Texte zu EU-Regelungen zur umweltgerechten Produktgestaltung und zur Energieverbrauchskennzeichnung in der Beleuchtung – Zusammenstellung [1] des Umweltbundesamtes (UBA), Deutschland

1194/2012/EU
874/2012/EU
245/2009/EG
§
2019/2020/EU
2019/2015/EU
244/2009/EG

Diskussion über eine künftige Änderungsverordnung (Produktgestaltung)

Anhang II Nummer 2 – SVM-Höchstwert: **Meßwerte von Energimyndigheten [2] vom 4. Februar 2020**

Hinweis: Bitte beachten Sie, daß der angehängte Text nur in Englisch verfaßt ist.

EN: Information on EU Lighting Regulations – Ecodesign and Energy Labelling – Compilation [1] of the Federal Environment Agency (UBA), Germany

Discussion of a future amending regulation (Product Design)

Annex II.2 – SVM limit value: Measured values by Energimyndigheten [2] as of 4 February 2020

FR: Informations sur réglementations de l'UE concernant l'éclairage – l'écoconception et l'étiquetage énergétique – Compilation [1] de l'Agence Fédérale de l'Environnement (UBA), Allemagne

Discussion d'un futur règlement modificatif (Conception des produit)

Annexe II, point 2 – Valeur maximale du SVM : Valeurs mesurées par Energimyndigheten [2] de 4 février 2020

Indication : Veuillez noter que le présent texte n'est disponible qu'en anglais.

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[1] https://www.eup-network.de/de/eup-netzwerk-deutschland/offenes-forum-eu-regelungen-beleuchtung/dokumente/texte/

[2] Energimyndigheten ist die staatliche Energieagentur Schwedens ◊ **EN**: Energimyndigheten is the national Energy Agency of Sweden (SEA) ◊ **FR** : Energimyndigheten et l'administration nationale suédoise de l'énergie ; https://www.energimyndigheten.se/en/

DE: ↓ EN: → page III FR : → page IV

Texte im Offenen Forum (**abc** = vorliegender Text)

- **Bestehende EG- und EU-Regelungen**
- **Studien der EU-Kommission**
- **Regelungsentwürfe**
  - Frühere Entwürfe
  - **Diskussion über eine künftige Änderungsverordnung**
    - **Vorab-Stellungnahmen und Hintergrundinformationen**
      - **Produktgestaltung Anhang II Nummer 2: SVM-Höchstwert**
        - Stellungnahme von Lighting Europe (29. März 2019) [EN]
        - Zu der Stellungnahme von Lighting Europe: Gegendarstellung von Peter Erwin (Juli 2019) [DE] [EN]
        - Meßwerte Lighting Europe (17. Dezember 2019) [EN]
        - **Meßwerte von Energimyndigheten (4. Februar 2019) [EN]**
        - Messungen im Umlaufverfahren im April 2020 – Bericht vom 30. April 2020 [DE|EN]
        - Stellungnahme von lichtfragen.info (4. Mai 2020) [DE|EN]
      - Andere Themen
    - Informelles Interessensgruppentreffen am 19. Februar 2020 *
- **Öffentliche Konsultationen auf EU-Ebene**
- **Diskussion im Offenen Forum**
- **Weitere Dokumente**

* Stand 20. März 2020: Diese Texte stehen noch nicht zur Verfügung.

Abkürzungen: ● EG = Europäische Gemeinschaft ● Energimyndigheten ist die staatliche Energieagentur Schwedens; https://www.energimyndigheten.se/en/ ● EU = Europäische Union ● SVM : Maß für die Sichtbarkeit des Stroboskopeffektes

EN

Documents in the Open Forum (**abc** = text at hand)

- **Existing EC and EU Regulations**
- **Studies of the European Commission**
- **Draft regulations**
  - Earlier drafts
  - **Discussion of a future amending regulation**
    - **Comments in advance and background information**
      - **Product design Annex II.2: SVM limit value**
        - Comments by Lighting Europe (29 March 2019) [EN]
        - Reply to Lighting Europe's comments: Peter Erwin (July 2019) [DE] [EN]
        - Measured by Lighting Europe (17 December 2019) [EN]
        - **Measured values by Energimyndigheten (4 Febraury 2019) [EN]**
        - Round Robin Test April 2020 – Report as of 30 April 2020 [DE|EN]
        - Comments by lichtfragen.info (4 May 2020) [DE|EN]
      - Other issues
    - Informal stakeholder meeting on 19 February 2020 *
- **Public Consultations at EU level**
- **Discussion in the Open Forum**
- **Further documents**

* Status as of 20 March 2020: These texts are not yet available.

Abbreviations: ● EC = European Communities ● Energimyndigheten is the national Energy Agency of Sweden (SEA); https://www.energimyndigheten.se/en/ ● EU = European Union ● SVM = Stroboscopic Visibility Measure

FR

Documents dans le forum ouvert (**abc** = présent document)

- **Règlements existants de la CE et de l’EU**
- **Études de la Commission européenne**
- **Projets de règlements**
  - Projets antérieurs
  - **Discussion d'un futur règlement modificatif**
    - **Commentaires en avance et informations de fond**
      - **Conception des produits, Annexe II, point 2 : Valeur maximale du SVM**
        - Commentaires par Lighting Europe (29 mars 2019) [EN]
        - Réponse aux commentaires de Lighting Europe : Peter Erwin (juillet 2019) [DE] [EN]
        - Valeurs mesurées par Lighting Europe (17 décembre 2019) [EN]
        - **Valeurs mesurées par Energimyndigheten (4 février 2020) [EN]**
        - Mesures dans le cadre de la procédure de circulation en avril 2020 – Rapport du 30 avril 2020 [DE|EN]
        - Commentaires de lichtfragen.info (4 mai 2020) [DE|EN]
      - Autres sujets
    - Réunion informelle des parties prenantes le 19 février 2020 *
- **Consultations publiques au niveau de l'UE**
- **Discussion dans le Forum Ouvert**
- **Autres documents**

* État au 20 mars 2020 : Ces textes ne sont pas encore disponibles.

Abréviations : ● CE = Communauté européenne ● Energimyndigheten et l'administration nationale suédoise de l'énergie ; https://www.energimyndigheten.se/en/ ● SVM : mesure de la visibilité stroboscopique ● UE = Union européenne

Es folgt ein unveränderter Originaltext.

EN: The following is an unmodified original text.

FR: Ce qui suit est un texte original.

Testing Report

Product Testing for P_{st}^{LM} and SVM

A report discussing the measured values of short-term light modulation (P_{st}^{LM}) and stroboscopic visibility measure (SVM) for six types of LED retrofit lamp types covered by the new Ecodesign lighting regulation

Foreword

This is a report providing findings from an on-going product testing study assessing the P_{st}^{LM} and SVM values for six types of retrofit LED lamps. These lamps were identified by LightingEurope as being at risk of being 'phased out' due to the stringency of the SVM requirements in the new draft lighting policy measure. The six LED lamp types investigated in this study are:

1) LEDtube – retrofit LED lamp for a linear fluorescent tube
2) LEDspot MV – mains voltage (GU10) spot lamp (PAR16)
3) Classic filament LED lamps – mains voltage A-type LED filament lamps
4) LEDcapsule G9 – mains voltage LED retrofit for G9 halogen capsules
5) LEDlinear R7s – LED replacement lamp for linear R7s halogen lamps
6) LEDspot PAR – LED retrofit lamp for PAR38 reflector lamp

A final report on our test results will be prepared and circulated after the Technical Workshop in February 2020. We invite stakeholders to comment on this draft report. Any questions about this work should be directed to Peter Bennich at the Swedish Energy Agency.

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Acronyms and Abbreviations

CE	Conformité Européenne
CRI	Colour Rendering Index
DTU	Technical University of Denmark
EMC	Electromagnetic Compatibility
EU	European Union
HID	High Intensity Discharge
IEC	International Electrotechnical Commission
LED	Light Emitting Diode
MLS	Mains-connected Light Source
OLED	Organic Light Emitting Diode
P_{st}^{LM}	Short Term Light Modulation
SVM	Stroboscopic Visibility Measure
UBA	German Federal Environment Agency

1 Introduction

On 17 December 2018, the Member State representatives of the Ecodesign Regulatory Committee met in Brussels to discuss the European Commission's draft policy measure for lighting. This policy measure brings together three ecodesign regulations of lighting products into one measure, incorporating requirements for domestic and professional applications, and encompassing all lighting technologies, from incandescent through to light emitting diode (LED).

Member State Representatives debated and discussed the regulation, and the key requirements contained therein. The amended draft policy measure was agreed by a majority of EU Member States, and on 7 February 2019 the Commission forwarded it to the European Council and Parliament. There was no objection in the Environment Committee, therefore no vote was held. The scrutiny period ended on 7 May 2019, and no feedback had been given to the Commission, which is understood to be the equivalent of approval. The Regulation was adopted by the College, and the policy was published in the Official Journal of the European Union on 5 December 2019 and entered into force 20 days later on 25 December 2019.[1]

The European Commission's draft lighting regulation under the Ecodesign Directive sets out mandatory product performance and quality requirements on all lighting products placed on the market in Europe starting on 1 September 2021. The title of the measure is as follows:

> *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).*

In Annex I, Definitions applicable for the Annexes, the terms flicker and stroboscopic effect are defined as follows:

(50) 'flicker' means the perception of visual unsteadiness induced by a light stimulus, the luminance or spectral distribution of which fluctuates with time, for a static observer in a static environment. The fluctuations can be periodic and non-periodic and may be induced by the light source itself, the power source or other influencing factors.

The metric for flicker used in this Regulation is the parameter 'P_{st}^{LM}', where 'st' stands for short term and 'LM' for light flickermeter method, as defined in standards. A value P_{st}^{LM} =1 means that the average observer has a 50 % probability of detecting flicker;

[1] 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

(51) ‘stroboscopic effect’ means a change in motion perception induced by a light stimulus, the luminance or spectral distribution of which fluctuates with time, for a static observer in a non-static environment. The fluctuations can be periodic and non-periodic and may be induced by the light source itself, the power source or other influencing factors.

The metric for the stroboscopic effect used in this Regulation is the ‘SVM’ (stroboscopic visibility measure), as defined in standards. SVM = 1 represents the visibility threshold for an average observer;

In Annex II, Table 4 of the draft policy measure for light sources and separate control gear, requirements for maximum allowable levels of P_{st}^{LM} and SVM are given. The limits applied to all LED and OLED light sources are as follows:

- P_{st}^{LM} ≤ 1,0 at full-load
- SVM ≤ 0,4 at full-load (except for HID with Φ_{use} > 4 klm and for light sources intended for use in outdoor applications, industrial applications or other applications where lighting standards allow a CRI<80)

LightingEurope has expressed concern about the level of ambition associated with the SVM requirements in the policy measure and on 29 March 2019, they issued four documents on this topic. These four documents were published by the Federal Environment Agency (UBA) in Germany, and can be downloaded by clicking on this link. The four documents are:

a) SVM ≤ 0.4: Simple Explanation
b) SVM ≤ 0.4: Impact on LED & OLED mains-connected light sources (MLS)
c) Stroboscopic effect: Visibility, Acceptability and Health concern
d) Stroboscopic effect: List of references

In these documents, LightingEurope warns that LED lighting products cannot be produced which meet these stringent SVM requirements along with the other regulatory requirements such as the Electromagnetic Compatibility Directive, while conforming to the small form-factor necessary for these lamps to fit into existing luminaires.

As products currently on the market are not sold with information relating to SVM and P_{st}^{LM}, there has been until now limited evidence as to the quantities of compliant LED products on the market. To provide some evidence and address the concerns of industry, several countries decided to work together, to purchase LED lamps from across the European markets and conduct laboratory testing on these lamps to better understand the concerns expressed by LightingEurope. In Europe, the countries working together on this testing study are Denmark, Sweden and the United Kingdom. Australia has also supported the work, with test data on “CE” marked products offered for sale in Australia (which has nominally the same AC mains voltage and frequency as Europe). The countries also obtained test data from CLASP Europe, who had contracted a UK laboratory to conduct testing on 60 A-type lamps in November 2018.

This document presents the findings of our on-going research on a variety of different lamp types. A final report will be prepared when the testing is complete. Ultimately, this study is intended to serve as part of the ‘evidence base’ to support decision-makers by providing product test data relating to LED light sources in the market.

