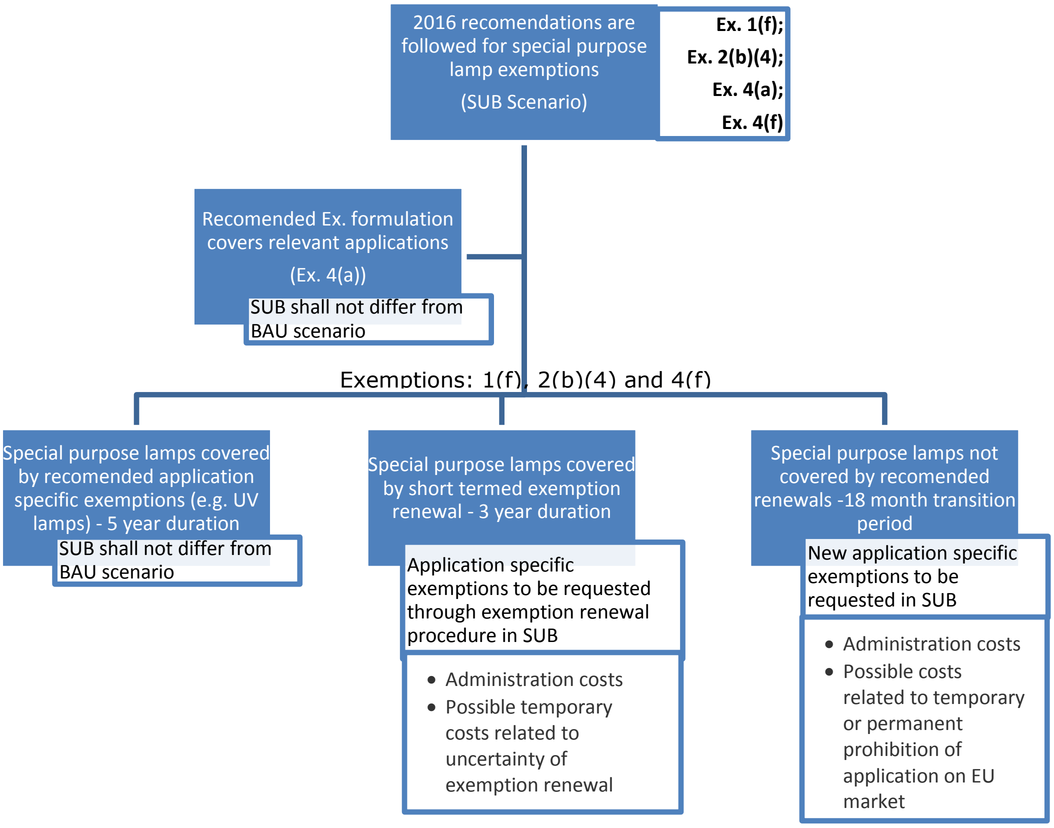
Exemptions 1(f), 2(b)(4), 4(a) and/or 4(f) all provide relief from the restriction of mercury in lamps considered to be “special purpose” or defined as “other” lamps in relation to other existing exemptions. As this terminology is not specific (and not clearly defined, for example in the RoHS Directive), it is understood to leave a potential for misinterpretation or misuse in cases where a certain lamp would not be sufficiently covered by one of the other exemptions (i.e. a loophole). As a result of the 2015-2016 evaluation, the consultants thus recommended:

- To renew exemptions for 5 years, in cases where justification according to the Article 5(1)(a) criteria could be associated with a specific functionality and application area. This effort towards application specific exemptions is understood to be required by the Directive stipulations: ”Exemptions from the restriction for certain specific materials or components should be limited in their scope and duration, in order to achieve a gradual phase-out of hazardous substances in EEE, given that the use of those substances in such applications should become avoidable.”[37]
- To renew some of the exemptions for three years, where it was clear from the evaluation that applications may exist that would not be covered by the new application specific formulations (for some of the exemptions). This recommendation was aimed at allowing industry a period to compile and submit further requests for application specific exemptions where certain lamps previously benefited from the general formulation of the exemptions and where justification could be clarified.

In this sense, in the SUB scenario, it is expected that where the newly recommended exemptions do not cover all relevant application areas (or where the recommended wording amendments require further adjustments) that new exemptions would be applied for. Where requested exemptions shall be justified according to the article 5(1)(a) criteria, it is assumed that they shall be granted and thus that substitution would not be expected. Based on these assumptions, Figure 19 gives an overview of the coverage of various exemptions in the SUB scenario and the impacts expected to incur.

[37] Directive 2011/65/EU (RoHS), Recital 19.

**Figure 19 Overview of exemption coverage and associated impacts in SUB scenario**




*Own illustration*

Though this process can be expected to have certain costs, they are expected to be much lower than a case in which the exemptions are revoked and the lamps denied market access. As demonstrated in the figure above, costs of two kinds could incur in the SUB scenario: costs related to the process of exemption application and processing (i.e., administrative costs) as well as costs related to perceived or actual market access denial.

The first type of costs is related to the efforts needed for application of exemptions and the process of their evaluation. Such costs are expected regardless if exemption renewals (amendments) or new exemptions shall be applied for. It is noted that such costs are the burden of stakeholders in all cases where RoHS substances are yet to be substituted and in this sense are expected to be considered acceptable. For example, renewal of application specific exemptions recommended in the 2016 review shall also become due within five years, but the costs thereof are the same in both scenarios. The focus on such costs in the socio-economic analysis of special lamps is performed as the total costs are expected to differ between where multiple applications can be covered under a single exemption and between where the same applications are addressed by separate exemptions. A difference is indeed expected in this regard, assuming it is possible to refer to an average of administrative costs for the handling of one exemption (by industry as also for regulators and for the evaluation performed by consultants). Nonetheless, these costs are also understood to be acceptable, seeing as RoHS recital 19 requires exemptions to be limited in scope as far as possible. The focus on such costs in this study reflects the need to specify the difference in costs and benefits of the investigated scenarios. The fact that higher costs incur in the substitution scenario however does not necessarily mean that the scenario is not acceptable, but needs to be evaluated in context of other possible costs.

**Administrative costs** can be expected to include:

- Administrative costs for industry for preparing applications for exemptions and providing further input throughout the exemption evaluation process;
- Administrative costs for industry related to the updating of product data sheets where exemption formulation and numbers need to be updated;
- Costs for regulation authorities: costs of the evaluation, of adaptations of EU and national legislation and of possible adaptations of market surveillance operations;

The second type of costs is related to the fate of exemptions applied for and how they are perceived by relevant to stakeholders. In these cases costs are incurred in light of **impacts on manufacture and use of lamps.** Such costs may include:

- **Costs of exemption validity uncertainty**: Costs to incur in light of uncertainties related to the approval of an exemption, which for the most part can be expected to be temporary in nature (e.g. costs related to temporary decrease in manufacture);
- **Costs of delay in exemption approval:** Costs to incur in light of uncertainties related to the delay in approval of new exemptions, expected to be temporary for the most part (costs related to temporary unavailability of lamps); and
- **Costs of exemption denial:** Costs to incur should an exemption not be granted, expected to be permanent in nature (e.g. costs related to loss of business).

