31 July 2020

Secretariat of the Minamata Convention on Mercury
United Nations Environment Programme
11-13, Chemin des Anémones
1219 Châtelaine, Switzerland

Email: MEA-MinamataSecretariat@un.org

Topic: European Market Study on Mercury-free Substitutes for Fluorescent Lighting

Dear Secretariat,

I am writing to submit the attached report for consideration by the Ad hoc Working Group reviewing the exemptions in Annex A of the Minamata Convention. This report presents a new product database which shows the very high rate of compatibility (91 to 93%) of LED retrofit LED tubes into existing fluorescent ballasts in Europe. Furthermore, it documents over 5 metric tonnes of mercury savings that can be captured if CFLni, T5 and T8 fluorescent lamps were to be phased out in Europe under RoHS in 2021. Economically, the case for this phase-out is very strong, with payback periods as short as 4 to 5 months in certain applications and a cumulative net savings across Europe of €30 billion.[1]

We ask that you please share this report with the Parties to the Convention and the Ad hoc Group. Thank you for your support.

Yours sincerely,

Michael Scholand

Michael Scholand, LC
Senior Advisor, CLASP

Cc: Peter Bennich, Ph.D., Swedish Energy Agency
Eric Gibbs, Jenny Mandel, Marie Baton, CLASP

[1] Update of the data provided by the analysis model developed in the course of the "Study to assess socio-economic impact of substitution of certain mercury-based lamps currently benefiting of RoHS2 exemptions in Annex III"; Oko-Institut e.V., Freiburg, 10.July 2020. Link to report.

Clarifications on Lighting Europe's Comments to the RoHS Committee

A report for the Committee on the Restriction of Hazardous Substances (RoHS) addressing Lighting Europe's comments of 20 May and 9 June relating to the exemption application for fluorescent lighting

Preface

Europe is considering whether to extend the exemptions granted to certain products listed in Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances (RoHS) in electrical and electronic equipment.[1] Fluorescent lighting is one of the product groups exempted from RoHS, even though mercury-free substitutes for this product are widely available in the lighting market.

The Swedish Energy Agency and CLASP have worked together to produce a series of market and technology studies that consider whether the exemptions for fluorescent lighting should be continued or retired. The first report was issued in October 2019, followed by an update to that report in December 2019[2] and later a review of the RoHS criteria relative to fluorescent lamps in February 2020[3].

This report, our fourth, was developed to address issues that were raised by Lighting Europe in two sets of comments they submitted directly to the RoHS Committee and the Commission. Lighting Europe is an association representing some of the lighting companies and national lighting associations in Europe, and they are seeking to extend the exemption from RoHS for mercury-containing fluorescent lamps.

The Lighting Europe comments we address in this report include the following:

1. "Lighting Europe concerns regarding the recent Oeko document dated 8 May 2020", dated 20 May 2020 and submitted to the RoHS Committee on 20 May by Roumiana Santos of Lighting Europe.

2. "Lighting Europe Calculations - Potential impact of an early phase out of most fluorescent lamps subject to RoHS 2015 exemption renewal requests", dated 9 June 2020 and submitted to the RoHS Committee on 10 June by Roumiana Santos of Lighting Europe.

This report provides an independent, evidence-based response to the points made in the comments from Lighting Europe. The report is lengthy because we reproduce the text from Lighting Europe's comments for clarity, transparency and completeness. In our responses, we frequently use published data from the Lighting Europe Members (Philips/Signify, Osram/LEDvance) and former members (Sylvania), and we also use data from other manufacturers and sources. All of our work is cited, referenced and included with this report (over 75 footnotes and more than 100 hyperlinks to sources of information).

The authors welcome any comments or suggestions on the work presented in this report.

[1] Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast) (Text with EEA relevance)Text with EEA relevance: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02011L0065-20190722

[2] "Evidence of the availability of mercury-free alternative products to certain fluorescent lamps", Report to the Committee on the Restriction of Hazardous Substances, prepared by the Swedish Energy Agency and CLASP. 12 December 2019. Link.

[3] "Assessing Annex III Fluorescent Lamp Exemptions in the Light of Scientific and Technical Progress", Report to the Committee on the Restriction of Hazardous Substances, prepared by the Swedish Energy Agency and CLASP. 28 February 2020. Link.

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The authors wish to thank **Seaborough Research**, a company who is constantly looking for (LED) innovations to replace fluorescent lamps, and in particular their CEO **Pieter Six** for the support in providing test results on LED retrofit tubes.

Table of Contents

List of Tables

List of Figures

1 Executive Summary

The Swedish Energy Agency and CLASP reviewed the comments submitted by Lighting Europe and were concerned that some of these comments could be misleading or only state partial information, therefore we felt a clarification report was necessary to present the facts to the RoHS Committee. First, we want to repeat that our main conclusion from our previous reports remains the same:

RoHS Criteria for Extending the Exemption for Fluorescent Light Sources. The Swedish Energy Agency and CLASP do not find that the criteria listed in Article 5(1)(a) in 2011/65/EU (the RoHS directive) for granting an exemption for fluorescent lighting have been met. We conducted a study of the scientific and technical progress of LED retrofits for fluorescent lamps relative to the six criteria listed under Article 5(1)(a): (i) Annex II Materials or Substances; (ii) Reliability of Substitutes; (iii) Environment, Health and Safety; (iv) Availability of Substitutes; (v) Socioeconomic Impact; and (vi) Impact on Innovation. We conclude that for all three fluorescent lamp types – T5, T8 and CFLni – the criteria for granting an exemption under Article 5(1)(a) do not apply. (See Section 3.5 and Annex B for a detailed assessment of the criteria).

By ending T5, T8 and CFLni exemptions from RoHS in 2021, Europe will avoid 5.36 metric tonnes of mercury – 2.88 MT from lamps and 2.48 MT from power plants.[4]

The following is a summary of the key points that are discussed in detail in this report, split into ***five themes***:

Process:

1) **Renewal Application and "de facto" Approval**. Lighting Europe states that they were granted a "de facto" renewal from 21 July 2016 to 21 July 2021, however as we understand it, this is not the case. From our perspective, restarting the exemption filing process from 2021 is not supported by the RoHS2 Directive. (see Section 2.1) Furthermore, it should be noted that four years ago, the Öko Institute stated that any outstanding technical issues with respect to availability of substitutes for fluorescent lamps would be solved within a few years and they recommended in their 2016 report that the Commission revoke the 2011 exemptions granted for T8 and T5. The RoHS2 Directive is a Delegated Act and decisions must be based on the RoHS2 evaluation criteria for substitutability. The 2016 Öko Institute report already confirmed those criteria were not met four years ago. Now, more recent reports published by Sweden and CLASP[5,6] further demonstrate that the RoHS2 exemption criteria have not been met.

[4] Avoided mercury from lamps published in Update of the data provided by the analysis model developed in the course of the "Study to assess socioeconomic impact of substitution of certain mercury-based lamps currently benefiting of RoHS 2 exemptions in Annex III"; by Yifaat Baron and Carl-Otto Gensch, Öko-Institut e.V., 10 July 2020; mercury avoided from power plants is based on energy savings from switching to LED retrofit lamps and the reduced consumption of mercury-containing coal which is 31% of Europe's generation mix, estimate adapted from the JRC calculation of 0.016 mg Hg/kWh.

[5] Mercury-Free Alternatives to Certain Fluorescent Lamps: A Report to the European Commission's Committee on the Restriction of Hazardous Substances. Swedish Energy Agency and CLASP. 19 December 2019. Link to report

[6] Assessing Annex III Fluorescent Lamp Exemptions in the Light of Scientific and Technical Progress: Report to the Committee on the Restriction of Hazardous Substances. Swedish Energy Agency and CLASP. 28 February 2020. Link to report

Data on compatible LED-based light sources and compatibility for drivers:

2) **Consideration of Current Market Data** - we strongly believe that current market data should always be taken into consideration by the RoHS Committee when considering an exemption application. It would be negligent to rely solely on the information submitted by the regulated entity as the submission of complete, current and accurate market data is not in their commercial interests if in doing so, they would undermine their own exemption application. (see Section 2.1)

3) **Ballast Compatibility Data is from Multiple Industry Sources**. Lighting Europe says that the compatibility data used in the 2020 Öko-Institute update report is derived from one stakeholder, but this is not correct. The market data provided in the Sweden-CLASP report is taken from the technical information published by Lighting Europe Member Companies (i.e., Philips/Signify, Osram/LEDvance) as well as Sylvania, Opple and LEDs Change the World (LCTW). We provide links to that material in our reports, and our findings were independently reviewed (and supported) by VHK at DG Environment's technical meeting on 12 February 2020. Our February 2020 review of these industry compatibility reports found that LED tubes are 90% compatible with the installed stock of T5 and T8 fluorescent fixtures in Europe. We have now updated our analysis and found that we were too conservative – the true compatibility rate, when looking at one ballast across multiple manufacturers is between 91.4% and 93.4%. (See Section 2.3 and Annex A).

4) **Retrofit LED Lamps with Plug-and-Play Compatibility** – as discussed in Section 2.3 and presented in Annex A, the new analysis of the manufacturer's ballast compatibility catalogues has found much higher rates of compatibility by looking at different lamps across more than one supplier. There are direct, plug-and-play retrofit LED lamps for nearly all of the fluorescent luminaires installed in Europe. VHK's independent market analysis confirmed what was presented in the December 2019 Sweden-CLASP report. VHK stated there are "adequate LED substitutes available for large majority of FL", and that there is "no technical barrier to create LED substitutes also for less widely used FL." (See Section 2.7)

5) **Overview of Compatibility Issues**. The Swedish Energy Agency and CLASP have looked at each of the issues raised in Annex II of Lighting Europe's comments (see Section 3.6) where they list constraints or problems encountered with retrofitting LED lamps. Our research found products already on the market that address these issues such as retrofit LED tubes which are flicker free, have 360 degree light output, operate on DC voltage, are installed in IP65 outdoor fixtures, and so-on. We have gone through each of the ten points raised in Annex II of Lighting Europe's comment and provided information and hyperlinks to examples of products which address the issues concerned.

6) **Recognising the market already here today**. Lighting Europe comments that it expects there to be significant disruption in the market if there is a phase-out of fluorescent lighting, but the reality is that the market is already transforming today and businesses and industries across Europe are benefitting from retrofitting LED lamps into existing fluorescent installations. Far from being disruptive, the installation of LED retrofit tubes into existing fluorescent lamps is common sense – it removes mercury, reduces energy consumption and provides better, longer-lasting service life from the lamps. Furthermore, since payback periods are often less than a year (and according to OSRAM can be as short as four months) upgrades can take place within on fiscal year cycle, where incremental costs are off-set by the substantial energy savings,

completely negating the cost of upgrading. Here are a few examples: Dansk Supermarked[7] in Denmark and Verhoef Access Technology[8] in the Netherlands. (see Section 3.2).

7) **Availability of Spare Parts – T5 Lamps.** Lighting Europe comments that T5 shouldn't be phased out because these are a more recent fixture and end-users deserve a right to access spare parts to operate these fixtures. However, there are T5 LED retrofit lamps that can be installed directly (no rewiring) into 80% of the T5 luminaires with a positive payback (based on the product catalogues of Philips/Signify, OSRAM/LEDvance and Sylvania, considering 208 T5 ballast and lamp combinations). In addition to these, a quick search on the Internet identifies another six additional manufacturers of T5 LED lamps whose products have not been analysed and who may well have addressed the other 20% of T5 luminaires. Furthermore, our economic analysis shows that T5 fluorescent lamps are inefficient compared to T5 LED, and owners who operate them are paying too much in energy bills for the lighting service they receive. Please see Section 3.3 where we present a "Cost of Light" graph, depicting running costs of fluorescent T5 vs. two LED T5 options on the same luminaire over a 15 year time period.

Model used by SEA/CLASP and Öko-Institute:

8) **Öko Institut's Methodology is Transparent**. Lighting Europe expresses concern over the model used to calculate the benefits to Europe from ending the exemption for fluorescent lighting. We find however that amble documentation is provided by the consultants, including both the Öko-Institut and the Dutch consultancy VHK who did the analysis for the lighting regulation in Ecodesign. (See Section 2.2 and Section 2.6)

9) **Calculation Problem in the Model**. Lighting Europe identified a problem in the market model presented in the May 2020 Öko-Institute model where savings become costs in later years, and presume that the model has "crashed". We identified this same issue and informed Öko-Institut of our findings. They isolated the problem and informed us that they will fix it, and that the corrected calculation would not change the conclusion of their 2020 report, but rather it will strengthen those positive findings. The updated Öko-Institute report was published on 10 July,[9] calculating €29.9 billion Euros in net savings for Europe through 2035 from phasing-out CFLni, T5 and T8 lamps in 2021. In other words, eliminating the RoHS exemption for fluorescent lamps will have a large, net positive economic benefit for Europe according to this impartial expert analysis. (See Section 2.4).

Environmental aspects:

10) **Mercury from Fluorescent Lighting is a major problem.** Setting aside collection targets given by Lighting Europe in their comments, the practical reality in the field is that recovery rates for fluorescent lamps are lower than rates reported for all WEEE directive products. Our research shows that 50-88% of fluorescent lamps placed on the market today are not disposed of properly, meaning most of the mercury in lighting is not recovered in Europe causing further damage to the environment and public health. Furthermore, the mercury savings in the Öko-Institut 2020 report are too low because Öko did not account for the avoided mercury emissions released from coal-fired power stations due to the improvement in energy-efficiency from LED

[7] https://www.lighting.philips.com/main/cases/cases/food-and-large-retailers/dansk-supermarked
[8] https://www.lighting.philips.com/main/cases/cases/industry-and-logistics/verhoef-access-technology
[9] Update of the data provided by the analysis model developed in the course of the "Study to assess socioeconomic impact of substitution of certain mercury-based lamps currently benefiting of RoHS 2 exemptions in Annex III"; by Yifaat Baron and Carl-Otto Gensch, Öko-Institut e.V., 10 July 2020.

lamps. These additional savings (i.e., avoided Hg emissions) represents an additional 3.6 metric tonnes of mercury. (See Section 2.8)

Cost-benefit analyses and job creation:

11) **Cost of Substitution in Public Places**. Lighting Europe states that substitution costs will be high in the market, and specifically names Public Places as having high costs. These statements conflict with impartial cost analysis conducted for the Ecodesign Directive as well as case studies on Lighting Europe's member's own websites. In Section 2.5, we provide a case study of an LED tube retrofit case study from the Netherlands. Philips/Signify states that this customer was able to cut its energy bill by 60% while extending lamp life to 17 years and improving light quality, all with a 1.5 year payback.[10] OSRAM/LEDvance states on their website that LED retrofit lamps can have payback periods as short as 4 months.[11] We calculated five months in our analysis published in December 2019.[12] Either way, this is within the cycle of one fiscal year, thus public authorities and other stakeholders can easily finance these retrofits with their capital maintenance budgets yielding net savings from the first year they start installing the LED lamps. The economic case is irrefutable; we are puzzled as to why Lighting Europe made this comment.

12) **Lighting Europe's Cost Model**. Lighting Europe submitted a table which provides undocumented, unsubstantiated costs that would result from the phase-out of fluorescent lighting. These cost estimates are misleading because they are based on incorrect LED substitution percentages and do not take into account the published literature of their own Members which show that LED retrofit lamps can be directly installed on over 90% of the stock of fluorescent luminaires and customers can have payback periods as short as four months. Since a payback period by definition is the length of time an incremental cost is recovered through energy savings (in this case the incremental cost of an LED retrofit lamp replacing a fluorescent tube), the economic facts published by Lighting Europe's Members' contradict the position taken by the Association. In addition to ignoring the fact that 90% of the luminaires can take a direct (no rewiring) LED retrofit lamp, the Lighting Europe table of costs also omits the financial savings that come from the lower energy use (roughly 50% reduction in electricity bills) and savings in maintenance because LED tubes can last 2-3 times longer than fluorescent lamps. Overall, there is simply no economic or technical basis for Lighting Europe's cost estimate. (see Section 3.1).

13) **Employment Impacts**. Lighting Europe comments about a risk of job losses in Europe from phasing out fluorescent lamps, however we are aware that over the last decade the vast majority of fluorescent lamp manufacturing in Europe has been closed voluntarily – 6 to 8 facilities have been closed and these manufacturers are now primarily sourcing their fluorescent lamps from China (see discussion and list of closed facilities in Section 3.4). Furthermore, we are aware that as fluorescent lamps are gradually removed from the market, LED luminaire business which are largely Europe-based and consisting of many small and medium-sized enterprises (SMEs) will experience higher demand. This market stimulus will enable these SME LED businesses to expand employment as the RoHS exemptions for fluorescent lamps are phased-out, repatriating lighting jobs back to Europe. Thus, removing the exemptions from RoHS for fluorescent lighting will create jobs and improve the balance sheet for all consumers of fluorescent lighting through lower energy bills and better quality light. Far from a negative impact on employment, phasing

[10] Click on this link to view the Case Study on Philips/Signify website.
[11] Click on this link to view the graphic where OSRAM/LEDvance make the following statement: "Economy: Replacement costs can be recouped in just four months"
[12] Click on this link to view the Swedish Energy Agency/CLASP study, and view Tables 7, 8 and 9 on pages 28-30.

out fluorescent lighting will be an economic stimulus for European employment (see Section 3.4).

Overall, our assessment of the compatibility of direct, drop-in retrofit LED lamps (presented in Annex A) shows that when looking across the published literature by Lighting Europe members and others, LED retrofits are compatible with over 90% of the ballasts in the installed stock of fluorescent luminaires in Europe today. The market is transforming now and maintaining the exemption in RoHS for fluorescent lamps will only slow that transition and allow more mercury pollution from the lighting sector.

The 2020 Öko-Institut report presents findings that clearly show the RoHS Directive is positioned to not only eliminate several metric tonnes of mercury from our homes, offices and environment, but it could also bring a very strong socio-economic benefit of €29.9 billion Euro. In these difficult times of Covid-19 and re-starting Europe's economic recovery, the phase-out of fluorescent lighting under RoHS offers a rare opportunity for an environmental and economic win-win. Retiring the fluorescent lighting exemptions aligns with the principles of the European Green Deal, while offering a green stimulus to the lighting market that will put money in end-user's pockets while protecting public and environmental health. Furthermore, refurbishing programmes (including lighting) are discussed as part of the Green recovery will mean more jobs for installers and sales of new LED-based lighting solutions.

We look forward to the publication of the Commission's draft implementing measure and the four-week comment period when Lighting Europe and other stakeholders will have an opportunity to provide feedback in a public forum at the allotted time in this process.

2 Lighting Europe's Comment of 20 May

In this section of the report, we address Lighting Europe's comments of the 20th May. We have included copy/paste text from the comments in order to facilitate review by the Committee and to be absolutely clear on which points we are responding. This chapter is broken up into subsections that relate to the topic areas of Lighting Europe's comments.

2.1 Using current market data and a "de facto" renewal

Table 1. Lighting Europe's Comment from pages 1 and 4 of their 20th May Comment

Lighting Europe's Comment:
• The exemptions under review were meant to expire in July 2016, their evaluation is based on Lighting Europe data supplied in 2015 and thereafter in response to the consultants request, and their maximum validity period for the present review is until July 2021. • Lighting Europe has applied for the renewal of these exemptions beyond July 2021 in January 2020, in line with the advice of our lawyers and also of the European Commission services' express recommendation to comply with the RoHS legal requirement to submit renewal applications maximum 18 months prior to the presumed expiry of these RoHS exemptions. • Any evaluation of impact post-2021 can only be done based on the January 2020 renewal applications submitted by Lighting Europe and must also consider the data these contain. • It is Lighting Europe members' reasonable and lawful expectation that the recent data contained in the Lighting Europe January 2020 renewal applications is taken into account when discussing impact of the exemptions post 2021. […] • Lighting Europe expects that recent data is reviewed in a lawful, fair and transparent way by all stakeholders impacted by these exemptions, including the many who were neither made aware of nor invited to provide feedback to the February 2020 meeting. Our new applications are and always have been our feedback to your request to provide recent data. • Any evaluation of more recent data and an impact assessment beyond 2021 can only take place based on the 2020 applications, must include all stakeholders and must evaluate all data supplied by all stakeholders. The 2015 applications are de facto renewed, by the Commission's lack of action to publish a decision within the maximum validity period and by Lighting Europe's positive action to apply for a renewal post-2021.

Swedish Energy Agency and CLASP Response:

Lighting Europe suggests that only outdated data on the market availability of retrofit (drop-in replacement) linear LED replacement lamps may lawfully be considered as the basis for the upcoming draft Directive for Pack 9. The suggestion that using updated market information is unlawful is linked to the Lighting Europe's decision in January 2020 to file for a further prolongation of the exemptions in question. This filing was made in the event that Lighting Europe would be successful in persuading the Commission that a prolongation should be granted on its 2015 application.

It is our view that current market data should always be assessed when considering RoHS exemption applications, particularly in circumstances where there has been an unforeseen delay in the decision-making process. Market data should never be limited to only that information submitted by an

industry association representing the interests of the regulated companies. Indeed, the submission of complete, current and accurate market data is not in their commercial interests, particularly if in doing so, they would undermine their own exemption application.

Lighting Europe argues that due to the fact that 5 years has lapsed between their original filing for the exemption prolongation in 2015, the whole exemption process should be restarted before any new and updated market information is accepted. They appear to conclude that since the Commission did not rule for 5 years after their 2015 exemption filing, they have "de facto" been granted an exemption for the (maximum) 5 year period from 21st July 2016 to 21st July 2021. However as we understand it, this is not the case.

From our perspective, restarting the exemption filing process from 2021 is not supported by the RoHS2 Directive. Annex 1 of the RoHS2 Directive provides maximum validity periods for exemptions granted for various Categories of products. Lighting equipment is Category 5, and according to Article 5.2., the maximum exemption period for this Category is 5 years, i.e. technically these exemptions expired on 21st July 2016. However, according to Article 5.5. the existing exemption shall remain valid until a decision on the renewal application is taken by the Commission. The Directive does not say for how long the Commission may exceed the expiration date before eventually ruling, however we do note that this decision is long overdue and we encourage the Commission to move forward with rejecting these applications from Lighting Europe given that fluorescent lighting – in all its forms – no longer meets the RoHS exemption criteria.

Furthermore, no where in the RoHS2 Directive does it say that the Commission cannot obtain and apply new (updated) market information in the course of processing and reviewing exemption applications. Indeed, we believe accessing data from the market directly, or considering market information submitted by independent stakeholders like ourselves, if properly referenced to public sources should also warrant consideration.

Finally, we note that the emergence of new and updated data on the evolution of LED technology was already contemplated and expected in the 2016 Öko-Institute report. In that report, the authors observed: " - - that LED replacements are available for T8 LFLs, however their comparability on the component level (lamp) and the system level (after installed in LFL luminaire as replacement) can have various shortcomings, expected to be resolved within a few years." [13] And in the conclusion: "The consultants recommend revoking specific exemptions for T5 and T8 lamps as substitutes, either in the form of long-life lamps or in the form of LEDs are available." [14]

Our research – including new compatibility tables in this report – has shown that LED retrofit tubes that are available on the market today that can directly retrofit into over 90% of the installed stock of fluorescent luminaires. Sweden and CLASP are prepared to make this new analysis available publicly to support building owners and EU citizens who wish to divest from mercury-based lighting while lowering their energy bills and improving their lighting.

[13] Assistance to the Commission on technological socio-economic and cost-benefit assessment related to exemptions from the substance restrictions in electrical and electronic equipment, July 2016 Report of the Öko-Institut, Section 8.5.4 Link to the report
[14] Assistance to the Commission on technological socio-economic and cost-benefit assessment related to exemptions from the substance restrictions in electrical and electronic equipment, July 2016 Report of the Öko-Institut, Section 8.6 Link to the report

2.2 ÖKO and VHK Modelling Inputs and Calculation Methods

Table 2. Lighting Europe's Comment from pages 1 and 2 of their 20th May Comment

Lighting Europe Concern:
• The 2020 document does not reveal neither the calculation methodology applied nor all the input data needed to recalculate and assess the robustness of the report's conclusions. Critical data, such as the used efficacy of LEDs or their price, have not been disclosed, the only reference is "varies with year". These variables seem to have changed in the 2020 report, compared to the data in the 2019 SEIA report. • The 2019 SEIA document refers to the publicly available 2016 VHK model. The 2020 Öko document refers to the 2019 VHK model which is not publicly available. Lighting Europe asks that the data for the basis/method of this calculation is made publicly available and that the consultants clarify the assumptions made during the calculation process to arrive to these conclusions. The new VHK model seems to have a huge impact on the calculations. For instance, the amount of T8 lamps to be substituted from 2021 to 2025 has decreased by more than 40% in the 2020 document.

Swedish Energy Agency and CLASP Response:

There is no problem with transparency in how the Öko-Institute conducted their analysis and in how VHK supported this analysis by adapting the MELISA lighting market model they developed for the Commission's Ecodesign regulation (to which Lighting Europe was a very active member of the Consultation Forum).

On page 11 of the Öko-Institut's 2020 updated report[15], the authors state "Detailed explanations as to how market flows and certain impacts have been calculated are specified in the 2019 SEA report. Additional input variables used appear in Annex I." Lighting Europe would benefit from following the suggestion in the text and review the methodology section in the 2019 Socio-Economic Assessment (SEA) report[16] and by looking in Annex I of this 2020 update report. In Annex I, titled "Variables used in VHK-Öko-Institut Combined Model for RoHS", the authors present all the important model inputs, including price and performance information of fluorescent lamps and control gear. The efficacy values and prices of LED products used in the model are not presented in this table because they vary from year to year in the model (i.e., for LEDs, efficacy is increasing while prices are coming down) – however since VHK is using the same MELISA[17] In Table 6-2 (shown below), the authors also provided "Additional data for LEDs" which includes projected LED efficacy, price, and wattage power for each of the three lamp types that are used in the MELISA model runs, from 2021 through 2035.

[15] Update of the data provided by the analysis model developed in the course of the "Study to assess socioeconomic impact of substitution of certain mercury-based lamps currently benefiting of RoHS 2 exemptions in Annex III"; by Yifaat Baron and Carl-Otto Gensch, Öko-Institut e.V., 10 July 2020.

[16] Study to assess socio-economic impact of substitution of certain mercury-based lamps currently benefitting of RoHS 2 exemptions in Annex III, Öko-Institut, July 2019. Link to report.

[17] Model for European Light Sources Analysis (MELISA), developed by VHK. Information is provided here.

Table 3. Data provided by Öko-Institut on EU Lighting Market Analysis (Öko-Institut, 2020)

Table 6-2: Additional data for LEDs

LED input data	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
LED efficacy, res, lm/W [1]	110	118	126	134	142	150	152	155	157	160	160	160	160	160	160
LED efficacy, nres, lm/W [2]	132	139	148	157	166	175	179	183	186	190	190	190	190	190	190
LED price, res, euros/klm [1]	7.62	7.68	7.62	7.48	7.22	7.23	6.83	6.52	6.36	6.24	6.24	6.24	6.24	6.24	6.24
LED price, nres, euros/klm [2]	11.85	10.77	10.16	9.65	9.10	9.03	8.65	8.30	8.15	8.00	8.00	8.00	8.00	8.00	8.00
LEDs replacing LFL T8															
Power (W/unit) res	21.8	20.3	19.0	17.9	16.9	16.0	15.8	15.5	15.3	15.0	15.0	15.0	15.0	15.0	15.0
Power (W/unit) nres	25.2	23.9	22.4	21.1	20.0	19.0	18.6	18.2	17.8	17.5	17.5	17.5	17.5	17.5	17.5
LEDs replacing LFL T5															
Power (W/unit) res	20.7	19.3	18.1	17.0	16.0	15.2	15.0	14.7	14.5	14.2	14.2	14.2	14.2	14.2	14.2
Power (W/unit) nres	19.7	18.7	17.6	16.6	15.7	14.9	14.5	14.2	14.0	13.7	13.7	13.7	13.7	13.7	13.7
LEDs replacing CFLni															
Power (W/unit) res	6.3	5.8	5.5	5.1	4.9	4.6	4.5	4.5	4.4	4.3	4.3	4.3	4.3	4.3	4.3
Power (W/unit) nres	9.1	8.6	8.1	7.6	7.2	6.9	6.7	6.6	6.4	6.3	6.3	6.3	6.3	6.3	6.3

Notes:
1 – LED efficacy (incl. control gear) and price for residential, from MELISA 2019 for low-end LEDs with energy label effect (same as used in Impact Assessment accompanying 2019 single lighting regulation, SWD 2019/357 part 2, Annex 4, section 2.2)
2 – LED efficacy (incl. control gear) and price for non-residential, from MELISA 2019 for high-end LEDs with energy label effect (same as used in Impact Assessment accompanying 2019 single lighting regulation, SWD 2019/357 part 2, Annex 4, section 2.2)
Source: Model for European LIght Sources (VHK 2019)

We note and applaud the fact that the Öko-Institut's 2020 updated report because it offers very detailed market and cost data in the analysis presented in three tables, numbered 3-1 and 3-2 (for CFLni), 4-1 and 4-2 (for T5) and 5-1 and 5-2 (for T8). These tables offer detailed numerical information on the units of shipments in the BAU and SUB scenarios. An example of this table appears below (this one is for T8):

Table 4. Example of the Öko-Institute's Presentation of a Product Scenario

Table 5-2: Revised estimated impacts calculated for T8 lamps (using CLASP/SwEA data set)

CLASP/SwEA data set	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Avoided purchase cost for LFLT8 in SUB, M euros	-1060	-854	-518	-242	-152	-106	-67	-60	-53	-45	-38	-32	-26	-21	-16
Additional purchase cost for LED plug&play in SUB, M euros	4509	3338	1923	855	504	351	210	180	154	127	12	11	11	10	9
Additional cost for LED+rewiring in SUB, M euros	34	26	15	7	4	3	2	2	1	1	0	0	0	0	0
Additional cost for LED+luminaire in SUB, M euros	604	487	296	138	87	61	38	34	30	25	3	3	3	3	3
Total additional purchase costs in SUB, M euros	4087	2998	1716	758	443	308	183	156	132	108	-23	-18	-12	-8	-5
Total additional cost in SUB, M euros (add. purchase cost minus energy cost savings)	3267	1448	-329	-1547	-2044	-2321	-2547	-2670	-2782	-2887	-2076	-1300	-829	-613	-480
Cumulative from period start in SUB, M euros	**3267**	**4714**	**4386**	**2838**	**794**	**-1527**	**-4074**	**-6745**	**-9527**	**-12414**	**-14490**	**-15790**	**-16619**	**-17232**	**-17712**
Total additional E-waste in SUB, in million kg	**10.6**	**8.6**	**5.2**	**2.4**	**1.5**	**1.1**	**0.7**	**0.6**	**0.5**	**0.4**	**0.1**	**0.1**	**0.1**	**0.0**	**0.0**

Source: Calculated with the VHK-Oeko-Institut Combined Model for RoHS; Note: Values are rounded; Negative values represent benefits

The Öko-Institut's tables present year-by-year data on unit sales, replacement in the residential and non-residential applications, energy savings, cost of energy savings and other information. These tables are extremely detailed, and provide an excellent basis on which to check and verify their validity.

2.3 Sources of Ballast Compatibility Data Used in the 2020 Öko-Institute Update

Table 5. Lighting Europe's Comment from page 2 of their 20th May Comment

Lighting Europe Concern:
• The European Commission appears to have supplied data to the Öko institute for this document that reflects only the assumptions of one stakeholder (see table 2.1 of the 2020 report, refers to data from CLASP/SwEA). The consultants have not provided an assessment of the reliability of the data in this new document. The feedback provided by other stakeholders, in particular Lighting Europe and VHK, during and after the February 2020 meeting of selected stakeholders that the European Commission organized, and where Öko was present, has not been acknowledged and appears not to have been taken into account. The 2020 document does not take into account the data in the Lighting Europe 2020 renewal applications.

Swedish Energy Agency and CLASP Response:

While Lighting Europe is correct in that the data submitted by the Swedish Energy Agency and CLASP was used in the 2020 Öko-Institut update to the SEA report, our input was based on multiple public sources of data, including that of major Lighting Europe members – Philips/Signify and OSRAM/LEDvance. We provide citations to all of our data sources in our Table which was given to the Öko-Institut by the Commission. For convenience and clarity, we reproduce that list of sources for T5 and T8 compatibility in the table below.

Table 6. Data Sources Used in Sweden/CLASP Compatibility Assessment, February 2020

Lamp Size	LED Tube Product Name	Number of Variants*
T5	Philips MASTER LEDtube HF InstantFit HE T5	9 models
	Osram Substitube T5 Universal	12 models
	Sylvania TOLEDO SUPERIA T5 ECG	15 models
T8	Philips MASTER LEDtube EM/Mains T8	30 models
	Osram Substitube T8 EM	44 models
	Sylvania TOLEDO SUPERIA T8 CCG AND AC	42 models
	Philips MASTER LEDtube HF InstantFit T8	16 models
	Osram Substitube T8 Universal	32 models
	Sylvania TOLEDO SUPERIA T8 ECG	12 models
	Opple Universal LED T8 Tube	6 models
	LCTW U-Tube T8 (Sengled)	12 models

*Lamp variants includes models with different CCT ratings, CRI values, wattages, lengths and other parameters.

It should be noted that this table itself was based on Lighting Europe's member's own technical reports and compatibility tables, as well as those of non-Lighting Europe members. In other words, the Swedish Energy Agency and CLASP compiled the compatibility table, but the calculation is based on substitution documents from several different and significant industry sources. The table below sets out the calculation method and the compatibility determined for retrofitting LED lamps into fluorescent fixtures in Europe.

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

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

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

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

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

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

Figure 1. CLASP Table Summarising Industry Estimates of T5 and T8 LED Retrofit Compatibility

CLASP have always maintained an open and transparent process, publishing our reports widely and sharing them with Lighting Europe and the Commission. However, the fact that Lighting Europe raised this concern compelled us to go back to our spreadsheet and conduct a more rigorous analysis. We have now completed that review of the data (see Annex A to this report) and found that we had been too conservative when reporting the compatibility of LED lamps into existing fluorescent luminaires. In actuality, the compatibility rates are significantly higher than what was reported.

We had reported compatibility rates on high-frequency (electronic) fluorescent lamp ballasts of around 70 to 80%, and that is true if you look at compatibility for an individual manufacturer's lamp product line in isolation. However, in our new analysis, we created a master database which merged together the ballast-lamp combinations across multiple product lines and multiple manufacturers. We found that for a given ballast-lamp combination, Philips may not have a compatible lamp available but Osram did; and vice-versa. We find that this new approach more accurately represents how the market functions – an installer will look across all the manufacturer's catalogues to find the right LED retrofit model which was compatible with their ballast/lamp combination.

For T5 lamps, when we organise the compatibility analysis this way – multiple LED tube manufacturers competing for the same lamp/ballast combination - we find a slight improvement in the compatibility rate. Annex A presents the large table of 208 unique ballasts for T5 fluorescent luminaires in Europe, and of these 79 to 80% of them are compatible with direct, drop-in replacement LED tubes.

Table 7. Retrofit T5 LED Lamp Compatibility Percentages (see Annex A)

Lamp Size	Retrofit LED Tube Manufacturer and Product	Philips & Osram	Philips, Osram and Sylvania
T5	Philips Master LEDtube HF 1200mm HE 16.5W 8xx T5	79%	80%
	Philips Master LEDtube HF 1200mm HO 26W 8xx T5		

	Philips Master LEDtube HF 1500mm HE 20W 8xx T5		
	Philips Master LEDtube HF 1500mm HO 26W 8xx T5		
	Philips Master LEDtube HF 1500mm UO 36W 8xx T5		
	Philips Master LEDtube HF 600mm HE 8W 8xx T5		
	OSRAM SubstiTUBE ® T5 HO49 26W UNIVERSAL - 1.5m		
	OSRAM SubstiTUBE ® T5 HO54 26W UNIVERSAL - 1.2m		
	OSRAM SubstiTUBE ® T5HE14 7W UNIVERSAL - 0.6m		
	OSRAM SubstiTUBE ® T5HE21 10W UNIVERSAL - 0.9m		
	OSRAM SubstiTUBE ® T5HE28 17W UNIVERSAL - 1.2m		
	OSRAM SubstiTUBE ® T5HE35 18W UNIVERSAL - 1.5m		
	OSRAM SubstiTUBE ® T5HO80 37W UNIVERSAL - 1.5m		
	Sylvania ToLEDo SUPERIA T5 HE 4FT 16W 2200LM/2400LM*		
	Sylvania ToLEDo SUPERIA T5 HE 5FT 18,5W 2600LM/2800LM*		
	Sylvania ToLEDo SUPERIA T5 HO 4FT 27W 3700LM/4000LM*		
	Sylvania ToLEDo SUPERIA T5 HO 5FT 26W 4050LM/4200LM*		
	Sylvania ToLEDo SUPERIA T5 HO 5FT 37W 5150LM/5600LM*		

*Sylvania lamps were omitted from the February 2020 calculation.

For T8 lamps, when we look at multiple LED lamp manufacturers competing for the same lamp/ballast combination - we find a significant improvement in the compatibility rate compared to what we had previously reported in February 2020. Annex A provides the large table of the 262 unique electronic (high-frequency) ballasts for T8 fluorescent luminaires in Europe, and of these 89 to 97% of them are compatible with direct, drop-in replacement LED tubes.

Table 8. Retrofit T8 LED Lamp Compatibility Percentages (see Annex A)

Lamp Size	Retrofit LED Tube Manufacturer and Product	Philips, Osram, Sylvania	All
T8	Philips Corepro LEDtube HF, Instant Fit 1200mm T8 1600lm	89%	97%
	Philips Corepro LEDtube HF, Instant Fit 1500mm T8 2000lm		
	Philips Corepro LEDtube HF, Instant Fit 600mm T8 800lm		
	Philips Corepro LEDtube UN, 1200mm HO 18W8xx T8		
	Philips Corepro LEDtube UN, 1500mm HO 18W8xx T8		
	Philips MASTER LEDtube 1200mm HF HO, InstantFit T8 2100 lm		
	Philips MASTER LEDtube 1200mm Universal, Instant Fit 2500lm		
	Philips MASTER LEDtube 1500mm HF HO, Instant Fit T8 3100 lm		
	Philips MASTER LEDtube 1500mm HF UO, Instant Fit T8 3700 lm		
	Philips MASTER LEDtube 1500mm Universal, Instant Fit 3700lm		
	Philips MASTER LEDtube HF 1200mm 16.5W 833 T8 MEAT		
	Philips MASTER LEDtube HF, Instant Fit T8 600mm HF 1050lm		
	OSRAM SubstiTUBE® T8 UNIVERSAL 0.6m ADVANCED 7.5W		
	OSRAM SubstiTUBE® T8 UNIVERSAL 0.6m STAR 8W		
	OSRAM SubstiTUBE® T8 UNIVERSAL 0.6m VALUE 8W		
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.2m Advanced 14W		
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.2m Advanced UO 15W		
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.2m Star 16W		
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.2m Value 16W		

	OSRAM SubstiTUBE® T8 UNIVERSAL 1.5m Advanced 20W		
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.5m Advanced UO 23W		
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.5m Star 19W		
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.5m Value 19W		
	Sylvania ToLEDo SUPERIA T8 ECG 2FT 1050LM/1100LM*		
	Sylvania ToLEDo SUPERIA T8 ECG 4FT 2200LM/2400LM*		
	Sylvania ToLEDo SUPERIA T8 ECG 5FT 2850LM/3100LM*		
	Sylvania ToLEDo SUPERIA T8 ECG 5FT 3300LM/3600LM*		
	Sylvania ToLEDo SUPERIA T8 UNI 2FT 1050LM/ 1100LM*		
	Sylvania ToLEDo SUPERIA T8 UNI 4FT 2200LM/ 2400LM*		
	Sylvania ToLEDo SUPERIA T8 UNI 5FT 3300LM/ 3600LM*		
	LEDs Change The World, TLED Tube 1200mm 36W HF Ballast, Dim*		
	LEDs Change The World, TLED Tube 1200mm 36W HF Ballast, Non-Dim*		
	LEDs Change The World, TLED Tube 1500mm 58W HF Ballast, Dim*		
	LEDs Change The World, TLED Tube 1500mm 58W HF Ballast, Non-Dim*		
	LEDs Change The World, TLED Tube 600mm 18W HF Ballast, Dim*		
	LEDs Change The World, TLED Tube 600mm 18W HF Ballast, Non-Dim*		
	Opple Universal T8 1200mm*		
	Opple Universal T8 1500mm*		

*Sylvania, LEDs Change The World and Opple lamps were omitted from the February 2020 calculation.

Given the revised estimates based on our more thorough analysis of the manufacturer's current catalogues providing their declared rates of compatibility, we have calculated new revised estimates for Europe for retrofit LED lamp compatibility in fluorescent luminaires across the EU. Our estimate published in our February 2020 report was 90% but we have now determined the actual rate of retrofitability to be 91.4% to 93.7% across all T5 and T8 luminaires installed in Europe today.

