

Lamps and Luminaires: Recommendations for Policy Design

November 2013

SUMMARY AND KEY POLICY RECOMMENDATIONS

With the ecodesign regulations from 2009 on classical ('non-directional') household lamps and professional lamps, from 2012 on reflectors ('directional' lamps) and LED lamps as well as with the new energy label (now covering all lamp types) important policy steps have been taken supporting the efficiency development of the lamp market. From its overview on the high efficiency market, Topten still sees important possibilities to guarantee an on-going market transformation towards higher efficiency and to cover additional, vast energy saving potentials. All regulations of concern will be revised in 2014 or 2015. This will be the moment to implement the recommendations described here.

Topten's key policy recommendations are:

1. Implement stage 6 of the ecodesign regulation as announced since 2009

There is no reason to abandon stage 6 of the ecodesign regulation No 244/2009 on non-directional household lamps, since class B halogen lamps are technically feasible, but large energy savings would be missed and the legal certainty undermined.

2. Introduce an energy label for office luminaires

A significant energy savings potential has been identified today and in the preparatory study Lot 8 in 2007. The preconditions for such a label are good. It should be introduced in the 2015 revision of the labelling regulation No 874/2012 on electrical lamps and luminaires.

3. More ambitious LED functionality requirements

The required switching cycles should be set much higher in the 2015 revision of regulation No 1194/2012: to minimum 4 times the lifetime in hours (compared to now half the lifetime).

4. Stop market entry of new fixtures and adapters for type G9 and R7s

No new fixtures and adapters for type G9 and R7s caps should enter the market to avoid a loophole for class C halogen lamps and a lock-in effect. There are good new alternatives.

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Why stage 6 should be assured and not weakened

In April 2013 the European Commission launched a discussion concerning stage 6 requirements for non-directional household lamps. Stage 6 will phase out class C lamps (except for lamps with G9 or R7s cap) and has been adopted with regulation No 244/2009 in 2009. Center of the current discussion is the risk that main-voltage halogen lamps for replacing incandescent lamps with type E27/E14 cap might be unintentionally phased out. Today the only available products are in energy efficiency class C. Class B products are technically feasible and one manufacturer has marketed a small selection for a while. But economical considerations seem to keep manufacturers from widely introducing class B main-voltage halogen lamps on the market today. One of the proposals is to recall stage 6 and allow class C halogen lamps to remain on the market beyond 2016. A study by VHK(pl)/VITO investigates the implications of this proposal (draft from 02.04.2013, final version not yet published).

Topten is concerned about this proposal. Straying from the planned shift to high-efficiency lamps would send a very negative signal. It could slow down market transformation and result in many TWh energy savings missed. In the worst case it would undermine efficiency policies as a whole – for lamps and also other product groups under the ecodesign directive. Topten advocates that stage 6 requirements are implemented as planned.

As the study points out it is technically feasible to make class B mains-voltage halogen lamps as replacement for incandescent lamps. They would be 3-7 times as expensive as class C halogen lamps marketed today (and about the same price as projections for 2016 LED lamps). It can be assumed that there will be a market demand for class B halogen lamps once low-price class C products are not an option anymore. Rather than as low-price alternative (with high operation cost) halogen lamps will be chosen for their specific qualities if so desired. They would offer brilliant light with excellent colour rendering (CRI 100), trouble-free dimming and immediate start-up for purposes where this is desired.

| Model | Total cost for 15'000 hours of lighting (Power for identical luminous flux) | | |
|--------------------------------|--|------------------------------|----------------------------|
| | Class C halogen | Class B halogen (EEI=0.6) | Class A+ LED (EEI=0.17) |
| Eco Halogen Classic E27 18W | 56 € | 77 € (12W) | 17 € (4W) |
| Eco Halogen Classic E27 28W | 78 € | 95 € (20W) | 24 € (7W) |
| Eco Halogen Classic E27 42W | 110 € | 122 € (32W) | 30 € (11W) |
| Eco Halogen Classic E27 53W | 134 € | 140 € (40W) | 35 € (14W) |

Table 1: Total cost (purchase price + energy cost) for today's class C halogen lamps, future class B halogen lamps and A+ LED lamps (available today and minimum standard in 2016). Calculated with 2'000, 3'000 and 15'000 hours lifetime for class C halogen, class B halogen and LED, respectively (7.5, 5 and 1 lamps for 15'000 hours), 2 € purchase price per class C halogen and 10 € for class B halogen and LED (in 2016), 0.15 €/kWh electricity tariff.

