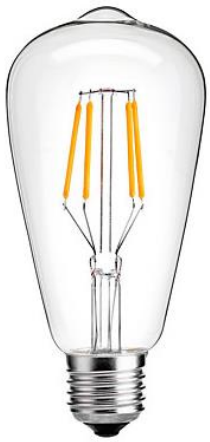
D2.2 - TOPTEN ACT CRITERIA PAPER

Lamps



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Topten ACT aims at transforming the European market of energy-using products towards higher energy efficiency.
Topten ACT identifies the top energy-efficient products in 16 European countries, and makes this information available to consumers and large buyers on tailored national websites. The most energy efficient models in different product categories (such as household appliances, lighting, office equipment, consumer electronics, cars) are presented with comprehensive product information based on official labels and standardized declarations. Topten works with manufacturers and thus increases both market offer and consumer demand of high energy efficiency products. Topten is strictly neutral and independent from manufacturers and retailers, its selection criteria are always published online.
Topten ACT is supported by the European Commission's research and innovation programme Horizon 2020, and many national organisations (energy agencies, environmental and consumer organisations, research institutes). The Topten ACT project involves 17 partners in 16 European countries. It is coordinated by ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie).
More information and access to all national websites on the European site: www.topten.eu

WP2 European Product Analysis, Task 2.1 Determining energy efficiency criteria, D 2.2 Periodic Criteria Papers (second set)

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1. Topten.eu: Lamps - current selection criteria and products selected

Topten.eu selection criteria were last updated in July 2018. Due to the rapid efficiency development especially thanks to LED filament, large share of the products is nowadays within A++ (see also Table 1). We needed also a luminous efficacy criteria.

Topten presents classic lamps (non-directional lamps), spots (directional lamps) and since 2018 also LED linear lamps (R7s). Only since shortly, the LED versions of R7s can produce 2000 Lumen and are therefore a valid replacement for halogen R7s. Current criteria are:

- Energy efficiency:
  - LED classic lamps (E14 & E27, non-dimmable): min. A++
  - LED classic lamps (E14 & E27, dimmable): min. A+
  - LED spots (E14, E27, GU 5.3, GU 10): min. A+
  - LED linear lamps (R7s): min. A+
  - LED special lamps (B22, G9, G4, E10): min. A+
- Luminous efficacy:
  - LED classic lamps (E14 & E27, non-dimmable): min. 115 lm/W
  - LED classic lamps (E14 & E27, dimmable): min. 100 lm/W
  - LED spots (E14, E27, GU 5.3, GU 10): min. 75 lm/W
  - LED linear lamps (R7s): min. 105 lm/W
  - LED special lamps (B22, G9, G4, E10): min. 100 lm/W
- Life time: minimum 15,000 hours
- Switching cycles: minimum 20,000 on/off cycles

The tables below show the number of lamp models on Topten.eu according to energy efficiency class and brightness (lumen) criteria, as of August 2018. Only Lighting Emitting Diodes (LED) lamps are able to meet such criteria:

Classic lamps

	A++	A+	Total
E27 less bright (200 - 400 lm)	5		5
E27 medium (401 – 750 lm)	18		18
E27 bright (751 – 900 lm)	16	2	18
E27 very bright (901 – 1200 lm)	18	1	19
E14 classic shape (200 - 500 lm)	14	1	15
E14 candles less bright (100 - 300 lm)	4	-	4
E14 candles medium/bright (301 - 806 lm)	13	1	14
RS7 tubes	10	1	11
Total	**98**	**6**	**104**

Table 1: number of classic (non-directional) lamps meeting the topten.eu criteria (August 2018)

Spots

	A++	A+	Total
E14 R	3	1	4
E27 R-PAR	1	15	16
GU10 medium (100 - 300 lm)	1	2	3
GU10 bright (301 - 600 lm)	9	20	29
GU5.3 medium (100 - 400 lm)	4	6	10
GU5.3 bright (401 - 700 lm)	-	7	7

Total	**18**	**51**	**69**

Table 2: number of spots (directional lamps) meeting the topten.eu criteria (August 2018)

There are 173 models of 11 different brands on the Topten.eu product list:

Girard Sudron, Ledisong, Luxram, Megaman, Nanoleaf, Onlux, Osram, Philips, Sylvania, V-Tac, Xnovum.
Similar models have not been counted if from the same brand.

59 models are dimmable (28 with class A++ and 31 with class A+).

Over the last 2-3 years, the number of models within the A++ class has risen significantly. In October 2015 we had only 50% of the classic lamps on topten.eu within A++, currently it's 95%. Spot lamps increased their share of A++ vs. A+ on topten.eu from 15% to 25% in the same period.

2. Expected selection criteria in 2019

We assume that a further efficiency push as it was seen the last 2-3 years for lighting sources will not continue due to two reasons. Firstly, most common products, such as E14 and E27 light bulbs are already now mainly found in class A++. Secondly, the energy label and Ecodesign requirements which are currently revised will not be effective within the next 2-3 years.

Expected Topten.eu selection criteria for 2019 will focus on aligning the criteria for other product categories, mainly trying to set A++ for all product categories.