Table 9. Revised LED Lamp Compatibility Percentages for T5 and T8 Luminaires in Europe

Lamp Size	Percentage of T5 & T8 in EU Stock	Ballast Type	Percentage of stock by ballast type	Estimated EU Stock of total T5 & T8	Compatibility, Low - High Estimate	Overall EU Stock Compatibility
T5	30%	HF/ECC	100% of T5	30%	79% - 80%	23.7% - 24%
T8	70%	EM/CGG	70% of T8	49%	100%*	49%
		HF/ECC	30% of T8	21%	89% - 97%	18.7% - 20.4%
EU Total:	**100%**			**100%**		**91.4% - 93.4%**

*No compatibility issues with electromagnetic T8 ballasts, LED lamps can retrofit 100% of these installations

In order to avoid any problems with Lighting Europe being critical of our analysis, we have prepared this spreadsheet analysis in Microsoft Excel and will share it with the Commission, the RoHS Committee and Lighting Europe. It is clear that retrofit LED lamps available on the market today can be installed directly (no rewiring, just change the bulb) into **over 91.4% of the installed stock** of fluorescent lamp luminaires in Europe (percentage calculated only using retrofit LED lamps from Philips, Osram and Sylvania). The investments made by industry – including Lighting Europe members and non-members – has paid off, and now warrants a retirement of the exclusions for fluorescent lighting under the RoHS Directive.

2.4 Calculation Problem in the ÖKO/VHK Market Model

Table 10. Lighting Europe's Comment from page 2 of their 20th May Comment

Lighting Europe Concern:
• It appears there are problems with the calculation model that has been applied: for non-residential lamps, a substitution of 0.0 pieces was used, for no comprehensible reason, in the calculations from the years 2027 (CFL-ni) and 2031 (T5, T8). As a result, the calculation model seems to have crashed and provide false values for total costs, as indicated by the total (cumulative) energy and energy cost savings that decrease again from these years for all lamp types. This assumption also results in underestimated investment costs for public and commercial households. • Both the 2020 and the 2019 documents show significant costs for the period up to 2025. The conclusion in the 2020 document that the impact will be a net benefit is misleading and not scientific – whereas the 2019 report deals with the impact over a period of 7 years until 2025, the 2020 report considers total impact over a period of 15 years until 2035 and thus concludes on a net benefit. This methodology is equivalent to comparing apples with oranges.

Swedish Energy Agency and CLASP Response:

We also found there was a calculation anomaly in the results presented. We contacted the Öko-Institut to inform them of this problem and found that it was caused by a stock inventory reduction in the business as usual (BAU) case without an equivalent reduction in the LED substitution (SUB) case. This resulted in an excess inventory in the SUB case which caused the savings to flip in the later years of the analysis.

The Öko-Institut worked with VHK to prepare a revised version of this analysis and that this issue highlighted by Lighting Europe will be corrected. The correction (which was published on 10 July 2020[18]) did not change the conclusion of the updated Öko-Institut 2020 report, but rather it strengthened those findings. The updated Öko-Institute report found €29.9 billion Euros in net savings for Europe through 2035 from phasing-out CFLni, T5 and T8 lamps in 2021. In other words, eliminating the RoHS exemption for fluorescent lamps will have a large, net positive economic benefit for Europe according to this impartial expert analysis. The table below presents a summary of the benefits quantified in this update to the Socioeconomic Impact Analysis.

[18] Update of the data provided by the analysis model developed in the course of the "Study to assess socioeconomic impact of substitution of certain mercury-based lamps currently benefiting of RoHS 2 exemptions in Annex III"; by Yifaat Baron and Carl-Otto Gensch, Öko-Institut e.V., 10 July 2020.

Table 11. Net Benefits from Phase-Out of T8, T5 and CFLni Lamps in 2021, Öko-Institute Report

Savings	Cumulative (2021-2035) Savings for:			
	T8	T5	CFLni	Sum
Mercury savings lamps (kg)	962	1064	856	**5360 kg**
Mercury savings, powerplant (kg)	1218	1032	227	
Electricity Savings (*TWh*)	152.3	129.0	28.4	**309.7 TWh**
CO_2 Savings (MMT)	45.3	38.4	8.4	**92.1 MMT CO_2**
Net savings including lamps & electricity (*€ billion*)	€17.7	€9.3	€2.8	**€29.9 billion**

Source: Öko-Institute report, 10 July 2020; Mercury and CO_2 savings estimate are calculated by SEA/CLASP.

Concerning Lighting Europe's comparison with the Öko-Institut's 2019 report, as they rightly note it is not appropriate to compare economic scenarios of two different time periods (i.e., 7 years and 15 years). The 2019 Öko-Institut report had a much shorter time period of analysis, therefore it is not appropriate to compare it to the 2020 Öko-Institut report which considered 15 years Öko-Institut was aware of this, and therefore in their 2020 update report, they presented results considering two scenarios: (1) the Sweden-CLASP compatibility table and (2) the same (very low) compatibility rates derived from the outdated data used in the 2019 report. They ran this analysis over the same time period of 2020 to 2035, so the numbers are comparable.

Once the calculation anomaly in the market model has been corrected, the results presented will supersede all the previous calculations for this analysis. Thus when discussing socioeconomic impacts, the new results should be the only ones referenced as they are presented over a comparable, consistent analysis period.

2.5 Cost of Substitution for Public Authorities and Others

Table 12. Lighting Europe's Comment from page 2 of their 20th May Comment

Lighting Europe Concern:
• The report does not clarify that the cost of substitution will be significant for public authorities across Europe. The lamps addressed in this Öko 2020 document are widely found in public places (public administration buildings including national ministries and the European Commission and European Parliament, metro and train stations, hospitals, schools, streets, industrial sites, offices, hotels, convention centres etc).

Swedish Energy Agency and CLASP Response:

Public authorities, like any other building owner and manager in Europe, have to pay for building operation and maintenance. As exhibited by Lighting Europe Member's websites, these institutions like all building owners will benefit from retrofitting LED lamps. The economic analysis demonstrating payback periods of less than one year for T8 lamps and 1-3 years for T5 lamps mean that public authorities will actually save money as they roll-out retrofit programmes, lowering their energy and maintenance bills, freeing up resources for managing COVID-19 and the economic recovery.

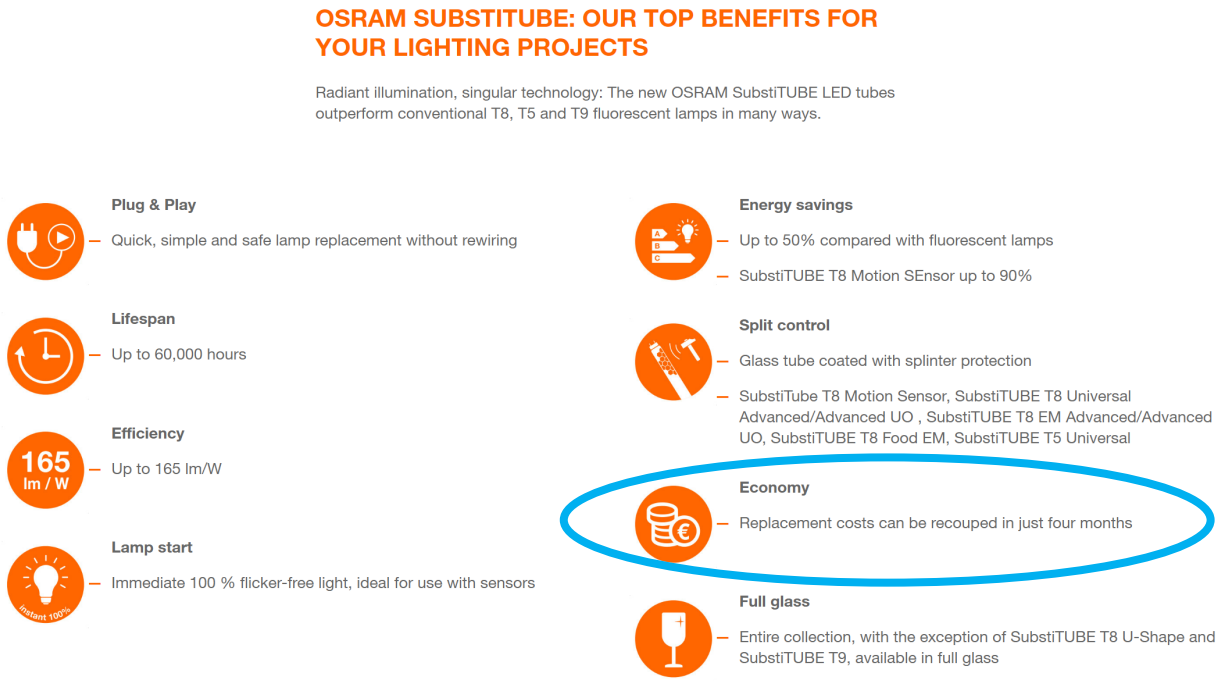
Philips/Signify have numerous case studies on their website which present the strong value proposition of LED lighting. Below are some clips from one case study in the Netherlands where they retrofitted all their fluorescent lamps with Philips/Signify MASTER LEDtubes. Not only did the plant manager eliminate mercury from his lighting system, but his energy bill was cut by 60%, the payback on the investment was one and a half years and no one has to go up on the scaffolding to change a lightbulb for 17 years.[19]

This type of case study is a real-life, verified example of the benefits that businesses, municipalities and other building owners will experience when switching from fluorescent lamps to LED. Indeed, to quote Dick Verhoef, the Facilities Manager at Verhoef Access Technology, "we saw that what Philips promised on paper was also realised in practice."

The screen capture below is from the OSRAM/LEDVANCE website[20]. We have added a blue circle to highlight the statement on their webpage that payback periods from LED retrofit tubular lamps can be

[19] https://www.lighting.philips.com/b-dam/b2b-li/en_AA/Experience/cases/Verhoef/1885_10_080_CS_Verhoef_210x297_UK_LR3.pdf
[20] https://www.ledvance.com/professional/products/product-stories/led-tubes-online-special/index.jsp

as short as four months. This is due to the long operating hours for these installations and the fact that direct-replacement LED retrofit tubes are now more than twice as efficient as some mercury-containing fluorescent lamps.



In addition to these two industry examples of the economic benefits, the Swedish Energy Agency and CLASP presented life-cycle cost calculations check if these very short payback periods claimed by manufacturers were realistic. The table below is an extract from our December 2019 report[21] which shows the economic case for retrofitting T8 luminaires with LED lamps.

This scenario considers a socket-for-socket replacement of a T8 fluorescent lamp with two different LED tubes. We compared a €3.68 OSRAM 36W T8 linear fluorescent lamp (20 000 hours life) with Philips' CorePro (entry-level, 30 000 hours life) LED replacement and Philips' MasterLED (professional-grade, 50 000 hours life) LED retrofit models. Assuming operation for 10 hours per day, the entry-level LED offers a payback of 4.9 months compared to the fluorescent (and will last 1.5 times longer than the fluorescent lamp) and the professional grade lamp offers a payback of 11 months (and will last 13 years, which is 2.5 times longer than the linear fluorescent lamp). The actual payback period will be shorter than this and the savings greater because these calculations reflect energy and bulb costs, but do not incorporate labour costs saved over time from the reduced frequency of lamp changes.

[21] Evidence of the availability of mercury-free alternative products to certain fluorescent lamps; Report to the Committee on the Restriction of Hazardous Substances, the Swedish Energy Agency / CLASP. 12 December 2019. Link to the report.

Table 13. Life-Cycle Economic Analysis of T8 Lamp Replacement in Europe

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

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

Notes: Electricity price of €0.1149/kWh from Eurostat for non-domestic sector[22]. Electricity price escalation rate of 4% is applied (following the MEErP methodology). CO_2 intensity of 295.8 g CO2/kWh from European Environment Agency[23].

All of the economics cases we have found indicate that the replacement of fluorescent lamps with LED retrofits is highly cost-effective.

2.6 Notable Differences between Öko-Institute's 2019 and 2020 Reports

Table 14. Lighting Europe's Comment from pages 2 – 3 of their 20th May Comment

Lighting Europe Concern:
There are significant differences between the Öko 2019 and 2020 documents that have not been explained and undermine the credibility of the entire report: • the investment costs were reduced by a factor 4 to 6 • e-waste has been reduced by a factor 4 to 25 • the 2019 document finds there is 0% compatibility for plug and play CFL-ni under 12W, the 2020 document assumes 100% compatibility

[22] https://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_price_statistics#Electricity_prices_for_non-household_consumers

[23] Link to European Environment Agency graphic depicting the 2016 CO2 intensity value of 295.8g CO2/kWh.

- the 2019 document finds there is a 1% compatibility for plug and play T5 lamps, the 2020 document assumes 76% compatibility.
- the 2019 document finds there is 12% compatibility for plug and play T8 lamps, the 2020 document assumes 96% compatibility.

Swedish Energy Agency and CLASP Response:

Lighting Europe highlights the differences between the 2019 Öko Institute report and the 2020 Öko Institute update report. However, comparing the results of these two scenarios is "equivalent to comparing apples with oranges" to borrow a phrase from Lighting Europe. Öko-Institut's 2019 and 2020 reports have two significant differences which means that the results being compared by Lighting Europe are simply not comparable.

First, the time period of analysis is not the same. The 2019 report has a shorter time period of analysis – only 7 years. While the 2020 report offers a new analysis over a longer time period (15 years) .

Secondly, the 2019 report is based on outdated products that were on the market on or around 2015. The 2020 Öko-Institute report offering a much more realistic analysis because it is based on current market data and utilises the European lighting market expertise embedded in VHK's MELISA model.

The reality of the market is what we are observing in the market today – customers are choosing to installed LED retrofit tubes across Europe in the absence of any regulation forcing them to do so – because LED retrofit tubes are a cost-effective solution that improves light quality while eliminating mercury, and lowering energy and maintenance bills.

The RoHS Directive is an opportunity to enshrine that practice across Europe, bringing and accelerating the realisation of those socioeconomic benefits more broadly.

2.7 Retrofit LED Lamps with Plug and Play Compatibility

Table 15. Lighting Europe's Comment from pages 3 – 4 of their 20th May Comment

Lighting Europe Concern:
The assumptions on compatibility, are based on the input of only one stakeholder, CLASP, and are incorrect, as already stated by Lighting Europe before, during and after the February 2020 meeting of selected stakeholders. Lack of compatibility between retrofit lamps and installed luminaires means that users do not have a plug & play spare part for their luminaire. The conclusions of the 2020 document highlight that "the total costs of not granting the exemption renewals requested (a substitution scenario) largely depend on the share of plug & play lamps available as replacements on the market at the time from when the exemptions expire". The compatibility assumptions used in the 2020 report are incorrect and unfair: • they are too high and partly refer to technologies and products that are not proven in use in the European Economic Area (meaning they may potentially be unsafe products).

- they ignore several facts that result effectively in strongly different ratios between available plug & play lamps as well as the needs to perform rewiring or luminaire replacement:

➢ Regarding T8, the report only uses compatibility claims provided by the company Seaborough, who in turn refer to the product claims of their clients Opple and Sengled. Lighting Europe has to date not managed to find these products on the EU market to confirm whether these claims are true and whether this is a functioning cost-effective solution. Lighting Europe objects that the calculations are based on estimates of one company only, in particular when that company is a developer of IP with no product on the market to prove their IP translates into a cost-effective technology that actually functions and satisfies all EU product requirements (safety, hazardous substances, energy performance requirements etc.).

➢ Regarding CFL-ni, the report claims an availability of plug & play lamps based on the ratio of available CFL-ni sockets compared to unavailable sockets for LED retrofits, and completely ignores the compatibility issues with up to 50% of HF drivers installed in the EEA (as stated by individual Lighting Europe members in compatibility tables for their individual products). The CLASP/SwEA data referred to in the Öko 2020 document regularly references products found on internet platforms located in the USA or China that are not available in the EEA.

• Marketing claims of Lighting Europe member companies are presented in the CLASP/SwEA report as evidence of compatibility with complete disregard to the disclaimers of these same companies. Lighting Europe estimates that 40-50% of all installed HF installations will encounter compatibility problems, due to:

- Incompatibility with certain HF drivers as stated in compatibility tables
- Special requirements for emergency lighting that do not allow retrofitting with LED lamp
- Flicker and no lighting up
- Dimmable/non-dimmable
- Light output out of specified range
- Serial luminaire applications
- Closed luminaire applications
- EMC problems
- DC applications

• For T8 lamps, the 2020 document assumes that 2/3 of the market is still electromagnetic drivers. This is factually not correct, as those drivers cannot be sold for the past 12 years anymore. If the office renovation/refurbishment cycle is about 14 years, this means that 90% of the drivers would have changed by now to HF drivers, resulting in a much lower percentage of compatible plug & play lamps.

Swedish Energy Agency and CLASP Response:

In this section of their comment, Lighting Europe raises questions about compatibility and claims that the input submitted by Sweden/CLASP was based on input from one company, Seaborough. As discussed in our response in Section 2.3 and Annex A, this is simply not true. Our review of ballast capability is based primarily on Lighting Europe members' own technical literature. Philips/Signify and Osram/LEDvance, two of the largest lighting companies in the world and who are both members of

Lighting Europe, formed the core of our analysis. We start with the reported compatibility tables from Philips/Signify and Osram/LEDvance and add more data from Sylvania, Opple and LEDs. We concluded from this detailed market analysis that over 91.4-93.4% of the existing stock of fluorescent lamps can be replaced today with mercury-free LED replacements (see Annex A).

Lighting Europe comments that 40-50% of HF (high-frequency, or electronic) lamp ballasts will experience problems , but this also is not true when one considers lamps from different suppliers. The table below – which is a small extract from our new compatibility analysis of the manufacturers' literature – shows that for a given ballast, the consumer can use our table to look-up and find an LED retrofit lamp which is compatible for their installation. Our new analysis more closely resembles how the market works (customers checking to find the right LED lamp across multiple compatibility catalogues), and we found the compatibility rates are significantly higher. We are providing this spreadsheet which we developed for this report to anyone who wishes to review it – all the information is there and is clearly referenced and cited. We will also make this table publicly available to any lighting designers or building owners who wish to make use of it when upgrading the lighting in their building from mercury-based fluorescent to LED.

The following description is how to interpret the table below:

- Ballasts are shaded in purple across the top (only two manufacturers are shown in this clip, but there are many more in the database – 262 in total)
- LED retrofit lamps are listed down the side – blue for Philips/Signify, orange for OSRAM/LEDvance and red for Sylvania
- The cells of the table are shaded green if that lamp/ballast combination is compatible or red if the combination is not compatible.
- Blank cells mean there was no data provided (e.g., the lamp is the wrong length for the ballast) or the lamp was not tested on that ballast.

So, for a given ballast, such as "BAG-HUECO; D58.1-23021 E; Lamps: 1", this model has test results for fifteen lamps. It was found to have 9 LED tubes that were compatible and 6 that were not. This means that for this ballast, 40% of the lamps it was tested on were not compatible. But the fact that 60% of the models were compatible means that someone who owns this ballast simply needs to use our table to find the right lamp for their installation. OSRAM/LEDvance does not offer a model which is compatible with this particular ballast, but Philips/Signify offers both a Corepro model and a MASTER model which are compatible. This example is typical of what we found when combining the compatibility tables of the different manufacturers – there are LED lamps available today that will operate on nearly every ballast in Europe today, without any rewiring or changing of the luminaires.

Table 16. Extract from the Lamp-Ballast Compatibility Table (see Annex A)

	LED Retrofit Lamps	High Frequency (HF) Electronic Ballasts								
		BAG-HUECO; BCS18.1FX-11/220-240; Lamps: 1	BAG-HUECO; BCS18.2FX-11/220-240; Lamps: 2	BAG-HUECO; BCS36.1FX-11/220-240; Lamps: 1	BAG-HUECO; D58.1-23021 E; Lamps: 1	HELVAR; EL1x36HF; Lamps: 1	HELVAR; EL1x36ngn; Lamps: 1	HELVAR; EL1x58s; Lamps: 1	HELVAR; EL2x18ngn; Lamps: 2	HELVAR; EL2x36/40s; Lamps: 2
Philips/Signify	Corepro LEDtube HF, Instant Fit 1200mm T8 1600lm									
	Corepro LEDtube HF, Instant Fit 1500mm T8 2000lm									
	Corepro LEDtube HF, Instant Fit 600mm T8 800lm									
	Corepro LEDtube UN, 1200mm HO 18W8xx T8									
	Corepro LEDtube UN, 1500mm HO 18W8xx T8									
	MASTER LEDtube 1200mm HF HO, InstantFit T8 2100 lm									
	MASTER LEDtube 1200mm Universal, Instant Fit 2500lm									
	MASTER LEDtube 1500mm HF HO, Instant Fit T8 3100 lm									
	MASTER LEDtube 1500mm HF UO, Instant Fit T8 3700 lm									
	MASTER LEDtube 1500mm Universal, Instant Fit 3700lm									
	MASTER LEDtube HF 1200mm 16.5W 833 T8 MEAT									
	MASTER LEDtube HF, Instant Fit T8 600mm HF 1050lm									
OSRAM/LEDvance	OSRAM SubstiTUBE® T8 UNIVERSAL 0.6m ADVANCED 7.5W									
	OSRAM SubstiTUBE® T8 UNIVERSAL 0.6m STAR 8W									
	OSRAM SubstiTUBE® T8 UNIVERSAL 0.6m VALUE 8W									
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.2m Advanced 14W									
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.2m Advanced UO 15W									
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.2m Star 16W									
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.2m Value 16W									
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.5m Advanced 20W									
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.5m Advanced UO 23W									
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.5m Star 19W									
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.5m Value 19W									
Sylvania	ToLEDo SUPERIA T8 ECG 2FT 1050LM/1100LM(18W korvaava)									
	ToLEDo SUPERIA T8 ECG 4FT 2200LM/2400LM(36W korvaava)									
	ToLEDo SUPERIA T8 ECG 5FT 2850LM/3100LM(58W korvaava)									
	ToLEDo SUPERIA T8 ECG 5FT 3300LM/3600LM(58W korvaava)									
	ToLEDo SUPERIA T8 UNI 2FT 1050LM/ 1100LM(18W vastaava)									
	ToLEDo SUPERIA T8 UNI 4FT 2200LM/ 2400LM(36W vastaava)									
	ToLEDo SUPERIA T8 UNI 5FT 3300LM/ 3600LM(58W vastaava)									

On the point of lengths and base types raised by Lighting Europe, we find this is not correct. The Swedish Energy Agency and CLASP studied this issue earlier this year and in our December 2019 report, we showed using both public websites such as www.amazon.de and the product catalogues of Lighting Europe's members, that their statements withheld information. Our Sweden-CLASP report was reviewed by VHK, an independent expert consultancy based in the Netherlands who were the lead technical analysts working for DG Energy on the recent Ecodesign lighting regulation. On the topic of the availability of LED base types and lengths, VHK found that Lighting Europe's statements were "Not true, even when considering only models from LE-members, availability is higher." VHK conducted their own analysis of the market and independently verified our finding, noting that the higher substitution rate had been "Demonstrated by CLASP report, confirmed by VHK on-line search." VHK's assessment of the Availability of LED substitutes validated our findings. The Figure below is a slide from a VHK presentation on 12 February 2020. We note that Lighting Europe was present in this meeting and did not contest the points on this slide, nor did they refer to VHK's conclusions in either comment submitted to the RoHS Committee.

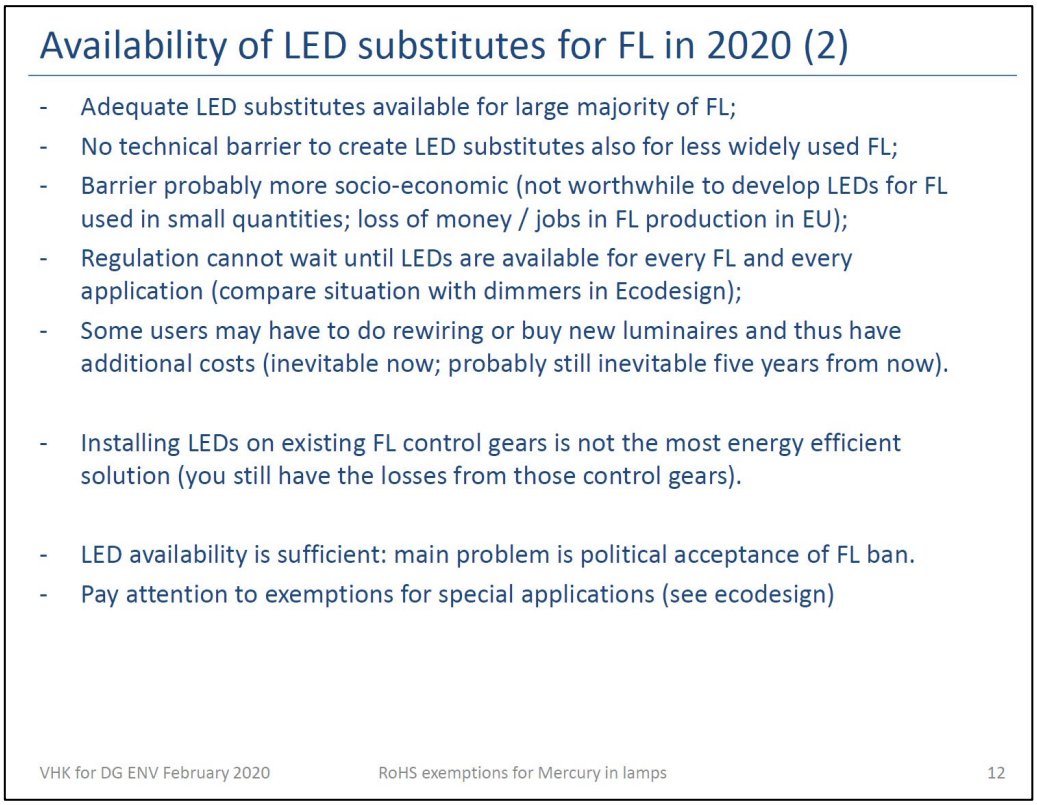


Figure 2. VHK Summary of their Assessment of LED Substitutes for Fluorescent Lamps (VHK, 2020)

Concerning the share of the installed stock of fluorescent lamp ballasts which are still electromagnetic, our table is presented as Figure 1 above. For T5 lamps, which represent about 30% of the European installed stock of linear fluorescent lamps, all ballasts are electronic. For T8 lamps, which represent the other 70% of the installed stock of linear fluorescent lamps, we estimate that 30% of the ballasts are electronic and 70% are magnetic. This estimate is derived from page 112 of the 2016 Öko-Institut Report[24] which reads:

> *"The share of installations with ECG, from the total stock of LFL installations, is growing and they currently represent around 30% of the market. Furthermore, from April 2017, CCGs shall no longer be permitted on the EU market in light of Regulation 245/2009/EC (Ecodesign requirements for fluorescent lamps), so ECG market share shall grow. LEU explains that the average lifetime of an installed luminaire in office or industrial areas is typically 15 years, so it is expected that the replacement market will be completely ECG by 2035-2040."*

Furthermore, we note that magnetic ballasts do not have an inherent expected maximum lifetime — in other words they do not fail, since there is nothing in the ballast that can break. Thus, in many installations, e.g., in schools and other public buildings that do not follow the average refurbishment cycle of 14-15 years, magnetic ballasts will continue to be used for a much longer time.

For all of these reasons, we maintain that our estimate is a reasonable and accurate estimate of the installed stock of magnetic lamp ballasts – just less than half of all linear fluorescent ballasts in Europe today.

[24] Note: in this report, "ECG" refers to electronic control gear, which is the same as an electronic ballast. Link to the report: http://publications.europa.eu/resource/cellar/a3fdcc8c-4273-11e6-af30-01aa75ed71a1.0001.01/DOC_1

2.8 Calculation of Mercury Not Recovered

Table 17. Lighting Europe's Comment from page 4 of their 20th May Comment

Lighting Europe Concern:
• The mercury calculations in the 2020 document are 2 times too high, as they are based on one stakeholders' assumption of outdated lamp recycling data and does not refer to actual Eurostat data revealing recycling rates above 50%.

Swedish Energy Agency and CLASP Response:

Lighting Europe's comment is confusing two issues, that of mercury being placed on the market (in fluorescent lamps) and the share of lamps that are recovered at the end of life. The Öko-Institut's 2020 update report refers to "mercury being placed on the EU market" thus they are referring to the quantity of mercury being placed on the market and installed in buildings and homes across Europe. The Öko-Institut report is therefore correct since this is a simple calculation of the lamps sold multiplied by the milligrams of mercury contained therein. The comment from Lighting Europe concerns the percentage of lamps recovered and recycled at the end of life. The recovery and recycling rate does not influence the quantity of mercury that is placed on the market.

The Swedish Energy Agency and CLASP, however, are concerned about Lighting Europe's claim that the recycling rate is "above 50%", as the data we reviewed indicates that is not the case. We analysed of numerous sources of information[25], and our 2019 SEA-CLASP report concluded that only 16% to 50% of the mercury-containing gas discharge lamps are collected and taken to recycling centres. The targets and goals may be "above 50%", but regrettably the reality and practical nature of recovering and recycling spent fluorescent lamps is considerably lower.

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

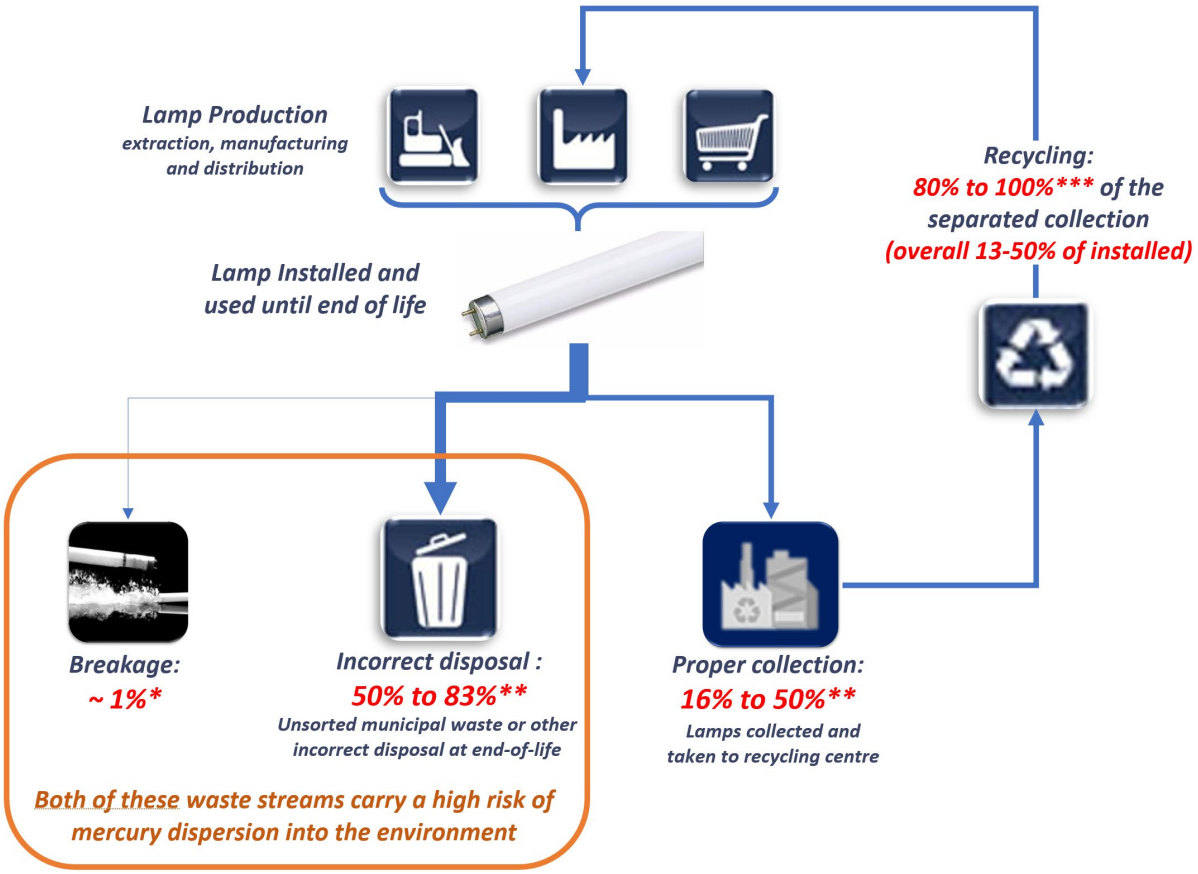


Figure 3. Life-cycle flow diagram of fluorescent lamps in Europe

Finally, concerning the quantity of mercury avoided, the 2019 SEA-CLASP report points to another reduction of mercury in the European environment due to the phase-out of T8, T5 and CFLni lamps: avoided mercury released to the environment from the burning of coal at European power stations. The SEA-CLASP report estimated those savings to 2.2 metric tonnes Hg avoided through 2030, associated with 138.3 TWh of electricity savings from phase-out of fluorescent T8, T5 and CFLni lamps in September 2021. The 2020 Öko-Institute report has a higher energy savings estimate, of 223.3 TWh consumption reduction through 2030, which would result in *an additional 3.6 metric tonnes of avoided mercury* from powerplants.[26] Thus, we conclude that the Öko-Institut report is correct in its statement, and if anything, is conservative in their estimate of avoided mercury since they do not calculate the avoided mercury emissions by the power station.

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

3 Lighting Europe's Comment of 9 June

In this section of the report, we address Lighting Europe's comments of the 9th June. As with the previous section, we have included copy/paste text from the comments in order to facilitate review by the Committee and to be absolutely clear on which points we are responding. This chapter is broken up into subsections that relate to the topic areas of Lighting Europe's comments.

3.1 Lighting Europe's Cost Model

Table 18. Lighting Europe's Comment from pages 2 and 4 of their 9th June Comment

Lighting Europe's Comment:
Lighting Europe assessment of a phase out of most fluorescent lamps subject to RoHS 2015 exemption renewal requests in 2021: Additional investment costs ➢ 133 billion € additional investment costs for public authorities and private companies/users, mainly to be borne until 2025, the split per lamp type is: o CFL-ni additional investment cost 17 billion € o T5 additional investment cost 78 billion € o T8 additional investment cost 38 billion € ➢ The split of the estimated additional investment costs to be incurred per EU Member State is found in Annex I. ➢ 1232 (kg) total mercury going into the environment until 2035 – the socio-economic impact outweighs the environmental benefits: o CFL-ni investment cost 70 Mio €/kg mercury o T5 investment cost 146 Mio €/kg mercury o T8 investment cost 84 Mio €/kg mercury ➢ 702 (Mio kg) average unnecessary and avoidable waste generated until 2035. [….] Annex I – Breakdown of investment costs for Member States CFL-ni, T5 and T8 lamps are found primarily in public spaces. Public authorities will also have to cover a significant part of the cost of transitioning to LED alternative. Explanation of methodology: We use the data for total lamps sales by Lighting Europe members in 2019 in all 27 EU Member States, we multiply the market share of these lamps per country and the total costs calculated in the LE scenario.

Country	Costs CFL-ni (Mio €)	Costs T5 (Mio €)	Costs T8 (Mio €)	Total costs (Mio €)
Austria	424	2797	954	**4175**
Belgium	357	2269	769	**3395**
Bulgaria	54	171	284	**509**
Croatia	300	1670	765	**2735**
Cyprus	16	142	101	**259**
Czech Republic	299	1635	1265	**3199**
Denmark	454	1810	512	**2776**
Estonia	59	269	132	**460**
Finland	505	1753	570	**2828**
France	1997	8798	5424	**16220**
Germany	5451	24914	9636	**40000**
Greece	180	1083	556	**1819**
Hungary	222	1043	625	**1890**
Ireland	137	858	267	**1262**
Italy	1434	5733	4933	**12100**
Latvia	25	120	114	**259**
Lithuania	40	201	310	**551**
Luxembourg	20	128	54	**202**
Malta	15	64	28	**107**
Netherlands	1358	5845	1349	**8551**
Poland	549	3135	3065	**6749**
Portugal	742	2105	918	**3764**
Romania	107	493	784	**1384**
Slovakia	103	613	324	**1040**
Slovenia	76	391	238	**705**
Spain	1356	2704	2134	**6195**
Sweden	1138	6937	1550	**9625**
Total EU-27	**17418**	**77682**	**37661**	**132760**

Swedish Energy Agency and CLASP Response:

Despite claiming to be transparent, Lighting Europe does not provide any information about how they arrived at the costs shown in their comment. A statement is made "we multiply the market share of these lamps per country and the total costs calculated in the LE scenario", however it is unclear whether any of the benefits associated with retrofitting LED lighting "total costs" include the following factual points of any substitution scenario:

- 91.4-93.4% of fluorescent luminaires can take a direct-retrofit LED lamp, eliminating the need to rewire or replace the luminaires for the vast majority of fixtures across Europe;
- Lower energy bills the customers would have to pay due to the 50% improvement in efficiency of LED compared to fluorescent; and
- Lower maintenance bills due to the 2-3 times longer service life of LED compared to fluorescent.

According to Lighting Europe's own customers, payback periods on LED retrofit lamps (which can be installed directly into 91.4-93.4% of existing fluorescent luminaires in Europe) are less than one year, and according to OSRAM/LEDvance states on their website that LED retrofit lamps can have payback periods as short as 4 months.[27] Under these circumstances, it seems very unlikely that the €132.8 billion of cost presented by Lighting Europe for the EU-27 is correct. Instead, it appears that

[27] Click on this link to view the graphic where OSRAM/LEDvance make the following statement: "Economy: Replacement costs can be recouped in just four months"

Lighting Europe has prepared a one-sided analysis which inflates the cost in order to mislead policy-makers into thinking that ending the exemption for fluorescent lamps would be problematic.

The Öko-Institute, with support from VHK, conducted a transparent, fair and impartial analysis into the costs of phasing-out mercury lighting. This analysis was published last month and took into consideration not only lamp replacement costs, but also operational costs like energy savings. The net effect of these were calculated as being €29.9 billion in savings for Europe. Furthermore, we understand that Öko-Institute and VHK have revised their analysis to correct a problem in model (see discussion in Section 2.4) which means the savings are going to be even greater than were originally thought – possibly twice as large. Furthermore, the Öko/VHK savings estimate were based on an estimated 90% retrofit compatibility rate for the stock of installed fluorescent luminaires in Europe, but as shown in Annex A of this report, we have now determined that number to be even greater (i.e., 91.4% - 93.4%), thus the net financial savings to Europe will be even larger.

Lighting Europe is not being transparent in their comment, and the costs they present are in conflict with the payback periods presented on their own members websites. Since a payback period by definition is the length of time the incremental cost is recovered through energy savings (in this case the incremental cost of an LED retrofit lamp replacing a fluorescent tube), Lighting Europe's Members' own websites already contradict the position taken by the Association. Lighting Europe should consult the current literature and information published by their own members before making such extraordinary claims about societal costs. Overall, we find these claims are not based on any evidence or data, nor is there any scientific or technical basis for their cost estimate.

3.2 Compatibility with Fluorescent Luminaires

Table 19. Lighting Europe's Comment from page 2 of their 9th June Comment

Lighting Europe's Comment:
Practical consequences for users in case of an early phase out in 2021: An early phase out will create a disruption on the market, both on the supplier and customer side. Below is the possible impact for users: About 50% of retrofit solutions are not compatible with installed luminaires: - In the absence of functioning substitutes, users will need to allocate sufficient resources to rewire or replace existing luminaires. Hence the high costs above. - Rewiring and replacing luminaires requires new certification to ensure the safety and quality of the product. - Planning for new installations and related investments usually takes up to 3 years, which means users will not have sufficient time to prepare. - Users will stockpile spare parts, because they will not have had the time to accumulate the necessary resources and expertise to transition to alternatives. - Manufacturers of compliant products will struggle to ramp up production of (higher priced) alternative technologies (demand replacement). - A sudden ban will create high demand for new LED luminaires and LED lamps, resulting in higher prices for users. - Phase-outs should be aligned to the luminaire replacement cycles (typically 14 years) to allow users time to allocate the sufficient resources to transition to the alternative technology. The

users of these products, together with Lighting Europe, have repeatedly called for a smooth transition timetable (2018 Joint Statement).

Swedish Energy Agency and CLASP Response:

Lighting Europe comments that it expects there to be significant disruption in the market if there is a phase-out of fluorescent lighting, but they do not acknowledge in their comment that the market is already transforming today; LED retrofit lamps are already being sold and installed directly into fluorescent luminaires across Europe (without rewiring). These businesses and industries across Europe are benefitting from retrofitting LED lamps into existing fluorescent installations.

Far from being disruptive, the installation of LED retrofit tubes into existing fluorescent lamps is common sense – it removes mercury, reduces energy consumption and provides better, longer-lasting service life from the lamps. Furthermore, since payback periods are often less than a year (and according to OSRAM can be as short as four months) upgrades can take place within on fiscal year cycle, where incremental costs are off-set by the substantial energy savings, thus negating the cost of upgrading to LED lighting.

Philips has a few case studies posted on their website where customers have provided very positive feedback about the quality of the light and the lower running costs associated with LED lighting: Dansk Supermarked[28], Denmark and Verhoef Access Technology[29], The Netherlands. In addition to these, the authors prepared a calculation of a socket-for-socket replacement of a T8 fluorescent lamp with two different LED tubes to check if OSRAM's reported four-month payback period is applicable in Europe. The table below presents our findings in relation to this assessment. We compared a €3.68 OSRAM 36W T8 linear fluorescent lamp (20 000 hours life) with Philips' CorePro (entry-level, 30 000 hours life) LED replacement and Philips' MasterLED (professional-grade, 50 000 hours life) LED retrofit models. Assuming operation for 10 hours per day, the entry-level LED offers a payback of 4.9 months compared to the fluorescent (and will last 1.5 times longer than the fluorescent lamp) and the professional grade lamp offers a payback of 11 months (and will last 13 years, which is 2.5 times longer than the linear fluorescent lamp). These calculations reflect energy costs and bulb costs, but do not incorporate labour costs saved over time from reduced frequency of bulb changes.