The calculation in Table 1 shows that class B halogen lamps are likely to cost consumers slightly more in total, but not much (between 4% and 34% more). The higher purchase price is mostly compensated by lower operation costs.

At the time of conception of the regulation in 2008-2009, exceptions were granted for main-voltage halogen lamps that are very small and therefore could technically not be improved to meet class B requirements. These are lamps with type R7s and G9 caps. Unfortunately this exception leads to a major loophole. No new fixtures (luminaires) for type R7s and G9 caps should be sold because otherwise consumers will be locked-in to lamp types without energy efficient replacements. Instead new LED and other efficient luminaires should make their way into European homes. Adapters for G9 halogen lamps to type E27 and E14 cap should be banned as well to keep from undermining market transition to class B lamps.






| Class B halogen lamps | | Class C halogen lamps | | |
|---|---|---|---|--|
|  |  |  |  |  |
| Mains-voltage (with transformer; currently not marketed) | Low-voltage (infrared coated or xenon filled) | R7s | G9 | Adapter G9 to E27 |

Figure 1: Halogen lamps allowed on the market after 2016 when stage 6 is applied as planned.

New energy label for lamps

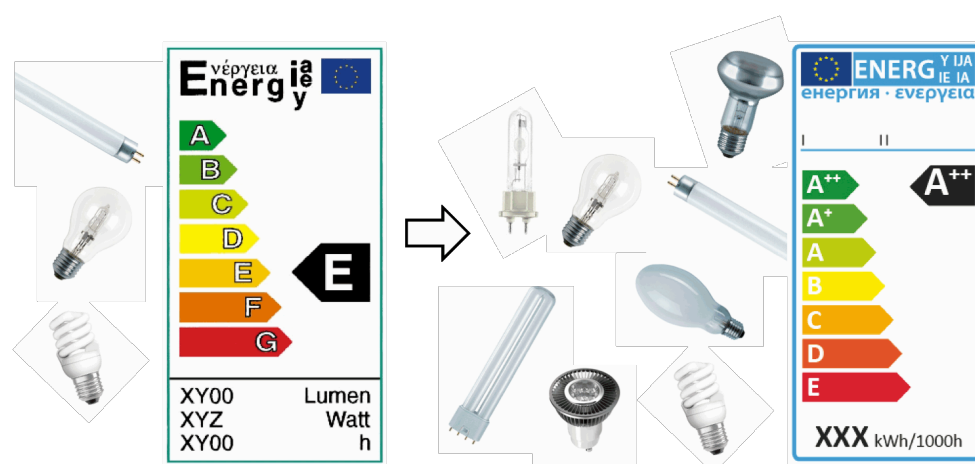


Figure 2: The old lamp label from 1999 has been replaced by a new label since 1st September 2013. The new label also covers reflectors and professional lamps and contains two new classes A+ and A++.

The old lamp label from 1999 has been replaced by a new label since 1st September 2013. The new label covers all lamp types (including reflectors and professional lamps) and contains two new energy classes A+ and A++. The underlying regulation is No 874/2012. It replaces the old Commission Directive 98/11/EC.

The class limits remain basically unchanged. Only for lamps above 1300 lumens class limits are alleviated with the result that halogen lamps with power above ca. 80 watts can be re-classified from D to C and therefore meet stage 4 requirements (applied from 2012). Many LED lamps can now be labeled A+ whereas most compact fluorescent lamps remain A.

Separate class limits were defined for directional lamps (spots). They are about 40% lower than for non-directional lamps (taking into account that spots typically have lower luminous efficacy). Solely class A+ is almost the same for both ($EEL < 0.17$ for non-directional, $EEL < 0.18$ for directional), and A++ is 15% lower. A number of LED spots can now be labeled A+.

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 an efficiency improvement from B to A, from A to A+ etc. means.