The structure of this Interim Report is as follows:

Chapter 2. Issue: Summary of the Problem Statement from Industry

Chapter 3. Methodology: Market Research and Laboratories

Chapter 4. Findings: Test Results by Lamp Type

Chapter 5. Conclusions and Discussion

2 Issue: Summary of the Problem Statement from Industry

The clearest way to summarise the position of LightingEurope is to reproduce a few of their slides that were published by the Federal Environment Agency in Germany (click here to download the files). These slides convey what LightingEurope expects to happen if the SVM requirement on LED lamps and luminaires is upheld.

LightingEurope writes that many popular retrofit LED lamps will be unintentionally phased out from the market due to the proposed stringent requirement of SVM ≤ 0.4.

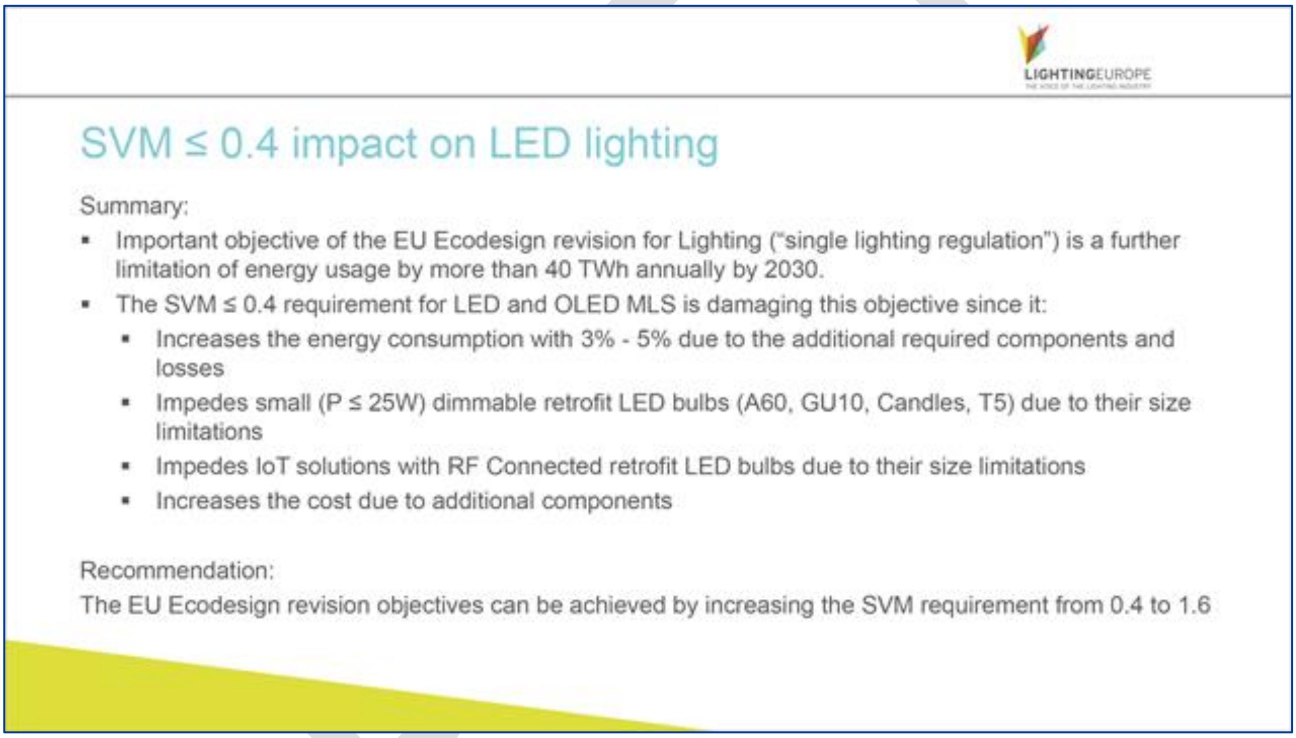


Figure 1. Summary of LightingEurope position and request for revised SVM level

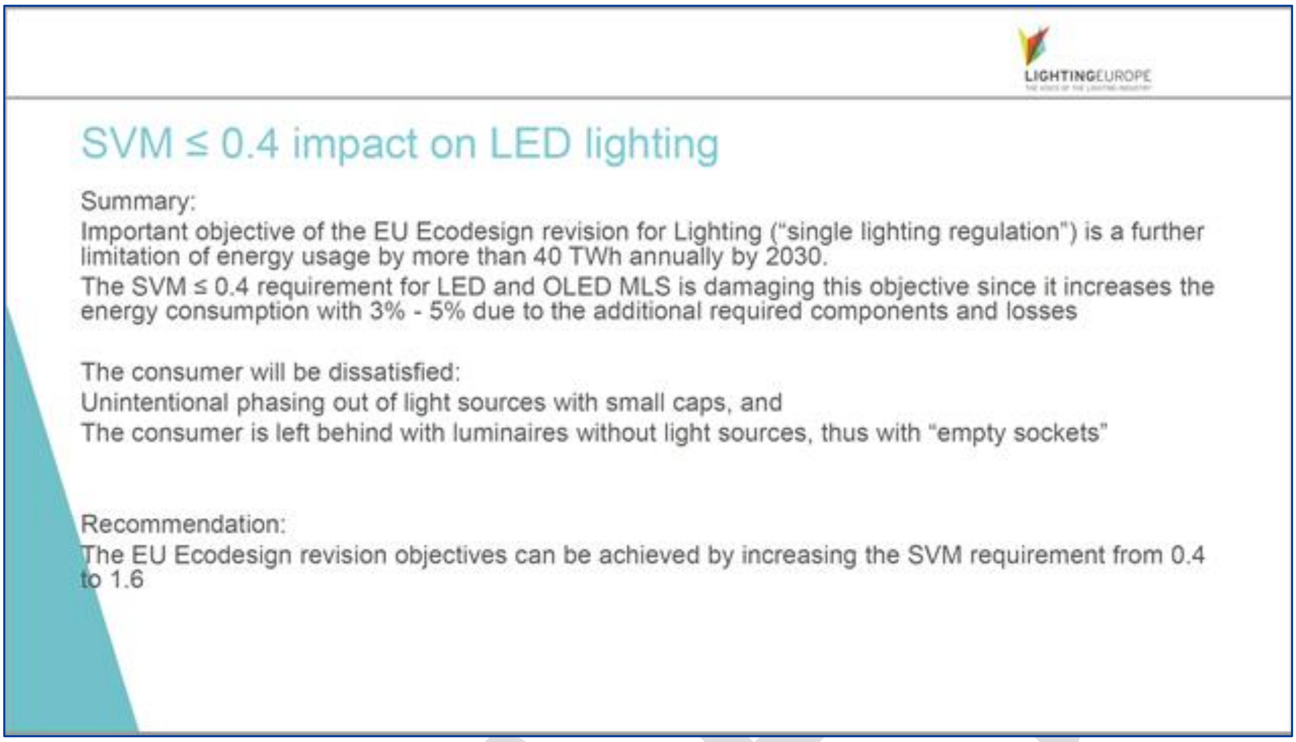


Figure 2. Summary of LightingEurope expected impact of SVM requirement

On the slide depicted in Figure 3, it reads: "*The LED replacement light sources of these product families are unintentionally phased out due to too strict SVM requirements*." LightingEurope notes that "The electronics for 'very strict SVM' do not fit in the cap."

Figure 3. Product families LightingEurope expects to be "unintentionally phased out" due to SVM requirements

Figure 4. Additional product families LightingEurope expects to be "unintentionally phased out" due to SVM requirements

LightingEurope then continues by saying that luminaires across Europe which use these lamp types will be left with "empty sockets" because no LED products will be available that can meet these strict SVM requirements. The six retrofit LED lamp types identified by LightingEurope to be at risk are:

1) LEDtube – retrofit LED lamp for a linear fluorescent tube
2) LEDspot MV – mains voltage (GU10) spot lamp (PAR16)
3) Classic filament LED lamps – mains voltage A-type LED filament lamps
4) LEDcapsule G9 – mains voltage LED retrofit for G9 halogen capsules
5) LEDlinear R7s – LED replacement lamp for linear R7s halogen lamps
6) LEDspot PAR – LED retrofit lamp for PAR38 reflector lamp

These six lamp types are the ones that were investigated in this study.

3 Methodology: Market Research and Laboratories

The countries working together decided to purchase and test LED retrofit lamps in all six categories identified by LightingEurope as being at risk. Purchasing was coordinated between the governments and that the testing burden was shared. This interim report provides the data and progress to date. A final version of this report incorporating the findings from additional research being conducted now will be prepared for circulation with all stakeholders after the Technical Meeting in February 2020.

LED retrofit lamps were purchased from retailers (both in-store and on-line) in the following countries:

- Belgium
- Denmark
- France
- The Netherlands
- Sweden
- United Kingdom

Additionally, lamps were purchased in Australia by the Australian government for benchmark testing and were included in this analysis if they had a “CE” mark. The CE mark is a manufacturer’s declaration of conformity that the lamp complies with all the European regulatory requirements. Given that Australian households have nominally the same AC mains voltage and frequency, these models were considered relevant to the study.

Table 1 presents the two technical reports from the International Electrotechnical Commission (IEC) that contained the test methods used to measure P_{st}^{LM} and SVM in the samples.

Table 1. Test Methods used by the labs to measure P_{st}^{LM} and SVM

Metric	Test Method
P_{st}^{LM}	IEC TR 61547-1:2017 “Technical Report: Equipment for general lighting purposes – EMC immunity requirements – Part 1: An objective voltage fluctuation immunity test method.”
SVM	IEC TR 63158-1:2018 “Technical Report: Equipment for general lighting purposes - Objective test method for stroboscopic effects of lighting equipment.”

Table 2 identifies the four laboratories where the testing was conducted in Australia, Denmark, Sweden and the United Kingdom.

Table 2. Laboratories that measured P_{st}^{LM} and SVM

Denmark	Sweden
The Technical University of Denmark – DTU - Fotonik Risø Campus Frederiksborgvej 399 Building 130 4000 Roskilde Denmark	Statens Energimyndighet Testlab Rosenlundsgatan 9 SE-118 53 Stockholm Sweden
United Kingdom	**Australia**
Lux-TSI Unit 1B Pencoed Technology Park Pencoed, Bridgend CF35 5AQ Wales United Kingdom	LEDLab - Light Emission Distribution Laboratory 4/140 George Street Hornsby, NSW, 2077 Australia LightLab International 50 Redcliffe Gardens Drive Clontarf QLD 4019 Australia In addition, some bench-top assessments were conducted by Light Naturally, Suite 1B/17 Peel Street, Brisbane, Australia.

Approximately half of the lamp models reported in this study were purchased in small batches of 3 units. The reported test result then used in this study is the average of those three units. Other lamp models were simply one unit purchased, tested and reported. Dimmable versions of the lamps had their P_{st}^{LM} and SVM tested at full-load, as per the requirements given in the draft regulation (Table 4, Annex II Ecodesign Requirements).

Out of a sample of 30 models tested with a sample size of 3 units each (i.e., a total of 90 lamps), the deviation between individual models was found to be extremely small, except for the P_{st}^{LM} measurement of one lamp (TP0012[2]). Figure 5 presents the distribution of sample average and min/max for each model shown with bars above and below the model average. Given that these deviations are so small – in most cases, the min/max values above and below the model average aren't even visible in the graph - we decided to report the sample (n=3) averages and the individual (n=1) test results in the same graphs. Please note the difference in the scale of the Y-axes.

[2] The three samples of TP0012 showed large variations on especially PstLM, and the measurements were repeated which showed consistent results.