[28] https://www.lighting.philips.com/main/cases/cases/food-and-large-retailers/dansk-supermarked
[29] https://www.lighting.philips.com/main/cases/cases/industry-and-logistics/verhoef-access-technology

Table 20. Life-Cycle Economic Analysis of T8 Lamp Replacement in Europe

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

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

Notes: Electricity price of €0.1149/kWh from Eurostat for non-domestic sector[30]. Electricity price escalation rate of 4% is applied (following the MEErP methodology). CO_2 intensity of 295.8 g CO2/kWh from European Environment Agency[31].

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

Simply put, there is no "disruption" associated with the retrofit of LED retrofit lamps. Instead, it represents good practice based on common sense – removing mercury, reducing energy consumption, extending service life of the lamps. And, with payback periods of less than a year (according to Philips and Osram), the planning cycle is greatly simplified because any small incremental cost for the LED tube is recovered within the same fiscal year through energy savings (i.e., the definition of a "payback period"). Thus European businesses stand to gain from the ban on fluorescent lamps – and there is the additional benefit of removing several metric tonnes of mercury from our homes, offices and prevented from being released into the environment.

30 https://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_price_statistics#Electricity_prices_for_non-household_consumers

31 Link to European Environment Agency graphic depicting the 2016 CO2 intensity value of 295.8g CO2/kWh.

3.3 Availability of Spare Parts – T5 Lamps

Table 21. Lighting Europe's Comment from pages 2-3 of their 9th June Comment

Lighting Europe's Comment:
Spare parts should be available for users in accordance with Article 4 RoHS: - This will avoid luminaire replacement costs, market disruption and unnecessary waste. - The right to repair is promoted in the EU Circular Economy Action plan March 2020. - Users may buy products online, where compliance with CE marking and product safety and quality requirements is not ensured. - Without access to compatible and functioning spare parts, users will have to discard essential applications prematurely (e.g. emergency lighting and modern daylight controlled dimming installations – see Annex II). Many businesses and municipalities were incentivised by government programmes to invest in efficient fluorescent lamps (especially T5) only a few years ago and need spare parts to recuperate their investments. Currently, nearly all new installations for general lighting are based on LED technology.

Swedish Energy Agency and CLASP Response:

As discussed in earlier sections of this report and shown in Annex A, there are T5 LED retrofit lamps that are compatible with existing T5 luminaires. Looking across only three manufacturers (Philips/Signify, OSRAM/LEDvance and Sylvania for this analysis) we find that 80% of the 208 different T5 ballasts have compatible LED T5 retrofit lamps that can be installed directly into the T5 luminaires (not changing the HF ballast or doing any rewiring). In addition to these three T5 LED tube manufacturers, there are many others available on the market, which will have different circuit designs and therefore the compatibility will be different. Some examples of these companies include: ATOMANT LED, Crompton Greaves, eLITe, LEDKIA Lighting, Print-Klex, Venture Lighting Europe, and others.

These T5 LED retrofit lamps are nearly twice as efficient as the T5 fluorescent lamps they replace, thus the businesses and municipalities who invested in T5 fluorescent technology will accelerate their savings and recuperate their investments faster through lower energy bills realised through the installation of T5 LED tubes. In other words, by keeping T5 fluorescent technology, these businesses and municipalities are paying a higher cost of light compared to if they retrofitted their existing T5 luminaires with LED tubes. The figure below illustrates the "cost of light" from a standard T5 fixture in Europe (including lamps and electricity only).

Figure 4 shows that the T5 lamp (depicted by a black line) has the highest total cost of light. It is initially less expensive than a T5 LED lamp, but the small savings on lamp price is soon wasted on electricity consumption, and by the end of the second year, T5 fluorescent becomes the most expensive option. From that point onwards it remains the most expensive light source due to the higher running cost and shorter lamp life (i.e., more frequent lamp replacements, although labour cost is not included in this calculation).

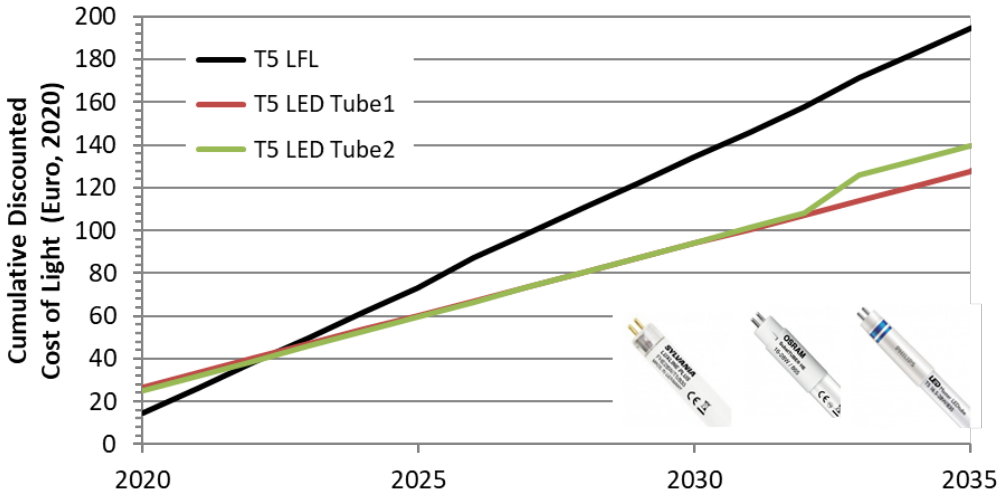


Figure 4. Cost of Light for a T5 Fluorescent Lamp vs. T5 LED Lamps in the Same Socket

For all of these reasons, phasing out the exemption for T5 fluorescent lamps will be beneficial for European businesses, municipalities and industries. Not only will these organisations be enjoying lower energy bills and less frequent lamp changes, but they will also be totally removing mercury from their lighting systems.

3.4 Employment Impacts

Table 22. Lighting Europe's Comment from page 3 of their 9th June Comment

Lighting Europe's Comment:
Impact on employment: - Thousands of employees in EU factories as well as in supply channels that today produce these lamps will not be able to move on to other jobs, such a transition requires time and training and has been planned according to the timetable voted on under the EU Ecodesign rules. - The Oeko 2019 assessment calculates up to 27,500 additional temporary electrician jobs for CFL-ni and up to 55,000 jobs for LFL to manage a fast transition during a few years' time. In a premature phase-out, Member States must ensure that enough trained electricians are available and have the skills to install new luminaires, to avoid causing health and safety issues for individuals, as well as legal risks for enterprises in case of violations of workplace laws.

Swedish Energy Agency and CLASP Response:

Four European light source manufacturers[32] have largely discontinued their European manufacturing of conventional fluorescent lamps for the general lighting market. These lamps were produced by

[32] COMMISSION STAFF WORKING DOCUMENT IMPACT ASSESSMENT of 01.10.2019 of Ecodesign Directive Page 140: "The major suppliers of light sources in EU28 are Philips Lighting, Ledvance/Osram, General Electric (GE) Lighting and Feilo-Sylvania. Together, in the EU28 they signify EUR 3 billion of estimated revenue from the sale of light sources for general lighting and 15 000 jobs (manufacturing only).

some six to eight factories located in The Netherlands (Philips-Rosendaal[33]), Poland (Philips-Pila), Germany (OSRAM/LEDvance - Augsburg[34] and Sylvania – Erlangen[35]), Hungary (GE/Tungsram – Nagykanizsa), and the Philips/Osram tube glass manufacturing plant in Lommel, Belgium has been closed. At most one or two factories (e.g., Pila, Poland) may still be operating, producing specialty tubular lamps, but for the most part the job losses have already occurred. And as these companies closed their European manufacturing facilities (in the absence of any regulatory pressure on fluorescent lamps), they shifted their production and sourcing of tubular lamps to China.

We do not see that there will be any impact on manufacturing jobs[36] associated with ending the exemptions for fluorescent lamps in 2021 because (1) the tubular lamp manufacturing jobs have already been lost and (2) for any manufacturing that does remain, the facilities can easily be converted to LED tubes. Furthermore, employment in the supply chain – the wholesalers and distributors who supply the businesses and installers – will be maintained, as they themselves are already smoothly handling LED tubes along with fluorescent tubes. I.e., the supply chain is still needed, even though the underlying technology contained within the tube is different.

Lighting Europe claims that banning conventional tubes would boost the need for replacement of conventional luminaires with LED luminaires. Even though this statement is not true for over 90% of the fluorescent luminaires in Europe, for those ones where the end-user decides to replace the luminaire, there would be a net increase in employment in the EU. This is true because the manufacturing of luminaires – including LED based luminaires – is a local/regional activity with a large number of small and medium sized manufacturers dominating the European market. In the UK for example, there is no manufacturing of "traditional" lightbulbs like fluorescent lamps, but there are dozens of new LED start-up companies who are producing quality product, designed for the local market, and they would experience a boost in demand (and growth / employment) from the end of the RoHS exemptions for fluorescent lamps. Back in 2011, European Commission Vice President Neelie Kroes said: "Expanding LED lighting is a 'no-brainer'. It means more money in your pocket, and a healthier planet. Please give us your ideas on how to speed up its deployment and maximise the number of jobs and savings Europe can gain from expanding the use of LED lighting."

[33] Philips Roosendaal factory to be closed in three steps, 19 September 2012. Link to the article (in Dutch)
[34] OSRAM subsidiary LEDvance cuts 1,300 jobs after being taken over by China. 13 November 2017. Link to the article (in German)
[35] Erlangen-based company Sylvania applies for bankruptcy protection. 3 February 2020. Link to article (in German)
[36] Indicative evidence of this suggestion: As noted in the Oeko-Institute Socio-Economic Study of July 2019 (chapters 3.4 and 5.3) Lighting Europe has refused to provide information about the number, location and employment of tubular lamp factories. On page 142 of the COMMISSION STAFF WORKING DOCUMENT IMPACT ASSESSMENT of 01.10.2019 of the Ecodesign Directive it is concluded that "A significant portion (60-70%) of the industry jobs reported above is expected to be outside EU28".

3.5 Article 5(1)(a) RoHS Criteria are Not Met

Table 23. Lighting Europe's Comment from page 3 of their 9th June Comment

Lighting Europe's Comment:
Article 5(1)(a) RoHS Criteria for granting an exemption are satisfied: - Substitutes are not available for all applications and products. - Alternatives, like most electronics, contain RoHS Annex II restricted substances. - A premature phase-out will result in significant costs and unnecessary and avoidable waste. - Lighting Europe has put forward a proposal which will result in a significant reduction in mercury placed on the EU market, in line with the objectives of RoHS (see Annex III). […] Annex III – Mercury placed on the market from lighting products Compared to the total mercury release from the main anthropogenic sources in the EU (77.2 ton)8, the proportion of mercury placed on the EU market by lighting LFL T8, T5 and non-linear products, is limited to below 1 metric ton per year and shows a steady decrease since many years due to continuous innovation by Lighting Europe companies, enabling lower RoHS Mercury limits. The current amount of Mercury release by these lamp types is 0.33 % of the total EU Mercury release in 2020 and decreasing to 0.1% in 2026. These values are calculated based on the EU Melissa model, an average lamp dosing value of 1/3 lower than the max RoHS limit and more than 50% recycling of all lamps.

Swedish Energy Agency and CLASP Response:

The Swedish Energy Agency and CLASP do not agree with Lighting Europe's assessment that the criteria for granting an exemption under Article 5(1)(a) have been met. We conducted our own study of the scientific and technical progress of mercury-free LED retrofits for various categories of fluorescent lamps listed in Annex III. This section presents the criteria under Article 5(1)(a) and our assessment of each of the exempted fluorescent lamp types. Figure 5 presents a screen capture of the relevant text from Article 5 of the RoHS Directive.

Article 5

Adaptation of the Annexes to scientific and technical progress

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

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

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

— the reliability of substitutes is not ensured,

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

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

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

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

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

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

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

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

Table 24. Assigning Numbers and Descriptive Titles to the Criteria from Article 5(1)(a)

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

3.5.1 (i) Annex II Materials or Substances

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

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

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

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

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

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

LED retrofit tubes and replacements for pin-based fluorescent lamps (CFLni) are sold and installed today and these products are RoHS compliant. We understand that the RoHS requirements are strictly enforced, so the components and parts used in LED lamps are already RoHS compliant and not only do

not contain mercury, but do not contain any other Annex II materials or substances. In fact, the electronics contained in LED drivers are no different on a materials basis than the ballast contained in a CFLi lamp. The only difference between the two lighting technologies is that there is mercury in the fluorescent tube and no mercury in the LED lamp.

We checked the website of two of Lighting Europe's leading members to see if their LED retrofit tubes were RoHS compliant or not. The following screen captures from their websites show that these companies are declaring their products as compliant with RoHS, meaning there are no Annex II materials or substances in their LED retrofit products.[37]

Figure 6 is the "Eco Passport" that Philips/Signify issues for their portfolio of products as part of their Sustainable Design process. In the box marked "Substances", it states that "EU RoHS compliant: Yes" and "EU RoHS phthalates compliant: Yes".

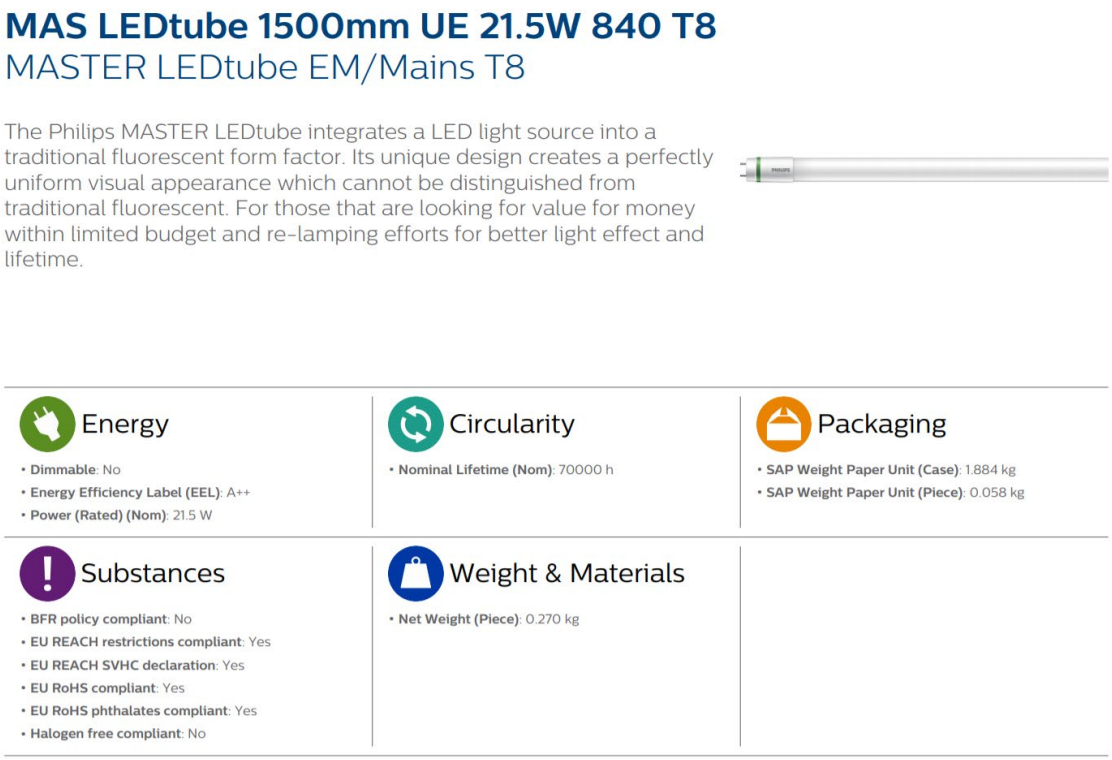
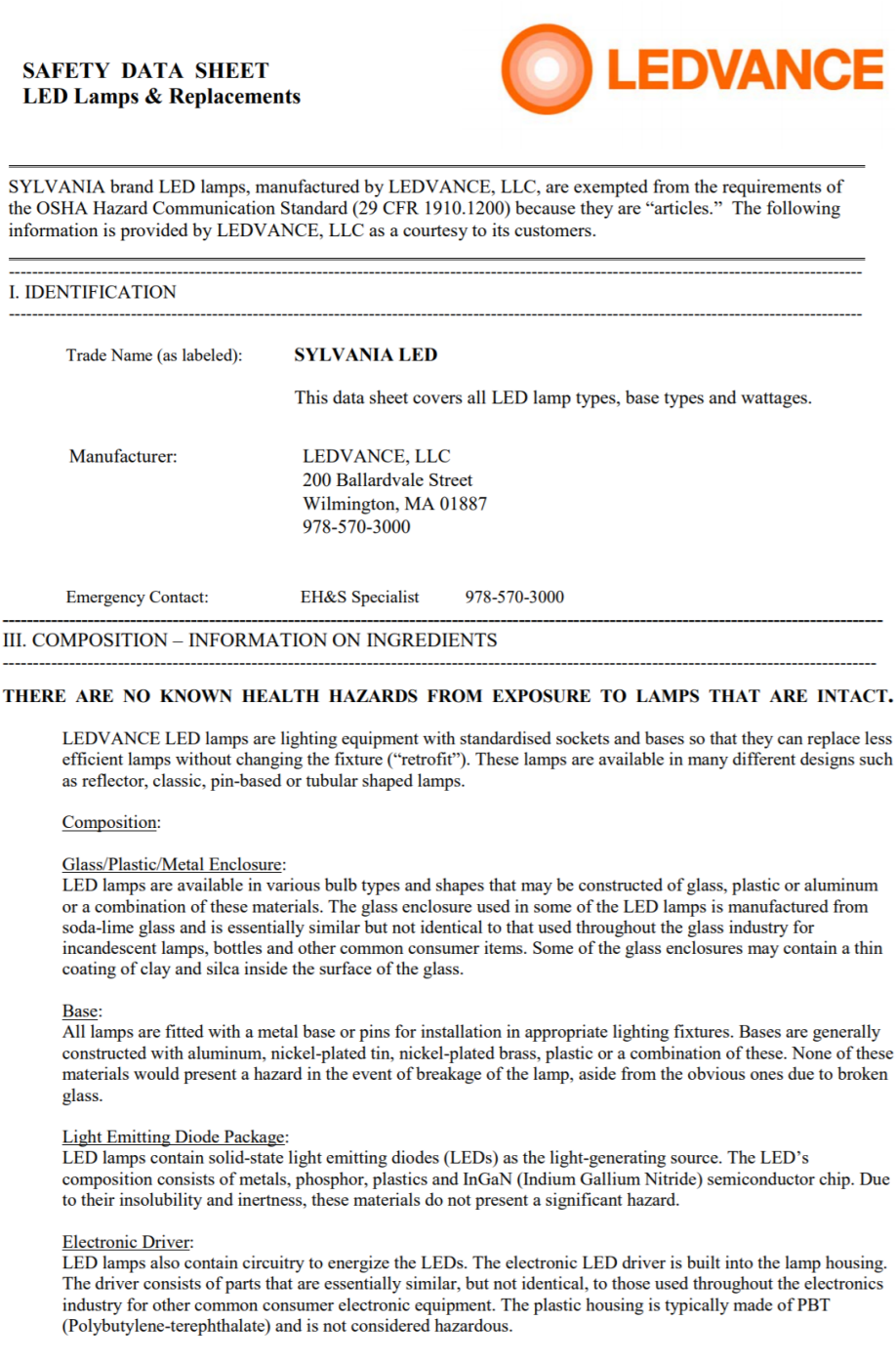


Figure 6. Screen Capture of Philips declaration of RoHS Compliance for their LEDtube[38]

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

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

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



SAFETY DATA SHEET
LED Lamps & Replacements

LEDVANCE

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

I. IDENTIFICATION

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

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

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

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

III. COMPOSITION – INFORMATION ON INGREDIENTS

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

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

Composition:

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

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

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

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

Figure 7. Screen Capture of LEDvance's Safety Data Sheet (SDS) filing in the USA

3.5.2 (ii) Reliability of Substitutes

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

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

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

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

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

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

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

3.5.3 (iii) Environment, Health and Safety

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

3.5.3.1 Environment

Fluorescent lamps contain several milligrams of mercury and our research has found that more than half of the fluorescent lamps sold in Europe are never recovered and instead end up being discarded with regular municipal waste, contaminating landfill sites and run-off. A 2014 European Commission study on collection rates found that the collection rate was only 12% in 2010 for all lamps under the WEEE Directive.[39] The WEEE Directive sets a target of 80% recycling, however some studies show that the actual rate of separate collection at the end-of-life is less than 50%, thus while reported recycling rates are high, these percentages are not based on total lamps removed from service, but are instead only considering those lamps that are delivered to the correct waste treatment facility.

In addition to eliminating the mercury, LED replacement lamps also offer an environmental benefit in the form of a reduction in greenhouse gas emissions due to their higher energy-efficiency. These energy savings translate into further reductions in the release of mercury by avoiding emissions from coal-fired power plants in Europe which release mercury trapped in the coal they burn. According to

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

the updated Öko-Institut report[40] published on 10 July 2020, they calculated that if the RoHS exemptions for CFLni, T5 and T8 lamp types were to all end in 2021, then mercury reductions would be 2882 kilograms from the lamps. And we calculate an additional 2478 kilograms of mercury emissions avoided at the power station from the electricity savings[41]. In total then, the avoided mercury emissions associated with lamp disposal and avoided electricity consumption would be 5360 kg. In addition, due to the lower consumption of power from the more energy-efficient LED replacements for fluorescent lamps, an additional environmental benefit of 92.1 million metric tonnes of carbon dioxide is avoided. These benefits are presented in Table 25 below.

Table 25. Environmental Benefits from Phase-Out of T8, T5 and CFLni Lamps in September 2021

Savings	Cumulative (2021-2035) Savings for:			
	T8	**T5**	**CFLni**	**Sum**
CO_2 Savings (*million metric tonnes*)	45.3	38.4	8.4	**92.1 MMT CO_2**
Mercury savings lamps (kg Hg)	962	1064	856	**5360 kg**
Mercury savings at powerplant (kg Hg)	1218	1032	227	

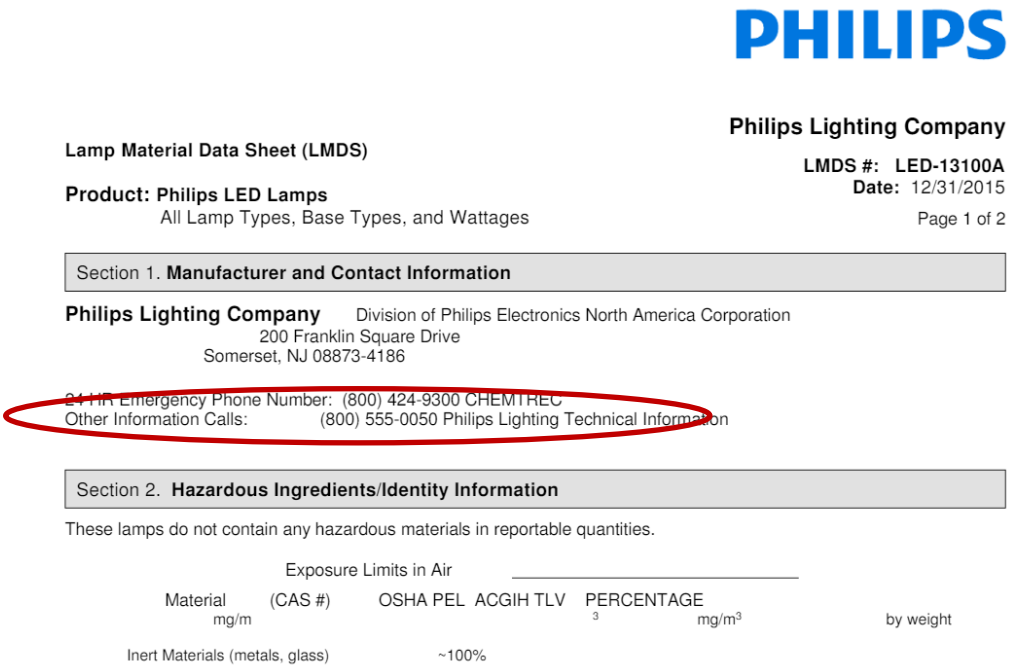
Source: Mercury in lamps Öko-Institute report, 10 July 2020; CO_2 and Hg power station estimate by SEA/CLASP.

3.5.3.2 Health

LED retrofit lamps do not contain any mercury; thus, they are better for human health than fluorescent lamps by the simple fact that they remove mercury from the living space, and the ever-present risk of breakage. Figure 8 below, a material data sheet filing in the United States for Philips Lighting for their LED lamps – including all lamp types, base types and wattages – clearly states "[t]hese lamps do not contain any hazardous materials in reportable quantities."

[40] Update of the data provided by the analysis model developed in the course of the "Study to assess socioeconomic impact of substitution of certain mercury-based lamps currently benefiting of RoHS 2 exemptions in Annex III"; by Yifaat Baron and Carl-Otto Gensch, Öko-Institut e.V., 10 July 2020.

[41] According to the Commission's Joint Research Centre, mercury is released into the air when coal is burned at the power station. The JRC estimates that with the current generation mix of 31% of EU power derived from coal, each kilowatt-hour releases 0.016 mg of mercury into the air. Electricity savings from LED lamps will therefore reduce power station mercury emissions when compared with less efficient fluorescent lamps. For this calculation, due to the long time period, we use 0.008 mg Hg/kWh assuming that coal will be a decreasing proportion of EU power generation in the future.



PHILIPS

Philips Lighting Company

Lamp Material Data Sheet (LMDS)

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

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

Page 1 of 2

Section 1. **Manufacturer and Contact Information**

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

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

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

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

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

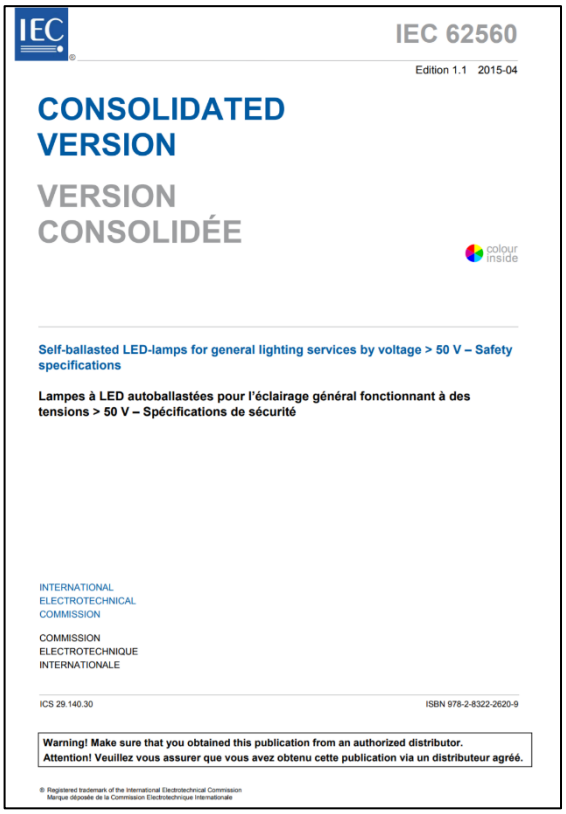
Figure 8. Screen Capture of Philips' Lamp Material Data Sheet (LMDS) in the USA

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

3.5.3.3 Safety

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

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


IEC 62560
Edition 1.1 2015-04
CONSOLIDATED VERSION
VERSION CONSOLIDÉE
Self-ballasted LED-lamps for general lighting services by voltage > 50 V – Safety specifications
Lampes à LED autoballastées pour l'éclairage général fonctionnant à des tensions > 50 V – Spécifications de sécurité
INTERNATIONAL ELECTROTECHNICAL COMMISSION
COMMISSION ELECTROTECHNIQUE INTERNATIONALE
ICS 29.140.30
ISBN 978-2-8322-2620-9
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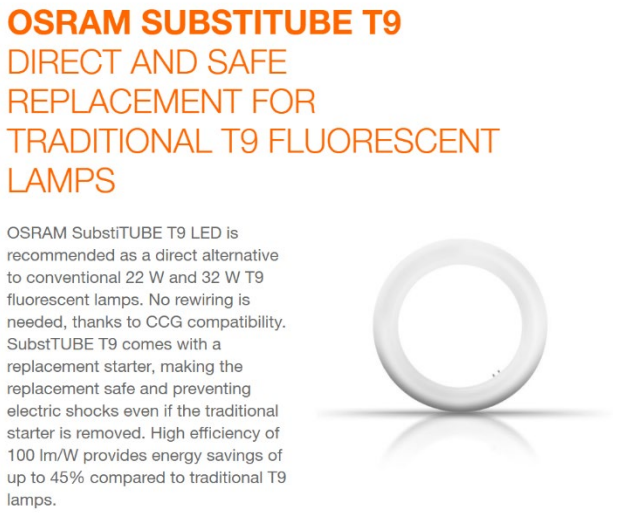
In this standard, safety requirements are set-out for all products that fall within the scope of this regulation:

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

And the manufacturer's literature and websites confirm that there are no safety hazards, as indicated by this OSRAM product[42], which notes that no rewiring is needed and that the LED lamp is supplied with a replacement starter so the replacement is safe and there is no risk of electrical shock.

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


OSRAM SUBSTITUBE T9
DIRECT AND SAFE REPLACEMENT FOR TRADITIONAL T9 FLUORESCENT LAMPS
OSRAM SubstiTUBE T9 LED is recommended as a direct alternative to conventional 22 W and 32 W T9 fluorescent lamps. No rewiring is needed, thanks to CCG compatibility. SubstTUBE T9 comes with a replacement starter, making the replacement safe and preventing electric shocks even if the traditional starter is removed. High efficiency of 100 lm/W provides energy savings of up to 45% compared to traditional T9 lamps.

42 https://www.ledvance.com/professional/products/product-stories/led-tubes-online-special/osram-substitube-t9/index.jsp

3.5.4 (iv) Availability of Substitutes

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

3.5.4.1 Model Availability

There are literally thousands of mercury-free LED replacement lamps available today to replace fluorescent lamps – different sizes, lengths, ballast types (i.e., magnetic/starter and high frequency electronic), colour temperatures, and regular, high output and ultra-high light output levels. Lamps are also available which are "universal" and can operate on a variety of input power configurations. Many of these LED products are designed as direct retrofits into existing fluorescent fixtures to avoid the need to rewire. For example, Philips/Signify states[43] that there is "No need to change drivers or rewire", noting that they offer a "plug and play solution that works straight out of the box". OSRAM/LEDvance state[44] that their "SubstiTUBE" product is a "Quick, simple and safe lamp replacement without rewiring." Sylvania lighting advertises that their SubstiTUBE product is "engineered to operate on existing instant start and select programmed rapid start electronic T8 ballasts, these lamps minimise labour and recycling costs."[45] Tungsram reports that in addition to "the 2.5-3x longer life (compared to T8 fluorescent lamps operated on electro-magnetic gear) and lower wattages, Tungsram LED T8 tubes provide lower system loss while existing fixtures remain intact."[46]

In the main body of this report, we address the specifics relating to base type and lamp length; however in this overview section we will address two important cross-cutting issues that apply to all LED lamps, namely correlated colour temperature (CCT) and colour rendering index (CRI). A question was raised by Lighting Europe about the range of available CCT and CRI for LED lamps, and whether they are able to provide equivalent light service compared to the range offered by linear fluorescent lamps. The tables below present our findings for these questions, which we developed by using the on-line search catalogues for these lamps.

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

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

Table 26. Comparison of Very High CRI Values – Best Fluorescent Tubes and Best LED Tubes

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

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

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

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

Figure 9 depicts the range of colour temperatures which are experienced as the light source moves along the Planckian black body radiator curve. In the x,y chromaticity plot, when following the Planckian black body radiator in the direction of the yellow arrow, the white-light appearance will change from warm to cool white. This variation is then shown in the figure below, with the light sources illuminating numbers that correspond to the approximate colour temperature they represent.

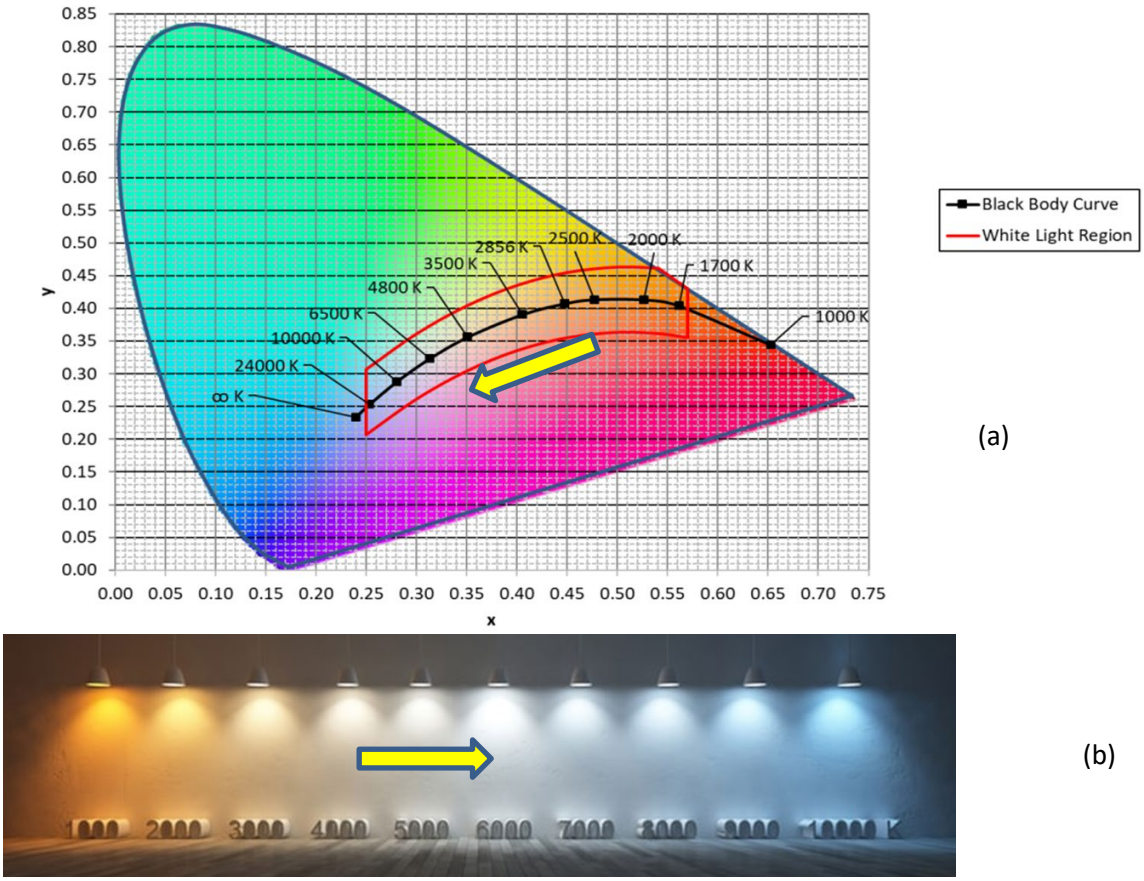


Figure 9. Movement along the curve in (a) results in changes in the CCT of white light in (b)

The CIE defines Correlated Colour Temperature as follows:

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

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

Table 27. Comparison of CCT Ranges for Fluorescent and LED Tubes

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

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

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

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

3.5.4.2 Volume Availability

The supply of T5 and T8 linear lamps requires heavy duty machinery and a glass furnace, which are capital intensive resources – and which forms one of more barriers to entry for newcomers to the conventional TL market. LED retrofit products are made up of electronics + plastic cap parts + a tube made either of plastic or of glass. Establishing and upscaling of the manufacturing of electronics and plastic parts requires little or no tooling and raw materials for manufacturing these lamps are abundantly available. Thus, for mechanical and driver electronics parts supply would be no issue at all.

To the extent glass tubes are used, the existing plant and machinery for manufacturing of glass tubes for conventional tubular lamps would be ideal (also avoiding glass manufacturers having to lay off workforce). In fact, existing European tubular lamp manufacturers might be said to have an advantage here as they should have the abovementioned glass tube manufacturing available (unless they may already have already shifted to Chinese glass suppliers).

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

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

Finally, two mitigating factors should be considered in relation to the availability of LED retrofit lamps: (1) stockpiling and (2) longer lifetime. First, on stockpiling, the phase out of incandescent and halogen lamps showed that a significant fraction of the market continued to legally purchase legacy lamps for a year or two after the phase-out date from suppliers that built up inventories prior to the transition phase. This practice softens whatever friction between supply and demand exists. If a T-LED replacement need if a ban on T8 / T5 becomes effective as of 1st September 2021. Second, on lifetime, the lifetime of LED retrofit lamps is 2-3 times longer than fluorescent lamps, thus the unit sales will be lower as those LED Lamps installed in sockets across Europe will last longer and won't need to be replaced as frequently as the fluorescent lamps were. The longer lifetime of LED lamps therefore reduces the unit demand experienced in the market, making the supply easier to achieve.

A report by Navigant Research finds that there will be a 7.6% annual growth rate in Tubular LED lamps from 2018 to 2027. A news item about this report is reproduced below[47]:

> *A new report from Navigant Research examines the commercial market for TLEDs, providing global market forecasts for shipments and revenue, segmented by offering type, building type, and region, through 2027. According its research, Navigant forecasts a 7.6% compound annual growth rate for global TLED shipments from 2018 to 2027.*
>
> *Navigant found that the TLED market is experiencing substantial growth thanks to declining prices, a desire to decrease energy consumption, and building codes and standards that require more efficient lighting solutions.*
>
> *"Price declines and utility incentives have made the initial cost of TLEDs more comparable to that of fluorescent tubes while the above-mentioned benefits have helped justify the higher price point," says Krystal Maxwell, senior research analyst at Navigant Research, in a release. "They provide a more attractive upfront cost than LED luminaires, as well as increased flexibility and ease of installation, which is helping to drive the TLED market."*
>
> *According to the report, the form factor of a fluorescent tube provides familiarity to building owners, managers, and tenants and provides a more efficient plug-and-play alternative, depending on the type of lamp. TLEDs also provide quicker retrofit solutions*

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

than a retrofit kit or LED luminaire, which incorporates the retrofit of the fixture with a new fixture and integrated light source.

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

3.5.5 (v) Socioeconomic Impact

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

The following screen capture from the OSRAM/LEDVANCE website[48] points to the fact that payback periods can be as short as four months. This is due to the lower sales prices for LED retrofit lamps, the long operating hours for these installations and the fact that direct-replacement LED retrofit tubes are now more than twice as efficient as some mercury-containing fluorescent lamps.

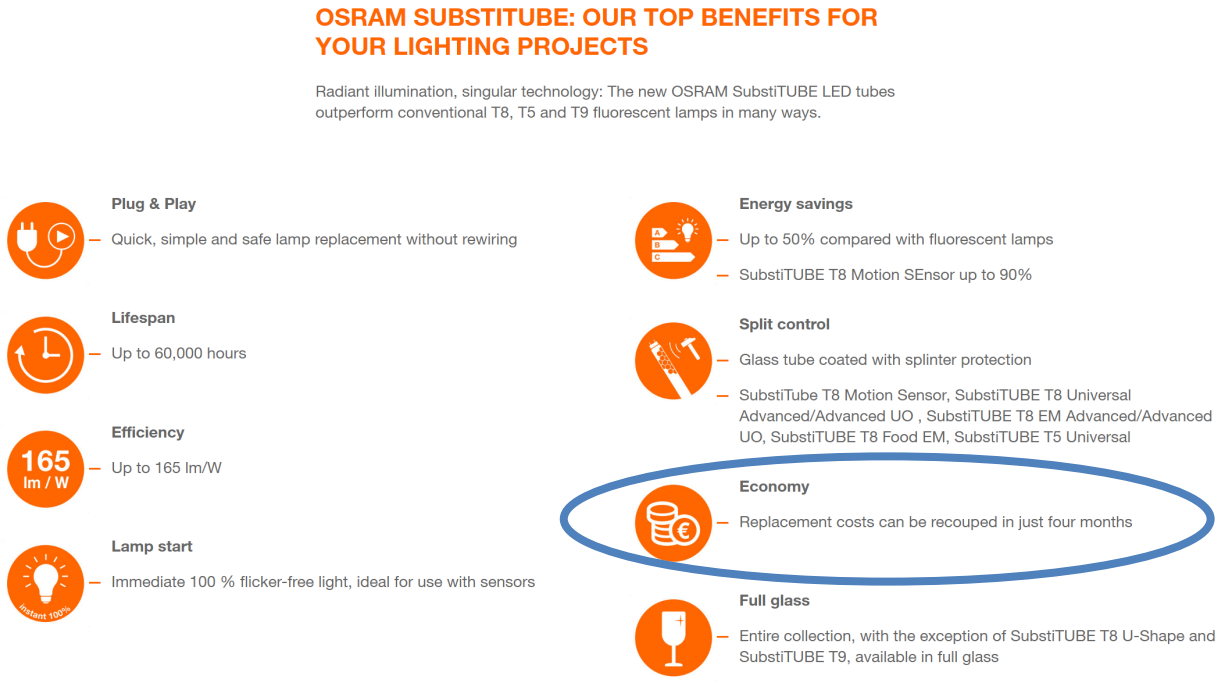


Figure 10. OSRAM/LEDvance Literature Highlighting Benefits of LED Tubular Retrofit Lamps

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

The payback period for replacing a 36W T8 linear fluorescent lamp with an LED retrofit lamp in Europe today is between 5 and 11 months, and the service life of these lamps is 1.5 to 2.5 times longer than fluorescent, saving on replacement costs. LED replacements for T5 fluorescent lamps have longer

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

payback periods of approximately 3 to 3.5 years, however they will operate for approximately 16 years and represent the best option for the end-user, with a net present value life-cycle cost savings of between €55 and €67 for each T5 fluorescent lamp replaced. LED replacements for compact fluorescent lamps not integrally ballasted (CFLni) offer very attractive payback periods of between 1.3 and 3.0 years and will last 2-3 times longer than the fluorescent lamp. For European businesses and households, there is a very strong value proposition in switching to LED, and lighting manufacturers' websites highlight the cost-effectiveness and energy savings potential of LED alternatives to fluorescent lamps.

