EUROPEAN
COMMISSION

Brussels, 1.10.2019
SWD(2019) 357 final

PART 2/3

COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT

Accompanying the document

COMMISSION REGULATION (EU) .../... 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

and

COMMISSION DELEGATED REGULATION (EU) .../... supplementing Regulation (EU) 2017/1369 of the European Parliament and of the Council with regard to energy labelling of light sources

and repealing Commission Delegated Regulation (EU) No 874/2012

{C(2019) 1805 final} - {C(2019) 2121 final} - {SEC(2019) 340 final} - {SWD(2019) 358 final}

Annex 1: Procedural information

1. Lead Directorates General (DG), DeCide Planning/CWP references

DG ENER is the lead DG for the Ecodesign and Energy labelling regulation for lighting products.

Decide planning number of the underlying initiative for the review of ecodesign requirements for lighting products is PLAN/2016/440 (inception impact assessment published on 23/01/2018 at https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2018-476175_en).

Decide planning number of the underlying initiative for the review of energy labelling for lighting products is PLAN/2016/438 (inception impact assessment published on 23/01/2018 at https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2018-476111_en).

The following DGs (Directorates General) have been invited to contribute to this impact assessment: ENER (Energy), SG (Secretariat-General), GROW (Internal Market, Industry, Entrepreneurship and SMEs), ENV (Environment), CNECT (Communications Networks, Content and Technology), JUST (Justice and Consumers), ECFIN (Economic and Financial Affairs), REGIO (Regional policy), RTD (Research and Innovation), CLIMA (Climate Action), COMP (Competition), TAXUD (Taxation and Customs Union) EMPL (Employment), MOVE (Mobility and Transport), TRADE (Trade) and the JRC (Joint Research Centre) were consulted on the draft IA in April 2018.

2. Organisation and timing

The last Ecodesign Working Plan 2016-2019, adopted in November 2016, confirms that lighting products continue to be a priority product group. Furthermore, the recent Energy Label Regulation (EU) 2017/1369 stipulated that lighting products are one of the five priority subjects for which the Commission should adopt a new energy label regulation in accordance with the said overall regulation by 2 November 2018.

Article 19 of the Ecodesign Directive foresees a regulatory procedure with scrutiny for the adoption of implementing measures. Subject to qualified majority support in the Regulatory Committee and after scrutiny of the European Parliament and of the Council, the adoption of the measure by the Commission is planned for the end of 2018.

3. Consultation of the RSB

The present impact assessment report was submitted to the Regulatory Scrutiny Board (RSB) on 16/05/2018.

Following a meeting on 13 June 2018, on 18 June 2018 the RSB delivered a positive opinion with reservations. The draft impact assessment was subsequently improved, based on the RSB's Opinion[1] and the horizontal and specific technical comments that the RSB sent prior to the meeting of 13 June 2018. The table below shows how those recommendations are addressed in this revised impact assessment report.

[1] Ref. Ares(2018)3220771 - 18/06/2018

RSB Opinion 18.06.2018	Where and how the comments have been taken into account
(B) Main considerations	
(1) The report does not sufficiently analyse current exemptions, i.e. explain what they cover, why they remain relevant, alternative ways to close loopholes, and the associated impacts.	Annex 11 is added to compare exemptions in the current legislation with the exemptions proposed with this review.
(2) The report does not integrate circular economy aspects comprehensively and in a way which is consistent across ecodesign products. It does not impact assess them either.	General explanations were added in Section 6.1 and specific explanations in Section 6.2.3.
(C) Further consideration and recommendations for improvement	
(1) The report relies mostly on stakeholder views and model simulations. It does not refer to e.g. horizontal or product specific evaluations that might have informed this initiative. It should present supporting evidence from such evaluations. It should also clarify what expectations were of the original legislation, how outcomes have been different from what was expected, and what lessons to draw from this. Key conclusions should directly feed into the problem definitions, and evaluation evidence should be summarised in the relevant annex.	Section 2.1 is added titled "How the problems are defined".
(2) The exemptions to the proposed rules should be transparently presented and their rationales explained in detail (e.g. exemptions for theatre lamps). This might involve adding a dedicated section on exemptions and loopholes. If some exemptions involve political as well as technical decisions, those choices should be duly reflected in policy suboptions. It should spell out the exemptions which will be kept and whether the preferred option includes new ones.	Annex 11 is added to compare exemptions in the current legislation with the exemptions proposed with this review.
(3) The circular economy dimension of the initiative needs clarification. In particular, the report should explain how and to what extent the measures on luminaires (i.e. integrated lighting	General explanations were added in Section 6.1 and specific explanations in Section 6.2.3, including on recyclability.

units) would contribute to the circular economy objective. It should explain why other measures such as recyclability are not considered.	
(4) The report should indicate the main limitations, risks and uncertainties of the methodological choices made for analysing the impacts of lighting products. This information should clarify how robust the model-based estimates are.	An explanation is added in Section 6.1.
(5) The report should better explain the value added of maintaining an energy label when the potential savings for consumers are negligible or even negative	Clarification is made in Sections 6.4, 6.2.1 and 5.3.4. Table 11 shows that the overall effect at 2030 for consumers when considering acquisition costs and electricity costs is positive for all options, including the one that supposes to review only the energy label regulation.
(6) For the preferred option, the report should include a REFIT reporting table on the quantified results from simplification and administrative burden reduction. The analysis should clarify the burden reduction of replacing the energy label for luminaires by similar information on the package.	The REFIT table in Section 8.2 and Table 18 in Annex 3 are adapted accordingly. More explanation is also added in Section 6.5. Moreover, more explanation is added in Section 5.2.2 on the reasons to replace the energy label for luminaires by similar information on the package.
(7) This report should be better aligned with the impact assessments that accompany the other proposals in this package of proposals for implementing legislation regarding ecodesign and energy labelling.	Alignment was checked, the structure is the same.
Other comments transmitted directly to the author DG prior to the RSB meeting	
(1) It is not clear whether and where in the text the criteria of Article 16(2) of the Energy Labelling Regulation are being fulfilled.	Explanation is added in Section 7.3.
(2) Explain better if the phase out of existing light sources is only based on efficiency requirements or also on other factors. Explain better the reasoning for the light sources that would be instead still allowed on the market.	Explanation is added in Section 5.2.3.

(3) Explain better the rationale for introducing a new formula for the energy label.	Explanation is added in Section 5.2.2.
(4) The report could wait for the publication of the Scientific Committee for Health – SCHEER report on effects on health for LEDs	The SCHEER report was published on 12 July 2018: the text was updated and a summary of the main conclusions of the report added.. It is to be noted that the SCHEER report is the last one of many reports on the effect of artificial lighting on health. Clarity on this point is added in Section 6.6.2.
(5) Important concepts should be explained when they are used for the first time (e.g. control gears, luminaire, verification tolerances, BAU2008)	Definitions are added or expanded in Section 1 and Section 2.

4. EVIDENCE, SOURCES AND QUALITY

For this impact assessment, the main supporting studies were as follows:

- Omnibus review Study 2014[2], which concluded that there was still significant energy savings potential for lighting products.
- Stage 6 review Study, done to verify the feasibility of last requirement in time of Commission Regulations (EC) 244 and 245.
- Review study 2015[3], which concluded that about 50TWh electricity savings could be achieved by setting stricter ecodesign and energy labelling requirements (1/3 savings would come from the new labelling).
- Impact Assessment Study 2017 by an external consultancy company, Van Holsteijn and Kemna (VHK)[4].

On the basis of this preparatory work, the Commission drafted the policy options presented in this IA.

Stakeholder input received during the above review studies, the two Consultation forum held on 7 December 2015 and on 7 December 2017 and the consultation on the Inception Impact Assessment for Ecodesign and Energy Label have also been taken into account.

A time-history and overview of the associated documents is provided in the table below, including preparatory and review studies, impact assessments, regulations, amendments.

Survey of Regulations and related documents on Lighting Products

Date	Document	Short Description
Non-directional Household Lighting (ENER Lot 19) Comm. Reg. (EC) 244/2009		
Oct. 2008	Preparatory Study Lot 19 part 1 (VITO)	Ecodesign Preparatory Study on NDLS for domestic lighting
Mar. 2009	Full Impact Assessment (EC) SEC(2009)327	EC document accompanying regulation 244/2009

[2] Omnibus Review Study on Cold Appliances, Washing Machines, Dishwashers, Washer-Driers, Lighting, Set-top Boxes and Pumps – VHK, VITO, Viegand Maagøe and Wuppertal institute, March 2014. (Omnibus Review Study 2014)

[3] Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements (‘Lot 8/9/19’), Final Report, Tasks 1-7, VHK for the European Commission, October 2015. http://ecodesign-lightsources.eu/documents

[4] https://www.vhk.nl/

Mar. 2009	Commission Regulation (EC) No 244/2009	Main lamp-types regulated: **CFLi, HL, GLS**
Sep. 2009	Commission Regulation (EC) No 859/2009	Amendment on 244/2009 for some UV-requirements
Jun. 2013	Stage 6 Review Study (VHK)	Review of stage 6 of 244/2009 for MV-HL lamps
Tertiary Lighting (ENER Lots 8 and 9) Comm. Reg. (EC) 245/2009		
Jan. 2007	Preparatory Study Lot 9 (VITO)	Ecodesign Preparatory Study on Public Street Lighting
Apr. 2007	Preparatory Study Lot 8 (VITO)	Ecodesign Preparatory Study on Office Lighting
Mar. 2009	Full Impact Assessment (EC) SEC(2009)324	EC document accompanying regulation 245/2009
Mar.2009	Commission Regulation (EC) No 245/2009	Main lamp-types regulated: **LFL, CFLni, HID** incl. related ballasts and luminaires
Apr. 2010	Commission Regulation (EU) No 347/2010	Amendments on regulation 245/2009
Directional Lighting (ENER Lot 19) Comm. Reg. (EU) 1184/2012		
Nov. 2009	Preparatory Study Lot 19 part 2 (VITO)	Ecodesign Preparatory Study on Directional lamps (DLS)
Mar. 2011	Follow-up study (ECEEE, DEFRA)	Support study for preparation of regulation on DLS
Dec. 2012	Impact Assessment (EC) SWD(2012)418	EC document accompanying regulation 1194/2012
Dec. 2012	Commission Regulation (EU) No 1194/2012	Main lamp-types regulated: **Directional lamps, LEDs** and related equipment
Sep. 2015	Market Assessment directional lamps [5]	Regarding the formal review of stage 3 of 1194/2012 for MV filament lamps
Nov. 2015	Commission Communication COM(2015) 443 [6]	Confirms 2016 for Stage 3 of 1194/2012 for MV filament lamps
Labelling for Lighting		
Sep. 1992	Directive 92/75/EEC	Framework, legal basis for labelling of light sources (now repealed)
Jan. 1998	Directive 98/11/EC	Labelling of household light sources (now repealed)
May 2010	Directive 2010/30/EU	Framework, legal basis for labelling of light sources (repealing 92/75/EEC)
Jul. 2012	Commission Delegated Regulation (EU) No 874/2012	Labelling of electrical lamps and luminaires (repealing 98/11/EC)
Mar. 2014	Commission delegated Regulation (EU) No 518/2014 [7]	Labelling on the internet
Jun. 2018	Centerdata study	Study on the impact on consumer understanding and purchase decisions of energy labels for lighting products
General for several or all light sources		
Feb. 2013	CLASP study	Main points for the review of regulations 244/2009 and 245/2009
Apr. 2014	Omnibus Study (VHK)	Review of regulations 244/2009 and 245/2009
Aug. 2015	Commission Regulation (EU) 2015/1428 [8]	Amending 244/2009, 245/2009,1194/2012. Stage 6 of 244/2009 postponed to 2018; definitions of special purpose lamps revised

[5] Market Overview on Directional Mains-Voltage Lamps related to stage 3 of Commission Regulation (EU) No 1194/2012, VHK for the European Commission, 3 September 2015, https://ec.europa.eu/energy/sites/ener/files/documents/Draft%20Final%20Market%20Assessment%20data.pdf

[6] Communication from the Commission, Market assessment on mains-voltage lamps as required by Commission Regulation (EU) No 1194/2012, COM(2015) 443 final, 11.9.2015

[7] Commission Delegated Regulation (EU) No 518/2014 of 5 March 2014 amending Commission Delegated Regulations (EU) No 1059/2010, (EU) No 1060/2010, (EU) No 1061/2010, (EU) No 1062/2010, (EU) No 626/2011, (EU) No 392/2012, (EU) No 874/2012, (EU) No 665/2013, (EU) No 811/2013 and (EU) No 812/2013 with regard to labelling of energy-related products on the internet, OJ L 147, 17.5.2014, p.1

[8] Commission Regulation (EU) 2015/1428 of 25 August 2015 amending Commission Regulation (EC) No 244/2009 with regard to ecodesign requirements for non-directional household lamps and Commission Regulation (EC) No 245/2009 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 and Commission Regulation (EU) No 1194/2012 with regard to ecodesign requirements for directional lamps, light emitting diode lamps and related equipment, OJ L 224, 27.8.2015, p.1

Annex 2: Stakeholder consultation

This Annex gives a brief summary of the consultation process. Details are given of how, who and which stakeholders were consulted. In addition, it explains how it was ensured that all stakeholders' opinion on the key elements relevant for the IA were gathered.

There has been extensive consultation of stakeholders during the review studies (see Annex 1.4), before and after and the consultation forum. External expertise on lighting products was collected and analysed during this process. The results of the stakeholder consultation during and after the Consultation Forum are further described in this section.

1. REVIEW STUDY AND STAKEHOLDER CONSULTATIONS

The Review Study 2015 started in January 2014 and was completed in October 2015. It followed the structure Methodology for Ecodesign of Energy related Products (MEErP)[9].

The review study covered lighting products in the current scope of those regulations. A technical, environmental and economic analysis was performed. This assessed the need of updating the requirements for these products and to assess policy options. This was done as per the review clause of the regulation, and within the Ecodesign framework Directive and Energy Labelling Framework Directive since August 2017 replaced by the Energy Labelling Framework Regulation.

The review study was developed in an open process, taking into account input from relevant stakeholders including manufacturers and their associations, environmental NGOs, consumer organisations and MS representatives. To facilitate communication with stakeholders, dedicated website was set up on which the interim results and other relevant materials were published. The study website http://ecodesign-lightsources.eu/documents is still open for download of the study documents and stakeholder comments (status April 2018). During the study, two open consultation meetings were organised at the Commission premises in Brussels on 5 February 2015 and 14 June 2015. During these meetings, the preliminary study was discussed and validated.

The first meeting on 5 February 2015 was to discuss Tasks 0, 1, 2 and 3 of the study. Tasks 0 and 1 concerned the scope of the study, definitions, and existing EU and non-EU standards and legislation. Task 2 concerned market data (light source sales, lifetimes, stock, unit prices). Task 3 addressed the use of light sources, including average annual operating hours, luminous fluxes, powers and efficacies of light sources. Health aspects, end-of-life aspects and compatibility between dimmers and light sources were also discussed with stakeholders in Task 3.

Following the first meeting, stakeholders had time until 28 February 2015 to provide written comments. The minutes of the meeting can be found in Annex A of the Task 7 report of the study and on the website.

The second meeting held on 17 June 2015 was to discuss Tasks 4, 5 and 6. Task 4 extensively described technology aspects, concentrating on the expected efficacy increase and price decrease for LED lamps and on the expected speed of replacement of classic technology lamps by LED lamps and luminaires. Bills-of-Materials, including

[9] Kemna, R.B.J., Methodology for the Ecodesign of Energy-related Products (MEErP) – Part 2, VHK for the European Commission, 2011. (MEErP)

packaging, were also discussed as part of Task 4. Task 5 addressed the input and the results of the EcoReports, focusing on life cycle costs and environmental impacts of the various lamp types. Task 6 regarded design options and focused on the cost comparison of classic technology lamps and their LED replacement, and on payback times for investments in LED technology.

Stakeholders had time until 15 July 2015 to provide written comments, and until 30 August 2015 to provide inputs for the scenario analyses of Task 7. The minutes of the meeting and the stakeholders' comments and inputs have been published on the project website and can be found in Annex B of the Task 7 report of the preparatory study.

The study team also engaged in several bilateral meetings with stakeholders.

2. WORKING DOCUMENT AND CONSULTATION FORUM

The Commission services prepared two Working Documents with ecodesign and energy labelling requirements based on the results of the Review Study 2015. The Working Documents were circulated to the members of the Ecodesign Consultation Forum for the meeting on 7 December 2015. The second and last version was circulated for and discussed at the Ecodesign Consultation Forum meeting of 7 December 2017. The Ecodesign Consultation Forum represents all EU Member States and EEA countries, together with industry associations and NGOs in line with Article 18 of the Ecodesign Directive.

The Working Documents and the stakeholder comments received in writing before and after the Consultation Forum meetings were posted on the Commission's CIRCA system. Minutes of the Consultation Forum meeting of 7 December 2017 can be found in Annex 5. For this Forum, around 30 written comments were received from different MSs' representatives (11), industry associations, consumers' associations and NGOs.

3. RESULTS OF STAKEHOLDER CONSULTATION DURING AND AFTER THE CONSULTATION FORUM

The comments of the main stakeholders on key features of the Commission services' Working Document received during and after the Consultation Forum of 7 December 2017 can be summarized as follows:

- **Scope and exemptions** – Stakeholders agreed that the current definition of the scope and of the exemptions create loopholes. Exemptions should be better defined, and loopholes should be closed.
- **Administrative burden** – Stakeholders welcomed the attempt to simplify the legislation, especially the merging of the three ecodesign regulations. Most MSs also agreed on simplifying the tests for verification, especially for the lifetime test which today happens to be longer than the average permanence of a light source on the market, but there was no obvious solution.
- **Energy efficiency requirements** – Stakeholders agreed on the principle of phasing out fluorescent lamps (especially linear T8 lamps) but there was no agreement on the date. NGOs and some MS agreed on an ambitious date, while the agreement of other MSs, of industry and sectorial representatives would depend on the timing and on exemptions that will be accorded to certain sectors.
- **Circular Economy** – Stakeholders generally welcomed the principle to have more requirements on the circular economy aspects of lighting products, in particular about fully integrated luminaires and other non-dismountable products

containing the light component. However, the lighting industry, the furniture industry and some MSs required for a proper assessment of the impact of these requirements, clear definition of responsibilities for manufactures of the containing products and timing.

- **Verification tolerances** - Environmental NGOs and most MSs welcomed the proposal for stricter verification tolerances.
- **Energy label classes** – Stakeholders generally welcomed the proposed classes and no-one strongly opposed them: class A and probably B will stay unpopulated, as requested in the new framework legislation.
- **Re-labelling products** – most stakeholders opposed the solution to re-label lighting products with a sticker, especially light sources were the label is printed on the package.

As a result, the following measures represent the consensus achieved (from Section 5.1):

1. the proposed new **calculation formula and bands for energy labelling**, which are the same in all options where an energy label is continued;

2. the proposed **simplified tests** that manufacturers apply to commercialise products and market surveillance apply to check compliance of the products, which are the same in the options that include the revision of the ecodesign legislation;

3. the **discontinuation of the energy label specifically dedicated to luminaires**, but with relevant information from the label kept on the packaging and improved;

4. **fully-integrated luminaires** will fall within both ecodesign and energy labelling generic requirements;

5. (i) a slightly reduced but more certain **scope**, where ambiguities about the products in scope are highly reduced; (ii) a change in the approach of **how exemptions are defined**, moving away from a definition based on the intended use of a product to clear exemptions based on technical characteristics and/or legislative reference;

6. The **exemptions**. The list of proposed exemptions and their comparison with what is exempted in the current legislation is provided in Annex 11;

7. **the proposed list of light sources to be phased** out is also the result of a long dialogue with stakeholders, with **one crucial exception: the phase out of the linear fluorescent lamps T8**.

Other measures are not proposed for discussion in the options in Section 5.2, despite there was no full agreement from all stakeholders. This is the case especially for the introduction of requirements that would protect consumers from products with bad quality or potential negative effects on health, like the flickering effect.

4. OPEN PUBLIC CONSULTATION

An *online public consultation (OPC)*[10] took place from 12th February to 7th May 2018, with the aim to collect stakeholders' views on issues such as the expected effect of potential legislative measures on business and on energy consumption trends.

The OPC contained a common part on Ecodesign and Energy labelling, followed by product specific questions on (i) refrigerators, (ii) dishwashers, (iii) washing machines, (iii) televisions, (iv) electronic displays and (v) lighting.

1230 responses were received of which 67% were consumers and 19% businesses (of which three quarters were SMEs and one-quarter large companies). NGOs made up 6% of respondents, and 7% were "other" categories. National or local governments were under 1% of respondents, and 0.25% came from national Market Surveillance Authorities.

The countries of residence of the participants were predominantly the UK (41%) and Germany (26%), with a second group of Austria, Belgium, France, the Netherlands and Spain comprising together some 17%. Nine other Member States comprised another 9.5% of replies, but residents in 12 EU Member States gave either zero or a negligible number of responses. Non-EU respondents comprised around 5% of replies.

It should be noted that of the 1230 respondents, 719 (58%) replied only to lighting related questions as part of a coordinated campaign related to lighting in theatres. This was considered to significantly distort the replies, and for some questions the "lighting respondents" were removed from the calculation. Furthermore, as respondents did not have to reply to all questions, a high rate of "no answer" was observed (from 5% - up to 90%), in addition to those who replied "don't know" or "no opinion". To reflect better the actual answers, the number of "no answers" was deducted and the remaining answers treated as 100%.

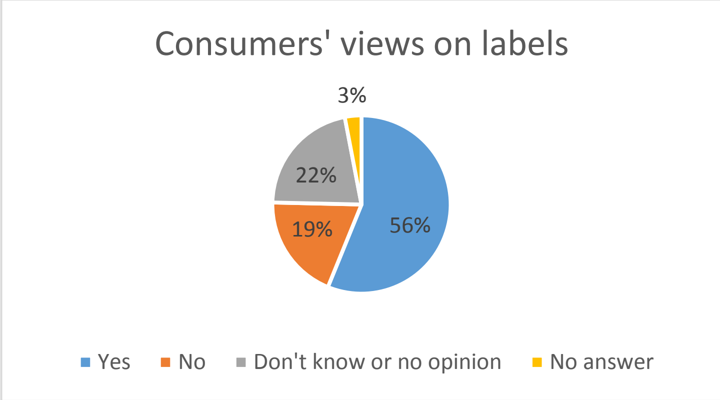
4.1. Overall results

The first part of the questionnaire asked general questions aimed at EU citizens and stakeholders with no particular specialised knowledge of ecodesign and energy labelling regulations.

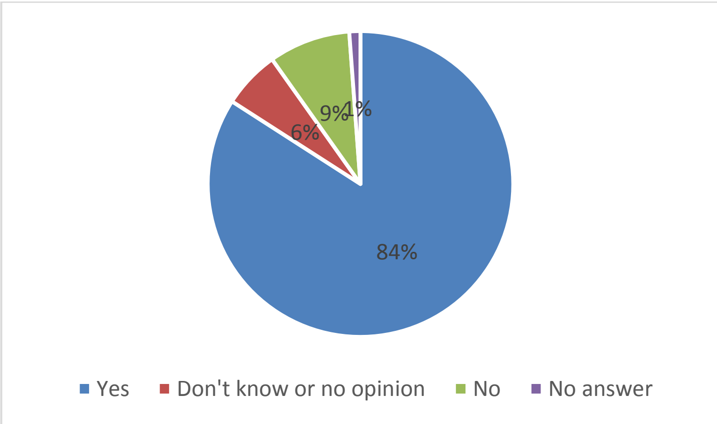
When asked regarding whether their professional activities related to products subject to Ecodesign or Energy Labelling, two-thirds (67%) of business respondents replied in the positive, and one-third (33%) in the negative, with no "no answer" replies. Almost the same percentages for "yes" (63%) and "no" (37%) were given when the business entities were asked whether they or their members knew of the Ecodesign requirements for one or more of the product groups concerned by the questionnaire, although this was reduced to 50% "yes" and 50% "no" when asked about Energy Labelling.

In reply to the question: "In your opinion, does the EU energy label help you (or your members) when deciding which product to buy?" 56% of the total respondents to the OPC gave a positive answer. Of the remainder, around 22% cited "don't know or no opinion", 3% did not reply and 19% responded negatively.

[10] https://ec.europa.eu/info/consultations/public-consultation-ecodesign-and-energy-labelling-refrigerators-dishwashers-washing-machines-televisions-computers-and-lamps_en



However, looking only at the ‘lighting respondents’ (526 of the total 1230), 73% of them replied ‘No’, ‘Don't know or no opinion’, or ‘no answer’. Given that the ‘lighting respondents’ mainly focused their comments on a narrow issue related to the current exemption for theatre lighting under ecodesign, the replies of these respondents to the earlier questions cannot necessarily be considered representative. Therefore, the calculation was also done with “lighting respondents” removed. Then, 84% of the respondents to the OPC agree that the EU Energy Label helps when deciding which product to buy. Of the remainder, around 7% cited "don't know or no opinion" or did not reply and 9% responded negatively.



When asked where they would look to find additional technical information about a product, respondents listed the following (more than one response permitted), ranked by the options provided: manufacturer's website (82%), the booklet of instructions (50%), [the Ecodesign] product information sheet (47%), internet user fora (39%), the retailer's website (18%), and consumer organisations (10%).

Some 63% of the participants were in favour of including Ecodesign requirements on reparability and durability, and 65% of respondents considered that this information should be on Energy Labels.

Regarding the reparability of products, participants valued mostly as "very important" to "important" (in the range 62%-68%)[11] each of the following: a warranty, the availability of spare parts, and a complete manual for repair and maintenance. The delivery time of spare parts was rated as 56% "very important" to "important".

[11] Scale ranging from not important, somewhat important, important, very important, don’t know or no opinion and no answer.

Small and Medium Enterprises (SME) Consultation [SMEs < 250 employees]

One of the aims of the OPC was to gather specific information on SMEs' roles and importance on the market, and to acquire more knowledge on how the aspects related to the environmental impacts of these six product groups were considered by SMEs.

The quali-quantitative evaluation of the effect on SMEs of potential regulatory measures for the environmental impact of all six product categories gave the following results. Approximately 10.5% or replies were from SMEs. These SMEs were involved in the following activities (most popular cited first): (i) product installation, (ii) rent/ leasing of appliances, (iii) repair, (iv) retail of appliances or spare parts, (v) final product manufacture/ assembly, (vi) sale of second-hand appliances, (vii) "other" activities, and (viii) manufacture of specific components.

In the OPC responses, SMEs reported that they were aware of the Ecodesign and EU Energy Label requirements applicable to the products they were involved in. Nevertheless, SMEs mostly declined to respond (90%) or replied in "don't know/ no opinion" (6%) when asked about the potential impact on their businesses per se, or potential impacts on SMEs compared to larger enterprises, of the introduction of resource efficiency requirements in the revised Ecodesign and Energy Labelling regulations. Of those SMEs who gave an opinion, some 3-4% considered that the impacts could be negative, and around 1% thought that the effects would be positive.

Responses relating specifically to lighting

Basically all respondents (1229 out of 1230) answered the questions on lighting products: the same numbers than for the overall results apply in terms of type and country of residence of respondents. 719 participants (58%) replied only on lighting.

With regards to whether ecodesign measures should be updated to take into account technological development, notably for LEDs, 75% answered yes; 11% answered no.

74% of respondents agreed on the idea that lamps should be tested against the flicker effect (11% disagreed) and 60% find it a relevant piece of information when they buy lamps (8% was against). The others had no opinion.

68% of respondents declared to dislike sealed fully integrated luminaires from where the light source cannot be removed, while 28% had no opinion on this issue.

With regards to what information respondents would like to have when they buy a light source, all options got consensus. Three of them got around 70% of positive answers (Quantity of light provided by the lamp; Lifetime; Warm/cold effect of LEDs). The Watt equivalence with old bulbs got the lowest result (54%) and the highest number of explicit "no" (14%). In details:

- Quantity of light provided by the lamp (expressed in Lumen): 74% yes, 2% no, no opinion 24%;
- Lifetime: 72% yes, 3% no, no opinion 26%;
- Warm/cold effect of LEDs: 69% yes, 4% no, no opinion 27%;
- Energy efficiency expressed in terms of lumen per Watt: 66% yes, 8% no, no opinion 27%;

- Watt equivalence with old bulbs (incandescents): 54% yes, 14% no, no opinion 32%.

Only 18% of the respondents indicated other information that they would like to have when they buy a light source. There are two main answers: the first is about the colour rendering of lamps. The second answer is about theatre lighting: in this case, more than answering to the question, the respondents raised their concern about the possible phase out from the market of light sources intended to be used in theatre and other stage contexts (this field was the only one where respondents could type messages).

Finally, with regard to the option to discontinue the energy label for luminaires, 30% of the respondents would like to keep the label as it is, while 28% would favour its replacement by a label that concerns only the light source which is contained in the luminaire. A high number – 37% – had no opinion. Only 5% favoured to discontinue the label for luminaires without an alternative.

5. IA

An IA is required when the expected economic, environmental or social impacts of EU action are likely to be significant. The IA for the review of the four regulations for lighting products (Commission Regulations (EC) No. 244/2009, (EC) No. 245/2009 and (EU) No. 1184/2012 for ecodesign; Commission Regulation (EU) No. 874/2012 was carried out between May 2017 and April 2018.

The data collected in the review studies, see Annex 1.4, served as a basis for the IA. Additional data and information was collected and discussed by the IA study team with industry and experts, and other stakeholders including MSs. During this process, several meetings were organised with industry and MSs experts. The additional data and information collection focused on:

- Additional market data on energy efficiency for the period 2015-2017;
- Update on lighting catalogues for the availability of LED replacements;
- Fine-tuning of the requirements;
- Fine-tuning of definitions;
- Investigation of various options for the phase out of T8 lamps;
- Sensitivity analysis regarding electricity tariffs;
- Extended information on SMEs, possible impacts;
- Extended information on specific sectors using T8 lamps.