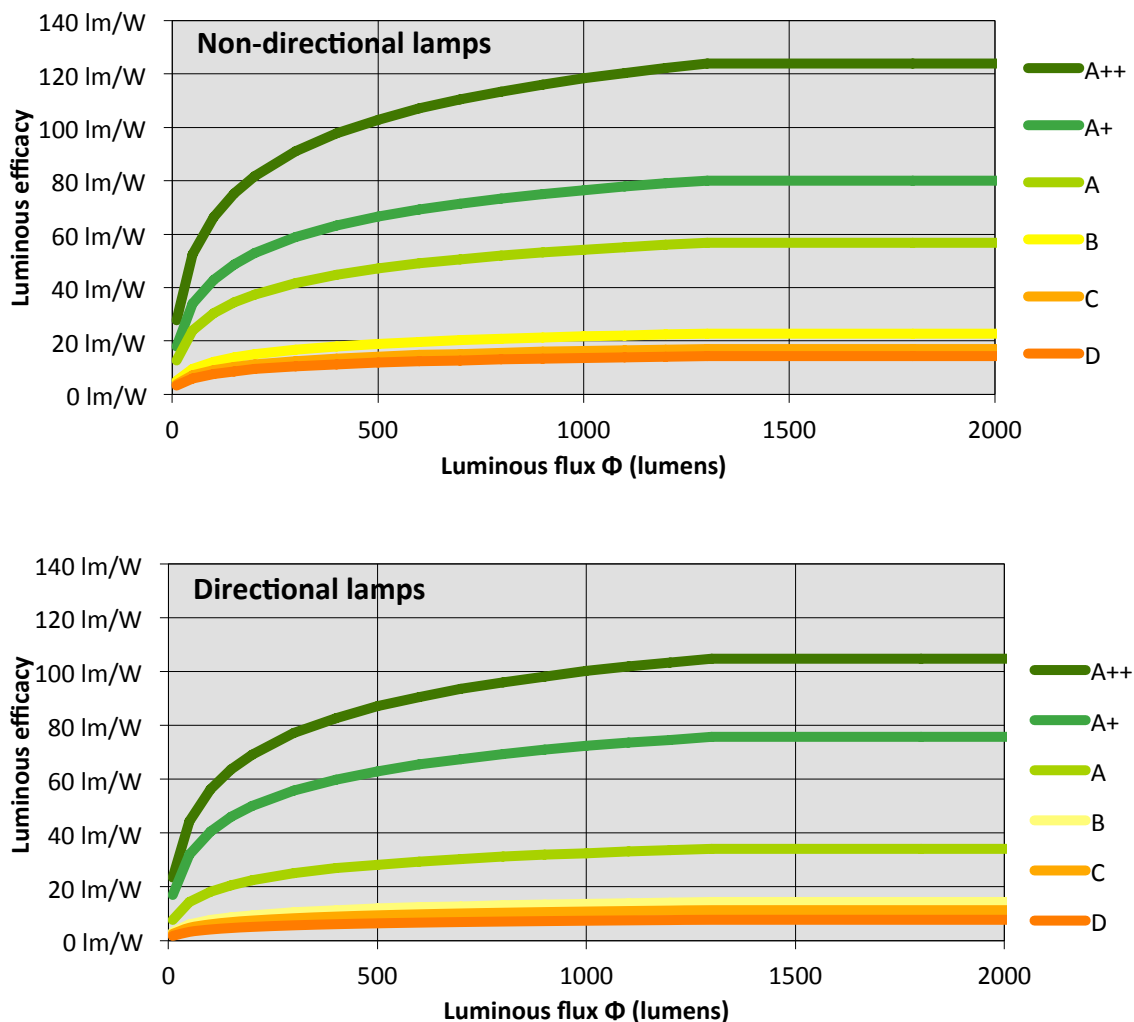


Figure 3: Class limits for non-directional and directional (ca. 40% lower) lamps from September 2013.

Ecodesign requirements so far

Non-directional incandescent lamps have been phased out in 4 stages between 2009 and 2012. They can still be sold from stock, but not be newly put on the market. The underlying regulation is (EC) No 244/2009.

| Date | Non-directional household |
|-------------|---|
| Sept. 2009 | 100 watts all frosted incandescent lamps |
| Sept. 2010 | 75 watts |
| Sept. 2011 | 60 watts |
| Sept. 2012 | 15, 25, 40 watts |



Table 2: Phase out of non-directional incandescent lamps between 2009 and 2012.

Ecodesign requirements coming

The ecodesign regulation No 244/2009 on non-directional household lamps has one more stage coming in 2016. From then on it is planned that only B class halogen lamps shall be placed on the market, and as an exception C class halogen lamps with R7s and G9 base.