The Öko-Institute worked with VHK, the consultants who prepared the one-lighting regulation review study and impact assessment for the European Commission, to conduct runs of the MELISA market model to help quantify the benefits of phasing out certain fluorescent lamps in 2021. The cumulative benefit through the year 2035 for these specific lamp types were reported in their updated report issued on 10 July 2020 to the members of the RoHS Committee:

- CFLni phase-out: cumulative savings of 28.4 TWh electricity (estimated 8.4 MMT CO_2 savings) and net €2.8 billion savings in electricity bills and lamps
- T5 phase-out: cumulative savings of 129.0 TWh electricity (estimated 38.4 MMT CO_2 savings) and net €9.3 billion savings in electricity bills and lamps
- T8 phase-out: cumulative savings of 152.2 TWh electricity (estimated 45.3 MMT CO_2 savings) and net €17.7 billion savings in electricity bills and lamps

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

Table 28. Net Benefits from Phase-Out of T8, T5 and CFLni Lamps in 2021

Savings	Cumulative (2021-2035) Savings for:			
	T8	**T5**	**CFLni**	**Sum**
Electricity Savings (*TWh*)	152.3	129.0	28.4	**309.7 TWh**
CO_2 Savings (MMT)	45.3	38.4	8.4	**92.1 MMT CO_2**
Net savings including lamps & electricity (*€ billion*)	€17.7	€9.3	€2.8	**€29.9 billion**

Source: Öko-Institute report, 10 July 2020; CO_2 estimate by SEA/CLASP.

The savings estimate from the Öko-Institut report which is presented in Table 25 considers a retrofit scenario where over 90% of existing T5/T8 fluorescent fixtures can accept LED retrofits across Europe. In other words, these luminaires do not need to be changed – simply the lamps will be changed in over 90 percent of the cases and the user will experience energy savings and performance benefits from day one. Our updated substitution analysis is discussed in Section 2.3 and presented in Annex A. LED Lamp – Ballast Compatibility Assessment, the new analysis of the manufacturer's ballast compatibility catalogues has found much higher rates of compatibility by looking at different lamps across more than one supplier. There are direct, plug-and-play retrofit LED lamps for nearly all of the fluorescent luminaires installed in Europe. VHK's independent market analysis confirmed what was presented in the December 2019 Sweden-CLASP report. VHK stated there are "adequate LED substitutes available for large majority of FL", and that there is "no technical barrier to create LED substitutes also for less widely used FL." (See Section 2.7)

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

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

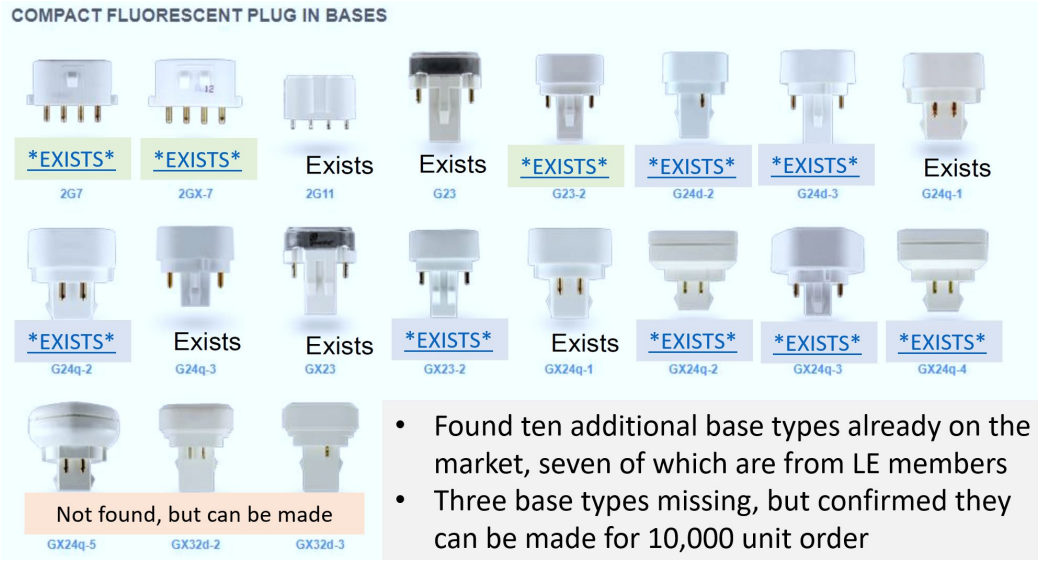


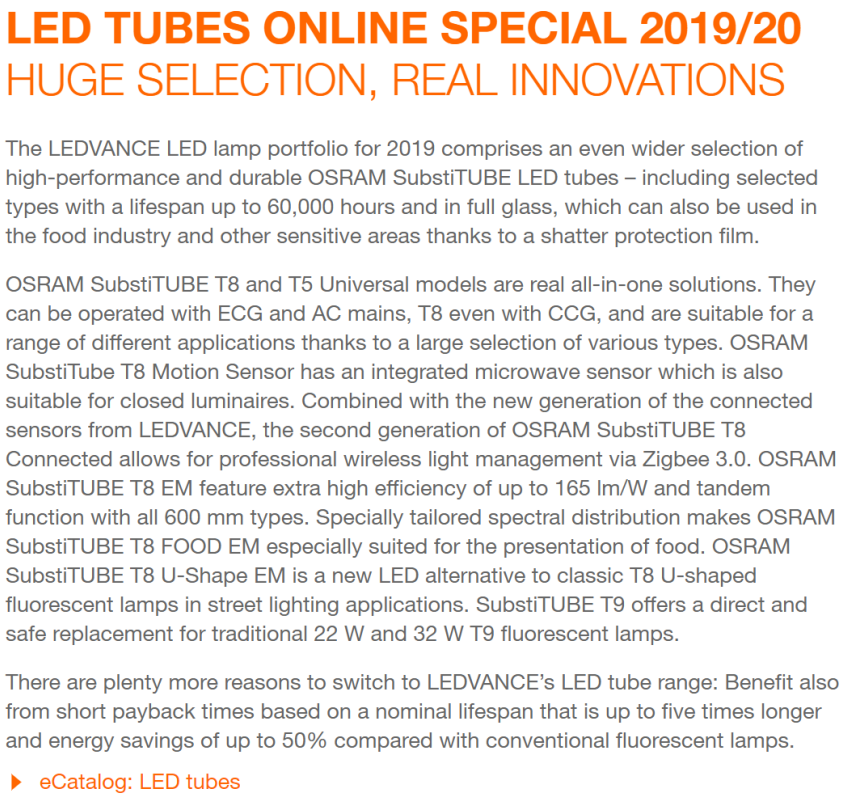
Figure 11. Illustration of the variety of CFLni base types and compatible LED Retrofit Lamps

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

3.5.6 (vi) Impact on Innovation

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

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



LED TUBES ONLINE SPECIAL 2019/20
HUGE SELECTION, REAL INNOVATIONS

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

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

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

▸ eCatalog: LED tubes

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

In Annex B of this report, we provide a detailed assessment on each of the three major fluorescent lamp types – T5, T8 and CFLni – according to the six criteria contained in Article 5(1)(a) of the RoHS Directive. It is clear that the exemption for fluorescent lamps cannot be granted as these criteria no longer justify extending it.

3.6 Overview of Compatibility Issues

Table 29. Lighting Europe's Comment from page 5 of their 9th June Comment

Lighting Europe's Comment:
Annex II Overview of compatibility issues As existing luminaires contain internal electronic drivers of many different topologies and manufacturers, many of them cannot function with newly designed LED substitutes in significant parts of installations or applications. Publicly available technical guidance documentation from companies (e.g. PHILIPS brand, OSRAM brand and Tungsram) illustrates that LED substitutes are

not compatible with many installed lighting fixtures or applications, and warranty does not apply, due to:
1) Flicker - effect of light variations which are annoying and fatiguing/not healthy for users.
2) Light specification out of range – light levels will not meet required application specifications for LED substitutes due to variations in installed electronics in luminaires.
3) Emergency Lighting - EL luminaires are obligatory to avoid casualties in case of emergencies to facilitate safety during evacuations in case of emergencies (e.g. fire, smoke etc) and mandatory for public buildings e.g. offices, theatres, schools, elderly homes, hospitals, public transport etc. Due to strict IEC and EN safety standards, LED lamps are not allowed to be used in installed conventional EL luminaires, as these are only certified for conventional lamps.
4) Dimming installations – used in modern daylight-controlled offices, conference rooms, theatres, cinemas, hospital rooms etc. Many LED tubes are not allowed to dim due to e.g. flicker or temperature problems of components inducing early lifetime failures for electronic driver and LED lamp.
5) Serial lamp connections - Rectangular luminaires are used in many office and shop applications where 4 lamps are operated by 2 magnetic drivers. Therefore, 2 lamps operate in a serial circuit connection which is not allowed for many LED tube lamps.
6) Water protected luminaires - used in car parking's, home garages, industry halls, food industry, streetlighting, train- and metro stations etc., where most LED retrofit lamps cannot be used as one-to-one replacements.
7) EMC - Electro Magnetic Compatibility problems can happen due to driver/wiring combinations which can disturb electronic (IT) equipment when the originally designed conventional lamp is substituted by different electronic LED lamp designs.
8) Light distribution problems due to the narrow beam of LED lamps compared to wide beams of conventional lamp, inducing inhomogeneous light levels and zebra effects.
9) DC operation applications for conventional lamps e.g. battery-operated applications like boats, trucks, trains. LED lamps are not suited for these applications.
10) B and C brand driver compatibility - is unclear as these drivers were not tested. Only A-brand compatibility table data are tested and listed.
Please note that the above references of Lighting Europe are based on the experience of many manufacturers and for all lamp types.

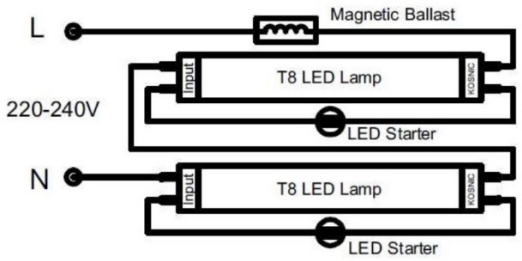
Swedish Energy Agency and CLASP Response:

In Annex II of the Lighting Europe comments, they raise possible issues about problems encountered when retrofitting with LED lamps. We have gone through this list of ten things and found there are many issues with the information they present in their comments. Brief Google searches have yielded products produced by Lighting Europe members and others that satisfy the issues being addressed. We provide links in our responses for independent verification of the information we provide in response to these issues.

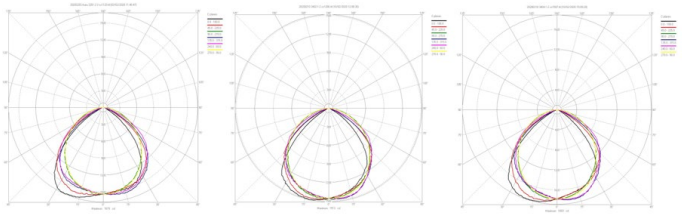
Table 30. Addressing the Ten Compatibility Issues Raised by Lighting Europe

Issue	Lighting Europe	Swedish Energy Agency/CLASP
1) Flicker	effect of light variations which are annoying and fatiguing/not healthy for users.	The Swedish Energy Agency has conducted testing on a small sample of LED linear retrofit tubes and found models from Philips, LEDvance, Noxion, ELT and Ecobright which are available for sale in the EU today and have flicker levels (i.e., PstLM and SVM) that are lower than the new Ecodesign requirements, meaning these products will not have detectable levels of flicker for most Europeans. In addition to those products tested by Sweden, a brief online search found several LED lamp suppliers who are marketing products which they classify as "flicker free" – for example, this product from GoodLight which is approved for use in the London Underground system, and this product from MaxLite. All of this information demonstrates that LED products are available without flicker and it is technologically feasibility to have good driver design in this form factor. Further, the product registry database will require suppliers to report PstLM and SVM, so in the future, consumers will be able to choose lamps on the basis of being flicker free according to the industry standards.
2) Light specification out of range	light levels will not meet required application specifications for LED substitutes due to variations in installed electronics in luminaires.	LEDs are more efficacious than fluorescent lamps, which means they produce more lumens of light per watt of power consumed. A consumer or installer who is retrofitting LED tubes will look at the rated lumen output of the fluorescent lamp they are replacing and compare that to the LED tube they are installing. By requiring suppliers to report the lumen output, this comparison can be made and light levels can be maintained. Indeed, building owners are satisfied with the performance of LED retrofit lamps, as we can see from the broad success in the market of this product which is offered by all the major lamp manufacturers as well as new market entrants. Many end-users leave comments about how much brighter the LED systems are due to the fact that LEDs come on at full brightness straight away whereas fluorescent lighting has a warm-up period before full light output.

Issue	Lighting Europe	Swedish Energy Agency/CLASP
3) Emergency Lighting	EL luminaires are obligatory to avoid casualties in case of emergencies to facilitate safety during evacuations in case of emergencies (e.g. fire, smoke etc) and mandatory for public buildings e.g. offices, theatres, schools, elderly homes, hospitals, public transport etc. Due to strict IEC and EN safety standards, LED lamps are not allowed to be used in installed conventional EL luminaires, as these are only certified for conventional lamps.	The trend in the Emergency Lighting market today is to switch out old fluorescent luminaires and install more energy-efficient LED luminaires. Here is a quote from a UK introduction to emergency lighting webpage published a few years ago which conveys that market trend: "LED emergency lighting: the way ahead? With the focus increasingly on protecting the environment as well as energy and cost saving, the LED (light emitting diode) is becoming an increasingly popular choice of light source for emergency lighting luminaires. […] LEDs contain no mercury and their low energy consumption, high efficiency and long life (typically 10 years) mean they are more environmentally sound than almost any other type of light source. They come on instantly, unlike some energy saving bulbs, and the fact that they are much smaller than, for example, the traditional fluorescent tube means that there is scope for much more stylish designs in emergency luminaires. State of the art models even incorporate three self-tests: a continuous battery test, a lamp test and a duration test. Over the lifetime of the product, this represents a significant reduction in maintenance costs."

Issue	Lighting Europe	Swedish Energy Agency/CLASP
4) Dimming installations	used in modern daylight-controlled offices, conference rooms, theatres, cinemas, hospital rooms etc. Many LED tubes are not allowed to dim due to e.g. flicker or temperature problems of components inducing early lifetime failures for electronic driver and LED lamp.	In a real-life situation, if an end-user has a dimmable lighting system, they will choose to retrofit with dimmable LED retrofit lamps. These are widely available from many suppliers, including Lighting Europe members. Please find this example from Philips Lighting. That said, dimming represents only a very small subset of the lighting market, we have found many dimmable drivers are installed where the dimming functionality is never used, so in that case compatibility at 100% power is enough. And for the small subset of the market where dimming is really necessary, for example in theatres, it does make sense to switch luminaire to LED instead of install retrofit tubes, since this will allow also additional functionality such as colour control etc. Furthermore, dimming on fluorescent systems does not provide a one for one return in terms of energy savings. The light output drops much faster than the power, meaning the efficacy gets worse as the fluorescent lamp is dimmed. So in that case, it also makes sense from an energy saving perspective to switch to an dimmable luminaire, where dimming indeed also leads to energy, and cost, savings. Finally, it should be noted that LEDs are much better suited to dimming than fluorescent technology. It is far easier to dim an LED lamp than a fluorescent lamp which must maintain an electrical arc to produce light.
5) Serial lamp connections	Rectangular luminaires are used in many office and shop applications where 4 lamps are operated by 2 magnetic drivers. Therefore, 2 lamps operate in a serial circuit connection which is not allowed for many LED tube lamps.	There are drop-in retrofit linear LED lamps which are specifically designed to operate in rectangular luminaires with serial-connected lamps, as depicted in the circuit diagram below:  Here is an example of a two-foot T8 (G13 socket) retrofit lamp that will operate in a serial connection installation. And here is an example with CFLni lamps. There is no technical or other barrier to producing serial-connected LED lamps, it just requires a small modification to the circuit so the lamp is able to operate in this configuration. OSRAM/LEDvance also has a solution for this type of lamp connection, noting on its website that its OSRAM SUBSTITUBE ADVANCED UO/ ADVANCED T8 EM: supports "Tandem function with all 600 mm types". Thus there are direct drop-in LED retrofits for these serial connection / tandem lamps.

Issue	Lighting Europe	Swedish Energy Agency/CLASP
6) Water protected luminaires	used in car parking's, home garages, industry halls, food industry, streetlighting, train- and metro stations etc., where most LED retrofit lamps cannot be used as one-to-one replacements.	The authors did some market research and identified quite a few examples of products which are designed to operate in this type of luminaire. Some of the products are given below, including a product which is equipped with a film sleeve to protect its glass housing so it can be used in applications that require shatterproof lighting, such as food processing/service buildings, daycare centers, and elevators. Example 1. Example 2. LED lamps produce less heat than their fluorescent counterparts because they use less wattage, thus there is no problem with installing LED lamps in water-protected (high IP-rating) fixtures that were designed for inefficient fluorescent lamps. Here is an example of a standard fluorescent fixture with an IP65 rating which is being sold with LED tubes. Here is another example of a similar, but longer standard fluorescent fixture with IP65, and sold with two LED tubes inside.
7) EMC - Electro Magnetic Compatibility	problems can happen due to driver/wiring combinations which can disturb electronic (IT) equipment when the originally designed conventional lamp is substituted by different electronic LED lamp designs.	LED lamps, just like every other electronic device, must thus comply with the EMC requirements, including both emission (where the light source can disturb other products) and immunity (where other devices with EMC emissions can affect the light source). There are standards in place to protect against these problems, and one would expect products on the market today to comply with these standards. Here is an example of a Philips CorePro LEDtube, which is described as "No EMC problems thanks to integrated driver." And here is a certificate from LEDvance which certifies their LED linear retrofit products meets the EMC regulations.

Issue	Lighting Europe	Swedish Energy Agency/CLASP
8) Light distribution problems	due to the narrow beam of LED lamps compared to wide beams of conventional lamp, inducing inhomogeneous light levels and zebra effects.	As discussed previously, this is not a problem in the vast majority of installations as per the feedback and discussions on LED retrofit tubes. Installers are very pleased with the products and are continuing to specify them. The Swedish Energy Agency conducted a lumen intensity distribution (LID) comparison of a fluorescent luminaire with a fluorescent lamp and then a retrofit LED lamp in the same fixture. The LID graphs are shown below with the T8 lamp on the left and two LED retrofits in the middle and on the right. The light distribution pattern is virtually identical and this helps to explain why the market is satisfied with the performance of LED retrofit tubes:  T8 Fluorescent Lamp (3201-1-3) T8 LED Lamp (3402-1-2) T8 LED Lamp (3404-1-2) Sweden has checked with stakeholders who have replaced the fluorescent lamps and they found: "Experiences from real installations prove the existing alternatives, including retrofit LED tubes….to be clearly satisfying or superior both from a technical (lifetime, maintenance, etc.) and lighting (light distribution, glare, colour temperature, safety, comfort, esthetical, etc.) point of view. Even when it comes to the LCC, existing alternatives are many times already attractive." Finally, for those few installations where a full emission pattern (360 degrees) is needed, manufacturers have produced LED tubes which offer a full emission pattern. Example 1. Example 2. Example 3. Note: given that retrofitting LED tubes into fluorescent fixtures is the current market trend, it makes sense that the RoHS Directive would step in now and accelerate this trend by ending the exemption for fluorescent lamps.

Issue	Lighting Europe	Swedish Energy Agency/CLASP
9) DC operation applications	for conventional lamps e.g. battery-operated applications like boats, trucks, trains. LED lamps are not suited for these applications.	Sweden and CLASP conducted market research and easily identified many DC voltage LED retrofit lamps which are available on the market today. There are DC-voltage LED lamps which are suited operational environments such as those found in boats, trucks and trains. Here are some examples we found: Example 1. Example 2. Example 3. In fact, here is one five star review from the www.boatlamps.co.uk product page which we thought was worth repeating from a boat owner in Sweden: "Marcus R. on Aug 07, 2018. Best possible service. I upgraded 10x 24V tube lights to LED in my engine room. Absolutely brilliant result! Thanks to Adrian for all support and knowledge. Delivery time from UK to Sweden less than 24 hours."
10) B and C brand driver compatibility	is unclear as these drivers were not tested. Only A-brand compatibility table data are tested and listed.	Compatibility tables for LED lamps are clearly a good idea, as they allow the end-users an opportunity to determine whether the lamp will operate on their existing fluorescent ballast prior to the purchase. And while some manufacturers may not have published these tables, there is still the Consumer rights which would protect the end-users. The following is taken from a European Commission website (link here): • "Under EU rules, a trader must repair, replace, reduce the price or give you a refund if goods you bought turn out to be faulty or do not look or work as advertised. • If you bought a product or a service online or outside of a shop (by telephone, mail order, from a door-to-door salesperson), you also have the right to cancel and return your order within 14 days, for any reason and without a justification." Thus, if there is any problem with compatibility, as long as the consumer determines that and returns the lamps within two weeks, there is no lost investment.

Annex A. LED Lamp – Ballast Compatibility Assessment

In this Annex, we present our detailed work combining the fluorescent ballast-lamp compatibility tables of several tubular LED lamp manufacturers. We started by downloading the current PDFs from the following manufacturers websites and then converting them into Excel tables:

- LEDvance; BALLAST COMPATIBILITY LIST – SubstiTUBE, Nov. 2019, Version2 Filename: Ballast
- Compatibility SubstiTUBE UNIVERSAL T8 , T5 Universal Gen 8
- Philips LEDtube compatibility list Professional Q2 2019 – MASTER LEDtube HF T5, MASTER LEDtube HF T8, CorePro LEDtube HF InstantFit; CorePro LEDtube Universal HO; May 2019
- Felio Sylvania Europe Limited, ToLEDo Superia T8 Universal Electronic ballast compatibility list, January 2018, Version 1.0
- Felio Sylvania Europe Limited, ToLEDo Superia T8 Electronic, Electronic ballast compatibility list, November 2018, Version 2.0
- Felio Sylvania Europe Limited, ToLEDo Superia T5 ECG

In addition to these, we contacted Seaborough and asked for test data on the lamps sold by Opple Lighting and LEDs Change the World. (Please click on the hyperlinks to learn more about the linear LED retrofit lamps products offered in Europe).

After merging all the databases and compatibility / non-compatibility indicators across all these catalogues and test reports, we found the following:

- For T5 linear lamps – 208 ballast-lamp combinations were given in the manufacturer's compatibility catalogues for the European market. Of these, 166 ballast-lamp combinations had compatible LED retrofit lamps from either Philips, Osram or Sylvania. Thus, 80% of the installed stock can be retrofit with LED lamps.

- For T8 linear lamps – 262 ballast-lamp combinations were given in the catalogues for the European market. Of these, 234 ballast-lamp combinations had compatible LED retrofit lamps from either Philips, Osram or Sylvania – amounting to 89% of the T8 high-frequency (electronic) ballast stock. However, if LED lamps from Opple and LEDs Change the World are added to the database, the compatibility jumps up to 97% (253 lamp-ballast combinations are compatible). In addition, it is worth noting that T8 magnetic ballasts are 100% compatible with LED retrofit lamps.

Given the revised estimates based on our more thorough analysis of the manufacturer's current catalogues providing their declared rates of compatibility, we have calculated new revised estimates for Europe for retrofit LED lamp compatibility in fluorescent luminaires across the EU.

Our previous estimate published in our February 2020 report was 90% but we have now determined the actual rate of retrofitability to be 91.4% to 93.7% across all T5 and T8 luminaires installed in Europe today.

Table 31. Revised LED Lamp Compatibility Percentages for T5 and T8 Luminaires in Europe

Lamp Size	Percentage of T5 & T8 in EU Stock	Ballast Type	Percentage of stock by ballast type	Estimated EU Stock of total T5 & T8	Compatibility, Low - High Estimate	Overall EU Stock Compatibility
T5	30%	HF/ECC	100% of T5	30%	79% - 80%	23.7% - 24%
T8	70%	EM/CGG	70% of T8	49%	100%*	49%
		HF/ECC	30% of T8	21%	89% - 97%	18.7% - 20.4%
EU Total:	**100%**			**100%**		**91.4% - 93.4%**

*No compatibility issues with electromagnetic T8 ballasts, LED lamps can retrofit 100% of these installations

On the following pages, we present the tables in printed form for review, but we are also providing the Excel spreadsheet itself which was used for this analysis. We believe this tool could prove useful to building owners for identifying compatible lamps to try based on the ballast/lamp combination they have in their building (although we recognise this table will quickly go out of date, as the compatibility is always increasing and products always improving with time).

A.1 Summary Table of T5 Compatibility

Table A.1. T5 Ballast and Lamp Combinations; Combined Result of Philips, Osram and Sylvania

Count	T5 Ballasts/Lamps	Compatible
1	BAG-HUECO; BCD35.1F-01/220-240/1-10V; Lamps: 1	
2	BAG-HUECO; BCD35.2F-01/220-240/1-10V; Lamps: 2	
3	BAG-HUECO; BCD54.1F-01/220-240/1-10V; Lamps: 1	
4	BAG-HUECO; BCS14.3-4FR-01/220-240; Lamps: 3	
5	BAG-HUECO; BCS14.3-4FR-01/220-240; Lamps: 4	
6	BAG-HUECO; BCS35.1FX-11/220-240; Lamps: 1	
7	BAG-HUECO; BCS35.2FX-11/220-240; Lamps: 2	
8	BAG-HUECO; BCS49.1FX-11/220-240; Lamps: 1	
9	BAG-HUECO; BCS49.2FX-11/220-240; Lamps: 2	
10	BAG-HUECO; BCS54.1FR-01/220-240; Lamps: 1	
11	BAG-HUECO; BCS54.1FX-11/220-240; Lamps: 1	
12	BAG-HUECO; BCS54.2FX-11/220-240; Lamps: 2	
13	BAG-HUECO; BCS80.1/54.2FR-11/220-240; Lamps: 1	
14	BAG-HUECO; BCS80.1FX-11/220-240; Lamps: 1	
15	BAG-HUECO; BCS80.2FX-11/220-240; Lamps: 2	
16	BAG-HUECO; MLS39.1-2FR-11/220-240; Lamps: 2	
17	BAG-HUECO; MLS80.1/54.2FR-11/220-240; Lamps: 1	
18	BAG-HUECO; MLS80.1/54.2FR-11/220-240; Lamps: 2	
19	BAG-HUECO; MLS80.1FR-11/220-240; Lamps: 1	
20	HELVAR; EL1x14-35ngn5; Lamps: 1	
21	HELVAR; EL1x14-35s 220-240V; Lamps: 1	
22	HELVAR; EL1x21sc; Lamps: 1	
23	HELVAR; EL1x49ngn5; Lamps: 1	
24	HELVAR; EL1x49s; Lamps: 1	
25	HELVAR; EL1x49s-u; Lamps: 1	
26	HELVAR; EL1x54iDim; Lamps: 1	
27	HELVAR; EL1x54ngn5; Lamps: 1	
28	HELVAR; EL1x54s; Lamps: 1	

Count	T5 Ballasts/Lamps	Compatible
29	HELVAR; EL1x54sc; Lamps: 1	
30	HELVAR; EL1x80iDim; Lamps: 1	
31	HELVAR; EL1x80sc; Lamps: 1	
32	HELVAR; EL2x14-35iDim; Lamps: 2	
33	HELVAR; EL2x14-35ngn5; Lamps: 2	
34	HELVAR; EL2x49ngn5; Lamps: 2	
35	HELVAR; EL2x49s; Lamps: 2	
36	HELVAR; EL2x54iDim; Lamps: 2	
37	HELVAR; EL2x54ngn5; Lamps: 2	
38	HELVAR; EL2x54sc; Lamps: 2	
39	HELVAR; EL2x80iDim; Lamps: 2	
40	OSRAM; EZP5 1x28/220-230; Lamps: 1	
41	OSRAM; EZP5 2x28/220-230; Lamps: 2	
42	OSRAM; EZ-T5 1x28/220; Lamps: 1	
43	OSRAM; QT-FIT 5/8 1x54-58; Lamps: 1	
44	OSRAM; QT-FIT 5/8 2x54-58; Lamps: 2	
45	OSRAM; QT-FIT5 1x14-35; Lamps: 1	
46	OSRAM; QT-FIT5 1x49; Lamps: 1	
47	OSRAM; QT-FIT5 1x54; Lamps: 1	
48	OSRAM; QT-FIT5 2x14-35; Lamps: 2	
49	OSRAM; QT-FIT5 2x49; Lamps: 2	
50	OSRAM; QT-FIT5 2x54; Lamps: 2	
51	OSRAM; QT-FIT5 3x14, 4x14; Lamps: 3	
52	OSRAM; QT-FIT5 3x14, 4x14; Lamps: 4	
53	OSRAM; QT-FQ 1x49/230-240 CW; Lamps: 1	
54	OSRAM; QT-FQ 1x80/230-240; Lamps: 1	
55	OSRAM; QT-FQ 2x80; Lamps: 2	
56	OSRAM; QTi 1x14/24/21/39 GII; Lamps: 1	
57	OSRAM; QTi 1x21/39 DIM(1-10V); Lamps: 1	
58	OSRAM; QTi 1x28/54/35/49 GII; Lamps: 1	
59	OSRAM; QTi 1x35/49/80/GII; Lamps: 1	
60	OSRAM; QTi 1x35/49/80/GII; Lamps: 1	
61	OSRAM; QTi 2x14/24/21/39 GII; Lamps: 2	
62	OSRAM; QTi 2x21/39 DIM(1-10V); Lamps: 2	
63	OSRAM; QTi 2x28/54/35/49 GII; Lamps: 2	
64	OSRAM; QTi 2x35/49 DIM;; Lamps: 2	
65	OSRAM; QTi 2x35/49/80 GII; Lamps: 2	
66	OSRAM; QTi DALI 1x35/49/80 DIM; Lamps: 1	
67	OSRAM; QTi DALI 2x35/49/80 DIM; Lamps: 2	
68	OSRAM; QTP5 1x14-35; Lamps: 1	
69	OSRAM; QTP5 1x49; Lamps: 1	
70	OSRAM; QTP5 1x80; Lamps: 1	
71	OSRAM; QTP5 2x14-35; Lamps: 2	
72	OSRAM; QTP5 2x49; Lamps: 2	
73	OSRAM; QTP5 3x14, 4x14; Lamps: 3	
74	OSRAM; QTP5 3x14, 4x14; Lamps: 4	
75	OSRAM; QTP-OPTIMAL 1x54-58; Lamps: 1	
76	OSRAM; QTP-OPTIMAL 2x54-58; Lamps: 2	
77	OSRAM; QTz5 1x28; Lamps: 1	
78	OSRAM; QTz5 2x28; Lamps: 2	
79	PHILIPS; EB-C 128 TL5; Lamps: 1	
80	PHILIPS; EB-C 228 TL5; Lamps: 2	
81	PHILIPS; EB-Ci 1-2 14-28W; Lamps: 1	

Count	T5 Ballasts/Lamps	Compatible
82	PHILIPS; EB-Ci 1-2 14-28W; Lamps: 2	
83	PHILIPS; HF-E 1/2 49 TL5 II; Lamps: 1	
84	PHILIPS; HF-E 1/2 49 TL5 II; Lamps: 2	
85	PHILIPS; HF-E 1/2 54 TL5 II; Lamps: 1	
86	PHILIPS; HF-E 1/2 54 TL5 II; Lamps: 2	
87	PHILIPS; HF-E 114 TL5 II; Lamps: 1	
88	PHILIPS; HF-E 214 TL5 II; Lamps: 2	
89	PHILIPS; HF-E 3/414 TL5 II; Lamps: 3	
90	PHILIPS; HF-E 3/414 TL5 II; Lamps: 4	
91	PHILIPS; HF-P 1 14-35 TL5 HE III 220-240V 50/60Hz; Lamps: 1	
92	PHILIPS; HF-P 1 14-35 TL5 HE III IDC; Lamps: 1	
93	PHILIPS; HF-P 149 TL5 220-240; Lamps: 1	
94	PHILIPS; HF-P 149 TL5 HO 220-240; Lamps: 1	
95	PHILIPS; HF-P 149 TL5 HO EII 220-240; Lamps: 1	
96	PHILIPS; HF-P 149 TL5 HO III IDC; Lamps: 1	
97	PHILIPS; HF-P 154 TL5 HO EII 220-240; Lamps: 1	
98	PHILIPS; HF-P 154/155 TL5 HO/PLL III IDC; Lamps: 1	
99	PHILIPS; HF-P 180 TL5/PLL III IDC; Lamps: 1	
100	PHILIPS; HF-P 2 14-35 TL5 HE III 220-240V 50/60Hz; Lamps: 2	
101	PHILIPS; HF-P 2 14-35 TL5 HE III IDC; Lamps: 2	
102	PHILIPS; HF-P 2 80 TL5/PLL III IDC; Lamps: 2	
103	PHILIPS; HF-P 249 TL5 220-240; Lamps: 2	
104	PHILIPS; HF-P 249 TL5 HO EII 220-240; Lamps: 2	
105	PHILIPS; HF-P 249 TL5 HO III IDC; Lamps: 2	
106	PHILIPS; HF-P 254/255 TL5 HO/PLL III IDC; Lamps: 2	
107	PHILIPS; HF-P 3/414 TL5 III IDC; Lamps: 3	
108	PHILIPS; HF-P 3/414 TL5 III IDC; Lamps: 4	
109	PHILIPS; HF-P I 14-35 TL5 HE III IDC; Lamps: 1	
110	PHILIPS; HF-P I 149 TL5 HO III IDC; Lamps: 1	
111	PHILIPS; HF-P I 80 TL5/PLL III IDC; Lamps: 1	
112	PHILIPS; HF-P Xt 149 TL5 EII 220-240; Lamps: 1	
113	PHILIPS; HF-P Xt 180 TL5 EII 220-240; Lamps: 1	
114	PHILIPS; HF-P Xt 249 TL5 EII 220-240; Lamps: 2	
115	PHILIPS; HF-P Xt 254 TL5 EII 220-240; Lamps: 2	
116	PHILIPS; HF-P Xt 280 TL5 EII 220-240; Lamps: 2	
117	PHILIPS; HF-Pi 1 14/21/24/39 TL5 EII 220-240; Lamps: 1	
118	PHILIPS; HF-Pi 1 28/35/49/54 TL5 EII 220-240; Lamps: 1	
119	PHILIPS; HF-Pi 1 28/35/49/80 TL5 EII 220-240; Lamps: 1	
120	PHILIPS; HF-Pi 2 14/21/24/39 TL5 EII 220-240; Lamps: 2	
121	PHILIPS; HF-Pi 2 28/35/49/54 TL5 EII 220-240; Lamps: 2	
122	PHILIPS; HF-Pi 2 28/35/49/80 TL5 EII 220-240; Lamps: 2	
123	PHILIPS; HF-R 114 TL5 220-240; Lamps: 1	
124	PHILIPS; HF-R 149 TL5 220-240; Lamps: 1	
125	PHILIPS; HF-R 154 TL5 220-240; Lamps: 1	
126	PHILIPS; HF-R 154 TL5 EII; Lamps: 1	
127	PHILIPS; HF-R 180 TL5/PLL EII; Lamps: 1	
128	PHILIPS; HF-R 214-35 TL5 EII; Lamps: 2	
129	PHILIPS; HF-R 254 TL5 EII; Lamps: 2	
130	PHILIPS; HF-R 280 TL5/PLL EII 220-240; Lamps: 2	
131	PHILIPS; HF-R 3/414 TL5 220-240; Lamps: 3	
132	PHILIPS; HF-R 3/414 TL5 220-240; Lamps: 4	
133	PHILIPS; HF-R DALI 154 TL5 220-240; Lamps: 1	
134	PHILIPS; HF-R DALI 214 TL5 220-240; Lamps: 2	

Count	T5 Ballasts/Lamps	Compatible
135	PHILIPS; HF-R Es 114-35 TL5; Lamps: 1	
136	PHILIPS; HF-R Es 149 TL5; Lamps: 1	
137	PHILIPS; HF-R Es 154 TL5; Lamps: 1	
138	PHILIPS; HF-R Es 214-35 TL5; Lamps: 2	
139	PHILIPS; HF-R Es 249 TL5; Lamps: 2	
140	PHILIPS; HF-R Es 254 TL5; Lamps: 2	
141	PHILIPS; HF-R T 228 TL5 220-240; Lamps: 2	
142	PHILIPS; HF-R TD 149 TL5 EII 220-240; Lamps: 1	
143	PHILIPS; HF-R TD 154 TL5 EII 220-240; Lamps: 1	
144	PHILIPS; HF-R TD 180 TL5/PLL 220-240; Lamps: 1	
145	PHILIPS; HF-R TD 180 TL5/PLL EII; Lamps: 1	
146	PHILIPS; HF-R TD 280 TL5/PLL EII; Lamps: 2	
147	PHILIPS; HF-R TD 314 TL5 EII; Lamps: 3	
148	PHILIPS; HF-Ri TD 2 14/21/24/39 TL5 E+; Lamps: 2	
149	PHILIPS; HF-Ri TD 280 TL5/PLL E+; Lamps: 2	
150	PHILIPS; HF-RiTD 1 28/35/49/54 TL5 E+; Lamps: 1	
151	PHILIPS; HF-S 1 28-35 TL5 II; Lamps: 1	
152	PHILIPS; HF-S 1 80 TL5/PLL II; Lamps: 1	
153	PHILIPS; HF-S 149 TL5 II; Lamps: 1	
154	PHILIPS; HF-S 154 TL5 II; Lamps: 1	
155	PHILIPS; HF-S 2 14-35 TL5 HE II; Lamps: 2	
156	PHILIPS; HF-S 2 80 TL5/PLL II; Lamps: 2	
157	PHILIPS; HF-S 249 TL5 II; Lamps: 2	
158	PHILIPS; HF-S 254 TL5 II; Lamps: 2	
159	PHILIPS; HF-S 3/414 TL5 II; Lamps: 3	
160	PHILIPS; HF-S 3/414 TL5 II; Lamps: 4	
161	TRIDONIC ATCO; PC 1/14-35 T5 TOP lp; Lamps: 1	
162	TRIDONIC ATCO; PC 1/14-35/49/54 T5 PRO-M lp; Lamps: 1	
163	TRIDONIC ATCO; PC 1/14-35/49/80 T5 PRO-M lp; Lamps: 1	
164	TRIDONIC ATCO; PC 1/49 T5 INDUSTRY; Lamps: 1	
165	TRIDONIC ATCO; PC 1/49 T5 PRO lp; Lamps: 1	
166	TRIDONIC ATCO; PC 1/54 T5 INDUSTRY; Lamps: 1	
167	TRIDONIC ATCO; PC 1/80 T5 INDUSTRY; Lamps: 1	
168	TRIDONIC ATCO; PC 1x14-35 T5 PRO lp; Lamps: 1	
169	TRIDONIC ATCO; PC 1x14-35 T5 TOP lp; Lamps: 1	
170	TRIDONIC ATCO; PC 1x28 T5 TEC lp; Lamps: 1	
171	TRIDONIC ATCO; PC 1x49 T5 PRO lp; Lamps: 1	
172	TRIDONIC ATCO; PC 1x49 T5 TOP lp; Lamps: 1	
173	TRIDONIC ATCO; PC 1x54 T5 PRO lp; Lamps: 1	
174	TRIDONIC ATCO; PC 1x54 T5 TOP lp; Lamps: 1	
175	TRIDONIC ATCO; PC 1x80 T5 PRO lp; Lamps: 1	
176	TRIDONIC ATCO; PC 2/14-28 T5 TOP lp; Lamps: 2	
177	TRIDONIC ATCO; PC 2/14-35 T5 PRO lp; Lamps: 2	
178	TRIDONIC ATCO; PC 2/14-35/49/54 T5 PRO-M lp; Lamps: 2	
179	TRIDONIC ATCO; PC 2/49 T5 INDUSTRY; Lamps: 2	
180	TRIDONIC ATCO; PC 2/49 T5 PRO lp; Lamps: 2	
181	TRIDONIC ATCO; PC 2/54 T5 INDUSTRY; Lamps: 2	
182	TRIDONIC ATCO; PC 2/80 T5 INDUSTRY; Lamps: 2	
183	TRIDONIC ATCO; PC 2x14-28 T5 TOP lp; Lamps: 2	
184	TRIDONIC ATCO; PC 2x14-35 T5 PRO lp; Lamps: 2	
185	TRIDONIC ATCO; PC 2x14-35 T5 TOP lp; Lamps: 2	
186	TRIDONIC ATCO; PC 2x35 T5 TOP lp; Lamps: 2	
187	TRIDONIC ATCO; PC 2x49 T5 PRO lp; Lamps: 2	

Count	T5 Ballasts/Lamps	Compatible
188	TRIDONIC ATCO; PC 2x49 T5 TOP lp; Lamps: 2	
189	TRIDONIC ATCO; PC 2x54 T5 PRO lp; Lamps: 2	
190	TRIDONIC ATCO; PC 2x54 T5 TOP lp; Lamps: 2	
191	TRIDONIC ATCO; PC 2x80 T5 PRO lp; Lamps: 2	
192	TRIDONIC ATCO; PC 3/4x14 T5 PRO lp; Lamps: 3	
193	TRIDONIC ATCO; PC 3/4x14 T5 PRO lp; Lamps: 4	
194	TRIDONIC ATCO; PC 3/4x14 T5 TOP lp; Lamps: 3	
195	TRIDONIC ATCO; PC 3/4x14 T5 TOP lp; Lamps: 4	
196	TRIDONIC ATCO; PCA 1x54 T5 BASIC lp; Lamps: 1	
197	TRIDONIC ATCO; PCA 1x80 T5 BASIC lp; Lamps: 1	
198	TRIDONIC ATCO; PCA 2/49 T5 ECO lp; Lamps: 2	
199	TRIDONIC ATCO; PCA 2x54 T5 BASIC lp; Lamps: 2	
200	TRIDONIC ATCO; PCA 2x80 T5 BASIC lp; Lamps: 2	
201	TRIDONIC ATCO; PCA 2x80 T5 ECO lp; Lamps: 2	
202	TRIDONIC ATCO; PCA 2x80 T5 EXCEL one4all lp; Lamps: 2	
203	VOSSLOH-SCHWABE; ELXc 135.220; Lamps: 1	
204	VOSSLOH-SCHWABE; ELXc 180.634; Lamps: 1	
205	VOSSLOH-SCHWABE; ELXc 180.866; Lamps: 1	
206	VOSSLOH-SCHWABE; ELXc 254.865; Lamps: 2	
207	VOSSLOH-SCHWABE; ELXc 280.538; Lamps: 2	
208	VOSSLOH-SCHWABE; ELXc 280.637; Lamps: 2	

A.2 Summary Table of T8 Compatibility

In the following table for T8 lamps, Compatible1 includes the lamps from Philips, Osram and Sylvania. Compatible2 includes the lamps from Philips, Osram, Sylvania, Opple and LEDS Change the World.