Spots

Looking at the recent developments, a large share of spots will probably remain within the A+ category. Anyhow, it's probably feasible to tighten luminous efficacy from 75 lm/W to 80 or 85 lm/W in 2019.

T5 & T8

Tubular light sources such as T5 and T8 are nowadays still mostly sold as fluorescent light tubes (LFL T5 or T8). But also the "ledification" of this product category is coming along and retrofits models allow to keep the existing fixture. This makes T5 and T8 LEDs the better choice. It's foreseen to add this product category in 2019 with the following selection criteria:

- LED tubes (T5 & T8): min. A++
- LED tubes (T5 & T8): min. 115 lm/W

3. Technical background

A Light Emitting Diode (LED) is a semiconductor light source. In very simple terms, LEDs follow the reverse principle of a solar cell: whereas solar cells transforms (sun)light into direct current, LEDs turn direct current into light.

Four key quality characteristics are crucial for the assessment of LED quality:

- **Lamp efficacy:** this is the ratio between the luminous flux (measured in lumens) and the power (in Watts) consumed by the lamp. Current consumer LED lamps already provide 80-140 lm/W and currently have improvement rate of 7.5% per annum. Figure

1 shows that efficacy levels of 200lm/W respectively 250lm/W are expected within the next decade for different types of LEDs:

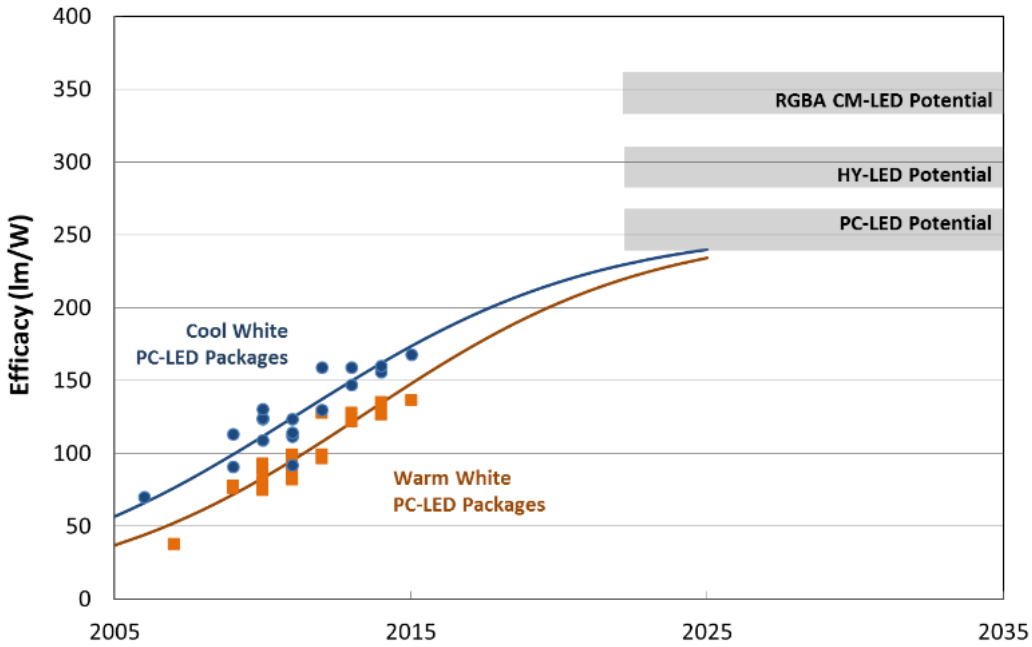


Figure 1: LED efficacy projections to 2025 (source: US Department of Energy, Solid State Lighting Plan R&D June 2016, p. 41)

- **Light quality:** The ability of a light source (lamp) to show the colours of lighted objects in a most natural way is indicated by the so-called colour rendering index (CRI). CRI assesses how well 8 defined standard colours are rendered, the best value being 100. Fluorescent lamps reach an index of 80 to 90. Incandescent lamps and halogen lamps reach a maximum of 100. Today's good LEDs reach a colour rendering index of 80 to 95. There is therefore scope for improvement, and indeed improving LEDs' CRI values might be something that manufacturers will pay more and more attention to, particularly as differences in efficacy become smaller and smaller between brands. It is important to note that there is some trade-off between high efficacy and high CRI levels.

- **Lamp life:** The lifetime of LEDs is typically declared as the useful lifetime. The useful lifetime does not only consider the average nominal life time (until 50% of the lamps of a lamp sample has failed) but the time until the luminous flux has decreased to the minimum acceptable level (e.g. 70% of the original flux). Long lamp lifetime can only be achieved if effective heat dissipation is ensured and good quality electronic components are used, which makes the products more expensive. The declared lamp lifetime of consumer LED products is typically between 10.000 and 30.000 hours.

  Anyhow, a study in Switzerland from 2016 shows that the measured lifetime can vary quite from the declared lifetime[1]. In Figure 2 it can be seen that four out of nine tested LED filament lamps have a steady decrease of light output and don't reach the declared lifetime of 15'000 hours (see yellow, orange and red lines in the Figure 2).

