# Preparatory study on lighting systems 'Lot 37'

# Annexes

*Specific contract N° ENER/C3/2012-418 Lot 1/06/SI2.668525*
*Implementing framework contract ENER/C3/2012-418 Lot 1*

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# ANNEX A ADDITIONAL, UNLIMITED LIST OF STANDARDS RELATED TO THE STUDY

## Standards about radiation, EMC and similar

EN 14255-1: Measurement and assessment of personal exposures to incoherent optical radiation Ultraviolet radiation emitted by artificial sources in the workplace

EN 14255-2: Measurement and assessment of personal exposures to incoherent optical radiation Visible and infrared radiation emitted by artificial sources in the workplace

EN 14255-4: Measurement and assessment of personal exposures to incoherent optical radiation Terminology and quantities used in UV-, visible and IR-exposure measurements

EN 55015: Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment

EN 61000-3-2: Electromagnetic compatibility (EMC) Limits. Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)

EN 61000-3-3: Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current <= 16 A per phase and not subject to conditional connection

EN 61000-4-1: Electromagnetic compatibility (EMC) - Part 4-1: Testing and measurement techniques - Overview of EN 61000-4 series

EN 61000-4-15: Electromagnetic compatibility (EMC) - Part 4-15: Testing and measurement techniques - Flickermeter - Functional and design specifications

EN 61547: Equipment for general lighting purposes - EMC immunity requirements

## Standards about lighting

EN 16276: Evacuation Lighting in Road Tunnels

EN 50512: Electrical installations for lighting and beaconing of aerodromes - Advanced Visual Docking Guidance Systems (A-VDGS)

## Standards related to control systems

EN 62386-101: Digital addressable lighting interface. General requirements. System

EN 62386-102: Digital addressable lighting interface. General requirements. Control gear.

EN 62386-103: Digital addressable lighting interface. Part 103. General requirements. Control devices.

EN 62386-201: Digital addressable lighting interface. Particular requirements for control gear. Fluorescent lamps (device type 0).

EN 62386-202: Digital addressable lighting interface. Particular requirements for control gear. Self-contained emergency lighting (device type 1).

EN 62386-203: Digital addressable lighting interface Particular requirements for control gear. Discharge lamps (excluding fluorescent lamps) (device type 2).

EN 62386-204: Digital addressable lighting interface Particular requirements for control gear. Low voltage halogen lamps (device type 3).

EN 62386-205: Digital addressable lighting interface Particular requirements for control gear. Supply voltage controller for incandescent lamps (device type 4).

EN 62386-206: Digital addressable lighting interface Particular requirements for control gear. Conversion from digital signal into d.c. voltage (device type 5).

EN 62386-207: Digital addressable lighting interface Particular requirements for control gear. LED modules (device type 6).

EN 62386-208: Digital addressable lighting interface. Particular requirements for control gear. Switching function (device type 7).

EN 62386-209: Digital addressable lighting interface. Particular requirements for control gear. Colour control (device type 8).

EN 62386-210: Digital addressable lighting interface Particular requirements for control gear. Sequencer (device type 9).

EN 50428: Switches for household and similar fixed electrical installations - Collateral standard - Switches and related accessories for use in home and building electronic systems (HBES)

EN 60669-1: Switches for household and similar fixed-electrical installations - Part 1: General requirements

EN 60669-2-1: Switches for household and similar fixed electrical installations - Part 2-1: Particular requirements - Electronic switches

EN 60669-2-2: Switches for household and similar fixed electrical installations Particular requirements. Electromagnetic remote-control switches (RCS)

EN 60669-2-3: Switches for household and similar fixed electrical installations. Particular requirements Time-delay switches (TDS)

EN 60669-2-4: Switches for household and similar fixed electrical installations - Part 2-4: Particular requirements - Isolating switches

EN 60669-2-5: Switches for household and similar fixed electrical installations - Part 2-5: Particular requirements - Switches and related accessories for use in home and building electronic systems (HBES)

## Standards about luminaires

EN 60598-1: Luminaires - Part 1: General requirements and tests

EN 60598-2-1: Luminaires - Part 2-1: Particular requirements - Fixed general purpose luminaires

EN 60598-2-2: Luminaires - Part 2-2: Particular requirements - Recessed luminaires

EN 60598-2-3: Luminaires - Part 2-3: Particular requirements - Luminaires for road and street lighting

EN 60598-2-4: Luminaires - Part 2-4: Particular requirements - Portable general purpose luminaires

EN 60598-2-5: Luminaires - Part 2-5: Particular requirements – Floodlights.

EN 60598-2-6: Luminaires - Part 2-6: Particular requirements - Luminaires with built-in transformers or convertors for filament lamps

EN 60598-2-7: Luminaires. Particular requirements. Portable luminaires for garden use.

EN 60598-2-8: Luminaires - Part 2-8: Particular requirements – Hand lamps

EN 60598-2-10: Luminaires - Part 2-10: Particular requirements - Portable luminaires for children

EN 60598-2-11: Luminaires - Part 2-11: Particular requirements - Aquarium luminaires

EN 60598-2-13: Luminaires - Part 2-13: Particular requirements - Ground recessed luminaires

EN 60598-2-18: Luminaires - Part 2-18: Particular requirements - Luminaires for swimming pools and similar applications

EN 60598-2-19: Luminaires - Part 2: Particular requirements - Air-handling luminaires (safety requirements)

EN 60598-2-20: Luminaires - Part 2-20: Particular requirements - Lighting chains

EN 60598-2-22: Luminaires - Part 2-22: Particular requirements - Luminaires for emergency lighting

EN 60598-2-23: Luminaires. Particular requirements - Extra low voltage lighting systems for filament lamps

EN 60598-2-24: Luminaires - Part 2-24: Particular requirements - Luminaires with limited surface temperatures

EN 60598-2-25: Luminaires. Part 2-25: Particular requirements. Luminaires for use in clinical areas of hospitals and health care buildings.