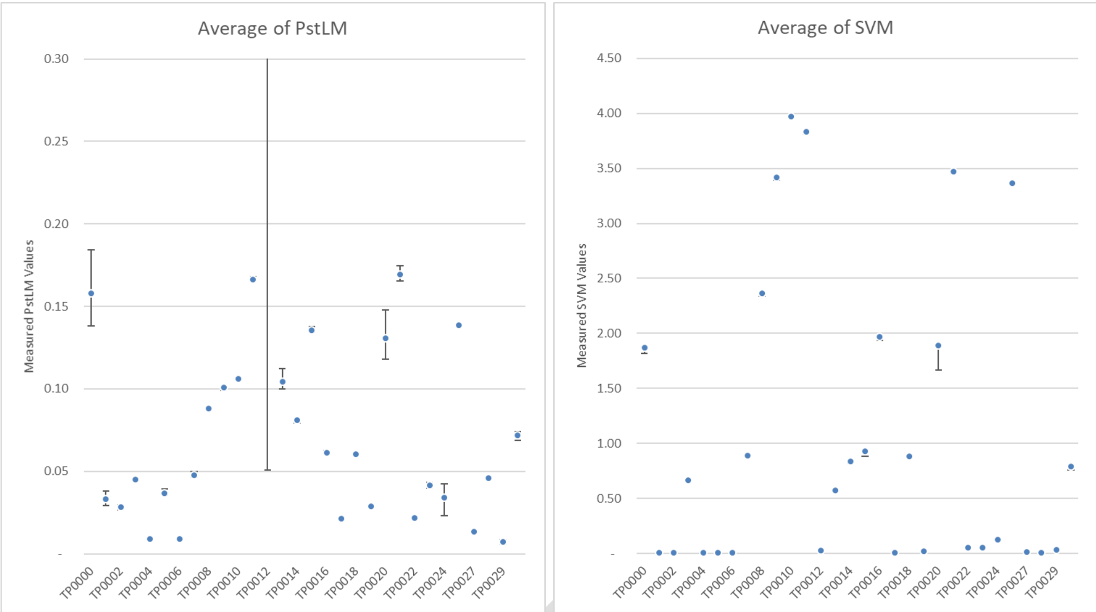


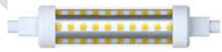
Figure 5. Scatter plot of averages with bars representing maximum and minimum measurements of P_{st}^{LM} and SVM values (separately) of 30 LED lamp models tested by DTU Fotonik

Finally, note that our work on this topic is continuing, and we will be updating this report in the future with the findings from our on-going research, including additional purchasing and testing of the LED retrofit lamp types of interest (i.e., some of the tables and graphs in this report will be updated) and continuing to study the circuit designs used in lamps with low and high SVM levels to enable us to make recommendations in the future as to good design practice for compliance.

4 Test Results for the Six Lamp Types

As discussed in Chapter 2, there are six lamp types which LightingEurope expressed concerns would be “phased out” due to the new SVM requirement.

Table 3. List of LED retrofit lamp types that LightingEurope considers to be at risk

Lamp Type Considered	Picture
LEDtube – retrofit LED lamp for a linear fluorescent tube	
LEDspot MV – mains voltage (GU10) spot lamp (PAR16)	
Classic filament LED lamps – mains voltage A-type LED filament lamps	
LEDcapsule G9 – mains voltage LED retrofit for G9 halogen capsules	
LEDlinear R7s – LED replacement lamp for linear R7s halogen lamps	
LEDspot PAR – LED retrofit lamp for PAR38 reflector lamp	

In this chapter we present the findings from the testing conducted on lamps from all of those categories by the lighting laboratories in the four countries. In total, over 100 models of LED retrofit lamps (more than 200 individual units) across the six categories were tested to measure their P_{st}^{LM} and SVM levels. The tables of test results are sorted in ascending values of SVM. The tables incorporate three different colours of shading, as described in Table 4.

Table 4. Key depicting the colour shading used in the test results tables in Chapter 4

Shading	Description	Values
(green)	Lamp is compliant with the new draft lighting regulation	$P_{st}^{LM} \leq 1.0$ and SVM ≤ 0.4
(yellow)	Lamp(s) that would be added if LightingEurope’s request to raise SVM to 1.6 is adopted	$P_{st}^{LM} \leq 1.0$ and SVM ≤ 1.6
(red)	Lamps that fail either P_{st}^{LM} or SVM requirements, even the higher SVM requested by LightingEurope	$P_{st}^{LM} > 1.0$ or SVM > 1.6

4.1 LEDtube – LED Retrofit for Tubular Fluorescent Lamps

The LED retrofit tube market has some models that are already compliant with the regulation and some that are not. There are models which far exceed the P_{st}^{LM} and SVM requirements in the draft regulation. Other models comply with slightly higher P_{st}^{LM} values. There were no models of T8 or T5 in our sample which were marketed as dimmable. Nine of them said they were not and two were not declared. There were five models in our sample of eleven which did not comply with the two requirements of P_{st}^{LM} and SVM. Only one model in this sample would be added if the SVM limit were raised to 1.6.

Table 5. Measured P_{st}^{LM} and SVM for tubular LED lamps that replace fluorescent lamps

Lab ID Code	Type	Dimmable	P_{st}^{LM}	SVM
TP0029	T8	No	0.007	0.030
TP0022	T8	Not declared	0.022	0.053
TP0023	T8	Not declared	0.042	0.055
TP0024	T5	No	0.034	0.127
LNLED180	T8	No	0.686	0.160
LNLED184	T8	No	0.861	0.172
LNLED182	T8	No	0.983	1.185
LNLED181	T8	No	1.113	1.818
TP0020	T8	No	0.131	1.893
TP0026	T8	No	0.139	3.366
TP0021	T8	No	0.170	3.471

Figure 6 depicts these 11 models on a graph of P_{st}^{LM} and SVM. Blue dots appearing in the green region within the orange box are compliant with the requirements in the draft regulation. Those above the box and to the right of it do not comply.

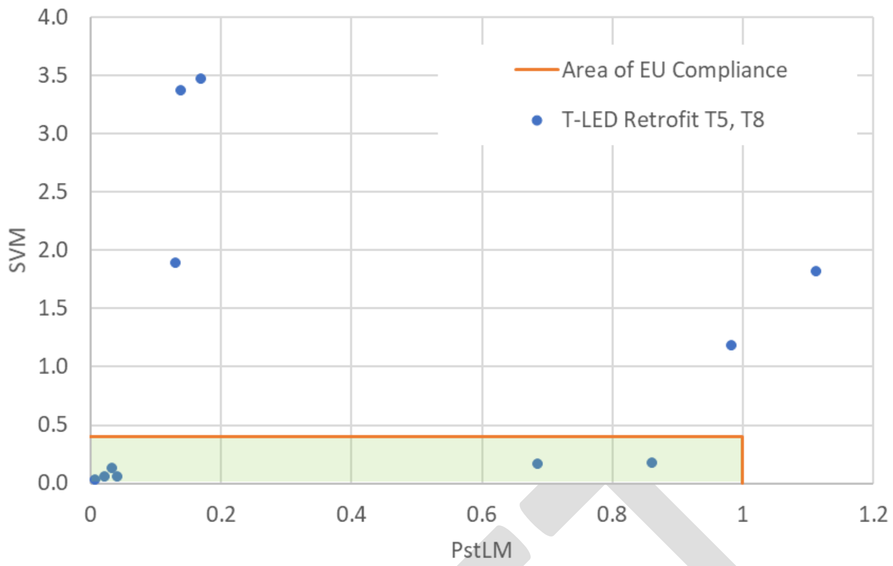


Figure 6. Plot of the T-LED Retrofit Lamps depicting the measured P_{st}^{LM} and SVM

Table 6. Summary analysis for the tubular LED retrofit lamps

Factor and Requirement	Passing and Percentage
Total number of models in the sample	***11 models***
Models with $P_{st}^{LM} \leq 1.0$ and SVM ≤ 0.4	6 (54%)
Additional models if $P_{st}^{LM} \leq 1.0$ and limit on SVM ≤ 1.6	1 (9%)
Models with $P_{st}^{LM} > 1.0$ or SVM > 1.6	4 (36%)
Total number of dimmable models in the sample	***0 models***
Models with $P_{st}^{LM} \leq 1.0$ and SVM ≤ 0.4	n/a
Additional models if $P_{st}^{LM} \leq 1.0$ and limit on SVM ≤ 1.6	n/a
Models with $P_{st}^{LM} > 1.0$ or SVM > 1.6	n/a

4.2 LEDspot MV – Mains Voltage (GU10) Spot Lamp (PAR16)

LED GU10 (mains voltage) spot lamps have a small form factor, but manufacturers have been able to design drivers that already comply with the P_{st}^{LM} and SVM requirements in both dimmable and non-dimmable models. Table 7 and Table 8 below list the GU10 LED PAR 16 lamps that were tested by the laboratories. In total, there were 36 different models tested, 16 non-dimmable and 20 dimmable models.

As shown by the coloured shading in Table 7, 12 of the 16 non-dimmable lamps already meet the P_{st}^{LM} and SVM requirements in the draft regulation. If the level for SVM were increased to 1.6, it would add two more models to the 12 that pass at 0.4. There was one model with a high P_{st}^{LM} (1.072) and one that had a high SVM (1.976).

Table 7. Measured P_{st}^{LM} and SVM for Mains Voltage (GU10) Spot Lamps (PAR16) – Non-Dimmable

Lab ID Code	Type	Dimmable?	P_{st}^{LM}	SVM
LNLED179	PAR16	No	0.921	0.000
3286-1	PAR16	No	0.017	0.002
LNLED003	PAR16	No	0.053	0.002
3307-1	PAR16	No	0.011	0.003
LNLED129	PAR16	No	0.015	0.006
LNLED153	PAR16	No	0.037	0.006
TP0004	PAR16	No	0.009	0.006
SB5	PAR16	No	0.025	0.008
LNLED099	PAR16	No	0.033	0.008
LNLED128	PAR16	No	0.024	0.011
3279-1	PAR16	No	0.019	0.013
LNLED097	PAR16	No	0.079	0.013
LNLED177	PAR16	No	1.072	0.119
LNLED174	PAR16	No	0.822	0.916
LNRD017	PAR16	No	0.084	1.446
LNRD019	PAR16	No	0.087	1.976

For dimmable lamps, Table 8 shows that 10 of the 20 dimmable lamps already meet the P_{st}^{LM} and SVM requirements in the draft regulation. Raising the limit of SVM to 1.6, would add 9 more models to the 10 that pass at the 0.4 level. One dimmable GU10 lamp is shaded red due to its SVM of 1.869 and no lamps failed due to P_{st}^{LM}.

Table 8. Measured P_{st}^{LM} and SVM for Mains Voltage (GU10) Spot Lamps (PAR16) – Dimmable

Lab ID Code	Type	Dimmable?	P_{st}^{LM}	SVM
LNRD036	PAR16	Yes	0.017	0.002
3275-1	PAR16	Yes	0.024	0.002
3275-3	PAR16	Yes	0.025	0.003
TP0005	PAR16	Yes	0.037	0.004
TP0001	PAR16	Yes	0.033	0.004
TP0002	PAR16	Yes	0.029	0.004
3350-1	PAR16	Yes	0.009	0.011
3349-3	PAR16	Yes	0.015	0.026
LNLED189	PAR16	Yes	0.189	0.055
LNRD018	PAR16	Yes	0.034	0.335
LNLED146	PAR16	Yes	0.055	0.632
LNLED098b	PAR16	Yes	0.051	0.634
TP0003	PAR16	Yes	0.045	0.664
3306-3	PAR16	Yes	0.023	0.712
3306-1	PAR16	Yes	0.030	0.758
3305-1	PAR16	Yes	0.031	0.782
TP0030	PAR16	Yes	0.072	0.791
LNRD035	PAR16	Yes	0.065	0.926
LNLED035	PAR16	Yes	0.766	1.096
TP0000	PAR16	Yes	0.158	1.869

Figure 7 depicts these 36 models on a graph of P_{st}^{LM} and SVM. Those dots which appear in the green region within the orange box are already compliant with the requirements in the draft regulation. The blue dots depict the dimmable lamps and the green dots are the non-dimmable ones. Note: not all models are visible in the graph, as the axes are zoomed in on the lower values for the lamps, in order to see where the models fall.