[1] S.A.F.E., LED-Filament-Lampen im Test, July 2016
http://www.energieeffizienz.ch/dam/studien/2016_Filament_LED/Filament-LED-Test_Bericht_2016-07-20.pdf

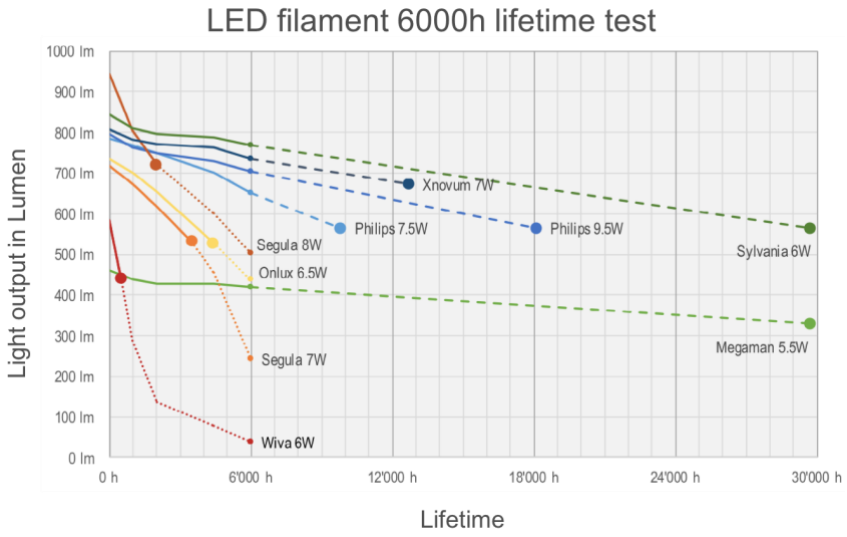


Figure 2: LED filament lifetime test in Switzerland, S.A.F.E., July 2016

- **Switch on/off cycles:** Unlike for fluorescent lamps, there is no limit to how fast and how often LEDs can be switched. Tests conducted by Stiftung Warentest on 10 LED lamps, 7 compact fluorescent lamps (CFLs) and 2 halogen lamps show that high-quality LED lamps easily reach high switching cycles: after testing 70,000 switching cycles, none of the LED lamps had failed while 2 CFLs and 1 halogen lamp broke during the test[2]

4. Policy measures, standards and labels

The EU energy label and Ecodesign regulations currently are under revision. This will lead to several modifications. Topten is involved in the process and will set appropriate criteria for lighting products as soon as more details are known.

Up to now there are three different regulations for lighting products in force – divided into product categories:

- Domestic lighting; incandescent, halogen, LED and compact fluorescent lamps (244/2009 and 874/2012)
- Directional lighting: luminaires, reflector lamps and LEDs (1194/2012 and 874/2012)
- Linear and compact fluorescent lamps (245/2009)

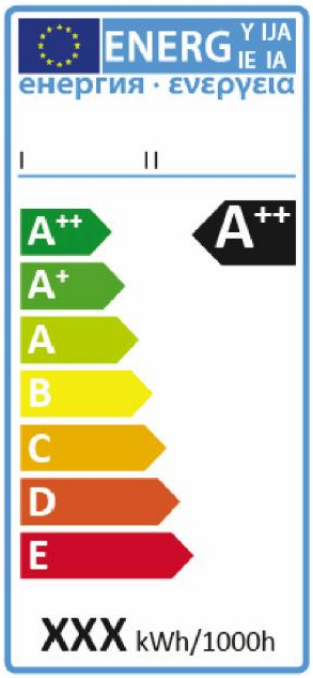
The new regulation aims to merge all these three regulations into one energy label and one Ecodesign requirement regulation for *all* lighting products.

Van Holsteijn en Kemna (VHK) published a preparatory in 2017 titled “Preparatory study on lighting systems (Lot 37)”. The Consultation Forum took place in December 2017 and the Inter-Service Consultation started in the summer of 2018. Both regulations are expected to be voted upon in late 2018 respectively early 2019.

[2] Stiftung Warentest, TEST 10/2013, p. 70-75, “Kleine LED ganz gross”

Energy Label

A new label for lamps was introduced in September 2013[3], replacing the old 1999 energy label. The new label covers both directional and non-directional lamps, and adds two additional energy classes A+ and A++. It also indicates the annual power consumption at the bottom (kWh/1000h), assuming that a lamp is about 3h burning a day.



For non-directional lamps, the old class limits remain mostly unchanged, with very minor exceptions for some lamp types. Many LED lamps are now labelled A++ (see Table 1). Most compact fluorescent lamps remain in class A or B.

Class limits are less tight for non-directional lamps (spots), reflecting the reality that they typically have lower luminous efficacy than classic lamps. A few LED spots are now labelled A++ (see Table 2 above). It is a disadvantage that the steps from one class to the next are more irregular than with other EU energy efficiency labels. This makes it almost impossible to understand and communicate what the efficiency improvement (e.g. from class B to A, or from class A to A+) means.