In addition, inception impact assessments for the regulatory measures on the review of ecodesign and energy labelling requirements for this product group were published on 26 January 2018 for feedback until 23 February 2018. In total 17 comments were received for the ecodesign measure and 16 for the energy labelling measure.

In general, all stakeholders are in favour of Ecodesign and Energy labelling requirements for lighting products. The submitted feedback commented amongst others on the strictness of Ecodesign requirements, the quality of light, the blue light content and requirements that would make light sources easily replaceable//repairable in containing products.

Annex 3: Who is affected and how?

This annex explains the practical implications of a potential ecodesign and energy labelling measures based on implementation of the preferred policy option, see Section 5.2.2.

1. PRACTICAL IMPLICATIONS OF THE INITIATIVE

The ecodesign regulation will apply to the manufacturers, importers and authorised representatives of lighting products in the scope of the regulations.

The energy labelling regulations will apply to the suppliers and the dealers of lighting products in the scope of the regulations.

They will need to comply with the ecodesign requirements summarised in Table 17.

Table 17: Summary of the Ecodesign requirements

Who	What	When
Manufacturers, importers and authorised representatives	New ecodesign requirements	1 September 2021
Manufacturers, importers and authorised representatives of products containing a light	Information requirements on the contained light	1 September 2021
Suppliers	Provide Energy labels rescaled from A to G	1 May 2021[12]
Dealers	Display Energy labels rescaled from A to G	1 September 2021
	Remove products from the shelves if they do not have the new label	1 June 2022

In addition to the above and to what described in the main text of this impact assessment, the following categories will be affected:

- **MANUFACTURERS OF LIGHTING-RELATED ELECTRONICS**

With the ongoing rapid shift to LED lighting, **manufacturers of lighting-related electronics** are required to adjust from electronic control gears for classical lighting technologies to drivers for LEDs. Less efficient electro-magnetic control gears are phased out from the market since 2017 and have been replaced by more efficient, high-frequency electronic ones. These manufactures have a dynamic business also for the increasing trend to have ‘smart lights" with new features.

[12] For products placed on the market before the date of application of the new label and that will be on the shelves of dealers with the old label after 1 June 2022, suppliers would need to provide dealers with a sticker with the new label on the request of dealers until 1 June 2022.

- **LIGHTING DESIGNERS**

Lighting designers tend to be conservative as regards legislation on light sources, as they are afraid that the requirements may limit their design options. LED light sources pose both challenges and opportunities on design**.** LEDs are different from conventional light sources in many aspects, e.g. they are smaller, mainly directional and have different thermal characteristics. In parallel, lighting designers can exploit the higher controllability of LEDs, including new intensity-change and colour-change possibilities, also related to creating a human-centric lighting and the possibility for different methods of power supply (e.g. Power-over-Ethernet). On top, organic LEDs (OLED) offer large, flexible surfaces emitting a diffuse light and enable a new approach to luminaire design with a variety of new possibilities.

Lighting designers are represented by the International Association of Lighting Designers (IALD).

- **PROFESSIONAL APPLICATIONS**

In **professional applications** as offices, shops, hotels, restaurants, theatres, sports facilities, industry, street lighting, etc., the average burning hours for lights are longer than in households, typically between 2000 and 4000 hours per year. It is therefore expected that future LED lamps for professional use will differ from those for household use, being more expensive, but with higher efficiency and longer lifetime.

In many professional applications the importance of light quality and controllability will increase, to create a "human centric lighting". Lamps are inserted in control systems to regulate light in function of daylight availability or space occupancy.

For some professional applications the availability of LED retrofit lamps for existing luminaires is disputed. Even where LED retrofit lamps are available, it may be necessary to substitute the control gear and/or to perform a rewiring in the luminaire. Specific exemptions are investigated in the most problematic sectors (e.g. theatre/stage lighting; railways). Businesses and municipalities that have recently invested in non-LED lighting solutions following the ban of some mercury lamps in the current ecodesign legislation, have asked to take this into account to avoid another change at short term.

- **CONSUMERS**

Due to more efficient and less expensive LED lighting products, this can decrease to EUR 80 in 2020 and to EUR 50 in the period 2025-2030[13]. An average household lamp burns around 500 hours per year. A LED lamp with a relatively low lifetime of 10 000 hours would on average last 20 years. Therefore light quality is a crucial aspect and consumers should be well informed on the lamp they buy.

2. SUMMARY OF COSTS AND BENEFITS

For the preferred option, Table 18 and Table 19 present the costs and benefits which will have been identified and assessed during the impact assessment process.

[13] Data from the MELISA model, October 2017 update.

Table 18: Overview of Benefits (total for all provisions) as compared to the baseline– Preferred Option

I. Overview of Benefits (total for all provisions) – Preferred Option ECOEL2021		
Description	***Amount***	***Comments***
Direct benefits		
Final Energy (Electricity) savings	41.9 TWh/a by 2030 Cumulative 267 TWh up to 2030	See Section 6.2.1 See Section 7.1
GHG-emission reduction	14.3 Mt CO_2eq/a by 2030 Cumulative 94 Mt CO_2eq up to 2030	See Section 6.2.2 See Section 7.1
Decreased consumer expenditure	EUR 7.7 billion less in 2030 Cumulative EUR 21 billion less up to 2030	See Section 6.4 See Section 7.1
Additional business revenue	EUR 1.1 billion extra in 2030 Cumulative EUR 29 billion extra up to 2030	See Section 6.3.1 See Section 7.1
Increased Employment	59 000 jobs extra in 2025 23 000 jobs extra in 2030	See Section 6.6.3
Single regulation for all light sources	General simplification	Existing three Ecodesign regulations replaced by a single new regulation. Welcomed by all stakeholders
Market surveillance facilitated	Possibility to perform more compliance checks with the same resources	Due to unifying regulations into one; less parameters to verify; improved definitions for parameters and exemptions; shorter lifetime-related tests. The freed resources for other surveillance activities cannot be easily monetised.
Luminaire labels abolished	EUR 0.001 billion (as a result of EUR 34 million cost for suppliers and dealers for re-labelling and EUR 35 million savings from the abolished obligation to upload data in the database EPREL)	For dealers and for SMEs. The result has to be treated cautiously: the decrease in total administrative costs also means freed resources for other activities and higher turnover. See Sections 6.5 and 7.2.
Reduced risk of circumvention	More light sources complying with regulation	Improved definitions for exemptions; redefinition of verification tolerances
Support of innovation, R&D and improved competition	New features in LEDs for smart lights and human centric lighting	See Section 6.3.2
Indirect benefits		
Circular economy	Incentive to have dismountable LED	

	luminaires	

Estimates are relative to the baseline for the preferred option as a whole (i.e. the impact of individual actions/obligations of the preferred option are aggregated together.

Table 19: Overview of the additional costs as compared to the baseline – Preferred option

II. Overview of costs – Preferred option ECOEL2021		
What	***Amount***	***Who***
Acquisition costs	EUR 1.1 billion extra in 2030 (but total expenditure including energy consumption decreases – see Table 18)	Consumers
Installers revenue	EUR -0.2 billion in 2030 (but total business revenues increase – see Table 18)	Installers

Table 20: Overview of stakeholder problems/challenges and main related actions in regulation		
EU Stakeholder	**Main problems / challenges**	**Main related actions in Regulation**
Manufacturers of light sources	Declining sales of classical light sources. Strong increase in LED sales, but more fragmented market and competition from low-cost low-quality from extra EU. Investments required in R&D for LED, OLED and new features.	Set ambitious requirements on efficiency and quality of LEDs to be sold on EU28 market, to avoid price-war, to avoid dumping of low-cost and low-quality products from extra-EU, promoting and safeguarding investments of EU-manufacturers.
Manufacturers of luminaires (many SME's)	LED- and OLED-luminaires require new design approach, but offer new possibilities. Choice to be made between existing luminaires using LED retrofit lamps, integrated LED luminaires, and luminaires with replaceable LED modules. Integration of new features; luminaires part of intelligently controlled lighting systems; trend towards human centric lighting. Luminaire labelling is a burden and not effective.	Limit ecodesign requirements to light sources. Most luminaire suppliers buy the contained light sources, which will usually already be supplied with a document of conformity, so minimal burden for SMEs. Take into account the demands that new features and integration in lighting systems pose on light sources and luminaires. Abolish labelling for luminaires.
Manufacturers of lighting-related electronics	Decrease in sales of control gears for classical light sources. Increase in drivers for LEDs, but more competition from extra-EU. Demand for new features and intelligent controls; new power supply methods (PoE). New dimmer standard (2018). Controls/dimmers built in lamps already by light source manufacturers.	Set ambitious requirements on efficiency and quality of control gears to be sold on EU28 market, to avoid price-war, to avoid dumping of low-cost and low-quality products from extra-EU. Set standby requirements sufficiently strict to avoid excessive energy consumption, but sufficiently wide to enable new features and intelligent controls.
Lighting designers	Exploit new possibilities of LED and OLED. Balance energy efficiency with lighting quality and new features.	Combination of actions mentioned above for manufacturers. Ensure OLEDs can be placed on the market.

	Recalculate lighting systems for new light distribution from LEDs. Implement intelligently controlled lighting systems and human centric lighting.	
Retailers and wholesalers	Dynamic market with shift from classical to LED products. LED models frequently changing. Introduction of new features. Short term: stable or increasing revenue from LEDs; later: decrease in sales. Increase of sales over internet. Display energy labels; informing consumers.	Revision of energy label for light sources; general revision of information requirements. Abolish labelling for luminaires.
Installation and maintenance (tertiary / industry)	Increased installation due to shift to LED: substitution of control gears, rewiring of luminaires, replacement of luminaires. Peak in 2020-2024, afterwards decrease. Increased installation for lighting systems, (sensors, timers, switches, communication, controls, cables for PoE, etc.). Maintenance: less substitutions of light sources and control gears (longer LED lifetime). More work to maintain lighting systems. Increased complexity of work and shift to electronics.	Phase-out of inefficient lamps. Stimulate quality / reliability of LEDs. Do not penalize LED luminaires with replaceable light sources.
Market surveillance	Definitions, scope and exemptions not always clear or not objectively verifiable. Too many parameters to test; tests too long and too costly.	General effort to unify and simplify existing regulations. Improve definitions, scope, exemptions and try to remove remaining loopholes. Simplify testing. Revision of tolerances for verification.
Households	Now: Should I already buy LED? Future: Which LED should I buy? How many lumens should my new lamp have? Is quality good? No induced health / discomfort problems? Demand for new features (e.g. intensity/colour control from smartphone)	Improve energy label and information requirements. Stimulate use of high efficiency, high quality LEDs, that do not have health problems. Enable new features to be implemented, but without excessive energy consumptions (standby).
Professional users	Need for high efficiency and high lifetime, even if at slightly higher acquisition cost. Importance of quality and controllability of light: trend towards human centric lighting. Increased implementation of intelligently controlled lighting systems. LEDs do not have lowest life cycle costs for all applications yet (2015). Expected by 2020. Substitution of control gears or rewiring may be necessary to install LED retrofits: higher upfront costs. For some existing luminaires LED retrofits are scarce; possible need to substitute entire	Combination of other actions mentioned above. Take into account new methods of power supply (e.g. PoE). Set standby requirements sufficiently strict to avoid excessive energy consumption, but sufficiently wide to enable new features and intelligent controls. Provide sufficient time for replacement of CFni, LFL, HID by LED, so that users can recuperate previous investments and prepare for luminaire substitutions.

	luminaire: higher upfront costs. Recent investments made in efficient office and street lighting. Time needed to recuperate this before passing to LED. Increased use of ESCO's and EPC.	
Society	Meet EU policy objectives regarding energy efficiency, security of energy supply, reduction of CO_2 emission, promoting the single market, stimulating EU business, and furthering innovation. Ensure safety, protect health, increase well-being of EU citizens.	Set requirements on lighting products sold on EU28 market that do no lag behind those in major extra-EU economies. Set requirements that ensure energy savings and reduction of environmental impact, while maintaining or increasing functionality and affordability, and avoiding negative impacts for the majority of the stakeholders. Ensure quality of products on the market, to ensure safety, health, comfort.

Annex 4: Analytical methods

ACRONYMS

AR111	Lamp shape: Wide and flat reflector lamp, 111 mm diameter
CFL	Compact Fluorescent Lamp (all types)
CFLi	CFL with integrated control gear
CFLni	CFL without integrated control gear
CMH	MH-lamp with ceramic technology
DLS	Directional Light Source (light concentrated in a beam, spot light)
E	Cap-type, screw-in
E14	Cap-type, screw with 14 mm diameter
E27	Cap-type, screw with 27 mm diameter
FL	Fluorescent lamp (all types)
G	Cap-type, push-in or push-in and turn
G4	Cap-type with two pins at 4 mm distance for low-voltage
G53	Cap-type with two pins at 53 mm distance for low-voltage
G9	Cap-type with two pins at 9 mm distance for mains-voltage
GLS	Incandescent, non-halogen, filament lamp (classic light bulb)
GLS R	GLS reflector lamp, DLS
GLS X	GLS non-reflector lamp, NDLS
GU4	Cap-type with two pins at 4 mm distance for low-voltage
GU5.3	Cap-type with two pins at 5.3 mm distance for low-voltage
GU10	Cap-type with two pins at 10 mm distance for mains-voltage
GY6.35	Cap-type with two pins at 6.35 mm distance for low-voltage
HID	High-Intensity Discharge lamp (all types)
HL	Halogen lamp (all types)
HL LV C	Halogen Low-Voltage Capsule, with G4 or GY6.35 cap, NDLS
HL LV R	Halogen lamp, Low-Voltage, Reflector type (mirrored), DLS: e.g. MR11-GU4, MR16-GU5.3, AR111-G53
HL MV C	Halogen Mains-Voltage Capsule, with G9 cap, NDLS
HL MV E	Halogen lamp, Mains-Voltage, most with E-cap, NDLS
HL MV L	Halogen lamp, linear, double-ended R7s cap, NDLS
HL MV X	Halogen lamp, Mains-Voltage, Reflector type (mirrored), DLS: e.g. MR16-GU10, R- and PAR-lamps with E14 and E27 caps
HPM	High-Pressure Mercury lamp (type of HID)
HPS	High-Pressure Sodium lamp (type of HID)
LED	Light-Emitting Diode light source
LFL	Linear Fluorescent Lamp (all types)
LFL T5	LFL with diameter of 16 mm (5/8 inch), 14-80W, incl. circular
LFL T8	LFL with diameter of 26 mm (8/8 inch) (all types)
LFL T8t	LFL T8 with tri-phosphor technology
LFL T8h	LFL T8 with halo-phosphor technology
LFL T12	LFL with diameter of 38 mm (12/8 inch)
LFL X	LFL other than T12, T8 and T5 (incl. e.g. T9, special FL, U-shaped, T5 ≤ 13 W)
LV	Low-Voltage (less than 230 V, typically 12 or 24 V)
MH	Metal-Halide lamp (type of HID)(all types)
MR11, MR16	Lamp shape: Small reflector lamps (DLS)
MV	Mains-Voltage (230 V)
NDLS	Non-Directional Light Source (light not concentrated in a beam)
PAR	Lamp shape: Parabolic reflector lamp (DLS)
QMH	MH-lamp with quartz technology
R	Lamp shape: Reflector lamp (DLS)
R7s	Cap-type, with thick pin at each extremity of a tube-shaped lamp

1. INTRODUCTION TO MELISA

The scenario analysis for this Impact Assessment has been performed using the 'Model for European Light Sources Analysis' (MELISA). This model was developed during the Ecodesign preparatory study on Light Sources (ENER Lot 8/9/19)[14].

MELISA has been developed on request of the European Commission with the aim to harmonize the data for the two related preparatory studies on lighting, i.e. the ENER Lot 8/9/19 study on Light Sources (concluded in October 2015 and basis for this Impact Assessment) and the ENER Lot 37 on Lighting Systems (concluded in December 2016).

A detailed description of the October 2015 version of MELISA can be found in the Task 7 report of the Light Sources study[15]. The input data for the model (e.g. annual sales volumes, average luminous flux, power and efficacy, light source prices, etc.) have been extensively checked against other data sources[16] and discussed with stakeholders.

The model validation, and the interaction with stakeholders, continued during the Impact Assessment study. In July 2016 this resulted in an updated MELISA version, incorporating new input data supplied by industry association LightingEurope[17], and implementing an enhanced method to compute the installed stock of light sources from the annual sales and (variable) lifetimes. The updated version was extensively checked by industry and generally appreciated and accepted.

A further update was performed in October 2017, in particular as regards the projections for the development of average LED efficacy and price. The projection curves were adapted to match the average LED efficacy derived from 2015-2017 catalogue data and taking into account recent projections from UNEP and US DoE [18]. A separate projection curve was created for directional lamps. In addition, electricity rates were updated from Eurostat data.

The updated MELISA version of October 2017 has been used for this Impact Assessment on Light Sources. The July 2016 version was used for the scenario analysis in the Lighting Systems study[19] (using a dedicated model extension), thus ensuring compatibility of data and methods between the two related studies (except for the October 2017 updates), and avoiding double counting of energy savings.

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14 http://ecodesign-lightsources.eu/documents

15 http://ecodesign-lightsources.eu/sites/ecodesign-lightsources.eu/files/attachments/LightSources%20Task7%20Final%2020151031.pdf, Annexes D, E and F.

16 See the Task 2 and Task 3 reports of the Lot 8/9/19 preparatory study on Light Sources.

17 These changes mainly regard the lifetime (longer), average luminous flux, power and efficacy of LFL and HID-lamps. The lifetime for LEDs substituting LFL and HID was also increased. To enable lifetime to be variable with the years, a lifetime distribution was introduced for LFL T8t, LFL T5, HPS, MH and LEDs substituting these lamps. The main effect of these changes, with respect to results reported in Task 7 of the Light Sources study, was that energy savings in 2020 and 2025 slightly decreased while savings in 2030 increased.

18 'Accelerating the Global Adoption of Energy-Efficient Lighting', UN Environment – Global Environment Facility | United for Efficiency (U4E), U4E policy guide series, UNEP 2017, in particular figure 4 (based on US DoE 2016 data).

19 http://ecodesign-lightingsystems.eu/documents

MELISA distinguishes the light source base cases presented in Table 21. There are five groups of light source types:

- Linear Fluorescent Lamps (LFL),
- High-Intensity Discharge lamps (HID-lamps),
- Compact Fluorescent Lamps without integrated ballast (CFLni),
- Directional lamps (DLS) and
- Non-directional lamps (NDLS).

As shown in the table, each group is further subdivided in classical technology base cases and also has two associated LED base cases, respectively for LED retrofit lamps and integrated LED luminaires. The shift in (light source) sales from the classical technology base cases to the LED base cases of the same group is one of the essential elements in the scenario projections in MELISA.

Although not shown in Table 21, all data in MELISA (both input data and calculated results) are subdivided in those related to the residential sector and those related to the non-residential sector.

MELISA derives the installed stock of light sources in the EU-28 from data on the annual sales and on the average useful lifetimes. These stock data are combined with average unit power values (W) and average annual operating hours per unit (h/a) to compute the total electricity consumption per base case (TWh/a). The contributions of the various base cases are summed to get the EU-28 totals per sector (residential, non-residential) and the sum of the latter two provides the overall EU-28 total for all sectors.

Greenhouse gas (GHG) emissions are directly related to electricity consumption by means of the Global Warming Potential (GWP) for electricity.

The electricity consumption is multiplied by the electricity rates (EUR/kWh)[20] to compute the associated annual electricity costs (billion EUR per year). These are combined with the annual maintenance costs to obtain the total annual running costs.

Multiplying the annual sales by unit prices per light source provides the purchase costs (per base case, per sector, and the overall EU-28 total). Adding the installation costs provides the total acquisition costs.

The sum of acquisition costs and running costs is the total consumer expense.

A survey of the main input variables and the calculated intermediate and final results for MELISA is provided in Table 22. For further details see the Light Sources study[114], in particular Task 2 (sales, stock), Task 3 (light source usage parameters), Task 4 (summary of input data per base case) and Task 7 reports.

For the residential sector the data are considered to be fairly accurate, within a maximum estimated error of 10%. For the non-residential sector some data could have a larger error, in particular the average annual operating hours for LFLs, the sales volumes of HID-lamps, and the useful lifetimes for non-residential lamps.

[20] Separate rates are used for residential and non-residential applications. Until 2016 the rates are based on Eurostat. For following years an escalation rate of 4% per year is applied according to the MEErP. An alternate approach using electricity rates from the PRIMES model has been used for sensitivity analysis.

The MELISA model has been specifically developed and paid for by the Commission (DG ENER) and is thus subject to the same intellectual property provisions as other contract work for the Commission.

Table 21 Light source base cases distinguished in the MELISA model. The shift in sales from classical technology base cases (on the left) to LED base cases (on the right) is one of the main mechanisms in the MELISA scenarios.

Classical technology base cases		LED base cases
LFL T12 LFL T8 halo-phosphor (T8h) LFL T8 tri-phosphor (T8t) LFL T5 (new 14-80 W) incl. circular LFL other (old T5 ≤ 13 W, special FL) (LFL X)	→	LED Retrofit lamps for LFL replacement Integrated LED luminaires for LFL applications
High-Pressure Mercury (HPM) High-Pressure Sodium (HPS) Metal Halide lamps (CMH, QMH)	→	LED Retrofit lamps for HID replacement Integrated LED luminaires for HID applications
Compact Fluorescent Lamps without integrated ballast (CFLni)	→	LED Retrofit lamps for CFLni replacement Integrated LED luminaires for CFLni applications
Halogen Low-Voltage mirrored (HL LV R) (MR11, MR16, etc. GU4, GU5.3 caps) Halogen Mains-Voltage reflector (HL MV X) (R-lamps, PAR-lamps, etc., GU10 or E-cap) Incandescent reflector lamps (GLS R)	→	LED Retrofit lamps for DLS replacement Integrated LED luminaires for DLS applications
Halogen LV capsules (HL LV C) G4, GY6.35 cap Halogen MV capsules (HL MV C) G9 cap Halogen MV, GLS substitute (HL MV E) E-cap Incandescent non-reflector (GLS X) Compact Fluorescent Lamps with integrated ballast (CFLi) Halogen MV linear (HL MV L) R7s-cap	→	LED Retrofit lamps for NDLS replacement Integrated LED luminaires for NDLS applications

Table 22 MELISA input data and calculated intermediate and final results (for every base case, for the residential and the non-residential sector)*.

Model Input data (per BC)	Intermediate results	Output data (EU-28 total)
Sales in EU-28 per year	Stock in EU-28 per year	
Avg. useful lifetime (hours)	Avg. useful lifetime (years)	
Avg. annual operating hours (h/a)		EU-28 total installed capacity (Tlm)
Avg. unit capacity (lm)	Avg. unit power (W)	EU-28 total installed power (GW)
Avg. sales efficiency (lm/W)	Avg. stock efficiency (lm/W)	Electric Energy (TWh/a)
Avg. unit price (euros) →	→	
Taxes (VAT 20% residential)	Purchase costs (billion euros)	
Avg. unit install cost (euros)		Acquisition costs (billion euros)
Electricity rates (euros/kWh)	Electricity costs (billion euros)	
Escalation rate (4% /a)		Running costs (billion euros)
Avg. unit maintenance (euros/a)		Total consumer expense (bn euros)

*For the formulas used in the calculations, see the Task 2 and 7 reports of the Lot 8/9/19 preparatory study.

2. BASIC FUNCTIONAL PARAMETERS

2.1. Basic functional parameters for non-LED base cases

Table 23 shows the luminous flux, power, efficacy, lifetime, annual operating hours and control gear efficiencies used in MELISA for the non-LED base cases. The values shown are sales average values for 2016. For some lamp types and some parameters the values may vary with the years (in particular before 2016). In some cases values might also differ between residential and non-residential sector. For details see the MELISA Excel file.

For non-LED light sources the efficacy is assumed to remain constant over the period 2016-2030, and the same values apply in all scenarios. The effect of Ecodesign measures is not an increase in the efficacy of classical technology lamps, but an acceleration of the shift in sales from these classical models to more efficient LED lighting products. Energy Labelling measures are assumed to affect only average LED efficacy.

Table 24 shows purchase prices, installation costs and repair & maintenance costs for non-LED light sources. All cost information is in fixed 2010 EUR, incl. 20% VAT for residential users and excl. VAT for non-residential. For residential users, no installation and maintenance costs have been considered. Only light source costs have been taken into account; additional luminaire costs are excluded. The economic non-LED light source data remain constant over the 2016-2030 period and the same values apply in all scenarios.

Table 23 Basic functional non-LED light source parameters used in MELISA in year 2016

Base Case[0]	Flux[1]	Power[1]	Efficacy[1]	Lifetime[1]	Hours RES[2]	Hours NRES[2]	CG eff[3]
	lm	W	lm/W	H	h/a	h/a	%
LFL T12	2450	35	70	8000	700	2200	80%
LFL T8h (halo-phosphor)	2400	32	75	8000	700	2200	80%
LFL T8t (tri-phosphor)	3320	39	85	21360	700	2200	88%
LFL T5 (13-80 W)	2600	28	93	23140	700	2200	89%
LFL X (other LFL)	1032	12	86	11000	700	2200	88%
HPM (High-Pressure Mercury)	10000	208	48	8000	700	4000	88%
HPS (High-Pressure Sodium)	20000	182	110	21360	700	4000	89%
MH (Metal-Halide)	10000	109	92	14240	700	4000	89%
CFLni (without control gear)	690	11	65	10000	700	1600	85%
HL LV R	560	35	16	2000	450	450	94%
HL MV X (DLS)	360	50	7	1500	450	450	100%
GLS R (DLS)	324	54	6	1000	450	450	100%
CFLi (integrated control gear)	605	11	55	6000	500	500	100%
HL MV E (NDLS)	504	36	14	1500	450	450	100%
GLS X (NDLS)	495	45	11	1000	450	450	100%
HL LV C (capsule)	515	30	17	2000	450	450	94%
HL MV C (capsule)	525	37	14	1500	450	450	100%
HL MV L (linear, R7s)	3800	200	19	1000	450	450	100%

[0] For further explanation of the base cases see Table 21 or the Lot 8/9/19 preparatory study

[1] Average value for sales in 2016. For other years value may differ. In some cases there are differences between residential and non-residential values. For details see the MELISA Excel file.

[2] RES=residential users; NRES=non-residential users. The hours in MELISA are full-power equivalent annual operating hours. E.g. if a light source on average burns 1000 h/a at full power and 500 h/a dimmed at half power, the full-power equivalent hours are 1000+500/2=1250 h/a.

[3] Control gear efficiency. A value of 100% indicates that no external control gear is used. In the model, values typically vary with the years; the value shown is the average of sales in 2016.

Table 24 Economic data for non-LED light sources used in MELISA in fixed 2010 EUR, incl. 20% VAT for residential (RES), excl. VAT for non-residential (NRES). For residential users, zero installation and maintenance costs are assumed.

Base Case	Price RES	Price NRES	Installation cost NRES	Maintenance cost NRES
	EUR	EUR	EUR	EUR/year
LFL T12	10.10	8.42	6.17	0.46
LFL T8h (halo-phosphor)	10.10	8.42	6.17	0.46
LFL T8t (tri-phosphor)	10.10	8.42	6.17	0.46
LFL T5 (13-80 W)	9.50	7.92	6.17	0.46
LFL X (other LFL)	9.50	7.92	6.17	0.46
HPM (High-Pressure Mercury)	20.40	17.00	9.25	6.17
HPS (High-Pressure Sodium)	32.40	27.00	9.25	6.17
MH (Metal-Halide)	32.40	27.00	9.25	6.17
CFLni (without control gear)	5.27	4.39	6.17	3.08
HL LV R	3.79	3.16	1.85	0.93
HL MV X (DLS)	6.00	5.00	1.85	0.93
GLS R (DLS)	1.37	1.14	1.85	0.93
CFLi (integrated control gear)	5.27	4.39	1.85	0.93
HL MV E (NDLS)	2.63	2.19	1.85	0.93
GLS X (NDLS)	0.84	0.70	1.85	0.93
HL LV C (capsule)	3.16	2.63	1.85	0.93
HL MV C (capsule)	3.79	3.16	1.85	0.93
HL MV L (linear, R7s)	3.16	2.63	1.85	0.93

2.2. LED efficacy and price projections

One of the main scenario mechanisms in MELISA is the shift in sales from classical technology light sources to LED lighting products. As shown in Table 21, five groups of LEDs are distinguished in MELISA, respectively for substitution of LFL, HID-lamps, CFLni, DLS and NDLS. For each group, two product variants are distinguished: retrofit LED lamps and (light sources in) integrated LED luminaires[21].

In MELISA, LED products inherit the luminous flux and the annual operating hours from the classical lamps they replace, but multiplied by a rebound factor[22].

The useful lifetime for LEDs has been chosen conservatively 20,000 hours, except for LEDs substituting LFL or HID in the non-residential sector, where 40,000 hours has been used.

In the residential sector, where annual operating hours are 450-700 h/a, this implies lifetimes from 30 to 40 years, i.e. LEDs bought after 2017 will never be replaced within the 2030 time-horizon of the model.

In the non-residential sector, where annual operating hours are 1600-4000 h/a, it implies lifetimes from 10 to 25 years, i.e. LEDs bought after 2017 will at maximum be replaced once within the 2030 time-horizon of the model.

MELISA assumes that between 2017 and 2030 the energy efficacy of the LED light sources will continue to increase, while prices will continue to come down. The projection curves were updated in October 2017 to match the average LED efficacy derived from 2015-2017 catalogue data and taking into account recent projections from UNEP and US DoE [118]. A separate projection curve was created for directional lamps. The projection curves presented below are therefore slightly different from those reported in the Lot 8/9/19 study.