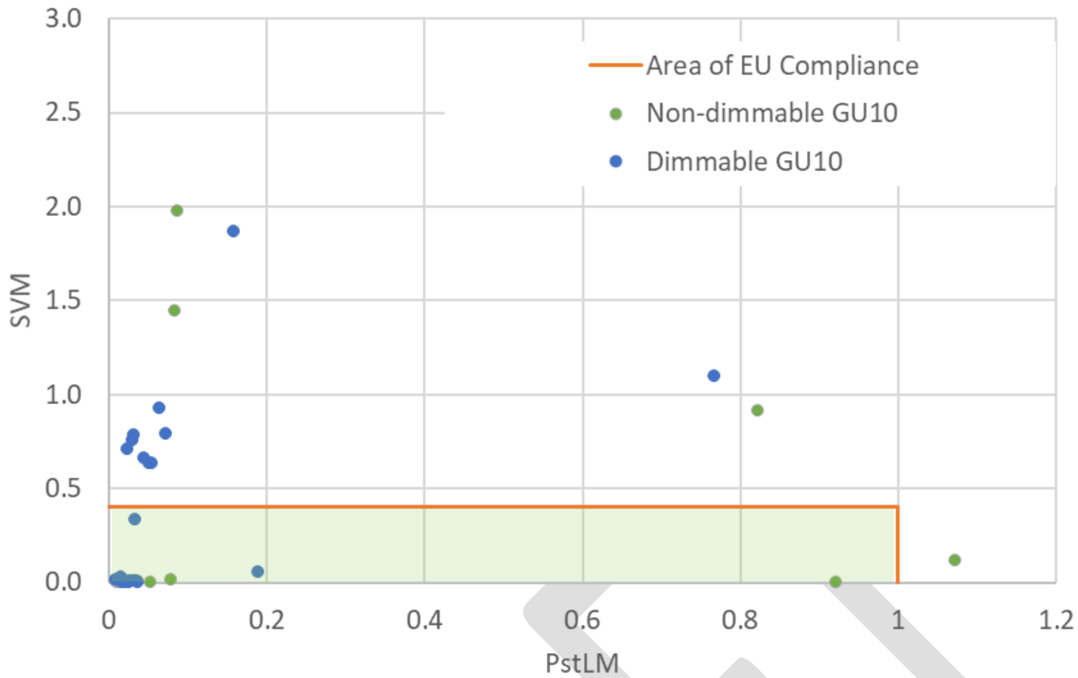


Figure 7. Plot of the PAR16 GU10 Lamps depicting the measured P_{st}^{LM} and SVM

Table 9. Summary analysis for the GU10 PAR16 retrofit lamps

Factor and Requirement	Passing and Percentage
Total number of models in the sample	***36 models***
Models with P_{st}^{LM} ≤ 1.0 and SVM ≤ 0.4	22 (62%)
Additional models if P_{st}^{LM} ≤ 1.0 and limit on SVM ≤ 1.6	11 (30%)
Models with P_{st}^{LM} > 1.0 or SVM > 1.6	3 (8%)
Total number of dimmable models in the sample	***20 models***
Models with P_{st}^{LM} ≤ 1.0 and SVM ≤ 0.4	10 (50%)
Additional models if P_{st}^{LM} ≤ 1.0 and limit on SVM ≤ 1.6	9 (45%)
Models with P_{st}^{LM} > 1.0 or SVM > 1.6	1 (5%)

4.3 Classic filament LED lamps – mains voltage A-type LED filament lamps

The classic filament LED lamps are based on the design of an incandescent or halogen lamps, whereby the lamp operates on mains voltage, but the driver is usually wholly contained in the end cap. Even though the end cap (B22, E27) is very small, we found that most of the tested lamps already comply with the P_{st}^{LM} and SVM requirements in both dimmable and non-dimmable models. The two tables below list the lamps that were tested for this study. In total, 17 non-dimmable models and 8 dimmable models were tested.

As shown in Table 10, 15 of the 17 non-dimmable model lamps already meet the P_{st}^{LM} and SVM requirements in the draft regulation. If the level for SVM were increased to

1.6 as requested by LightingEurope, it would not enable any additional models to pass the SVM level. Two models fail, one on SVM only and the other on P_{st}^{LM} and SVM. The SVM scores for these two models that failed are 4.79 and 5.60.

Table 10. Measured P_{st}^{LM} and SVM for Clear A-Type Lamps, LED Filament, Non-Dimmable

Lab ID Code	Type	Dimmable?	P_{st}^{LM}	SVM
LNRD009	A type, filament	No	0.023	0.002
TI-20101(DE14)	A type, filament	No	0.015	0.003
TI-20124(FR9)	A type, filament	No	0.017	0.003
TI-20124(FR14)	A type, filament	No	0.015	0.003
TI-20101(DE19)	A type, filament	No	0.013	0.004
TI-20124(FR20)	A type, filament	No	0.017	0.004
TI-20124(FR8)	A type, filament	No	0.022	0.004
TI-20101(DE2)	A type, filament	No	0.015	0.004
TI-20124(FR5)	A type, filament	No	0.016	0.005
TI-20101(DE3)	A type, filament	No	0.013	0.006
TI-20101(DE13)	A type, filament	No	0.020	0.008
TI-20101(DE17)	A type, filament	No	0.014	0.012
TI-20124(FR19)	A type, filament	No	0.021	0.059
LNLED170(a-k)	A type, filament	No	0.928	0.152
TI-20019(UK18)	A type, filament	No	0.117	0.273
LNLED169(a-k)	A type, filament	No	1.020	4.790
LNLED171(a-k)	A type, filament	No	0.832	5.600

In Table 11, the coloured shading indicates 3 of the 8 dimmable lamps already meet the PstLM and SVM requirements in the draft regulation. If the level SVM were increased to 1.6, it would add 1 more model to the 3 that pass at the 0.4 level. There were four models that failed, one of which had a very high SVM score. The P_{st}^{LM} values were all well within the limits established by the regulation.

Table 11. Measured P_{st}^{LM} and SVM for Clear A-Type Lamps, LED Filament, Dimmable

Lab ID Code	Type	Dimmable?	P_{st}^{LM}	SVM
3272-1	A type, filament	Yes	0.014	0.016
3272-3	A type, filament	Yes	0.012	0.017
LNRD002	A type, filament	Yes	0.069	0.119
TI-20101(DE15)	A type, filament	Yes	0.039	1.199
LNRD042	A type, filament	Yes	0.088	1.677
3348-1	A type, filament	Yes	0.046	2.008
TI-20124(FR10)	A type, filament	Yes	0.053	2.430
3347-1	A type, filament	Yes	0.103	5.016

The figure below depicts all 25 models of A-type LED filament lamps on a graph of P_{st}^{LM} and SVM. Those dots which appear in the green region within the orange box are already compliant with the requirements in the draft regulation. The P_{st}^{LM} values were all within the limit set by the regulation ($P_{st}^{LM} \leq 1.0$). Note: not all models are visible in the graph, as the axes are zoomed in on the lower values for the lamps, in order to see where the models fall.

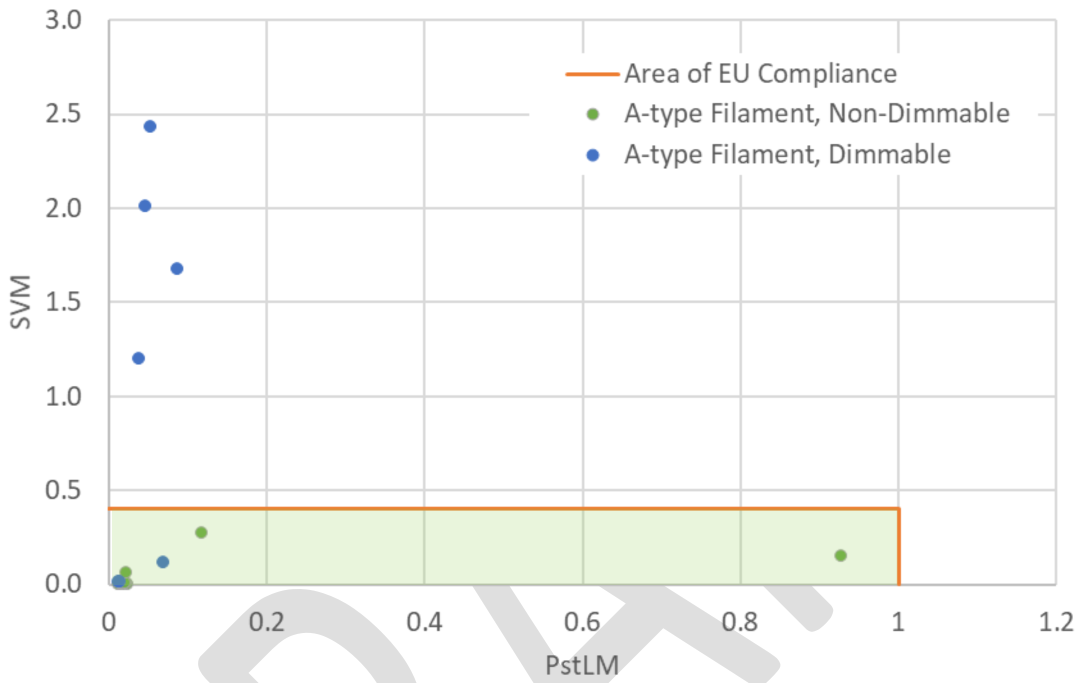


Figure 8. Plot of the A-type LED Filament Lamps depicting Measured P_{st}^{LM} and SVM

Table 12. Summary analysis for the A-type LED Filament retrofit lamps

Factor and Requirement	Passing and Percentage
Total number of models in the sample	***25 models***
Models with $P_{st}^{LM} \leq 1.0$ and SVM ≤ 0.4	18 (72%)
Additional models if $P_{st}^{LM} \leq 1.0$ and limit on SVM ≤ 1.6	1 (4%)
Models with $P_{st}^{LM} > 1.0$ or SVM > 1.6	6 (24%)
Total number of dimmable models in the sample	***8 models***
Models with $P_{st}^{LM} \leq 1.0$ and SVM ≤ 0.4	3 (38%)
Additional models if $P_{st}^{LM} \leq 1.0$ and limit on SVM ≤ 1.6	1 (12%)
Models with $P_{st}^{LM} > 1.0$ or SVM > 1.6	4 (50%)

4.4 LEDcapsule G9 – mains voltage LED retrofit for G9 halogen capsules

The G9 capsule LED lamps are designed as a direct (mains voltage) replacement for small G9 halogen lamps. Even though the form factor for this lamp is very small, we found both dimmable and non-dimmable G9 capsule LED lamps which are on the market today which already comply with the P_{st}^{LM} and SVM requirements. The two tables below present our findings for this study, where we tested 7 non-dimmable and 16 dimmable G9 capsule LED lamp models.

Table 13 shows that for the non-dimmable G9 capsules, 5 out of 7 models already meet the P_{st}^{LM} and SVM requirements in the draft regulation. If the level SVM were increased to 1.6, it would not enable any additional models to pass. There were two models that failed, one of which had a very high SVM score, greater than 4.5.

Table 13. Measured P_{st}^{LM} and SVM for G9 capsule LED lamps, non-dimmable

Lab ID Code	Type	Dimmable?	P_{st}^{LM}	SVM
LNRD039	Capsule	No	0.000	0.000
3310-1	Capsule	No	0.011	0.003
LNRD023	Capsule	No	0.026	0.006
3309-1	Capsule	No	0.004	0.006
TP0006	Capsule	No	0.009	0.006
LNRD021	Capsule	No	0.075	2.063
LNRD022	Capsule	No	0.183	4.596

Table 14 depicts the 16 dimmable G9 capsules tested. Of these, two models meet the P_{st}^{LM} and SVM requirements in the draft regulation. If the limit on SVM were increased to 1.6, it would enable 1 more model to pass. There were 13 models that failed to meet the requirements, all of which failed on SVM.

Table 14. Measured P_{st}^{LM} and SVM for G9 capsule LED lamps, dimmable

Lab ID Code	Type	Dimmable?	P_{st}^{LM}	SVM
3343-1	Capsule	Yes	0.032	0.046
3343-3	Capsule	Yes	0.030	0.051
TP0007	Capsule	Yes	0.048	0.890
3093-15	Capsule	Yes	0.071	1.788
3093-16	Capsule	Yes	0.055	1.985
LNRD038	Capsule	Yes	0.130	1.998
3344-1	Capsule	Yes	0.048	2.267
TP0008	Capsule	Yes	0.088	2.366
TP0009	Capsule	Yes	0.101	3.420
TP0011	Capsule	Yes	0.166	3.835
TP0010	Capsule	Yes	0.106	3.971
LNRD041	Capsule	Yes	0.181	4.063
LNRD034	Capsule	Yes	0.189	4.698
3342-1	Capsule	Yes	0.096	4.787
LNRD033	Capsule	Yes	0.200	5.073
LNRD040	Capsule	Yes	0.183	5.175

Of the 23 LED G9 capsules tested, 7 were found to already comply with the P_{st}^{LM} and SVM requirements in the draft regulation. Of these, 5 models were non-dimmable and

2 models were dimmable. This seems to indicate that it is harder to make a dimmable G9 capsule which meets the requirements, but it is certainly possible. The P_{st}^{LM} values were all within the limit set by the regulation ($P_{st}^{LM} \leq 1.0$).

Figure 9 depicts these 23 models on a graph of P_{st}^{LM} and SVM. Those dots which appear in the green region within the orange box are already compliant with the requirements in the draft regulation. Note: not all models are visible in the graph, as the axes are zoomed in on the lower values for the lamps, in order to see where the models fall.