Energy efficiency class	Energy efficiency index (EEI) for non-directional lamps	Energy efficiency index (EEI) for directional lamps
A++ (most efficient)	EEI ≤ 0,11	EEI ≤ 0,13
A+	0,11 < EEI ≤ 0,17	0,13 < EEI ≤ 0,18
A	0,17 < EEI ≤ 0,24	0,18 < EEI ≤ 0,40
B	0,24 < EEI ≤ 0,60	0,40 < EEI ≤ 0,95
C	0,60 < EEI ≤ 0,80	0,95 < EEI ≤ 1,20
D	0,80 < EEI ≤ 0,95	1,20 < EEI ≤ 1,75
E (least efficient)	EEI > 0,95	EEI > 1,75

For the calculation of the energy efficiency index (EEI) of a model, its power corrected for any control gear losses is compared with its reference power. The reference power is obtained from the useful luminous flux, which is the total flux for non-directional lamps, and the flux in a 90° or 120° cone for directional lamps.

The EEI is calculated as follows and rounded to two decimal places:

$EEI = P_{cor}/P_{ref}$

Table 3: Energy efficiency index and efficiency classes for directional and non-directional LEDs

Ecodesign

Non-directional lamps

[3] Commission Delegated Regulation (EU) No 874/2012 with regard to energy labelling of electrical lamps and luminaires.

The energy efficiency requirements for non-directional lamps were defined in 2009[4]. Requirements for lamp efficacy have been implemented in a staged process between September 2009 (stage 1) and September 2012 (stage 5). This last requirement banned classic lamps with energy efficiency below class C (according to the label index), effectively leading to the complete phase-out of the standard incandescent lamp.

The original 2009 regulation also required under stage 6 a phase-out of lamps not reaching class B efficiency (most halogens are below class B) by September 2016. Based on manufacturers position that this phase out would restrict consumer choice of classic lamps however, the European Commission recently backtracked on this requirement and allowed for a two year delay of the entry into force of this measure. Therefore, the Ecodesign regulation was amended in 2015 by the regulations 2015/1428 postponing stage 6 to September 2018. This amendment – which sets the minimum energy class to B – is also called "halogen ban" since halogen light bulbs won't reach this criteria. Studies estimated that delaying the phase-out of halogens has slown the uptake of LED lamps in Europe, resulting in 33 TWh of lost electricity savings over a ten-year period from 2016 through 2026. These savings represent approximately €6.6 billion in higher electricity bills for Europeans.

Directional lamps

Similarly to classic lamps, energy efficiency requirements for directional lamps come into force in a staged process[5]; stage 1 becomes effective in September 2013 and last stage 3 was implemented as of September 2016, effectively banning mains-voltage halogen lamps with efficiency below class B. For LED lamps and fluorescent lamps only products of class A or better will be acceptable after 2016.

Table 4 below shows a timeline of past and upcoming impact of Ecodesign regulations for directional and non-directional lamps in the EU:

	Non-directional household	Directional (reflectors)
2009	Ban of 100-watt incandescent lamps + all frosted incandescent lamps	
2010	Ban of 75-watt incandescent lamps	
2011	Ban of 60-watt incandescent lamps	
2012	Ban of 15-, 25- and 40-watt inc. lamps	
2013		Ban of incandescent reflectors; Shift to conventional main voltage halogens (phase out of poorest); Shift to infrared coated or xenon filled low voltage halogens >450lm.
2014		Shift to infrared coated or xenon filled low voltage halogens <450lm.
2015	Review of the regulation.	Review of the regulation.
2016	(Delayed to 2018)	Shift to mains voltage halogens with transformer;

[4] COMMISSION REGULATION (EC) No 244/2009 with regard to ecodesign requirements for non-directional household lamps

[5] COMMISSION REGULATION (EU) No 1194/2012 with regard to ecodesign requirements for directional lamps, light emitting diode lamps and related equipment

		Phase out of CFL reflectors; Shift to today's best HID and LED.
2018	"halogen ban": minimum energy class is set to B; Exception for R7s and G9 (which correspond energy class C).	

Table 4: timeline of Ecodesign measures for lamps

Halogen ban

Due to the Stage 3 of the directional lamps Ecodesign regulation (1. September 2016) and the delayed Stage 6 of the non-directional lamps Ecodesign regulation (1. September 2018) as described above, large part of halogen light sources have been banned from the European market (see Table 5). Still some light sources are exempted from the ban and are allowed on the market (see Table 6), namely: halogen linear bulbs R7s, halogen bi-pin base (G4, G9, GY6.35) and halogen spots (GU 5.3 – 12 Volt). Halogen R7s and bi-pin bases are still allowed since due to their small size the required light output was not yet reached when the regulations were in discussion. The low voltage GU 5.3 halogens are still allowed since these run with a transformer for the mains voltage. By replacing these halogens lamps with LEDs that use up to ten time less energy, the transformer might not work correctly. Consumers would be forced to change it.