In respect to such costs, it is necessary to differentiate between the type of exemption to be applied for and how it could affect stakeholders as a result of the duration and outcome of the evaluation process.

As mentioned above, **where amendments have been recommended in 2016 in the form of application specific exemptions with a five year duration**, affected lamps remain covered and impacts are not expected to differ from the BAU scenario, aside from possible administrative costs of updating product information such as data sheets to changed exemption formulations and numbers. In the following, where impacts of such cases are discussed, they shall be referred to as costs and benefits of the "2016 amendments".

**Where broad scope (special purpose lamps) exemption renewals have been recommended for 3 years**, stakeholders shall be expected to apply for the renewal of such exemptions through the request of future amendments in the form of further application specific exemptions. It is assumed that respective amendments shall be granted, where sufficient information is provided through the application and evaluation process, to justify exemptions on the basis of the Art. 5(1)(a) criteria. As an exemption applied for renewal remains valid "*until a decision on the renewal application is taken by the Commission*." (Art. 5(5)), lamps covered by such exemptions shall retain market access at least until the evaluation process is concluded. Where new amendments are granted, market access shall be further retained throughout the granted duration. Where impacts of such cases are discussed in the following, they shall be referred to as costs and benefits of "new amendments".

Based on the information made available through the course of the exemption evaluation procedure for each of the exemptions, for Ex. 1(f) and Ex. 4(f) the consultants concluded that the application specific amendments that had been recommended in the 2016 report would cover all relevant application areas. In such cases, a broad scope renewal was not recommended as it was assumed that it was not needed. For example, it was understood that lamps covered by Ex. 4(f) are used in projectors, in horticulture lighting or that such lamps emitting in the UV spectrum are used for curing and disinfection applications[38]. Application specific amendments were recommended for these application areas and a further broad scope exemption was not viewed as necessary so that an 18 month transition period was recommended (legally valid once Commission decisions are published in the Official Journal). Should there be lamps used for additional application areas not covered by the recommended amendments, **new application specific exemptions** shall need to be applied for. In such cases, lamps could still be placed on the market throughout the transition period, however should the evaluation extend beyond this period, market access would be denied, at least until the additional exemptions were to be granted. Where impacts of such cases are discussed in the following, they shall be referred to as costs and benefits of "new exemption requests" and three sub-cases shall be differentiated:

- **New exemption requests to be approved within the transition period** – impacts shall be similar to the case of "new amendments";
- **New exemption requests to be approved after transition period** (also termed late approval) – additional costs could incur where manufacture and marketing of relevant lamps is temporarily suspended. Whether such impacts are temporary or permanent shall depend on how long market access is to be denied;
- **New exemption requests to be denied** – here, any costs to incur shall be permanent.

In the next sections, the various types of costs shall be discussed, followed by a summary of what costs are to be expected for each case/sub-case.

## 7.2. Expected market development in each of the scenarios

Data related to the market shares has been shared by LE in most of its applications for exemption renewal. In this respect, from past information, the following can be summarized:

- 1(f): the number of lamps placed on the market in 2013 was estimated at approximately 400,000 lamps in the renewal application (Gensch et al. 2016);
- 2(b)(4): LE (LightingEurope 2016) recently stated that "This group of lamps represents only a small market of a few million lamps.";
- 2(b)(4) and 4(a): It has been estimated in the renewal applications that 18.6 million lamps were placed on the market in 2013 for Ex. 2(b)(3), Ex. 2(b)(4) and Ex. 4(a). The share of lamps relevant for each of the exemptions was not specified (Gensch et al. 2016);

[38] The application limitation to disinfection and curing applications was proposed, but it was specified that should other UV applications be relevant that their technical justification could be followed and that the exemption formulation could also remain broader, i.e. lamps emitting light in the ultra-violet spectrum.

- 4(f): Data is not available as to all lamps falling under this exemption. The renewal application estimated 3 million projection lamps, 130,000 UV curing lamps and 180,000 UV disinfection lamps understood to have been placed on the market in 2013 (Gensch et al. 2016).

Without specific data, it cannot be concluded whether the number of lamps annually placed on the market for applications relevant to these exemptions is decreasing for all or for some areas of application in the BAU scenario. That said, it is assumed that where application specific exemptions could be justified, that the SUB scenario would not differ from the BAU scenario in relation to the actual production and sales of lamps.

## 7.3. Expected impacts on employment

Though some examples are to be discussed in the next sections, specific data as to the actual volume of manufacture of special purpose lamps and the respective number of jobs associated with such manufacture (directly, or indirectly where lamps are used in manufacture of other sectors) is not available. Without a better understanding of the expected development of lamp market shares for different applications it is difficult to discuss impacts on employment.

In the consultants' view, where application specific exemptions could be justified in the SUB scenario, changes to employment related to the production and sales of lamps are not expected. The same is true for employment related to possible regulatory driven substitution and replacement of lamps and luminaires (in this context usually equipment), assuming that such substitution is not expected. In such a case, most impacts on employment are related to the applications for new exemptions, their evaluation and maintenance (future applications for renewal), and are discussed in more detail in section 7.4. In rare cases, manufactures may be unaware of the continuous validity of initial exemptions for their lamps and the consequential allowed market access. This may lead in some cases to a temporary decrease or suspension of manufacture, with implications (mainly temporary) to associated employment.

If the approval of new exemptions should be delayed (granted after a period of denied market access) this may lead to a temporary decrease in the manufacture of certain special purpose lamps. Depending on how long the market access would be denied, manufacturers of lamps may decide to decrease or to suspend manufacture, leading to implications for associated employment. Where lamps are used for production of other sectors or in the provision of services, a longer period in which lamps cannot be placed on the market may affect such activities, assuming that lamps stocked by such users would not suffice to bridge this period. Here too, impacts should be temporary, though a significant delay in market access, may lead to some impacts becoming permanent.

Where exemptions shall be denied, market access shall be prohibited permanently and thus associated employment shall also be affected permanently. Where affected lamps are used in the EU manufacture of other sectors, subsequent impacts would be expected to such manufacture, assuming that alternatives cannot be timely developed. In such cases it can be expected that manufacture would need to be transferred to non-EU countries, permanently shifting associated jobs.