Three sets of projection curves are used in the model, respectively for:

- low-end non-directional (NDLS) LED,
- low-end directional (DLS) LED,
- high-end LED.

High-End LED products are those substituting LFL, HID, CFLni in the non-residential sector (‘professional’, high annual operating hours). Low-End LED products are those substituting GLS, HL, CFLi in any sector, and LFL and CFLni in the residential sector (‘consumer’, low annual operating hours).

For each set there are two variant curves for the average efficacy projection:

- BAU, expected development if no new measures are taken

[21] MELISA is a light sources model and does not consider luminaire data. All data for ‘integrated LED luminaires’ actually refer to the light sources (LED modules, LED light engines) inside those luminaires.

[22] This factor reflects the tendency for users to buy LEDs with slightly higher flux than the classical lamps they replace, and the tendency to increase the annual operating hours, knowing that LEDs consume less energy. The rebound factor for flux varies from 1.025 to 1.1; the factor for hours from 1.0 to 1.025.

- EL, expected development if new Energy Labelling measures are taken, used in the ELOnly, ECOEL2021 and ECOEL2tiers scenarios.

The EL curves shown in the graphs below assume an introduction of the new labelling scheme in 2020. For an introduction in 2021, as assumed in the most recent analyses, the curve is shifted to the right by one year.

The average efficacies in these projections are in terms of total flux divided by mains power input. Total flux is also used for directional lamps (flux in cone assumed to be 85% of total flux). The reference to mains power implies that control gear efficacy is included in the reported LED efficacy.

Each efficacy projection curve has a corresponding price projection curve, where the price is expressed in EUR per 1000 lm of light output (EUR/klm). The price is in fixed 2010 EUR, excl. VAT and incl. control gear. Installation costs are not included.

The lowest curve leads to a price of EUR 4 / klm in 2030 and is assumed to be valid for the efficacies of low-end NDLS LED in the BAU scenario (122 lm/W in 2030). This curve was agreed with industry during the Lot 8/9/19 study.

The highest curve leads to a price of EUR 8 / klm in 2030 and is assumed to be valid for the efficacies of high-end NDLS LED in all scenarios except BAU (190 lm/W in 2030). This curve is based on information from industry during the Lot 8/9/19 study, that prices for higher efficacy 'professional lamps' will be approximately double the prices for lower efficacy 'consumer lamps'.

For other NDLS efficacies, prices are interpolated between the EUR 4 and EUR 8 curves in function of efficacy. For DLS, that use the (smaller) flux in a cone in the MELISA model and in general have lower efficacies than NDLS, the price curve was set 25% higher than the NDLS curve (based on information gathered during the Lot 8/9/19 study), leading to EUR 5 / klm in 2030 in the BAU scenario (101 lm/W in 2030).

For LED luminaires the projections cover only the efficacy and price of the contained light sources, not of the entire luminaire. Additional luminaire costs or luminaire efficacy losses are not considered[23].

In addition to the projection curves for efficacy and price there are also projection curves for control gear efficiency. These are used only to enable a subdivision between light source energy and control gear energy in the model, where applicable. The control gear efficiencies vary from 85% in 2020 to 90-96% in 2030 (90% for low-end in BAU; 96% for high-end in other scenarios). No graphs are presented here; for details see the MELISA Excel file.

<u>Projections for low-end NDLS (see graphs below):</u>

The solid blue curve indicates the efficacy projection for the BAU scenario, leading to 122 lm/W in 2030. The dashed blue curve (EL) gives the efficacy projection for the other scenarios, 160 lm/W in 2030. The assumed effect of energy labelling is 38 lm/W in 2030, approximately 1.5 label class widths of 25 lm/W.

[23] These aspects are being considered in the parallel ENER Lot 37 Lighting Systems study.

For comparison, the UNEP/US DoE curves for the same lamp types are shown. They lead to the same 122 lm/W in 2030.

The vertical lines near year 2017 indicate the efficacies for different lamp types as gathered during the Lot 8/9/19 study and this Impact Assessment study (2015-2017 data). For each line the large dot is the average efficacy, the solid line indicates the 25% and 75% percentiles, and the dotted lines indicate the minimum and maximum efficacies encountered.

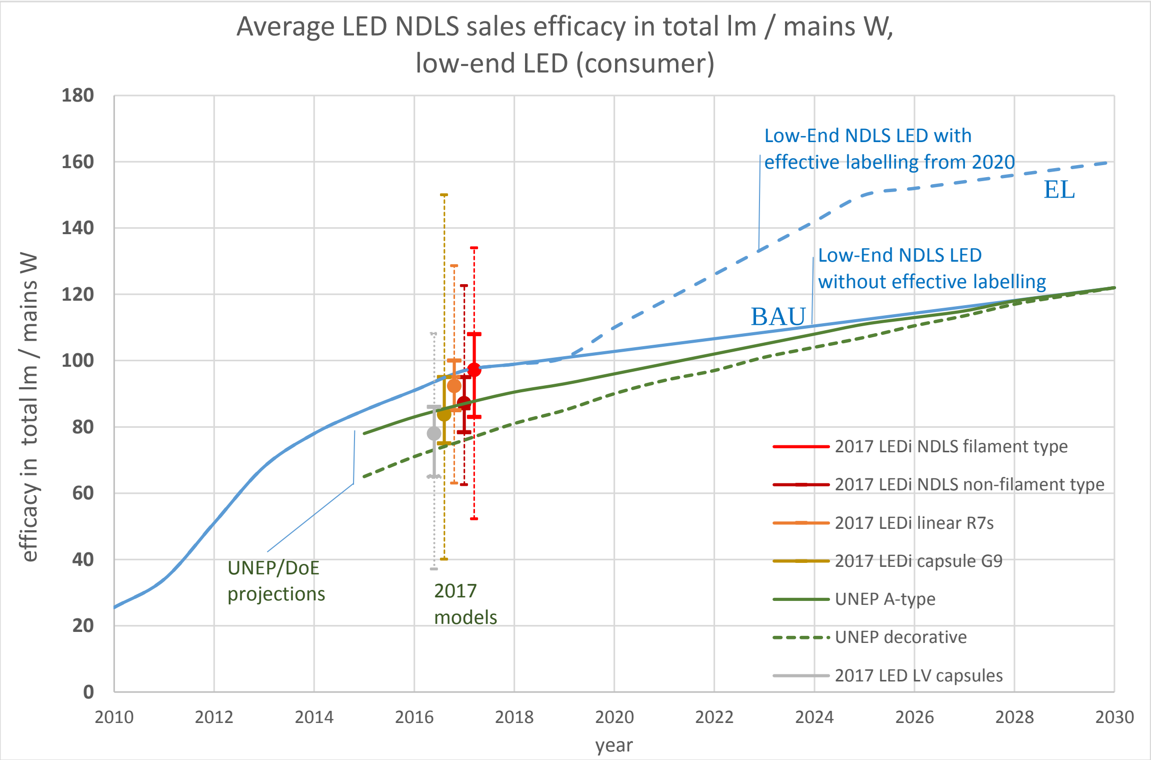
Corresponding price curves lead to EUR 4 /klm in 2030 for the BAU projection and EUR 6.24 /klm in 2030 for the other scenarios.

For the purposes of estimating the distribution of light source models over the proposed energy efficiency classes in 2020 and 2030, the following efficacy increases with respect to 2017 catalogue data have been assumed:

+7.2% in 2020

+27.2% in 2030

+67% in 2030 with effective label



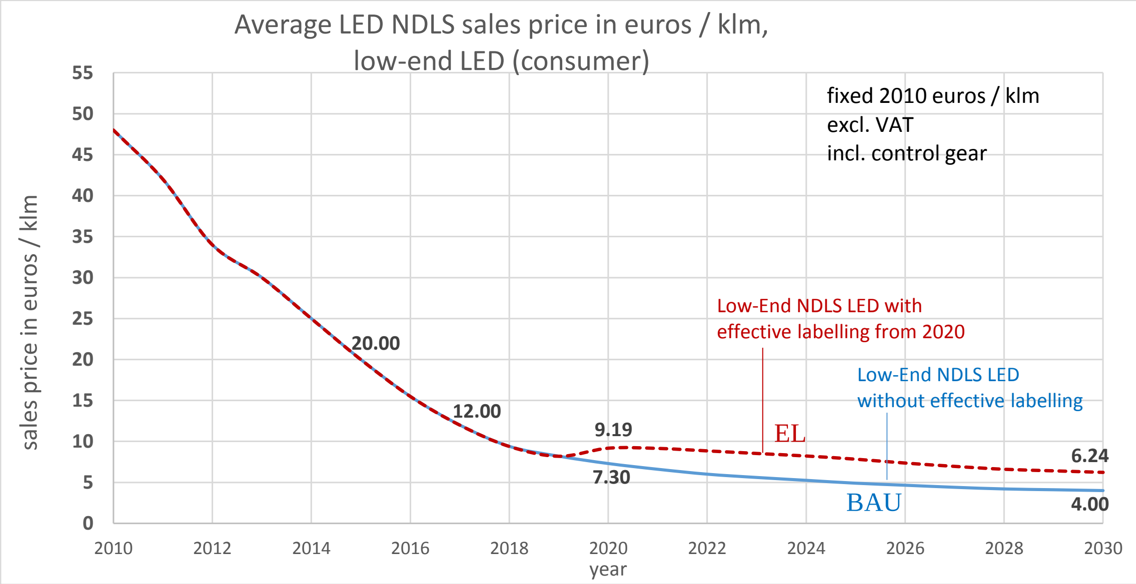


Figure 10 Average sales-efficacy and -prices of low-end NDLS LED light sources (incl. control gear). (for introduction in 2021, shift the EL curve one year to the right)

<u>Projections for low-end DLS (see graphs below):</u>

The solid blue curve indicates the efficacy projection for the BAU scenario, leading to 101 lm/W in 2030. The dashed blue curve (EL) gives the efficacy projection for the other scenarios, 130 lm/W in 2030. The assumed effect of energy labelling (if fully effective) is 29 lm/W in 2030, slightly more than 1 label class width of 25 lm/W. These efficacies consider total flux.

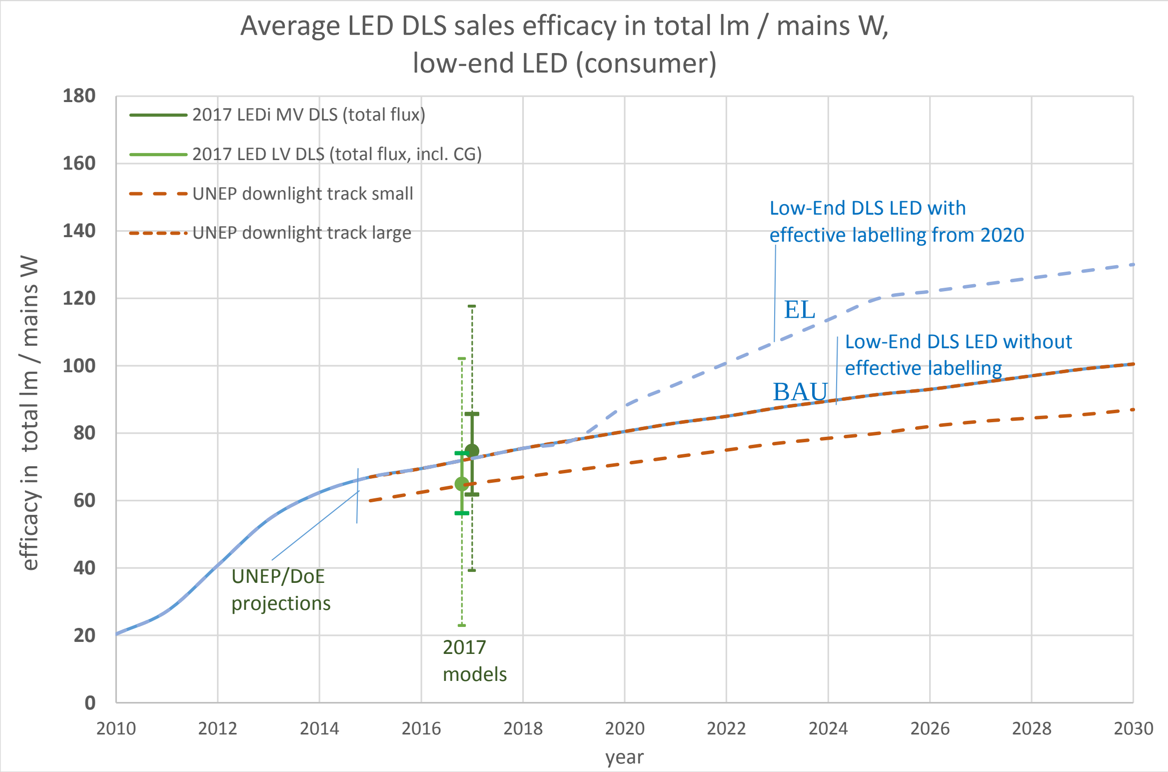
For comparison, the UNEP/US DoE curves for the same lamp types are shown. The MELISA curve has been taken identical to the UNEP curve for 'downlight track large'.

The vertical lines near year 2017 indicate the efficacies for different lamp types as gathered during the Lot 8/9/19 study and this Impact Assessment study (2015-2017 data). For each line the large dot is the average efficacy, the solid line indicates the 25% and 75% percentiles, and the dotted lines indicate the minimum and maximum efficacies encountered.

Corresponding price curves lead to EUR 5 /klm in 2030 for the BAU projection and EUR 7.86 /klm in 2030 for the other scenarios. Prices assumed to be valid for flux in a cone.

For the purposes of estimating the distribution of light source models over the proposed energy efficiency classes in 2020 and 2030, the following efficacy increases with respect to 2017 catalogue data have been assumed:

+7.2% in 2020 +34% in 2030 +74% in 2030 with effective label



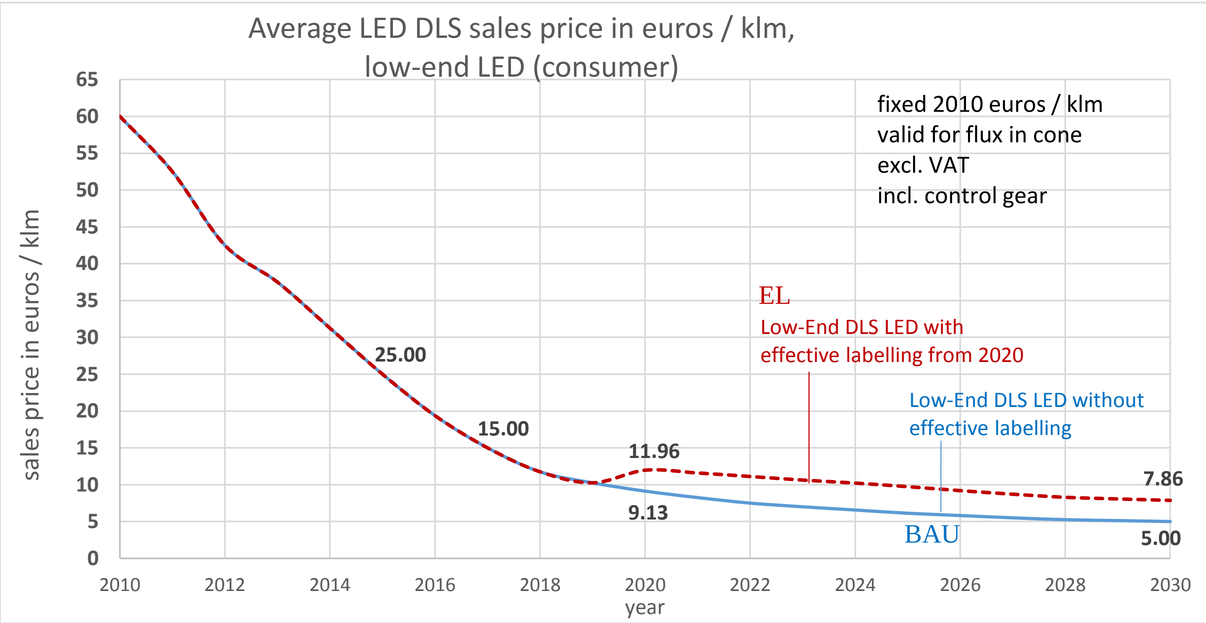


Figure 11 Average sales-efficacy and -prices of low-end DLS LED light sources (incl. control gear). (for introduction in 2021, shift the ECOEL2021 curve one year to the right)

<u>Projections for high-end LED (see graphs below):</u>

The solid blue curve indicates the efficacy projection for the BAU scenario, leading to 174 lm/W in 2030. The dashed blue curve (EL) gives the efficacy projection for the other scenarios, 190 lm/W in 2030. The assumed effect of energy labelling (if fully effective) is 16 lm/W in 2030, approximately 2/3 label class width of 25 lm/W.

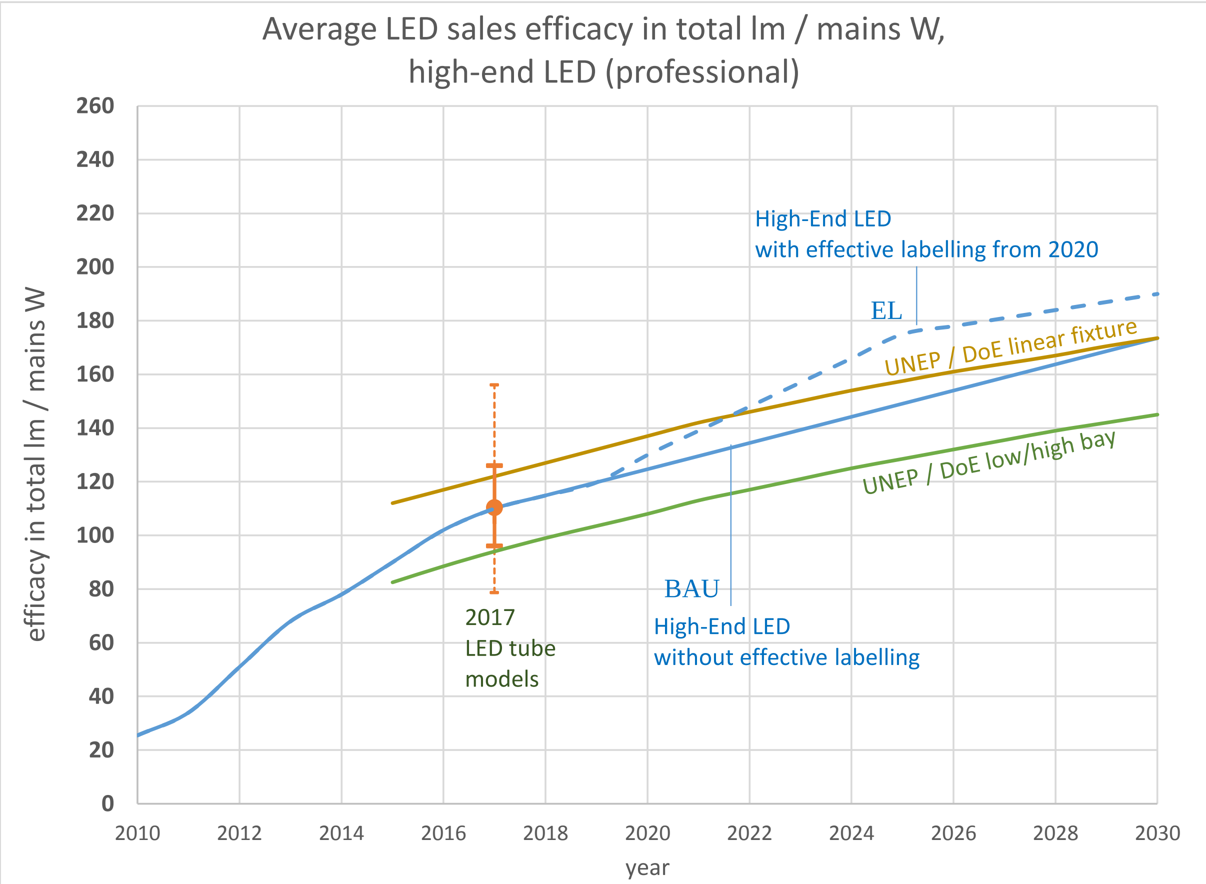
For comparison, the UNEP/US DoE curves for the same lamp types are shown.

The vertical line near year 2017 indicates the efficacies for LED tubes as gathered during the Lot 8/9/19 study and this Impact Assessment study (2015-2017 data). The large dot is the average efficacy, the solid line indicates the 25% and 75% percentiles, and the dotted line indicates the minimum and maximum efficacies encountered.

Corresponding price curves lead to EUR 7.03 /klm in 2030 for the BAU projection and EUR 8 /klm in 2030 for the other scenarios.

For the purposes of estimating the distribution of light source models over the proposed energy efficiency classes in 2020 and 2030, the following efficacy increases with respect to 2017 catalogue data have been assumed:

+12% in 2020   +55% in 2030   +70% in 2030 with effective label



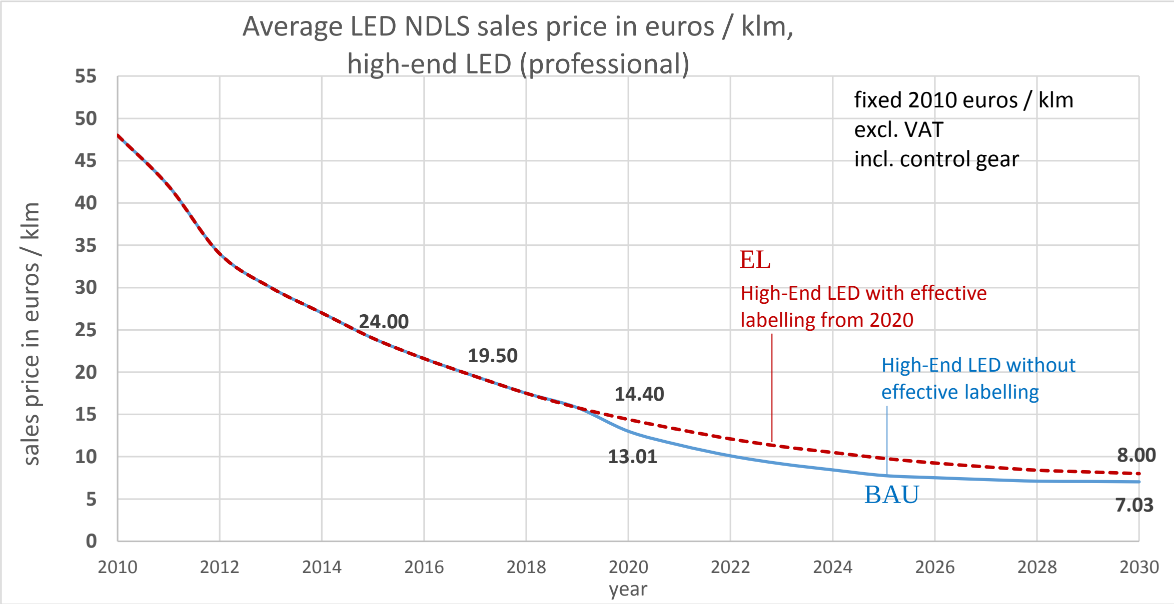


Figure 12 Average sales-efficacy and -prices of high-end LED light sources (incl. control gear). (for introduction in 2021, shift the ECOEL2021 curve one year to the right)

3. General input parameters

3.1. Price shares per business sector

For purposes of computation of light source revenues for industry, wholesale, retail and government, these sectors are assigned a share of the light source price as specified below.

Table 25 Shares of light source prices assigned to a business sector for purposes of revenue computation per sector

Base Case	Industry	Wholesale	Retail	VAT
Non-Residential, LFL, HID and LED	80%	10%	10%	0%
Non-Residential, all other lamp types	46%	30%	24%	0%
Residential, LFL, HID and LED	66%	10%	7%	17%
Residential, all other lamp types	38%	23%	22%	17%

3.2. Electricity rates

Table 26 shows the electricity prices applied in MELISA. The prices are in EUR/kWh, in fixed EUR at year 2010. For the residential sector they include 20% VAT.

Electricity prices for the years 1990-2016 are based on Eurostat data [24]. For later years an escalation rate of 4% has been applied (following the MEErP). The values shown in the table are not discounted (and no discounting is applied elsewhere in the scenario analysis).

[24] For residential the prices up to 2016 are based on Eurostat, extraction 27 October 2017, Households Band DC 2500<consumption<5000 kWh, all taxes and levies included.
For non-residential the reference for prices up to 2016 was Eurostat, extraction 18 July 2017, Industrial users Band IC: 500 MWh < Consumption < 2000 MWh, excluding VAT and other recoverable taxes and levies.

Table 26 Electricity prices used in the scenario analyses, in EUR/kWh, fixed EUR at year 2010. Residential values include 20% VAT; non-residential values exclude VAT. (Escalation rate 4% after 2016, from MEErP, not discounted)

Residential prices, incl. VAT									
1990	1995	2000	2005	2010	2015	*2016*	2020	2025	2030
0.178	**0.181**	**0.162**	**0.153**	**0.170**	**0.209**	***0.205***	**0.240**	**0.292**	**0.355**
Non-residential prices, excl. VAT									
1990	1995	2000	2005	2010	2015	*2016*	2020	2025	2030
0.119	**0.103**	**0.084**	**0.087**	**0.106**	**0.120**	***0.115***	**0.135**	**0.164**	**0.200**

In sensitivity analyses, the effect of lower electricity rates was examined by applying the projected rates from the PRIMES model[25]. For the residential sector PRIMES-rates were used as supplied; for the non-residential sector, based on data from the Ecodesign Impact Accounting, a weighted-average electricity rate was applied, assuming that 80% of the lighting electricity is consumed in the tertiary sector and 20% in industry. These PRIMES' electricity rates are shown in Table 27.

Table 27 Electricity prices used in the sensitivity analyses, in EUR/kWh. These rates derive from the PRIMES model. Non-residential prices assume 80% tertiary sector and 20% industry.

Residential prices, incl. VAT									
1990	1995	2000	2005	2010	2015	*2016*	2020	2025	2030
0.178	**0.181**	**0.162**	**0.156**	**0.172**	**0.190**	***0.192***	**0.203**	**0.209**	**0.212**
Non-residential prices, excl. VAT									
1990	1995	2000	2005	2010	2015	*2016*	2020	2025	2030
0.155	**0.134**	**0.109**	**0.118**	**0.138**	**0.144**	***0.147***	**0.156**	**0.160**	**0.163**

3.3. Global Warming Potential

Greenhouse gas (GHG-) emissions are expressed in $MtCO_2eq$[26] and obtained directly from the electricity consumption, multiplying by the Global Warming Potential (GWP) for electricity. The GWP values defined in MELISA (and also used in the Ecodesign Impact Accounting) are assumed to decrease over the years: e.g. 0.395 $kgCO_2eq/kWh$ in 2015, 0.380 in 2020, 0.360 in 2025, 0.340 in 2030 [27].

4. BAU-SCENARIO

4.1. BAU-scenario assumptions

The Business-as-Usual (BAU) scenario that is used as reference for the computation of savings is the same as described in the Lot 8/9/19 Task 7 report[114].

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[25] EU-28 Reference scenario (REF2015f)

[26] Mega-tonnes carbon dioxide equivalent global warming potential; Mt = 1 billion kilos. For comparison, the total EU-28 GHG emission is 4721 $MtCO_2eq/a$ (source: EEA, GHG Inventory 2012. Total for EU-28 excl. land use, land-use change and forestry (LULUCF).)

[27] These values have been taken from MEErP Part 1 table 30 and Part 2 page 125-126, http://ec.europa.eu/growth/industry/sustainability/ecodesign_en (section on 'support tools for experts'). MEErP in turn uses latest PRIMES model projections that were available in 2011 for the carbon intensity of EU strict electricity generation, increased with (a small number of around 0.028kg/kWh) CO2 emissions for extraction, preparation and transport of fuels as well as distribution losses minus a credit for for derived heat

The BAU-scenario assumes that no new ecodesign or energy labelling regulations will be introduced for light sources, but takes into account all measures of existing Regulations 244/2009, 245/2009 and 1194/2012, including those that still have to take effect in 2016-2018 (phase-out of mains-voltage directional halogen lamps in 2016, more severe requirements for metal-halide lamps in 2017, phase-out of many non-directional halogen lamps in 2018).

In addition, considering current trends and future expectations, the BAU-scenario assumes that a shift in sales from classical lighting technologies to LED lighting products (retrofit lamps or light sources in integrated luminaires) will anyway take place, also without new regulation. The assumed speed of this shift is indicated in Table 28.

Table 28: Percentage of the potential sales (replacements and new sales) for a non-LED base case technology that is assumed to shift to LED products (retrofit or luminaire) in the BAU scenario for years 2015, 2020, 2025 and 2030.

Base Case	2015	2020	2025	2030
LFL T8 & T12[28]	5	20	40	60
LFL T5	0	10	40	60
LFL X	0	10	40	60
HPS	6	18	40	60
MH	18	20	40	60
CFLni	15	40	60	80
CFLi (NDLS)	25	80	90	90
HL LV R (DLS)	15	30	50	70
HL LV C (NDLS)	10	50	70	90
HL MV C (G9, NDLS)	10	50	70	90
HL MV L (R7s, NDLS)	10	50	70	90
HPM	42	99	100	
HL MV E (NDLS)	15	90	100	
HL MV X (DLS)	30	100		
GLS R (DLS)	50	100		
GLS X (NDLS)	30	100		

Considering current trends and future expectations, the BAU-scenario also assumes that between 2017 and 2030 the energy efficacy of the LED light sources will continue to increase, while prices will continue to come down (see section on basic functional parameters for LEDs).

Consequently, the BAU scenario is not at all a freeze scenario, but already includes expectations on the future development of the light sources market, and already leads to energy savings with respect to a scenario that freezes the current situation.