Between 2013 and 2014 ecodesign requirements for reflectors will “catch up” with the non-directional household lamps: Incandescent reflectors and poorly performing halogen reflectors will be phased out in 2 stages. The last stage is in 2016, like for non-directional household lamps, and it will bring a shift to today’s best HID and LED and to B class halogen spots. CFL spots and C class halogen spots will be phased out. The underlying regulation is No 1194/2012.

A revision of both ecodesign regulations for lamps is foreseen in 2015 and discussions have already begun (see first chapter). As it stands a shift to best performing products is foreseen in 2016.

| | Non-directional household | Directional (reflectors) |
|------|--|---|
| 2013 | | Phase out 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 | Shift to mains voltage halogens with transformer; Exception for R7s and G9. | Shift to mains voltage halogens with transformer; Phase out CFL reflectors; Shift to today’s best HID and LED. |

Table 3: Phase out of incandescent reflectors and poorly performing halogen reflectors between 2013 and 2014. Review of both regulations in 2015. In 2016 it is foreseen to shift to best performing products.

| | Non-directional household | | Directional (reflectors) | | |
|----------------|---------------------------|-----------------------------|------------------------------|--------------------------|--|
| | frosted | clear | Mains-voltage filament lamps | Other filament lamps | Fluorescent lamps, LED lamps, HID lamps ¹ |
| Since Sep 2012 | A | C | | | |
| Since Sep 2013 | | | Stage 1 | | |
| | | | D (without lamps <450lm) | B (without lamps <450lm) | A |
| Sep 2014 | | | Stage 2 | | |
| | | | D (all) | B (all) | |
| 2015 | Revision | | Revision | | |
| 2016 | Stage 6 | | Stage 3 | | |
| | | B (except C for R7s and G9) | B | | A+ (except between A and A+ for HID lamps) |

Table 4: Overview of the required minimum energy classes.

Ensured quality and product information for LED lamps and LED luminaires

Since 1st September 2013 the EU sets functionality requirements for LED lamps. They also apply to household luminaires with fixed LED modules. This is an important accomplishment to ensure that consumers choosing high-efficiency lighting like LED lamps are not disappointed by their quality.

Standard product information is now provided on the packaging or online. This allows consumers to make informed choices. Also the crucial parameter 'switching cycles' is displayed on the packaging.

The minimum required switching cycles should be set much higher in the next revision: to minimum 4 times the lifetime in hours (compared to now half the lifetime in hours). Unlike for fluorescent lamps, there is no limit to how fast and how often LED can be switched (the lifetime of most fluorescent lamps suffers when they are switched faster than in 10 minutes intervals). Recently published test results of 10 LED lamps, 7 compact fluorescent lamps (CFLs) and 2 halogen lamps show that 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 (Stiftung Warentest, TEST 10/2013, p. 70-75, "Kleine LED ganz gross" [13]). The sticking point is the quality of the electronic components in LED lamps. If those are of poor quality the LED lamp can be sensible to switching. The easiest way to save energy is by switching off (manually or with presence detection / daylight sensors). Switching should in no way cause risk of premature failure.

In the past LED products with poor qualities have sometimes caused disappointment and prejudices against LED. The new functionality requirements ensure good colour rendering and good colour consistency (meaning that colours appear natural in the LED lamp's light and the light itself is a consistent white tone). The minimum required colour rendering is now

¹ High-intensity discharge lamps

the same level as for fluorescent lamps. Since LED lamps can reach very high levels of colour rendering (comparable to halogen lamps) more ambitious requirements could be set in the future. Though efficiency loss through better colour rendering would have to be balanced in this consideration.

| Functionality parameter | Requirement |
|---|---|
| Lamp survival factor at 6000h | ≥ 0.90 (2014) |
| Lumen maintenance at 6000h | ≥ 0.80 (2014) |
| Number of switching cycles before failure | ≥ 15000 if rated lamp life ≥ 30000 h otherwise: \geq 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 | $\leq 5.0\%$ at 1000h |
| Colour rendering (Ra) | ≥ 80 ≥ 65 (outdoor) |
| Colour consistency | Correlated colour temperature (CCT) spread within a six-step MacAdam ellipse or less. |
| Lamp power factor (PF) | $P \leq 2$ W : no requirement 2 W $< P \leq 5$ W : PF > 0.4 5 W $< P \leq 25$ W : PF > 0.5 $P > 25$ W : PF > 0.9 |

Table 5: New functionality requirements for LED lamps apply since September 2013.