In all cases where the access of special purpose lamps to the EU market is denied (temporarily or permanently), lamp manufacturers marketing special purpose lamps in this region would be affected, regardless of their being located in the EU or outside it. Where special lamps are manufactured in the EU, a share of manufacture is expected to be used locally (in the EU) and a share of manufacture is assumed to be exported to non-EU countries. For non-EU manufactures, though some may export to the EU, some may market their products only outside the EU. In this sense the effect on the lighting industry depends on the dependency of a certain actor on the EU market, as the RoHS Directive only prohibits the placing of articles on the EU market. For all manufacturers, manufacture for marketing outside the EU would not need to be abandoned, whereas within the EU this shall depend on the actual types of lamps marketed and their being covered by valid exemptions (or not). The range of impacts on employment associated with the manufacture of special purpose lamps shall thus also depend on the share of lamps manufactured for local (EU) use. This cannot be said for manufacture in other sectors, where prohibited lamps are used. In such cases impacts on employment shall only be temporary where the impact on manufacture is temporary (e.g., delay in new exemptions).

## 7.4. Possible costs and benefits which are administrative in nature

As explained above, an exemption requested for renewal is to be granted with amendments, this could result in various administrative costs:

- Administrative costs for industry for preparing applications for exemptions and providing further input throughout the exemption evaluation process;
- Administrative costs for industry related to the updating of product data sheets where exemption formulation and numbers need to be updated;
- Costs for regulation authorities: costs of the evaluation, of adaptations of EU and national legislation and of possible adaptations of market surveillance operations.

The following section discusses the nature of such costs and their applicability to specific cases. Where possible, cost estimations are detailed, though these are based on various assumptions and should only be perceived as indicative to actual costs.

### 7.4.1. Costs for industry for the preparation of exemption applications and accompanying the evaluation process

In relation to costs for industry for the preparation of exemption applications and accompanying the evaluation process, LE provided the following data as to the effort related to exemption applications:

- The hours of labour that have been invested by LE (LightingEurope 2017a) in applying for exemptions 1-4 (and sub-items) in the last review (applications submitted in January 2015 and evaluated in 2015-2016): 300 hours were required for participation in meetings during 2016 (hours spent during the evaluation process of the exemptions). The LE estimation does not include "*the amount of time spent on discussions and preparing documents. With preparations this number would be multiplied by 2-3 times*." --> The consultants have concluded a **total of 1,200 hours** for the below calculation;
- The hours of labour invested by LE' members in applying for exemptions 1-4 (and sub-items) in the last review: **20,000 hours** for the companies assisting in preparation and processing of the requests.

- Example costs for preparation of an exemption dossier: an example was given of one of LEs members, which needed ca. 50 hours for preparing an application, for which most data was available. **-->**The consultants have concluded a **total of 900** hours for Ex. 1-4 and sub-items (total of 18 applications)

Assuming that the hours mentioned above represent the hours required (~22,100 hours) for preparing and following up on the exemption application process for industry of exemptions 1-4, the consultants conclude that an average of approximately 1250 hours of labour (representing ~8.5 months of work) are required per exemption. This number is only indicative as some exemptions shall be more complex than others, requiring more resources, and vice versa.

Industry has provided detail as to the application areas currently covered by each of the special purpose exemption recommendations. The applications and their classification in terms of applications covered by SUB exemptions and applications for which a further exemption would be needed are specified in the table below, followed by an estimation per exemption as to the hours needed to prepare and follow up on requests for specific exemptions for lamps not covered under the SUB exemption formulations.

**Table 48 Application areas to be covered by the special purpose exemptions and their classification in terms of coverage in the SUB scenario**

*Application covered (5 year renewal recommended);* [green]

*Application covered (3 year renewal recommended to allow approval of application specific exemption), exemption renewal must be applied for in the short term;* [yellow]

*Not clear if application covered;* [orange]

*Application not covered, new exemption must be applied for;* [red]

*Application understood to be out of scope.* [white]

| Application | Ex. | Covered by | Not covered | Comments |
|---|---|---|---|---|
| Non-UV applications* | 1(f) | | 1(f) II: Renewal until 21.07.2019 | |
| UV applications | 1(f) | 1(f) I | | UV |
| Seasonal Affective Disorder (SAD) treatment | 2(b)(4) | Exemption available for Cat. 8 | | Visible spectrum |
| Cutaneous T-cell lymphoma treatment (CTCL) | 2(b)(4) | 2(b)(4) II or Ex. available for Cat. 8 | | UV |
| Hyper-bilirubin treatment for infant jaundice | 2(b)(4) | Exemption available for Cat. 8 | | Visible spectrum |
| Eczema treatment | 2(b)(4) | 2(b)(4) II or Ex. available for Cat. 8 | | UV |
| Psoriasis treatment | 2(b)(4) | 2(b)(4) II or Ex. available for Cat. 8 | | UV |
| Acne treatment | 2(b)(4) | 2(b)(4) II or Ex. available for Cat. 8 | | UV |
| Vitiligo treatment | 2(b)(4) | 2(b)(4) II or Ex. available for Cat. 8 | | UV |
| Industrial vision systems | 2(b)(4) | | Renewal until 21.07.2019 | Visible spectrum |
| Industrial optical sorting | 2(b)(4) | | Renewal until 21.07.2019 | Visible spectrum |
| Industrial printing | 2(b)(4) | 2(b)(4) II | | UV |
| Industrial color comparison cabinets | 2(b)(4) | | Renewal until 21.07.2019 | Visible spectrum |
| Industrial weathering champbers | 2(b)(4) | 2(b)(4) II | | UV |
| Industrial UV polymerization | 2(b)(4) | 2(b)(4) II | | UV |