4.2. BAU-scenario, Sales

Light source sales quantities for the BAU-scenario are reported below in million units. The graph clearly shows the phase-out of legacy incandescent lamps (GLS, purple area) between 2009 and 2013, the phase-out of the majority of halogen lamps (Tungsten-HL, green area) between 2016 and 2018, and the reduction of CFL popularity after 2010. In addition, starting from about 2014, the increase in sales of LEDs is evident.

The light purple and light green areas, indicated as GLS and HL 'from storage', are not real sales but represent lamps that are installed by mainly residential users from the supplies they had in house. These are lamps bought in previous years and are not counted

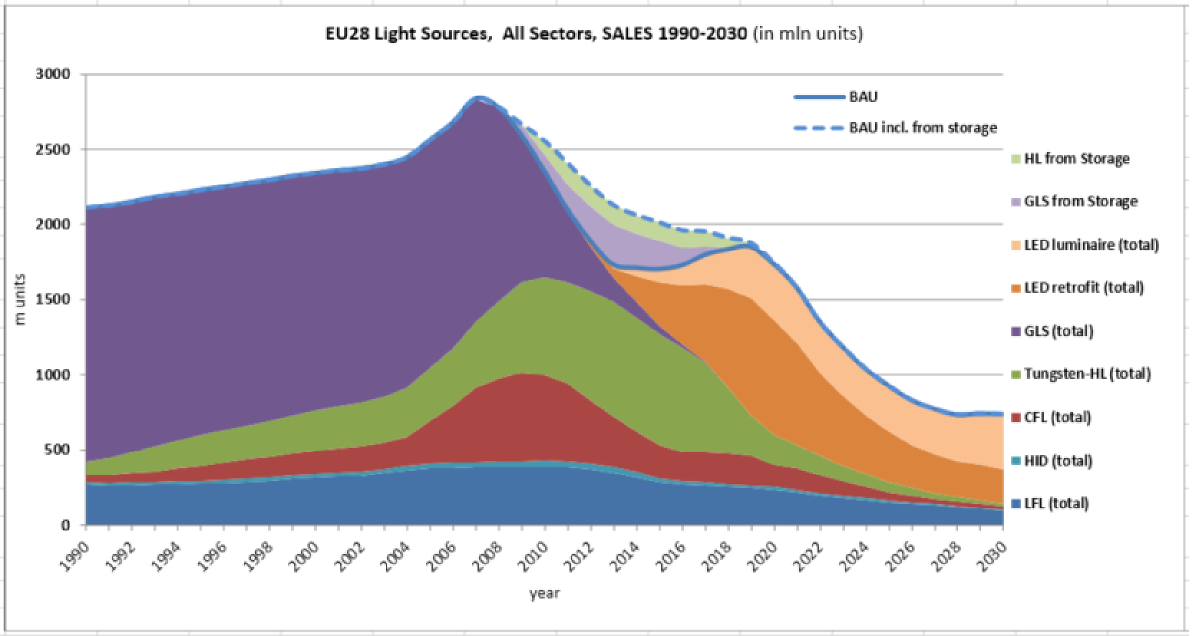
[28] In the model, potential sales of LFL T12 and LFL T8h first shift to potential sales of LFL T8t. The share that becomes LED is applied to these latter potential sales.

(again) as sales in the model in the years where they 'appear', but they are taken into account for stock calculations.

In general, from 2008, there is a strong decrease in sales quantities. This is due to lamps with (much) longer lifetimes (first CFL, later LED) replacing lamps with short lifetimes (GLS, HL).

Table 29: BAU-scenario, annual light source sales volumes in million units

EU-28 SALES	1990	2010	2015	2020	2025	2030
LFL	269	390	285	236	154	98
CFL	51	567	220	151	58	25
Tungsten-HL	88	650	738	200	66	13
GLS	1688	697	58	0	0	0
HID	17	41	28	17	11	4
LED	0	8	372	1133	641	597
GLS from Storage	*0*	*112*	*187*	*0*	*0*	*0*
HL from Storage	*0*	*90*	*124*	*10*	*0*	*0*
TOTAL (excl. from Storage)	**2112**	**2353**	**1702**	**1737**	**929**	**737**



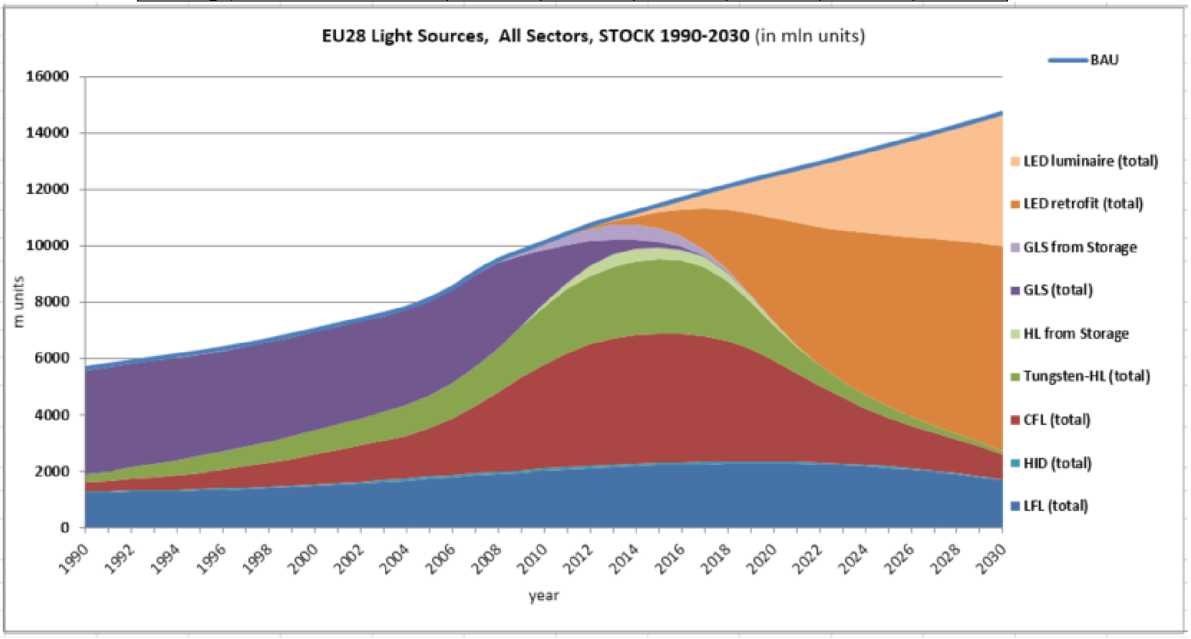
4.3. BAU-scenario, Stock

The installed stock of light sources in EU-28 for the BAU-scenario is reported below in million units. The quantity of installed light sources shows a continuous increase since 1990 and this trend is expected to continue. The growth rate after 2016 is between 1.18%/a and 0.86%/a for the residential sector (increase in number of households and in number of lamps per household) and 2.5%/a for the non-residential sector (based on GDP annual growth rate).

The graph clearly shows that, from about 2008, CFL (red area) and Halogen lamps (green area) are substituting the legacy incandescent lamps (GLS, purple area) phased-out by the 2009 Ecodesign regulation. Starting from 2014, LED products are increasingly substituting CFL and Halogen lamps and this trend is expected to continue in the BAU-scenario, also without new Ecodesign measures.

Table 30: BAU-scenario, installed stock of light sources in million units

EU-28 STOCK	1990	2010	2015	2020	2025	2030
LFL	1232	2008	2210	2264	2115	1685
CFL	326	3684	4576	3604	1734	879
Tungsten-HL	284	2043	2657	1240	394	116
GLS	3694	1923	193	1	0	0
HID	40	95	91	79	57	29
LED	0	14	745	5138	9192	11926
GLS from Storage	*0*	*187*	*471*	*6*	*0*	*0*
HL from Storage	*0*	*90*	*417*	*126*	*0*	*0*
TOTAL (excl. from Storage)	**5576**	**10045**	**11360**	**12459**	**13492**	**14635**



4.4. BAU-scenario, Electricity

The tables and graph in this section show the total EU-28 electricity consumption by light sources in the BAU-scenario[29].

In 2015 the EU-28 electricity consumption for lighting was 336 TWh/a, covering 12.4% of the overall EU-28 electricity use [30]. The primary energy necessary to generate and distribute this electricity was 72 Mtoe, covering 4.5% of the EU-28 Gross Inland Consumption of energy [31].

In the BAU-scenario the electricity for lighting is expected to decrease to 299 TWh/a in 2030 (-12% vs. 2015), notwithstanding a 25% increase in the quantity of installed light

[29] All electricity values include control gear energy but exclude control devices, special purpose lamps and stand-by. The primary energy consumption is approximately 2.5 times the reported amount of electricity.

[30] According to the Eurostat Energy Balance Sheet 2014, the total EU-28 electricity consumption in 2014 was 232.7 Mtoe = 2706 TWh, http://ec.europa.eu/eurostat/documents/3217494/7571929/KS-EN-16-001-EN-N.pdf/28165740-1051-49ea-83a3-a2a51c7ad304

[31] Assuming an average EU-28 efficiency of electricity generation and distribution of 40%, and conversion factors 1 Mtoe = 11.63 TWh = 41.87 PJ: 335*2.5 = 837 TWh /11.63 = 72 Mtoe * 41.87 = 3014 PJ. According to the Eurostat Energy Balance Sheet 2014 the Gross Inland Consumption of Energy was 1606 Mtoe in 2014.

sources (see previous section). This decrease is due to the increased use of high-efficacy LED products.

In 2015, the largest part is consumed in the non-residential sector (253 TWh, 75%), mainly by LFL-applications (161 TWh/a, 48%, e.g. offices), HID-applications (69 TWh/a, 20%, e.g. road lighting) and some by CFLni-applications (10 TWh/a, 3%). Other non-directional applications (mainly residential) consume 72 TWh/a (21%) and directional applications 24 TWh/a (7%).

In 2015, 96% of the electricity (321 TWh/a) is consumed by classical (non-LED) lighting technologies. In 2030 this is expected to drop to 51% (152 TWh/a). Table 32 also shows the cumulative electricity uses over the period 2015-2030.

The electricity consumption data for the BAU-scenario clearly indicates the importance of LFL- and HID-applications, and in particular the high contribution (approximately one-third of the total) of LFL T8 tri-phosphor.

Table 31: BAU-scenario, EU-28 total Electricity consumption by light sources. Includes control gear energy. Excluded: controls, special purpose lamps, standby.

EU-28 ELECTRICITY	1990	2010	2015	2020	2025	2030
LFL	91	136	159	169	158	124
CFL	3	25	30	24	13	6
Tungsten-HL	8	46	52	23	7	2
GLS	90	46	4	0	0	0
HID	34	69	59	50	37	20
LED	0	0	15	51	98	147
GLS from Storage	*0*	*4*	*10*	*0*	*0*	*0*
HL from Storage	*0*	*1*	*7*	*2*	*0*	*0*
TOTAL (excl. from Storage)	**225**	**328**	**336**	**320**	**312**	**299**

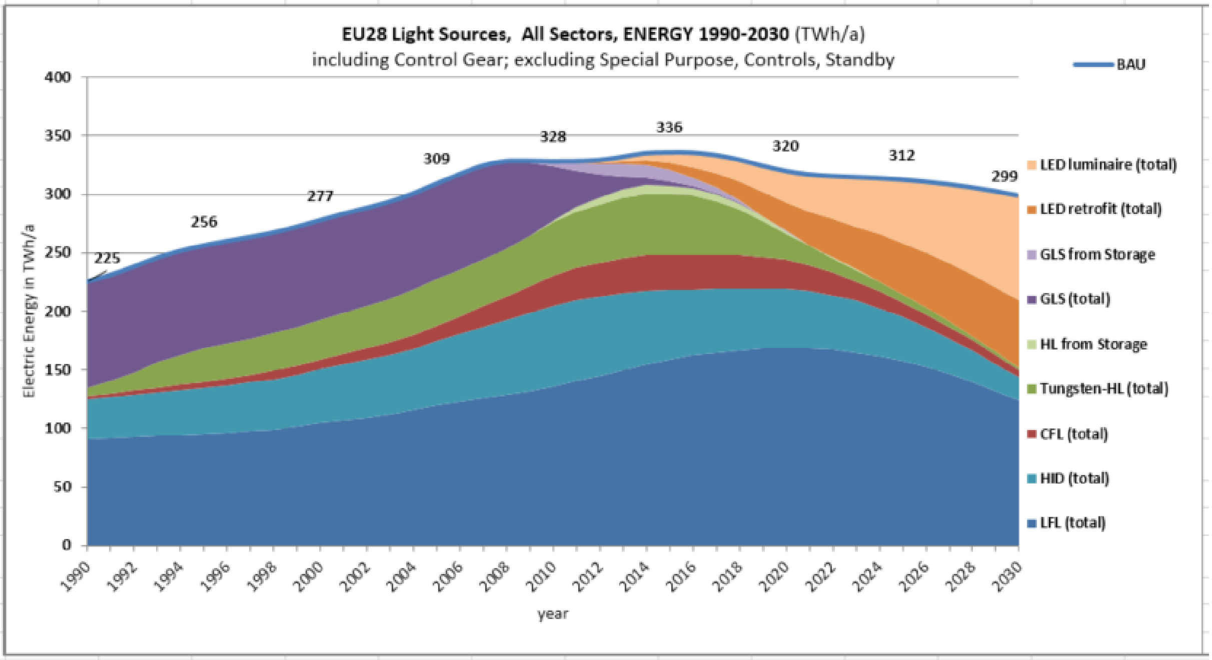


Table 32 BAU-scenario, EU-28 Total Electricity Consumption for Lighting, in TWh/a or TWh cumulative). Includes electricity for light sources and control gears. Does not include electricity for control devices, special purpose lamps and during stand-by.

	1990	2015	2020	2025	2030	cumulative 2015-2030
Total EU-28, all sectors	**225**	**336**	**320**	**312**	**299**	**5079**

total Residential (RES)	83	82	49	37	34	772
total Non-Residential (NRES)	142	253	271	276	265	4307
total Classic Technology	225	321	269	215	152	3855
total LED	0	15	51	98	147	1224
LFL T8t	32	117	124	115	90	1838
LFL T5 (13-80 W)	0	35	42	40	32	620
other LFL	59	6	3	2	1	48
LED in former LFL-applications	0	2	13	34	64	425
Total LFL-applications	**91**	**161**	**182**	**192**	**188**	**2930**
HPM	16	4	0	0	0	6
HPS	15	31	31	24	14	416
MH	3	25	20	13	6	253
LED in former HID-applications	0	10	21	33	47	443
Total HID-applications	**34**	**69**	**71**	**71**	**66**	**1118**
CFLni	2	9	8	5	3	103
LED in former CFLni-applications	0	0	1	3	4	35
Total CFLni-applications	**2**	**10**	**9**	**8**	**7**	**138**
HL LV R (MR/AR) (GU4,GU5.3,G53)	1	11	9	5	2	111
HL MV (DLS) (GU10 or E-cap)	0	11	1	0	0	34
GLS (DLS)	9	1	0	0	0	2
LED in DLS-applications	0	1	4	5	6	64
Total DLS-applications	**10**	**24**	**13**	**10**	**8**	**210**
CFLi	1	21	17	7	4	195
HL MV (NDLS, E-cap)	0	24	8	0	0	120
GLS (NDLS)	81	13	0	0	0	30
HL LV Capsule (G4, GY6.35)	3	3	1	1	0	19
HL MV Capsule (G9)	0	3	2	1	0	24
HL MV Linear (R7s)	3	7	3	0	0	37
LED in NDLS-applications	0	2	12	22	26	258
Total NDLS-applications	**88**	**72**	**44**	**31**	**30**	**682**

4.5. BAU-scenario, GHG-emissions

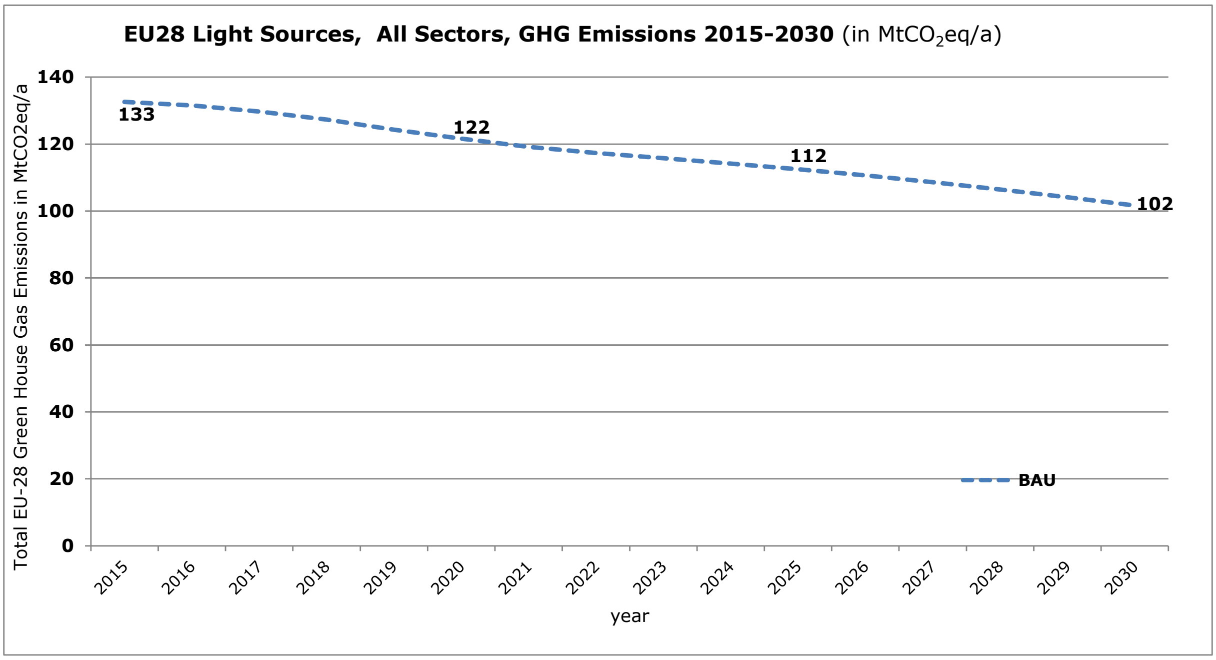
In 2015 the EU-28 GHG-emission due to use of light sources is estimated 133 $MtCO_2eq/a$ (2.8% of the total EU-28 emission[32]). In 2030 this is expected to decrease to 102 $MtCO_2eq/a$ in the BAU-scenario, due to decreasing electricity consumption for lighting and due to decreasing GWP for electricity.

GHG-emissions have been computed for the electricity consumption of all light sources together, not per light source type. The distribution of the emissions over the types is proportional to the distribution of electricity use in Table 32.

Table 33: BAU-Total EU-28 Greenhouse gas (GHG-) emission due to lighting electricity consumption in MtCO2eq/a or MtCO2eq cumulative

$MtCO_2eq$		**2015**	**2020**	**2025**	**2030**	**cumulative**
BAU	GHG-emis	133	122	112	102	1878

[32] The total EU-28 GHG emission is 4721 MtCO2eq/a (source: EEA, GHG Inventory 2012. Total for EU-28 excl. land use, land-use change and forestry (LULUCF).)



4.6. BAU-scenario, User Expense for light sources

Table 34, Table 35 and Table 36 respectively provide the EU-28 total Acquisition costs (purchase and installation), Electricity costs, and total User Expense (including also maintenance costs) for light sources. Corresponding graphs are shown in Figure 13.

All costs are in fixed EUR at year 2010 and include VAT for residential users.

Acquisition costs show two peaks. The first one around 2010 is due to investments in Halogen lamps and CFLs to replace the incandescent lamps (GLS) phased-out by the 2009 Ecodesign regulation. The one between 2015 and 2020 is due to investments in LED lighting products, replacing Halogen lamps phased-out by Ecodesign regulations in 2016 and 2018, replacing increasingly unpopular CFLs, replacing some LFL T8 in office lighting, and some HID-lamps in street lighting.

Peak acquisition costs are EUR 17.8 billion in 2016. In later years these costs decrease to EUR 11.0 billion in 2030, due to decreasing sales quantities (Table 29) and due to LED prices coming down (Annex 5 Section 2.3).

Electricity costs amount to EUR 46 billion in 2016, which is almost three times the acquisition costs in the same year. Electricity costs are expected to continue to increase, reaching EUR 65 billion by 2030. This increase occurs notwithstanding a decrease in electricity consumption (Table 31) and is due to the increase in electricity rates (Table 26).

Without the 2015-2020 investments in more efficient LED lighting products, electricity costs would have risen much more: Applying the difference in electricity rates between 2016 and 2030 (factor 1.8 increase) and the difference in stock over the same period (factor 1.25 increase) to the EUR 46 billion electricity costs of 2016, the 2030 electricity costs would have been 46*1.8*1.25 = EUR 104 billion instead of the now estimated EUR 65 billion.

As electricity costs are far higher than acquisition costs, the Total User Expense also shows an increasing trend. Details on User Expense are presented in Table 37.

In 2015 the EU-28 Total User Expense for lighting was EUR 70 billion, of which EUR46 billion (66%) were spend in the non-residential sector. The expenses for LED light sources (retrofit lamps or light sources in integrated luminaires) in 2015 amounted to EUR 10 billion (14% of total expense). Major expenses were made for LFL-applications (EUR 26 billion, 37%) and NDLS-applications (EUR 22 billion, 31%).

In 2030 Total User Expenses are projected to increase to EUR 83 billion.

Table 34: BAU-scenario, EU-28 total <u>Acquisition</u> costs for light sources (acquisition and installation), in bn euros. Fixed EUR 2010, incl. 20% VAT for residential.

EU-28 ACQUISITION COST	1990	2010	2015	2020	2025	2030
LFL	3.84	5.53	4.01	3.34	2.18	1.38
CFL	0.36	3.49	1.48	1.02	0.41	0.16
Tungsten-HL	0.34	2.79	2.90	0.80	0.29	0.06
GLS	2.08	0.86	0.07	0.00	0.00	0.00
HID	0.52	1.44	1.02	0.62	0.38	0.15
LED	0	0.29	8.05	10.34	7.69	9.04
GLS from Storage	*0*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
HL from Storage	*0*	*0.00*	*0.33*	*0.03*	*0.00*	*0.00*
TOTAL	**7.15**	**14.40**	**17.86**	**16.14**	**10.95**	**10.79**

Table 35: BAU-scenario, EU-28 total <u>Electricity</u> costs for light sources, in bn euros. Fixed EUR 2010, incl. 20% VAT for residential. See Table 26 for applied electricity rates (from MEErP, incl. escalation 4%/a)**.**

EU-28 ELECTRICITY COST	1990	2010	2015	2020	2025	2030
LFL	11.13	14.91	19.68	23.55	26.79	25.69
CFL	0.45	3.45	4.99	4.58	2.87	1.80
Tungsten-HL	1.17	6.93	9.57	4.61	1.54	0.52
GLS	14.91	7.21	0.78	0.00	0.00	0.00
HID	4.02	7.29	7.09	6.81	6.14	3.92
LED	0	0.03	2.01	8.21	18.62	33.10
GLS from Storage	*0*	*0.75*	*1.99*	*0.03*	*0.00*	*0.00*
HL from Storage	*0*	*0.25*	*1.41*	*0.49*	*0.00*	*0.00*
TOTAL	**31.68**	**40.83**	**47.52**	**48.29**	**55.96**	**65.03**

Table 36: BAU-scenario, EU-28 total <u>User Expense</u> for light sources, in bn euros. Fixed EUR 2010, incl. 20% VAT for residential. In addition to Acquisition- and Electricity-costs from previous tables, this also includes maintenance costs for non-residential sector.

EU-28 TOTAL USER EXPENSE	1990	2010	2015	2020	2025	2030
LFL	15.44	21.23	24.56	27.79	29.79	27.72
CFL	1.13	9.10	8.98	7.60	4.34	2.44
Tungsten-HL	1.64	10.34	13.19	5.84	2.01	0.64
GLS	17.68	8.43	0.88	0.00	0.00	0.00
HID	4.79	9.32	8.67	7.92	6.88	4.24
LED	0	0.32	10.34	20.35	30.23	47.96
GLS from Storage	*0*	*0.75*	*1.99*	*0.03*	*0.00*	*0.00*
HL from Storage	*0*	*0.25*	*1.74*	*0.52*	*0.00*	*0.00*
TOTAL	**40.68**	**59.74**	**70.36**	**70.05**	**73.26**	**83.00**

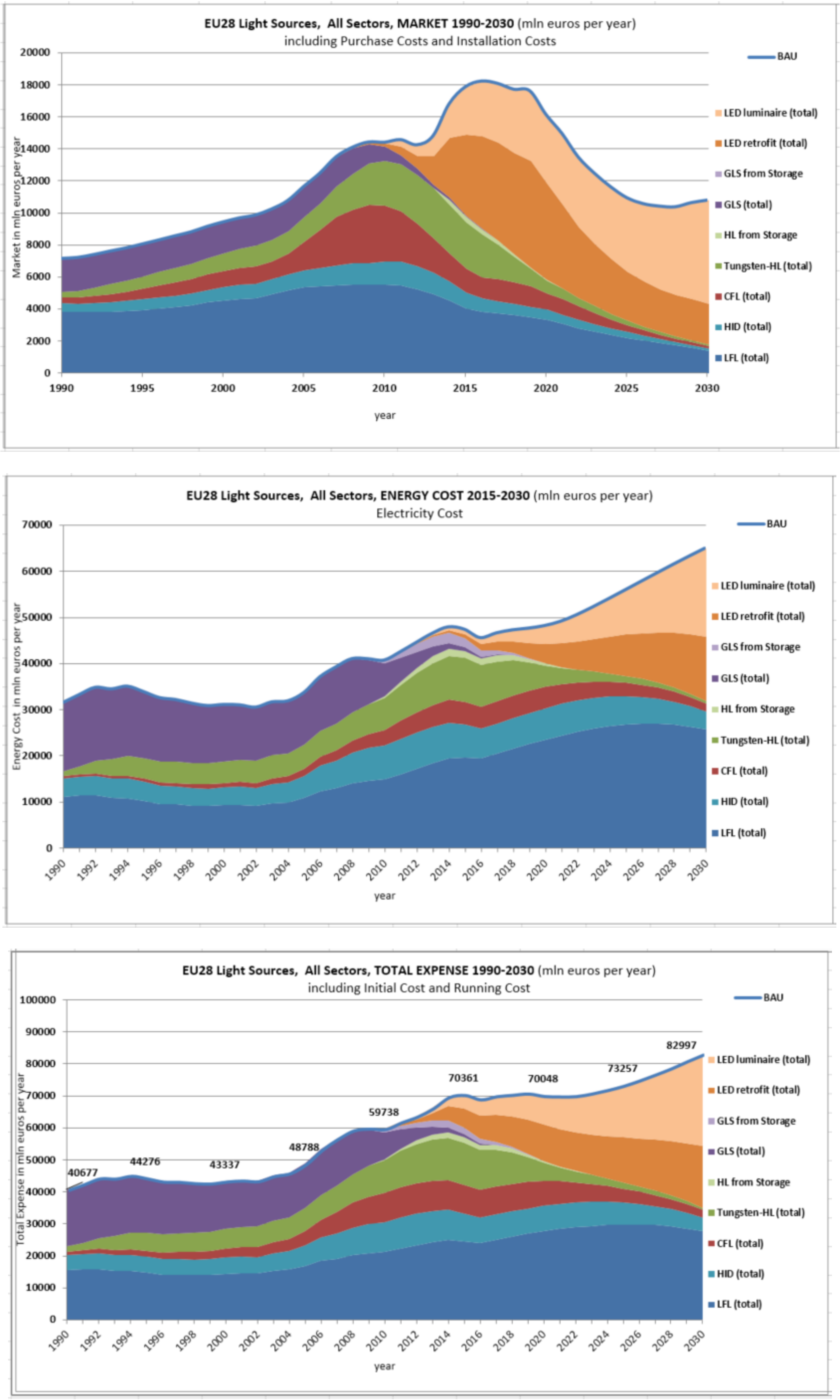


Figure 13 BAU-scenario, EU-28 Total Acquisition Cost (top), Electricity Cost (centre) and Total User Expense (bottom) for light sources, in million euros, fixed EUR 2010 incl. residential VAT. Scales for graphs are different. (this uses electricity rates from MEErP with 4%/a escalation, see Section 3.2)

Table 37 BAU-scenario, EU-28 Total User Expense for Lighting, in billion euros. Fixed 2010 euros, includes VAT for residential.