IEC 62717: LED MODULES FOR GENERAL LIGHTING Performance requirements

CIE DIS 024/E: 2015: Light Emitting Diodes (LEDs) and LED Assemblies – Terms and Definitions

## Standards about lamps

EN 61231: International lamp coding system (ILCOS)

EN 60357: Tungsten halogen lamps (non-vehicle) - Performance specifications

EN 60432-2: Incandescent lamps - Safety specifications - Part 2: Tungsten halogen lamps for domestic and similar general lighting purposes.

EN 60432-3: Incandescent lamps - Safety specifications - Part 3: Tungsten-halogen lamps (non-vehicle)

EN 60630: Maximum lamp outlines for incandescent lamps

EN 60662: High-pressure sodium vapour lamps. Performance specifications

EN 60968: Self-ballasted lamps for general lighting services - Safety requirements

EN 61195: Double-capped fluorescent lamps. Safety specifications

EN 61199: Single-capped fluorescent lamps - Safety specifications

EN 61341: Method of measurement of centre beam intensity and beam angle(s) of reflector lamps

EN 61549: Miscellaneous lamps

EN 62035: Discharge lamps (excluding fluorescent lamps) - Safety specifications

EN 62532: Fluorescent induction lamps - Safety specifications

EN 62639: Fluorescent induction lamps - Performance specification

## Standards about lamp control gear

EN 60923: Auxiliaries for lamps - Ballasts for discharge lamps (excluding tubular fluorescent lamps) - Performance requirements

EN 60927: Auxiliaries for lamps - Starting devices (other than glow starters) - Performance requirements

EN 60929: AC and/or DC-supplied electronic control gear for tubular fluorescent lamps. Performance requirements

EN 62442-1: Energy performance of lamp control-gear - Part 1: Control-gear for fluorescent lamps - Method of measurement to determine the total input power of control-gear circuits and the efficiency of the control-gear

EN 60155: Glow-starters for fluorescent lamps

EN 61048: Auxiliaries for lamps - Capacitors for use in tubular fluorescent and other discharge lamp circuits - General and safety requirements

EN 61347-1: Lamp control-gear - Part 1: General and safety requirements

EN 61347-2-1: Lamp control-gear - Part 2-1: Particular requirements for starting devices (other than glow starters)

EN 61347-2-2: Lamp control-gear - Part 2-2: Particular requirements for DC or AC supplied electronic step-down convertors for filament lamps

EN 61347-2-3: Lamp control-gear - Part 2-3: Particular requirements for AC and/or Dc supplied electronic control gear for fluorescent lamps

EN 61347-2-4: Lamp control-gear - Part 2-4: Particular requirements for DC supplied electronic ballasts for general lighting

EN 61347-2-8: Lamp control-gear - Part 2-8: Particular requirements for ballasts for fluorescent lamps

EN 61347-2-9: Lamp control-gear – Part 2-9: Particular requirements for electromagnetic control-gear for discharge lamps (excluding fluorescent lamps)

EN 61347-2-11: Lamp control-gear. - Part 2-11: Particular requirements for miscellaneous electronic circuits used with luminaires.

EN 61347-2-12: Lamp control-gear - Part 2-12: Particular requirements for DC or AC supplied electronic ballasts for discharge lamps (excluding fluorescent lamps)

## Standards about lamp caps and holders

EN 60061-1: Lamp caps and holders together with gauges for the control of interchangeability and safety - Part 1: Lamp caps

EN 60061-2: Lamp caps and holders together with gauges for the control of interchangeability and safety - Part 2: Lamp-holders

EN 60061-3: Lamp caps and holders together with gauges for the control of interchangeability and safety - Part 3: Gauges

EN 60061-4: Lamp caps and holders together with gauges for the control of interchangeability and safety - Part 4: Guidelines and general information

EN 60238: Edison screw lamp-holders

EN 60360: Standard method of measurement of lamp cap temperature rise

EN 60838-1: Miscellaneous lamp-holders - Part 1: General requirements and tests

EN 60838-2-1: Miscellaneous lamp-holders - Part 2-1: Particular requirements – Lamp-holders S14

EN 60838-2-2: Miscellaneous lamp-holders - Part 2-2: Particular requirements - Connectors for LED-modules

## Standards related to LED

EN 62560: Self-ballasted LED-lamps for general lighting services by voltage > 50 V - Safety specifications

EN 62612: Self-ballasted LED lamps for general lighting services with supply voltages > 50 V - Performance requirements

EN 62031: LED modules for general lighting - Safety specifications

EN 61347-2-13: Lamp control-gear - Part 2-13: Particular requirements for DC or AC supplied electronic control-gear for LED modules

EN 62384: DC or AC supplied electronic control gear for LED modules. Performance requirements

## Important standards in development

Project EN 62504: General lighting - Light emitting diode (LED) products and related equipment - Terms and definitions

Project EN 60838-2-3: Miscellaneous lamp-holders - Part 2-3: Particular requirements – Lamp-holders for double-capped linear LED lamps

Project EN 62442-2: Energy performance of lamp control-gear - Part 2: Control-gear for high intensity discharge lamps (excluding fluorescent lamps) - Method of measurement to determine the efficiency of control-gear

Project EN 62442-3: Energy performance of lamp control-gear - Part 3: Control-gear for halogen lamps and LED modules - Method of measurement to determine the efficiency of the control-gear

Project EN 62722-1: Luminaire performance - Part 1: General Requirements

Project EN 62722-2-1: Luminaire performance - Part 2-1: Particular requirements for LED luminaires

# ANNEX B MEERP GUIDELINE TASK 2 MARKETS

**TASK 2 MARKETS**

**2.1 Generic economic data**

Identify and report
a. EU Production;
b. Extra-EU Trade;
c. Intra-EU Trade;
d. EU sales and trade= production + import - export.