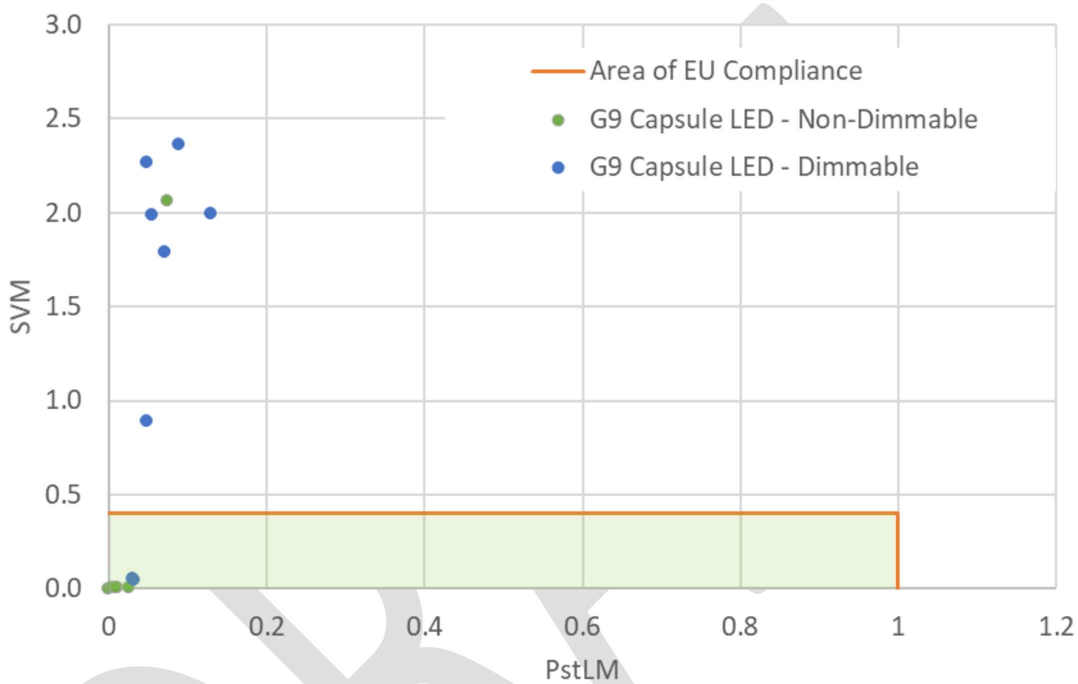


Figure 9. Plot of the G9 capsule LED lamps depicting measured PstLM and SVM

Table 15. Summary analysis for the G9 capsule LED retrofit lamps

Factor and Requirement	Passing and Percentage
Total number of models in the sample	***23 models***
Models with $P_{st}^{LM} \leq 1.0$ and SVM ≤ 0.4	7 (30%)
Additional models if $P_{st}^{LM} \leq 1.0$ and limit on SVM ≤ 1.6	1 (4%)
Models with $P_{st}^{LM} > 1.0$ or SVM > 1.6	15 (65%)
Total number of dimmable models in the sample	***16 models***
Models with $P_{st}^{LM} \leq 1.0$ and SVM ≤ 0.4	2 (12%)
Additional models if $P_{st}^{LM} \leq 1.0$ and limit on SVM ≤ 1.6	1 (6%)
Models with $P_{st}^{LM} > 1.0$ or SVM > 1.6	13 (81%)

4.5 LEDlinear R7s – LED replacement lamp for linear R7s halogen lamps

The R7s retrofit lamps are designed to replace the R7s (double-ended) halogen lamps used in luminaires such as wall-washers, torchieres and security lighting. These lamps operate on mains voltage and have a very restricted form factor. For this study, we purchased and tested five models of R7s lamp, including one non-dimmable and four dimmable lamps. The table below lists the lamps that were tested for this study.

The non-dimmable model passed with very low values for both P_{st}^{LM} and SVM. For the dimmable models, one model passed the draft regulation requirements of both P_{st}^{LM} and SVM. Two additional models would pass if the SVM limit were raised to 1.6. One model would not pass a higher SVM limit of 1.6 because the measured SVM was 1.966.

Table 16. Measured P_{st}^{LM} and SVM for R7s LED Lamps, Non-Dimmable and Dimmable

Lab ID Code	Type	Dimmable?	P_{st}^{LM}	SVM
TP0017	R7s	No	0.021	0.003
3345-1	R7s	Yes	0.024	0.007
TP0018	R7s	Yes	0.060	0.879
TP0015	R7s	Yes	0.136	0.931
TP0016	R7s	Yes	0.061	1.966

Figure 10 depicts these 5 models on a graph of P_{st}^{LM} and SVM. Dots appearing in the green region within the orange box are compliant with the requirements in the draft regulation. Those above the box and to the right of it do not comply. The P_{st}^{LM} values were all within the limit set by the regulation ($P_{st}^{LM} \leq 1.0$). Note: not all models are visible in the graph, as the axes are zoomed in on the lower values for the lamps, in order to see where the models fall.

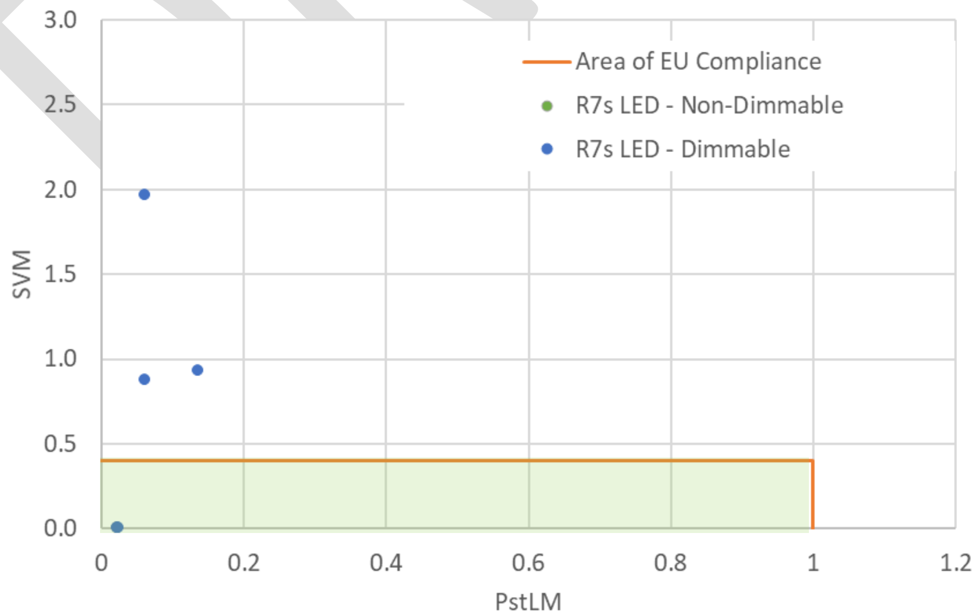


Figure 10. Plot of the R7s LED retrofit lamps depicting measured P_{st}^{LM} and SVM

Table 17. Summary analysis for the R7s LED retrofit lamps

Factor and Requirement	Passing and Percentage
Total number of models in the sample	***5 models***
Models with $P_{st}^{LM} \leq 1.0$ and SVM ≤ 0.4	2 (40%)
Additional models if $P_{st}^{LM} \leq 1.0$ and limit on SVM ≤ 1.6	2 (40%)
Models with $P_{st}^{LM} > 1.0$ or SVM > 1.6	1 (20%)
Total number of dimmable models in the sample	***4 models***
Models with $P_{st}^{LM} \leq 1.0$ and SVM ≤ 0.4	1 (25%)
Additional models if $P_{st}^{LM} \leq 1.0$ and limit on SVM ≤ 1.6	2 (50%)
Models with $P_{st}^{LM} > 1.0$ or SVM > 1.6	1 (25%)

4.6 LEDspot PAR – LED retrofit lamp for PAR38 reflector lamp

The PAR38 LED lamps are designed to replace incandescent and halogen flood lamps, whereby the lamp operates on mains voltage and the driver is contained within the lamp. We purchased and tested samples of seven different models of PAR38 lamp, four non-dimmable and three dimmable. As shown in Table 18, we found two of non-dimmable lamps and two of the dimmable already complied with the P_{st}^{LM} and SVM requirements in the draft regulation. If the SVM limit were raised to 1.6, then all seven models tested in our sample would pass.

Table 18. Measured P_{st}^{LM} and SVM for PAR38 LED Lamps, Non-Dimmable and Dimmable

Lab ID Code	Type	Dimmable?	P_{st}^{LM}	SVM
3282-1	PAR38	No	0.000	0.000
TP0012	PAR38	No	0.527	0.024
TP0014	PAR38	No	0.081	0.833
LNLED187b	PAR38	No	0.050	1.322
LNLED188b	PAR38	Yes	0.114	0.000
TP0019	PAR38	Yes	0.029	0.017
TP0013	PAR38	Yes	0.105	0.572

Figure 11 shows a scatter plot of the seven PAR38 LED lamps tested, four of which already meet the P_{st}^{LM} and SVM requirements, two dimmable and two non-dimmable models. The P_{st}^{LM} values were all within the limit set by the regulation ($P_{st}^{LM} \leq 1.0$).

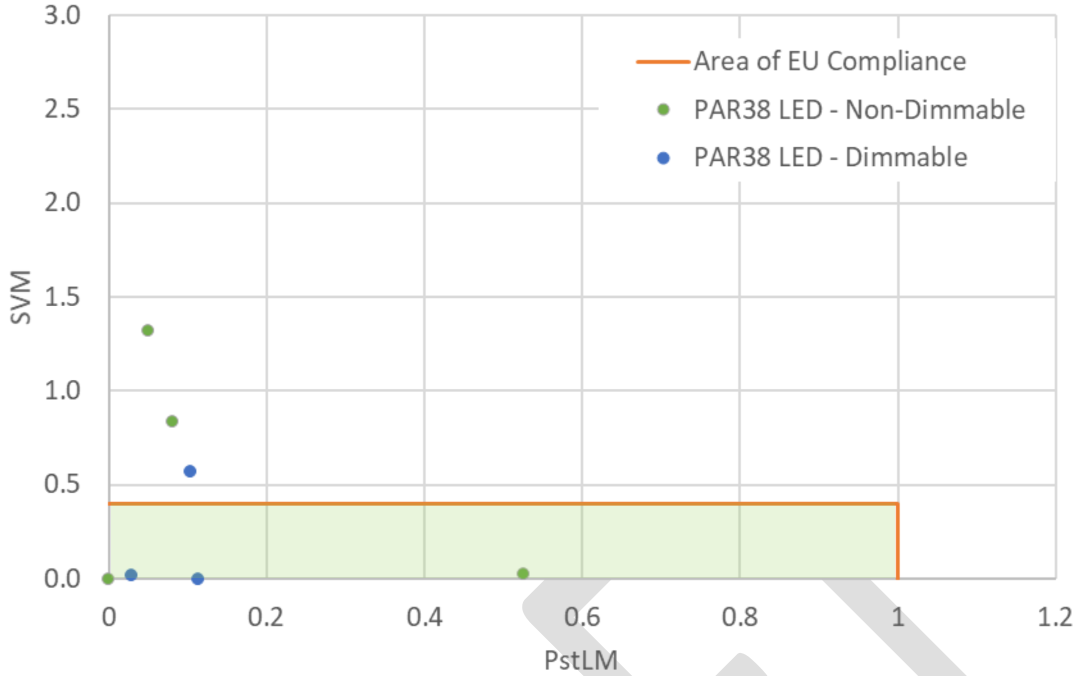


Figure 11. Plot of the PAR38 LED Lamps depicting measured P_{st}^{LM} and SVM

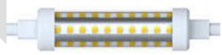
Table 19. Summary analysis for the PAR38 LED retrofit lamps

Factor and Requirement	Passing and Percentage
Total number of models in the sample	***7 models***
Models with P_{st}^{LM} ≤ 1.0 and SVM ≤ 0.4	4 (57%)
Additional models if P_{st}^{LM} ≤ 1.0 and limit on SVM ≤ 1.6	3 (43%)
Models with P_{st}^{LM} > 1.0 or SVM > 1.6	0 (0%)
Total number of dimmable models in the sample	***3 models***
Models with P_{st}^{LM} ≤ 1.0 and SVM ≤ 0.4	2 (66%)
Additional models if P_{st}^{LM} ≤ 1.0 and limit on SVM ≤ 1.6	1 (33%)
Models with P_{st}^{LM} > 1.0 or SVM > 1.6	0 (25%)

4.7 The Black Swans – Summary of Lamps that Already Meet the Requirements

This section brings together all the lamps that were found in this set of LED lamp product testing presented in the subsections above.