	1990	2015	2020	2025	2030	cumulative 2015-2030
Total EU-28, all sectors	**41**	**70**	**70**	**73**	**83**	**1171**
total Residential (RES)	16	24	17	12	13	255
total Non-Residential (NRES)	24	46	53	61	70	916
total Classic Technology	41	60	50	43	35	748
total LED	0	10	20	30	48	423
LFL T8t	5.1	17.8	20.0	21.6	20.1	323
LFL T5 (13-80 W)	0.0	5.5	6.9	7.6	7.2	111
other LFL	10.4	1.2	0.8	0.6	0.4	12
LED in former LFL-applications	0.0	1.3	4.4	9.5	18.9	128
Total LFL-applications	**15**	**26**	**32**	**39**	**47**	**574**
HPM	2.2	0.5	0.0	0.0	0.0	1
HPS	2.2	4.3	4.6	4.4	3.0	67
MH	0.4	3.8	3.3	2.5	1.2	44
LED in former HID-applications	0.0	3.1	4.3	7.5	12.0	103
Total HID-applications	**5**	**12**	**12**	**14**	**16**	**215**
CFLni	0.8	3.0	2.6	1.9	1.0	35
LED in former CFLni-applications	0.0	0.3	1.0	1.8	2.8	23
Total CFLni-applications	**1**	**3**	**4**	**4**	**4**	**58**
HL LV R (MR/AR) (GU4,GU5.3,G53)	0.3	2.8	2.4	1.6	0.6	30
HL MV (DLS) (GU10 or E-cap)	0.0	2.9	0.1	0.0	0.0	9
GLS (DLS)	1.9	0.2	0.0	0.0	0.0	0
LED in DLS-applications	0.0	1.5	1.6	2.0	2.7	31
Total DLS-applications	**2**	**7**	**4**	**4**	**3**	**70**
CFLi	0.4	6.0	5.0	2.5	1.4	60
HL MV (NDLS, E-cap)	0.0	6.1	2.1	0.0	0.0	30
GLS (NDLS)	15.8	2.7	0.0	0.0	0.0	6
HL LV Capsule (G4, GY6.35)	0.8	0.7	0.4	0.2	0.0	5
HL MV Capsule (G9)	0.0	0.9	0.6	0.2	0.0	7
HL MV Linear (R7s)	0.6	1.5	0.7	0.1	0.0	8
LED in NDLS-applications	0.0	4.2	9.1	9.3	11.6	137
Total NDLS-applications	**18**	**22**	**18**	**12**	**13**	**254**

4.7. BAU-scenario, Revenues per business sector

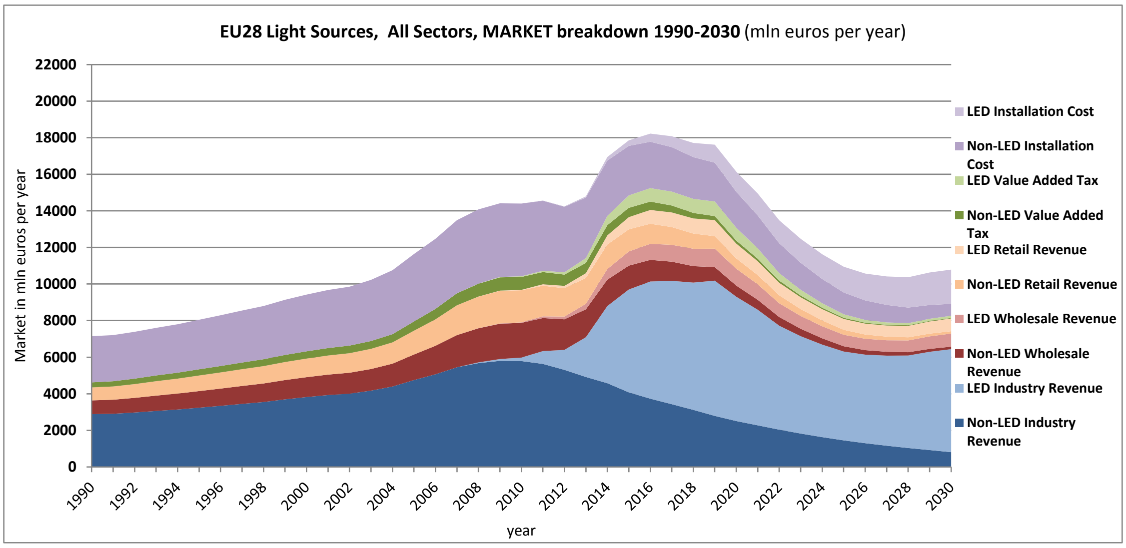


Figure 14 BAU-scenario, EU-28 Total Revenues from light sources per business sector, in million euros, fixed EUR 2010. For assumed price shares per sector, see Table 25.

5. ELONLY SCENARIO

5.1. ELONLY scenario, assumptions

In this scenario the new energy labelling A-G scheme is assumed to be introduced in 2021, while no new Ecodesign measures are taken (existing Ecodesign regulations remain valid), so this is a Label-only scenario.

The change in energy labelling is assumed not to affect the shift from traditional lighting technologies to LED products: this shift remains the same as in the BAU-scenario. Consequently sales and stock are the same as reported for the BAU-scenario.

What changes in the ELONLY scenario is the average efficacy of the LED lighting products being sold, and the corresponding average LED light source price. The applied LED efficacies and prices have been explained in Section 2.2, but the graphs presented there are for introduction of the new labelling measures in 2020: shift the curves one year to the right to get those for introduction in 2021. The following tables summarize the data used in the analyses. After 2030 efficacies and prices are assumed to remain constant.

Table 38 LED-efficacies in the ELONLY scenario in total lm / mains W, incl. control gear. New LBL introduction assumed in 2021. See Section 2.2 for further information

lm/W	2010	2012	2014	2016	2018	2020	2022	2025	2030
Low-End NDLS	**26**	**51**	**78**	**91**	**99**	**103**	**118**	**142**	**160**
Low-End DLS	**20**	**41**	**62**	**70**	**76**	**81**	**94**	**114**	**130**
High-End	**26**	**51**	**78**	**102**	**115**	**125**	**139**	**166**	**190**

Table 39 LED-prices in the ELONLY scenario in EUR/klm, incl. control gear. New LBL introduction assumed in 2021. See Section 2.2 for further information

EUR/klm	2010	2012	2014	2016	2018	2020	2022	2025	2030
Low-End NDLS	**48.00**	**34.00**	**25.00**	**15.50**	**9.40**	**7.30**	**7.68**	**7.22**	**6.24**
Low-End DLS	**60.00**	**42.50**	**31.25**	**19.38**	**11.75**	**9.13**	**10.24**	**9.40**	**7.86**
High-End	**48.00**	**34.00**	**25.00**	**21.60**	**17.50**	**13.01**	**10.77**	**9.10**	**8.00**

5.2. ELONLY scenario, Electricity

Compared to a BAU scenario without changes in energy label regulation, introduction of the new labelling scheme in 2021 saves 4.2 TWh/a of electricity in 2025 and 11.5 TWh/a in 2030.

Table 40: ELONLY scenario, EU-28 total Electricity consumption by light sources. Includes control gear energy. Excluded: controls, special purpose lamps, standby.

EU-28 ELECTRICITY	**1990**	**2010**	**2015**	**2020**	**2025**	**2030**
LFL	91	136	159	169	158	124
CFL	3	25	30	24	13	6
Tungsten-HL	8	46	52	23	7	2
GLS	90	46	4	0	0	0
HID	34	69	59	50	37	20
LED	0	0	15	51	94	136
GLS from Storage	*0*	*4*	*10*	*0*	*0*	*0*
HL from Storage	*0*	*1*	*7*	*2*	*0*	*0*
TOTAL (excl. from Storage)	**225**	**328**	**336**	**320**	**308**	**288**
TOTAL for BAU for comparison	***225***	***328***	***336***	***320***	***312***	***299***
Savings due to ELOnly					**4.2**	**11.5**

5.3. ELONLY scenario, GHG-emissions

Compared to a BAU scenario without changes in energy label regulation, introduction of the new labelling scheme in 2021 saves 1.5 $MtCO_2eq/a$ of GHG-emissions in 2025 and 3.9 $MtCO_2eq/a$ in 2030.

Table 41: ELONLY Total EU-28 Greenhouse gas (GHG-) emission due to lighting electricity consumption in MtCO2eq/a or MtCO2eq cumulative

$MtCO_2eq$		2015	2020	2025	2030	cumulative
ELONLY		**133**	**122**	**111**	**98**	**1859**
BAU for comparison		*133*	*122*	*112*	*102*	*1878*
Reduction due to ELOnly				**1.5**	**3.9**	**19**

5.4. ELONLY scenario, User Expense for light sources

In the ELONLY scenario, acquisition costs are higher than in the BAU scenario: EUR 1.7 billion per year higher in 2025 and 1.5 billion per year in 2030. Users buy the same quantity of LED products as in the BAU scenario, but in the ELONLY scenario these LEDs on average have higher prices, and higher efficacy.

Due to the higher average efficacy, the electricity costs are lower than in the BAU scenario: EUR 0.8 billion per year less in 2025 and EUR 2.6 billion per year in 2030.

The balance of the costs, i.e. the total user-expense for lighting, is negative in 2025 (EUR -0.9 billion per year) where additional acquisition costs (investment) are still dominant, but already positive in 2030 (EUR +1.1 billion per year) where lower electricity costs (payback) are dominant. This positive trend continues even stronger in later years.

Table 42: ELONLY scenario, EU-28 total Acquisition costs for light sources (purchase and installation), in bn euros. Fixed EUR 2010, incl. 20% VAT for residential.

EU-28 ACQUISITION COST	1990	2010	2015	2020	2025	2030
LFL	3.84	5.53	4.01	3.34	2.18	1.38
CFL	0.36	3.49	1.48	1.02	0.41	0.16
Tungsten-HL	0.34	2.79	2.90	0.80	0.29	0.06
GLS	2.08	0.86	0.07	0.00	0.00	0.00
HID	0.52	1.44	1.02	0.62	0.38	0.15
LED	0	0.29	8.05	10.34	9.35	10.52
GLS from Storage	*0*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
HL from Storage	*0*	*0.00*	*0.33*	*0.03*	*0.00*	*0.00*
TOTAL ELONLY	**7.15**	**14.40**	**17.86**	**16.14**	**12.61**	**12.28**
BAU for comparison	*7.15*	*14.40*	*17.86*	*16.14*	*10.95*	*10.79*
Additional due to ELOnly					**1.7**	**1.5**

Table 43: ELONLY scenario, EU-28 total Electricity costs for light sources, in bn euros. Fixed EUR 2010, incl. 20% VAT for residential. See Table 26 for applied electricity rates (from MEErP, incl. escalation 4%/a)**.**

EU-28 ELECTRICITY COST	1990	2010	2015	2020	2025	2030
LFL	11.13	14.91	19.68	23.55	26.79	25.69
CFL	0.45	3.45	4.99	4.58	2.87	1.80
Tungsten-HL	1.17	6.93	9.57	4.61	1.54	0.52

GLS	14.91	7.21	0.78	0.00	0.00	0.00
HID	4.02	7.29	7.09	6.81	6.14	3.92
LED	0	0.03	2.01	8.21	17.83	30.54
GLS from Storage	*0*	*0.75*	*1.99*	*0.03*	*0.00*	*0.00*
HL from Storage	*0*	*0.25*	*1.41*	*0.49*	*0.00*	*0.00*
TOTAL ELONLY	**31.68**	**40.83**	**47.52**	**48.29**	**55.17**	**62.46**
BAU for comparison	***31.68***	***40.83***	***47.52***	***48.29***	***55.96***	***65.03***
Saving due to ELOnly					**0.8**	**2.6**

Table 44: ELONLY scenario, EU-28 total User Expense for light sources, in bn euros. Fixed EUR 2010, incl. 20% VAT for residential. In addition to Acquisition- and Electricity-costs from previous tables, this also includes maintenance costs for non-residential sector.

EU-28 TOTAL USER EXPENSE	**1990**	**2010**	**2015**	**2020**	**2025**	**2030**
LFL	15.44	21.23	24.56	27.79	29.79	27.72
CFL	1.13	9.10	8.98	7.60	4.34	2.44
Tungsten-HL	1.64	10.34	13.19	5.84	2.01	0.64
GLS	17.68	8.43	0.88	0.00	0.00	0.00
HID	4.79	9.32	8.67	7.92	6.88	4.24
LED	0	0.32	10.34	20.35	31.10	46.88
GLS from Storage	*0*	*0.75*	*1.99*	*0.03*	*0.00*	*0.00*
HL from Storage	*0*	*0.25*	*1.74*	*0.52*	*0.00*	*0.00*
TOTAL ELONLY	**40.68**	**59.74**	**70.36**	**70.05**	**74.12**	**81.92**
BAU for comparison	***40.68***	***59.74***	***70.36***	***70.05***	***73.26***	***83.00***
Saving due to ELOnly					**-0.9**	**+1.1**

6. ECOEL2021 SCENARIO

6.1. ECOEL2021 scenario, model assumptions

This scenario assumes that Ecodesign measures are introduced in 2021 in a single tier and that the new Energy Labelling A-G scheme is also introduced in 2021.

The assumed effects of the introduction of the new labelling scheme on average LED-efficacy and average LED-prices are the same as described in Section 5.1 for the ELONLY scenario.

As regards the Ecodesign measures, the main difference between the ECOEL2021 and the BAU-scenario is that some classical lighting technologies are phased-out by the new proposed minimum efficacy requirements, and this leads to an accelerated shift of sales towards LED lighting products [33].

Some classical lamp types are already phased-out by existing regulations (244/2009, 245/2009, 1194/2012) and this effect is included in the BAU scenario. Consequently for the following light source types there is no difference between BAU and ECOEL2021:

- LFL T12 (phased-out from 2014)
- LFL T8 halo-phosphor (phased-out from 2014)
- HPM (High Pressure Mercury) (phased-out from 2015)
- HL MV X (DLS) (Directional mains-voltage halogen lamps) (phased-out from 2016)
- GLS R (DLS) (Incandescent non-halogen reflector lamps) (phased-out from 2016)
- HL MV E (NDLS) (Non-directional mains-voltage halogen lamps) (phased-out from 2018)
- GLS X (NDLS) (Non-directional incandescent non-halogen lamps) (phased-out 2009-2013)

For some other classical lamp types the new proposed efficacy requirements are identical to the existing requirements (even if there are some deviations due to the approximation by the new maximum power formula), or they are exempted both in the new proposal and in the existing regulations. Also in these cases, there is no difference between BAU and ECOEL2021:

- LFL T5 13-80W and T5 circular
- LFL X (all other LFL lamps, in the model including also T9 circular)
- HPS (High Pressure Sodium)
- MH (Metal Halide)
- CFLni (compact fluorescent without integrated control gear)

[33] In the model, such a phase-out and associated accelerated shift to LED is gradual. As a general guide, the following is applied when a lamp type is phased-out in a year X:
Year X-2: % sales remaining classical technology is 90% of the BAU-value
Year X-1: % sales remaining classical technology is 80% of the BAU-value
Year X : % sales remaining classical technology is 50% of the BAU-value
Year X+1: % sales remaining classical technology is 20% of the BAU-value
Year X+2: % sales remaining classical technology is 10% of the BAU-value
Year X+3: % sales remaining classical technology is 5% of the BAU-value
Later: % sales remaining classical technology is 0% (all sales shift to LED)

- HL R7s < 2700 lm [34]

For a third group of classical lamp types, proposed requirements are such that they will no longer be allowed on the market. For these lamps, a difference between the ECOEL2021- and the BAU-scenario appears from 2021, with some anticipatory effects from 2019 [133]:

- LFL T8t (tri-phosphor) with 2-, 4 or 5-feet length [35]
- CFLi (compact fluorescent with integrated control gear)
- HL LV C (Low-voltage halogen capsules with G4 or GY6.35 cap)
- HL MV C (Mains-voltage halogen capsules with G9 cap)
- HL R7s > 2700 lm [36]
- HL LV R (DLS) (MR11 - GU4 cap, MR16 - GU5.3 cap, AR111 - G53 cap) [37]

The above leads to the following shares of potential sales of non-LED lamps that are assumed to shift to LED lighting products (Table 45).

Table 45: Percentage of the potential sales (replacements and new sales) for a non-LED base case technology that is assumed to shift to LED products (retrofit or light source in luminaire) in the BAU scenario and in the ECOEL2021 scenario for years 2015, 2020, 2025 and 2030.

	BAU scenario				ECOEL2021 scenario			
Base Case	2015	2020	2025	2030	2015	2020	2025	2030
LFL T8 & T12[128]	5	20	40	60	5	34	94	96
CFLi (NDLS)	25	80	90	90	25	84	100	
HL LV C (NDLS)	10	50	70	90	10	60	99	100
HL MV C (G9, NDLS)	10	50	70	90	10	60	99	100
HL MV L (R7s, NDLS)	10	50	70	90	10	58	94	98
HL LV R (DLS)	15	30	50	70	15	44	100	
LFL T5	0	10	40	60	same as BAU			
LFL X	0	10	40	60	same as BAU			
HPS	6	18	40	60	same as BAU			
MH	18	20	40	60	same as BAU			
HPM	42	99	100		same as BAU			
CFLni	15	40	60	80	same as BAU			
HL MV E (NDLS)	15	90	100		same as BAU			
HL MV X (DLS)	30	100			same as BAU			
GLS R (DLS)	50	100			same as BAU			
GLS X (NDLS)	30	100			same as BAU			

6.2. ECOEL2021 scenario, Sales

In the BAU-scenario the 2030 light source sales are 737 million units (Table 29). In the ECOEL2021-scenario this drops to 650 million (-12%). The reason for this decrease is that in the ECOEL2021-scenario more classical lamp types with relatively low lifetime

[34] For the residential sector it is assumed that this regards 80% of all HL R7s models; for the non-residential sector 20%.

[35] The analysis assumes that this regards 90% of LFL T8 models

[36] For the residential sector it is assumed that this regards 20% of all HL R7s models; for the non-residential sector 80%.

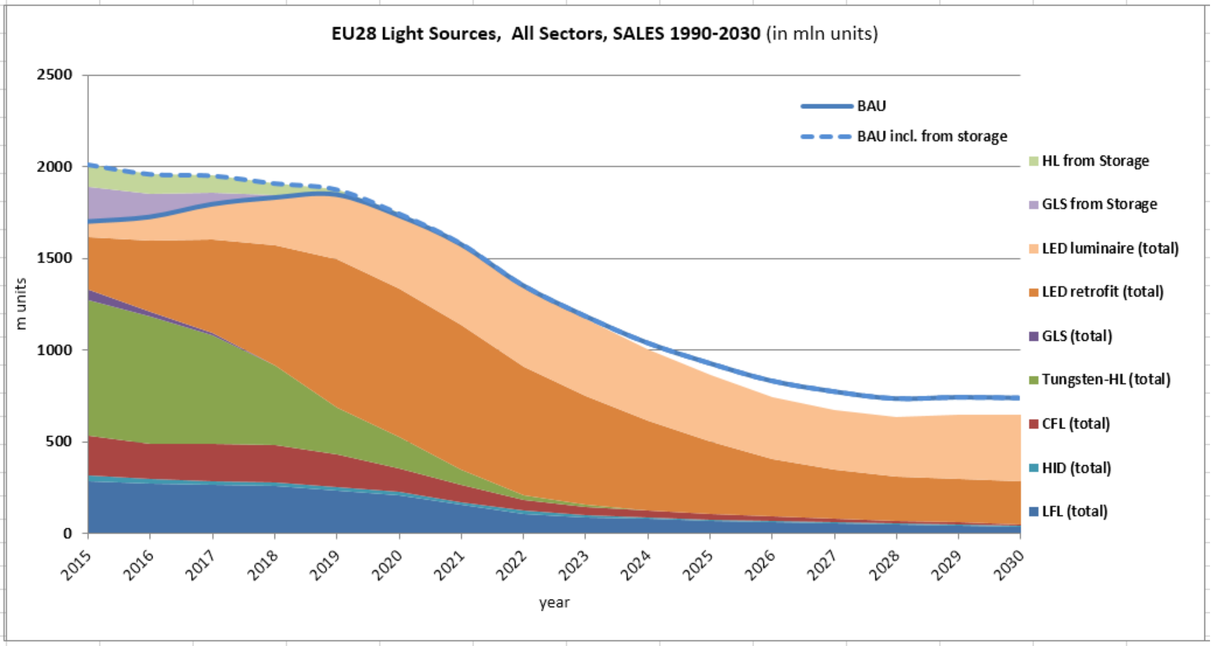
[37] A small part with beam angle ≤10˚ is exempted from the proposal and might continue to exist, but this has a non-quantifiable (but anyway small) impact and is neglected in the analyses.

are replaced by LED products with higher lifetime. The latter need less frequent replacement (or none at all within the 2030 time-horizon) and thus replacement sales go down.

In 2030 almost all sales in the ECOEL2021-scenario regard LEDs; only some LFLs (T5), CFLni and HID-lamps remain. Note the peak in LED sales around 2020.

Table 46: ECOEL2021-scenario, annual light source sales volumes in million units

EU-28 SALES	1990	2010	2015	2020	2025	2030
LFL	269	390	285	209	66	37
CFL	51	567	220	130	29	8
Tungsten-HL	88	650	738	168	1	0
GLS	1688	697	58	0	0	0
HID	17	41	28	17	11	4
LED	0	8	372	1213	759	601
GLS from Storage	*0*	*112*	*187*	*0*	*0*	*0*
HL from Storage	*0*	*90*	*124*	*10*	*0*	*0*
TOTAL (excl. from Storage)	**2112**	**2353**	**1702**	**1737**	**865**	**650**
BAU for comparison	***2112***	***2353***	***1702***	***1737***	***929***	***737***
Variation in ECOEL2021					**-64**	**-87**



6.3. ECOEL2021 scenario, Stock

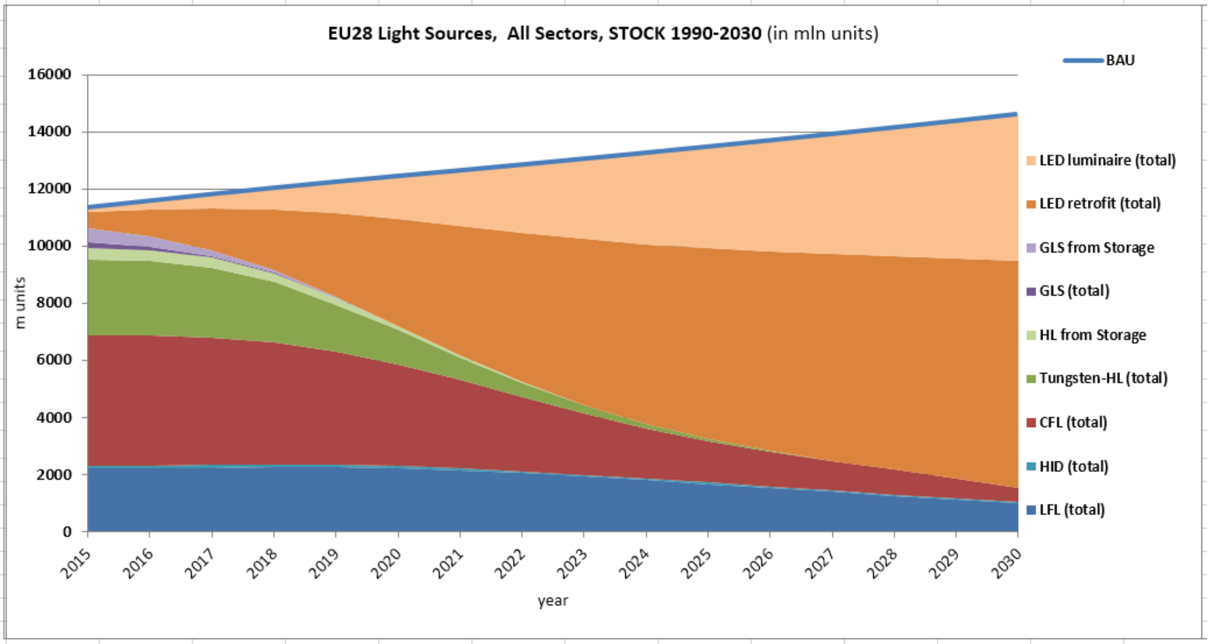
The total number of light sources installed in EU-28 is identical in the BAU- and ECO-scenarios. It increases with the years (more households, more light sources per household, increase in non-residential GDP), but in the same manner in all scenarios.

This reflects the assumption in MELISA that Ecodesign and Labelling measures do not lead to changes in the installed number of light sources[38].

However, the composition of the stock changes. In the BAU-scenario the 2030 stock for LEDs is 11.9 billion units (Table 30). In the ECOEL2021-scenario this increases to 13.1 billion (+10%). The stock for non-LED light sources decreases correspondingly.

Table 47: ECOEL2021 scenario, installed stock of light sources in million units

EU-28 STOCK	1990	2010	2015	2020	2025	2030
LFL	1232	2008	2210	2222	1668	1002
CFL	326	3684	4576	3569	1449	508
Tungsten-HL	284	2043	2657	1190	58	0
GLS	3694	1923	193	1	0	0
HID	40	95	91	79	57	29
LED	0	14	745	5265	10259	13096
GLS from Storage	*0*	*187*	*471*	*6*	*0*	*0*
HL from Storage	*0*	*90*	*417*	*126*	*0*	*0*
TOTAL (incl. from Storage)	**5576**	**10045**	**11360**	**12459**	**13492**	**14635**
BAU for comparison	*5576*	*10045*	*11360*	*12459*	*13492*	*14635*
Variation in ECOEL2021					**0**	**0**



6.4. ECOEL2021 scenario, Electricity

Table 48 shows the EU-28 total electricity consumption for lighting in the ECOEL2021 scenario; the total consumption in the BAU-scenario is also shown for reference.

The savings (BAU – ECO) are 2 TWh/a (0.6%) in 2020, 26 TWh/a (8.4%) in 2025 and 41 TWh/a (14.0%) in 2030. A breakdown of these savings is presented in Table 49, which also indicates cumulative savings of 267 TWh (5.3%) over the period 2015-2030.

In Table 49 the electricity savings on classical technologies are separated from the additional electricity consumption (negative savings) by the LED products that replace

[38] The average luminous flux and/or the average annual operating hours are assumed to change slightly when passing to LED, but this is implemented by a rebound factor on these parameters; it does not change the quantity of installed light sources.

them. For example, in 2030, the electricity consumption by LFL T8t is 59.9 TWh/a less than in the BAU-scenario, but these lamps have been replaced by LEDs that consume 26.9 TWh/a more than in the BAU-scenario, so the overall savings are 59.9-26.9 = 33.0 TWh/a.

By far the largest part of the electricity savings is due to the phase-out (and substitution by LED) of the LFL T8 tri-phosphor lamps in 2021. In 2030, 33 of the 41.9 TWh/a savings (79%) are due to LFL T8t. For the 2015-2030 cumulative savings this is 74%.

In comparison, savings on other classical lamp types are modest, even if not negligible: for some other (non-lighting) ecodesign products, savings of 1-4 TWh/a are considered important.

The 2021 phase-out of CFLi's saves approximately 1.6 TWh/a in 2025 and 1.3 TWh/a in 2030 (net values, considering additional electricity by LEDs replacing them).

The 2021 phase-out of low-voltage halogen reflector lamps (HL LV R DLS) saves 3.7 TWh/a in 2025 and 1.7 TWh/a in 2030.

The 2020 phase-out of halogen capsules (HL LV C & HL MV C) saves approximately 0.9 TWh/a in 2025 while hardly any savings are obtained in 2030.

The partial phase-out in 2020 of linear halogen lamps with R7s cap (HL MV L) > 2700 lm leads to less than 0.2 TWh/a savings in 2025 while hardly any savings are obtained in 2030.

Table 48: ECOEL2021 scenario, EU-28 total Electricity consumption by light sources. Includes control gear energy. Excluded: controls, special purpose lamps, standby.

EU-28 ELECTRICITY	1990	2010	2015	2020	2025	2030
LFL	91	136	159	165	118	64
CFL	3	25	30	24	11	4
Tungsten-HL	8	46	52	22	1	0
GLS	90	46	4	0	0	0
HID	34	69	59	50	37	20
LED	0	0	15	54	119	169
GLS from Storage	*0*	*4*	*10*	*0*	*0*	*0*
HL from Storage	*0*	*1*	*7*	*2*	*0*	*0*
TOTAL (incl. from Storage)	**225**	**328**	**336**	**318**	**286**	**257**
BAU for comparison	***225***	***328***	***336***	***320***	***312***	***299***
Savings in ECOEL2021				**2.0**	**26.3**	**41.9**

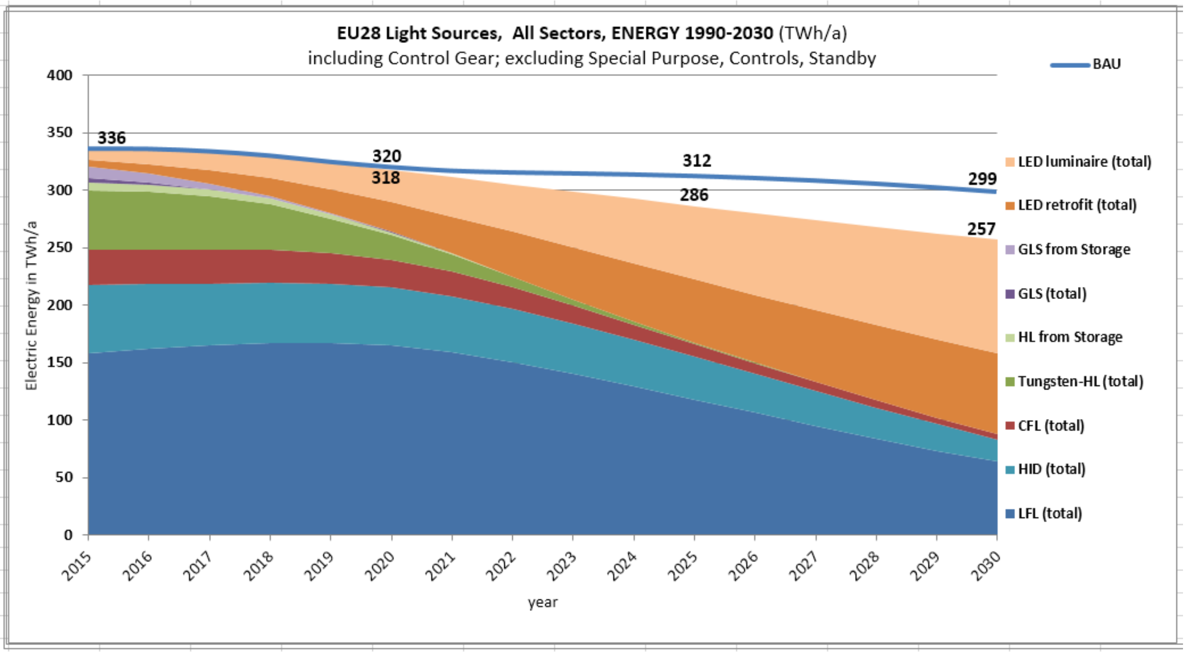


Table 49 ECOEL2021 scenario, Savings on EU-28 Total Electricity Consumption for Lighting, in TWh/a or TWh cumulative) with respect to the BAU-scenario. Positive number indicates saving; negative number an additional electricity consumption. Includes electricity for light sources and control gears. Does not include electricity for control devices, special purpose lamps and during stand-by.