Table A.2. T8 Ballast and Lamp Combinations; Combined Result

Count	T8 Ballasts / Lamps	Compatible1	Compatible2
1	ABB; ABB 1x58 CF; Lamps: 1		
2	ABB; ABB 2x58 CF; Lamps: 2		
3	ABB; EVG 2x58 CF ABB; Lamps: 2		
4	ABB; EVG 2x58 CF; Lamps: 2		
5	ABB; EVG 2x58 GF ABB; Lamps: 2		
6	BAG-HUECO; BCD58.1F-01/220-240/1-10V; Lamps: 1		
7	BAG-HUECO; BCS18.1FX-11/220-240; Lamps: 1		
8	BAG-HUECO; BCS18.2FX-11/220-240; Lamps: 2		
9	BAG-HUECO; BCS18.3-4LR-01/220-240; Lamps: 3		
10	BAG-HUECO; BCS18.3-4LR-01/220-240; Lamps: 4		
11	BAG-HUECO; BCS36.1FX-11/220-240; Lamps: 1		
12	BAG-HUECO; BCS36.1FX-11; Lamps: 1		
13	BAG-HUECO; BCS36.1R-01/220-240; Lamps: 1		
14	BAG-HUECO; BCS36.2FX-11/220-240; Lamps: 2		
15	BAG-HUECO; BCS36.2FX-11; Lamps: 2		
16	BAG-HUECO; BCS58.1FX-11/220-240; Lamps: 1		
17	BAG-HUECO; BCS58.1FX-11/220-240; Lamps: 2		
18	BAG-HUECO; BCS58.1SR-01/220-240; Lamps: 1		
19	BAG-HUECO; BCS58.2FX-11/220-240; Lamps: 2		
20	BAG-HUECO; BCS58.2SX-01/220-240; Lamps: 2		

Count	T8 Ballasts / Lamps	Compatible1	Compatible2
21	BAG-HUECO; D36.2-23021 E; Lamps: 2		
22	BAG-HUECO; D58.1-23021 E; Lamps: 1		
23	BAG-HUECO; D58.2-23021 E; Lamps: 2		
24	BAG-HUECO; ECS36.2 S-01/220-240; Lamps: 2		
25	BAG-HUECO; ECS36.2SR-01/220-240; Lamps: 2		
26	BAG-HUECO; SCS58.2SR-11/220-240; Lamps: 2		
27	BAG-HUECO; T8 36W/TC-L/F; Lamps: 1		
28	HELVAR; EL1x18ngn; Lamps: 1		
29	HELVAR; EL1x18s; Lamps: 1		
30	HELVAR; EL1x18sc; Lamps: 1		
31	HELVAR; EL1x36/40/18S; Lamps: 1		
32	HELVAR; EL1x36/40s/18s; Lamps: 1		
33	HELVAR; EL1x36HF; Lamps: 1		
34	HELVAR; EL1x36ngn; Lamps: 1		
35	HELVAR; EL1x58HF; Lamps: 1		
36	HELVAR; EL1x58ngn; Lamps: 1		
37	HELVAR; EL1x58s; Lamps: 1		
38	HELVAR; EL2x18ngn; Lamps: 2		
39	HELVAR; EL2x18s; Lamps: 2		
40	HELVAR; EL2x36/40s; Lamps: 2		
41	HELVAR; EL2x36/40s-u; Lamps: 2		
42	HELVAR; EL2x36HF; Lamps: 2		
43	HELVAR; EL2x36ngn; Lamps: 2		
44	HELVAR; EL2x36sc; Lamps: 2		
45	HELVAR; EL2x58es; Lamps: 2		
46	HELVAR; EL2x58HF; Lamps: 2		
47	HELVAR; EL2x58ngn; Lamps: 2		
48	HELVAR; EL2x58s; Lamps: 2		
49	HELVAR; EL3/4x18ngn; Lamps: 3		
50	HELVAR; EL3/4x18ngn; Lamps: 4		
51	HELVAR; EL3/4x18s; Lamps: 3		
52	HELVAR; EL3/4x18s; Lamps: 4		
53	HELVAR; EL4x18ngn; Lamps: 4		
54	May + Christie; MCU 158; Lamps: 1		
55	May + Christie; MCU 258; Lamps: 2		
56	OSRAM; EZ-PLUS 2X36/220-230; Lamps: 2		
57	OSRAM; OTP-OPTIMAL 1x36-40; Lamps: 1		
58	OSRAM; QT 1X58 DIM; Lamps: 1		
59	OSRAM; QT Deluxe HF 1x58/230-240 DIM; Lamps: 1		
60	OSRAM; QT Deluxe HF 2x58/230-240 DIM; Lamps: 2		
61	OSRAM; QT-FIT 3x18,4x18; Lamps: 4		
62	OSRAM; QT-FIT 5/8 1x18-39; Lamps: 1		
63	OSRAM; QT-FIT 5/8 1x54-58; Lamps: 1		
64	OSRAM; QT-FIT 5/8 2x18-39; Lamps: 2		
65	OSRAM; QT-FIT 5/8 2x54-58; Lamps: 2		
66	OSRAM; QT-FIT8 1x18; Lamps: 1		
67	OSRAM; QT-FIT8 1x36; Lamps: 1		
68	OSRAM; QT-FIT8 1x58-70; Lamps: 1		
69	OSRAM; QT-FIT8 2x18; Lamps: 2		
70	OSRAM; QT-FIT8 2x36; Lamps: 2		
71	OSRAM; QT-FIT8 2x54-58; Lamps: 2		
72	OSRAM; QT-FIT8 2x58; Lamps: 2		
73	OSRAM; QT-FIT8 2x58-70; Lamps: 2		

Count	T8 Ballasts / Lamps	Compatible1	Compatible2
74	OSRAM; QT-FIT8 3/4x18; Lamps: 3		
75	OSRAM; QT-FIT8 3/4x18; Lamps: 4		
76	OSRAM; QT-FIT8 3x18,4x18; Lamps: 3		
77	OSRAM; QT-FIT8 3x18,4x18; Lamps: 4		
78	OSRAM; QT-FIT8 3x36; Lamps: 3		
79	OSRAM; QTP8 1x18; Lamps: 1		
80	OSRAM; QTP8 1x36; Lamps: 1		
81	OSRAM; QTP8 1x58; Lamps: 1		
82	OSRAM; QTP8 2x18; Lamps: 2		
83	OSRAM; QTP8 2x36; Lamps: 2		
84	OSRAM; QTP8 2x58; Lamps: 2		
85	OSRAM; QTP8 3/4x18; Lamps: 3		
86	OSRAM; QTP8 3/4x18; Lamps: 4		
87	OSRAM; QTP-OPTIMAL 118-40; Lamps: 1		
88	OSRAM; QTP-OPTIMAL 1x18-40; Lamps: 1		
89	OSRAM; QTP-OPTIMAL 1x54-58; Lamps: 1		
90	OSRAM; QTP-OPTIMAL 218-40; Lamps: 2		
91	OSRAM; QTP-OPTIMAL 2x18-40; Lamps: 2		
92	OSRAM; QTP-OPTIMAL 2x54-58; Lamps: 2		
93	PHILIPS; EB-C 136 TLD 220-240; Lamps: 1		
94	PHILIPS; EB-P 258 TLD ICC 220-240; Lamps: 2		
95	PHILIPS; EB-S 236 TLD 220-230; Lamps: 2		
96	PHILIPS; EI 158 TLD 220-240; Lamps: 1		
97	PHILIPS; HF-B 136 TLD 220-240; Lamps: 1		
98	PHILIPS; HF-B 136 TLD EII 220-240; Lamps: 1		
99	PHILIPS; HF-B 136/236 TLD EII 220-240; Lamps: 2		
100	PHILIPS; HF-B 158 TLD 220-240; Lamps: 1		
101	PHILIPS; HF-B 158 TLD EII 220-240; Lamps: 1		
102	PHILIPS; HF-B 236 TLD 220-240; Lamps: 2		
103	PHILIPS; HF-B 236 TLD EII 220-240; Lamps: 2		
104	PHILIPS; HF-B 258 TLD 220-240; Lamps: 2		
105	PHILIPS; HF-B 258 TLD EII 220-240; Lamps: 2		
106	PHILIPS; HF-E 1/2 58 TLD II; Lamps: 1		
107	PHILIPS; HF-E 1/2 58 TLD II; Lamps: 2		
108	PHILIPS; HF-E 136 TLD II 220-240V 50/60Hz (HF-E 218 TLD); Lamps: 2		
109	PHILIPS; HF-E 136 TLD II; Lamps: 1		
110	PHILIPS; HF-E 158 TLD; Lamps: 1		
111	PHILIPS; HF-E 236 TLD II; Lamps: 2		
112	PHILIPS; HF-E 236 TLD; Lamps: 2		
113	PHILIPS; HF-E 418 TLD II 220-240V 50/60Hz-parl; Lamps: 4		
114	PHILIPS; HF-K 136 TLD 220-240; Lamps: 1		
115	PHILIPS; HF-Matchbox 1x18 Blue; Lamps: 1		
116	PHILIPS; HF-Matchbox 1x18 RED; Lamps: 1		
117	PHILIPS; HF-P 118 TLD 220-240; Lamps: 1		
118	PHILIPS; HF-P 118 TLD III IDC; Lamps: 1		
119	PHILIPS; HF-P 118/136 TLD III; Lamps: 1		
120	PHILIPS; HF-P 136 TLD 220-240; Lamps: 1		
121	PHILIPS; HF-P 136 TLD EII 220-240; Lamps: 1		
122	PHILIPS; HF-P 136 TLD III IDC; Lamps: 1		
123	PHILIPS; HF-P 138 TLD 220-240; Lamps: 1		
124	PHILIPS; HF-P 154/155 TL5 HO/PL-L III IDC; Lamps: 1		
125	PHILIPS; HF-P 158 TLD 220-240; Lamps: 1		

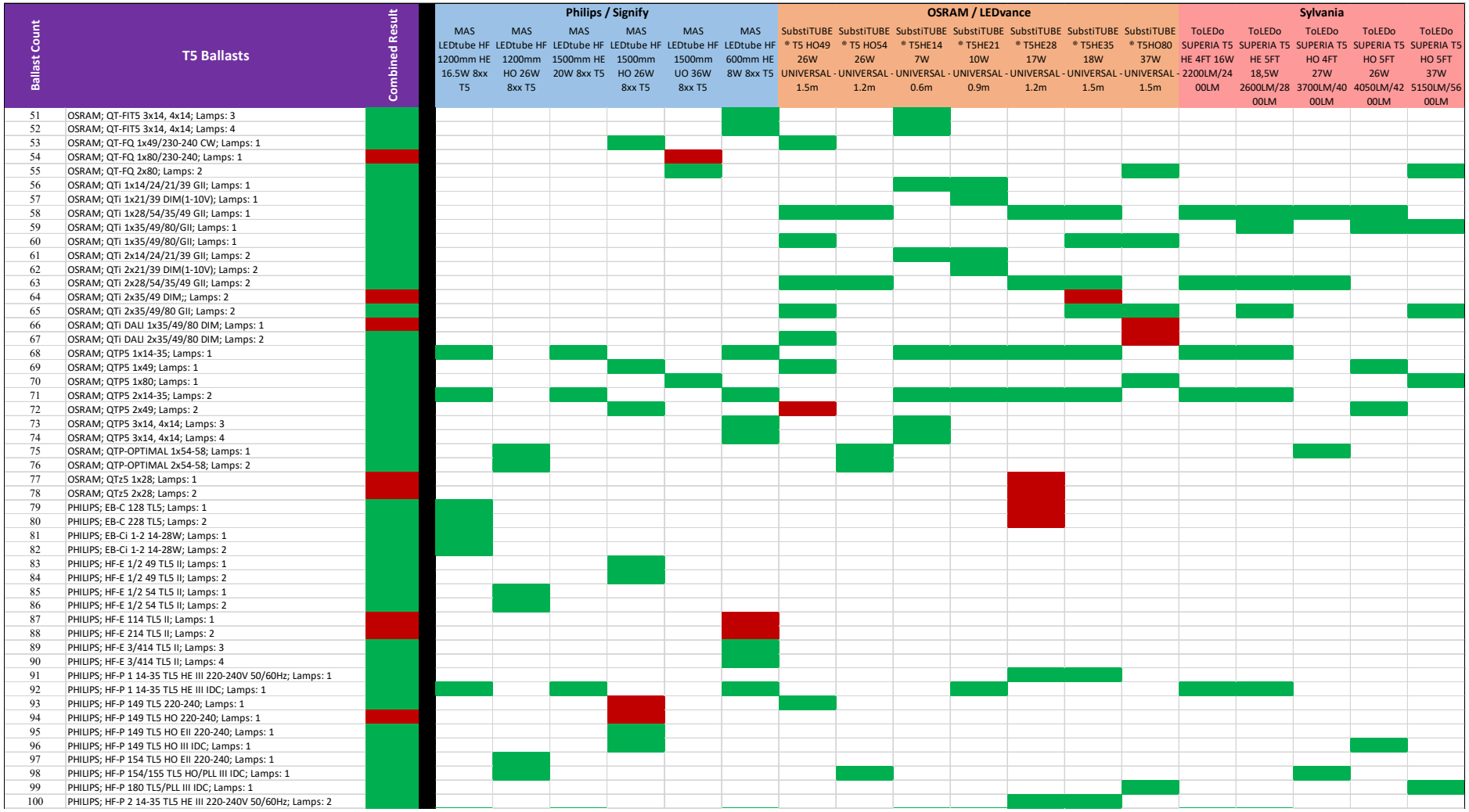
Count	T8 Ballasts / Lamps	Compatible1	Compatible2
126	PHILIPS; HF-P 158 TLD EII 220-240; Lamps: 1		
127	PHILIPS; HF-P 158 TLD III IDC; Lamps: 1		
128	PHILIPS; HF-P 218 TLD EII 220-240; Lamps: 2		
129	PHILIPS; HF-P 218 TLD III IDC; Lamps: 2		
130	PHILIPS; HF-P 218/236 TLD III; Lamps: 2		
131	PHILIPS; HF-P 236 TLD 230-240; Lamps: 2		
132	PHILIPS; HF-P 236 TLD EII 220-240; Lamps: 2		
133	PHILIPS; HF-P 236 TLD III IDC; Lamps: 2		
134	PHILIPS; HF-P 258 TLD 220-240; Lamps: 2		
135	PHILIPS; HF-P 258 TLD 230-240; Lamps: 2		
136	PHILIPS; HF-P 258 TLD EII 220-240; Lamps: 2		
137	PHILIPS; HF-P 258 TLD III IDC; Lamps: 2		
138	PHILIPS; HF-P 3/4x18 TLD EII 220-240; Lamps: 3		
139	PHILIPS; HF-P 3/4x18 TLD EII 220-240; Lamps: 4		
140	PHILIPS; HF-P 3/4x18 TLD III IDC; Lamps: 3		
141	PHILIPS; HF-P 3/4x18 TLD III IDC; Lamps: 4		
142	PHILIPS; HF-P 336 TLD III 220-240; Lamps: 2		
143	PHILIPS; HF-P 336 TLD III IDC; Lamps: 3		
144	PHILIPS; HF-P Xt 136 TLD EII 220-240; Lamps: 1		
145	PHILIPS; HF-P Xt 158 TLD EII 220-240; Lamps: 1		
146	PHILIPS; HF-P XT 236 TLD EII 220-240; Lamps: 2		
147	PHILIPS; HF-P Xt 258 TLD EII 220-240; Lamps: 2		
148	PHILIPS; HF-Pi 1 14/21/24/28/39 TL5 EII 220-240; Lamps: 1		
149	PHILIPS; HF-Pi 1 14/21/24/39 TL5 EII 220-240; Lamps: 1		
150	PHILIPS; HF-R 136 TLD 220-240V 50/60Hz; Lamps: 1		
151	PHILIPS; HF-R 136 TLD EII 220-240V 50/60Hz; Lamps: 1		
152	PHILIPS; HF-R 136 TLD EII; Lamps: 1		
153	PHILIPS; HF-R 158 TLD 220-240; Lamps: 1		
154	PHILIPS; HF-R 158 TLD EII; Lamps: 1		
155	PHILIPS; HF-R 236 TLD 220-240V 50/60Hz; Lamps: 2		
156	PHILIPS; HF-R 236 TLD EII 220-240V 50/60Hz; Lamps: 2		
157	PHILIPS; HF-R 236 TLD EII; Lamps: 2		
158	PHILIPS; HF-R 258 TLD 220-240; Lamps: 2		
159	PHILIPS; HF-R 258 TLD EII; Lamps: 2		
160	PHILIPS; HF-R TD 258 TLD EII 220-240; Lamps: 2		
161	PHILIPS; HF-RiTD 1 14/21/24/39TL5 E+; Lamps: 1		
162	PHILIPS; HF-RiTD 1 28/35/49/54TL5 E+; Lamps: 1		
163	PHILIPS; HF-RiTD 2 14/21/24/39TL5 E+; Lamps: 2		
164	PHILIPS; HF-RiTD 2 28/35/49/54TL5 E+; Lamps: 2		
165	PHILIPS; HF-S 118 TLD II; Lamps: 1		
166	PHILIPS; HF-S 118/136 TLD II; Lamps: 1		
167	PHILIPS; HF-S 136 TLD II; Lamps: 1		
168	PHILIPS; HF-S 158 TLD 220-240; Lamps: 1		
169	PHILIPS; HF-S 158 TLD II 220-240V 50/60Hz; Lamps: 1		
170	PHILIPS; HF-S 158 TLD II; Lamps: 1		
171	PHILIPS; HF-S 158; Lamps: 1		
172	PHILIPS; HF-S 218 TLD II 220-240V 50/60Hz; Lamps: 2		
173	PHILIPS; HF-S 218 TLD II; Lamps: 2		
174	PHILIPS; HF-S 218/236 TLD II; Lamps: 2		
175	PHILIPS; HF-S 236 TLD II; Lamps: 2		
176	PHILIPS; HF-S 258 TLD II HT; Lamps: 2		
177	PHILIPS; HF-S 258 TLD II; Lamps: 2		
178	PHILIPS; HF-S 3/4x18 TLD II; Lamps: 3		

Count	T8 Ballasts / Lamps	Compatible1	Compatible2
179	PHILIPS; HF-S 3/4x18 TLD II; Lamps: 4		
180	PHILIPS; HF-S 336 TLD II; Lamps: 3		
181	TCI; BTL 118; Lamps: 1		
182	TCI; BTL 136; Lamps: 1		
183	TCI; BTL 158; Lamps: 1		
184	TCI; BTL 258; Lamps: 2		
185	TRIDONIC ATCO; D58.1-23021E; Lamps: 1		
186	TRIDONIC ATCO; PC 1/14-35/24/39 T5 PRO-M lp; Lamps: 1		
187	TRIDONIC ATCO; PC 1/30 T8 PRO; Lamps: 1		
188	TRIDONIC ATCO; PC 1/36 T8 INDUSTRY; Lamps: 1		
189	TRIDONIC ATCO; PC 1/36 T8 PRO lp 220–240 V 50/60/0 Hz; Lamps: 1		
190	TRIDONIC ATCO; PC 1/36 T8 PRO sc x!tec; Lamps: 1		
191	TRIDONIC ATCO; PC 1/36 T8 PRO sc; Lamps: 1		
192	TRIDONIC ATCO; PC 1/36 T8 PRO; Lamps: 1		
193	TRIDONIC ATCO; PC 1/58 T8 INDUSTRY; Lamps: 1		
194	TRIDONIC ATCO; PC 1/58 T8 PRO; Lamps: 1		
195	TRIDONIC ATCO; PC 118 PRO lp; Lamps: 1		
196	TRIDONIC ATCO; PC 1x18 T8 PRO lp; Lamps: 1		
197	TRIDONIC ATCO; PC 1x18 T8 TEC; Lamps: 1		
198	TRIDONIC ATCO; PC 1x18 T8 TOP sl; Lamps: 1		
199	TRIDONIC ATCO; PC 1x18-24W BASIC; Lamps: 1		
200	TRIDONIC ATCO; PC 1x36 T8 PRO lp; Lamps: 1		
201	TRIDONIC ATCO; PC 1x36 T8 TOP sl; Lamps: 1		
202	TRIDONIC ATCO; PC 1x58 T8 PRO lp; Lamps: 1		
203	TRIDONIC ATCO; PC 1x58 T8 PRO lp; Lamps: 1		
204	TRIDONIC ATCO; PC 1x58 T8 TOP sl; Lamps: 1		
205	TRIDONIC ATCO; PC 2/14-35/24/39 T5 PRO-M lp; Lamps: 2		
206	TRIDONIC ATCO; PC 2/58 T8 INDUSTRY; Lamps: 2		
207	TRIDONIC ATCO; PC 2/58 T8 PRO; Lamps: 2		
208	TRIDONIC ATCO; PC 218 PRO lp; Lamps: 2		
209	TRIDONIC ATCO; PC 2x18 T8 PRO lp; Lamps: 2		
210	TRIDONIC ATCO; PC 2x18 T8 TEC; Lamps: 2		
211	TRIDONIC ATCO; PC 2x18 T8 TOP sl; Lamps: 2		
212	TRIDONIC ATCO; PC 2x36 T8 PRO sl; Lamps: 2		
213	TRIDONIC ATCO; PC 2x36 T8 TEC; Lamps: 2		
214	TRIDONIC ATCO; PC 2x36 T8 TEC; Lamps: 4		
215	TRIDONIC ATCO; PC 2x36 T8 TOP sl; Lamps: 2		
216	TRIDONIC ATCO; PC 2x36/4x18 T8 TEC; Lamps: 2		
217	TRIDONIC ATCO; PC 2x58 E011 IDC; Lamps: 2		
218	TRIDONIC ATCO; PC 2x58 E011; Lamps: 2		
219	TRIDONIC ATCO; PC 2x58 EO11 IDC; Lamps: 2		
220	TRIDONIC ATCO; PC 2x58 T8 PRO sl; Lamps: 2		
221	TRIDONIC ATCO; PC 2x58 T8 TOP sl; Lamps: 2		
222	TRIDONIC ATCO; PC 3/36 T8 PRO x!tec; Lamps: 3		
223	TRIDONIC ATCO; PC 3/36 T8 PRO; Lamps: 3		
224	TRIDONIC ATCO; PC 3/418 T8 PRO lp; Lamps: 3		
225	TRIDONIC ATCO; PC 3/418 T8 PRO lp; Lamps: 4		
226	TRIDONIC ATCO; PC 3/4x18 T8 TOP lp; Lamps: 3		
227	TRIDONIC ATCO; PC 3/4x18 T8 TOP lp; Lamps: 4		
228	TRIDONIC ATCO; PC 3/4X18 TOP lp; Lamps: 3		
229	TRIDONIC ATCO; PC 3/4X18 TOP lp; Lamps: 4		
230	TRIDONIC ATCO; PC1/36 T8 PRO sc; Lamps: 1		

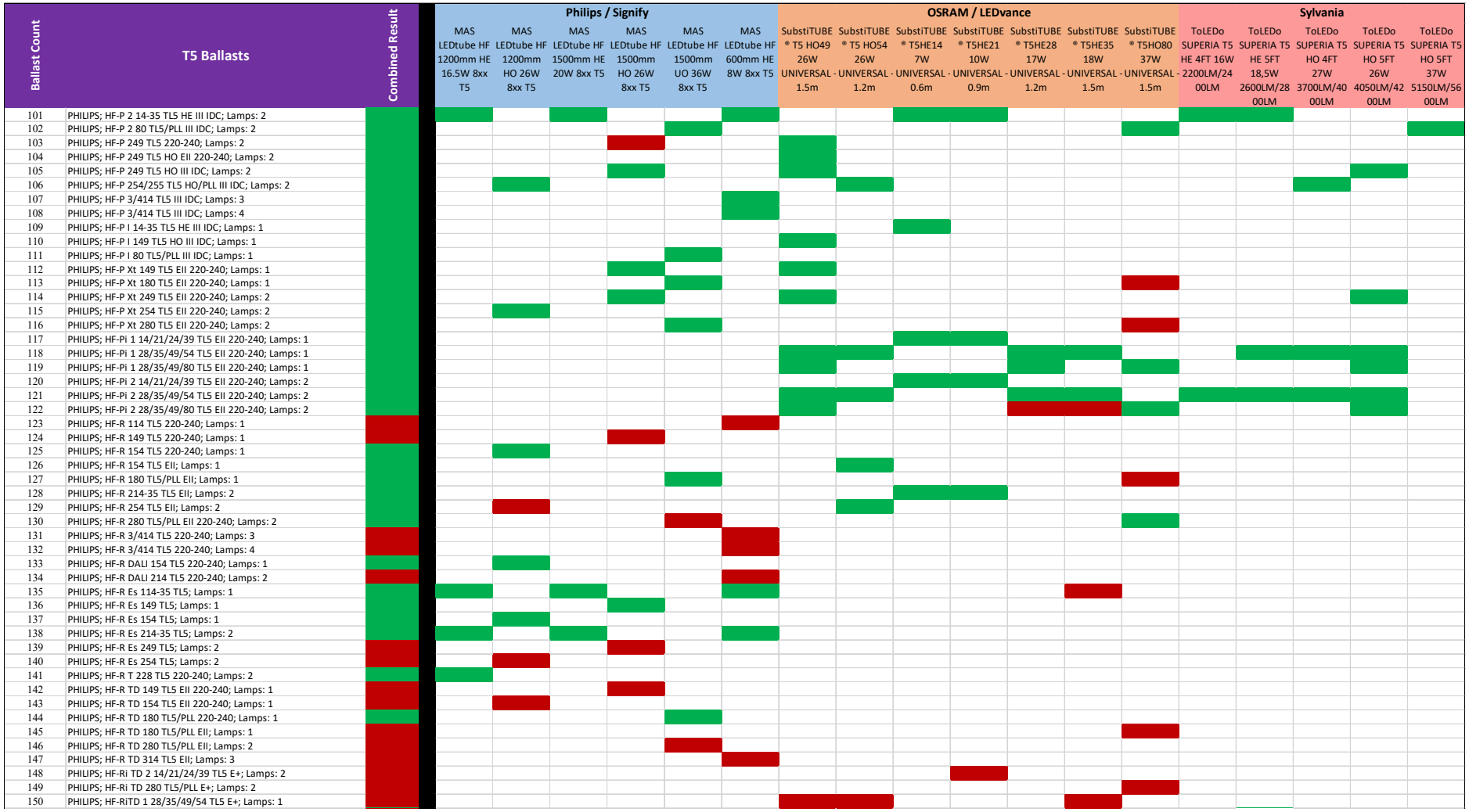
Count	T8 Ballasts / Lamps	Compatible1	Compatible2
231	TRIDONIC ATCO; PC1/36 T8 PRO; Lamps: 1		
232	TRIDONIC ATCO; PC2/36 T8 INDUSTRY; Lamps: 2		
233	TRIDONIC ATCO; PC2x36 T8 PRO sl; Lamps: 2		
234	TRIDONIC ATCO; PCA 1/58 EXCEL one4all; Lamps: 1		
235	TRIDONIC ATCO; PCA 2x58 EXCEL One4all lp; Lamps: 2		
236	TRILUX; ABB 1x58 CF; Lamps: 1		
237	TRILUX; D36.2-23021 E; Lamps: 2		
238	TRILUX; D58.1-23021E; Lamps: 1		
239	TRILUX; D58.2-23021E; Lamps: 2		
240	TRILUX; DD58.1-23031E; Lamps: 1		
241	TRILUX; DD58.2-23021E; Lamps: 2		
242	VOSSLOH-SCHWABE; ELXc 136.200; Lamps: 1		
243	VOSSLOH-SCHWABE; ELXc 136.207; Lamps: 1		
244	VOSSLOH-SCHWABE; ELXc 158.201; Lamps: 1		
245	VOSSLOH-SCHWABE; ELXc 158.209; Lamps: 1		
246	VOSSLOH-SCHWABE; ELXc 158.218; Lamps: 1		
247	VOSSLOH-SCHWABE; ELXc 236.202; Lamps: 2		
248	VOSSLOH-SCHWABE; ELXc 236.208; Lamps: 2		
249	VOSSLOH-SCHWABE; ELXc 236.217; Lamps: 2		
250	VOSSLOH-SCHWABE; ELXc 258.203; Lamps: 2		
251	VOSSLOH-SCHWABE; ELXc 258.210; Lamps: 2		
252	VOSSLOH-SCHWABE; ELXc 258.219; Lamps: 2		
253	VOSSLOH-SCHWABE; ELXc 336.214; Lamps: 3		
254	VOSSLOH-SCHWABE; ELXc 418.204; Lamps: 3		
255	VOSSLOH-SCHWABE; ELXc 418.204; Lamps: 4		
256	VOSSLOH-SCHWABE; ELXc 424.379; Lamps: 3		
257	VOSSLOH-SCHWABE; ELXc 424.379; Lamps: 4		
258	VOSSLOH-SCHWABE; ELXe 158.524; Lamps: 1		
259	VOSSLOH-SCHWABE; ELXe 238.527; Lamps: 1		
260	VOSSLOH-SCHWABE; ELXe 238.527; Lamps: 2		
261	VOSSLOH-SCHWABE; ELXe 258.222; Lamps: 1		
262	VOSSLOH-SCHWABE; ELXe 258.222; Lamps: 2		

A.3 Detailed Tables of T5 Compatibility

Ballast Count	T5 Ballasts	Combined Result	Philips / Signify						OSRAM / LEDvance							Sylvania				
			MAS LEDtube HF 1200mm HE 16.5W 8xx T5	MAS LEDtube HF 1200mm HO 26W 8xx T5	MAS LEDtube HF 1500mm HE 20W 8xx T5	MAS LEDtube HF 1500mm HO 26W 8xx T5	MAS LEDtube HF 1500mm UO 36W 8xx T5	MAS LEDtube HF 600mm HE 8W 8xx T5	SubstiTUBE ® T5 HO49 26W UNIVERSAL - 1.5m	SubstiTUBE ® T5 HO54 26W UNIVERSAL - 1.2m	SubstiTUBE ® T5HE14 7W UNIVERSAL - 0.6m	SubstiTUBE ® T5HE21 10W UNIVERSAL - 0.9m	SubstiTUBE ® T5HE28 17W UNIVERSAL - 1.2m	SubstiTUBE ® T5HE35 18W UNIVERSAL - 1.5m	SubstiTUBE ® T5HO80 37W UNIVERSAL - 1.5m	ToLEDo SUPERIA T5 HE 4FT 16W 2200LM/24 00LM	ToLEDo SUPERIA T5 HE 5FT 18,5W 2600LM/28 00LM	ToLEDo SUPERIA T5 HO 4FT 27W 3700LM/40 00LM	ToLEDo SUPERIA T5 HO 5FT 26W 4050LM/42 00LM	ToLEDo SUPERIA T5 HO 5FT 37W 5150LM/56 00LM
1	BAG-HUECO; BCD35.1F-01/220-240/1-10V; Lamps: 1																			
2	BAG-HUECO; BCD35.2F-01/220-240/1-10V; Lamps: 2																			
3	BAG-HUECO; BCD54.1F-01/220-240/1-10V; Lamps: 1																			
4	BAG-HUECO; BCS14.3-4FR-01/220-240; Lamps: 3																			
5	BAG-HUECO; BCS14.3-4FR-01/220-240; Lamps: 4																			
6	BAG-HUECO; BCS35.1FX-11/220-240; Lamps: 1																			
7	BAG-HUECO; BCS35.2FX-11/220-240; Lamps: 2																			
8	BAG-HUECO; BCS49.1FX-11/220-240; Lamps: 1																			
9	BAG-HUECO; BCS49.2FX-11/220-240; Lamps: 2																			
10	BAG-HUECO; BCS54.1FR-01/220-240; Lamps: 1																			
11	BAG-HUECO; BCS54.1FX-11/220-240; Lamps: 1																			
12	BAG-HUECO; BCS54.2FX-11/220-240; Lamps: 2																			
13	BAG-HUECO; BCS80.1/54.2FR-11/220-240; Lamps: 1																			
14	BAG-HUECO; BCS80.1FX-11/220-240; Lamps: 1																			
15	BAG-HUECO; BCS80.2FX-11/220-240; Lamps: 2																			
16	BAG-HUECO; MLS39.1-2FR-11/220-240; Lamps: 2																			
17	BAG-HUECO; MLS80.1/54.2FR-11/220-240; Lamps: 1																			
18	BAG-HUECO; MLS80.1/54.2FR-11/220-240; Lamps: 2																			
19	BAG-HUECO; MLS80.1FR-11/220-240; Lamps: 1																			
20	HELVAR; EL1x14-35ngn5; Lamps: 1																			
21	HELVAR; EL1x14-35s 220-240V; Lamps: 1																			
22	HELVAR; EL1x21sc; Lamps: 1																			
23	HELVAR; EL1x49ngn5; Lamps: 1																			
24	HELVAR; EL1x49s; Lamps: 1																			
25	HELVAR; EL1x49s-u; Lamps: 1																			
26	HELVAR; EL1x54iDim; Lamps: 1																			
27	HELVAR; EL1x54ngn5; Lamps: 1																			
28	HELVAR; EL1x54s; Lamps: 1																			
29	HELVAR; EL1x54sc; Lamps: 1																			
30	HELVAR; EL1x80iDim; Lamps: 1																			
31	HELVAR; EL1x80sc; Lamps: 1																			
32	HELVAR; EL2x14-35iDim; Lamps: 2																			
33	HELVAR; EL2x14-35ngn5; Lamps: 2																			
34	HELVAR; EL2x49ngn5; Lamps: 2																			
35	HELVAR; EL2x49s; Lamps: 2																			
36	HELVAR; EL2x54iDim; Lamps: 2																			
37	HELVAR; EL2x54ngn5; Lamps: 2																			
38	HELVAR; EL2x54sc; Lamps: 2																			
39	HELVAR; EL2x80iDim; Lamps: 2																			
40	OSRAM; EZP5 1x28/220-230; Lamps: 1																			
41	OSRAM; EZP5 2x28/220-230; Lamps: 2																			
42	OSRAM; EZ-T5 1x28/220; Lamps: 1																			
43	OSRAM; QT-FIT 5/8 1x54-58; Lamps: 1																			
44	OSRAM; QT-FIT 5/8 2x54-58; Lamps: 2																			
45	OSRAM; QT-FIT5 1x14-35; Lamps: 1																			
46	OSRAM; QT-FIT5 1x49; Lamps: 1																			
47	OSRAM; QT-FIT5 1x54; Lamps: 1																			
48	OSRAM; QT-FIT5 2x14-35; Lamps: 2																			
49	OSRAM; QT-FIT5 2x49; Lamps: 2																			
50	OSRAM; QT-FIT5 2x54; Lamps: 2																			



Ballast Count	T5 Ballasts	Combined Result	Philips / Signify						OSRAM / LEDvance							Sylvania				
			MAS LEDtube HF 1200mm HE 16.5W 8xx T5	MAS LEDtube HF 1200mm HO 26W 8xx T5	MAS LEDtube HF 1500mm HE 20W 8xx T5	MAS LEDtube HF 1500mm HO 26W 8xx T5	MAS LEDtube HF 1500mm UO 36W 8xx T5	MAS LEDtube HF 600mm HE 8W 8xx T5	SubstiTUBE ® T5 HO49 26W UNIVERSAL - 1.5m	SubstiTUBE ® T5 HO54 26W UNIVERSAL - 1.2m	SubstiTUBE ® T5HE14 7W UNIVERSAL - 0.6m	SubstiTUBE ® T5HE21 10W UNIVERSAL - 0.9m	SubstiTUBE ® T5HE28 17W UNIVERSAL - 1.2m	SubstiTUBE ® T5HE35 18W UNIVERSAL - 1.5m	SubstiTUBE ® T5HO80 37W UNIVERSAL - 1.5m	ToLEDo SUPERIA T5 HE 4FT 16W 2200LM/24 00LM	ToLEDo SUPERIA T5 HE 5FT 18,5W 2600LM/28 00LM	ToLEDo SUPERIA T5 HO 4FT 27W 3700LM/40 00LM	ToLEDo SUPERIA T5 HO 5FT 26W 4050LM/42 00LM	ToLEDo SUPERIA T5 HO 5FT 37W 5150LM/56 00LM
51	OSRAM; QT-FIT5 3x14, 4x14; Lamps: 3																			
52	OSRAM; QT-FIT5 3x14, 4x14; Lamps: 4																			
53	OSRAM; QT-FQ 1x49/230-240 CW; Lamps: 1																			
54	OSRAM; QT-FQ 1x80/230-240; Lamps: 1																			
55	OSRAM; QT-FQ 2x80; Lamps: 2																			
56	OSRAM; QTi 1x14/24/21/39 GII; Lamps: 1																			
57	OSRAM; QTi 1x21/39 DIM(1-10V); Lamps: 1																			
58	OSRAM; QTi 1x28/54/35/49 GII; Lamps: 1																			
59	OSRAM; QTi 1x35/49/80/GII; Lamps: 1																			
60	OSRAM; QTi 1x35/49/80/GII; Lamps: 1																			
61	OSRAM; QTi 2x14/24/21/39 GII; Lamps: 2																			
62	OSRAM; QTi 2x21/39 DIM(1-10V); Lamps: 2																			
63	OSRAM; QTi 2x28/54/35/49 GII; Lamps: 2																			
64	OSRAM; QTi 2x35/49 DIM;; Lamps: 2																			
65	OSRAM; QTi 2x35/49/80 GII; Lamps: 2																			
66	OSRAM; QTi DALI 1x35/49/80 DIM; Lamps: 1																			
67	OSRAM; QTi DALI 2x35/49/80 DIM; Lamps: 2																			
68	OSRAM; QTP5 1x14-35; Lamps: 1																			
69	OSRAM; QTP5 1x49; Lamps: 1																			
70	OSRAM; QTP5 1x80; Lamps: 1																			
71	OSRAM; QTP5 2x14-35; Lamps: 2																			
72	OSRAM; QTP5 2x49; Lamps: 2																			
73	OSRAM; QTP5 3x14, 4x14; Lamps: 3																			
74	OSRAM; QTP5 3x14, 4x14; Lamps: 4																			
75	OSRAM; QTP-OPTIMAL 1x54-58; Lamps: 1																			
76	OSRAM; QTP-OPTIMAL 2x54-58; Lamps: 2																			
77	OSRAM; QTz5 1x28; Lamps: 1																			
78	OSRAM; QTz5 2x28; Lamps: 2																			
79	PHILIPS; EB-C 128 TL5; Lamps: 1																			
80	PHILIPS; EB-C 228 TL5; Lamps: 2																			
81	PHILIPS; EB-Ci 1-2 14-28W; Lamps: 1																			
82	PHILIPS; EB-Ci 1-2 14-28W; Lamps: 2																			
83	PHILIPS; HF-E 1/2 49 TL5 II; Lamps: 1																			
84	PHILIPS; HF-E 1/2 49 TL5 II; Lamps: 2																			
85	PHILIPS; HF-E 1/2 54 TL5 II; Lamps: 1																			
86	PHILIPS; HF-E 1/2 54 TL5 II; Lamps: 2																			
87	PHILIPS; HF-E 114 TL5 II; Lamps: 1																			
88	PHILIPS; HF-E 214 TL5 II; Lamps: 2																			
89	PHILIPS; HF-E 3/414 TL5 II; Lamps: 3																			
90	PHILIPS; HF-E 3/414 TL5 II; Lamps: 4																			
91	PHILIPS; HF-P 1 14-35 TL5 HE III 220-240V 50/60Hz; Lamps: 1																			
92	PHILIPS; HF-P 1 14-35 TL5 HE III IDC; Lamps: 1																			
93	PHILIPS; HF-P 149 TL5 220-240; Lamps: 1																			
94	PHILIPS; HF-P 149 TL5 HO 220-240; Lamps: 1																			
95	PHILIPS; HF-P 149 TL5 HO EII 220-240; Lamps: 1																			
96	PHILIPS; HF-P 149 TL5 HO III IDC; Lamps: 1																			
97	PHILIPS; HF-P 154 TL5 HO EII 220-240; Lamps: 1																			
98	PHILIPS; HF-P 154/155 TL5 HO/PLL III IDC; Lamps: 1																			
99	PHILIPS; HF-P 180 TL5/PLL III IDC; Lamps: 1																			
100	PHILIPS; HF-P 2 14-35 TL5 HE III 220-240V 50/60Hz; Lamps: 2																			