Today the Labelling regulation 1194/2012 does not clearly formulate if for LED luminaires product information has to be provided for the luminaire or the lamps. Most manufacturers declare for the lamps only, even if these are integrated in a luminaire: the power measured is often twice that declared. It should be stated clearly that the product information should be declared for the luminaire, including Standby power. Suggested changes to Regulation (EU) No 1194/2012 are:

Article 1, Subject matter and scope:

(b) light-emitting diode (LED) lamps *and household LED luminaires (marketed to end-users and from which the LED modules are not intended to be removed by the end-user)*;

For household LED luminaires power in standby mode (0.1 W precision) should be visibly displayed to end-users, prior to their purchase, on the packaging and on free access websites.

Office luminaires: Preconditions are good for implementing an energy label

One of Topten's key policy recommendations is to introduce a mandatory EU energy label for office luminaires, as was recommended in the preparatory study Lot 8 for office lighting in 2007 [12]. A good moment would be the revision of regulation No 874/2012 with regard to energy labelling of electrical lamps and luminaires, which is set to happen in 2015.

Both luminous efficacy of light sources and ballast efficiency have been covered by EU policies for over a decade². High energy saving potential is left to tap with luminaires,

² 1999 the energy label for household lamps was introduced. Starting in 2009, poorly performing lamps have been banned from the market in several stages. By 2017, the last stage defined in the

especially with office luminaires. Household lighting might have received more public attention in the past due to manifold energy saving initiatives and the “incandescent lamp phase-out”, but office lighting accounts for twice the energy consumption compared. Office lighting consumed an estimated 164 TWh in 2007, whereas household lighting consumed 84 TWh in 2007 and 80 TWh in 2009 [11].

A luminaire’s efficiency is given by the Luminaire Efficiency Factor (LEF) that indicates the luminous flux emitted from the luminaire in lumens per watt electrical power. The Light Output Ratio (LOR) indicates how much light is lost inside the luminaire through shadowing and absorption.

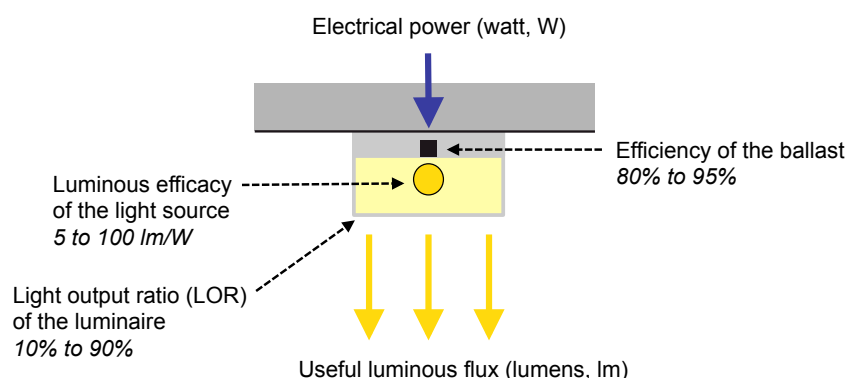


Figure 4: Parameters of the luminaire efficiency factor (LEF).

Preconditions are good for implementing an energy label for office luminaires:

- Product information for most office luminaires on the European market is already available in lighting simulation software such as Dialux and Relux. The standardized data format is Eulumdat with the file extension *.ldt (the American IES format can be transformed into Eulumdat).
- A mandatory energy label would be a strong incentive for electricians, planners, private and public procurement agents and awarding authorities to consider the LEF.
- The energy label could provide information on the annual energy consumption (kWh/year) for typical use. This would directly support the goals of the recast Energy Performance of Buildings Directive 2010/31/EU which asks to consider built-in lighting installation for the calculation of energy performance of buildings. It would give EU countries a tool to implement energy performance standards.
- Four voluntary labels and initiatives (Minergie [7], Der Blaue Engel [8], Energy Star [9], Topten.eu [10]) guide to the current best available technology. They can be an inspiration to EU labelling and ecodesign measures.

A straightforward and transparent approach to energy efficiency classification could be taken. Knowing that the most efficient office luminaires from the voluntary label ‘Minergie’ have a

current ecodesign regulations, only improved halogens and well performing fluorescent lamps, LED lamps and high intensity discharge lamps will meet the minimum requirements. Also ballast losses have been limited in several stages since 2002. [1] - [2]

luminaire efficiency factor LEF of just above 100 lm/W and that every year increasingly efficient LED luminaires enter the market, the limit for class A could be set at 108 lm/W with equal steps of 18 lm/W between each class.








| Energy efficiency class | Luminaire efficiency factor LEF |
|---|---------------------------------|
|  | > 108 lm/W |
|  | > 90 lm/W |
|  | > 72 lm/W |
|  | > 54 lm/W |
|  | > 36 lm/W |
|  | > 18 lm/W |
|  | < 18 lm/W |

Table 5: A possible approach to an energy label that is straightforward and transparent.