Data should relate to the latest full year for which at least half of the Member States have reported to Eurostat. Preferably data should be in physical volume (e.g. units) and in money units and split up per Member State.

Information for this subtask should be derived from official EU statistics so as to be coherent with official data used in EU industry and trade policy.

**2.2 Market and stock data**

In physical units, for EU-27, for each of the categories as defined in 1.1 and for reference years
a. 1990 (Kyoto and "20-20-20" reference);
b. 2010 (or most recent real data);
c. 2013-2016 (forecast, presumable entry into force of measures);
d. 2020-2030-2050 (forecast, years in which all new ecodesigns of today will be absorbed by the market).

the following parameters are to be identified:
a. Installed base (“stock”) and penetration rate;
b. Annual sales growth rate (% or physical units);
c. Average Product Life (in years), in service, and a rough indication of the spread (e.g. standard deviation);
d. Total sales/ real EU-consumption, (also in €, when available);
e. Replacement sales (derived);
f. New sales (derived).

**2.3 Market trends**

2.3.1. General market trends (growth/ decline, if applicable per segment), trends in product-design and product-features.

2.3.2 Market channels and production structure; identification of the major players (associations, large companies, share SMEs, employment);

2.3.3 Trends in product design/ features, illustrated by recent consumer association tests (valuable, but not necessarily fully representative of the diversity of products put on the market);

**2.4 Consumer expenditure base data**

For each of the categories defined in subtask 1.1, determine:
a. Average EU consumer prices, incl. VAT (for consumer prices; streetprice)/ excl. VAT (for B2B products), in Euro.
b. Consumer prices of consumables (detergent, toner, paper, etc.) (€/kg or €/piece);
c. Repair and Maintenance costs (€/product life);
d. Installation costs (for installed appliances only);
e. Disposal tariffs/ taxes (€/product);

For electricity, fossil fuel, water, interest, inflation and discount rates use values for Jan. 2011 in MEErP Chapter 2, including the average annual price increases mentioned there .

For regional differentiation of consumer prices (for sensitivity analysis) also see Chapter 2

### 2.5 Recommendations

Make recommendations on

2.5.1 refined product scope from the economical/ commercial perspective (e.g. exclude niche markets)

2.5.2 barriers and opportunities for Ecodesign from the economical/ commercial perspective

# ANNEX C SALES OF LIGHT SOURCES

The data in this annex have been taken from the MELISA model (see par. **Error! Reference source not found.** of main text) that was used for the scenario analyses in Task 7 of the Light Sources study [1]. The data provided here are not presented in the Light Sources reports but could be useful as reference for the Lighting Systems study.

## Sales and Stock in LFL application group

*Table 0-1 Sales data in mln units per year for lamp types of the LFL-application group. Per base case, for all sectors, residential and non-residential*

| | LFL - EU-28 SALES mln units TOTAL, All Sectors | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| LFL | T12 | 80 | 6 | 0 | 0 | 0 | 0 |
| | T8 Halophosphor | 95 | 68 | 0 | 0 | 0 | 0 |
| | T8 tri-phosphor | 71 | 216 | 204 | 197 | 146 | 78 |
| | T5 new (14 - 80w) including Circular | 0 | 68 | 67 | 78 | 49 | 36 |
| | T5 old (4 - 13W), Special FL, Others | 23 | 32 | 21 | 21 | 14 | 6 |
| | **LFL (total)** | **269** | **390** | **292** | **296** | **209** | **120** |
| LED | LED retrofit for LFL replacement | 0 | 0 | 9 | 36 | 72 | 88 |
| | LED luminaire for LFL replacement | 0 | 0 | 4 | 30 | 108 | 206 |
| | **LED for LFL (total)** | **0** | **0** | **13** | **66** | **180** | **294** |

| | LFL - EU-28 SALES mln units RESIDENTIAL | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| LFL | T12 | 5 | 0 | 0 | 0 | 0 | 0 |
| | T8 Halophosphor | 6 | 4 | 0 | 0 | 0 | 0 |
| | T8 tri-phosphor | 5 | 14 | 17 | 13 | 7 | 7 |
| | T5 new (14 - 80w) including Circular | 0 | 4 | 4 | 0 | 0 | 0 |
| | T5 old (4 - 13W), Special FL, Others | 1 | 2 | 1 | 2 | 1 | 1 |
| | **LFL (total)** | **17** | **25** | **22** | **15** | **8** | **8** |
| LED | LED retrofit for LFL replacement | 0 | 0 | 1 | 3 | 2 | 3 |
| | LED luminaire for LFL replacement | 0 | 0 | 1 | 2 | 4 | 10 |
| | **LED for LFL (total)** | **0** | **0** | **2** | **4** | **6** | **13** |

| | LFL - EU-28 SALES mln units NON-RESIDENTIAL | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| LFL | T12 | 75 | 6 | 0 | 0 | 0 | 0 |
| | T8 Halophosphor | 89 | 63 | 0 | 0 | 0 | 0 |
| | T8 tri-phosphor | 67 | 203 | 187 | 184 | 140 | 70 |
| | T5 new (14 - 80w) including Circular | 0 | 64 | 63 | 77 | 48 | 36 |
| | T5 old (4 - 13W), Special FL, Others | 21 | 30 | 19 | 20 | 13 | 6 |
| | **LFL (total)** | **252** | **365** | **270** | **281** | **201** | **111** |
| LED | LED retrofit for LFL replacement | 0 | 0 | 8 | 33 | 70 | 86 |
| | LED luminaire for LFL replacement | 0 | 0 | 3 | 28 | 104 | 196 |
| | **LED for LFL (total)** | **0** | **0** | **11** | **62** | **174** | **281** |