Table 20. List of LED retrofit lamp types that LightingEurope considers to be at risk

Lamp Type Considered	Picture
LEDtube – retrofit LED lamp for a linear fluorescent tube	
LEDspot MV – mains voltage (GU10) spot lamp (PAR16)	
Classic filament LED lamps – mains voltage A-type LED filament lamps	
LEDcapsule G9 – mains voltage LED retrofit for G9 halogen capsules	
LEDlinear R7s – LED replacement lamp for linear R7s halogen lamps	
LEDspot PAR – LED retrofit lamp for PAR38 reflector lamp	

Additional information on the performance of these lamps that already meet the ecodesign requirements for PstLM and SVM is given in the table below. This performance information includes Power Factor (PF), Displacement Factor (DF) and electromagnetic compatibility (EMC), where available. Additional work is being done at this time to further complete more of the fields in this table.

Table 21. The "Black Swans" – Lamps that Already Meet the Ecodesign Requirements

Lab ID Code	Type	Dimmable ?	P_{st}^{LM}	SVM	PF	DF	EMC
TP0029	T8	No	0.007	0.030		--	--
TP0022	T8	Not declared	0.022	0.053		--	--
TP0023	T8	Not declared	0.042	0.055		--	--

Lab ID Code	Type	Dimmable ?	P_{st}^{LM}	SVM	PF	DF	EMC
TP0024	T5	No	0.034	0.127		--	--
LNLED180	T8	No	0.686	0.160	0.92	0.93	--
LNLED184	T8	No	0.861	0.172	0.863	0.99	--
LNLED179	PAR16	No	0.921	0.000	0.480	0.90--	--
3286-1	PAR16	No	0.017	0.002	0.598	0.893	--
LNLED003	PAR16	No	0.053	0.002	--	--	--
3307-1	PAR16	No	0.011	0.003	0.511	0.968	--
LNLED129	PAR16	No	0.015	0.006	--	--	--
LNLED153	PAR16	No	0.037	0.006	0.448	0.84	--
TP0004	PAR16	No	0.009	0.006		--	--
SB5	PAR16	No	0.025	0.008		--	--
LNLED099	PAR16	No	0.033	0.008	--	--	--
LNLED128	PAR16	No	0.024	0.011	--	--	--
3279-1	PAR16	No	0.019	0.013	0.505	0.889	--
LNLED097	PAR16	No	0.079	0.013	--	--	--
LNRD036	PAR16	Yes	0.017	0.002	--	--	--
3275-1	PAR16	Yes	0.024	0.002	0.822	0.863	--
3275-3	PAR16	Yes	0.025	0.003	0.814	0.858	Pass
TP0005	PAR16	Yes	0.037	0.004		--	--
TP0001	PAR16	Yes	0.033	0.004		--	--
TP0002	PAR16	Yes	0.029	0.004		--	--
3350-1	PAR16	Yes	0.009	0.011	0.522	0.964	--
3349-3	PAR16	Yes	0.015	0.026	0.842	0.927	Pass
LNLED189	PAR16	Yes	0.189	0.055		0.79	--
LNRD018	PAR16	Yes	0.034	0.335		--	--
LNRD009	A type, filament	No	0.023	0.002		--	--
TI-20101(DE14)	A type, filament	No	0.015	0.003	0.54	--	--
TI-20124(FR9)	A type, filament	No	0.017	0.003	0.485	--	--
TI-20124(FR14)	A type, filament	No	0.015	0.003	0.529	--	--
TI-20101(DE19)	A type, filament	No	0.013	0.004	0.53	--	--
TI-20124(FR20)	A type, filament	No	0.017	0.004	0.54	--	--
TI-20124(FR8)	A type, filament	No	0.022	0.004	0.59	--	--

Lab ID Code	Type	Dimmable ?	P_{st}^{LM}	SVM	PF	DF	EMC
TI-20101(DE2)	A type, filament	No	0.015	0.004	0.525	--	--
TI-20124(FR5)	0.52A type, filament	No	0.016	0.005	0.53	--	--
TI-20101(DE3)	A type, filament	No	0.013	0.006	0.52	--	--
TI-20101(DE13)	A type, filament	No	0.020	0.008	0.53	--	--
TI-20101(DE17)	A type, filament	No	0.014	0.012	0.51	--	--
TI-20124(FR19)	A type, filament	No	0.021	0.059	0.52	--	--
LNLED170(a-k)	A type, filament	No	0.928	0.152		0.93	--
TI-20019(UK18)	A type, filament	No	0.117	0.273	0.87	--	--
3272-1	A type, filament	Yes	0.014	0.016	0.829	0.929	--
3272-3	A type, filament	Yes	0.012	0.017	0.824	0.927	Pass
LNRD002	A type, filament	Yes	0.069	0.119		--	--
LNRD039	Capsule	No	0.000	0.000		--	--
3310-1	Capsule	No	0.011	0.003	0.500	0.964	--
LNRD023	Capsule	No	0.026	0.006		--	--
3309-1	Capsule	No	0.004	0.006	0.519	0.950	--
TP0006	Capsule	No	0.009	0.006		--	--
3343-1	Capsule	Yes	0.032	0.046	0.669	0.999	--
3343-3	Capsule	Yes	0.030	0.051	0.721	0.999	Fail
TP0017	R7s	No	0.021	0.003		--	--
3345-1	R7s	Yes	0.024	0.007	0.940	0.968	--
3282-1	PAR38	No	0.000	0.000	0.471	0.971	--
TP0012	PAR38	No	0.527	0.024		--	--
LNLED188b	PAR38	Yes	0.114	0.000	--	0.90	--
TP0019	PAR38	Yes	0.029	0.017		--	--

5 Additional Analysis and Research

This section of the report provides discussion on some additional analysis and research that was performed on some of the lamps presented in Chapter 4. This additional work included a review of the relationship between price and SVM, a study of circuit designs to better understand design techniques that should allow for low SVM, and EMC testing to verify that some of the lamps met the EMC requirements.

5.1 Assessment of Price and SVM performance

In a letter to the Member State Regulatory Committee Members dated 12 December 2018, Sweden prepared an estimate of the cost of a low SVM driver, providing the following methodologies for estimating the cost:

[H]ow much more does a low SVM driver cost compared to one with high SVM values? In general, the feedback we received was that there is no retail price difference between those with high and low SVM values – there are lamps and luminaires in the market which have high and low SVM values – and they compete with each other on price. The following three examples support this feedback and summarise our main findings on this question of the cost difference for low SVM drivers:

> *Example 1) One of the SSL Annex Experts consulted an OSRAM expert in February 2017 and was told that the incremental manufacturing cost increase for a low SVM driver was approximately ten Euro cents (€0.10).*
>
> *Example 2) Peter Erwin, a German researcher and expert on flicker who has purchased and tested >1000 LED lamps over the years commented that the retail price paid in shops and on-line is the same or even in some cases less for SVM=0 and SVM>4.0. Thus, the small incremental manufacturing cost of the improved driver design to achieve an SVM=0 is simply being adsorbed by those suppliers through slightly less profit.*
>
> *Example 3) One of the SSL Annex Management Committee members contacted an industry source in November 2018 who estimated that the driver cost was "an extra 30%". To try and compare that estimate to the number quoted from OSRAM, we referenced the US Department of Energy's Solid State Lighting Multi-year Program Plan from 2016 which says that for a typical A-type lamp, the driver is 15-20% of the manufacturing cost, so assuming a 100% retail price mark-up on cost, we can roughly estimate the incremental cost of the SVM=0 driver:*
>
> a) *Retail price of LED Lamp: €4.00*
> b) *Manufacturing cost of that LED lamp: €2.00 (assumes 100% retail mark-up)*
> c) *Manufacturing cost of SVM >4.0 driver (15-20%): €0.30 – 0.40*
> d) *Incremental cost of SVM=0 driver (+30% of (c)): €0.09 – 0.12*

e) This estimate of €0.09 – 0.12 is right in line with Osram's estimate of €0.10

Thus, this 2018 industry estimate corroborates the 2017 estimate from Osram and is consistent with Peter Erwin's observation of lamps he's purchased and tested in his lab in Germany.

Overall, the evidence shows that from a manufacturing cost point of view, having stringent SVM levels would have a negligible impact on retail prices and yet they would protect the public health and well-being, delivering more human centric lighting to Europe.

To explore this further, we prepared a scatter plot of the A-type lamps tested and presented in this study, and we have found that there is no detectable correlation between price and SVM. The figure below presents this scatter plot for the A-type lamps presented in this report. The least expensive A-type lamp purchased has an SVM which is close to zero (and well below the maximum <0.4 limit set by the Ecodesign regulation).

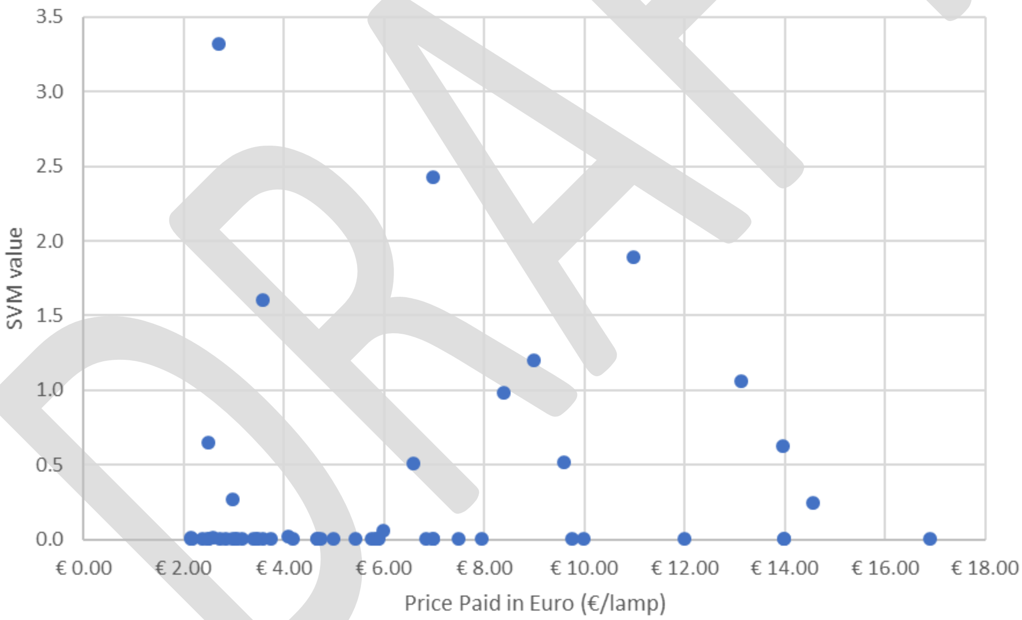


Figure 12. Scatter Plot of A-type Lamp Purchase Price and SVM

5.2 Teardown and Design Analysis of LED Drivers

In order to better understand some of the driver designs which had very good performance in terms of SVM (i.e., low values), we conducted a tear-down analysis and circuit analysis to try and identify those common designs and components. As demonstrated by the test data presented in Chapter 4 of this report, there are LED lamps that already exist on the market today which meet the P_{st}^{LM} and SVM

requirements and we want to understand those design features to highlight these successful designs.

Ten lamps were studied in total, five which had low (i.e., compliant) SVM values and five which had high values (i.e., non-compliant). For this report, manufacturer names have been obscured to protect their identity, although all models studied were commercially available products purchased in Europe.

5.2.1 Example #1 of Lamp Design Studied

The following presents one of the ten lamps which was studied, which was a 7.8 Watt lightweight lamp made of glass and containing four long LED filaments as shown in the picture below. This lamp has a P_{ST}^{LM} of 0.0153 and an SVM of 0.003 – both values far below the required levels. The LED driver is very compact, and was contained within the socket.