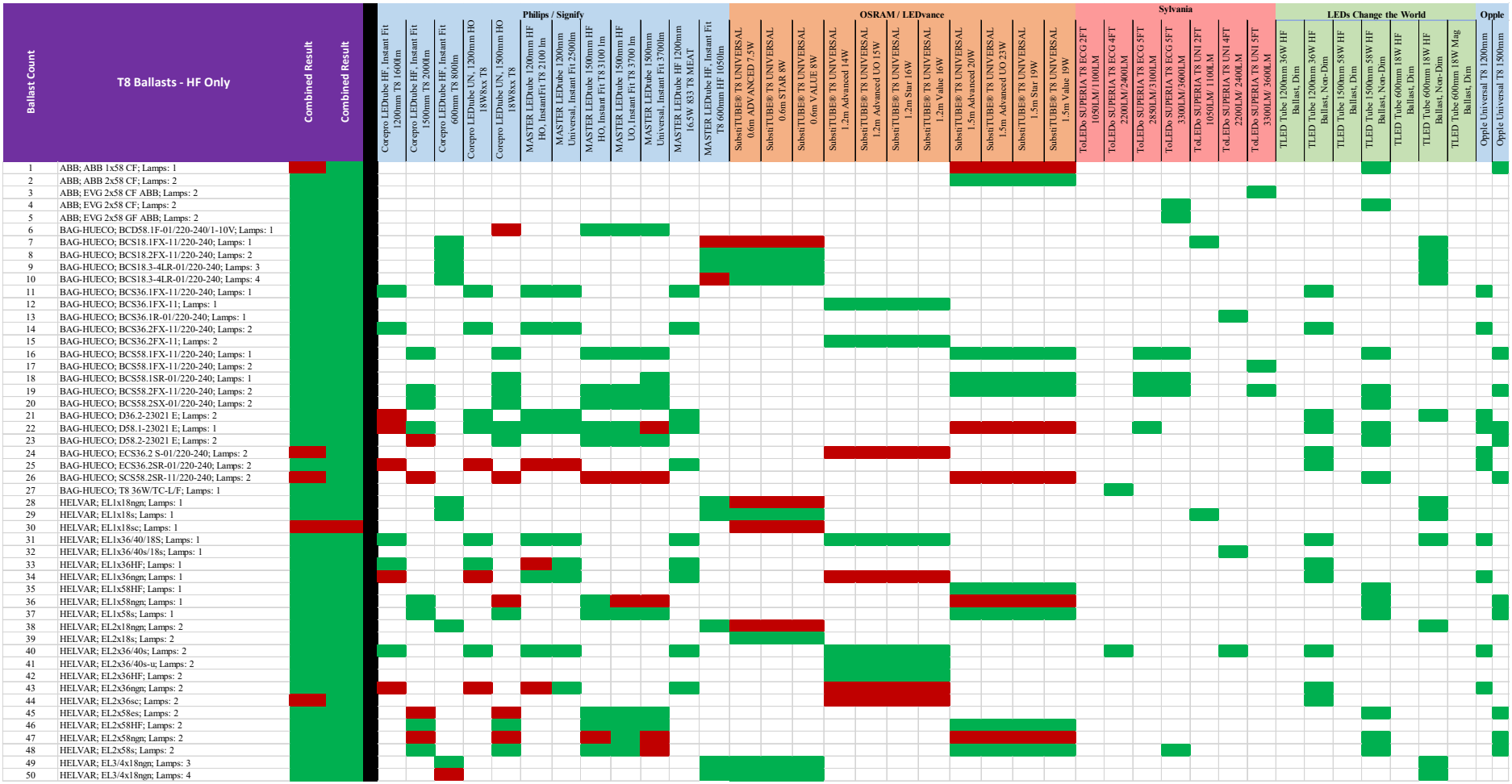


Ballast Count	T5 Ballasts	Combined Result	Philips / Signify						OSRAM / LEDvance							Sylvania				
			MAS LEDtube HF 1200mm HE 16.5W 8xx T5	MAS LEDtube HF 1200mm HO 26W 8xx T5	MAS LEDtube HF 1500mm HE 20W 8xx T5	MAS LEDtube HF 1500mm HO 26W 8xx T5	MAS LEDtube HF 1500mm UO 36W 8xx T5	MAS LEDtube HF 600mm HE 8W 8xx T5	SubstiTUBE ® T5 HO49 26W UNIVERSAL - 1.5m	SubstiTUBE ® T5 HO54 26W UNIVERSAL - 1.2m	SubstiTUBE ® T5HE14 7W UNIVERSAL - 0.6m	SubstiTUBE ® T5HE21 10W UNIVERSAL - 0.9m	SubstiTUBE ® T5HE28 17W UNIVERSAL - 1.2m	SubstiTUBE ® T5HE35 18W UNIVERSAL - 1.5m	SubstiTUBE ® T5HO80 37W UNIVERSAL - 1.5m	ToLEDo SUPERIA T5 HE 4FT 16W 2200LM/24 00LM	ToLEDo SUPERIA T5 HE 5FT 18,5W 2600LM/28 00LM	ToLEDo SUPERIA T5 HO 4FT 27W 3700LM/40 00LM	ToLEDo SUPERIA T5 HO 5FT 26W 4050LM/42 00LM	ToLEDo SUPERIA T5 HO 5FT 37W 5150LM/56 00LM
101	PHILIPS; HF-P 2 14-35 TL5 HE III IDC; Lamps: 2																			
102	PHILIPS; HF-P 2 80 TL5/PLL III IDC; Lamps: 2																			
103	PHILIPS; HF-P 249 TL5 220-240; Lamps: 2																			
104	PHILIPS; HF-P 249 TL5 HO EII 220-240; Lamps: 2																			
105	PHILIPS; HF-P 249 TL5 HO III IDC; Lamps: 2																			
106	PHILIPS; HF-P 254/255 TL5 HO/PLL III IDC; Lamps: 2																			
107	PHILIPS; HF-P 3/414 TL5 III IDC; Lamps: 3																			
108	PHILIPS; HF-P 3/414 TL5 III IDC; Lamps: 4																			
109	PHILIPS; HF-P I 14-35 TL5 HE III IDC; Lamps: 1																			
110	PHILIPS; HF-P I 149 TL5 HO III IDC; Lamps: 1																			
111	PHILIPS; HF-P I 80 TL5/PLL III IDC; Lamps: 1																			
112	PHILIPS; HF-P Xt 149 TL5 EII 220-240; Lamps: 1																			
113	PHILIPS; HF-P Xt 180 TL5 EII 220-240; Lamps: 1																			
114	PHILIPS; HF-P Xt 249 TL5 EII 220-240; Lamps: 2																			
115	PHILIPS; HF-P Xt 254 TL5 EII 220-240; Lamps: 2																			
116	PHILIPS; HF-P Xt 280 TL5 EII 220-240; Lamps: 2																			
117	PHILIPS; HF-Pi 1 14/21/24/39 TL5 EII 220-240; Lamps: 1																			
118	PHILIPS; HF-Pi 1 28/35/49/54 TL5 EII 220-240; Lamps: 1																			
119	PHILIPS; HF-Pi 1 28/35/49/80 TL5 EII 220-240; Lamps: 1																			
120	PHILIPS; HF-Pi 2 14/21/24/39 TL5 EII 220-240; Lamps: 2																			
121	PHILIPS; HF-Pi 2 28/35/49/54 TL5 EII 220-240; Lamps: 2																			
122	PHILIPS; HF-Pi 2 28/35/49/80 TL5 EII 220-240; Lamps: 2																			
123	PHILIPS; HF-R 114 TL5 220-240; Lamps: 1																			
124	PHILIPS; HF-R 149 TL5 220-240; Lamps: 1																			
125	PHILIPS; HF-R 154 TL5 220-240; Lamps: 1																			
126	PHILIPS; HF-R 154 TL5 EII; Lamps: 1																			
127	PHILIPS; HF-R 180 TL5/PLL EII; Lamps: 1																			
128	PHILIPS; HF-R 214-35 TL5 EII; Lamps: 2																			
129	PHILIPS; HF-R 254 TL5 EII; Lamps: 2																			
130	PHILIPS; HF-R 280 TL5/PLL EII 220-240; Lamps: 2																			
131	PHILIPS; HF-R 3/414 TL5 220-240; Lamps: 3																			
132	PHILIPS; HF-R 3/414 TL5 220-240; Lamps: 4																			
133	PHILIPS; HF-R DALI 154 TL5 220-240; Lamps: 1																			
134	PHILIPS; HF-R DALI 214 TL5 220-240; Lamps: 2																			
135	PHILIPS; HF-R Es 114-35 TL5; Lamps: 1																			
136	PHILIPS; HF-R Es 149 TL5; Lamps: 1																			
137	PHILIPS; HF-R Es 154 TL5; Lamps: 1																			
138	PHILIPS; HF-R Es 214-35 TL5; Lamps: 2																			
139	PHILIPS; HF-R Es 249 TL5; Lamps: 2																			
140	PHILIPS; HF-R Es 254 TL5; Lamps: 2																			
141	PHILIPS; HF-R T 228 TL5 220-240; Lamps: 2																			
142	PHILIPS; HF-R TD 149 TL5 EII 220-240; Lamps: 1																			
143	PHILIPS; HF-R TD 154 TL5 EII 220-240; Lamps: 1																			
144	PHILIPS; HF-R TD 180 TL5/PLL 220-240; Lamps: 1																			
145	PHILIPS; HF-R TD 180 TL5/PLL EII; Lamps: 1																			
146	PHILIPS; HF-R TD 280 TL5/PLL EII; Lamps: 2																			
147	PHILIPS; HF-R TD 314 TL5 EII; Lamps: 3																			
148	PHILIPS; HF-Ri TD 2 14/21/24/39 TL5 E+; Lamps: 2																			
149	PHILIPS; HF-Ri TD 280 TL5/PLL E+; Lamps: 2																			
150	PHILIPS; HF-RiTD 1 28/35/49/54 TL5 E+; Lamps: 1																			

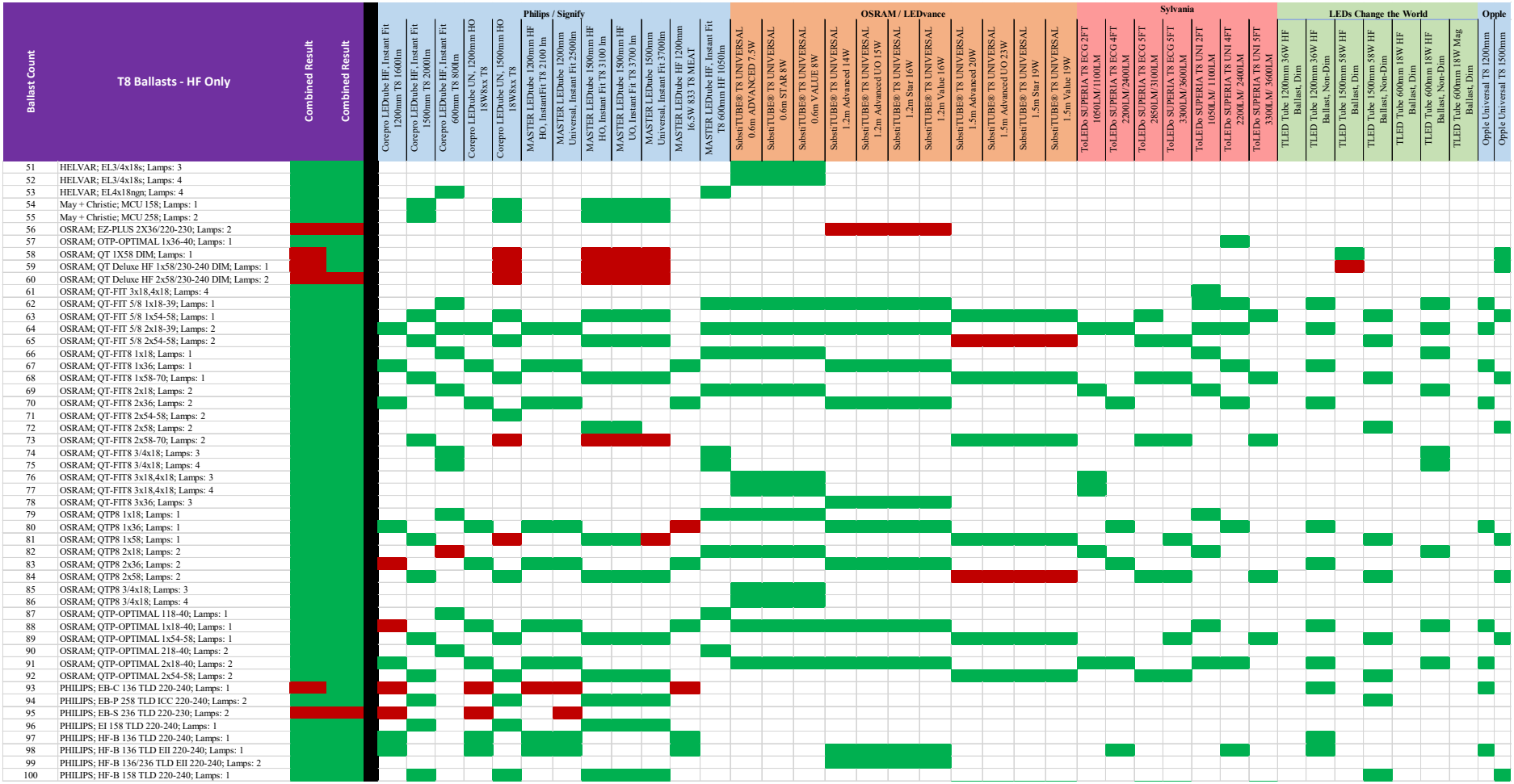
Ballast Count	T5 Ballasts	Combined Result	Philips / Signify						OSRAM / LEDvance							Sylvania				
			MAS LEDtube HF 1200mm HE 16.5W 8xx T5	MAS LEDtube HF 1200mm HO 26W 8xx T5	MAS LEDtube HF 1500mm HE 20W 8xx T5	MAS LEDtube HF 1500mm HO 26W 8xx T5	MAS LEDtube HF 1500mm UO 36W 8xx T5	MAS LEDtube HF 600mm HE 8W 8xx T5	SubstiTUBE ® T5 HO49 26W UNIVERSAL - 1.5m	SubstiTUBE ® T5 HO54 26W UNIVERSAL - 1.2m	SubstiTUBE ® T5HE14 7W UNIVERSAL - 0.6m	SubstiTUBE ® T5HE21 10W UNIVERSAL - 0.9m	SubstiTUBE ® T5HE28 17W UNIVERSAL - 1.2m	SubstiTUBE ® T5HE35 18W UNIVERSAL - 1.5m	SubstiTUBE ® T5HO80 37W UNIVERSAL - 1.5m	ToLEDo SUPERIA T5 HE 4FT 16W 2200LM/24 00LM	ToLEDo SUPERIA T5 HE 5FT 18,5W 2600LM/28 00LM	ToLEDo SUPERIA T5 HO 4FT 27W 3700LM/40 00LM	ToLEDo SUPERIA T5 HO 5FT 26W 4050LM/42 00LM	ToLEDo SUPERIA T5 HO 5FT 37W 5150LM/56 00LM
151	PHILIPS; HF-S 1 28-35 TL5 II; Lamps: 1																			
152	PHILIPS; HF-S 1 80 TL5/PLL II; Lamps: 1																			
153	PHILIPS; HF-S 149 TL5 II; Lamps: 1																			
154	PHILIPS; HF-S 154 TL5 II; Lamps: 1																			
155	PHILIPS; HF-S 2 14-35 TL5 HE II; Lamps: 2																			
156	PHILIPS; HF-S 2 80 TL5/PLL II; Lamps: 2																			
157	PHILIPS; HF-S 249 TL5 II; Lamps: 2																			
158	PHILIPS; HF-S 254 TL5 II; Lamps: 2																			
159	PHILIPS; HF-S 3/414 TL5 II; Lamps: 3																			
160	PHILIPS; HF-S 3/414 TL5 II; Lamps: 4																			
161	TRIDONIC ATCO; PC 1/14-35 T5 TOP lp; Lamps: 1																			
162	TRIDONIC ATCO; PC 1/14-35/49/54 T5 PRO-M lp; Lamps: 1																			
163	TRIDONIC ATCO; PC 1/14-35/49/80 T5 PRO-M lp; Lamps: 1																			
164	TRIDONIC ATCO; PC 1/49 T5 INDUSTRY; Lamps: 1																			
165	TRIDONIC ATCO; PC 1/49 T5 PRO lp; Lamps: 1																			
166	TRIDONIC ATCO; PC 1/54 T5 INDUSTRY; Lamps: 1																			
167	TRIDONIC ATCO; PC 1/80 T5 INDUSTRY; Lamps: 1																			
168	TRIDONIC ATCO; PC 1x14-35 T5 PRO lp; Lamps: 1																			
169	TRIDONIC ATCO; PC 1x14-35 T5 TOP lp; Lamps: 1																			
170	TRIDONIC ATCO; PC 1x28 T5 TEC lp; Lamps: 1																			
171	TRIDONIC ATCO; PC 1x49 T5 PRO lp; Lamps: 1																			
172	TRIDONIC ATCO; PC 1x49 T5 TOP lp; Lamps: 1																			
173	TRIDONIC ATCO; PC 1x54 T5 PRO lp; Lamps: 1																			
174	TRIDONIC ATCO; PC 1x54 T5 TOP lp; Lamps: 1																			
175	TRIDONIC ATCO; PC 1x80 T5 PRO lp; Lamps: 1																			
176	TRIDONIC ATCO; PC 2/14-28 T5 TOP lp; Lamps: 2																			
177	TRIDONIC ATCO; PC 2/14-35 T5 PRO lp; Lamps: 2																			
178	TRIDONIC ATCO; PC 2/14-35/49/54 T5 PRO-M lp; Lamps: 2																			
179	TRIDONIC ATCO; PC 2/49 T5 INDUSTRY; Lamps: 2																			
180	TRIDONIC ATCO; PC 2/49 T5 PRO lp; Lamps: 2																			
181	TRIDONIC ATCO; PC 2/54 T5 INDUSTRY; Lamps: 2																			
182	TRIDONIC ATCO; PC 2/80 T5 INDUSTRY; Lamps: 2																			
183	TRIDONIC ATCO; PC 2x14-28 T5 TOP lp; Lamps: 2																			
184	TRIDONIC ATCO; PC 2x14-35 T5 PRO lp; Lamps: 2																			
185	TRIDONIC ATCO; PC 2x14-35 T5 TOP lp; Lamps: 2																			
186	TRIDONIC ATCO; PC 2x35 T5 TOP lp; Lamps: 2																			
187	TRIDONIC ATCO; PC 2x49 T5 PRO lp; Lamps: 2																			
188	TRIDONIC ATCO; PC 2x49 T5 TOP lp; Lamps: 2																			
189	TRIDONIC ATCO; PC 2x54 T5 PRO lp; Lamps: 2																			
190	TRIDONIC ATCO; PC 2x54 T5 TOP lp; Lamps: 2																			
191	TRIDONIC ATCO; PC 2x80 T5 PRO lp; Lamps: 2																			
192	TRIDONIC ATCO; PC 3/4x14 T5 PRO lp; Lamps: 3																			
193	TRIDONIC ATCO; PC 3/4x14 T5 PRO lp; Lamps: 4																			
194	TRIDONIC ATCO; PC 3/4x14 T5 TOP lp; Lamps: 3																			
195	TRIDONIC ATCO; PC 3/4x14 T5 TOP lp; Lamps: 4																			
196	TRIDONIC ATCO; PCA 1x54 T5 BASIC lp; Lamps: 1																			
197	TRIDONIC ATCO; PCA 1x80 T5 BASIC lp; Lamps: 1																			
198	TRIDONIC ATCO; PCA 2/49 T5 ECO lp; Lamps: 2																			
199	TRIDONIC ATCO; PCA 2x54 T5 BASIC lp; Lamps: 2																			
200	TRIDONIC ATCO; PCA 2x80 T5 BASIC lp; Lamps: 2																			

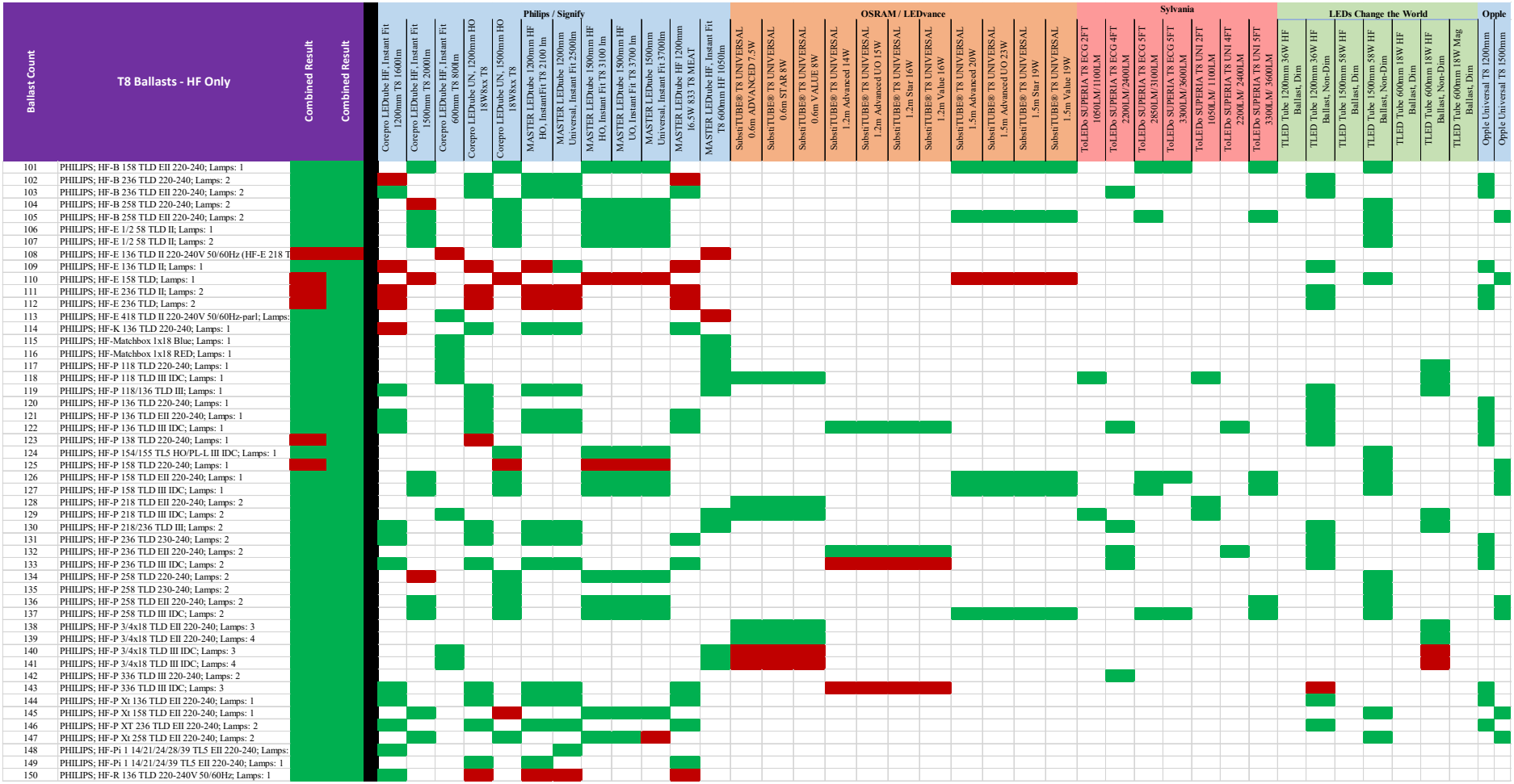
Ballast Count	T5 Ballasts	Combined Result	Philips / Signify						OSRAM / LEDvance							Sylvania				
			MAS LEDtube HF 1200mm HE 16.5W 8xx T5	MAS LEDtube HF 1200mm HO 26W 8xx T5	MAS LEDtube HF 1500mm HE 20W 8xx T5	MAS LEDtube HF 1500mm HO 26W 8xx T5	MAS LEDtube HF 1500mm UO 36W 8xx T5	MAS LEDtube HF 600mm HE 8W 8xx T5	SubstiTUBE ® T5 HO49 26W UNIVERSAL - 1.5m	SubstiTUBE ® T5 HO54 26W UNIVERSAL - 1.2m	SubstiTUBE ® T5HE14 7W UNIVERSAL - 0.6m	SubstiTUBE ® T5HE21 10W UNIVERSAL - 0.9m	SubstiTUBE ® T5HE28 17W UNIVERSAL - 1.2m	SubstiTUBE ® T5HE35 18W UNIVERSAL - 1.5m	SubstiTUBE ® T5HO80 37W UNIVERSAL - 1.5m	ToLEDo SUPERIA T5 HE 4FT 16W 2200LM/24 00LM	ToLEDo SUPERIA T5 HE 5FT 18,5W 2600LM/28 00LM	ToLEDo SUPERIA T5 HO 4FT 27W 3700LM/40 00LM	ToLEDo SUPERIA T5 HO 5FT 26W 4050LM/42 00LM	ToLEDo SUPERIA T5 HO 5FT 37W 5150LM/56 00LM
201	TRIDONIC ATCO; PCA 2x80 T5 ECO lp; Lamps: 2																			
202	TRIDONIC ATCO; PCA 2x80 T5 EXCEL one4all lp; Lamps: 2																			
203	VOSSLOH-SCHWABE; ELXc 135.220; Lamps: 1																			
204	VOSSLOH-SCHWABE; ELXc 180.634; Lamps: 1																			
205	VOSSLOH-SCHWABE; ELXc 180.866; Lamps: 1																			
206	VOSSLOH-SCHWABE; ELXc 254.865; Lamps: 2																			
207	VOSSLOH-SCHWABE; ELXc 280.538; Lamps: 2																			
208	VOSSLOH-SCHWABE; ELXc 280.637; Lamps: 2																			

A.4 Detailed Tables of T8 Compatibility



Ballast Count	T8 Ballasts - HF Only	Combined Result	Combined Result	Philips / Signify														OSRAM / LEDvance												Sylvania								LEDs Change the World								Opple	
				Corepro LEDtube HF, Instant Fit 1200mm T8 1600lm	Corepro LEDtube HF, Instant Fit 1500mm T8 2000lm	Corepro LEDtube HF, Instant Fit 600mm T8 800lm	Corepro LEDtube UN, 1200mm HO 14W8xx T8	Corepro LEDtube UN, 1500mm HO 18W8xx T8	MASTER LEDtube 1200mm HF HO, InstantFit T8 2100 lm	MASTER LEDtube 1200mm Universal, Instant Fit 2500lm	MASTER LEDtube 1500mm HF HO, Instant Fit T8 3100 lm	MASTER LEDtube 1500mm HF UO, Instant Fit T8 3700 lm	MASTER LEDtube 1500mm Universal, Instant Fit 3700lm	MASTER LEDtube HF 1200mm 16.5W 833 T8 MEAT	MASTER LEDtube HF, Instant Fit T8 600mm HF 1050lm	SubstiTUBE® T8 UNIVERSAL 0.6m ADVANCED 7.5W	SubstiTUBE® T8 UNIVERSAL 0.6m STAR 8W	SubstiTUBE® T8 UNIVERSAL 0.6m VALUE 8W	SubstiTUBE® T8 UNIVERSAL 1.2m Advanced 14W	SubstiTUBE® T8 UNIVERSAL 1.2m Advanced UO 15W	SubstiTUBE® T8 UNIVERSAL 1.2m Star 16W	SubstiTUBE® T8 UNIVERSAL 1.2m Value 16W	SubstiTUBE® T8 UNIVERSAL 1.5m Advanced 20W	SubstiTUBE® T8 UNIVERSAL 1.5m Advanced UO 23W	SubstiTUBE® T8 UNIVERSAL 1.5m Star 19W	SubstiTUBE® T8 UNIVERSAL 1.5m Value 19W	ToLEDo SUPERIA T8 ECG 2FT 1050LM/1100LM	ToLEDo SUPERIA T8 ECG 4FT 2200LM/2400LM	ToLEDo SUPERIA T8 ECG 5FT 2850LM/3100LM	ToLEDo SUPERIA T8 ECG 5FT 3300LM/3600LM	ToLEDo SUPERIA T8 UNI 2FT 1050LM/ 1100LM	ToLEDo SUPERIA T8 UNI 4FT 2200LM/ 2400LM	ToLEDo SUPERIA T8 UNI 5FT 3300LM/ 3600LM	TLED Tube 1200mm 36W HF Ballast, Dim	TLED Tube 1200mm 36W HF Ballast, Non-Dim	TLED Tube 1500mm 58W HF Ballast, Dim	TLED Tube 1500mm 58W HF Ballast, Non-Dim	TLED Tube 600mm 18W HF Ballast, Dim	TLED Tube 600mm 18W HF Ballast, Non-Dim	TLED Tube 600mm 18W Mag Ballast, Dim	Opple Universal T8 1200mm	Opple Universal T8 1500mm
1	ABB; ABB 1x58 CF; Lamps: 1																																										
2	ABB; ABB 2x58 CF; Lamps: 2																																										
3	ABB; EVG 2x58 CF ABB; Lamps: 2																																										
4	ABB; EVG 2x58 CF; Lamps: 2																																										
5	ABB; EVG 2x58 GF ABB; Lamps: 2																																										
6	BAG-HUECO; BCD58.1F-01/220-240/1-10V; Lamps: 1																																										
7	BAG-HUECO; BCS18.1FX-11/220-240; Lamps: 1																																										
8	BAG-HUECO; BCS18.2FX-11/220-240; Lamps: 2																																										
9	BAG-HUECO; BCS18.3-4LR-01/220-240; Lamps: 3																																										
10	BAG-HUECO; BCS18.3-4LR-01/220-240; Lamps: 4																																										
11	BAG-HUECO; BCS36.1FX-11/220-240; Lamps: 1																																										
12	BAG-HUECO; BCS36.1FX-11; Lamps: 1																																										
13	BAG-HUECO; BCS36.1R-01/220-240; Lamps: 1																																										
14	BAG-HUECO; BCS36.2FX-11/220-240; Lamps: 2																																										
15	BAG-HUECO; BCS36.2FX-11; Lamps: 2																																										
16	BAG-HUECO; BCS58.1FX-11/220-240; Lamps: 1																																										
17	BAG-HUECO; BCS58.1FX-11/220-240; Lamps: 2																																										
18	BAG-HUECO; BCS58.1SR-01/220-240; Lamps: 1																																										
19	BAG-HUECO; BCS58.2FX-11/220-240; Lamps: 2																																										
20	BAG-HUECO; BCS58.2SX-01/220-240; Lamps: 2																																										
21	BAG-HUECO; D36.2-23021 E; Lamps: 2																																										
22	BAG-HUECO; D58.1-23021 E; Lamps: 1																																										
23	BAG-HUECO; D58.2-23021 E; Lamps: 2																																										
24	BAG-HUECO; ECS36.2 S-01/220-240; Lamps: 2																																										
25	BAG-HUECO; ECS36.2SR-01/220-240; Lamps: 2																																										
26	BAG-HUECO; SCS58.2SR-11/220-240; Lamps: 2																																										
27	BAG-HUECO; T8 36W/TC-L/F; Lamps: 1																																										
28	HELVAR; EL1x18ngn; Lamps: 1																																										
29	HELVAR; EL1x18s; Lamps: 1																																										
30	HELVAR; EL1x18sc; Lamps: 1																																										
31	HELVAR; EL1x36/40/18S; Lamps: 1																																										
32	HELVAR; EL1x36/40s/18s; Lamps: 1																																										
33	HELVAR; EL1x36HF; Lamps: 1																																										
34	HELVAR; EL1x36ngn; Lamps: 1																																										
35	HELVAR; EL1x58HF; Lamps: 1																																										
36	HELVAR; EL1x58ngn; Lamps: 1																																										
37	HELVAR; EL1x58s; Lamps: 1																																										
38	HELVAR; EL2x18ngn; Lamps: 2																																										
39	HELVAR; EL2x18s; Lamps: 2																																										
40	HELVAR; EL2x36/40s; Lamps: 2																																										
41	HELVAR; EL2x36/40s-u; Lamps: 2																																										
42	HELVAR; EL2x36HF; Lamps: 2																																										
43	HELVAR; EL2x36ngn; Lamps: 2																																										
44	HELVAR; EL2x36sc; Lamps: 2																																										
45	HELVAR; EL2x58es; Lamps: 2																																										
46	HELVAR; EL2x58HF; Lamps: 2																																										
47	HELVAR; EL2x58ngn; Lamps: 2																																										
48	HELVAR; EL2x58s; Lamps: 2																																										
49	HELVAR; EL3/4x18ngn; Lamps: 3																																										
50	HELVAR; EL3/4x18ngn; Lamps: 4																																										


Ballast Count
T8 Ballasts - HF Only
Combined Result
Combined Result
Philips / Signify
OSRAM / LEDvance
Sylvania
LEDs Change the World
Opple
Corepro LEDtube HF, Instant Fit 1200mm T8 1600lm
Corepro LEDtube HF, Instant Fit 1500mm T8 3000lm
Corepro LEDtube HF, Instant Fit 600mm T8 800lm
Corepro LEDtube UN, 1200mm HO 14W8xx T8
Corepro LEDtube UN, 1500mm HO 18W8xx T8
MASTER LEDtube 1200mm HF HO, InstantFit T8 2100 lm
MASTER LEDtube 1200mm Universal, Instant Fit 2500lm
MASTER LEDtube 1500mm HF HO, Instant Fit T8 3100 lm
MASTER LEDtube 1500mm HF UO, Instant Fit T8 3700 lm
MASTER LEDtube 1500mm Universal, Instant Fit 3700lm
MASTER LEDtube HF 1200mm 16.5W 833 T8 MEAT
MASTER LEDtube HF, Instant Fit T8 600mm HF 1050lm
SubstiTUBE® T8 UNIVERSAL 0.6m ADVANCED 7.5W
SubstiTUBE® T8 UNIVERSAL 0.6m STAR 8W
SubstiTUBE® T8 UNIVERSAL 0.6m VALUE 8W
SubstiTUBE® T8 UNIVERSAL 1.2m Advanced 14W
SubstiTUBE® T8 UNIVERSAL 1.2m Advanced UO 15W
SubstiTUBE® T8 UNIVERSAL 1.2m Star 16W
SubstiTUBE® T8 UNIVERSAL 1.2m Value 16W
SubstiTUBE® T8 UNIVERSAL 1.5m Advanced 20W
SubstiTUBE® T8 UNIVERSAL 1.5m Advanced UO 23W
SubstiTUBE® T8 UNIVERSAL 1.5m Star 19W
SubstiTUBE® T8 UNIVERSAL 1.5m Value 19W
ToLEDo SUPERIA T8 ECG 2FT 1050LM/1100LM
ToLEDo SUPERIA T8 ECG 4FT 2200LM/2400LM
ToLEDo SUPERIA T8 ECG 5FT 2850LM/3100LM
ToLEDo SUPERIA T8 ECG 5FT 3300LM/3600LM
ToLEDo SUPERIA T8 UNI 2FT 1050LM/ 1100LM
ToLEDo SUPERIA T8 UNI 4FT 2200LM/ 2400LM
ToLEDo SUPERIA T8 UNI 5FT 3300LM/ 3600LM
TLED Tube 1200mm 36W HF Ballast, Dim
TLED Tube 1200mm 36W HF Ballast, Non-Dim
TLED Tube 1500mm 58W HF Ballast, Dim
TLED Tube 1500mm 58W HF Ballast, Non-Dim
TLED Tube 600mm 18W HF Ballast, Dim
TLED Tube 600mm 18W HF Ballast, Non-Dim
TLED Tube 600mm 18W Mag Ballast, Dim
Opple Universal T8 1200mm
Opple Universal T8 1500mm
51 HELVAR; EL3/4x18s; Lamps: 3
52 HELVAR; EL3/4x18s; Lamps: 4
53 HELVAR; EL4x18ngn; Lamps: 4
54 May + Christie; MCU 158; Lamps: 1
55 May + Christie; MCU 258; Lamps: 2
56 OSRAM; EZ-PLUS 2X36/220-230; Lamps: 2
57 OSRAM; OTP-OPTIMAL 1x36-40; Lamps: 1
58 OSRAM; QT 1X58 DIM; Lamps: 1
59 OSRAM; QT Deluxe HF 1x58/230-240 DIM; Lamps: 1
60 OSRAM; QT Deluxe HF 2x58/230-240 DIM; Lamps: 2
61 OSRAM; QT-FIT 3x18,4x18; Lamps: 4
62 OSRAM; QT-FIT 5/8 1x18-39; Lamps: 1
63 OSRAM; QT-FIT 5/8 1x54-58; Lamps: 1
64 OSRAM; QT-FIT 5/8 2x18-39; Lamps: 2
65 OSRAM; QT-FIT 5/8 2x54-58; Lamps: 2
66 OSRAM; QT-FIT8 1x18; Lamps: 1
67 OSRAM; QT-FIT8 1x36; Lamps: 1
68 OSRAM; QT-FIT8 1x58-70; Lamps: 1
69 OSRAM; QT-FIT8 2x18; Lamps: 2
70 OSRAM; QT-FIT8 2x36; Lamps: 2
71 OSRAM; QT-FIT8 2x54-58; Lamps: 2
72 OSRAM; QT-FIT8 2x58; Lamps: 2
73 OSRAM; QT-FIT8 2x58-70; Lamps: 2
74 OSRAM; QT-FIT8 3/4x18; Lamps: 3
75 OSRAM; QT-FIT8 3/4x18; Lamps: 4
76 OSRAM; QT-FIT8 3x18,4x18; Lamps: 3
77 OSRAM; QT-FIT8 3x18,4x18; Lamps: 4
78 OSRAM; QT-FIT8 3x36; Lamps: 3
79 OSRAM; QTP8 1x18; Lamps: 1
80 OSRAM; QTP8 1x36; Lamps: 1
81 OSRAM; QTP8 1x58; Lamps: 1
82 OSRAM; QTP8 2x18; Lamps: 2
83 OSRAM; QTP8 2x36; Lamps: 2
84 OSRAM; QTP8 2x58; Lamps: 2
85 OSRAM; QTP8 3/4x18; Lamps: 3
86 OSRAM; QTP8 3/4x18; Lamps: 4
87 OSRAM; QTP-OPTIMAL 118-40; Lamps: 1
88 OSRAM; QTP-OPTIMAL 1x18-40; Lamps: 1
89 OSRAM; QTP-OPTIMAL 1x54-58; Lamps: 1
90 OSRAM; QTP-OPTIMAL 218-40; Lamps: 2
91 OSRAM; QTP-OPTIMAL 2x18-40; Lamps: 2
92 OSRAM; QTP-OPTIMAL 2x54-58; Lamps: 2
93 PHILIPS; EB-C 136 TLD 220-240; Lamps: 1
94 PHILIPS; EB-P 258 TLD ICC 220-240; Lamps: 2
95 PHILIPS; EB-S 236 TLD 220-230; Lamps: 2
96 PHILIPS; EI 158 TLD 220-240; Lamps: 1
97 PHILIPS; HF-B 136 TLD 220-240; Lamps: 1
98 PHILIPS; HF-B 136 TLD EII 220-240; Lamps: 1
99 PHILIPS; HF-B 136/236 TLD EII 220-240; Lamps: 2
100 PHILIPS; HF-B 158 TLD 220-240; Lamps: 1