Directional **E14, E27 (230 V)**	**Non-directional** **E14, E27 (230 V)**	**Non-directional** **GU10 (230 V)**
		
Stage 6: 1.9.2018 (EU Nr. 244/2009 amended by EU Nr. 2015/1428)	Stage 3: 1.9.2016 (EU Nr. 1194/2012)	Stage 3: 1.9.2016 (EU Nr. 1194/2012)

Table 5: Banned halogen lamps (graphic: topten.eu)

Directional **R7s (230 V)**	**Directional** **G9 (230V), G4 (12V), GY6.35 (12V)**	**Non-directional** **GU5.3 (12 V)**
		

Table 6: Lamp types which are still exempted from the halogen ban (graphic: topten.eu)

Further requirements

In addition to these energy efficiency requirements, a number of lamp functionality requirements and information requirements are set under the 2009 Ecodesign regulation for lamps. The lamp functionality requirements are set out in Table 5 for compact fluorescent lamps and in Table 6 for lamps excluding compact fluorescent lamps and LED lamps:

Functionality parameter	Stage 1	Stage 5
Lamp survival factor at 6 000 h	≥ 0,50	≥ 0,70
Lumen maintenance	At 2 000 h: ≥ 85 % (≥ 80 % for lamps with second lamp envelope)	At 2 000 h: ≥ 88 % (≥ 83 % for lamps with second lamp envelope) At 6 000 h: ≥ 70 %
Number of switching cycles before failure	≥ half the lamp lifetime expressed in hours ≥ 10 000 if lamp starting time > 0,3 s	≥ lamp lifetime expressed in hours ≥ 30 000 if lamp starting time > 0,3 s
Starting time	< 2,0 s	< 1,5 s if P < 10 W < 1,0 s if P ≥ 10 W
Lamp warm-up time to 60 % Φ	< 60 s or < 120 s for lamps containing mercury in amalgam form	< 40 s or < 100 s for lamps containing mercury in amalgam form
Premature failure rate	≤ 2,0 % at 200 h	≤ 2,0 % at 400 h
UVA + UVB radiation	≤ 2,0 mW/klm	≤ 2,0 mW/klm
UVC radiation	≤ 0,01 mW/klm	≤ 0,01 mW/klm
Lamp power factor	≥ 0,50 if P < 25 W ≥ 0,90 if P ≥ 25 W	≥ 0,55 if P < 25 W ≥ 0,90 if P ≥ 25 W
Colour rendering (Ra)	≥ 80	≥ 80

Table 5: Functionality requirements for compact fluorescent lamps

Functionality parameter	Stage 1	Stage 5
Rated lamp lifetime	≥ 1 000 h	≥ 2 000 h
Lumen maintenance	≥ 85 % at 75 % of rated average lifetime	≥ 85 % at 75 % of rated average lifetime
Number of switching cycles	≥ four times the rated lamp life expressed in hours	≥ four times the rated lamp life expressed in hours
Starting time	< 0,2 s	< 0,2 s
Lamp warm-up time to 60 % Φ	≤ 1,0 s	≤ 1,0 s
Premature failure rate	≤ 5,0 % at 100 h	≤ 5,0 % at 200 h
UVA + UVB radiation	≤ 2,0 mW/klm	≤ 2,0 mW/klm
UVC radiation	≤ 0,01 mW/klm	≤ 0,01 mW/klm
Lamp power factor	≥ 0,95	≥ 0,95

Table 6: Functionality requirements for lamps excluding compact fluorescent lamps and LEDs

Table 7 displays the functionality requirements for LED lamps, as established in the relevant 2012 Ecodesign Regulation[6]:

Functionality parameter	Requirement as from stage 1, except where indicated otherwise
Lamp survival factor at 6 000 h	From 1 March 2014: ≥ 0,90
Lumen Maintenance at 6 000 h	From 1 March 2014: ≥ 0,80
Number of switching cycles before failure	≥ 15 000 if rated lamp life ≥ 30 000 h otherwise: ≥ half the rated lamp life expressed in hours
Starting time	< 0,5 s
Lamp warm-up time to 95 % Φ	< 2 s
Premature failure rate	≤ 5,0 % at 1 000 h
Colour rendering (Ra)	≥ 80 ≥ 65 if the lamp is intended for outdoor or industrial applications in accordance with point 3.1.3(l) of this Annex
Colour consistency	Variation of chromaticity coordinates within a six-step MacAdam ellipse or less.
Lamp power factor (PF) for lamps with integrated control gear	P ≤ 2 W: no requirement 2 W < P ≤ 5 W: PF > 0,4 5 W < P ≤ 25 W: PF > 0,5 P > 25 W: PF > 0,9

Table 7: Functionality requirements for LED lamps

Information requirements on the lamp packaging include (non-exhaustive list): the nominal life time of the lamp, the number of switching cycles before premature lamp failure, the colour temperature, warm-up time, the dimmability of the lamp, lamp dimensions, the claimed equivalent incandescent lamp and mercury content. Additional there is a requirement to include information on free-of-access websites, which includes all of the above aspects, plus: rated wattage; rated luminous flux; rated lamp life time; lamp power factor; lumen maintenance factor at the end of the nominal life; starting time, colour rendering, and information on how to clean and dispose of lamps that contain mercury.