[1] http://ecodesign-lightsources.eu/documents

*Table 0-2 Stock data in mln units for lamp types of the LFL-application group. Per base case, for all sectors, residential and non-residential*

| LFL - EU-28 STOCK mln units TOTAL, All Sectors | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| LFL | T12 | 318 | 41 | 8 | 1 | 0 | 0 |
| | T8 Halophosphor | 367 | 498 | 64 | 9 | 0 | 0 |
| | T8 tri-phosphor | 431 | 1002 | 1473 | 1454 | 1216 | 797 |
| | T5 new (14 - 80w) including Circular | 0 | 295 | 595 | 696 | 659 | 502 |
| | T5 old (4 - 13W), Special FL, Others | 119 | 203 | 135 | 120 | 98 | 60 |
| | **LFL (total)** | **1235** | **2040** | **2274** | **2281** | **1973** | **1359** |
| LED | LED retrofit for LFL replacement | 0 | 0 | 17 | 162 | 416 | 683 |
| | LED luminaire for LFL replacement | 0 | 0 | 7 | 110 | 466 | 1157 |
| | **LED for LFL (total)** | **0** | **0** | **24** | **272** | **882** | **1840** |

| LFL - EU-28 STOCK mln units RESIDENTIAL | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| LFL | T12 | 59 | 12 | 5 | 1 | 0 | 0 |
| | T8 Halophosphor | 59 | 109 | 59 | 9 | 0 | 0 |
| | T8 tri-phosphor | 66 | 135 | 191 | 236 | 239 | 210 |
| | T5 new (14 - 80w) including Circular | 0 | 19 | 42 | 50 | 52 | 53 |
| | T5 old (4 - 13W), Special FL, Others | 18 | 35 | 33 | 27 | 23 | 20 |
| | **LFL (total)** | **202** | **310** | **330** | **325** | **314** | **283** |
| LED | LED retrofit for LFL replacement | 0 | 0 | 4 | 15 | 26 | 38 |
| | LED luminaire for LFL replacement | 0 | 0 | 2 | 8 | 21 | 55 |
| | **LED for LFL (total)** | **0** | **0** | **6** | **23** | **47** | **94** |

| LFL - EU-28 STOCK mln units NON-RESIDENTIAL | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| LFL | T12 | 260 | 29 | 3 | 0 | 0 | 0 |
| | T8 Halophosphor | 308 | 389 | 4 | 0 | 0 | 0 |
| | T8 tri-phosphor | 365 | 867 | 1282 | 1218 | 977 | 587 |
| | T5 new (14 - 80w) including Circular | 0 | 276 | 553 | 645 | 607 | 449 |
| | T5 old (4 - 13W), Special FL, Others | 100 | 168 | 102 | 93 | 75 | 40 |
| | **LFL (total)** | **1033** | **1730** | **1944** | **1956** | **1659** | **1076** |
| LED | LED retrofit for LFL replacement | 0 | 0 | 13 | 147 | 390 | 644 |
| | LED luminaire for LFL replacement | 0 | 0 | 5 | 101 | 445 | 1102 |
| | **LED for LFL (total)** | **0** | **0** | **19** | **248** | **835** | **1746** |

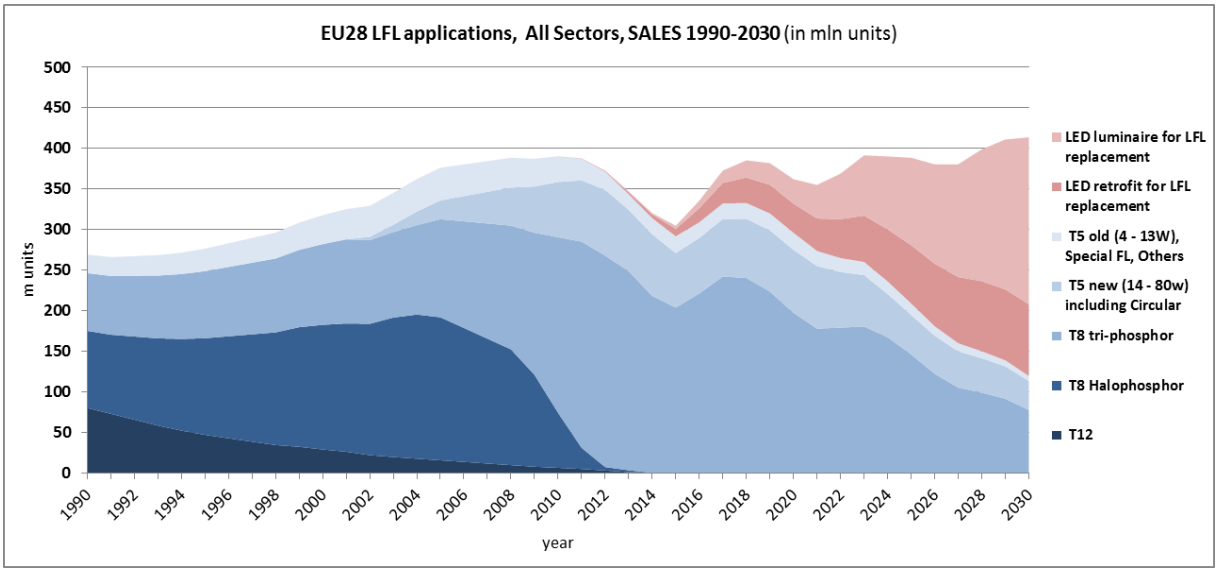



*Figure 0-1 Sales data in mln units per year for lamp types of the LFL-application group. Data are for all sectors (residential and non-residential), but around 92% of sales is in the non-residential sector.*