| | | | | |
|---|---|---|---|---|
| Industrial UV curing | 2(b)(4) | 2(b)(4) II | | UV |
| Industrial UV coating, decorating, stereolithography | 2(b)(4) | 2(b)(4) II | | UV |
| Trafic cabin lighting | 2(b)(4) | Specified as out of scope | Specified as out of scope | Specified as out of scope |
| Agricultural Plant Grow Lights - UV | 2(b)(4) | 2(b)(4) II | | UV |
| Agricultural Plant Grow Lights - Non-UV | 2(b)(4) | | Renewal until 21.07.2019 | Visible spectrum |
| Agricultural - Rice / Food Processing | 2(b)(4) | | Renewal until 21.07.2019 | Visible spectrum |
| Aquarium lighting | 2(b)(4) | | Renewal until 21.07.2019 | Visible spectrum |
| Artificial Lighting (UVB source) for reptiles | 2(b)(4) | 2(b)(4) II | | UV |
| Vertical Alignment (for LCD Television | 2(b)(4) | 2(b)(4) II | | UV |
| Food Displays | 2(b)(4) | | Renewal until 21.07.2019 | Visible spectrum |
| Movie / Cinema Lamps | 2(b)(4) | | Renewal until 21.07.2019 | Visible spectrum |
| Tanning lamps | 2(b)(4) | 2(b)(4) II or Exemption available for Cat. 8 | | UV |
| Explosion protection | 2(b)(4) | | Renewal until 21.07.2019 | Visible spectrum |
| High color rendering index - for presentation purposes | 2(b)(4) | | Renewal until 21.07.2019 | Visible spectrum |
| Studio lamps - for presentation purposes | 2(b)(4) | | Renewal until 21.07.2019 | Visible spectrum |
| Induction lamps | 2(b)(4) | | Renewal until 21.07.2019 | Visible spectrum |
| Black Light Blue lamps - for (photochemical and) photobiological purposes | 2(b)(4) | 2(b)(4) II or Exemption available for Cat. 8 | | UV |
| Cold temperature lamps - for outdoor use, cold storage, refrigeration | 2(b)(4) | | Renewal until 21.07.2019 | Visible spectrum |
| Livestock, poultry, farming – air and odor abatement | 4(a) | 4(a): Assumed to be covered | | Understood to be UV |
| Food&Bevarage Photo catalytic activation | 4(a) | 4(a): Assumed to be covered | | Understood to be UV |
| Food packaging activation (moisture protection chemical activation,) | 4(a) | 4(a): Assumed to be covered | | Understood to be UV |
| high pressure mercury lamps projection applications for stage lighting | 4(f) | | 4(f) II: Transition period | Visible spectrum |
| high pressure mercury lamps projection applications for technical use in spectroscopy research | 4(f) | | 4(f) II: Transition period | Visible spectrum |
| high pressure mercury lamps projection applications used in projectors ≥ 2000 ANSI lumen | 4(f) | 4(f) II | | Visible spectrum |
| high pressure mercury lamps projection applications used in projectors < 2000 ANSI lumen | 4(f) | | 4(f) II: Transition period | Visible spectrum |
| micro lithography applications in integrated circuit production (LED chips, other IC, memory, MEMs, sensors, ASICs etc.) | 4(f) | 4(f) IV: Not clear if covered | | UV |
| Micro lithography: PCB manufacturing | 4(f) | 4(f) IV: Not clear if covered | | UV |
| Analytic applications e.g. endoscopy, boroscopy | 4(f) | | 4(f) IV:Transition period | UV |
| Preliminary tests at chemical reaction plants | 4(f) | | 4(f) IV:Transition | UV |

| | | | | |
|---|---|---|---|---|
| | | | period | |
| Photochemistry, e.g. photolysis of H2O2 | 4(f) | | 4(f) IV:Transition period | UV |
| Skin tanning | 4(f) | | 4(f) IV:Transition period | UV |
| UV oxidation e.g. activated wet air oxidation | 4(f) | | 4(f) IV:Transition period | UV |
| Oxidation of air and surfaces in cooking vents and exhausts. | 4(f) | | 4(f) IV:Transition period | UV |
| UV air treatment | 4(f) | | 4(f) IV:Transition period | UV |
| Fluorescence microscopy in industrial applications. | 4(f) | 4(f) IV: Not clear if covered | | UV |
| *high pressure sodium vapour lamps used for horticulture lighting* | 4(f) | 4(f) III | | Visible spectrum |
| *Curing applications** | 4(f) | 4(f) VI | | UV |
| *Disinfection applications** | 4(f) | 4(f) VI | | UV |

*Source: Information compiled from current LE feedback (LightingEurope 2017b, 2017d) as well as on basis of recommended exemptions (Gensch et al. 2016) where marked *.*

It can be understood that not all applications are specified in this table. In some cases this is related to areas covered and not specified in detail (e.g. UV curing applications under Ex. 4(f)) and in some, related to unavailable data (it can be understood that information from manufacturers who are not LE members is not included, while LE states that there are lamp application areas mainly covered by such manufacturers). Nonetheless, on the basis of this specification it can be summarized that:

- 25 application areas are covered by exemptions to be renewed for 5 years (application specific formulation); Costs for renewal applications consistent with BAU scenario;
- 14 application areas are covered by exemptions to be renewed until 21.07.2019 (non-application specific exemption formulation for shorter period) for which a renewal application would need to be submitted. An estimated 1,250 hours of labour are required per exemption, amounting to 17,500 hours of labour in total;
- For 3 application areas, it is not clear if they would be covered or not, depending on how wide "curing" and "disinfection" applications would be interpreted for Ex. 4(f)., subsequently, this may require an additional 3,750 hours of labour;
- 10 application areas are understood not to be covered where the application specific formulations are too narrow (projection and projector applications, UV that are not curing or disinfection). Requests for new exemptions would require a total of 12,500 hours of labour and can be expected to result in a temporary phase-out as lamps could not be placed on the market during evaluation period. In some areas this may result in subsequent costs for lamp users.

To summarise, on the basis of the LE data representing costs of the evaluation of Ex. 1-4, or of single exemptions thereof, the consultants expect that over 30,000 hours of labour would need to be invested to apply for missing exemptions and to follow-up on the evaluation process of exemptions in the SUB scenario. LE (LightingEurope 2017b) also emphasises the challenge related to "a situation where requests have to be filled for each of the applications individually, this would cause a significant burden in terms of administration, as well as resources".

In this respect, as the RoHS Directive requires that exemptions are limited in scope, the consultants note that it should be kept in mind that exemptions can refer to application groups where a mutual justification, e.g. regarding a common functionality applies. For example in the case of UV lamps, omitting "for curing and disinfection"[39] from the proposed Ex. 4(f) IV formulation is understood to be justified from a technical perspective should other UV lamps be of relevance. Based on the application areas listed in Table 48, this would change the number of applications covered from 2 to 12, thus also affecting impacts related to such applications (costs for requests of new exemption; costs for lamp users and possible additional generated waste in contrast to the respective amount of mercury to be placed on the market through additional applications.

LE (LightingEurope 2017c) also comments on the feasibility of this process, specifying that where the full exemption period is proposed (e.g., UV lamps), it sees no further risk in the coming years, as it shall be feasible to prepare a new exemption renewal application in time. "*For non-UV applications an exemption period until January 2019 is proposed. As in most cases a substitution lamp is not available the exemption renewal has to be applied until July 2017, 18 months ahead of the end of the exemption. As it cannot be assumed that the ongoing exemption renewal is finalized before that date it would be too late to apply for a renewal within 18 months before the end of the exemption. So the lamps would be banned as of January 2019 without further transition time. A substitution is not available or only partly in certain applications. A new exemption request has to be applied. Currently it takes 2.5-4 years until it is finally decided and published. In addition LightingEurope has to prepare the new requests. All data and justified arguments are available today*."