In 2013 175'000 data sets for office luminaires were analysed in order to better understand the efficiency range of today's market. The data comes from Relux, next to Dialux the common lighting simulation software in Europe. Manufacturers provide the freeware and luminaire data to use for professionals to plan lighting installations. The resulting efficiency range suggests a great potential for technological development and efficiency improvement. Half of the models do not even reach 40 lm/W and would be in the poorest classes G, F and E according to the approach in Table 5. Less than 10% of the models are candidates for representing the best available technology and would fill the best classes C, B and A.

| | Ceiling-mounted | Recessed | Suspended | Floor-standing |
|-------------------------------|-----------------|-----------|-----------|----------------|
| Top 10% of luminaires | > 67 lm/W | > 62 lm/W | > 70 lm/W | > 72 lm/W |
| Top 20% of luminaires | > 60 lm/W | > 53 lm/W | > 62 lm/W | > 63 lm/W |
| 50% - Median | > 37 lm/W | > 30 lm/W | > 39 lm/W | > 33 lm/W |
| Poorest 20% of luminaires | < 22 lm/W | < 17 lm/W | < 24 lm/W | < 16 lm/W |
| Poorest 10% of luminaires | < 16 lm/W | < 12 lm/W | < 17 lm/W | < 10 lm/W |
| Factor top 10% to poorest 10% | 4 | 5 | 4 | 7 |

Table 6: Efficiency range resulting from an analysis of 175'000 data sets for office luminaires (Relux data).

Household luminaires

An EU energy label will be provided for household luminaires from March 2014 on. The underlying regulation is No 874/2012. This label does not inform about the energy efficiency of the luminaire itself; it only informs about the type of lamps to be used in the luminaire. The luminaire efficiency factor LEF or light output ratio LOR are not addressed. In the future this label should be replaced with an actual luminaire efficiency label, after first experiences have been made with an energy label for office luminaires.

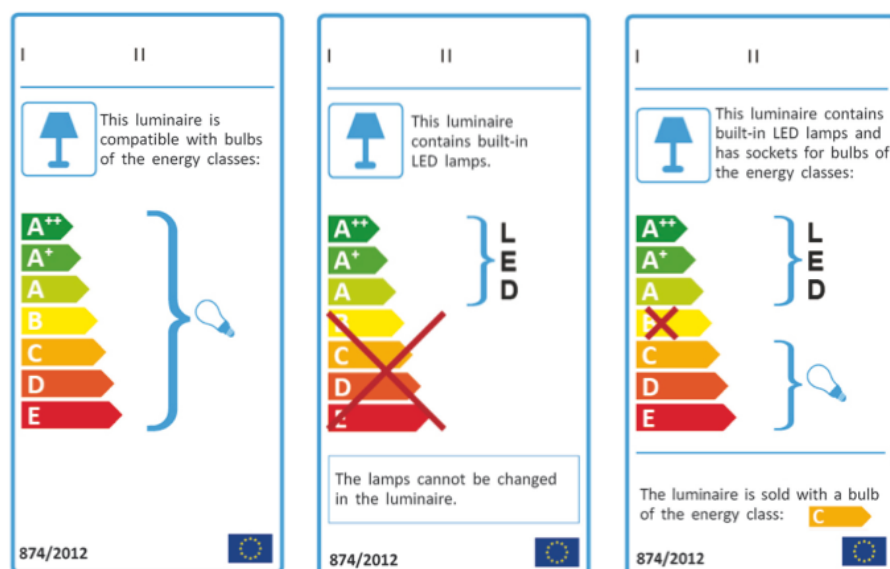


Figure 5: Label provided for household luminaires from March 2014. It informs about the type of lamps to be used in the luminaire but not about the energy efficiency of the luminaire.

Key policy recommendations (long version)

All regulations of concern will be revised in 2014 or 2015. This will be the moment to implement the recommendations described here.