	2020	2025	2030	cumulative 2015-2030
Total EU-28, all sectors	**2.0**	**26.3**	**41.9**	**267**
total Residential (RES)	0	4	3	31
total Non-Residential (NRES)	2	23	39	236
total Classic Technology	5	47	64	456
total LED	-3	-21	-22	-189
LFL T8t	3.7	39.9	59.9	400
LFL T5 (13-80 W)	0.0	0.0	0.0	0
other LFL	0.0	0.0	0.0	0
LED in former LFL-applications	-2.5	-21.4	-26.9	-204
Total LFL-applications	**1.2**	**18.5**	**33.0**	**197**
HPM	0.0	0.0	0.0	0
HPS	0.0	0.0	0.0	0
MH	0.0	0.0	0.0	0
LED in former HID-applications	0.0	1.3	3.8	18
Total HID-applications	**0**	**1**	**4**	**18**
CFLni	0.0	0.0	0.0	0
LED in former CFLni-applications	0.0	0.1	0.4	2
Total CFLni-applications	**0**	**0**	**0**	**2**
HL LV R (MR/AR) (GU4,GU5.3,G53)	0.6	4.5	1.8	32
HL MV (DLS) (GU10 or E-cap)	0.0	0.0	0.0	0
GLS (DLS)	0.0	0.0	0.0	0
LED in DLS-applications	-0.1	-0.8	-0.1	-6
Total DLS-applications	**0.4**	**3.7**	**1.7**	**26**
CFLi	0.2	1.6	2.0	15
HL MV (NDLS, E-cap)	0.0	0.0	0.0	0
GLS (NDLS)	0.0	0.0	0.0	0
HL LV Capsule (G4, GY6.35)	0.1	0.4	0.1	3
HL MV Capsule (G9)	0.2	0.5	0.0	4
HL MV Linear (R7s)	0.1	0.2	0.0	2
LED in NDLS-applications	-0.2	0.0	0.8	1
Total NDLS-applications	**0.4**	**2.7**	**3.0**	**24**

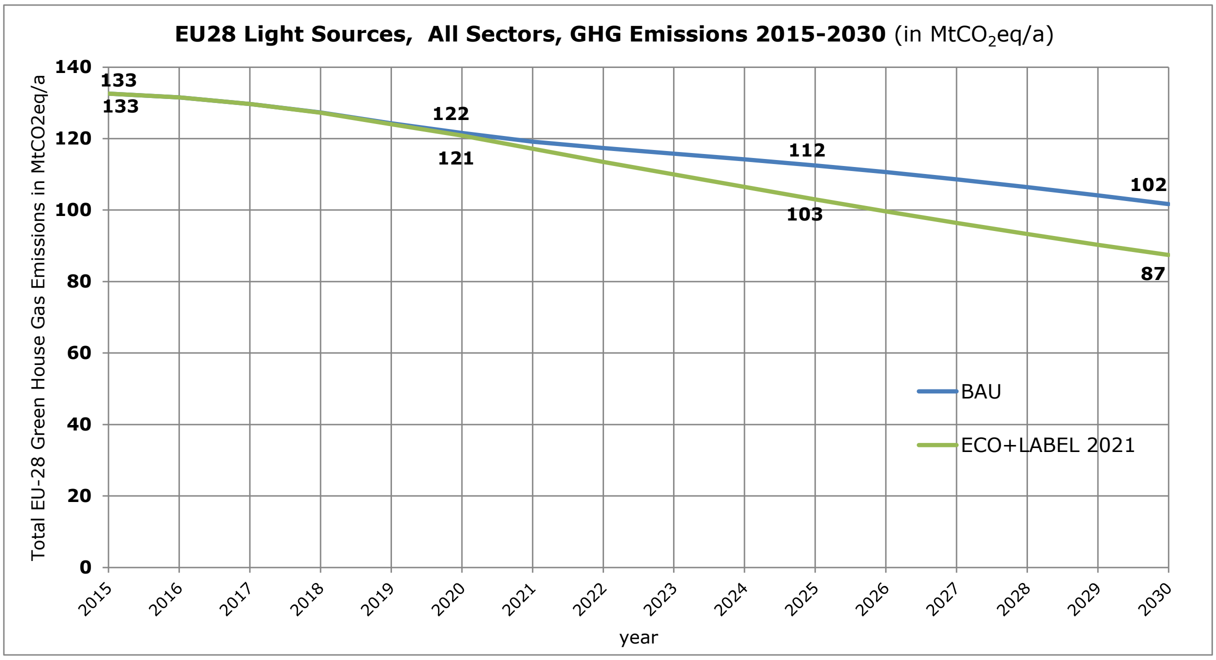
6.5. ECOEL2021 scenario, GHG-emissions

The reduction in GHG-emissions in the ECOEL2021 scenario with respect to the BAU-scenario is 14.3 $MtCO_2eq/a$ in 2030 (-14%) or 94 $MtCO_2eq$ (-5%) cumulative over the period 2015-2030.

This reduction is a direct effect of the reduction in electricity consumption for light sources.

Table 50: BAU-Total EU-28 Greenhouse gas (GHG-) emission due to lighting electricity consumption in MtCO2eq/a or MtCO2eq cumulative, and reductions in the ECOEL2021 scenario

$MtCO_2eq$		2015	2020	2025	2030	cumulative
BAU	emission	133	122	112	102	1878
ECOEL2021	reduction		-0.7	-9.5	-14.3	-94



6.6. ECOEL2021 scenario, User Expense for light sources

Figure 15 shows the EU-28 total Acquisition Cost, Electricity Cost and overall User Expense for light sources in the ECOEL2021-scenario; the corresponding values for the BAU-scenario are also indicated for comparison (blue line).

The Acquisition costs in the ECOEL2021 scenario are higher than in the BAU-scenario, with a maximum difference of +4.2 billion EUR/a around 2022/2023. This additional expense is due to the accelerated shift of sales towards LED products, and is the investment needed to obtain the electricity savings reported earlier.

The Electricity Costs in the ECOEL2021 scenario are lower than in the BAU-scenario, with a maximum decrease of -8.9 billion EUR/a in 2030. This decrease is due to the decrease of the electricity consumption.

As a consequence the total User Expense for light sources in the ECOEL2021 scenario is slightly higher than in the BAU-scenario for a short period around 2022. In later years the ECOEL2021 expense is lower than for BAU Expense.

A further breakdown of the User Expense Savings is presented in Table 54. In 2020 the additional expense (negative saving) in the ECOEL2021-scenario is -0.8 billion EUR/a, in 2025 the savings are 1.5 billion EUR/a and in 2030 7.7 billion EUR/a (9.3% of the BAU-Expense in that year). The cumulative savings over the period 2015-2030 are EUR 21 billion (1.8% of the BAU cumulative Expense).

In line with earlier findings, the major part of the monetary savings is obtained due to the 2021 phase-out of LFL T8t (6.0 of the EUR 7.7 billion per year in 2030).

Table 51: ECOEL2021 scenario, EU-28 total Acquisition costs for light sources (acquisition and installation), in bn euros. Fixed EUR 2010, incl. 20% VAT for residential.

EU-28 ACQUISITION COST	1990	2010	2015	2020	2025	2030
LFL	3.84	5.53	4.01	2.95	0.92	0.52
CFL	0.36	3.49	1.48	0.90	0.24	0.07
Tungsten-HL	0.34	2.79	2.90	0.67	0.00	0.00
GLS	2.08	0.86	0.07	0.00	0.00	0.00
HID	0.52	1.44	1.02	0.62	0.38	0.15
LED	0	0.29	8.05	12.09	12.65	11.22
GLS from Storage	*0*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
HL from Storage	*0*	*0.00*	*0.33*	*0.03*	*0.00*	*0.00*
TOTAL ECOEL2021	**7.15**	**14.40**	**17.86**	**17.25**	**14.20**	**11.96**
BAU for comparison	***7.15***	***14.40***	***17.86***	***16.14***	***10.95***	***10.79***
Additional due to ECOEL2021				**1.1**	**3.3**	**1.2**

Table 52: ECOEL2021 scenario, EU-28 total Electricity costs for light sources, in bn euros. Fixed EUR 2010, incl. 20% VAT for residential. See Table 26 for applied electricity rates (from MEErP, incl. escalation 4%/a)**.**

EU-28 ELECTRICITY COST	1990	2010	2015	2020	2025	2030
LFL	11.13	14.91	19.68	23.05	20.14	13.49
CFL	0.45	3.45	4.99	4.54	2.50	1.21
Tungsten-HL	1.17	6.93	9.57	4.43	0.26	0.00
GLS	14.91	7.21	0.78	0.00	0.00	0.00
HID	4.02	7.29	7.09	6.81	6.14	3.92
LED	0	0.03	2.01	8.62	22.12	37.50
GLS from Storage	*0*	*0.75*	*1.99*	*0.03*	*0.00*	*0.00*
HL from Storage	*0*	*0.25*	*1.41*	*0.49*	*0.00*	*0.00*
TOTAL ECOEL2021	**31.68**	**40.83**	**47.52**	**47.98**	**51.17**	**56.12**
BAU for comparison	***31.68***	***40.83***	***47.52***	***48.29***	***55.96***	***65.03***
Saving due to ECOEL2021				**0.3**	**4.8**	**8.9**

Table 53: ECOEL2021 scenario, EU-28 total User Expense for light sources, in bn euros. Fixed EUR 2010, incl. 20% VAT for residential. In addition to Acquisition- and Electricity-costs from previous tables, this also includes maintenance costs for non-residential sector.

EU-28 TOTAL USER EXPENSE	1990	2010	2015	2020	2025	2030
LFL	15.44	21.23	24.56	26.87	21.70	14.38
CFL	1.13	9.10	8.98	7.43	3.68	1.61
Tungsten-HL	1.64	10.34	13.19	5.51	0.29	0.00
GLS	17.68	8.43	0.88	0.00	0.00	0.00
HID	4.79	9.32	8.67	7.92	6.88	4.24
LED	0	0.32	10.34	22.56	39.16	55.03
GLS from Storage	*0*	*0.75*	*1.99*	*0.03*	*0.00*	*0.00*
HL from Storage	*0*	*0.25*	*1.74*	*0.52*	*0.00*	*0.00*
TOTAL ECOEL2021	**40.68**	**59.74**	**70.36**	**70.84**	**71.72**	**75.26**
BAU for comparison	***40.68***	***59.74***	***70.36***	***70.05***	***73.26***	***83.00***
Saving due to ECOEL2021				**-0.8**	**+1.5**	**+7.7**

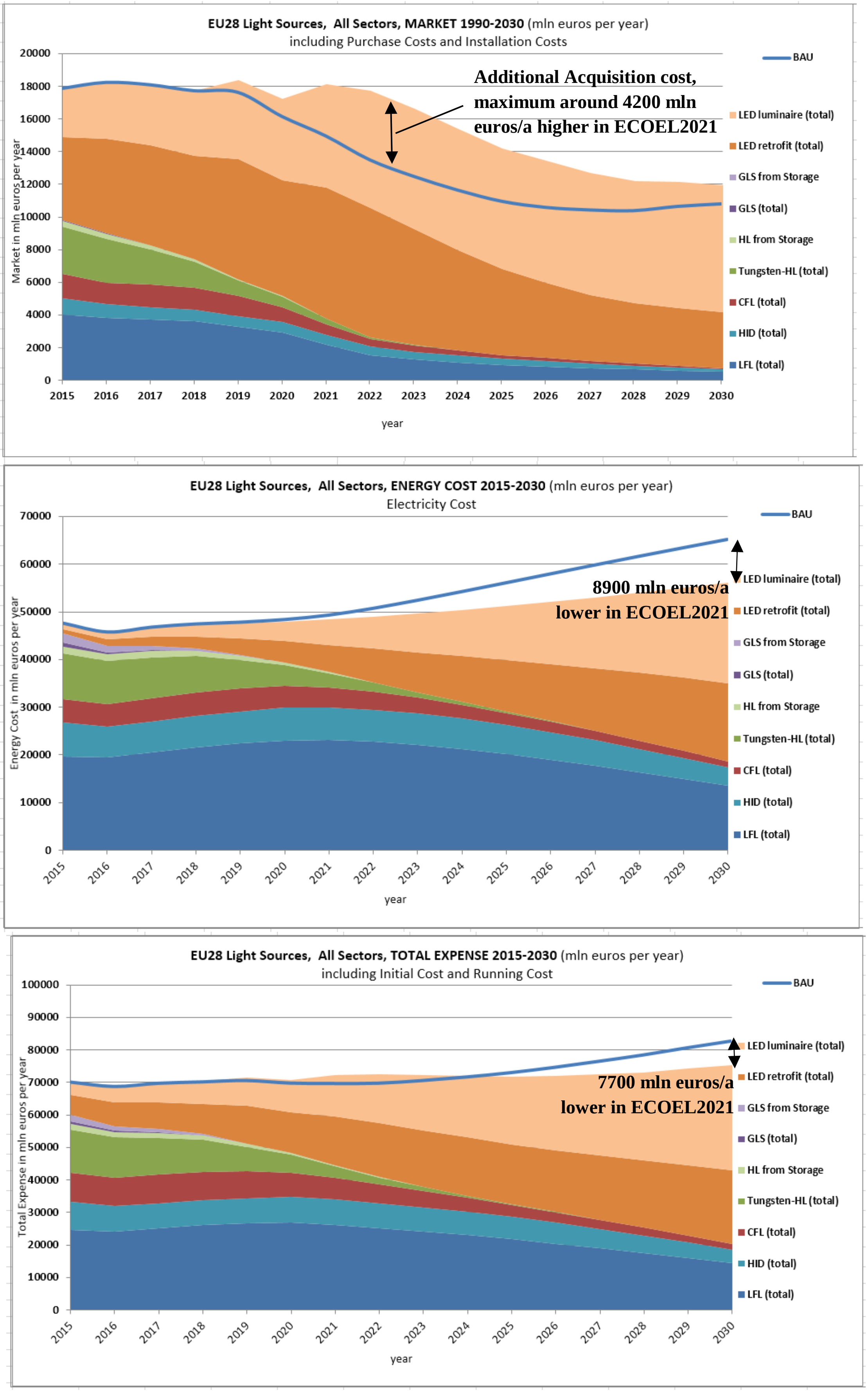


Figure 15 ECOEL2021 scenario, EU-28 Total Acquisition Cost (top), Electricity Cost (centre) and Total User Expense (bottom) for light sources, in million euros, fixed EUR 2010 incl. residential VAT. BAU-totals shown for reference (blue line). Note: graphs have different scales.

Table 54 ECOEL2021 scenario, Savings on EU-28 Total User Expense for Lighting, in billion euros, with respect to the BAU-scenario. Positive number indicates saving; negative number an additional expense. Fixed 2010 euros, includes VAT for residential.

ECOEL2021 cost savings vs. BAU	2020	2025	2030	cumulative 2015-2030
Total EU-28, all sectors	**-0.8**	**1.5**	**7.7**	**21.2**
total Residential (RES)	0.0	0.5	0.9	3.9
total Non-Residential (NRES)	-0.8	1.0	6.8	17.3
total Classic Technology	1.4	10.5	14.8	105.1
total LED	-2.2	-8.9	-7.1	-83.9
LFL T8t	0.9	8.1	13.3	85.2
LFL T5 (13-80 W)	0.0	0.0	0.0	0.0
other LFL	0.0	0.0	0.0	0.0
LED in former LFL-applications	-1.7	-7.3	-7.3	-70.7
Total LFL-applications	**-1**	**1**	**6**	**15**
HPM	0.0	0.0	0.0	0.0
HPS	0.0	0.0	0.0	0.0
MH	0.0	0.0	0.0	0.0
LED in former HID-applications	0.0	0.0	0.5	1.2
Total HID-applications	**0**	**0**	**1**	**1**
CFLni	0.0	0.0	0.0	0.0
LED in former CFLni-applications	0.0	0.0	0.0	-0.2
Total CFLni-applications	**0**	**0**	**0**	**0**
HL LV R (MR/AR) (GU4,GU5.3,G53)	0.2	1.4	0.6	10.3
HL MV (DLS) (GU10 or E-cap)	0.0	0.0	0.0	0.0
GLS (DLS)	0.0	0.0	0.0	0.0
LED in DLS-applications	-0.2	-0.6	0.0	-4.6
Total DLS-applications	**0**	**1**	**1**	**6**
CFLi	0.2	0.7	0.8	7.0
HL MV (NDLS, E-cap)	0.0	0.0	0.0	0.0
GLS (NDLS)	0.0	0.0	0.0	0.0
HL LV Capsule (G4, GY6.35)	0.0	0.1	0.0	1.0
HL MV Capsule (G9)	0.1	0.2	0.0	1.2
HL MV Linear (R7s)	0.0	0.0	0.0	0.4
LED in NDLS-applications	-0.3	-0.9	-0.4	-9.6
Total NDLS-applications	**0**	**0**	**0**	**0**

7. ECOEL2TIERS SCENARIO

The only difference with the ECOEL2021 scenario is that the phase-out of LFL T8 in the Ecodesign measures is postponed from 2021 to 2023. In the analysis model this translates into a different shift from LFL T8 to LEDs (see table below). Other light source types continue to be phased-out in 2021 (e.g. CFLi, halogens). Hence, the Ecodesign measures have two tiers, one in 2021 and one in 2023.

Introduction of the new Energy Labelling A-G scheme remains in 2021.

Table 55: Percentage of the potential sales (replacements and new sales) for LFL T8 that is assumed to shift to LED products in the BAU-, ECOEL2021 and ECOEL2TIERS scenarios

	LFL T8 => LED (%)			
Base Case	2015	2020	2025	2030
BAU	5	20	40	60
ECOEL2021	5	34	94	96
ECOEL2TIERS	5	20	94	100

Postponing the phase-out of LFL T8 from 2021 to 2023 decreases the electricity savings by 6.2 TWh/a in 2025 and 1.8 TWh/a in 2030. Cumulatively the decrease is 47 TWh over the period 2015-2030.

Table 56: ECOEL2TIERS scenario, EU-28 total Electricity for light sources.

EU-28 ELECTRICITY (TWh/a)	1990	2010	2015	2020	2025	2030	Cumulative 2015-2030
LFL	91	136	159	169	134	72	
CFL	3	25	30	24	11	4	
Tungsten-HL	8	46	52	22	1	0	
GLS	90	46	4	0	0	0	
HID	34	69	59	50	37	20	
LED	0	0	15	52	108	163	
GLS from Storage	*0*	*4*	*10*	*0*	*0*	*0*	
HL from Storage	*0*	*1*	*7*	*2*	*0*	*0*	
TOTAL ECOEL2TIERS	**225**	**328**	**336**	**319**	**292**	**259**	**4860**
ECOEL2021 for comparison	***225***	***328***	***336***	***318***	***286***	***257***	***4812***
Effect of postponement of LFL T8 phase-out from 2021 to 2023				**+1.2**	**+6.2**	**+1.8**	**+47**

Postponing the phase-out of LFL T8 from 2021 to 2023 decreases the consumer expense savings by 1.2 billion EUR/a in 2025 and 0.9 billion EUR/a in 2030. Cumulatively the decrease is EUR 4.5 billion over the period 2015-2030.

Table 57: ECOEL2TIERS scenario, EU-28 total Consumer Expense for light sources.

EU-28 EXPENSE (bn EUR/a)	1990	2010	2015	2020	2025	2030	Cumulative 2015-2030
LFL	15.44	21.23	24.56	27.79	24.53	15.97	
CFL	1.13	9.10	8.98	7.43	3.68	1.61	
Tungsten-HL	1.64	10.34	13.19	5.51	0.29	0.00	
GLS	17.68	8.43	0.88	0.00	0.00	0.00	
HID	4.79	9.32	8.67	7.92	6.88	4.24	
LED	0	0.32	10.34	20.82	37.53	54.36	
GLS from Storage	*0*	*0.75*	*1.99*	*0.03*	*0.00*	*0.00*	
HL from Storage	*0*	*0.25*	*1.74*	*0.52*	*0.00*	*0.00*	
TOTAL ECOEL2TIERS	**40.68**	**59.74**	**70.36**	**70.01**	**72.92**	**76.18**	**1154**
ECOEL2021 for comparison	***40.68***	***59.74***	***70.36***	***70.84***	***71.72***	***75.26***	***1150***
Effect of postponement of LFL T8 phase-out from 2021 to 2023				**-0.8**	**+1.2**	**+0.9**	**+4.5**

8. SCENARIO COMPARISON, SUMMARY AND CONCLUSIONS

Table 58 summarizes the total EU-28 Electricity consumption, Greenhouse Gas emission and User Expense for lighting for the BAU-scenario, and the savings for the other scenarios. For additional insight see the graphs at the end of this summary.

Table 58: Total EU-28 Electricity Consumption for lighting in TWh/a or TWh cumulative, Total EU-28 GHG-emissions related to use of lighting in $MtCO_2eq/a$ or $MtCO_2eq$ cumulative, and Total EU-28 User Expense for lighting in bn EUR/a or bn EUR cumulative. Totals for the BAU-scenario and savings vs. BAU for the other scenarios.

Electricity (TWh) [39]		**2015**	**2020**	**2025**	**2030**	Cumul [40]
BAU	Electricity	336	320	312	299	5079
ELONLY	saving		0.0	-4.2	-11.5	-54
ECOEL2021	saving		-2.0	-26.3	-41.9	-267
ECOEL2TIERS	saving		-0.8	-20.1	-40.1	-220
Emission ($MtCO_2eq$)		**2015**	**2020**	**2025**	**2030**	Cumulative
BAU	Emission	133	122	112	102	1878
ELONLY	saving		0.0	-1.5	-3.9	-19
ECOEL2021	saving		-0.7	-9.5	-14.3	-94
ECOEL2TIERS	saving		-0.3	-7.2	-13.6	-77
Expense (bn euros) [41]		**2015**	**2020**	**2025**	**2030**	Cumulative
BAU	Expense	70	70	73	83	1171
ELONLY	saving		0.0	0.9	-1.1	4
ECOEL2021	saving		0.8	-1.5	-7.7	-21
ECOEL2TIERS	saving		0.0	-0.3	-6.8	-17

8.1. Electricity Consumption

In 2015 the EU-28 electricity consumption for lighting was 336 TWh/a, covering 12.2% of the overall EU-28 electricity use [42]. The primary energy necessary to generate and distribute this electricity was 72 Mtoe, covering 4.4% of the EU-28 Gross Inland Consumption of energy [43].

In the BAU-scenario the electricity for lighting is expected to decrease to 299 TWh/a in 2030 (-12% vs. 2015), notwithstanding a 25% increase in the quantity of installed light sources. This decrease is due to the increased use of high-efficacy LED products.

Introduction of a new Energy Labelling A-G scheme in 2021 (ELONLY scenario) is projected to save 11.5 TWh/a (-3.8%) in 2030, and cumulatively 54 TWh until 2030.

[39] Electricity consumption includes control gears, but excludes controls, special purpose, stand-by

[40] Cumulative over period 2015-2030

[41] User Expense includes purchase, installation, operation and maintenance of light sources and control gears. Additional luminaire costs are not included. Expense is in fixed 2010 euros, incl. VAT for residential. Negative numbers are a saving; positive numbers indicate an additional expense.

[42] According to the Eurostat Energy Balance Sheet, 2017 edition with 2015 data, the total EU-28 electricity consumption in 2015 was 235.9 Mtoe = 2743 TWh

[43] Assuming an average EU-28 efficiency of electricity generation and distribution of 40%, and conversion factors 1 Mtoe = 11.63 TWh = 41.87 PJ: 336*2.5 = 840 TWh /11.63 = 72 Mtoe * 41.87 = 3024 PJ. According to the Eurostat Energy Balance Sheet, 2017 edition with 2015 data, the Gross Inland Consumption of Energy was 1626 Mtoe in 2015.

Adding the Ecodesign measures with a single tier in 2021 (ECOEL2021 scenario), phasing-out CFLi, most halogen lamps and LFL T8 (2-, 4- and 5-feet), is projected to save 41.9 TWh/a (-14.0%) in 2030, and cumulatively 267 TWh until 2030.

Implementing the Ecodesign measures in 2 tiers, postponing the phase-out of LFL T8 to 2023, is projected to save 40.1 TWh/a (-13.4%) in 2030, and cumulatively 220 TWh until 2030.

Postponing the phase-out of LFL T8 from 2021 to 2023 decreases the electricity savings by 6.2 TWh/a in 2025 and 1.8 TWh/a in 2030. Cumulatively the decrease in savings is 47 TWh over the period 2015-2030.

The largest part of the ECOEL2021 electricity savings derives from the 2021 phase-out of LFL T8 tri-phosphor (79% of the 2030 savings; 74% of the cumulative savings) (Table 59).

Table 59 Distribution over the various lamp types of the electricity savings in the ECOEL2021 scenario. 79% of the 2030 savings and 74% of the cumulative savings is due to the phase-out of LFL T8 in 2021.

ECOEL2021 scenario electricity savings vs. BAU	2020	2025	2030	cumulative 2015-2030
Total EU-28, all sectors	**2.0**	**26.3**	**41.9**	**267**
LFL-applications	**1.2**	**18.5**	**33.0**	**197**
HID-applications	0.0	1.3	3.8	18
CFLni-applications	0.0	0.1	0.4	2
DLS-applications	0.4	3.7	1.7	26
NDLS-applications	0.4	2.7	3.0	24

8.2. Greenhouse Gas (GHG-) emissions

In 2015 the EU-28 GHG-emission due to use of light sources was 133 $MtCO_2eq/a$, covering 2.8% of the overall EU-28 GHG-emission [44]. In the BAU-scenario this is expected to reduce to 102 $MtCO_2eq/a$ in 2030 (-30% vs. 2015), due to decreased electricity use for lighting and due to reduced emissions per kWh during electricity generation and distribution.

Introduction of a new Energy Labelling A-G scheme in 2021 (ELONLY scenario) is projected to reduce GHG-emissions by 3.9 $MtCO_2eq/a$ (-3.8%) in 2030, and cumulatively by 19 $MtCO_2eq$ until 2030.

Adding the Ecodesign measures with a single tier in 2021 (ECOEL2021 scenario), phasing-out CFLi, most halogen lamps and LFL T8 (2-, 4- and 5-feet), is projected to reduce GHG-emissions by 14.3 $MtCO_2eq/a$ (-14.0%) in 2030, and cumulatively by 94 $MtCO_2eq$ until 2030.

Implementing the Ecodesign measures in 2 tiers, postponing the phase-out of LFL T8 to 2023, is projected to reduce emissions by 13.6 $MtCO_2eq/a$ (-13.3%) in 2030, and cumulatively by 77 $MtCO_2eq$ until 2030.

[44] $MtCO_2eq$= Mega-tonnes carbon dioxide equivalent global warming potential; Mt = 1 billion kilos. For comparison, the total EU-28 GHG emission is 4721 Mt CO_2 eq/a (source: EEA, GHG Inventory 2012. Total for EU-28 excl. land use, land-use change and forestry (LULUCF).)

Postponing the phase-out of LFL T8 from 2021 to 2023 thus increases the GHG-emissions by 2.3 TWh/a in 2025 and by 0.7 TWh/a in 2030. Cumulatively the increase is 17 TWh over the period 2015-2030.

8.3. User Expense saving

The total EU-28 user expense for light sources (acquisition, installation, use, maintenance) in 2015 was 70 billion EUR/a[45]. In the BAU-scenario this is estimated to increase to 83 billion EUR/a by 2030, notwithstanding the decrease in electricity consumption. The increase is due to the assumed increase in electricity rate (euros/kWh, +4% per year, not counting inflation, MEErP prices, see Section 3.2 of this Annex).

Introduction of a new Energy Labelling A-G scheme in 2021 (ELONLY scenario) is projected to initially increase total user expenses for lighting by 0.9 billion EUR/a (+1.2%) in 2025. This additional expense is due to higher acquisition costs, i.e. an investment in LED light sources with higher energy efficiency, but also with higher unit prices. This investment gradually pays back in following years due to lower electricity costs, leading to 1.1 billion EUR/a lower user expenses (-1.3%) by 2030. Cumulatively over the period 2015-2030, the projection is an additional user expense of 4 billion euros. However, LED light sources bought in the period 2021-2030 will continue to provide monetary advantages also beyond 2030, leading to zero additional cumulative expenses around 2032 and EUR 8 billion cumulative expense savings by 2035.

Adding the Ecodesign measures with a single tier in 2021 (ECOEL2021 scenario), phasing-out CFLi, most halogen lamps and LFL T8 (2-, 4- and 5-feet), is projected to lead to 0.8 billion EUR/a additional expenses by 2020 (investment), to 1.5 billion EUR/a expense savings by 2025 and to 7.7 billion EUR/a savings by 2030. Cumulative savings over the period until 2030 are 21 billion euros.

Postponing the phase-out of LFL T8 from 2021 to 2023 increases the total user expenses in 2025 by 1.2 billion EUR/a and in 2030 by 0.9 billion EUR/a. Cumulatively over the period until 2030, total user expense is EUR 4 billion higher due to the postponement.

8.4. Graphs

For Electricity consumption, GHG-emission and User expense the following graphs are shown for the period 2015-2030:

- total annual values for the four scenarios;
- annual savings vs. BAU of the same year for the other three scenarios;
- Cumulative 2015-2030 savings vs. BAU for the other three scenarios.

[45] This does not include additional costs for the acquisition, installation and maintenance of luminaires: only the light sources and control gears inside these luminaires and the costs for their electricity consumption are included.