In contrast and as already noted above, the consultants' interpretation of Article 5(5) (see Section 7.1) is that, where an exemption is requested as a renewal of an existing one (amendment where the text is changed), the initial exemption would remain valid until a decision were to be made by the COM in the form of a published delegated act. Where exemptions shall need to be requested as new exemptions (e.g., where a three year period is not provided through exemption for this process), indeed products shall be denied market access once not covered by an existing exemption or by a transition period of an exemption that has been amended and no longer covers that product. Such cases shall result in additional costs as detailed further on in this section.

### 7.4.2. Costs for industry related to updating product information (data sheets)

It should also be noted that industry has stated in various incidents that a split of an exemption (or a change in the numbers of exemptions) is associated with an administrative cost, even when all applications formerly covered by the exemption would be covered by the new version. This is said to be related with the administrative burden of updating the documentation of EEE in relation to new exemption numbers and formulations. LE did not provide information as to the scope of such costs, however, a

[39] Proposed formulation in Gensch et al. 2016: "*Mercury in lamps emitting light in the ultraviolet spectrum for curing and disinfection*" , though the report also states "*It should be noted that the specification of the proposed formulation for Ex. 4(f)(IV) related to curing and disinfection applications could be removed. In general it can be understood that the limitations of LED alternatives emitting in the non-visible range would most likely apply to other applications, should such be communicated (i.e. non-comparable spectral output and insufficient wall plug efficiency)…*".

quantification made in the past by Spectaris is reproduced here to provide insight as to the possible range of costs:

Spectaris (Spectaris 2015) views such changes as purely administrative, requiring supply chain actors (manufacturers, suppliers, OEMs) to re-categorize all products again and thus causing significant costs to supply chain companies. Spectaris thus believes that such changes should be avoided, elaborating that "*Smaller companies try to avoid expensive software implementations to comply with RoHS, but work with spreadsheets or similar. The needed man-power per product group stays the same or is even higher in SMEs due to lack of smart software solutions.*" To demonstrate the related burden of such a change, Spectaris provides the cost estimation example in Table 49 below. In the consultants understanding, not all cost segments relate to the effort of updating product information; however the table is reproduced as a whole to avoid misinterpretations.

The consultants note that it is not clear how representative the demonstrated costs may be. Manufacturers are required to produce and maintain data sheets not only in relation to the RoHS directive but also in relation to other legislation and performance characteristics. Changes in production or changes arising from the amendment of other legislation are assumed to take place regularly and in this sense it is not clear whether the costs below are only to be associated to possible changes to the numbers of RoHS exemptions. Only estimated "costs due to the wording of exemptions" are understood to be relevant for the current discussion. The first item mentioned is related to adaptation costs of software for changes of a single exemption, where 25,000-50,000 EUR are said to be necessary for each change. It is not clear whether the amendment of one exemption resulting in for example 3 sub-exemptions is to be considered as a single change or as three. The second item mentioned is related to the testing of software changes in relation to part numbers and amounts to 80,000 EUR per change. As the original exemption for which the estimation was made related to the use of RoHS substances in various glass lenses, the consultants assume that this segment relates to assemblies in which the affected lense is used, as the lense is rarely the product placed on the market. In the case of special lamps, though they are used within other products (equipment, luminaires), it is understood that they are usually marketed as lamps and not within a further assembly. It is thus not clear how this item would translate in relation to exemptions for special purpose lamps and whether it would apply or not.

**Table 49 Costs of Corporate RoHS Administration**

| | Costs [in €] |
|---|---|
| **RoHS: One-time implementation costs** | |
| Compliance-Software SAP-CfP (software cost, software implementation in 2005 and companywide licence) | 300.000 |
| Project to implement RoHS-issue in company (2 years project 2005-2006: software, materials, substitution, training, RoHS compliant process development etc.) | 700.000 |
| Cost for Software-replacement due to business practise of SAP after 10 years from SAP-CfP to SAP-EHSM4.0 in 2014 | 300.000 |
| **RoHS: Yearly ongoing costs** | |
| Annual Software-costs (licensing (50 k€) and renewal costs (30 k€)) | 80.000 / a |
| 1 fulltime capacity equivalent in each business group producing RoHS-relevant devices (5 RoHS-relevant business groups; main affected functions: R&D, construction, supply chain, purchasing, production and assembly, quality assurance, quality management, testing, quality and environmental auditing), 140 k€/a | 700.000 / a |
| 1 fulltime capacity equivalent in total for central functions (IT, EH&S, chemistry/materials, central R&D, product data management), 140 k€/a | 140.000 / a |
| **RoHS: Costs due to changes in the wording of exemptions** | |
| Adaption of compliance software due to changes, i.e. changes in scope, wording of exemptions etc. Necessary for every change. | 25.000 – 50.000/sw-change |
| Extensive testing of every software change over approx. 250.000 part numbers (i.e. each part number is an individual RoHS compliance data set) within the compliance software (IT, EH&S, chemistry/materials, product data management, training of persons in business groups about changes etc.), ca. 0,25 fulltime equivalent capacity for each change before final release | 40.000/sw-change |

*Source: (Spectaris 2015)*

## 7.5. Costs related to market accessibility of lamps

Though it is understood that new exemptions (or exemption renewals) could be applied for in the case of applications not covered in the SUB scenario, leading to administrative costs, in the consultants view it is important to note that other costs may also be generated. Should exemptions not be granted timely, or should exemptions be requested as new exemptions and not as exemption renewals, the production of lamps could be impacted, creating costs for the lighting industry (manufacture, supply chain, etc.) and possibly also for consumers of such lamps. Such costs may include:

- Costs to incur in light of exemption validity uncertainty during the evaluation of a request for renewal, which for the most part can be expected to be temporary in nature (e.g. costs related to temporary decrease in manufacture);
- Costs to incur in light of the delay of approval of new exemptions, expected to be temporary for the most part (costs related to temporary unavailability of lamps); and
- Costs to incur should an exemption not be granted, expected to be permanent in nature (e.g. costs related to loss of business).

In the following, such possible costs are discussed and where possible indicative estimations are made to allow a better understanding of the possible costs to incur.