5. Market analysis

From a historical point of view, progress on lighting technologies has tremendously accelerated in the last decades (see **Figure 3**). LED lamps are today ten times more efficient than incandescent lamps. After a century of not much progress (from the 1879 invention of the incandescent lamp), CFLs were invented in the 1980s. More importantly, LEDs were also invented in the late XX century, and in particular the 2014 Nobel-prize winning invention of the blue LED in 1995 has allowed for a revolution in the lighting industry in the last two decades. In 2017 Philips presented its market-ready Dubai lamp with luminous efficacy of 200 lm/W and showed what is already today possible.

[6] COMMISSION REGULATION (EU) No 1194/2012 with regard to ecodesign requirements for directional lamps, light emitting diode lamps and related equipment

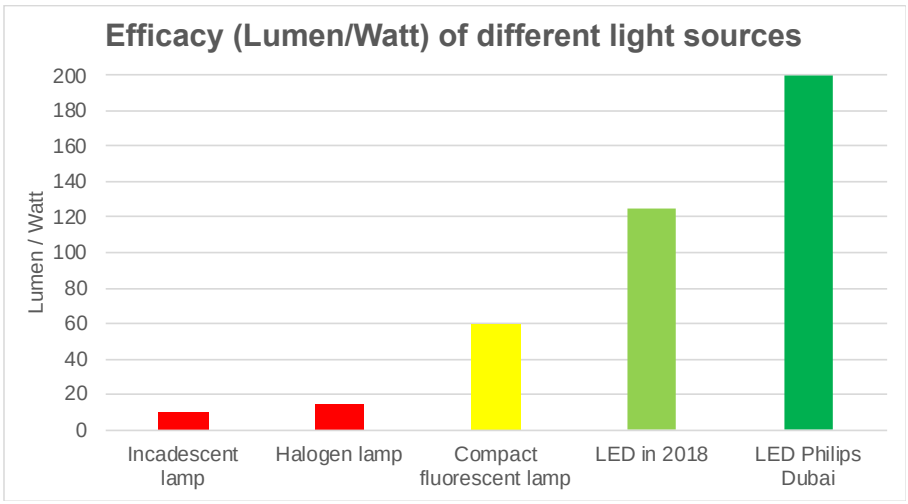


Figure 3: Efficacy development in light sources (graphic: topten.eu)

In 2015 prices for LED lamps have dropped by 40% and in 2016 about 25%[7]. Purchasing a LED lamps cost in the first place today 2-3 times more than a halogen lamp but they have payback periods of less than a 1 year in sockets used 3 hours per day[8]. LED lamps are therefore not only the most energy-efficient but also the most cost-effective solution. Additional research published in 2014 found that LED lamps meet the shape, size and light quality of the tungsten filament lamps they are replacing[9]. Since around 2017 basically for all lighting replacements there are LED retrofits available.

Finally, at around 2016 the LED filament lamps have become popular and helped the market penetration of LED lamps. Thanks to their comparable shape and size to the classical incandescent lamps – and even traditional Edison types (see Figure 4) – they are very apparelling to consumers from a design point of view. Anyhow, LEDs are today the best light replacement thanks to:

- 360° light distribution through clear glass envelope (i.e., sparkle effect for certain light fixtures)
- 140 lm/W (more than ten times efficient than incandescent lamps and two times better than CFL)
- Warm-white light - 2700 K, same as incandescent/halogen lamps
- High colour rendering, CRI Ra > 90
- Long lifetime – 15,000 hours (7 times longer than halogen)

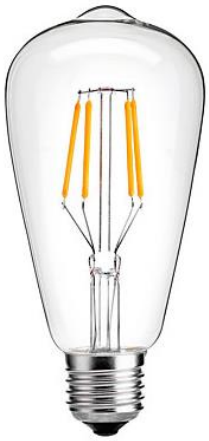


Figure 4: LED filament

It is no surprise therefore that consumer and professional lighting companies have made the switch: IKEA, a global retailer specialising in household furnishings, sells since 2016 only LED lamps. Erco, a professional luminaire manufacturer, announced that from January 2015 they will only supply luminaires that use LED as the light source.

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[7] LED Magazin, Strategies Unlimited reports LED price stability and robust SSL opportunity, April 2018 https://www.ledsmagazine.com/articles/print/volume-15/issue-4/features/markets/strategies-unlimited-reports-led-price-stability-and-robust-ssl-opportunity.html

[8] Danish Energy Agency, CLASP and Energy Piano (2015). 'European LED Market Evolution and Policy Impacts'

[9] Swedish Energy Agency, Belgian Federal Ministry for Health, Food Chain Safety and Environment, CLASP and eceee. 'Test Report – Clear, Non-Directional LED Lamps: A test report prepared for the European Commission and the Consultation Forum on the performance of clear LED lamps in the European Market in the third quarter of 2014.' 19 November 2014.