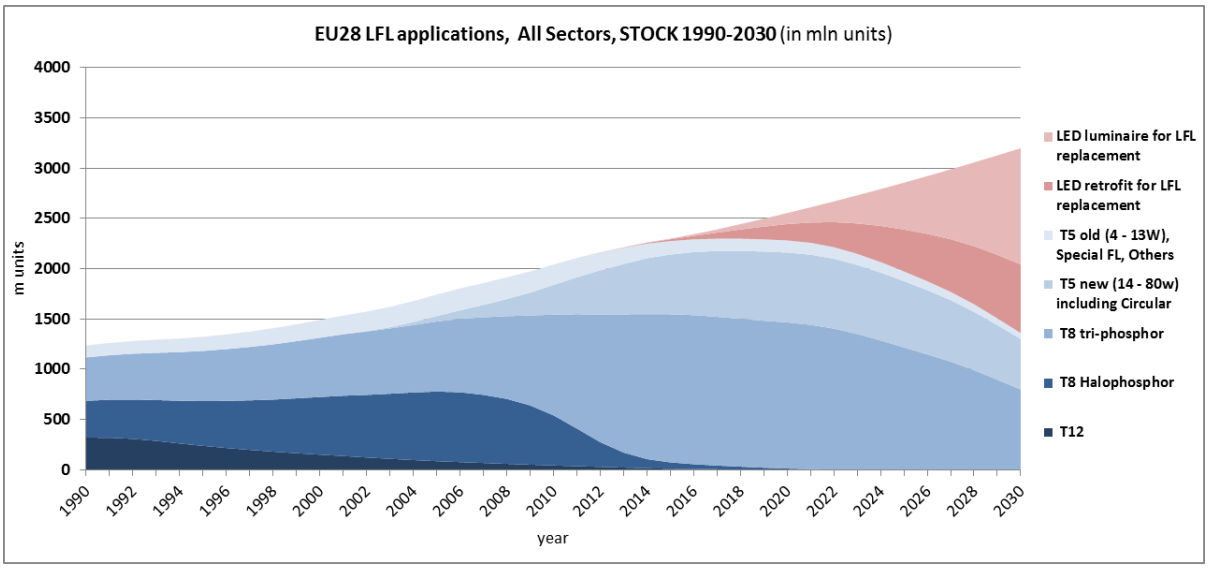



*Figure 0-2 Stock data in mln units for lamp types of the LFL-application group. Data are for all sectors (residential and non-residential), but around 85% of stock is in the non-residential sector.*

## Sales and Stock in HID application group

*Table 0-3 Sales data in mln units per year for lamp types of the HID-application group. Per base case, for all sectors = non-residential sector (no residential sales)*

| HID - EU-28 SALES mln units<br>TOTAL, All Sectors= Non-Residential | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| HID | HPM | 8 | 5 | 2 | 0 | 0 | 0 |
| | HPS | 7 | 15 | 13 | 10 | 5 | 2 |
| | MH | 2 | 21 | 20 | 15 | 6 | 1 |
| | **HID (total)** | **17** | **41** | **35** | **25** | **11** | **3** |
| LED | LED retrofit for HID replacement | 0 | 0 | 1 | 3 | 5 | 6 |
| | LED luminaire for HID replacement | 0 | 0 | 6 | 12 | 20 | 26 |
| | **LED for HID (total)** | **0** | **0** | **7** | **15** | **25** | **32** |

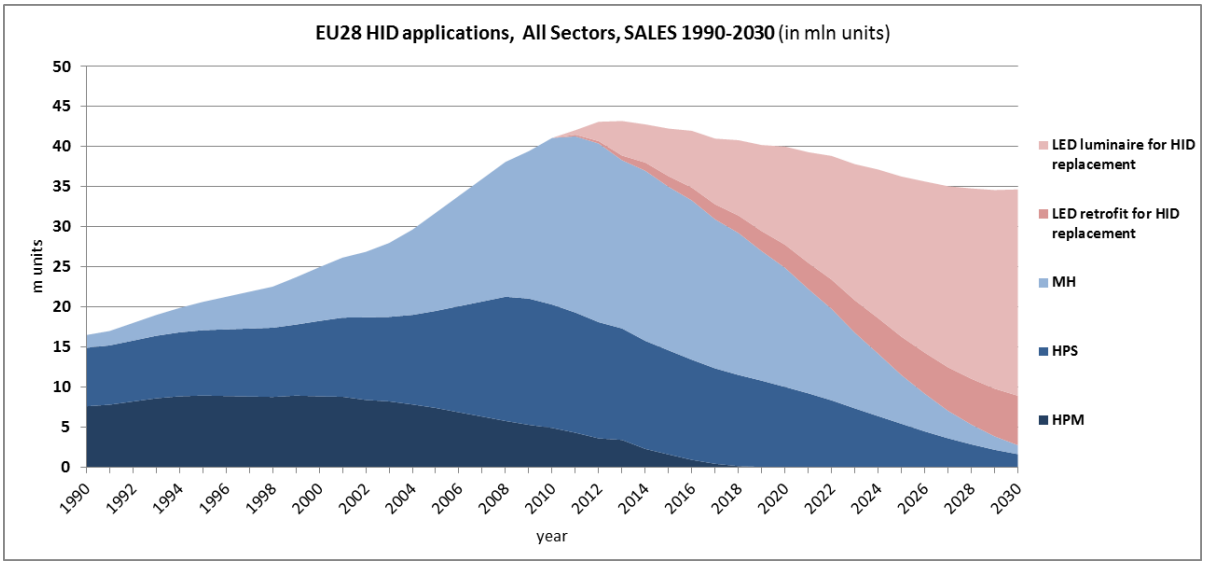



*Figure 0-3 Sales data in mln units for lamp types of the HID-application group. Per base case, for all sectors = non-residential sector (no residential sales)*