### 7.5.1. Costs in light of exemption validity uncertainty during the evaluation of a request for renewal

Delayed processing of exemption requests could create uncertainty as to the future marketing of lamps, which may influence lamp development and production activities. It needs to be assumed that stakeholders are aware of their rights and duties in relation to various legislation (for example the RoHS requirement to phase-out restricted substances) and thus also to the extended validity of an exemption requested for renewal until the Commissions' decision is published (Article 5(5)). However, from the consultants experience some stakeholders are uncertain as to this aspect. Following the publication of the final report for the 2015-2016 evaluation, the consultant has received multiple inquiries as to the status of exemptions reviewed and their validity until a Commission decision is made public. Though it seems that most stakeholders assume this validity is granted, they search for further assurance for this interpretation. It is possible that even if most stakeholders are aware of the extended validity, that this aspect may not be clear for all stakeholders. In such cases, stakeholders may apply measures stemming from this uncertainty, i.e. decrease or suspension of production. If such cases exist, it is assumed that they would mainly be relevant for smaller enterprises (SMEs), which do not always have sufficient resources for allowing a comprehensive understanding of all applicable legislation. This could affect small manufacturers of special purpose lamps, though it is not clear if and how many such enterprises should be expected to exist in the EU and outside of the EU. Though such impacts could be relevant in all regions, it is assumed that manufacturers within the EU shall have a larger share of production marketed within the EU in comparison to non-EU manufacturers of special purpose lamps.

As for users of such lamps, users should be classified into a few groups:

Private users which apply special lamps in residential luminaires (for example lamps used in tanning equipment) – if supply would be limited, private consumers would probably assume that retailers are experiencing a temporary lack of supply and search for replacements later. Thus, assuming that exemptions are provided within the validity period, such users would not be expected to notice possible limitations to lamp supply and are not expected to have costs.

Other users, applying lamps in equipment associated for example with manufacture and production (e.g. semiconductor manufacture, horticulture) or provision of services (e.g. medical equipment) – such users are expected to have a certain stock of lamps to allow operation to continue should there be fluctuations in supply. In the case that the exemption remains valid while it is evaluated and approved, impacts would not be expected. Even should certain lamp manufacturers suspend manufacture, it is assumed that at least for the vast majority of applications that more than a single manufacturer shall provide lamps for the market and should a short termed unavailability be experienced, lamps stocked by the users should be sufficient to bridge this gap.

As there is no comprehensive detail as to the number of manufacturers and their respective product portfolios, it cannot be estimated how many small manufacturers exist which might have uncertainties that would generate a temporary shortage in marketed lamps, leading to the impacts mentioned above. Though it cannot be estimated what the range of such impacts could be, it is assumed that they would be temporary in nature.

### 7.5.2. Costs resulting from uncertainties where exemptions are granted in delay

In such cases, a temporary denied market access could generate various costs. For the lighting industry, aside from administrative costs for the exemption process, a suspension of manufacture could mean a loss of revenue. Since special lamps are understood to be produced in small volumes, it is assumed that they are not produced year round. In this sense, a temporary market denial may not necessarily affect manufacture but would rather affect sales in so far that certain lamps would not be allowed on the EU for a certain period. In such cases, all manufacturers are to be affected in the same way, and once the market prohibition is removed, sales can be expected to at first compensate any temporary decreases in sales and later to return to normal. In this sense, though a certain loss of revenue may be relevant, it is most probably understood as a delay in revenue in most cases and not an actual loss. As all suppliers are affected in the same way, the risk of this period creating unfair competition within the lighting sector is not expected.

In contrast, EU users of special lamps to be prohibited may experience some actual costs. Where a lamp shortage affects a users' ability to manufacture within its sector or to provide certain services, and where possible stocked lamps do not enable bridging the period of market prohibition, consumers may experience a decrease in their productivity and a subsequent loss of revenue. Where users manufacture various items, this could give similar manufacturers located outside the EU a competitive advantage and in extreme cases also lead users to relocate their manufacturing facilities to non-EU countries. Such impacts are expected to be rare in light of the temporary market prohibition in this case, however examples given in Section 7.5.3 below can be seen as indicative of such costs, though probably much larger in their magnitude.

Where users provide certain services within the EU, and where stock is not sufficient, a decrease or a temporary shortage in provision of certain services could incur, with possible subsequent impacts on service users. For example where medical services depend on special lamps, a decrease in the volume of services that could be provided may lead to some patients having health impacts. Though in such cases, service provision affected shall be EU based and unfair competition would not result, such health results may be permanent and irreversible.

Where the users of lamps are private consumers, as explained in section 7.5.1, users would be less sensitive to temporary lamp unavailability, though in some cases certain impacts may also temporarily occur.

### 7.5.3. Costs to incur where exemptions are denied

In cases where exemptions are denied (or where the evaluation of a new exemption is significantly delayed, leading to a longer market prohibition of a certain lamp type), the lighting sector shall suffer a decrease in manufacture (permanent or long termed) and a subsequent decrease in revenue. This can also be expected to affect employment associated with the lamps production and marketing. Though such impacts are not to be neglected, LE has explained that the subsequent impacts for users of special purpose lamps could be more severe, i.e. for manufacturers of equipment in which the lamps are used but also for the consumers of such equipment. In this respect, LE details possible impacts, for some of which an interpretation is included by the consultants as to the possible implications for employment:

*"1. Direct impact to lamp producer: The lamp cannot be sold anymore to EU market. A part of the loss can be compensated by a higher increase of sales outside EU, e.g. if semiconductors can no longer be manufactured in EU a higher demand outside EU is expected."* For lamp manufacturers this could result in decrease in business within the EU and possibly also a shift of such manufacture and related jobs from the EU to outside the EU.

*"2. Impact to equipment producer: Full loss of EU business, even for R&D the lamps are required."* For lamps used in research and development applications, this could mean a shift of R&D facilities and thus of jobs from the EU to outside the EU.

*"3. Impact to equipment user: Full loss of EU production, e.g complete EU semiconductor and chip production business"* For lamps used in semi-conductor manufacture this could result in a shift of jobs from the EU to outside the EU.

*"4. Impact to downstream supply chain: Full loss of EU suppliers, high costs for requalification of components and products."* For lamps used by suppliers or for suppliers depending for example on manufacture linked to special lamps (e.g., semi-conductor) this could result in reduction of business (and jobs) in the EU, possibly shifting business to other countries outside the EU.