Anyhow, market share of LED has still much room to win. Due to the delayed halogen ban (2018 instead of 2016) sales share of halogen lamps has remained stable within the last years or even slightly raised. LED were mainly replacing CFLs and incandescent lamps. A market development analysis based on three annual studies initiated by the Swiss Federal Office of Energy show the current share of LED, halogen and other lighting sources (mainly fluorescent tubes and CFLs). LED holds currently around 25% and halogen 50% of the lighting sales in Switzerland, probably same figures apply to Europe.

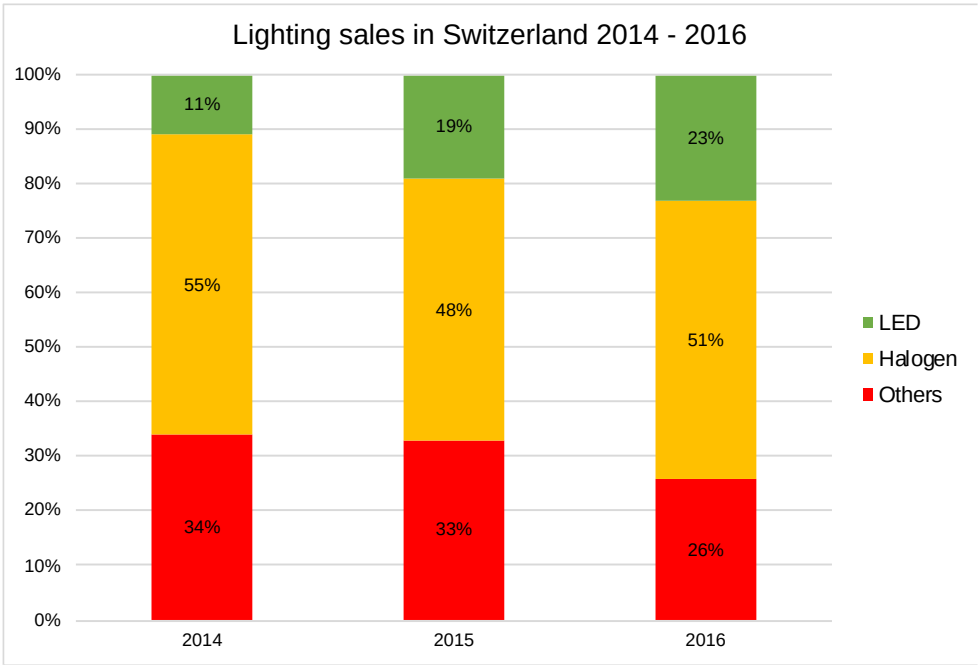

Figure 5: Development of the lighting sales in Switzerland from 2014 – 2016 (data: SFOE 2014, 2015, 2016, graphic: topten.eu)

The recent halogen ban will bring fresh air into the market development but further regulations are strongly needed. For some product categories no further requirements are in place until the next revision. Namely for tubular light sources, especially the linear fluorescent T8 light tubes (LFL T8) which are widely used in offices, industry building, public areas, retail, cellars, indoor parking etc. a phase-out is only being discussed in the current revision. Maybe even a second stage in the regulation will be granted for these T8 which would delay their phase-out even more. We proved input on supporting the Commission on a quick phase-out since the largest part of of the 125 TWh/a energy savings come from the LFL T8 phase-out (50 TWh/a) according to the Ecodesign Working Plan 2016-2019. The best available LED T8 currently are at 145 – 160 lm/W (including retrofit models) reaching the highest energy class A++; thus, energy consumption can be cut by half already now.

What also needs to be noticed are smart or connected lamps which have come up within recent years. These lamps have integrated connectivity functions in order to control them remotely with additional functions such as dimming or colour changer. Due this connectivity feature these lamps have a standby energy consumption which can exceed their energy consumption in on-mode. Since LED lamps are low-wattage products (2-8 W) which are only for some hours on per day (1-3 hours) a standby of 0.5-1W which runs for 21-23hours a day impacts the annual energy consumption substantially. A report (2016) from the IEA 4E Solid State Lighting Annex has tested 27 smart lamps and compared the standby share versus the on-mode consumption (see).