*Table 0-4 Stock data in mln units for lamp types of the HID-application group. Per base case, for all sectors = non-residential sector (no residential stock)*

| HID - EU-28 STOCK mln units TOTAL, All Sectors= Non-Residential | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| HID | HPM | 15 | 10 | 4 | 0 | 0 | 0 |
| | HPS | 22 | 47 | 41 | 32 | 19 | 6 |
| | MH | 3 | 39 | 42 | 31 | 14 | 2 |
| | **HID (total)** | **40** | **96** | **87** | **64** | **33** | **9** |
| LED | LED retrofit for HID replacement | 0 | 0 | 4 | 11 | 20 | 29 |
| | LED luminaire for HID replacement | 0 | 0 | 17 | 47 | 85 | 119 |
| | **LED for HID (total)** | **0** | **0** | **21** | **58** | **105** | **147** |

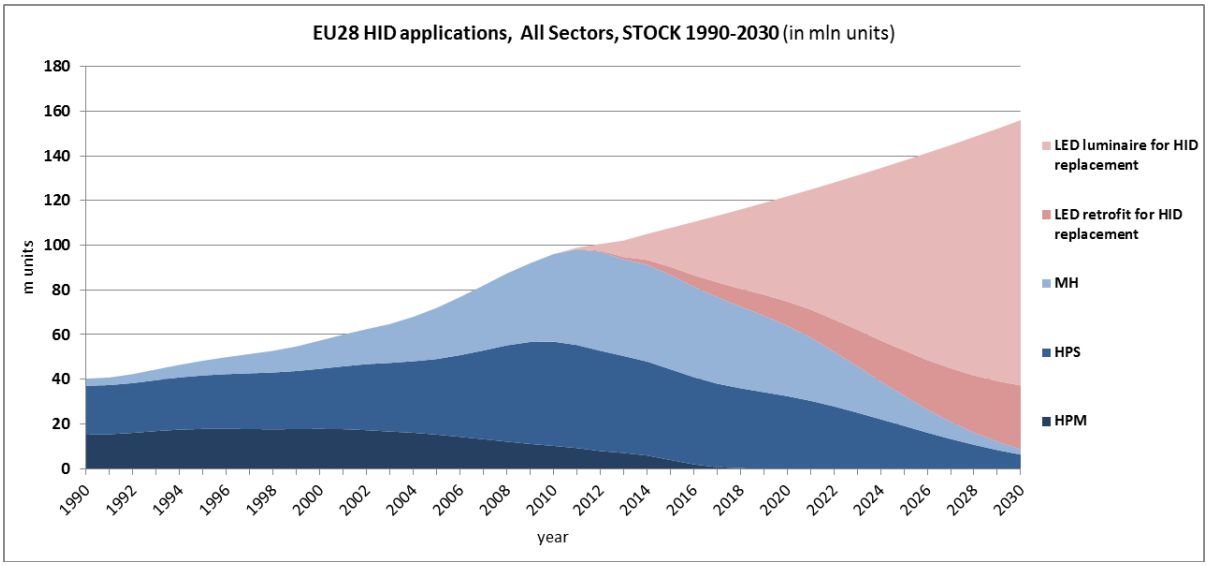



*Figure 0-4 Stock data in mln units for lamp types of the HID-application group. Per base case, for all sectors = non-residential sector (no residential stock)*

## Sales and Stock in CFLni application group

*Table 0-5 Sales data in mln units per year for lamp types of the CFLni-application group. Per base case, for all sectors, residential and non-residential*

| CFLni - EU-28 SALES mln units TOTAL, All Sectors | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| CFLni | CFLni | 23 | 87 | 66 | 47 | 29 | 8 |
| | | | | | | | |
| | **CFLni (total)** | **23** | **87** | **66** | **47** | **29** | **8** |
| LED | LED retrofit for CFLni replacement | 0 | 0 | 2 | 7 | 10 | 12 |
| | LED luminaire for CFLni replacement | 0 | 0 | 9 | 27 | 39 | 49 |
| | **LED for CFLni (total)** | **0** | **0** | **12** | **34** | **49** | **62** |

| CFLni - EU-28 SALES mln units RESIDENTIAL | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| CFLni | CFLni | 7 | 26 | 16 | 13 | 11 | 3 |
| | | | | | | | |
| | **CFLni (total)** | **7** | **26** | **16** | **13** | **11** | **3** |
| LED | LED retrofit for CFLni replacement | 0 | 0 | 1 | 2 | 3 | 3 |
| | LED luminaire for CFLni replacement | 0 | 0 | 2 | 7 | 14 | 12 |
| | **LED for CFLni (total)** | **0** | **0** | **3** | **9** | **17** | **15** |

| CFLni - EU-28 SALES mln units NON-RESIDENTIAL | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| CFLni | CFLni | 16 | 61 | 49 | 34 | 18 | 5 |
| | | | | | | | |
| | **CFLni (total)** | **16** | **61** | **49** | **34** | **18** | **5** |
| LED | LED retrofit for CFLni replacement | 0 | 0 | 2 | 5 | 6 | 9 |
| | LED luminaire for CFLni replacement | 0 | 0 | 7 | 20 | 26 | 37 |
| | **LED for CFLni (total)** | **0** | **0** | **9** | **25** | **32** | **47** |