*"5. Impact to end customers: Higher product prices, no availability of needed products (e.g. stage lighting, loss of existing equipment prior to end of life e.g. projectors up to 2000 Watt, stage fixtures, microscopes."*

In the consultants view, though it can be understood that there is a large range of different applications using lamps covered by the special purpose exemption, it is difficult to assume, which of these would be affected and what the range of subsequent costs would be in each case. The range of such costs shall depend on the use of lamps in a specific application (see Table 48 for examples). Though data is not available to allow a full estimation of the range of such costs, a few examples have been detailed by LE:

- In relation to exemption 4(f) IV (see footnote 39), the proposal restricts the use of **UV lamps** to curing and disinfection applications. These terms are not defined, neither in legislation nor in the Commissions FAQ. According to LE (LightingEurope 2017b) if the terms are interpreted with a wider scope, a majority of the known applications would be covered, but not all. If the terms are interpreted with a narrower scope, this would have dramatic consequences for EU industry, service providers, equipment producers and others, especially for high intensity discharge lamps (high pressure short arc mercury lamps). LE thus strongly recommends not to limit applications and specifies examples:
  - **Medium Pressure UV lamps**: In this market mainly lamp and equipment makers are involved which are not members of LightingEurope. Market data are not available to LE, neither for lamps, equipment or for the installed base of equipment. For the exemption renewal application an amount of >130.000 pcs p.a. was estimated for the curing lamps market. Data for other applications are missing. (LightingEurope 2017b)

- **High pressure short arc mercury lamps**: The world market for these lamps is roughly estimated to be 80.000 to 100.000 pcs. Around 5.000 pcs are sold in EU with an overall mercury content of 2.5 kg (rough estimation). These lamps are used for micro lithography applications in integrated circuit production (LED chips, other IC, memory, MEMs, sensors, ASICs etc.). Without these lamps the manufacturing sites have to be closed and/or relocated to outside EU. Another example is the production of highly integrated printed circuit boards, fluorescence microscopy in industrial applications. Subsequent impacts of this measure are listed by LE as follows: (LightingEurope 2017b)
  - *"Direct **impact to lamp producer**: 5.000 lamps can no longer be sold to EU market. A big part of the loss might be compensated by a sales increase outside EU. Loss of turnover in EU: **ca. 5 Mio EUR***
  - ***Impact to equipment producer**: Total loss of EU business, even for R&D the lamps are required. Affected companies: ASML (NL), Süss MicroTec (D), Canon, Nikon. **Relocation of business** from EU to exEU.*
  - ***Impact to Semiconductor and other IC producing industry** as user of lamps and equipment: Total loss of EU semiconductor and chip production business. Affected companies: OSRAM Opto Semiconductor, (D, LED production) NXP (NL), Infineon (D, A), Bosch (D), ST Microelectronics (I, F), TDK-Epcos (D), Elmos Semiconductor (D), Texas Instruments (UK), Nanium (P), Altis (F), Global Foundries (former AMD, D). Investment needs for exEU factories: **25-40 billion EUR; job losses: >10.000 direct** (highly qualified), **> 50.000 indirectly** (rough conservative estimation by LightingEurope); loss of know how. In addition, many companies using fluorescence microscopy, mainly SMEs, can no longer use these processes without equipment.*
  - ***Impact to downstream supply chain**: Full loss of EU suppliers, high costs for requalification of components and products, risk for production downtimes*
  - ***Impact to end customers**: Higher product prices, no availability of needed products.*
  - ***Environmental impact**: nearly zero. Professional lamps, handled by professional users, are no longer marketed in EU (with WEEE collection) but instead exported outside EU."*

- In relation to exemption 4(f) II[40], LE (LightingEurope 2017b) states that „*high pressure mercury lamps with extreme brightness are used in many **projection applications**, varying form stage lighting, to technical use in spectroscopy research. The limit to 2000 ANSI lumens leaves a gap between 1500-2000 lumens but also results in a lack of retrofit lamps in those projection applications where the screen intensity is not measured in ANSI lumens. Home cinema, rear projection TV, video walls in control rooms are further examples of these applications."* In the professional entertainment sector, LEs rough estimation is that around 100,000 lamps are placed on the market in new equipment and around 25,000 lamps as replacements lamps for this application. According to LE, the consequences of the exemption are:
  - In the case of lamps for [new] projectors ≥ 2000 ANSI lumen neither a change for lamp and equipment producers nor for customers is expected as replacement lamps will remain available;

40 Recommended in Gensch et al. 2016 as:4(f) II: "Mercury in high pressure mercury vapour lamps used in projectors where an output ≥2000 lumen ANSI is required".

- In the case of lamps for [new] projectors < 2000 ANSI lumen, such projectors can no longer be offered on the EU market. EU customers have to choose to buy projectors with either too low light output or with too high light output, increased energy consumption and more mercury than necessary;
- Where replacement lamps shall not be available for existing projectors (or other projection equipment) the equipment shall become WEEE prior to end of life and shall be scrapped;
- In the case of lamps for other projection purposes, such as technical microscopy and professional entertainment:
  - Entertainment: Lamp producers loose complete EU business for > 100.000 lamps and control gears per year;
  - Equipment producers loose complete EU business which cannot be replaced by LED or laser technologies;
  - Owners of existing equipment loose this equipment if replacement lamps (lifetime 1500–5000 h) are no longer available;

In the consultants view, an exhaustive list of applications cannot be concluded, nor the scale of expected impacts in relation to the current recommendations (SUB scenario) and to each application type. However, it can be followed that in some cases, impacts may extend beyond direct impacts tied to lamp manufacture, supply and use to indirect impacts that may incur to the activities of other sectors (manufacture, research, entertainment, etc.). From the provided information, in the consultants view, it can be observed that in some cases a slight adjustment of the recommended exemption formulations could suffice to prevent some of the possible impacts. In others, extending a broad scope exemption for the first three years shall allow an exemption evaluation in parallel to a retained exemption validity and can be expected to avoid costs associated with delayed evaluation of new exemptions requested.

## 7.6. Impacts on the generation of waste

As it is assumed that further specified exemptions could be granted in the SUB scenario for applications for which the justification could be clarified, it is assumed that a regulatory driven phase-out is not expected in the SUB scenario and thus that additional waste should not be generated in most cases. In this sense differences between the scenarios in relation to generated waste are not expected where amendments of existing exemptions can be requested with the purpose of approving application specific exemptions. That said, should new exemptions need to be applied for in some cases, this could result in temporary denial of market access to some lamps (possibly also relevant where exemption amendments are requested and lamps are not placed on the market in light of uncertainties). Where lamps shall not be available to relevant consumers (equipment users), this may result in an early scrapping of equipment where the lack of replacement lamps is perceived to be permanent. As in some cases equipment is understood to be manufacturing installations, such equipment may also be sold as second hand equipment to non-EU countries (or transferred where manufacture facilities are relocated). Though it is difficult to estimate how many lamps would be affected, and subsequently to estimate the amount and weight of equipment, the annual sales provide some insight in relation to this aspect, though it is clear that only a share of all sales would be affected. Please see Section 7.2 for details on annual sales.