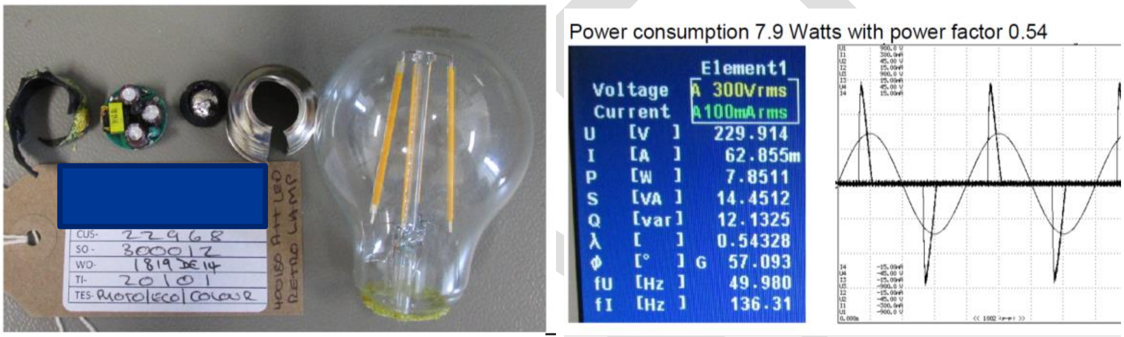


Figure 13. Tear-down Lamp #1: LED Filament Lamp

This product shows that it is possible to do low flicker lighting with a very small and low cost power supply placed inside the lamp socket. The capacitors are of 105°C type and not exposed to heat, so they will not fail. The double filtering using a coil and a 2nd capacitor leads to very stable supply voltage of the driver IC and improves power factor slightly. 100Hz hum is filtered sufficiently to avoid SVM flicker. The buck converter IC is used as a constant current driver. Finally, the last electrolytic capacitor removes remaining high frequency current ripple.

5.2.2 Example #2 of Lamp Design Studied

The following presents a second lamps which was studied, which was a 9.5 Watt lightweight A-60 style frosted retrofit LED lamp with an E27 screw base socket. This lamp has a P_{ST}^{LM} of 0.0209 and an SVM of 0.003 – both values far below the required levels. The LED driver is very compact, and was contained within the opaque plastic housing at the base of the lamp (connected to the screw base).

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Figure 14. Tear-down Lamp #2: LED Frosted Retrofit Lamp

This electronic driver design in this lamp is considered to be very good. The compact LED driver circuit is plugged into the LED board (10 triple LED on an aluminium heat sink). There is poor thermal connection to the heat sink made of aluminium sheet inside the opaque plastic housing at the base of the lamp. There is a fusible resistor of 20 Ohms between the mains and the circuit. This resistor may limit the inrush current sufficiently to ensure good switching cycle performance. The double filtering using a coil and a 2nd capacitor leads to very stable supply voltage of the driver IC and improves power factor slightly. 100Hz hum is filtered sufficiently to avoid SVM flicker. The circuit uses a buck converter IC as a constant current driver. Finally, the last electrolytic capacitor removes remaining high frequency current ripple.

5.2.3 Set of Lamps Tested

The table below presents an anonymised list of products that we have tested (some in-house TLA measurements) which pass the new regulatory requirements on SVM, displacement factor (DF) and harmonics. These products listed in the table include A-shape, PAR16, candle and capsule lamps. So it appears that compact driver designs have been developed in all of these lamp types which meet the regulatory requirements.

Table 22. Summary of P_{ST}^{LM} and SVM Testing of 17 LED Lamps with Displacement Factor

Lamp Category	Lamp shape	Cap type	Filament (Y/N)	Dimmable	Tested Power (W)	Tested True PF	Tested THD	Calculated Disp PF	P_{ST}	SVM
Non-Directional	Candle	B22	N	N	5.4	0.567	72%	0.70	0.786	0.000
Non-Directional	A60	E27	N	N	8.2	0.415	150%	0.75	0.455	0.000
Directional - GU10	PAR16	GU10	N	Y	4.5	0.89	30%	0.93	0.017	0.002
Directional - GU10	PAR16	GU10	N	N	8.0	0.54	114%	0.82	0.053	0.002
Non-Directional	A60	E27	N	N	9.3	0.416	120%	0.65	0.363	0.002
Non-Directional	A50	E27	N	?	3.1	0.451	187%	0.96	0.104	0.004
Non-Directional	Capsule	G9	N	N	2.7	0.34	152%	0.62	0.026	0.006
Directional - GU10	PAR16	GU10	N	N	4.6	0.52	149%	0.93	0.015	0.006
Non-Directional	A60	B22	N	N	7.6	0.532	157%	0.99	0.033	0.007
Directional - GU10	PAR16	GU10	N	N	6.2	0.54	117%	0.83	0.033	0.008
Directional - GU10	PAR16	GU10	N	N	6.1	0.48	146%	0.85	0.024	0.011
Directional - GU10	PAR16	GU10	N	N	3.0	0.51	143%	0.89	0.079	0.013
Non-Directional	A60	E27	N	N	7.8	0.564	138%	0.96	0.598	0.051
Non-Directional	A60	E27	N	N	6.2	0.554	79%	0.71	0.701	0.133
Non-Directional	A45	E27	N		4.1	0.529	70%	0.65	1.035	0.147
on-Directional Filament	A60	E27	Y	N	4.3	0.542	140%	0.93	0.928	0.152
Directional - GU10	PAR16	GU10	N	Y	5.0	0.64	55%	0.73	0.034	0.335

5.3 EMC Testing of LED Lamps

In order to check whether the SVM requirement resulted in a problem on electromagnetic compatibility (EMC), we selected and shipped twenty different lamps to Korea to be tested at the Korea Institute of Lighting and ICT (KILT). They conducted three tests on each of the products:

- Main Terminal Disturbance Voltage Measurement
- Radiated disturbance (9 kHz to 30 MHz) Measurement
- Radiated disturbance (30 MHz to 300 MHz) Measurement

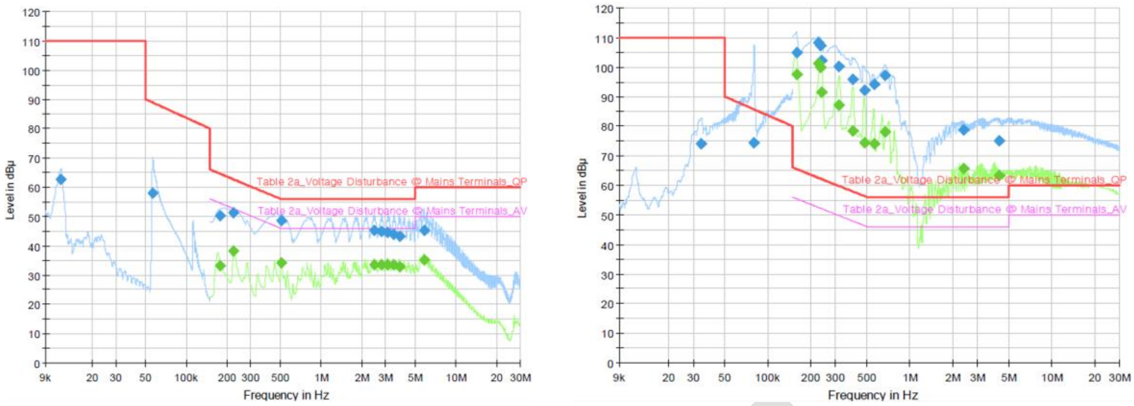
The lamps shipped to KILT were of a variety of different manufacturers, base-types, wattages, and SVM measurements – six models that had failed the SVM requirement and fourteen models that passed. The intention here was to check and determine whether passing or failing the SVM requirements may result in an unintentional impact on the EMC disturbance. All lamps tested had PstLM values that met the requirements.

The results of this testing are presented in the following table. For 19 out of 20 lamps tested, there were no problems with any of the three EMC tests – irrespective of SVM value.

Table 23. Summary of EMC Testing of 20 LED Lamps with Various SVM Values

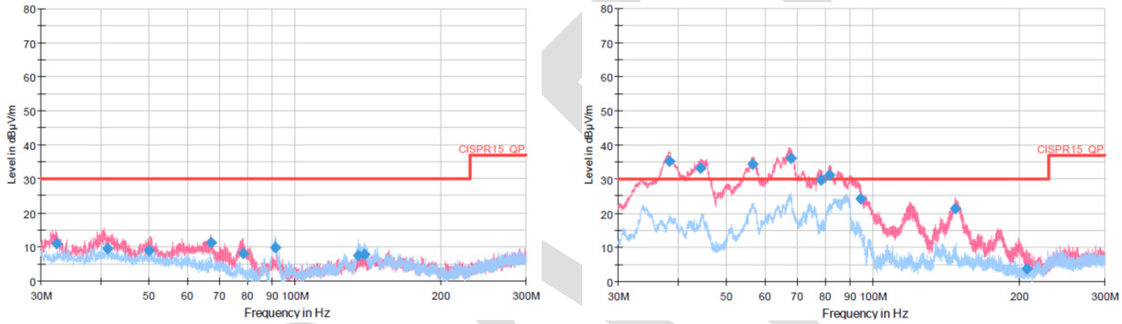
Lab ID Code	Type	Base	Watts	Dimmable?	PstLM	SVM	Flicker Frequency	Disturbance Voltage	Radiated disturbance (9 kHz to 30 MHz)	Radiated disturbance (30 MHz to 300 MHz)
3302-3	A-type	E14	5.5	3-way	0.007	0.002	17.829	Pass	Pass	Pass
TI-20101(DE16)	A-type	E27	9.0	Yes	0.013	0.007	100	Pass	Pass	Pass
3272-3	A-type	E27	7.0	Yes	0.012	0.017	100	Pass	Pass	Pass
L31690	A-type	E27	14.5	Yes	0.030	0.020	100	Pass	Pass	Pass
3290-3	A-type	E27	4.0	Yes		0.120		Pass	Pass	Pass
TI-20019(UK15)	A-type	E27	8.5	Yes	0.021	**0.517**	100	Pass	Pass	Pass
3297-3	A-type	E27	7.5	Yes	0.063	**2.943**	99.999	Pass	Pass	Pass
L31642	Capsule	G9	2.6	No	0.009	0.010	100.1	Pass	Pass	Pass
3343-3	Capsule	G9	3.6	Yes	0.030	0.051	200	Fail	Pass	Fail
L31654	Capsule	G9	4.0	Yes	0.106	**3.970**	100	Pass	Pass	Pass
L31684	LED linear	R7s	7.5	No	0.022	0.000	100.1	Pass	Pass	Pass
L31681	LED linear	R7s	11.5	Yes	0.063	**2.030**	100	Pass	Pass	Pass
L31627	PAR16	GU10	5.0	Yes	0.033	0.000	98.3	Pass	Pass	Pass
L31639	PAR16	GU10	4.5	Yes	0.035	0.000	103.8	Pass	Pass	Pass
L31630	PAR16	GU10	5.0	Yes	0.029	0.000	99.3	Pass	Pass	Pass
3275-3	PAR16	GU10	6.5	Yes	0.025	0.003	100	Pass	Pass	Pass
3277-3	PAR16	GU10	4.1	Yes		0.020		Pass	Pass	Pass
3349-3	PAR16	GU10	5.0	Yes	0.015	0.026	100	Pass	Pass	Pass
3306-3	PAR16	GU10	7.0	Yes	0.023	**0.712**	100	Pass	Pass	Pass
L31624	PAR16	GU10	6.0	Yes	0.138	**1.820**	100	Pass	Pass	Pass

Of all of the different makes and models, there was just one model which failed. This lamp was a small, 3.6W G9 lamp rated for 360 lumens, and it failed the main terminal disturbance voltage test and the radiated disturbance (30 MHz to 300 MHz) test. To illustrate the failure, two sets of graphs are included below which depict the test results for two G9 lamps in this sample – one which passed and one which failed.



(a) (b)

Figure 15. Disturbance Voltage Test for Passing G9 (a) and Failing G9 (b) LED lamps



(a) (b)

Figure 16. Radiated Disturbance (30 MHz to 300 MHz) Test for Passing G9 (a) and Failing G9 (b) LED lamps

Overall, our conclusion from this check on EMC testing is that there does not seem to be any impact on the EMC compliance associated with lamp size / formfactor and either P_{st}^{LM} or SVM values of the lamp. Products were found at the smallest size which were compliant with the P_{st}^{LM} and SVM requirements in the new lighting regulation, and which also met the EMC requirements.

6 Conclusions and Discussion

In this section of the report, we present our test findings which demonstrate that for all six of the lamp types that LightingEurope identified as being “unintentionally phased out”, there are products from different manufacturers on the market today which are already compliant. The table below summarises the findings, providing total number of models tested, the number found to be compliant (both dimmable and non-dimmable models) and the number of compliant dimmable models only.