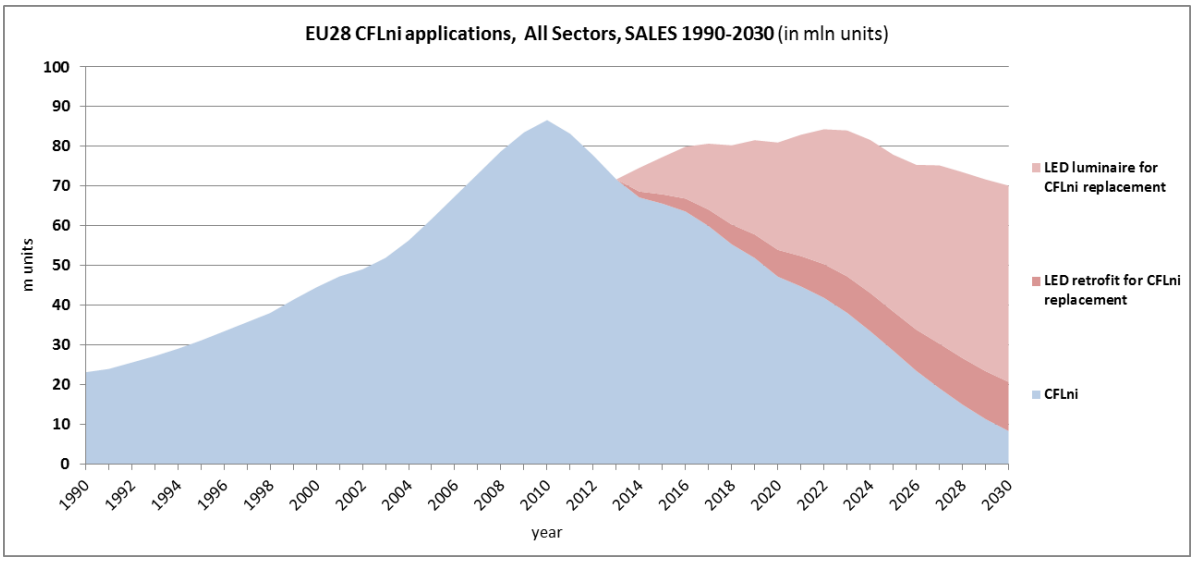



*Figure 0-5 Sales data in mln units per year for lamp types of the CFLni-application group. Per base case, for all sectors (residential + non-residential)*

*Table 0-6 Stock data in mln units for lamp types of the CFLni-application group. Per base case, for all sectors, residential and non-residential*

| CFLni - EU-28 STOCK mln units TOTAL, All Sectors | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| CFLni | CFLni | 128 | 575 | 630 | 549 | 389 | 223 |
| | | | | | | | |
| | **CFLni (total)** | **128** | **575** | **630** | **549** | **389** | **223** |
| LED | LED retrofit for CFLni replacement | 0 | 0 | 4 | 29 | 74 | 121 |
| | LED luminaire for CFLni replacement | 0 | 0 | 15 | 116 | 295 | 484 |
| | **LED for CFLni (total)** | **0** | **0** | **19** | **145** | **369** | **605** |

| CFLni - EU-28 STOCK mln units RESIDENTIAL | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| CFLni | CFLni | 50 | 248 | 291 | 277 | 219 | 152 |
| | | | | | | | |
| | **CFLni (total)** | **50** | **248** | **291** | **277** | **219** | **152** |
| LED | LED retrofit for CFLni replacement | 0 | 0 | 1 | 7 | 22 | 38 |
| | LED luminaire for CFLni replacement | 0 | 0 | 4 | 29 | 86 | 151 |
| | **LED for CFLni (total)** | **0** | **0** | **5** | **36** | **108** | **189** |

| CFLni - EU-28 STOCK mln units NON-RESIDENTIAL | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| CFLni | CFLni | 78 | 328 | 339 | 272 | 169 | 71 |
| | | | | | | | |
| | **CFLni (total)** | **78** | **328** | **339** | **272** | **169** | **71** |
| LED | LED retrofit for CFLni replacement | 0 | 0 | 3 | 22 | 52 | 83 |
| | LED luminaire for CFLni replacement | 0 | 0 | 11 | 87 | 209 | 333 |
| | **LED for CFLni (total)** | **0** | **0** | **14** | **108** | **261** | **417** |

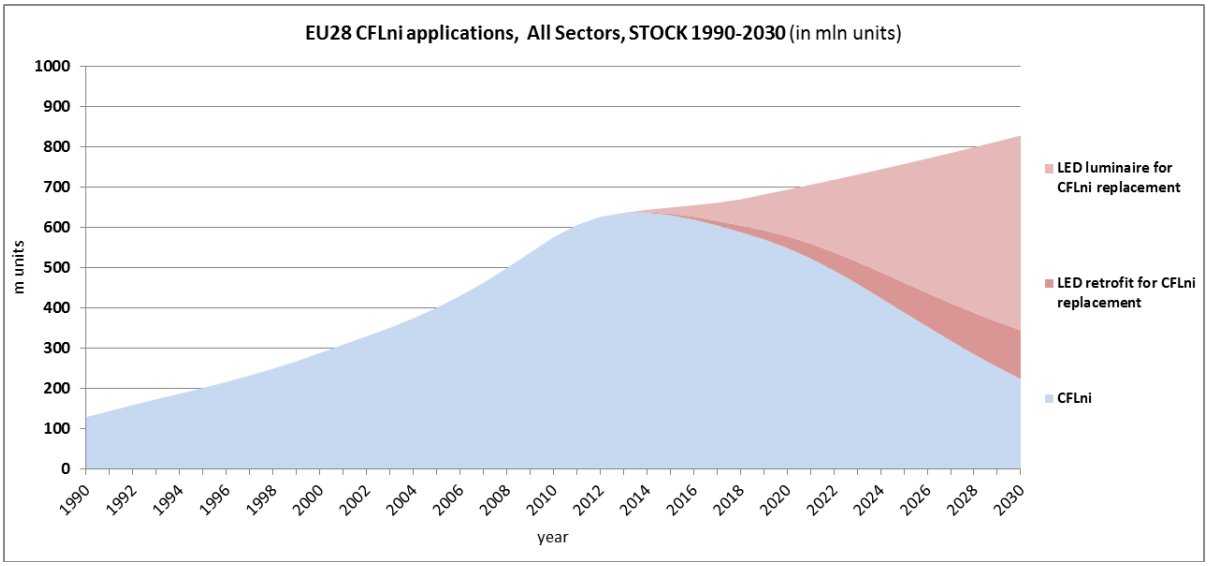



*Figure 0-6 Stock data in mln units for lamp types of the CFLni-application group. Per base case, for all sectors (residential + non-residential)*