Ballast Count
T8 Ballasts - HF Only
Combined Result
Combined Result
Philips / Signify
OSRAM / LEDvance
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Corepro LEDtube HF, Instant Fit 600mm T8 800lm
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MASTER LEDtube 1200mm HF HO, InstantFit T8 2100 lm
MASTER LEDtube 1200mm Universal, Instant Fit 2500lm
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MASTER LEDtube 1500mm HF UO, Instant Fit T8 3700 lm
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MASTER LEDtube HF 1200mm 16.5W 833 T8 MEAT
MASTER LEDtube HF, Instant Fit T8 600mm HF 1050lm
SubstiTUBE® T8 UNIVERSAL 0.6m ADVANCED 7.5W
SubstiTUBE® T8 UNIVERSAL 0.6m STAR 8W
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SubstiTUBE® T8 UNIVERSAL 1.2m Advanced 14W
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SubstiTUBE® T8 UNIVERSAL 1.2m Star 16W
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ToLEDo SUPERIA T8 ECG 2FT 1050LM/1100LM
ToLEDo SUPERIA T8 ECG 4FT 2200LM/2400LM
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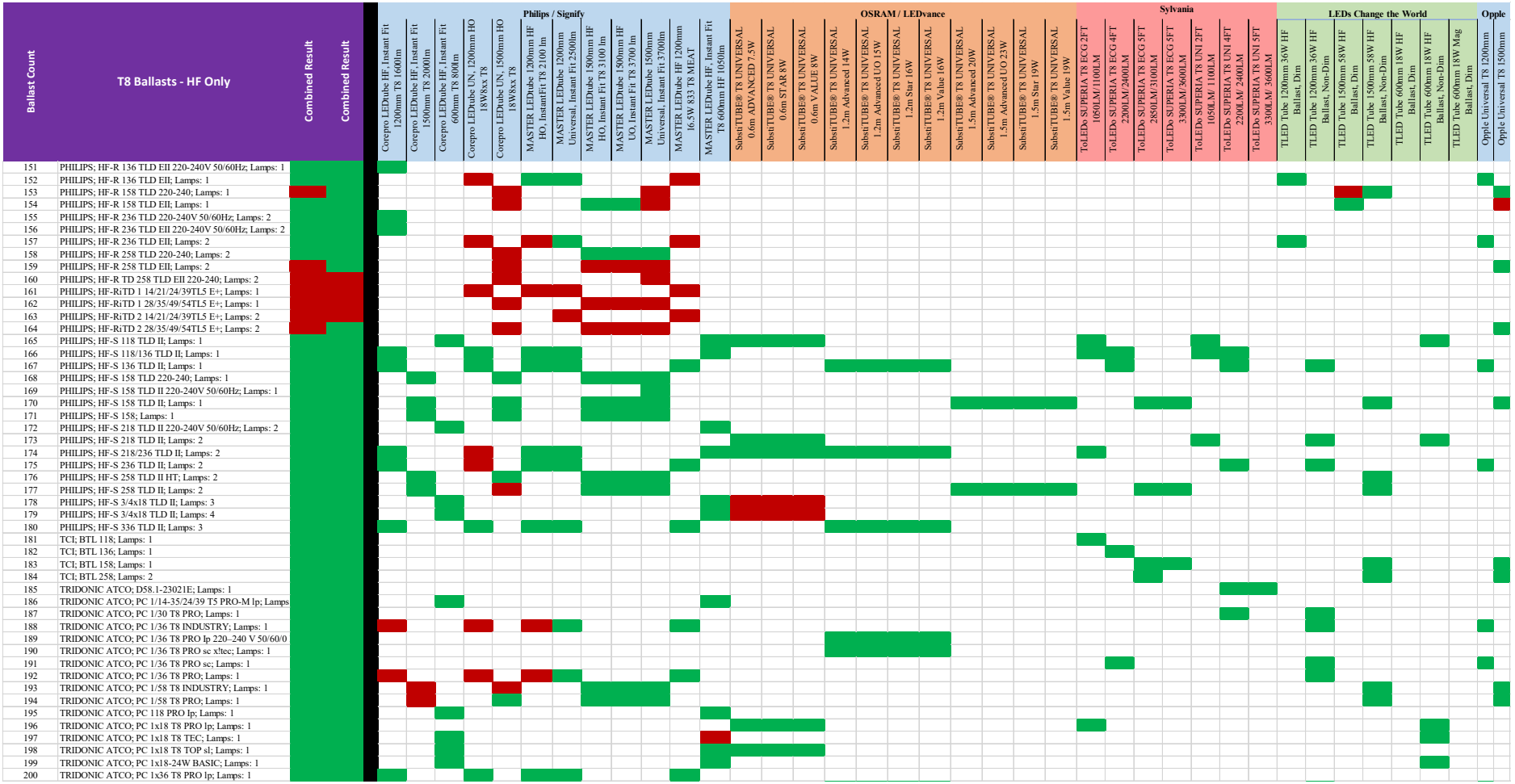
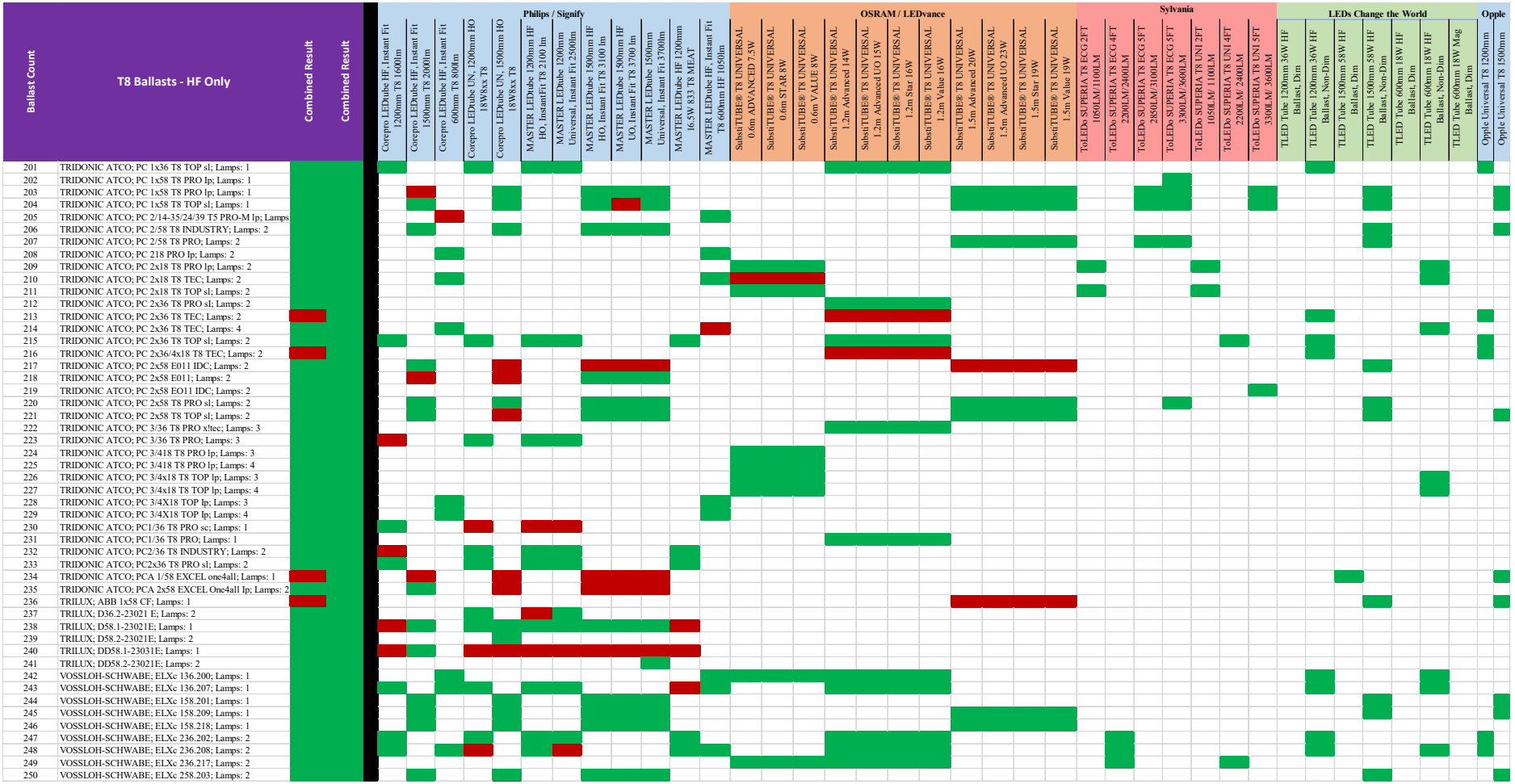
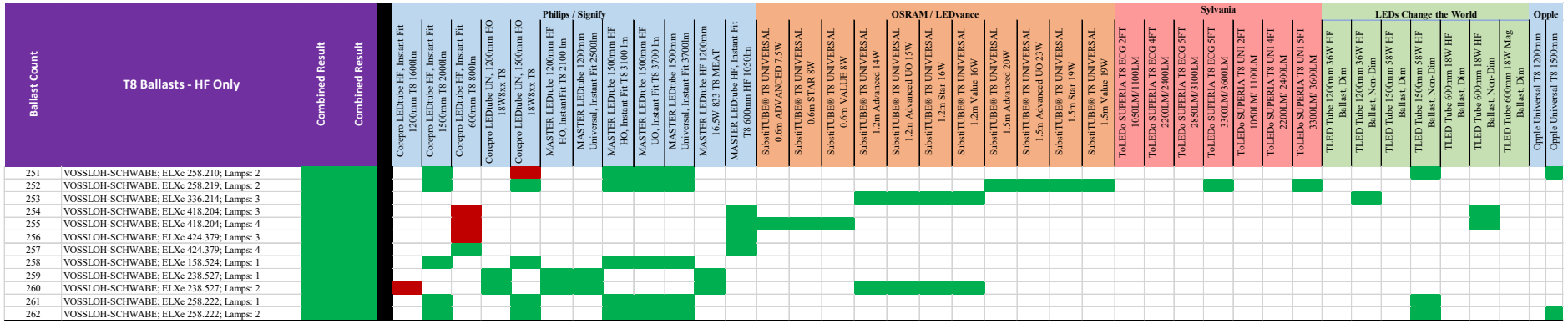
ToLEDo SUPERIA T8 UNI 4FT 2200LM/ 2400LM
ToLEDo SUPERIA T8 UNI 5FT 3300LM/ 3600LM
TLED Tube 1200mm 36W HF Ballast, Dim
TLED Tube 1200mm 36W HF Ballast, Non-Dim
TLED Tube 1500mm 58W HF Ballast, Dim
TLED Tube 1500mm 58W HF Ballast, Non-Dim
TLED Tube 600mm 18W HF Ballast, Dim
TLED Tube 600mm 18W HF Ballast, Non-Dim
TLED Tube 600mm 18W Mag Ballast, Dim
Opple Universal T8 1200mm
Opple Universal T8 1500mm
101 PHILIPS; HF-B 158 TLD EII 220-240; Lamps: 1
102 PHILIPS; HF-B 236 TLD 220-240; Lamps: 2
103 PHILIPS; HF-B 236 TLD EII 220-240; Lamps: 2
104 PHILIPS; HF-B 258 TLD 220-240; Lamps: 2
105 PHILIPS; HF-B 258 TLD EII 220-240; Lamps: 2
106 PHILIPS; HF-E 1/2 58 TLD II; Lamps: 1
107 PHILIPS; HF-E 1/2 58 TLD II; Lamps: 2
108 PHILIPS; HF-E 136 TLD II 220-240V 50/60Hz (HF-E 218 T
109 PHILIPS; HF-E 136 TLD II; Lamps: 1
110 PHILIPS; HF-E 158 TLD; Lamps: 1
111 PHILIPS; HF-E 236 TLD II; Lamps: 2
112 PHILIPS; HF-E 236 TLD; Lamps: 2
113 PHILIPS; HF-E 418 TLD II 220-240V 50/60Hz-parl; Lamps:
114 PHILIPS; HF-K 136 TLD 220-240; Lamps: 1
115 PHILIPS; HF-Matchbox 1x18 Blue; Lamps: 1
116 PHILIPS; HF-Matchbox 1x18 RED; Lamps: 1
117 PHILIPS; HF-P 118 TLD 220-240; Lamps: 1
118 PHILIPS; HF-P 118 TLD III IDC; Lamps: 1
119 PHILIPS; HF-P 118/136 TLD III; Lamps: 1
120 PHILIPS; HF-P 136 TLD 220-240; Lamps: 1
121 PHILIPS; HF-P 136 TLD EII 220-240; Lamps: 1
122 PHILIPS; HF-P 136 TLD III IDC; Lamps: 1
123 PHILIPS; HF-P 138 TLD 220-240; Lamps: 1
124 PHILIPS; HF-P 154/155 TL5 HO/PL-L III IDC; Lamps: 1
125 PHILIPS; HF-P 158 TLD 220-240; Lamps: 1
126 PHILIPS; HF-P 158 TLD EII 220-240; Lamps: 1
127 PHILIPS; HF-P 158 TLD III IDC; Lamps: 1
128 PHILIPS; HF-P 218 TLD EII 220-240; Lamps: 2
129 PHILIPS; HF-P 218 TLD III IDC; Lamps: 2
130 PHILIPS; HF-P 218/236 TLD III; Lamps: 2
131 PHILIPS; HF-P 236 TLD 230-240; Lamps: 2
132 PHILIPS; HF-P 236 TLD EII 220-240; Lamps: 2
133 PHILIPS; HF-P 236 TLD III IDC; Lamps: 2
134 PHILIPS; HF-P 258 TLD 220-240; Lamps: 2
135 PHILIPS; HF-P 258 TLD 230-240; Lamps: 2
136 PHILIPS; HF-P 258 TLD EII 220-240; Lamps: 2
137 PHILIPS; HF-P 258 TLD III IDC; Lamps: 2
138 PHILIPS; HF-P 3/4x18 TLD EII 220-240; Lamps: 3
139 PHILIPS; HF-P 3/4x18 TLD EII 220-240; Lamps: 4
140 PHILIPS; HF-P 3/4x18 TLD III IDC; Lamps: 3
141 PHILIPS; HF-P 3/4x18 TLD III IDC; Lamps: 4
142 PHILIPS; HF-P 336 TLD III 220-240; Lamps: 2
143 PHILIPS; HF-P 336 TLD III IDC; Lamps: 3
144 PHILIPS; HF-P Xt 136 TLD EII 220-240; Lamps: 1
145 PHILIPS; HF-P Xt 158 TLD EII 220-240; Lamps: 1
146 PHILIPS; HF-P XT 236 TLD EII 220-240; Lamps: 2
147 PHILIPS; HF-P Xt 258 TLD EII 220-240; Lamps: 2
148 PHILIPS; HF-Pi 1 14/21/24/28/39 TL5 EII 220-240; Lamps:
149 PHILIPS; HF-Pi 1 14/21/24/39 TL5 EII 220-240; Lamps: 1
150 PHILIPS; HF-R 136 TLD 220-240V 50/60Hz; Lamps: 1



Ballast Count	T8 Ballasts - HF Only
151	PHILIPS; HF-R 136 TLD EII 220-240V 50/60Hz; Lamps: 1
152	PHILIPS; HF-R 136 TLD EII; Lamps: 1
153	PHILIPS; HF-R 158 TLD 220-240; Lamps: 1
154	PHILIPS; HF-R 158 TLD EII; Lamps: 1
155	PHILIPS; HF-R 236 TLD 220-240V 50/60Hz; Lamps: 2
156	PHILIPS; HF-R 236 TLD EII 220-240V 50/60Hz; Lamps: 2
157	PHILIPS; HF-R 236 TLD EII; Lamps: 2
158	PHILIPS; HF-R 258 TLD 220-240; Lamps: 2
159	PHILIPS; HF-R 258 TLD EII; Lamps: 2
160	PHILIPS; HF-R TD 258 TLD EII 220-240; Lamps: 2
161	PHILIPS; HF-RiTD 1 14/21/24/39TL5 E+; Lamps: 1
162	PHILIPS; HF-RiTD 1 28/35/49/54TL5 E+; Lamps: 1
163	PHILIPS; HF-RiTD 2 14/21/24/39TL5 E+; Lamps: 2
164	PHILIPS; HF-RiTD 2 28/35/49/54TL5 E+; Lamps: 2
165	PHILIPS; HF-S 118 TLD II; Lamps: 1
166	PHILIPS; HF-S 118/136 TLD II; Lamps: 1
167	PHILIPS; HF-S 136 TLD II; Lamps: 1
168	PHILIPS; HF-S 158 TLD 220-240; Lamps: 1
169	PHILIPS; HF-S 158 TLD II 220-240V 50/60Hz; Lamps: 1
170	PHILIPS; HF-S 158 TLD II; Lamps: 1
171	PHILIPS; HF-S 158; Lamps: 1
172	PHILIPS; HF-S 218 TLD II 220-240V 50/60Hz; Lamps: 2
173	PHILIPS; HF-S 218 TLD II; Lamps: 2
174	PHILIPS; HF-S 218/236 TLD II; Lamps: 2
175	PHILIPS; HF-S 236 TLD II; Lamps: 2
176	PHILIPS; HF-S 258 TLD II HT; Lamps: 2
177	PHILIPS; HF-S 258 TLD II; Lamps: 2
178	PHILIPS; HF-S 3/4x18 TLD II; Lamps: 3
179	PHILIPS; HF-S 3/4x18 TLD II; Lamps: 4
180	PHILIPS; HF-S 336 TLD II; Lamps: 3
181	TCI; BTL 118; Lamps: 1
182	TCI; BTL 136; Lamps: 1
183	TCI; BTL 158; Lamps: 1
184	TCI; BTL 258; Lamps: 2
185	TRIDONIC ATCO; D58.1-23021E; Lamps: 1
186	TRIDONIC ATCO; PC 1/14-35/24/39 T5 PRO-M lp; Lamps
187	TRIDONIC ATCO; PC 1/30 T8 PRO; Lamps: 1
188	TRIDONIC ATCO; PC 1/36 T8 INDUSTRY; Lamps: 1
189	TRIDONIC ATCO; PC 1/36 T8 PRO lp 220–240 V 50/60/0
190	TRIDONIC ATCO; PC 1/36 T8 PRO sc x!tec; Lamps: 1
191	TRIDONIC ATCO; PC 1/36 T8 PRO sc; Lamps: 1
192	TRIDONIC ATCO; PC 1/36 T8 PRO; Lamps: 1
193	TRIDONIC ATCO; PC 1/58 T8 INDUSTRY; Lamps: 1
194	TRIDONIC ATCO; PC 1/58 T8 PRO; Lamps: 1
195	TRIDONIC ATCO; PC 118 PRO lp; Lamps: 1
196	TRIDONIC ATCO; PC 1x18 T8 PRO lp; Lamps: 1
197	TRIDONIC ATCO; PC 1x18 T8 TEC; Lamps: 1
198	TRIDONIC ATCO; PC 1x18 T8 TOP sl; Lamps: 1
199	TRIDONIC ATCO; PC 1x18-24W BASIC; Lamps: 1
200	TRIDONIC ATCO; PC 1x36 T8 PRO lp; Lamps: 1



Ballast Count	T8 Ballasts - HF Only	Combined Result	Combined Result
201	TRIDONIC ATCO; PC 1x36 T8 TOP sl; Lamps: 1		
202	TRIDONIC ATCO; PC 1x58 T8 PRO lp; Lamps: 1		
203	TRIDONIC ATCO; PC 1x58 T8 PRO lp; Lamps: 1		
204	TRIDONIC ATCO; PC 1x58 T8 TOP sl; Lamps: 1		
205	TRIDONIC ATCO; PC 2/14-35/24/39 T5 PRO-M lp; Lamps		
206	TRIDONIC ATCO; PC 2/58 T8 INDUSTRY; Lamps: 2		
207	TRIDONIC ATCO; PC 2/58 T8 PRO; Lamps: 2		
208	TRIDONIC ATCO; PC 218 PRO lp; Lamps: 2		
209	TRIDONIC ATCO; PC 2x18 T8 PRO lp; Lamps: 2		
210	TRIDONIC ATCO; PC 2x18 T8 TEC; Lamps: 2		
211	TRIDONIC ATCO; PC 2x18 T8 TOP sl; Lamps: 2		
212	TRIDONIC ATCO; PC 2x36 T8 PRO sl; Lamps: 2		
213	TRIDONIC ATCO; PC 2x36 T8 TEC; Lamps: 2		
214	TRIDONIC ATCO; PC 2x36 T8 TEC; Lamps: 4		
215	TRIDONIC ATCO; PC 2x36 T8 TOP sl; Lamps: 2		
216	TRIDONIC ATCO; PC 2x36/4x18 T8 TEC; Lamps: 2		
217	TRIDONIC ATCO; PC 2x58 E011 IDC; Lamps: 2		
218	TRIDONIC ATCO; PC 2x58 E011; Lamps: 2		
219	TRIDONIC ATCO; PC 2x58 EO11 IDC; Lamps: 2		
220	TRIDONIC ATCO; PC 2x58 T8 PRO sl; Lamps: 2		
221	TRIDONIC ATCO; PC 2x58 T8 TOP sl; Lamps: 2		
222	TRIDONIC ATCO; PC 3/36 T8 PRO xltec; Lamps: 3		
223	TRIDONIC ATCO; PC 3/36 T8 PRO; Lamps: 3		
224	TRIDONIC ATCO; PC 3/418 T8 PRO lp; Lamps: 3		
225	TRIDONIC ATCO; PC 3/418 T8 PRO lp; Lamps: 4		
226	TRIDONIC ATCO; PC 3/4x18 T8 TOP lp; Lamps: 3		
227	TRIDONIC ATCO; PC 3/4x18 T8 TOP lp; Lamps: 4		
228	TRIDONIC ATCO; PC 3/4X18 TOP lp; Lamps: 3		
229	TRIDONIC ATCO; PC 3/4X18 TOP lp; Lamps: 4		
230	TRIDONIC ATCO; PC1/36 T8 PRO sc; Lamps: 1		
231	TRIDONIC ATCO; PC1/36 T8 PRO; Lamps: 1		
232	TRIDONIC ATCO; PC2/36 T8 INDUSTRY; Lamps: 2		
233	TRIDONIC ATCO; PC2x36 T8 PRO sl; Lamps: 2		
234	TRIDONIC ATCO; PCA 1/58 EXCEL one4all; Lamps: 1		
235	TRIDONIC ATCO; PCA 2x58 EXCEL One4all lp; Lamps: 2		
236	TRILUX; ABB 1x58 CF; Lamps: 1		
237	TRILUX; D36.2-23021 E; Lamps: 2		
238	TRILUX; D58.1-23021E; Lamps: 1		
239	TRILUX; D58.2-23021E; Lamps: 2		
240	TRILUX; DD58.1-23031E; Lamps: 1		
241	TRILUX; DD58.2-23021E; Lamps: 2		
242	VOSSLOH-SCHWABE; ELXe 136.200; Lamps: 1		
243	VOSSLOH-SCHWABE; ELXe 136.207; Lamps: 1		
244	VOSSLOH-SCHWABE; ELXe 158.201; Lamps: 1		
245	VOSSLOH-SCHWABE; ELXe 158.209; Lamps: 1		
246	VOSSLOH-SCHWABE; ELXe 158.218; Lamps: 1		
247	VOSSLOH-SCHWABE; ELXe 236.202; Lamps: 2		
248	VOSSLOH-SCHWABE; ELXe 236.208; Lamps: 2		
249	VOSSLOH-SCHWABE; ELXe 236.217; Lamps: 2		
250	VOSSLOH-SCHWABE; ELXe 258.203; Lamps: 2		



Ballast Count	T8 Ballasts - HF Only	Combined Result	Combined Result	Philips / Signify: Corepro LEDtube HF, Instant Fit 1200mm T8 1600lm	Corepro LEDtube HF, Instant Fit 1500mm T8 2000lm	Corepro LEDtube HF, Instant Fit 600mm T8 800lm	Corepro LEDtube UN, 1200mm HO 14W8xx T8	Corepro LEDtube UN, 1500mm HO 18W8xx T8	MASTER LEDtube 1200mm HF HO, InstantFit T8 2100 lm	MASTER LEDtube 1200mm Universal, Instant Fit 2500lm	MASTER LEDtube 1500mm HF HO, Instant Fit T8 3100 lm	MASTER LEDtube 1500mm HF UO, Instant Fit T8 3700 lm	MASTER LEDtube 1500mm Universal, Instant Fit 3700lm	MASTER LEDtube HF 1200mm 16.5W 833 T8 MEAT	MASTER LEDtube HF, Instant Fit T8 600mm HF 1050lm	OSRAM / LEDvance: SubstiTUBE® T8 UNIVERSAL 0.6m ADVANCED 7.5W	SubstiTUBE® T8 UNIVERSAL 0.6m STAR 8W	SubstiTUBE® T8 UNIVERSAL 0.6m VALUE 8W	SubstiTUBE® T8 UNIVERSAL 1.2m Advanced 14W	SubstiTUBE® T8 UNIVERSAL 1.2m Advanced UO 15W	SubstiTUBE® T8 UNIVERSAL 1.2m Star 16W	SubstiTUBE® T8 UNIVERSAL 1.2m Value 16W	SubstiTUBE® T8 UNIVERSAL 1.5m Advanced 20W	SubstiTUBE® T8 UNIVERSAL 1.5m Advanced UO 23W	SubstiTUBE® T8 UNIVERSAL 1.5m Star 19W	SubstiTUBE® T8 UNIVERSAL 1.5m Value 19W	Sylvania: ToLEDo SUPERIA T8 ECG 2FT 1050LM/ 1100LM	ToLEDo SUPERIA T8 ECG 4FT 2200LM/2400LM	ToLEDo SUPERIA T8 ECG 5FT 2850LM/3100LM	ToLEDo SUPERIA T8 ECG 5FT 3300LM/3600LM	ToLEDo SUPERIA T8 UNI 2FT 1050LM/ 1100LM	ToLEDo SUPERIA T8 UNI 4FT 2200LM/ 2400LM	ToLEDo SUPERIA T8 UNI 5FT 3300LM/ 3600LM	LEDs Change the World: TLED Tube 1200mm 36W HF Ballast, Dim	TLED Tube 1200mm 36W HF Ballast, Non-Dim	TLED Tube 1500mm 58W HF Ballast, Dim	TLED Tube 1500mm 58W HF Ballast, Non-Dim	TLED Tube 600mm 18W HF Ballast, Dim	TLED Tube 600mm 18W HF Ballast, Non-Dim	TLED Tube 600mm 18W Mag Ballast, Dim	Opple: Opple Universal T8 1200mm	Opple Universal T8 1500mm
251	VOSSLOH-SCHWABE; ELXc 258.210; Lamps: 2																																						
252	VOSSLOH-SCHWABE; ELXc 258.219; Lamps: 2																																						
253	VOSSLOH-SCHWABE; ELXc 336.214; Lamps: 3																																						
254	VOSSLOH-SCHWABE; ELXc 418.204; Lamps: 3																																						
255	VOSSLOH-SCHWABE; ELXc 418.204; Lamps: 4																																						
256	VOSSLOH-SCHWABE; ELXc 424.379; Lamps: 3																																						
257	VOSSLOH-SCHWABE; ELXc 424.379; Lamps: 4																																						
258	VOSSLOH-SCHWABE; ELXc 158.524; Lamps: 1																																						
259	VOSSLOH-SCHWABE; ELXc 238.527; Lamps: 1																																						
260	VOSSLOH-SCHWABE; ELXc 238.527; Lamps: 2																																						
261	VOSSLOH-SCHWABE; ELXc 258.222; Lamps: 1																																						
262	VOSSLOH-SCHWABE; ELXc 258.222; Lamps: 2																																						

Annex B. Review of CFLni, T5 and T8 Fluorescent Lamp by RoHS Article 5(1)(a)

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

This category covers single ended fluorescent lamps which both have an integral ballast (i.e., operates on mains voltage and has an internal ballast) and those that do not have an internal ballast (e.g., pin-based, not integrally ballasted) lamps. The integrally ballasted lamps are abbreviated as "CFLi" and the lamps that are not integrally ballasted are called "CFLni". Since CFLi lamps have been phased-out by the recent Ecodesign regulation[49], this section will focus on the CFLni lamps, examples of which are shown below.

Figure 12. Examples of CFLni Lamps Exempted from RoHS in III.1(a-g)

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

Table 32. Summary Table of findings for Single capped (compact) fluorescent lamps, III.1(a-g)

Article 5(1)(a) Criteria	Summary of Finding Discussed below
(i) Annex II Materials or Substances	LED replacements for CFLni lamps are compliant with RoHS and do not contain any Annex II materials or substances.
(ii) Reliability of Substitutes	The LED replacements for single-capped fluorescent lamps are reliable; the LED lamps have rated lifetimes that are between 2.7 and 5.0 times longer than the fluorescent lamps they are replacing.
(iii) Environment, Health and Safety	The LED replacements for CFLni reduce the environmental impact both in terms of CO_2 emissions and mercury released to the environment; they do not present any health hazards and they are designed to comply with the product safety standards and therefore do not introduce any safety concerns.
(iv) Availability of Substitutes	Yes, there is a vast range and variety of LED replacements for CFLni fluorescent lamps, spanning a wide range of CCT, CRI, wattages, light output and so-on. There are over 880 different models of LED replacements in the US market, which has been found to be similar to the EU market based on sampling. In terms of base types, over 85% of the sockets can be met with an LED replacement.
(v) Socioeconomic Impact	Yes, there is a strong socioeconomic benefit from the installation of LED replacements for CFLni fluorescent lamps, with payback periods from 1.3 to 3.0 years and net cumulative savings (lamps and ballasts) for Europe from 2021 to 2035 of €2.8 billion Euro.

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

Article 5(1)(a) Criteria	Summary of Finding Discussed below
(vi) Impact on Innovation	As noted in section 2.6 of this report, continuing to extend the exemption of CFLni lamps from the RoHS Directive is negatively impacting innovation by keeping the legacy technologies on the market and preventing return on investment in the mercury-free alternative LED products.

B.1.1 (i) Annex II Materials or Substances – CFLni, III.1(a-g)

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

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

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

CorePro LED PLL

CorePro LED PLL HF 16.5W 865 4P 2G11

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

Product data

General Information	
[illegible]	2G11 [2G11]
EU RoHS compliant	Yes
[illegible]	30000 h
Switching Cycle	50000X

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

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

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

AREAS OF APPLICATION

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

PRODUCT FEATURES

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

B.1.2 (ii) Reliability of Substitutes – CFLni, III.1(a-g)

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

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

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

Table 33. Lifetime Comparison for Single capped (compact) fluorescent lamps, III.1(a-g)

Single Capped Fluorescent (CFLni)			LED Direct Retrofits (LED)		
	Philips bulb G10Q CIRCLINE 32w 4000K / 840[50]	9,000 hours		OSRAM/ LEDvance's Substitute T9; 20w 4000K G10q [51]	30,000 hours 3 Year guarantee
	Philips PL-C 10W 830 4P (MASTER) | Warm White - 4-Pin[52]	10,000 hours		Philips CorePro PL-C LED 4.5W 830 | Warm White - 4-Pin[53]	50,000 hours 5 year warranty
	GE 2D Watt-Miser 28W 827 4 pins HomeWhite[54]	15,000 hours		GE 2D Retrofit LED EM GR10q 12.5W 827 Frosted[55]	40,000 hours

The circline product is rated 9000 hours in fluorescent and the LED retrofit is 30,000 hours – which is 3.33 times longer life. The PL-C product is rated 10,000 hours in fluorescent and the LED retrofit is 50,000 hours – so 5 times longer life. And finally, the 2D shaped product is 15,000 hours in fluorescent or 40,000 hours in LED – 2.67 times longer life. Thus, it is safe to conclude that across the range of LED direct retrofits for fluorescent CFLni lamps, the lifetime is considerably longer – between 2.7 and 5.0 times longer – and thus these are reliable substitutes.

B.1.3 (iii) Environmental, Health and Safety – CFLni, III.1(a-g)

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

As shown in Table 34, the environmental benefits for phasing out CFLni lamps in September 2021 are significant. Energy bill savings amount to 28.4 TWh of electricity on a cumulative basis if fluorescent CFLni lamps are phased out in September 2021. Using a constant level of carbon intensity (0.296 kg/kWh), the avoided CO_2 emissions would be 8.4 MT of CO_2 for a CFLni phase out in 2021.

The mercury emission reductions from phasing out CFLni fluorescent lamps are two-fold: emissions into the environment from broken and improperly disposed lamps is avoided, and by reducing electricity demand, mercury released to the environment from the burning of coal at European power stations is avoided. We calculate the sum of mercury from avoided lamp shipments and mercury

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

emissions from avoided electricity production that result from retiring the exemption for CFLni fluorescent lamps in 2021, then 1083 kg Hg is avoided by 2030:

Table 34. Environmental Benefit from Phase-Out of CFLni fluorescent lamps in Europe[56]

Benefits of CFLni phase-out in Sept 2021	Cumulative Savings (2021-2035)
Electricity Savings and Avoided CO_2 Emissions	28.4 TWh (8.4 MT CO_2)
Mercury Savings – Lamps and Power Plant Emissions (*kg Hg*)	856 kg – lamps 227 kg – power plant 1083 kg - TOTAL

Source: Electricity and mercury in lamps from Öko-Institute report, 10 July 2020; CO_2 and mercury emissions from power plant estimates by SEA/CLASP.

As discussed in section 3.5.3.3, there are no safety concerns for LED replacements for CFLni lamps. This conclusion is drawn from the fact that LED products have been designed for installation into existing fluorescent luminaires, thus safety issues have been included from the beginning, as indicated in the Osram figure below – note the statement "SubstiTUBE T9 comes with a replacement starter, making the replacement safe and preventing electric shocks even if the traditional starter is removed". Furthermore, all LED products must comply with the requisite international safety standards, which protect for a range of consumer-related safety issues listed in section 3.5.3.3.

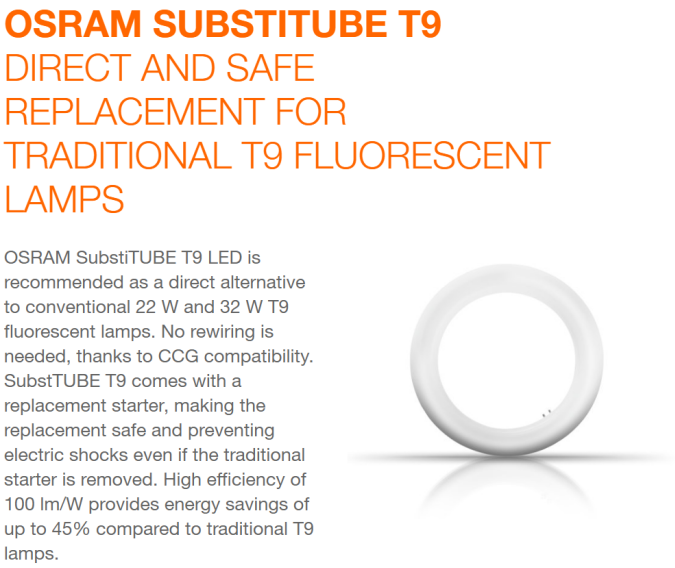


Figure 13. OSRAM advertisement advertising the safety aspect of their CFLni products

B.1.4 (iv) Availability of Substitutes – CFLni, III.1(a-g)

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

[56] Update of the data provided by the analysis model developed in the course of the "Study to assess socioeconomic impact of substitution of certain mercury-based lamps currently benefiting of RoHS 2 exemptions in Annex III"; by Yifaat Baron and Carl-Otto Gensch, Öko-Institut e.V., 10 July 2020.

According to the Design Lights Consortium Quality Products List in the US, there are over 880 different models of pin-based compact fluorescent lamps (i.e., not integrally ballasted) CFLni products. [57] Although we don´t have access to a similar database for the EU, sampling on the EU market shows a similar range of products.

In Figure 14, GE/Tungsram highlights the wide range of pin-based LED retrofit products it offers, enabling the end-user to "replace inefficient CFL lighting without the need for tools or a costly upgrade."[58] On the same webpage, GE/Tungsram notes that its LED plug-in 2Pin range is designed with a universal base (G24d) to replace G24d-1, G24d-2, G24d-3 CFL plug-in base types, and that it "easily plugs into existing relevant CFL plug-in sockets." In this way, existing CFL pin-base luminaires can be used while the light source is upgraded to LED, avoiding mercury-containing products.

Figure 14. GE/Tungsram offers direct retrofit pin-based LED replacements for CFLs with a 4x longer life

LE presented additional evidence in their letter indicating that only 6 out of 19 lamp base types for non-integrally ballasted compact fluorescent lamps (CFLni) have LED retrofits. We checked this finding and were able to find 16 out of 19 base types available in the market today (85% of the base types listed in the LE comment). Please see the screen capture from the LE letter below, where LE have indicated that 2G11, G23, G24q-1, G24q-3, GX23 and GX24q-1 base types are available. SEA/CLASP's analysis found ten additional base types already on the

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

market, over and above the six Lighting Europe indicated exist in the market. Of those ten, seven of these base types were recently introduced to the market by Lighting Europe members. The table below lists the base types and provides links to the examples we found online.

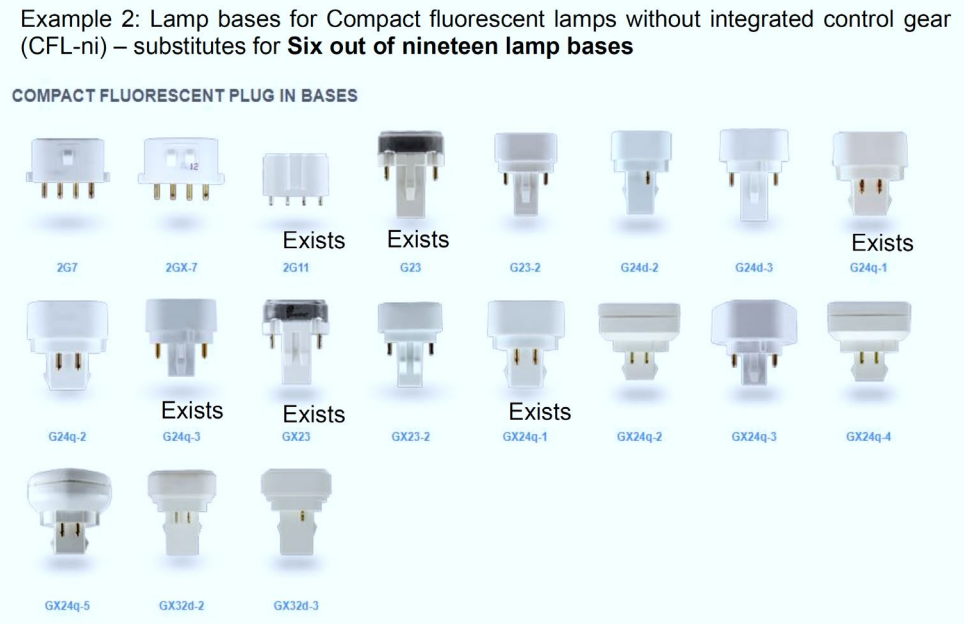


Figure 15. Lighting Europe comment claiming only 6 of 19 CFLni base types exist

Table 35. SEA/CLASP research on CFLni base types – 16 out of 19 base types exist

Base Type from LE Comment	Does this Base Type Exist in a Retrofit LED Lamp?	Links to Examples of LED Lamps
2G7	**Yes**	Link to example
2GX-7	**Yes**	Link to example
2G11	**Yes**	Link to example
G23	**Yes**	Link to example
G23-2	**Yes**	Link to example
G24d-2	**Yes**	Link to example
G24d-3	**Yes**	Link to example
G24q-1	**Yes**	Link to example
G24q-2	**Yes**	Link to example
G24q-3	**Yes**	Link to example
GX23	**Yes**	Link to example
GX23-2	**Yes**	Link to example
GX24q-1	**Yes**	Link to example
GX24q-2	**Yes**	Link to example
GX24q-3	**Yes**	Link to example
GX24q-4	**Yes**	Link to example

Base Type from LE Comment	Does this Base Type Exist in a Retrofit LED Lamp?	Links to Examples of LED Lamps
GX24q-5	**Not found***	
GX32d-2	**Not found***	
GX32d-3	**Not found***	

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

B.1.5 (v) Socioeconomic Impact – CFLni, III.1(a-g)

Yes, there is a strong socioeconomic benefit from the installation of LED replacements for CFLni fluorescent lamps, with payback periods from 1.3 to 3.0 years and net cumulative savings (lamps and ballasts) from 2021 to 2035 of €2.8 billion Euro.

Starting from the standpoint of a single CFLni socket, the authors prepared a calculation of the payback period for a CFLni replacement, the payback periods vary with the LED installed but are all positive, allowing end-users to recover their investment. In this calculation, an OSRAM 2D GR10q 28W is compared with a General Electric LED 2D shaped lamp and a Kosnic LED planar retrofit with the same socket (GR10q). Both LED replacements last more than twice as long as the fluorescent lamp, and the payback periods vary from 1.3 to 3.0 years. The results are presented in Table 36 which shows replacement offering European businesses €63.25 with the GE product or €24.02 with the Kosnic retrofit lamp.

Table 36. Life-Cycle Cost Economic Analysis of CFLni Lamp Replacement in Europe

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

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

The Öko-Institute updated their Socio-Economic Analysis with support from VHK who ran MELISA European Lighting market model to estimate the energy and economic impact of a phase-out of CFLni fluorescent lamps. The savings from a CFLni phase-out in September 2021 are significant, saving 28.4 TWh of electricity on a cumulative basis and €2.8 billion Euro.

Table 37. Energy & Financial Savings from Phase-Out of CFLni Lamps in Europe[59]

Benefits of CFLni phase-out	Cumulative Savings (2021-2035)
Electricity Savings	28.4 TWh
CO_2 emission savings (MMT)	8.4 MMT CO_2
Net Financial Savings (taking into account savings on the energy bill and slightly higher lamp costs)	€2.8 billion

Source: Electricity savings and financial savings from Öko-Institute, 10 July 2020 Updated Report; CO2 savings estimate, SEA/CLASP.

B.1.6 (vi) Impact on Innovation – CFLni, III.1(a-g)

[59] Update of the data provided by the analysis model developed in the course of the "Study to assess socioeconomic impact of substitution of certain mercury-based lamps currently benefiting of RoHS 2 exemptions in Annex III"; by Yifaat Baron and Carl-Otto Gensch, Öko-Institut e.V., 10 July 2020.

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

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

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

This category covers double ended fluorescent lamps with tube diameter between 9 and 17mm, of which the most popular size is called "T5". T5 lamps are covered in the recent Ecodesign regulation[60] but have an efficacy requirement that still allows fluorescent technology to persist, therefore T5 fluorescent lamps have no phase-out date. For the purposes of this analysis, we consider a phase-out date within the 12-18 month notice period of RoHS, suggesting 1 September 2021 for all lamps in this category.