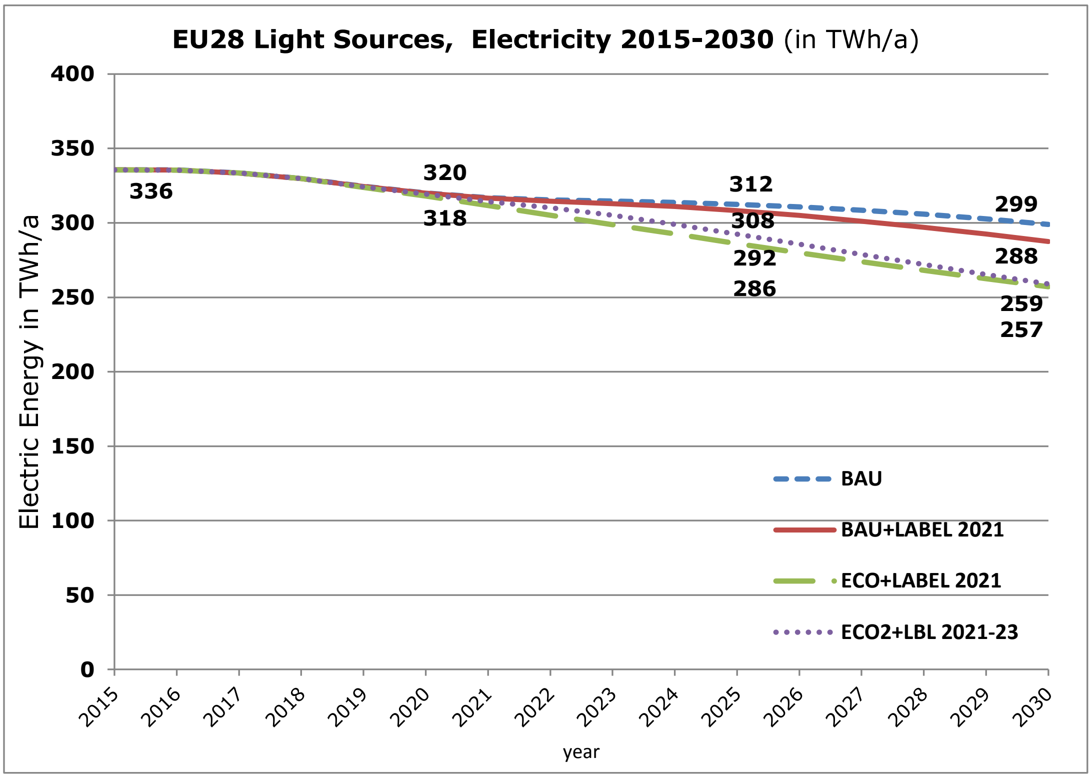


Figure 16 Total EU-28 electricity consumption for lighting in TWh/a for BAU, ELONLY, ECOEL2021, and ECOEL2TIERS scenarios.

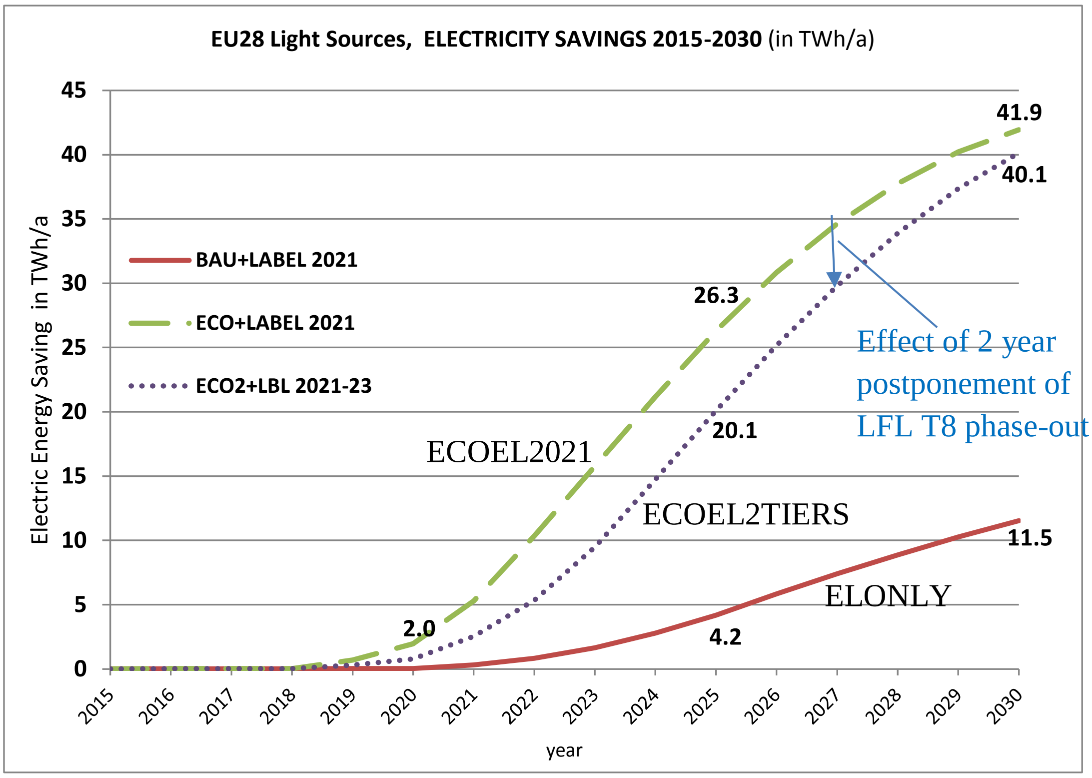


Figure 17 Total EU-28 annual electricity savings in TWh/a for ELONLY, ECOEL2021, and ECOEL2TIERS scenarios with respect to BAU.

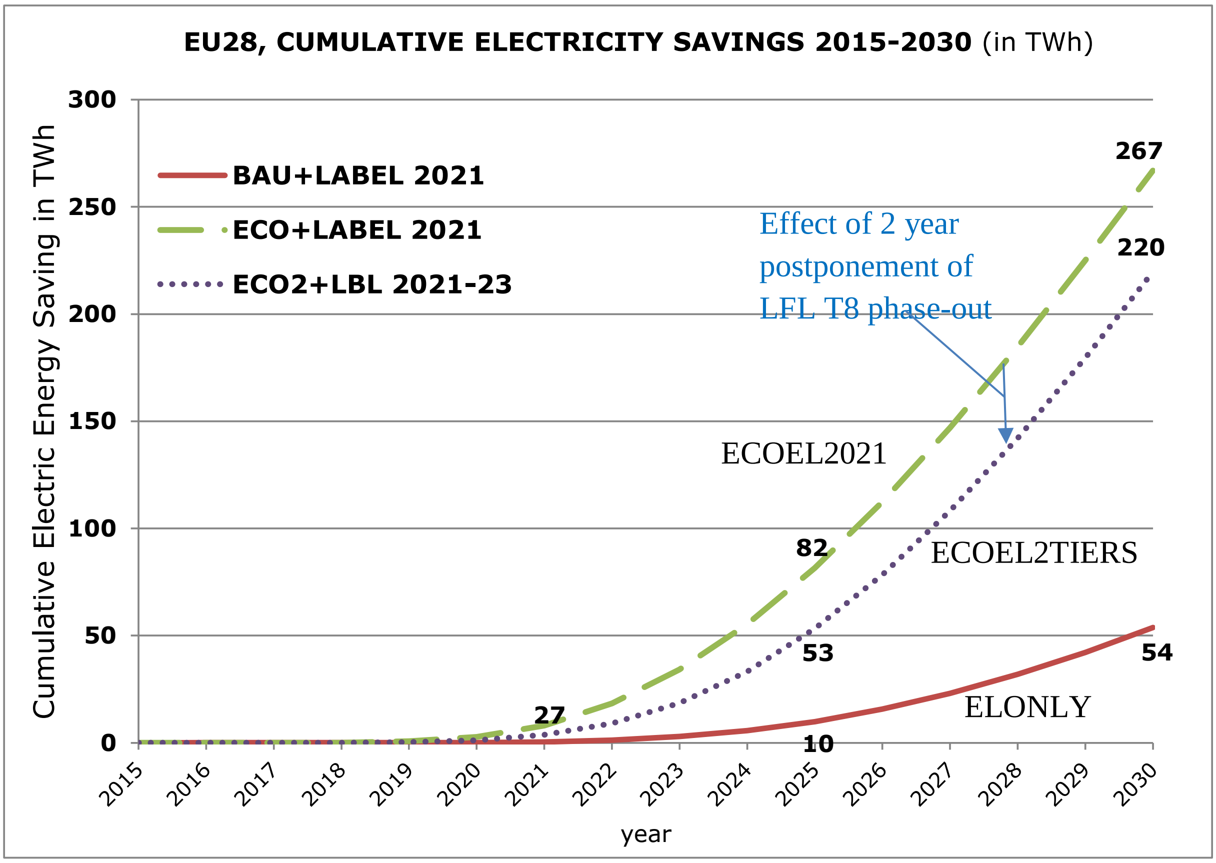


Figure 18 Total EU-28 cumulative electricity savings in TWh for ELONLY, ECOEL2021, and ECOEL2TIERS scenarios with respect to BAU.

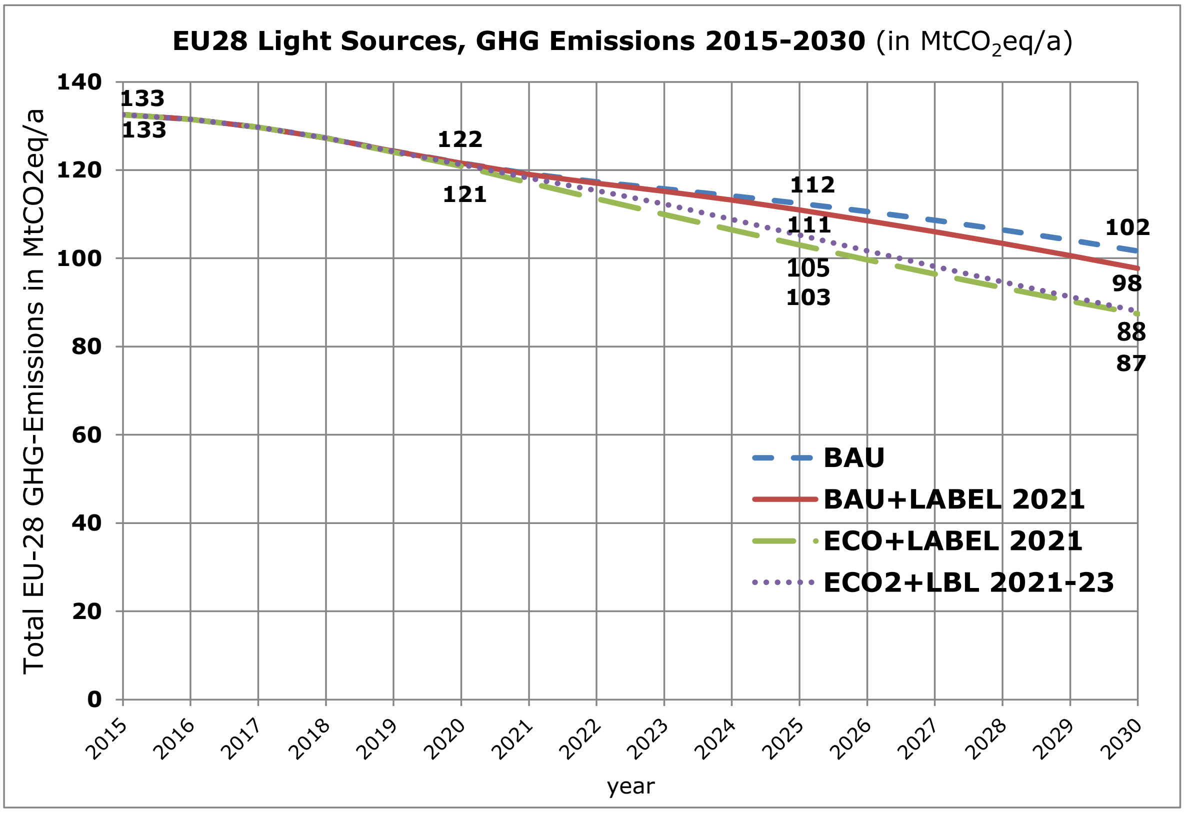


Figure 19 Total EU-28 GHG-emission related to use of light sources in $MtCO_2eq/a$ for BAU, ELONLY, ECOEL2021, and ECOEL2TIERS scenarios.

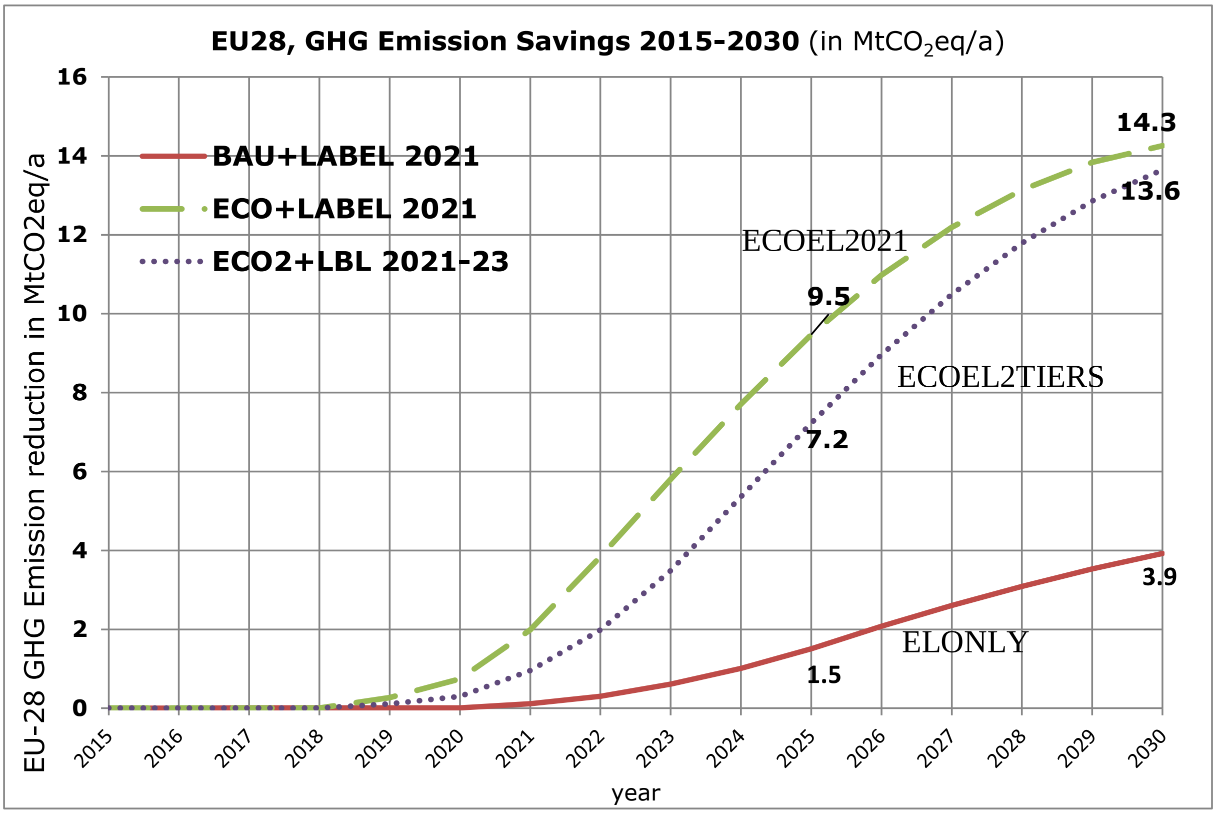


Figure 20 Total EU-28 <u>annual reduction</u> in GHG-emission, in MtCO$_2$eq/a, for ELONLY, ECOEL2021, and ECOEL2TIERS scenarios with respect to BAU.

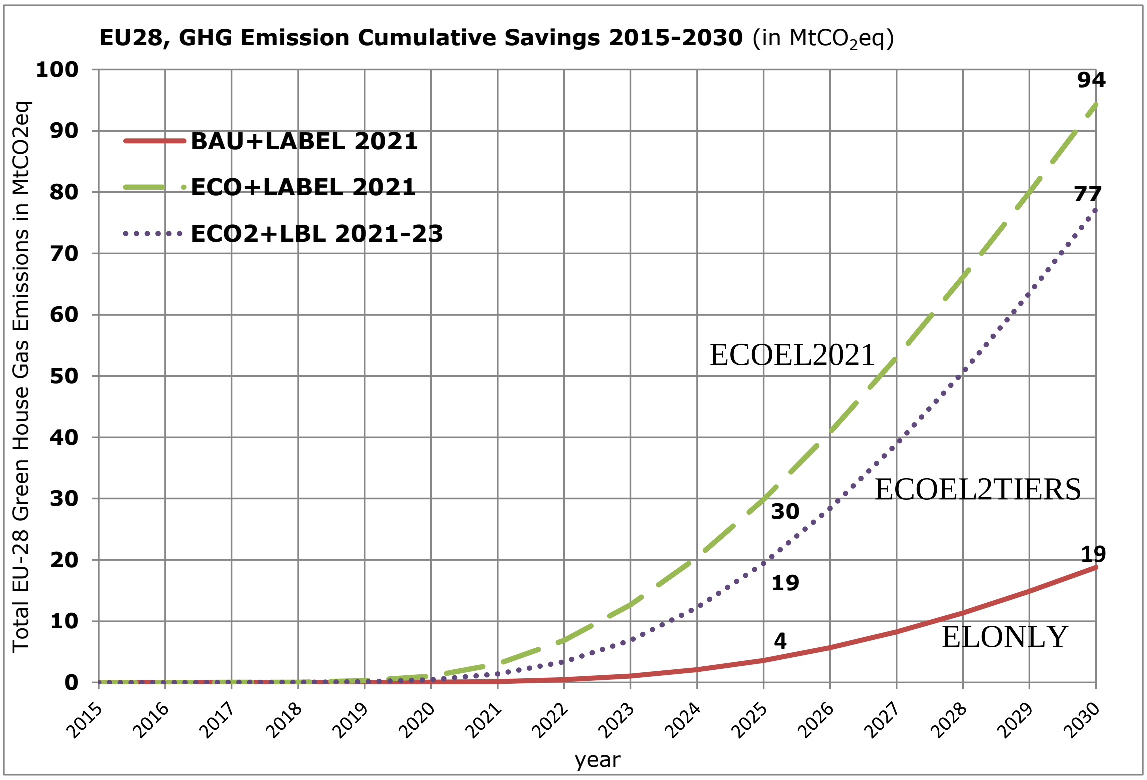


Figure 21 Total EU-28 <u>cumulative reduction</u> in GHG-emission, in MtCO$_2$eq, for ELONLY, ECOEL2021, and ECOEL2TIERS scenarios with respect to BAU.

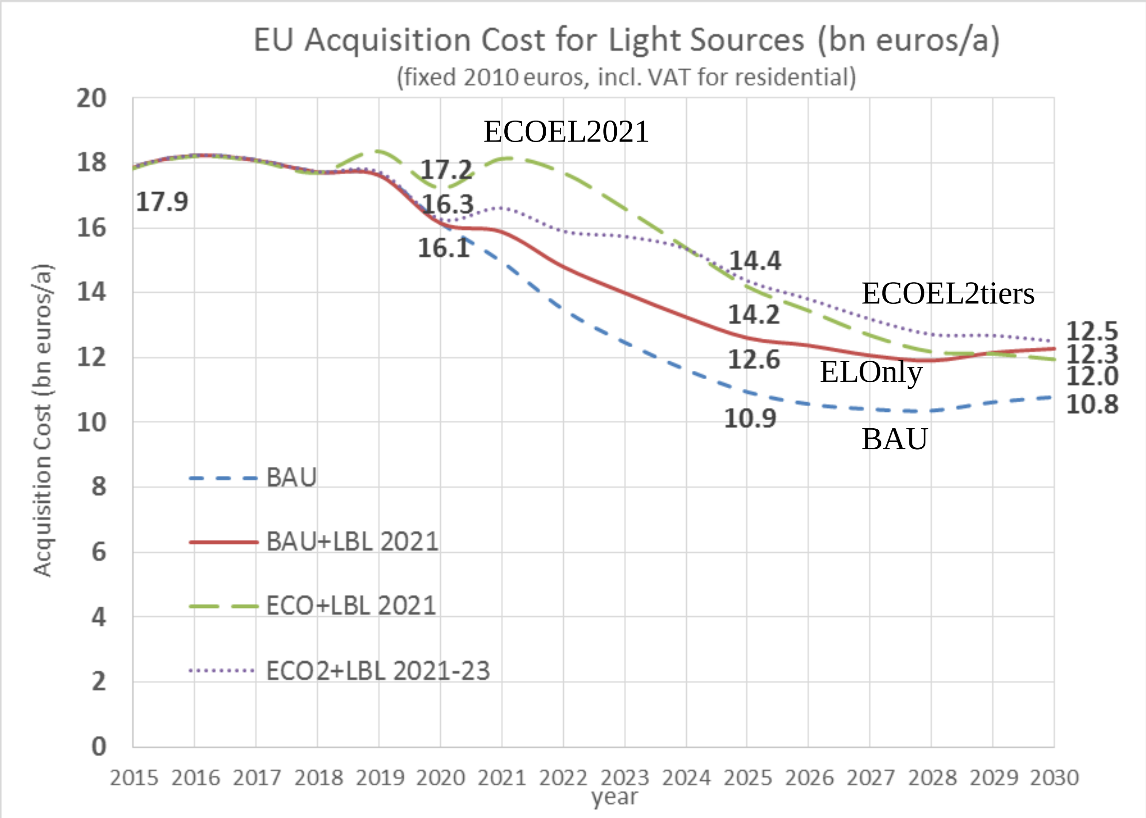


Figure 22 Total EU-28 acquisition cost for lighting in bn EUR/a for BAU, ELONLY, ECOEL2021, and ECOEL2TIERS scenarios.

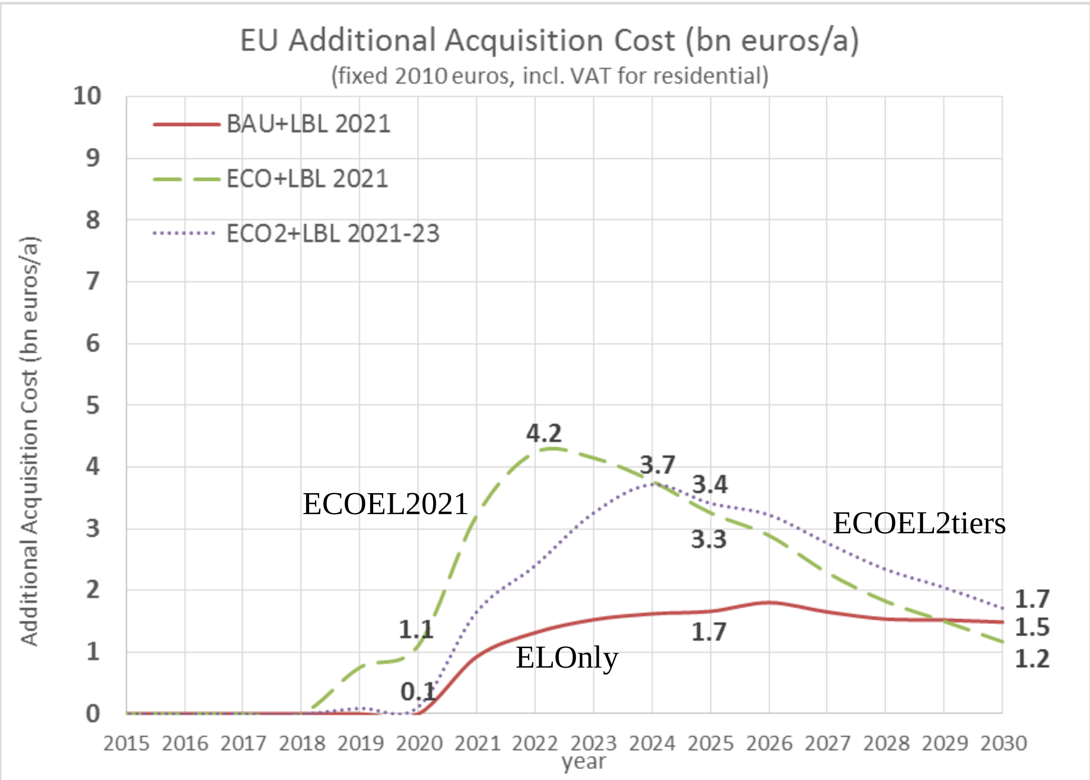


Figure 23 Total EU-28 <u>annual additional acquisition cost</u>, in bn EUR/a, for ELONLY, ECOEL2021, and ECOEL2TIERS scenarios with respect to BAU

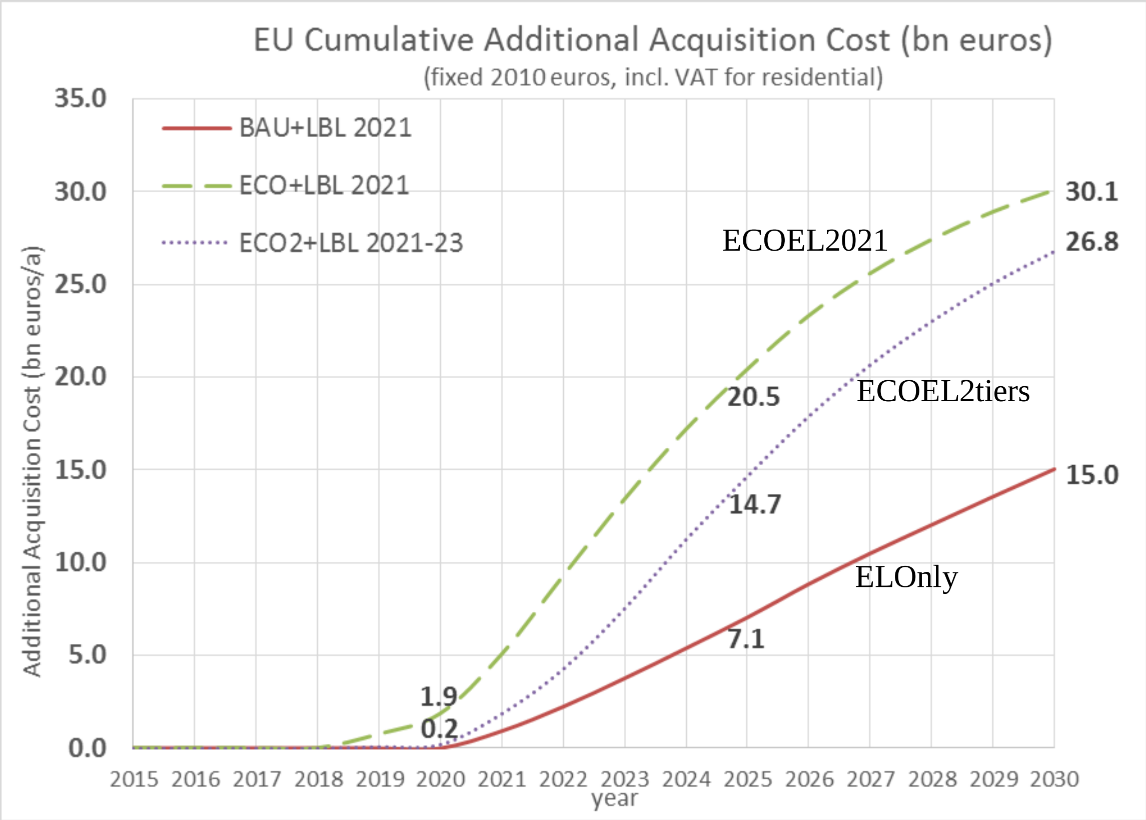


Figure 24 Total EU-28 <u>cumulative additional acquisition cost</u>, in bn euros, for ELONLY, ECOEL2021, and ECOEL2TIERS scenarios with respect to BAU

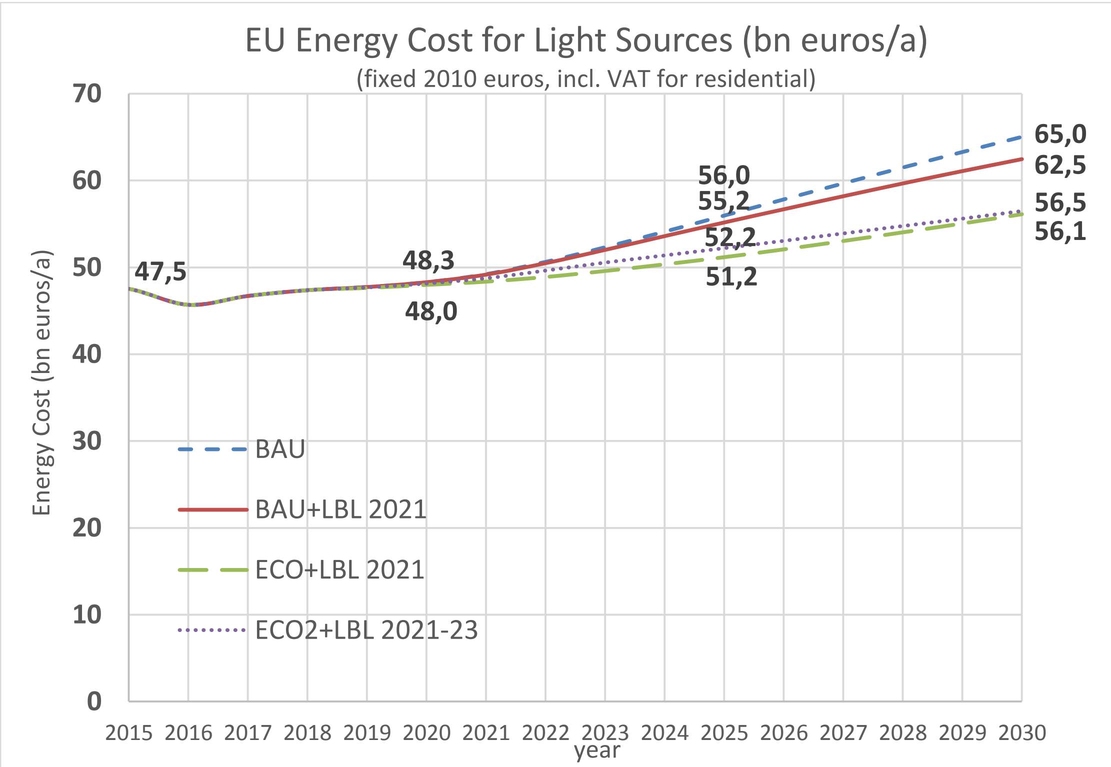


Figure 25 Total EU-28 electricity cost for lighting in bn EUR/a for BAU, ELONLY, ECOEL2021, and ECOEL2TIERS scenarios.