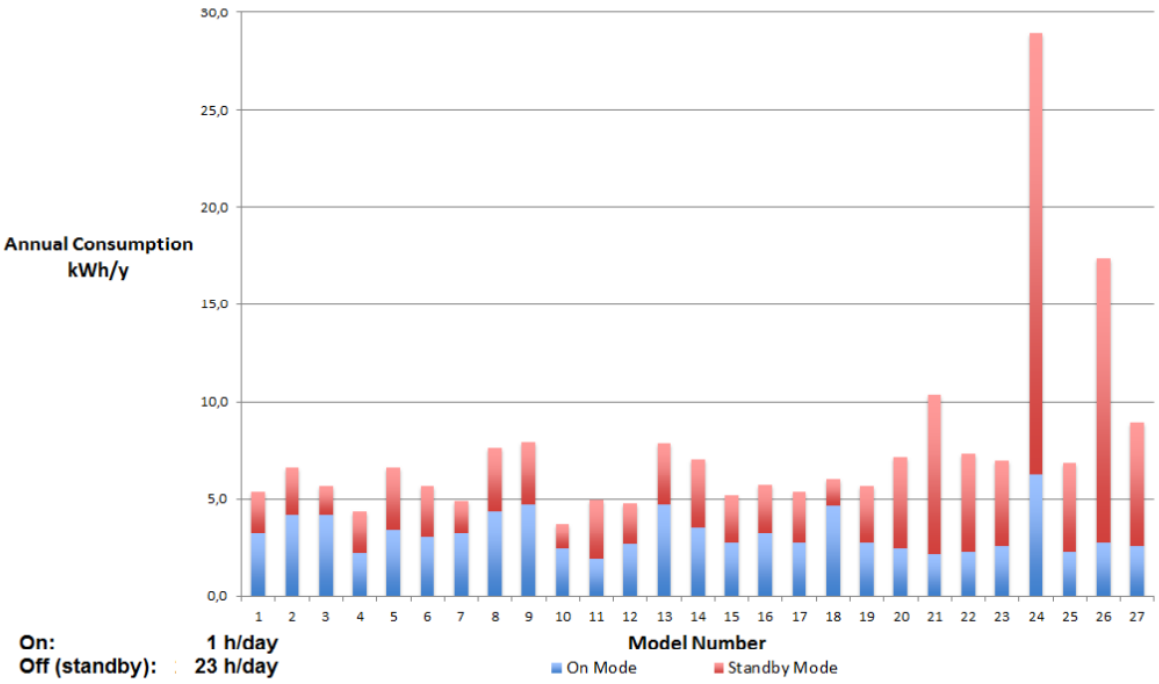

Figure 6: IEA 4E Solid State Lighting Annex measuring standby of smart lamps (2016)

6. FAQ

Does the production of LED involve the extraction of rare earths?

The LED industry uses a wide and growing range of phosphor materials to convert the light emission from LED chips into a different wavelength spectrum. LED makers rely on their supply of phosphor materials as a crucial aspect of the production process. The most common use is the combination of a blue LED chip with one or more phosphors to create a white LED. Many of the phosphors used in LEDs contain rare-earth elements, and the availability of these materials causes some concern, with China controlling some 95% of production worldwide.

Dependence on China, rising prices of rare earths and tough competition in the LED market is forcing LED manufacturers to innovate in search for alternatives, or at least a reduction in the amounts of rare earths used.

Can LEDs cause epilepsy?

One potentially dangerous side effect of LED lighting is seizures in people who suffer from photosensitive epilepsy, just as watching TV or playing video games can. LEDs can flicker at high frequencies causing a so-called strobe effect. Most people cannot see and are not affected by the flicker, but for people who can see the effect it can be a trigger for the seizure. Not all LEDs have the issue of causing seizures. The issue appears most problematic when LEDs are the only light source or the main light source; if other sources are lighting the room such as sunlight shining through a window, the strobe effect is minimized for causing a seizure.

7. References and links

Useful links

Topten.eu lamps product lists:
http://www.topten.eu/english/lamps/led-classic-lamps/e27-less-bright.html
http://www.topten.eu/english/lamps/led-classic-lamps/e27-medium.html
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http://www.topten.eu/english/lamps/led-classic-lamps/e27-very-bright.html
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http://www.topten.eu/english/lamps/led-classic-lamps/e14-candles.html

http://www.topten.eu/english/lamps/led-spots/e14-r.html
http://www.topten.eu/english/lamps/led-spots/e27-e14-medium.html
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http://www.topten.eu/english/lamps/led-spots/gu10-medium.html
http://www.topten.eu/english/lamps/led-spots/gu10-bright.html
http://www.topten.eu/english/lamps/led-spots/gu5_3-medium.html
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Topten.eu lamps selection criteria:
http://www.topten.eu/english/criteria/selection_criteria_energy_saving_lamps.html&fromid=

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http://www.topten.eu/uploads/File/Online-Energy-Labels-518:2014-EN.pdf

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Commission regulation (EU) No 1194/2012 of 12 December 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for directional lamps, light emitting diode lamps and related equipment.
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http://www.topten.eu/uploads/File/lamps_regulation-244-2009-EC.pdf

Danish Energy Agency, CLASP and Energy Piano (2015). 'European LED Market Evolution and Policy Impacts'

Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.
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European Commission, Ecodesign Working Plan 2016-2019, November 2016
https://ec.europa.eu/energy/sites/ener/files/documents/com_2016_773.en_.pdf

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http://mappingandbenchmarking.iea-4e.org/shared_files/643/download

IEA 4E Solid State Lighting Annex. Task 7: Smart Lighting – New Features Impacting Energy Consumption, September 2016
https://ssl.iea-4e.org/files/otherfiles/0000/0085/SSL_Annex_Task_7_-_First_Report_-_6_Sept_2016.pdf

S.A.F.E., LED-Filament-Lampen im Test, July 2016
http://www.energieeffizienz.ch/dam/studien/2016_Filament_LED/Filament-LED-Test_Bericht_2016-07-20.pdf

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https://www.newsd.admin.ch/newsd/message/attachments/46460.pdf

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