Figure 16. Examples of T5 Fluorescent Lamps Exempted from RoHS in III.2(a)(2)

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

Table 38. Summary Table of findings for Double-capped fluorescent lamps, III.2(a)(2)

Article 5(1)(a) Criteria	Summary of Finding Discussed below
(i) Annex II Materials or Substances	LED replacements for T5 fluorescent lamps are compliant with RoHS and do not contain any Annex II materials or substances.
(ii) Reliability of Substitutes	The LED replacements for double-capped T5 fluorescent lamps are reliable; the LED lamps have rated lifetimes are 2.1 times longer than the fluorescent lamps they are replacing. Furthermore, the product warranty offered on one of the two lamps sampled for this comparison was 5 times longer for the LED retrofit than for the fluorescent lamp it replaces.
(iii) Environment, Health and Safety	The LED replacements for T5 reduce the environmental impact both in terms of CO_2 emissions and mercury released to the environment; they do not present any health hazards and they are designed to comply with the product safety standards and therefore do not introduce any safety concerns.
(iv) Availability of Substitutes	Yes, there is a vast range and variety of LED replacements for T5 fluorescent lamps, spanning a wide range of CCT, CRI, wattages, light output and so-on. There are over 2280 different models of LED replacements in the US market, which has been found to be similar to the EU market based on sampling. In terms of ballast compatibility, 80% of the existing T5 sockets in Europe can be met with an LED replacement today.

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

Article 5(1)(a) Criteria	Summary of Finding Discussed below
(v) Socioeconomic Impact	Yes, there is a strong socioeconomic benefit from the installation of LED replacements for T5 fluorescent lamps, with payback periods from 3.2-3.4 years and net cumulative savings (lamps and electricity) from 2021 through 2035 of €9.3 billion Euro.
(vi) Impact on Innovation	As noted in section 2.6 of this report, continuing to extend the exemption of T5 fluorescent lamps from the RoHS Directive is negatively impacting innovation by keeping the legacy technologies on the market and preventing return on investment in the mercury-free alternative LED products.

B.2.1 (i) Annex II Materials or Substances – T5, III.2(a)(2)

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

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

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

OSRAM

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

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

AREAS OF APPLICATION

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

PRODUCT BENEFITS

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

PRODUCT FEATURES

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

MASTER LEDtube InstantFit HF T5

MAS LEDtube HF 1500mm HO 26W 830 T5

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

MASTER LEDtube InstantFit HF T5

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

Product Data	
Full product code	871869668552500

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

B.2.2 (ii) Reliability of Substitutes – T5, III.2(a)(2)

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

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

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

Table 39. Lifetime Comparison for Tri-band phosphor with normal lifetime and a tube diameter ≥ 9 mm and ≤ 17 mm (e.g. T5), III.2(a)(2)

T5 Fluorescent Lamps			T5 LED Direct Retrofits		
	Philips TL5 HE 35W 840 (MASTER) | 145cm - Cool White[61]	24,000 hours		Philips LEDtube T5 HF HE 20W 840 145cm (MASTER) | Cool White [62]	50,000 hours 5 Year warranty
	Osram FQ HO 54W 865 G5 Lumilux - 115cm[63]	24,000 hours 1 year warranty		Noxion Avant LEDtube T5 Extreme HO (Direct) 120cm 26W 865 [64]	50,000 hours 5 year warranty

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

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

B.2.3 (iii) Environmental, Health and Safety – T5, III.2(a)(2)

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

As shown in Table 40, the environmental benefits for phasing out T5 fluorescent lamps in September 2021 are significant. Energy bill savings amount to 129 TWh of electricity on a cumulative basis if fluorescent T5 fluorescent lamps are phased out in September 2021. Using a constant level of carbon intensity (0.296 kg/kWh), the avoided CO_2 emissions would be 38.4 MT of CO_2 for a T5 fluorescent lamp phase out in 2021.

The mercury emission reductions from phasing out T5 fluorescent lamps are two-fold: emissions into the environment from broken and improperly disposed lamps is avoided, and by reducing electricity demand, mercury released to the environment from the burning of coal at European power stations is avoided. We calculate the sum of mercury from avoided lamp shipments and mercury emissions from avoided electricity production that result from retiring the exemption for T5 fluorescent lamps in 2021, then 2096 kg Hg is avoided by 2035:

Table 40. Environmental Benefit from Phase-Out of T5 fluorescent lamps in Europe[65]

Benefits of T5 phase-out in Sept 2021	Cumulative Savings (2021-2035)
Electricity Savings and Avoided CO_2 Emissions	129 TWh (38.4 MT CO_2)
Mercury Savings – Lamps and Power Plant Emissions (*kg Hg*)	1064 kg – lamps 1032 kg – power plant 2096 kg - TOTAL

Source: Electricity savings and lamp Hg savings from Öko-Institute, 10 July 2020 Updated Report; CO2 savings estimate and Hg savings from the power plant, SEA/CLASP estimate.

Today, fluorescent lamps are rapidly being replaced across Europe with LED retrofit lamps that are mercury-free, cost-effective, longer-lasting and provides the same or better lighting service compared to fluorescent. Figure 17 is from Philips Lighting/Signify[66] who market LED lighting to businesses as "A green choice", noting that "LED tubes are a mercury-free alternative to traditional fluorescent tubes, a responsible choice that can also contribute towards your green credentials."

[65] Update of the data provided by the analysis model developed in the course of the "Study to assess socioeconomic impact of substitution of certain mercury-based lamps currently benefiting of RoHS 2 exemptions in Annex III"; by Yifaat Baron and Carl-Otto Gensch, Öko-Institut e.V., 10 July 2020.

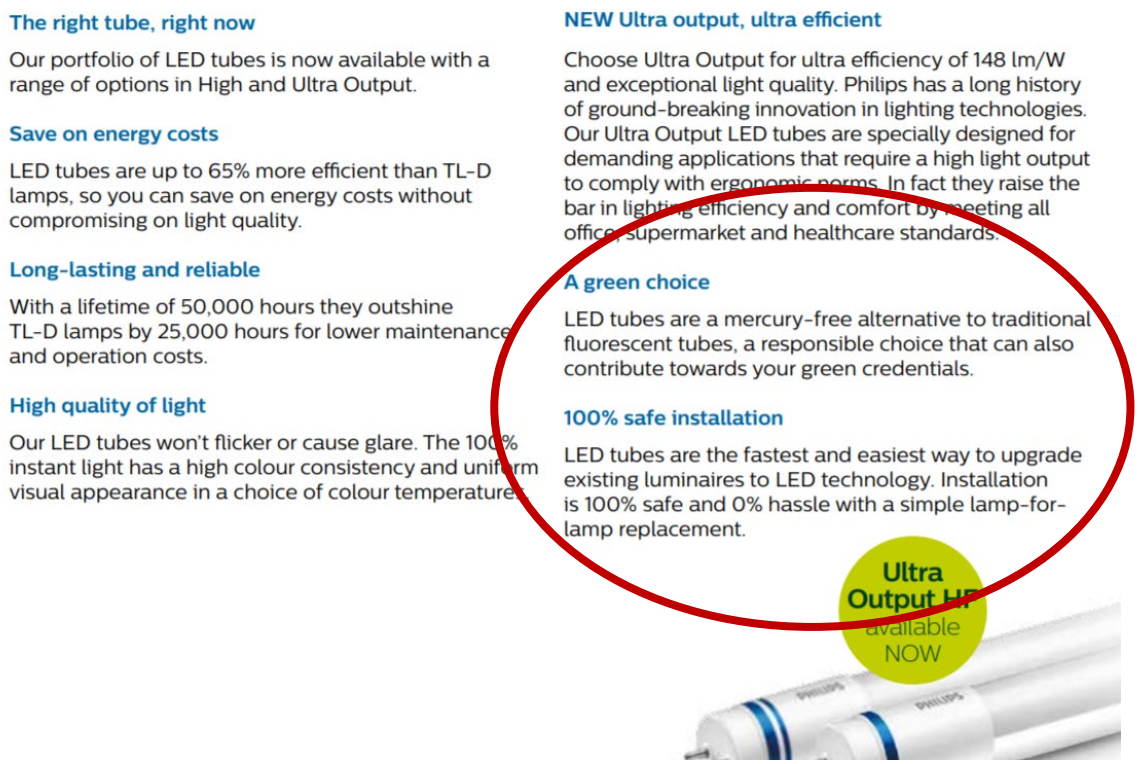


Figure 17. Philips Lighting/Signify highlighting the mercury-free alternative to fluorescent lighting

As discussed in section 3.5.3.3, there are no safety concerns for LED replacements for T5 fluorescent lamps. This conclusion is drawn from the fact that LED products have been designed for installation into existing fluorescent luminaires, thus safety issues have been included from the beginning, as indicated in the Philips information presented in Figure 17 above. The note reads: "100% safe installation LED tubes are the fastest and easiest way to upgrade existing luminaires to LED technology. Installation is 100% safe and 0% hassle with a simple lamp-for-lamp replacement". Furthermore, all LED products must comply with the requisite international safety standards, which protect for a range of consumer-related safety issues listed in section 3.5.3.3.

B.2.4 (iv) Availability of Substitutes – T5, III.2(a)(2)

Yes, there is a vast range and variety of LED replacements for T5 fluorescent lamps, spanning a wide range of CCT, CRI, wattages, light output and so-on. There are over 2280 different models of LED replacements in the US market, which has been found to be similar to the EU market based on sampling. In terms of ballast compatibility, 80% of the existing T5 sockets in Europe can be met with an LED replacement today.

According to the Design Lights Consortium Quality Products List in the US, there are literally thousands of different models of linear LED replacement lamps for T5 installations[67] - 2280 different models. Although we don´t have access to a similar database for the EU, sampling on the EU market shows a similar wide catalogue of products.

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

In terms of compatibility, the manufacturer catalogues indicate that their direct-replacement T5 LED lamps are compatible with approximately 80% of the T5 fluorescent ballasts installed in Europe today. This is reflected in the table below, and this percentage is expected to increase if the RoHS exemptions for fluorescent lamps are phased out, creating a better market for (mercury-free) T5 LED lamps. By organising the data in this way – multiple LED tube manufacturers competing for the same lamp/ballast combination - we find a slight improvement in the compatibility rate. Annex A presents the large table of 208 unique ballasts for T5 fluorescent luminaires in Europe, and of these 79 to 80% of them are compatible with direct, drop-in replacement LED tubes.

Table 41. Retrofit T5 LED Lamp Compatibility Percentages (see Annex A)

Lamp Size	Retrofit LED Tube Manufacturer and Product	Philips & Osram	Philips, Osram and Sylvania
T5	Philips Master LEDtube HF 1200mm HE 16.5W 8xx T5	79%	80%
	Philips Master LEDtube HF 1200mm HO 26W 8xx T5		
	Philips Master LEDtube HF 1500mm HE 20W 8xx T5		
	Philips Master LEDtube HF 1500mm HO 26W 8xx T5		
	Philips Master LEDtube HF 1500mm UO 36W 8xx T5		
	Philips Master LEDtube HF 600mm HE 8W 8xx T5		
	OSRAM SubstiTUBE ® T5 HO49 26W UNIVERSAL - 1.5m		
	OSRAM SubstiTUBE ® T5 HO54 26W UNIVERSAL - 1.2m		
	OSRAM SubstiTUBE ® T5HE14 7W UNIVERSAL - 0.6m		
	OSRAM SubstiTUBE ® T5HE21 10W UNIVERSAL - 0.9m		
	OSRAM SubstiTUBE ® T5HE28 17W UNIVERSAL - 1.2m		
	OSRAM SubstiTUBE ® T5HE35 18W UNIVERSAL - 1.5m		
	OSRAM SubstiTUBE ® T5HO80 37W UNIVERSAL - 1.5m		
	Sylvania ToLEDo SUPERIA T5 HE 4FT 16W 2200LM/2400LM*		
	Sylvania ToLEDo SUPERIA T5 HE 5FT 18,5W 2600LM/2800LM*		
	Sylvania ToLEDo SUPERIA T5 HO 4FT 27W 3700LM/4000LM*		
	Sylvania ToLEDo SUPERIA T5 HO 5FT 26W 4050LM/4200LM*		
	Sylvania ToLEDo SUPERIA T5 HO 5FT 37W 5150LM/5600LM*		

*Sylvania lamps were omitted from the February 2020 calculation.

B.2.5 (v) Socioeconomic Impact – T5, III.2(a)(2)

Yes, there is a strong socioeconomic benefit from the installation of LED replacements for T5 fluorescent lamps, with payback periods from 3.2-3.4 years and net cumulative savings (lamps and energy) through 2030 of €9.3 billion Euro.

Starting from the standpoint of a single T5 socket, the authors prepared a calculation for a T5 replacement. The payback periods are longer than T8, however they are still positive, and end-users will easily recover their investment over the 50,000-hour rated life of the LED T5 replacement lamps. In addition, if there were to be a phase-out, T5 LED lamp sales volumes would be expected to rise and

prices to fall through competition, yielding shorter payback periods. There isn't an LED entry-level and professional-grade option in T5, thus a single calculation comparison is performed, comparing a 28-Watt linear fluorescent T5 with an LED direct replacement lamp from OSRAM/LEDvance. The results are presented in Table 42, which shows a payback period of between 3.2 and 3.4 years. The net present value of the life-cycle cost savings is still strongly positive, offering European businesses €67.30 with the OSRAM product or €54.93 with the Philips product for each lamp replaced in terms of electricity savings.

Table 42. Life-Cycle Cost Economic Analysis of T5 Lamp Replacement in Europe

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

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

Notes: Electricity price of €0.1149/kWh from Eurostat for non-domestic sector[68]. Electricity price escalation rate of 4% is applied (following the MEErP methodology). CO_2 intensity of 295.8 g CO2/kWh from European Environment Agency[69].

The Öko-Institute published an updated Socio Economic Assessment report on 10 July 2020 which was based on the MELISA European Lighting market model to estimate the energy and economic impact of a phase-out of T5 fluorescent lamps. The savings from a T5 phase-out in September 2021 are significant, saving up to 129.0 TWh of electricity on a cumulative basis and €9.3 billion Euro in net savings (including lamp purchase costs).

[68] https://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_price_statistics#Electricity_prices_for_non-household_consumers

[69] Link to European Environment Agency graphic depicting the 2016 CO2 intensity value of 295.8g CO2/kWh.

Table 43. Energy & Financial Savings from Phase-Out of T5 Fluorescent Lamps in Europe [70]

Benefits of T5 phase-out in Sept. 2021	Cumulative Savings (2021-2035)
Electricity Savings	129 TWh
CO_2 emissions Savings	38.4 MMT CO_2
Net Financial Savings (taking into account savings on the energy bill and slightly higher lamp costs)	€9.3 billion

Source: Öko-Institute report, 10 July 2020; CO2 estimate by SEA/CLASP.

B.2.6 (vi) Impact on Innovation – T5, III.2(a)(2)

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

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

[70] Update of the data provided by the analysis model developed in the course of the "Study to assess socioeconomic impact of substitution of certain mercury-based lamps currently benefiting of RoHS 2 exemptions in Annex III"; by Yifaat Baron and Carl-Otto Gensch, Öko-Institut e.V., 10 July 2020.

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

This category covers double ended fluorescent lamps with tube diameter between 17 and 28mm, of which the most popular size is called "T8". Certain (the most popular) lengths of T8 lamps are scheduled to be phased-out by the recent Ecodesign regulation[71] on 1 September 2023, but this date was only agreed after extensive lobbying by the lighting industry as the original proposal was to have them phased out on 1 September 2020. For the purposes of this analysis, we consider a phase-out date within the 12-18-month notice period of RoHS, suggesting 1 September 2021 for all lamps in this category. This represents a two-year acceleration in the phase-out date, which yields significant mercury savings and other stakeholder and environmental benefits.

Figure 18. Examples of T8 Lamps Exempted from RoHS in III.2(a)(3)

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

Table 44. Summary Table of findings for Double-capped fluorescent lamps, III.2(a)(3)

Article 5(1)(a) Criteria	Summary of Finding Discussed below
(i) Annex II Materials or Substances	LED replacements for T8 fluorescent lamps are compliant with RoHS and do not contain any Annex II materials or substances.
(ii) Reliability of Substitutes	The LED replacements for double-capped T8 fluorescent lamps are reliable; the LED lamps have rated lifetimes are 2.5 to 3.0 times longer than the fluorescent lamps they are replacing. Furthermore, the product warranty offered on one of the two lamps sampled for this comparison was 5 times longer for the LED retrofit than for the fluorescent lamp it replaces.
(iii) Environment, Health and Safety	The LED replacements for T8 reduce the environmental impact both in terms of CO2 emissions and mercury released to the environment; they do not present any health hazards and they are designed to comply with the product safety standards and therefore do not introduce any safety concerns.
(iv) Availability of Substitutes	Yes, there is a vast range and variety of LED replacements for T8 fluorescent lamps, spanning a wide range of CCT, CRI, wattages, light output and so-on. There are over 24,000 different models of LED replacements in the US market, which has been found to be similar to the EU market based on sampling. In terms of ballast compatibility, 96.7-99.1% of the existing T8 sockets in Europe can be met with an LED replacement today.

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

Article 5(1)(a) Criteria	Summary of Finding Discussed below
(v) Socioeconomic Impact	Yes, there is a strong socioeconomic benefit from the installation of LED replacements for T8 fluorescent lamps, with payback periods from 0.4-0.9 years and net cumulative savings (lamps and electricity) from 2021 through 2035 of €17.7 billion Euro.
(vi) Impact on Innovation	As noted in section 2.6 of this report, continuing to extend the exemption of T8 fluorescent lamps from the RoHS Directive is negatively impacting innovation by keeping the legacy technologies on the market and preventing return on investment in the mercury-free alternative LED products.

B.3.1 (i) Annex II Materials or Substances – T8, III.2(a)(3)

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

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

In Figure 19, Tungsram advertises[72] that its products contain no lead or mercury and are compliant with the material restriction requirements of RoHS.

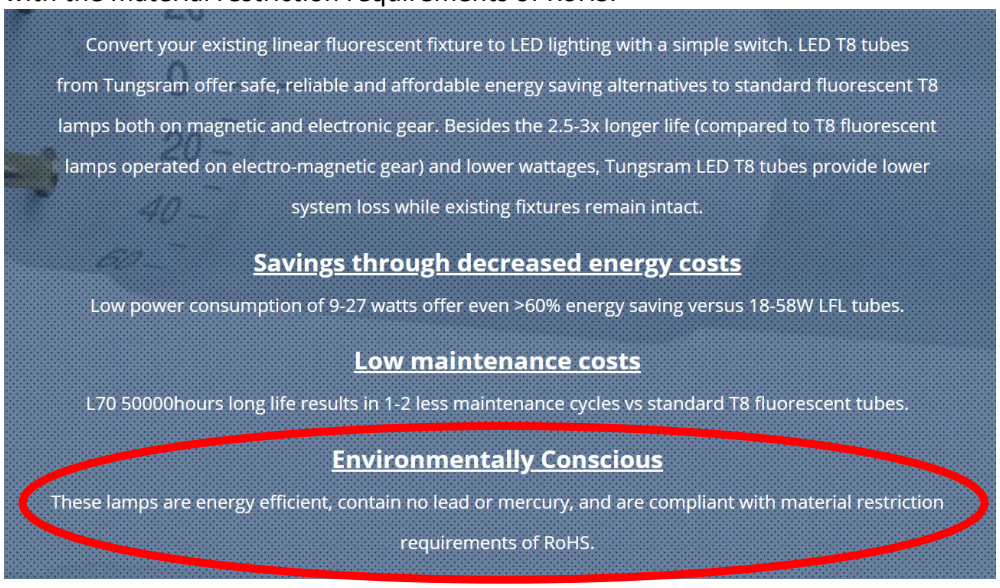


Figure 19. Tungsram advertisement noting the "quick and easy installation" of its LED retrofit lamps

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

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

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

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

AREAS OF APPLICATION

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

PRODUCT BENEFITS

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

PRODUCT FEATURES

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

Figure 20. OSRAM/LEDvance Product Data Sheet for a T8 retrofit lamp

B.3.2 (ii) Reliability of Substitutes – T8, III.2(a)(3)

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

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

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

Table 45. Lifetime Comparison for Tri-band phosphor with normal lifetime and a tube diameter > 17 mm and ≤ 28 mm (e.g. T8), III.2(a)(3)

T8 Fluorescent Lamps			T8 LED Direct Retrofits		
	Philips TL-D 18W 827 Super 80 (MASTER) | 59cm[73]	20,000 hours 1 year warranty		Philips LEDtube HF 8W 830 60cm (MASTER) | Warm White[74]	50,000 hours 5 year warranty
	Osram L 36W 840 Lumilux | 120cm - Cool White[75]	20,000 hours 1 year warranty		Osram SubstiTUBE Advanced HF UO 15.5W 840 120cm | Cool White [76]	60,000 hours 5 year warranty

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

B.3.3 (iii) Environmental, Health and Safety – T8, III.2(a)(3)

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

As shown above, the environmental benefits for phasing out T8 fluorescent lamps in September 2021 are significant – even though it is only a two year acceleration on the phase-out of T8 scheduled under the Ecodesign Directive. Energy bill savings amount to 152.3 TWh of electricity on a cumulative basis if fluorescent T8 fluorescent lamps are phased out in September 2021. Using a constant level of carbon intensity (0.296 kg/kWh), the avoided CO_2 emissions would be 45.3 MT of CO_2 for a T8 fluorescent lamp phase out in 2021.

The mercury emission reductions from phasing out T8 fluorescent lamps are two-fold: emissions into the environment from broken and improperly disposed lamps is avoided, and by reducing electricity demand, mercury released to the environment from the burning of coal at European power stations is avoided. We calculate the sum of mercury from avoided lamp shipments and mercury emissions from

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

avoided electricity production that result from retiring the exemption for T8 fluorescent lamps in 2021, then 2180 kg Hg is avoided by 2035:

Table 46. Environmental Benefit from Phase-Out of T8 fluorescent lamps in Europe[77]

Benefits of T8 phase-out in Sept 2021	Cumulative Savings (2021-2035)
Electricity Savings and Avoided CO_2 Emissions	152.3 TWh (45.3 MT CO_2)
Mercury Savings – Lamps and Power Plant Emissions (*kg Hg*)	962 kg – lamps 1218 kg – power plant 2180 kg - TOTAL

Source: Öko-Institute report, 10 July 2020; CO_2 calculation and Hg power station estimate by SEA/CLASP.

Today, fluorescent lamps are rapidly being replaced across Europe with LED retrofit lamps that are mercury-free, cost-effective, longer-lasting and provides the same or better lighting service compared to fluorescent. Figure 21 is from Philips Lighting/Signify[78] who market LED lighting to businesses as "A green choice", noting that "LED tubes are a mercury-free alternative to traditional fluorescent tubes, a responsible choice that can also contribute towards your green credentials."

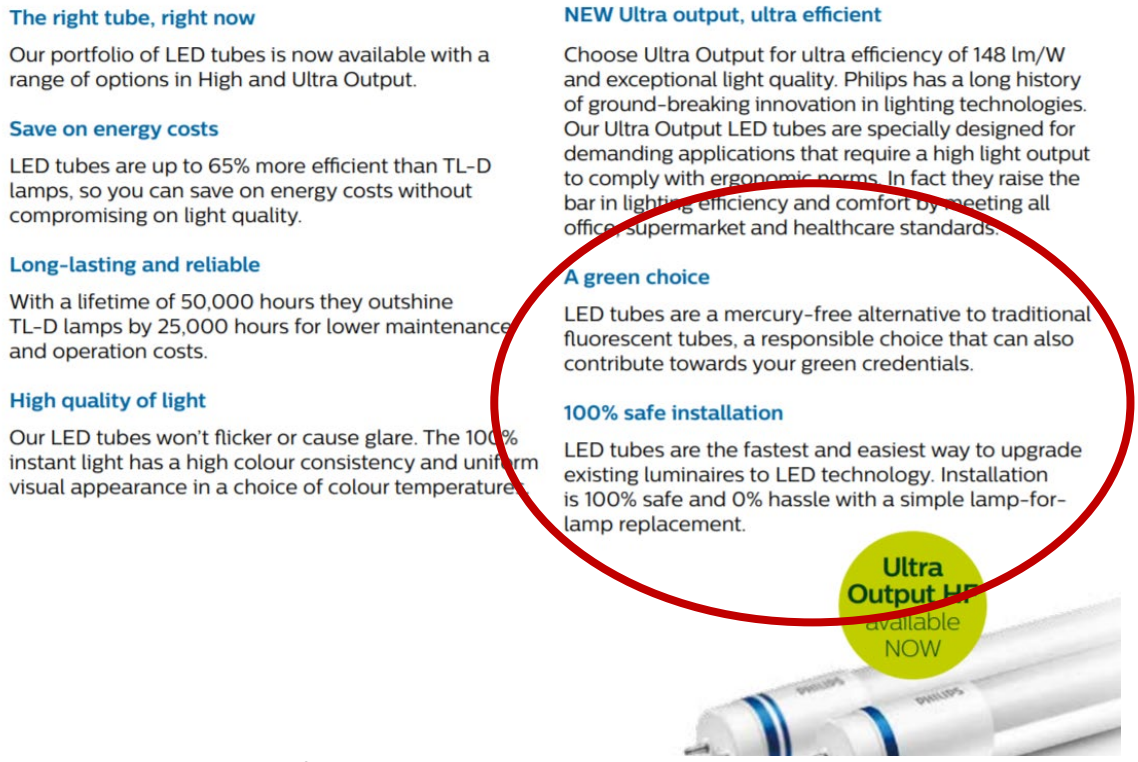


Figure 21. Philips Lighting/Signify highlighting the mercury-free alternative to fluorescent lighting

As discussed in section 3.5.3.3, there are no safety concerns for LED replacements for T8 fluorescent lamps. This conclusion is drawn from the fact that LED products have been designed for installation into existing fluorescent luminaires, thus safety issues have been included from the beginning, as indicated in the Philips information presented in Figure 21 above. The note reads: "100% safe

[77] Update of the data provided by the analysis model developed in the course of the "Study to assess socioeconomic impact of substitution of certain mercury-based lamps currently benefiting of RoHS 2 exemptions in Annex III"; by Yifaat Baron and Carl-Otto Gensch, Öko-Institut e.V., 10 July 2020.

installation LED tubes are the fastest and easiest way to upgrade existing luminaires to LED technology. Installation is 100% safe and 0% hassle with a simple lamp-for-lamp replacement". Furthermore, all LED products must comply with the requisite international safety standards, which protect for a range of consumer-related safety issues listed in section 3.5.3.3.

B.3.4 (iv) Availability of Substitutes – T8, III.2(a)(3)

Yes, there is a vast range and variety of LED replacements for T8 fluorescent lamps, spanning a wide range of CCT, CRI, wattages, light output and so-on. There are over 24,000 different models of LED replacements in the US market, which has been found to be similar to the EU market based on sampling. In terms of ballast compatibility, 96.7-99.1% of the existing T8 sockets in Europe can be met with an LED replacement today.

According to the Design Lights Consortium Quality Products List in the US, there are literally tens of thousands of different models of linear LED replacement lamps for T8 installations[79] - 24,076 different models. Although we don´t have access to a similar database for the EU, sampling on the EU market shows a similar wide catalogue of products.

For T8 lamps, when we look at multiple LED lamp manufacturers competing for the same lamp/ballast combination - we find a significant improvement in the compatibility rate compared to what we had previously reported in February 2020. Annex A provides the large table of the 262 unique electronic (high-frequency) ballasts for T8 fluorescent luminaires in Europe, and of these 89 to 97% of them are compatible with direct, drop-in replacement LED tubes.

Table 47. Retrofit T8 LED Lamp Compatibility Percentages (see Annex A)

Lamp Size	Retrofit LED Tube Manufacturer and Product	Philips, Osram, Sylvania	All
T8	Philips Corepro LEDtube HF, Instant Fit 1200mm T8 1600lm	89%	97%
	Philips Corepro LEDtube HF, Instant Fit 1500mm T8 2000lm		
	Philips Corepro LEDtube HF, Instant Fit 600mm T8 800lm		
	Philips Corepro LEDtube UN, 1200mm HO 18W8xx T8		
	Philips Corepro LEDtube UN, 1500mm HO 18W8xx T8		
	Philips MASTER LEDtube 1200mm HF HO, InstantFit T8 2100 lm		
	Philips MASTER LEDtube 1200mm Universal, Instant Fit 2500lm		
	Philips MASTER LEDtube 1500mm HF HO, Instant Fit T8 3100 lm		
	Philips MASTER LEDtube 1500mm HF UO, Instant Fit T8 3700 lm		
	Philips MASTER LEDtube 1500mm Universal, Instant Fit 3700lm		
	Philips MASTER LEDtube HF 1200mm 16.5W 833 T8 MEAT		
	Philips MASTER LEDtube HF, Instant Fit T8 600mm HF 1050lm		
	OSRAM SubstiTUBE® T8 UNIVERSAL 0.6m ADVANCED 7.5W		
	OSRAM SubstiTUBE® T8 UNIVERSAL 0.6m STAR 8W		
	OSRAM SubstiTUBE® T8 UNIVERSAL 0.6m VALUE 8W		
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.2m Advanced 14W		
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.2m Advanced UO 15W		

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

	OSRAM SubstiTUBE® T8 UNIVERSAL 1.2m Star 16W		
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.2m Value 16W		
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.5m Advanced 20W		
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.5m Advanced UO 23W		
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.5m Star 19W		
	OSRAM SubstiTUBE® T8 UNIVERSAL 1.5m Value 19W		
	Sylvania ToLEDo SUPERIA T8 ECG 2FT 1050LM/1100LM*		
	Sylvania ToLEDo SUPERIA T8 ECG 4FT 2200LM/2400LM*		
	Sylvania ToLEDo SUPERIA T8 ECG 5FT 2850LM/3100LM*		
	Sylvania ToLEDo SUPERIA T8 ECG 5FT 3300LM/3600LM*		
	Sylvania ToLEDo SUPERIA T8 UNI 2FT 1050LM/ 1100LM*		
	Sylvania ToLEDo SUPERIA T8 UNI 4FT 2200LM/ 2400LM*		
	Sylvania ToLEDo SUPERIA T8 UNI 5FT 3300LM/ 3600LM*		
	LEDs Change The World, TLED Tube 1200mm 36W HF Ballast, Dim*		
	LEDs Change The World, TLED Tube 1200mm 36W HF Ballast, Non-Dim*		
	LEDs Change The World, TLED Tube 1500mm 58W HF Ballast, Dim*		
	LEDs Change The World, TLED Tube 1500mm 58W HF Ballast, Non-Dim*		
	LEDs Change The World, TLED Tube 600mm 18W HF Ballast, Dim*		
	LEDs Change The World, TLED Tube 600mm 18W HF Ballast, Non-Dim*		
	Opple Universal T8 1200mm*		
	Opple Universal T8 1500mm*		

*Sylvania, LEDs Change The World and Opple lamps were omitted from the February 2020 calculation.

In terms of compatibility, the manufacturer catalogues indicate that their direct-replacement T8 LED lamps are compatible with approximately 89-97% of the high-frequency (electronic) T8 fluorescent ballasts installed in Europe today, and it is known that LED lamps are compatible with 100% of magnetic ballasts. Taken together then and accounting for the fact that around 70% of the T8 fixtures in Europe have a magnetic ballast and 30% have a high-frequency electronic ballast, the overall compatibility for T8 fixtures in Europe is weighting for the different market percentages, a total of 96.7 to 99.1% of T8 fluorescent fixtures in Europe today can use a direct LED replacement.

Table 48. Revised LED Lamp Compatibility Percentages for T5 and T8 Luminaires in Europe

Lamp Size	Ballast Type	Percentage of stock by ballast type	Compatibility, Low - High Estimate	Overall EU Stock Compatibility
T8	EM/CGG	70% of T8	100%*	70%
	HF/ECC	30% of T8	89% - 97%	26.7% - 29.1%
EU Total:				**96.7% - 99.1%**

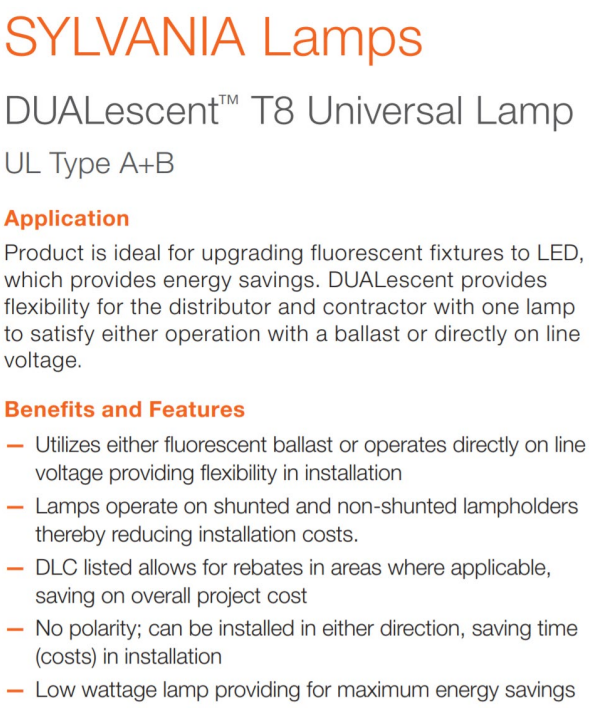
LED retrofit lamps are designed to fit into existing fluorescent fixtures to minimise inconvenience and avoid the need for rewiring. The types of LED retrofit tubes available now include lamps that can be installed directly into fixtures with the following configurations:

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

Manufacturers also offer "universal" lamp replacements, which can operate on several of these combinations of power supplies. As OSRAM[80] states in a description of one of its "universal" T8 lamps:

> *OSRAM SUBSTITUBE T8 UNIVERSAL: ONE FOR ALL*
> *With OSRAM SubstiTUBE T8 Universal, you no longer need to give any thought to the driver technology being used. The innovative all-in-one LED tube can be operated with ECG, CCG and AC mains. It not only makes it much easier for users to operate, but also eliminates the need to keep a double amount of lamps on hand. SubstiTube T8 Universal is suitable for a range of different applications thanks to a selection of three different types: Advanced Ultra Output, Advanced and Value. With a long lifetime up to 60,000 hours and a lumen output up to 3,700 lm, the Advanced Ultra Output and the Advanced models are especially suitable for supermarkets, offices, industrial and public buildings, as well as the illumination of production areas.*

Figure 22 presents marketing material from Sylvania, which offers a T8 retrofit solution[81] it describes as "ideal for upgrading fluorescent fixtures to LED." That product operates "with a ballast or directly online voltage" for a high degree of flexibility, making these lamps ideal for upgrading fluorescent installations to LED.



SYLVANIA Lamps

DUALescent™ T8 Universal Lamp

UL Type A+B

Application

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

Benefits and Features

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

Figure 22. Sylvania offers products that are ideal for upgrading fluorescent fixtures to LED

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

[80] https://www.ledvance.com/professional/products/product-stories/led-tubes-online-special/osram-substitube-t8-universal/index.jsp
[81] https://assets2.sylvania.com/media/bin/asset-7401814/asset-7401814

types are available. lists the base types and provides links to the examples we found online.

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

Table 49. SEA/CLASP research on lamp base types for Linear Fluorescent Lamps – 8 out of 9 base types exist

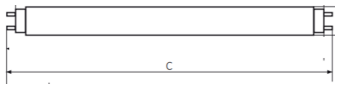
Base Type from Lighting Europe Comment	Does this Base Type Exist in a Retrofit LED Lamp?	Links to Examples of LED Lamps
Miniature Bipin	**Yes**	Link to example
Medium Bipin	**Yes**	Link to example
Single Pin	**Yes**	Link to example
Recessed Double Contact	**Yes**	Link to example
4-Pin	**Yes**	Link to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

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

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

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

Table 50. Maximum overall lengths of T8 lamps offered in Europe by the three largest global lamp manufacturers

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

Next, SEA/CLASP sought to verify whether there were indeed only five lengths of LED lamps available to replace these lengths of T8 lamps. We were able to find direct replacement LED lamps for 9 out of our 10 lengths on Amazon.DE (see Table 51)– although it should be noted that some of the suppliers offering product are not Lighting Europe members. When conducting this search, we noted that some suppliers used the overall length (C length) and others used the B length or a nominal length. The figure below illustrates the standardised measurements used for fluorescent tubes.

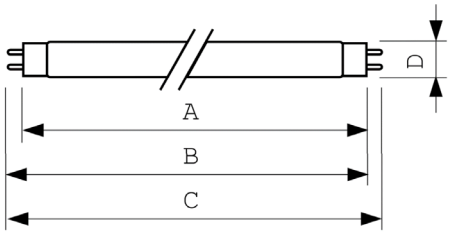


Table 51. Replacement T8 LED lamps on Amazon.DE for lengths identified

C Length	B Length	Product Description on Amazon.DE	Link to Amazon.DE
451.6 mm	438 mm	eLITe PLUS LED Röhre T8 | G13 Sockel | 1040lm | 8W | 4000K Neutralweiß | FWI: 840 | 44cm Lang | ASW: [Energieklasse A++]	Click here
484 mm	470 mm	This length was not available on Amazon.DE, therefore we contacted Zhejiang Boden Electronic Technology Co., Ltd in Zhejiang, China and confirmed that 470mm can be made, but must order 10,000 pieces.[82]	n/a
604 mm	590 mm	Osram LED Substitube Star PC T8 Leuchtstoffröhre, in 60 cm Länge mit G13-Sockel, Ersetzt 18 Watt, Kaltweiß - 4000 Kelvin, 1er-Pack [Energieklasse A+]	Click here
734 mm	720 mm	eLITe PLUS LED Röhre T8 | G13 Sockel | 1300lm | 10W | 4000K Neutralweiß | FWI: 840 | 72cm Lang | ASW: 120° [Energieklasse A++]	Click here
908.8 mm	895 mm	90 cm LED Röhre T8-G13 14 Watt, 300° AUSSTRAHLUNG, 1860 Lumen, Tageslichtweiß/ Kaltweiß 6000 Kelvin, 1:1 Ersatz für 24-30 Watt Leuchtstoffröhren - inclusive LED Starter [Energieklasse A++]	Click here
984.2 mm	970 mm	LED Röhre [kein Starter nötig!] T8 Länge 97,0 cm (!!Sondergröße!!) Leistung 16W Lumen 2240lm Lichtfarbe 4500K Farbreinheit CRI >80 Durchmesser 26mm Sockel G13 [Energieklasse A++]	Click here
1061 mm	1047 mm	Philips Master LEDtube Leuchtstofflampe Value UO T8 1047mm 16 Watt 2300 Lumen 830 3000 Kelvin warmweiß KVG/VVG drehbare Endkappe	Click here
1213.6 mm	1200 mm	Osram LED Substitube Star PC T8 Leuchtstoffröhre, in 120 cm Länge mit G13-Sockel, Ersetzt 36 Watt, Kaltweiß - 4000 Kelvin, 1er-Pack [Energieklasse A+]	Click here
1514.2 mm	1500 mm	Für EVG OHNE Starter, 150 cm LED Röhre T8 / G13, 29 Watt, 330° AUSSTRAHLUNG, 3480 LUMEN, Neutralweiß ~ 4000 Kelvin, ersetzt 58-70 Watt Leuchtstoffröhre. EVG KOMPATIBEL, TÜV zertifiziert [Energieklasse A+]	Click here
1778 mm	1764 mm	Sylvania LED-Tube T8 6Ft = 180cm = 1800mm 3240Lm 840=4000K Sockel G13 für Konventionelle Vorschaltgeräte mit Dummy-Starter [Energieklasse A+]	Click here

B.3.5 (v) Socioeconomic Impact – T8, III.2(a)(3)

Yes, there is a strong socioeconomic benefit from the installation of LED replacements for T8 fluorescent lamps, with payback periods from 0.4-0.9 years and net cumulative savings (lamps and electricity) from 2021 through 2035 of €17.7 billion Euro.

Starting from the standpoint of a single T8 socket, the authors prepared a calculation for a T8 fluorescent lamp with two different LED tubes. The table below presents our findings in relation to

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

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

Table 52. Life-Cycle Economic Analysis of T8 Lamp Replacement in Europe

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

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

Notes: Electricity price of €0.1149/kWh from Eurostat for non-domestic sector[83]. Electricity price escalation rate of 4% is applied (following the MEErP methodology). CO_2 intensity of 295.8 g CO2/kWh from European Environment Agency[84].

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

The Öko-Institute published an updated Socio Economic Assessment report on 10 July 2020 which was based on the MELISA European Lighting market model to estimate the energy and economic impact of a phase-out of T8 fluorescent lamps. The savings from a T8 phase-out in September 2021 are

[83] https://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_price_statistics#Electricity_prices_for_non-household_consumers

[84] Link to European Environment Agency graphic depicting the 2016 CO2 intensity value of 295.8g CO2/kWh.

significant, saving up to 152.3 TWh of electricity on a cumulative basis and €17.7 billion Euro in net savings (including lamp purchase costs).

Table 53. Energy & Financial Savings from Phase-Out of T8 Fluorescent Lamps in Europe [85]

Benefits of T5 phase-out in Sept. 2021	Cumulative Savings (2021-2035)
Electricity Savings	152.3 TWh
CO_2 emissions Savings	45.3 MMT CO_2
Net Financial Savings (taking into account savings on the energy bill and slightly higher lamp costs)	€17.7 billion

Source: Öko-Institute report, 10 July 2020; CO2 estimate by SEA/CLASP.

B.3.6 (vi) Impact on Innovation – T8, III.2(a)(3)

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

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

[85] Update of the data provided by the analysis model developed in the course of the "Study to assess socioeconomic impact of substitution of certain mercury-based lamps currently benefiting of RoHS 2 exemptions in Annex III"; by Yifaat Baron and Carl-Otto Gensch, Öko-Institut e.V., 10 July 2020.