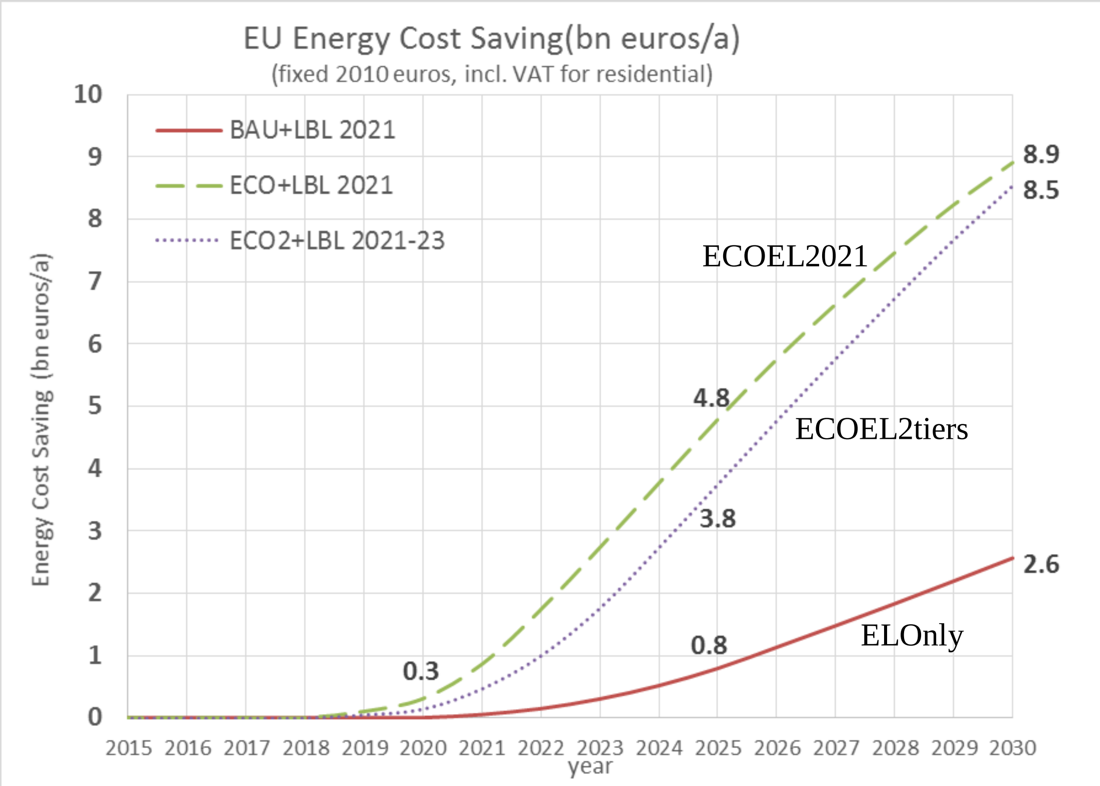


Figure 26 Total EU-28 annual energy cost saving, in bn EUR/a, for ELONLY, ECOEL2021, and ECOEL2TIERS scenarios with respect to BAU

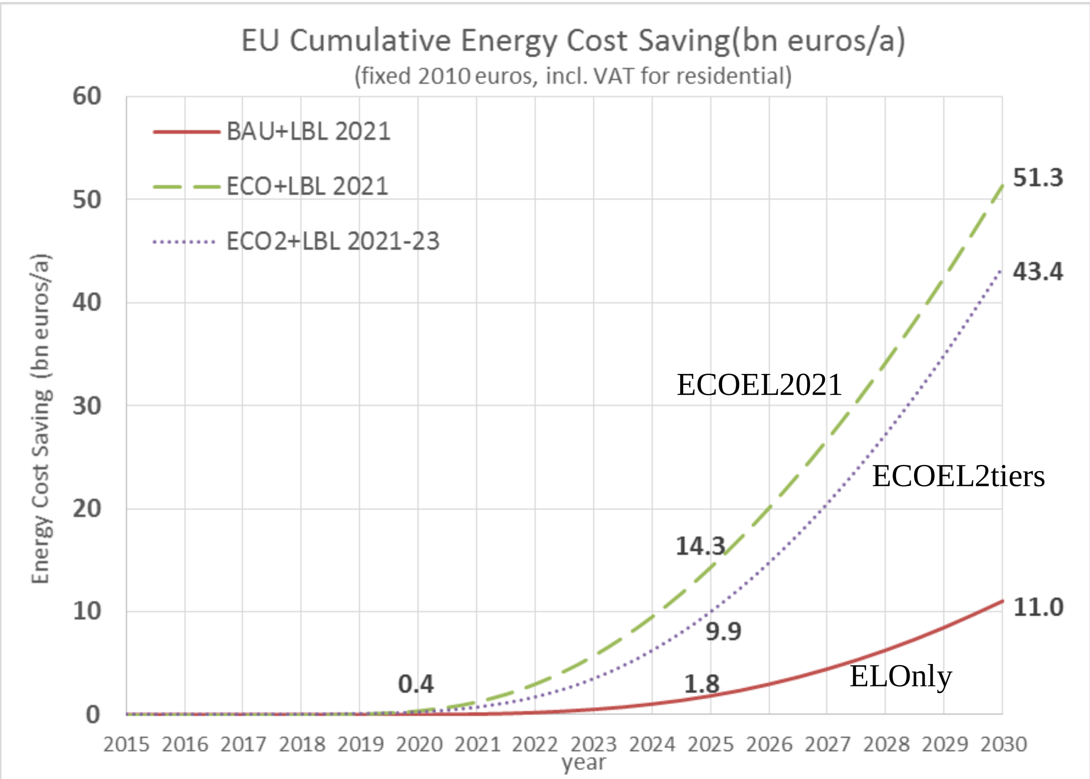


Figure 27 Total EU-28 cumulative energy cost saving, in bn EUR/a, for ELONLY, ECOEL2021, and ECOEL2TIERS scenarios with respect to BAU

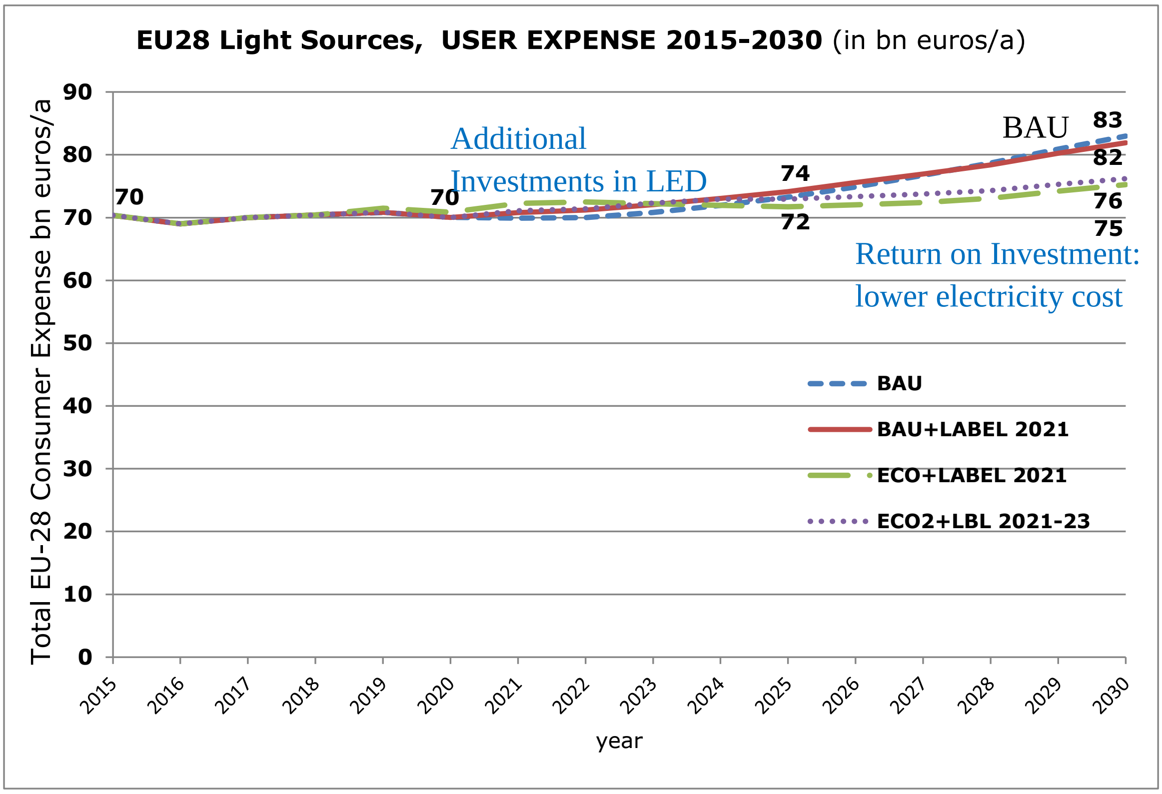


Figure 28 Total EU-28 user expense for lighting in bn EUR/a for BAU, ELONLY, ECOEL2021, and ECOEL2TIERS scenarios.

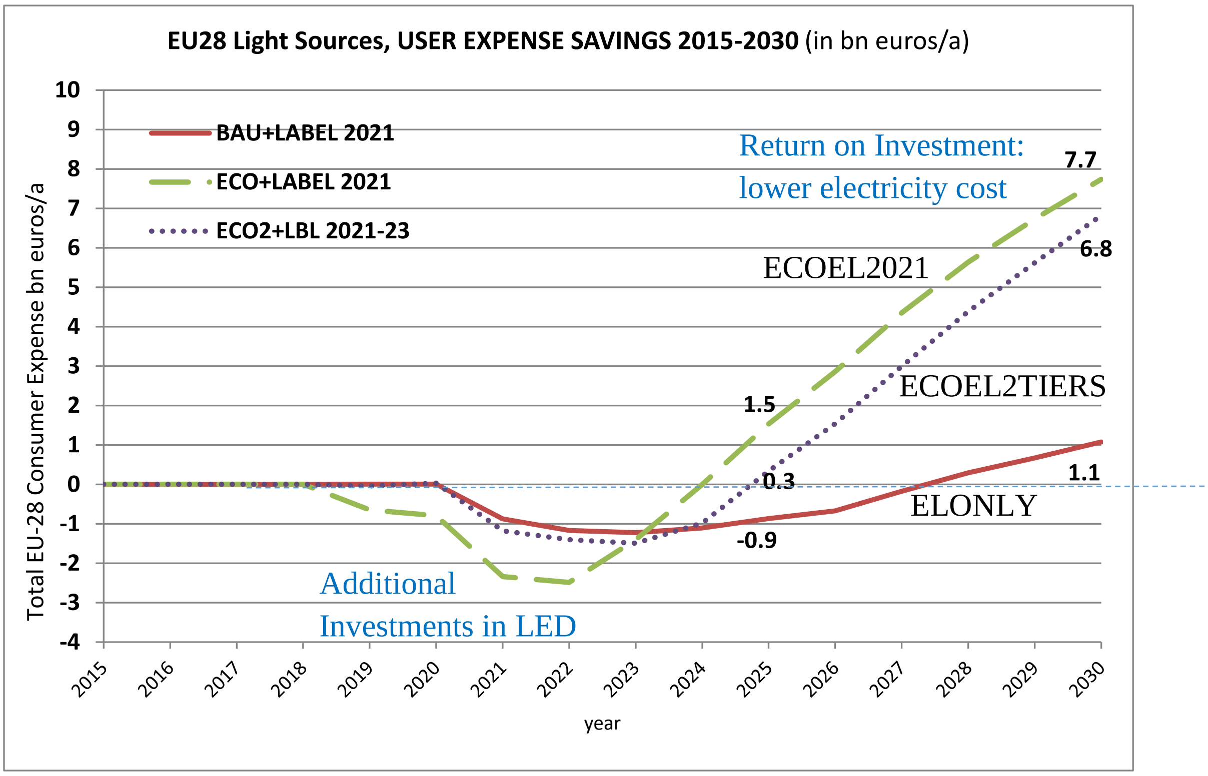
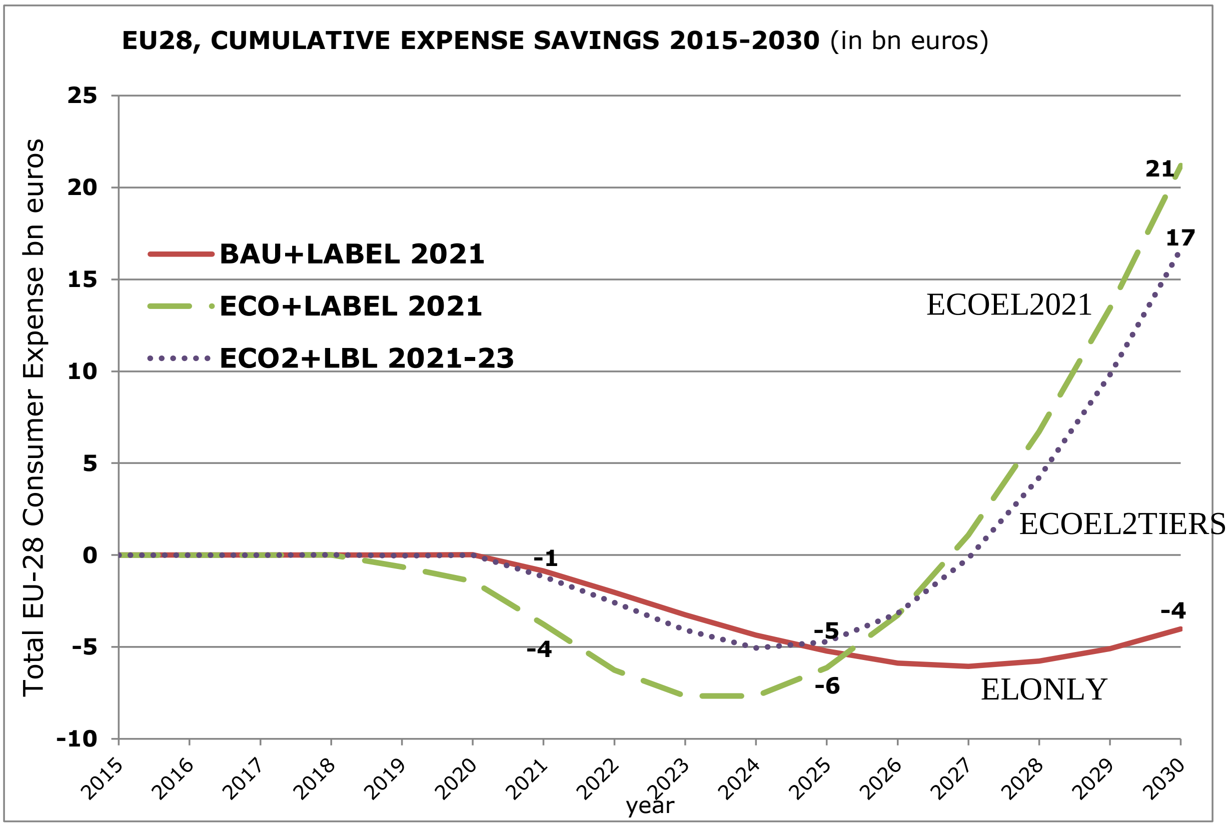


Figure 29 Total EU-28 <u>annual user expense saving</u>, in bn EUR/a, for ELONLY, ECOEL2021, and ECOEL2TIERS scenarios with respect to BAU (negative value is additional expense)



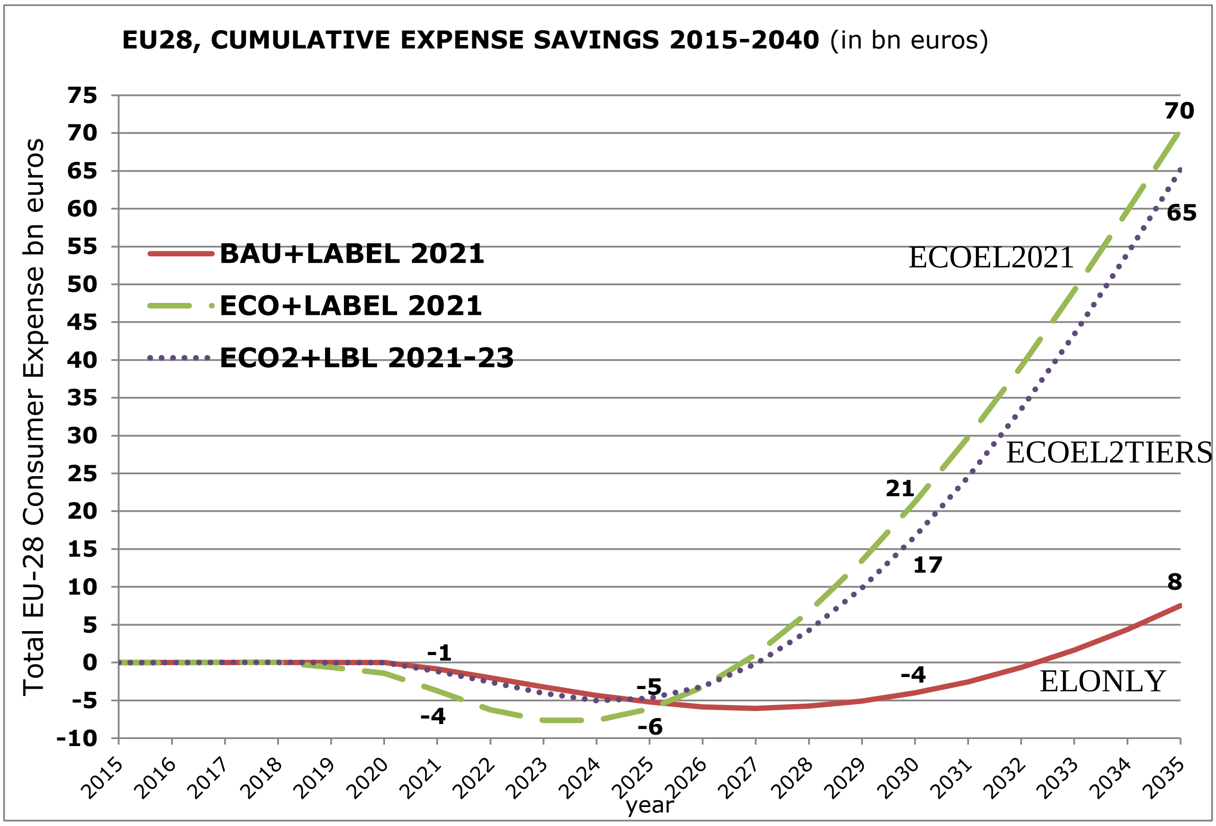


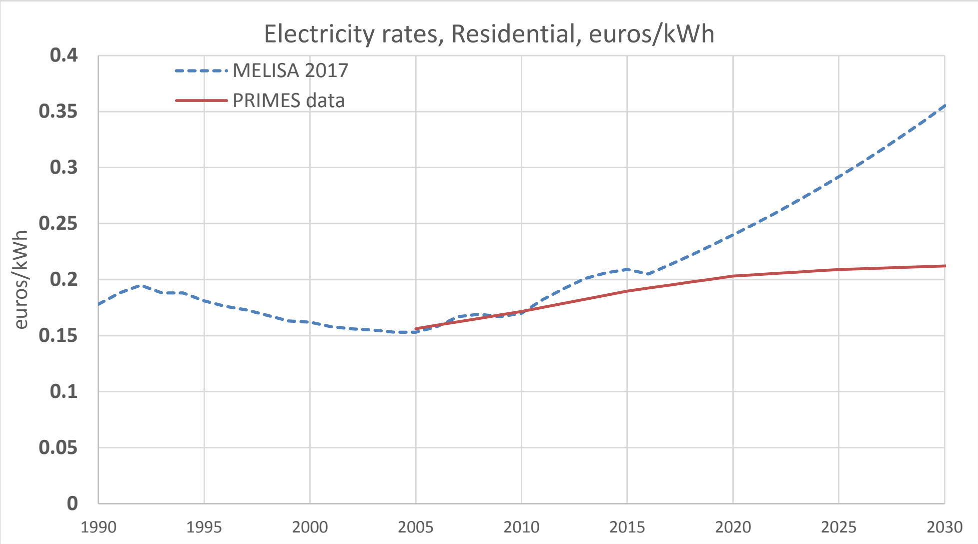
Figure 30 Total EU-28 cumulative user expense saving, in bn EUR, for ELONLY, ECOEL2021, and ECOEL2TIERS scenarios with respect to BAU (negative value is additional expense). Top: period 2015-2030; bottom: period 2015-2040.

9. SENSITIVITY ANALYSIS FOR ELECTRICITY RATES

The monetary results presented in the preceding sections are based on the MEErP electricity rates (EUR/kWh) presented in Section 3.2 of this Annex. These rates follow Eurostat data until 2016 and then apply a 4%/a escalation rate, as suggested in the MEErP.

In the PRIMES model of the Commission, a different projection for electricity rates is used, with a much lower price escalation. The PRIMES model has separate rates for the tertiary sector (higher) and for industry (lower). For application in MELISA, a single electricity rate for non-residential has been defined assuming 80% tertiary sector and 20% industry sector. This leads to a non-residential electricity rate that is higher than the 'MEErP' rate (that is based on industry-only), also in earlier years. The electricity prices derived from PRIMES have been presented in Section 3.2 of this Annex.

Graphs below compare the electricity rates from MEErP and PRIMES.



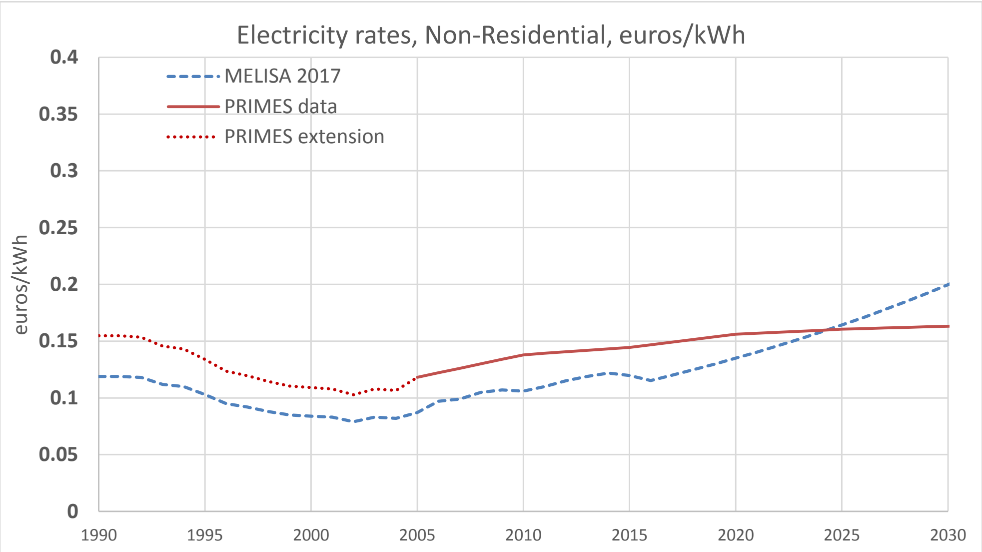


Figure 31 Comparison of electricity rates according to MEErP (Eurostat until 2016, then 4%/a escalation) and according to PRIMES model (EU-28 Reference scenario REF2015f; uses 80% tertiary, 20% industry).

Table 60 Difference in monetary results between using MEErP or PRIMES electricity rates in MELISA. Costs in bn EUR for EU-28 all sectors. Fixed EUR 2010, incl. VAT for residential. Total expenses also include maintenance costs, which are not shown separately. Positive savings indicate additional costs. (see remarks following the table)

BAU MEErP rates	**2015**	**2020**	**2025**	**2030**	**Cumulative 2015-2030**	**BAU PRIMES rates**	**2015**	**2020**	**2025**	**2030**	**Cumulative 2015-2030**
Acquisition cost	17.86	16.14	10.95	10.79	221.90	Acquisition cost	17.86	16.14	10.95	10.79	221.90
Electricity cost	47.52	48.29	55.96	65.03	852.90	Electricity cost	52.22	52.26	51.92	50.45	830.90
Total expense	70.36	70.05	73.26	83.00	1170.90	Total expense	75.06	74.02	69.21	68.42	1148.90
ELONLY MEErP rates	**2015**	**2020**	**2025**	**2030**	**Cumulative 2015-2030**	**ELONLY PRIMES rates**	**2015**	**2020**	**2025**	**2030**	**Cumulative 2015-2030**
Acquisition cost	17.86	16.14	12.61	12.28	236.90	Acquisition cost	17.86	16.14	12.61	12.28	236.90
Electricity cost	47.52	48.29	55.17	62.46	841.80	Electricity cost	52.22	52.26	51.21	48.49	821.80
Total expense	70.36	70.05	74.12	81.92	1174.90	Total expense	75.06	74.01	70.16	67.95	1154.80
ELONLY vs. BAU MEErP rates	***2015***	***2020***	***2025***	***2030***	***Cumulative 2015-2030***	***ELONLY vs. BAU PRIMES rates***	***2015***	***2020***	***2025***	***2030***	***Cumulative 2015-2030***
Acquisition cost saving	***0***	***0***	***1.66***	***1.49***	***15.00***	*Acquisition cost saving*	***0***	***0***	***1.66***	***1.49***	***15.00***
Electricity cost saving	***0***	***0***	***-0.79***	***-2.56***	***-11.10***	*Electricity cost saving*	***0***	***0***	***-0.71***	***-1.96***	***-9.10***
Total expense saving	***0***	***0***	***0.87***	***-1.08***	***4.00***	*Total expense saving*	***0***	***0***	***0.95***	***-0.48***	***5.90***
ECOEL2021 MEErP rates	**2015**	**2020**	**2025**	**2030**	**Cumulative 2015-2030**	**ECOEL2021 PRIMES rates**	**2015**	**2020**	**2025**	**2030**	**Cumulative 2015-2030**
Acquisition cost	17.86	17.25	14.20	11.96	252.00	Acquisition cost	17.86	17.25	14.20	11.96	252.00
Electricity cost	47.52	47.98	51.17	56.12	801.60	Electricity cost	52.22	51.93	47.52	43.45	786.40
Total expense	70.36	70.84	71.72	75.26	1149.70	Total expense	75.06	74.79	68.07	62.59	1134.50
ECOEL2021 vs. BAU MEErP rates	***2015***	***2020***	***2025***	***2030***	***Cumulative 2015-2030***	***ECOEL2021 vs. BAU PRIMES rates***	***2015***	***2020***	***2025***	***2030***	***Cumulative 2015-2030***
Acquisition cost saving	***0***	***1***	***3.25***	***1.17***	***30.10***	*Acquisition cost saving*	***0***	***1***	***3.25***	***1.17***	***30.10***
Electricity cost saving	***0***	***0***	***-4.79***	***-8.91***	***-51.30***	*Electricity cost saving*	***0***	***0***	***-4.40***	***-7.01***	***-44.50***
Total expense saving	***0***	***1***	***-1.53***	***-7.73***	***-21.20***	*Total expense saving*	***0***	***1***	***-1.14***	***-5.84***	***-14.40***
ECOEL2TIERS MEErP rates	**2015**	**2020**	**2025**	**2030**	**Cumulative 2015-2030**	**ECOEL2TIERS PRIMES rates**	**2015**	**2020**	**2025**	**2030**	**Cumulative 2015-2030**
Acquisition cost	17.86	16.26	14.36	12.51	248.70	Acquisition cost	17.86	16.26	14.36	12.51	248.70
Electricity cost	47.52	48.14	52.21	56.49	809.40	Electricity cost	52.22	52.12	48.52	43.74	794.00
Total expense	70.36	70.01	72.92	76.18	1154.20	Total expense	75.06	73.99	69.23	63.43	1138.70
ECOEL2TIERS vs. BAU MEErP rates	***2015***	***2020***	***2025***	***2030***	***Cumulative 2015-2030***	***ECOEL2TIERS vs. BAU PRIMES rates***	***2015***	***2020***	***2025***	***2030***	***Cumulative 2015-2030***
Acquisition cost saving	***0***	***0***	***3.42***	***1.72***	***26.80***	*Acquisition cost saving*	***0***	***0***	***3.42***	***1.72***	***26.80***
Electricity cost saving	***0***	***0***	***-3.75***	***-8.54***	***-43.50***	*Electricity cost saving*	***0***	***0***	***-3.39***	***-6.71***	***-36.90***
Total expense saving	***0***	***0***	***-0.34***	***-6.82***	***-16.70***	*Total expense saving*	***0***	***0***	***0.02***	***-4.99***	***-10.20***

Acquisition costs do not change when considering different electricity rates, so the columns for MEErP rates and for PRIMES rates display the same acquisition costs and associated savings (additional costs).

The electricity costs using PRIMES rates are generally higher in earlier years (2015, 2020) and lower in later years (2025, 2030). In earlier years this is due to the non-residential rate being higher for PRIMES. In later years this is due to the much smaller price escalation in PRIMES, both for residential and for non-residential rates. See the graphs at the start of this section for reference.

For all scenarios, the total expense savings with respect to the BAU-scenario are smaller when using PRIMES electricity rates, but the differences do not change overall trends. The classification of the scenario options according to their monetary savings does not change when using PRIMES electricity rates instead of MEErP electricity rates.