1. Implement stage 6 of the ecodesign regulation as announced since 2009

Stage 6 of the ecodesign regulation No 244/2009 on non-directional household lamps will ban class C (except for lamps with G9 and R7s caps) from the market. It has been in force since 2009 and to alleviate this efficiency requirement would be a dangerous signal. The legal certainty should not be undermined. Class B main-voltage halogen lamps are technically feasible and will become economically interesting to market once the cheaper class C halogen lamps have been phased out. The high possible energy savings must not be missed.

2. Introduce an energy label for office luminaires

The Lot 8 preparatory study has proposed the introduction of an energy label for office luminaires based on the Luminaire Efficiency Factor (LEF) in 2007 already. The electricity saving potential is huge and the preconditions for such a label are good, with product information widely available, an objective to consider in-built lighting under the recast Energy Performance of Buildings Directive 2010/31/EU and several voluntary labels and initiatives serving as examples. It should be introduced in the 2015 revision of the labelling regulation No 874/2012 on electrical lamps and luminaires.

The label that is introduced now for household luminaires based on regulation No 874/2012 does not rate the efficiency of the luminaires but only gives a guidance on what lamp types can be operated in the product. In the future also this label should be replaced with an energy label based on the Luminaire Efficiency Factor (LEF).

3. More ambitious LED functionality requirements

The functionality requirements for LED lamps that have been introduced by regulation No 1194/2012 are assuring a certain minimum quality which can prevent consumers from disappointments. LED lamps can perform much better than the minimum requirement when it comes to withstand frequent switching. The minimum required switching cycles should be set much higher in the 2015 revision of regulation No 1194/2012: to minimum 4 times the lifetime in hours (compared to now half the lifetime in hours). As it is now manufacturers have no incentive to invest in high-quality electronic components that make LED lamps durable and there is a risk that frequent switching can cause premature lamp failure. This would unnecessarily damage consumers' trust in this technology that can really do much better.

Furthermore the declaration obligation should clearly apply for LED luminaires.

4. Phase out fixtures and adapters for type G9 and R7s

Fixtures and adapters for type G9 and R7s caps should be phased out to avoid a major loophole and lock-in effect. Otherwise consumers might exceedingly shift to fixtures for type G9 and R7s caps because of the much lower purchase price of the lamps, misunderstanding the total cost. This would cause higher total costs for consumers and would hinder the market transition to class B halogen lamps. The phase-outs, announced as soon as possible (at next revision in 2015), would provide planning security for industry and consumers.

References

EU labelling and ecodesign regulations

- [1] Commission Delegated Regulation (EU) No 874/2012 of 12 July 2012 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of electrical lamps and luminaires
- [2] 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
- [3] Commission Regulation (EC) No 244/2009 of 18 March 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for non-directional household lamps
- [4] Commission Regulation (EC) No 245/2009 of 18 March 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps, and repealing Directive 2000/55/EC of the European Parliament and of the Council
- [5] Directive 2000/55/EC of the European Parliament and of the Council of 18 September 2000 on energy efficiency requirements for ballasts for fluorescent lighting (replaced by regulation 245/2009)
- [6] Commission Directive 98/11/EC of 27 January 1998 implementing Council Directive 92/75/EEC with regard to energy labelling of household lamps (replaced by regulation No 874/2012)

Voluntary labels for office luminaires

- [7] Reglement und Nachweisverfahren zur Vergabe des MINERGIE®-Labels für Leuchten. Durch Labelkommission genehmigte Version vom 11.9.09. Ausgearbeitet durch Schweizerische Agentur für Energieeffizienz S.A.F.E.
- [8] Vergabegrundlage für Umweltzeichen, Leuchten für die Anwendung in Büros und verwandten Einsatzbereichen, Ausgabe 2012 (DRAFT)
- [9] ENERGY STAR® Program Requirements Product Specification for Luminaires (Light Fixtures), Eligibility Criteria Version 1.2
- [10] Topten.eu Selection Criteria for Office luminaires:
http://www.topten.eu/english/criteria/office_lighting_crit.html&fromid=

Other References

- [11] Bertoldi P., Hirt B. and Labanca N. *Energy Efficiency Status Report 2012*. European Commission, Joint Research Centre, Institute for Energy and Transport.
- [12] Preparatory Studies for Eco-design Requirements of EuPs, *Final Report Lot 8: Office lighting*, VITO, 2007.
- [13] Stiftung Warentest, TEST 10/2013, p. 70-75, *Kleine LED ganz gross*.