## 7.7. Impacts on the amounts of mercury to be placed on the EU market

Here too, on the basis of available information, it is not feasible to estimate possible changes in sales related to temporary denial of market access of specific lamp types. To provide some insight as to the possible amounts of mercury that may be relevant, the total amount of Hg entering the EU market annually through special purpose lamps is reproduced from (Gensch et al. 2016):

The amount of Hg (in kg) placed on the market in 2013 for lamps covered by the following exemptions was estimated by LE in exemption applications submitted in January 2015:

- Ex. 1(f): 2 kg ;
- Ex. 2(b)(4) and Ex. 4(a): 188 kg, estimated as the total amount for Ex. 2(b)(3), Ex. 2(b)(4) and Ex. 4(a).
- Ex. 4(f): 45 kg for projection lamps; 20 kg for UV short arc mercury lamps; 75 kg for UV curing lamps; 81 kg for UV disinfection lamps; not detailed for other applications;

In this case, it should be clear that only a share of this mercury would not enter the market, depending on the applications for which market access would be denied. It is also noted that market sales for some application areas may have changed, leading to possible decreases and increases in the amount of Hg entering the market. A limitation in exemption availability may promote earlier development of replacement lamps in some cases (reducing the respective amount of Hg to be placed on the market). However, in light of the very wide range of applications covered by the term special purpose lamps, it is assumed that the development of replacements shall not differ significantly from the BAU scenario.

## 7.8. Analysis and discussion of results

In the discussion of the results of the evaluation for special purpose lamps a distinction needs to be made between:

- Costs expected assuming that the lighting industry applies and is granted application specific exemptions for applications of relevance where sufficient justification was not provided in the 2015-2016 evaluation (costs for new amendments and for new exemptions granted within the transition period).
- Costs expected assuming that such exemptions are significantly delayed or denied (for new exemptions granted in delay or denied).

The first case assumes that the bulk of costs shall be associated with the effort to prepare exemption applications as well as the effort associated with the evaluation of such requests, whereas actual substitution costs are not expected in such cases. In this sense, costs expected can be considered to be administrative in nature. They may comprise a certain burden to manufactures and their supply chain; however it should be kept in mind that such costs are the burden of stakeholders in all cases where RoHS substances are yet to be substituted and in this sense are expected to be considered acceptable. Rough estimations of such costs and their applicability to certain cases are summarised in Table 50 below.

Where exemptions are not granted or significantly delayed, aside from administrative costs for requesting the new exemptions, direct costs that the lighting industry would incur in light of loss of business are to be expected, as well as indirect costs of consumers of special purpose lamps , the latter of which could be considerable in certain cases. Such costs and their applicability are also summarised in Table 50 below.

**Table 50 Summary of possible costs and their case applicability related to special purpsose lamps and the SUB Scenario**

| Type of cost | Detail | Range of costs | Case applicability | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | New exemption request | | |
| | | | 2016 amendments | New amendments | Approved within transition | Late approval | Denied |
| Administrative costs | Costs for industry related to exemption application and evaluation process | Possible costs can be estimated on the basis of 1,250 hours of labour needed to be invested per exemption. This could amount to a total of 30,000-33,750 hours of labour: 17,500 hours for applications understood to require new amendments and 12,500-16,250 hours for applications understood to require (or possibly require) new exemption requests. Costs may be higher if additional lamp types are relevant or lower if sub-groups can be defined based on mutual technical justification. | | X | X | X | X |
| | Costs for industry related to updating of product data | 25,000-50,000 EUR per change, based on Spectaris estimation for exemption 13b for software adaptation required as a result of changes to an exemption. It is not clear how a "change" is to be interpreted, neither whether all costs can be attributed to amendment of RoHS exemptions. In some case additional costs related to testing of software updates may be relevant. | X | X | X | X | |
| | Costs for regulation authorities (evaluation, legislation, market surveillance) | Cost estimations are not available for this aspect. In general it is assumed that personnel of authorities work on a certain subject (e.g., waste, waste EEE) and in relation to certain legislation (e.g., RoHS) and fluctuations in workload are understood to be expected from time to time, resulting only in some cases in the hiring of additional staff. | X | X | X | X | X |
| Costs related to market accessibility of lamps | Costs to incur in light of uncertainties of stakeholders as to timely approval of exemption (market access to remain valid until exemption granted) | Costs may be expected, however estimations as to their range are not available and not possible on the basis of available data. Such costs are assumed to be temporary in nature and if relevant, should only affect a fraction of the lighting sector (should uncertainties as to exemption validity lead to actions). | | X | X | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Costs to incur if exemption is granted late (market access suspended temporarily in light of delay in approval of new exemption) | Costs may be expected, however are also expected to be temporary in most cases, though they might affect both the lighting industry (where a certain lamp is denied market access) as well as possible users (dependent manufacture or provision of services). Estimations as to the range of possible costs are not available and are not possible on the basis of available data. Where costs shall be permanent, examples given below for costs to incur where exemptions are denied may be indicative, though in this case the magnitude is expected to be much lower. | | | | X | |
| | Costs to incur where exemption is not granted and lamps are no longer available | Costs expected would be permanent in nature and could affect the lighting industry (where a certain lamp is denied market access) as well as respective users (private consumers, manufacturers, providers of services). Costs shall vary, depending on the lamp affected and its use (impacts on manufacture, on employment and in some cases on health of patients treated by equipment using special purpose lamps). Provided examples show that costs could vary significantly. For example, in the case of high pressure short arc mercury lamps, manufacture costs are estimated at 5 million EUR, whereas users (semiconductor and IC producing industry) may need to invest as much as 25-40 billion EUR to transfer facilities outside the EU. | | | | | X |
| **Impacts on waste** | Increase in waste EEE | Where certain lamps may no longer be available, and where replacement lamps to be developed for respective applications are not compatible, luminaires and in many cases also equipment in which such lamps are used could become waste early (or may be sold to non-EU countries). The available data and information do not allow an estimation of the expected increase in waste in the SUB Scenario. | (x) | (x) | (x) | (x) | X |
| **Impacts on Hg to enter the EU** | Hg to enter the market through lamps shall be eliminated where certain lamps no longer in use. | Hg inputs shall only decrease where a certain type of lamp is no longer to be placed on the market (or placed on the market in lower qualities). This could be the case in two cases:<br>▪ Replacement lamps developed and Hg lamps no longer placed on the market;<br>▪ Exemptions to be denied for specific applications;<br><br>The available data and information do not allow an estimation of the expected reduction in HG entering the EU market in the SUB Scenario. | (x) | (x) | (x) | (x) | X |

**(x) –this symbol only appears where the cost/benefit is understood to be based on the appearance of compatible substitutes.*

# 8. References

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