Table 24. Summary of measured test results – lamps meeting the P_{st}^{LM} and SVM requirements

Lamp Type	Picture	Models Tested (Total)	Compliant Models (Total)	Compliant Models (Dimmable)
LEDtube – retrofit LED lamp for a linear fluorescent tube		11	6	--
LEDspot MV – mains voltage (GU10) spot lamp (PAR16)		36	22	10
Classic filament LED lamps – mains voltage A-type LED filament lamps		25	18	3
LEDcapsule G9 – mains voltage LED retrofit for G9 halogen capsules		23	7	2
LEDspot R7s – LED replacement lamp for linear R7s halogen lamps		5	2	1
LEDspot PAR – LED retrofit lamp for PAR38 reflector lamp		7	4	2
Total		107	59	18

Table 25 provides more detail on the models that passed, bringing together the ‘summary analysis’ tables from each of the six lamp types reported in Chapter 4. In this table it can be seen on both a model and percentage basis that there are models available on the market in Europe today in all six categories that meet the new P_{st}^{LM} and SVM requirements. However, the percentages shown in Table 25 should be interpreted with caution because the number of different models randomly sampled for this study were limited and should not be interpreted exhaustive sampling of EU market.

Table 25. Summary of tested models passing the requirements for the six lamp types

Factor and Requirement	LED T8 Tubes	GU10 PAR16	A-Type Filament	G9 Capsule	R7s Retrofit	PAR38 LED	Total
Total number of models in the sample	***11***	***36***	***25***	***23***	***5***	***7***	***107***
Models with $P_{st}^{LM} \leq 1.0$ and SVM ≤ 0.4	6 (54%)	22 (62%)	18 (72%)	7 (30%)	2 (40%)	4 (57%)	59 (55%)
Additional models if $P_{st}^{LM} \leq 1.0$ and SVM ≤ 1.6	1 (9%)	11 (30%)	1 (4%)	1 (4%)	2 (40%)	3 (43%)	19 (18%)
Models with $P_{st}^{LM} > 1.0$ or SVM > 1.6	4 (36%)	3 (8%)	6 (24%)	15 (65%)	1 (20%)	0 (0%)	29 (27%)
Total number of dimmable models in the sample	***0***	***20***	***8***	***16***	***4***	***3***	***51***
Models with $P_{st}^{LM} \leq 1.0$ and SVM ≤ 0.4	n/a	10 (50%)	3 (38%)	2 (12%)	1 (25%)	2 (66%)	18 (35%)
Additional models if $P_{st}^{LM} \leq 1.0$ and SVM ≤ 1.6	n/a	9 (45%)	1 (12%)	1 (6%)	2 (50%)	1 (33%)	14 (27%)
Models with $P_{st}^{LM} > 1.0$ or SVM > 1.6	n/a	1 (5%)	4 (50%)	13 (81%)	1 (25%)	0 (25%)	19 (37%)

Figure 17 presents the frequency distribution of the P_{st}^{LM} values measured for the lamp models tested in this study. Out of the 107 models, 97% of the models have a P_{st}^{LM} less than or equal to 1.0 and only 3% have a P_{st}^{LM} greater than 1.0.

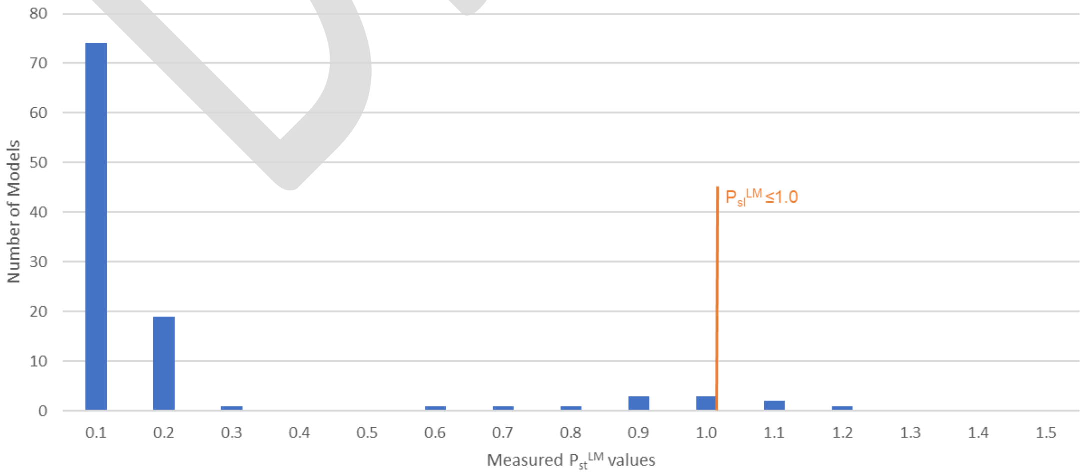


Figure 17. Count of the models by P_{st}^{LM} for all the lamps tested in this study (n=107)

Figure 18 presents the frequency distribution of the SVM values measured for the lamp models tested in this study. Out of the 107 models, 54% of the models have an SVM ≤ 0.4, 18% have an SVM between 0.4 and 1.6 and 28% of the models are greater than 1.6.

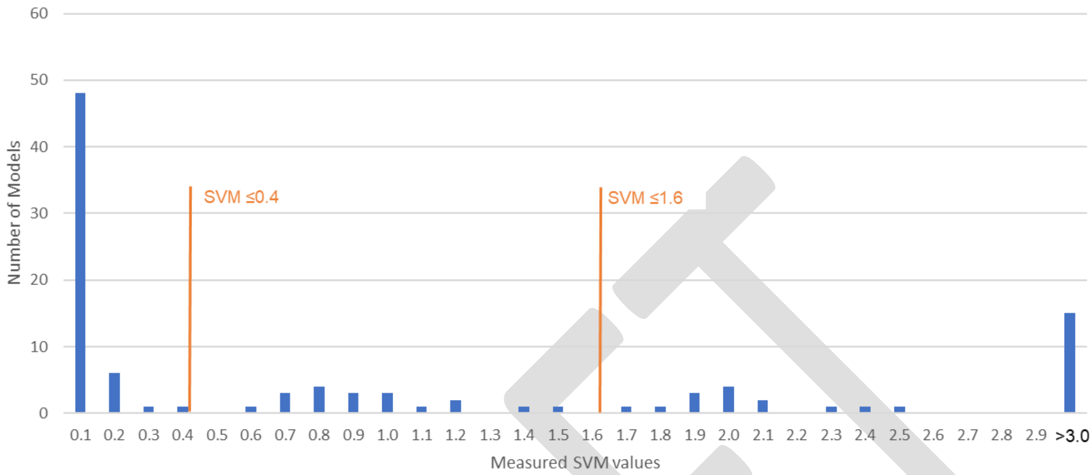


Figure 18. Count of the models by SVM for all the lamps tested in this study (n=107)

Our conclusion thus far is that there are already a significant number of LED replacement lamps on the market that are compliant with the P_{st}^{LM} and SVM requirements. We have found lamps – both dimmable and non-dimmable versions – in five of the six form factors that already meet the new P_{st}^{LM} and SVM requirements and in total 54% of the tested lamps already pass the EU regulation. Linear LED tubes – the category where we only had non-dimmable versions of the lamp – should be the easiest form factor to achieve a compliant dimmable product because it has more space for driver circuitry. Far from having "empty sockets", EU consumers in the future will still be able to purchase replacement lamps and enjoy high quality lighting in their homes.

We conclude that it is technologically feasible to make good quality drivers for LED lamps in all six form factors – and there are still 1.5 years to design products that will meet the requirements. The concerns from the lighting industry to the new draft regulation might thus be more likely based on cost and profit margins rather than technological limits. For this reason, we examined the purchase prices of products that meet or did not meet the new P_{st}^{LM} and SVM requirements to see if there was any observable difference in price between models that meet the requirements and those that did not.

We looked at the commercially available designs today and found that there are good products in the market which have low P_{st}^{LM} and low SVM and which meet the requirements of the regulation. We analysed these drivers and found some design attributes which make them 'state of the art' designs.

We investigated the relationship between price and SVM, and found that while we had previously estimated a small incremental cost for the components on the driver to

create a 'state of the art' design, there was no discernible impact on the retail price that was evident from the lamps purchased for this study.

We looked at whether there was any impact on EMC emissions from the LED lamps in relation to the SVM values, and we did not find any correlation.

As of today, European consumers have no ability to differentiate between products, and yet virtually flicker-free versions of these lamps are sold on the same websites and store shelves as flickering versions. When the new regulation becomes law, EU citizens will continue to be able to purchase replacement lamps for all six of the socket types examined in this study. EU citizens will thus benefit from the fact that all LED products will have to be designed to meet the new requirements, ensuring all models offered on the market incorporate are of a quality design.

Appendix A. Additional A-type Lamp Testing

This Appendix presents the P_{st}^{LM} and SVM of non-directional LED lamps which are not clear – in other words, they are frosted / white so the LED light source is obscured. These are not included in the main body of the report because LightingEurope did not identify these are a product type that were at risk. However, in this study, we had 96 different models tested, and found that 65 of them (68%) already complied with the requirements for P_{st}^{LM} and SVM.

Looking more specifically at the dimmable vs. non-dimmable, we had 71 non-dimmable models tested, and found that 54 of those models (76%) already complied with both requirements. Of the dimmable A-type non-clear LED lamps, we had 25 different models and 11 of those (44%) comply with the P_{st}^{LM} and SVM requirements.

Figure 19 presents the scatter plot of all the lamps that have SVM less than 3.0. Note that there were no lamps found with P_{st}^{LM} greater than 1.11.

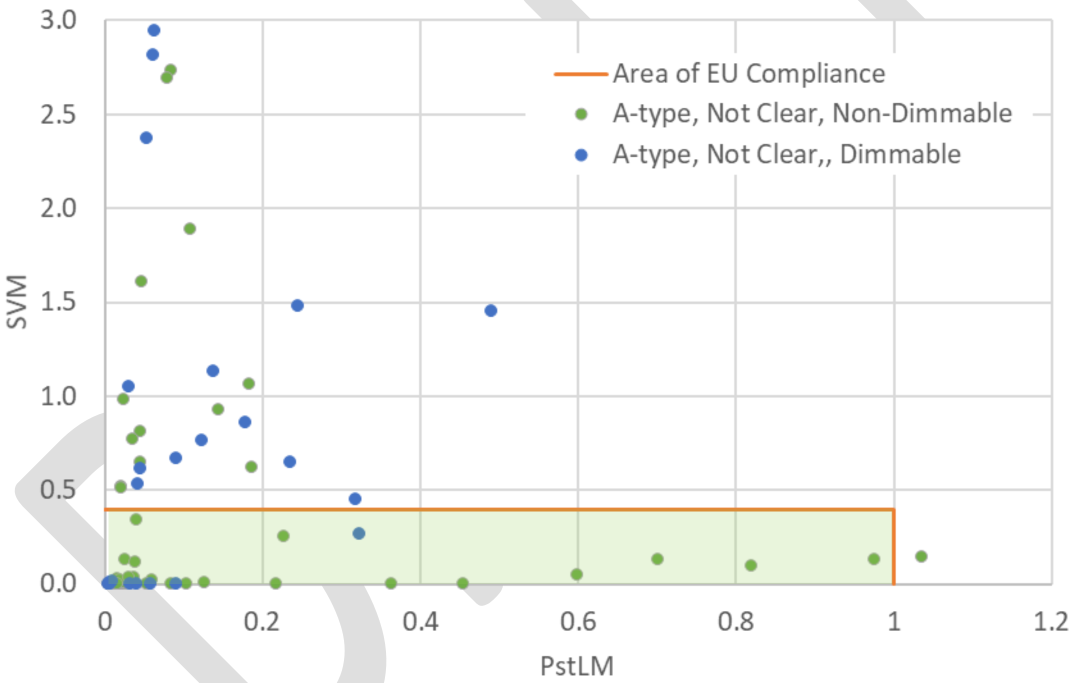


Figure 19. Scatter plot of the A-type, Non-Clear, LED Lamps on a graph depicting P_{st}^{LM} and SVM

Appendix B. Alphabetical Listing of Manufacturers from which LED lamps were sourced.

Manufacturers	
Anslut	Littil
Art. 46-3316	Luce Bella
Aurora Enlite	Lumidas
AwoX	Lvwit
BELL Lighting	Megaman
BonLux	Mirabella
Bright	MixiGoo
Brilliant	Muller Licht
CLA Lighting	MullerLicht
Clas Ohlson	n/a
Click	NASC
Crompton Lamps	Noxion
Crown	OSRAM
Ecobright	Philips
EcoLightUp	SAL
ELT	SanGlory
Emerald Planet	Sengled
Eyexiaotong	Soraa
GooBay	StarTrading
Green and co	Sunny Lighting
GRV	Sunseed
IKEA	Sylvania
Integral LED	Telefunken
Knightsbridge	Unison
Kosnic	Verbatim
LAP	Vintage LED
LEDARE	V-LIGHT
LEDvance	V-TAC
LiFx	XCSource