## Sales and Stock in DLS application group

*Table 0-7 Sales data in mln units per year for lamp types of the DLS-application group. Per base case, for all sectors, residential and non-residential*

| DLS - EU-28 SALES mln units TOTAL, All Sectors | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| DLS | HL LV R | 20 | 150 | 145 | 108 | 54 | 12 |
| | HL MV X (DLS) | 0 | 162 | 126 | 0 | 0 | 0 |
| | GLS R (DLS) | 173 | 72 | 8 | 0 | 0 | 0 |
| | **DLS (total)** | **193** | **384** | **279** | **108** | **54** | **12** |
| LED | LED retrofit for DLS replacement | 0 | 5 | 72 | 78 | 45 | 32 |
| | LED luminaire for DLS replacement | 0 | 1 | 18 | 32 | 26 | 30 |
| | **LED for DLS (total)** | **0** | **6** | **90** | **111** | **72** | **62** |

| DLS - EU-28 SALES mln units RESIDENTIAL | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| DLS | HL LV R | 10 | 75 | 73 | 52 | 25 | 6 |
| | HL MV X (DLS) | 0 | 129 | 101 | 0 | 0 | 0 |
| | GLS R (DLS) | 138 | 58 | 6 | 0 | 0 | 0 |
| | **DLS (total)** | **149** | **262** | **180** | **52** | **25** | **6** |
| LED | LED retrofit for DLS replacement | 0 | 4 | 51 | 49 | 20 | 13 |
| | LED luminaire for DLS replacement | 0 | 1 | 13 | 21 | 12 | 13 |
| | **LED for DLS (total)** | **0** | **5** | **64** | **70** | **32** | **25** |

| DLS - EU-28 SALES mln units NON-RESIDENTIAL | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| DLS | HL LV R | 10 | 75 | 73 | 55 | 29 | 7 |
| | HL MV X (DLS) | 0 | 32 | 25 | 0 | 0 | 0 |
| | GLS R (DLS) | 35 | 14 | 2 | 0 | 0 | 0 |
| | **DLS (total)** | **45** | **122** | **99** | **55** | **29** | **7** |
| LED | LED retrofit for DLS replacement | 0 | 1 | 21 | 29 | 25 | 19 |
| | LED luminaire for DLS replacement | 0 | 0 | 5 | 12 | 14 | 17 |
| | **LED for DLS (total)** | **0** | **1** | **26** | **41** | **39** | **36** |

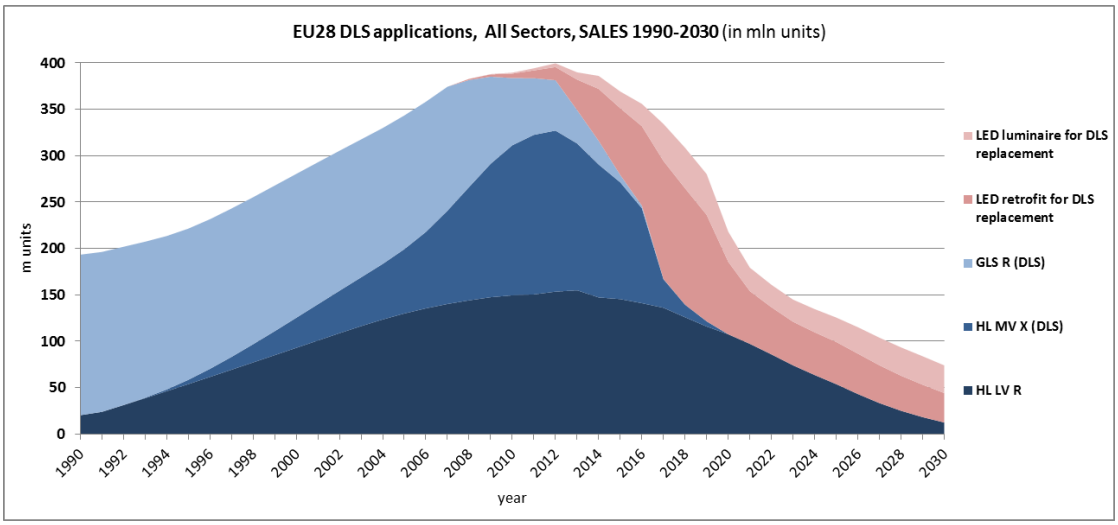



*Figure 0-7 Sales data in mln units per year for lamp types of the DLS-application group. Per base case, for all sectors (residential + non-residential)*

*Table 0-8 Stock data in mln units per year for lamp types of the DLS-application group. Per base case, for all sectors, residential and non-residential*

| DLS - EU-28 STOCK mln units TOTAL, All Sectors | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| DLS | HL LV R | 63 | 636 | 662 | 542 | 316 | 106 |
| | HL MV X (DLS) | 0 | 458 | 480 | 28 | 0 | 0 |
| | GLS R (DLS) | 379 | 189 | 41 | 0 | 0 | 0 |
| | **DLS (total)** | **442** | **1283** | **1182** | **570** | **316** | **106** |
| LED | LED retrofit for DLS replacement | 0 | 8 | 192 | 723 | 970 | 1158 |
| | LED luminaire for DLS replacement | 0 | 1 | 47 | 231 | 356 | 505 |
| | **LED for DLS (total)** | **0** | **10** | **239** | **955** | **1326** | **1664** |

| DLS - EU-28 STOCK mln units RESIDENTIAL | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| DLS | HL LV R | 32 | 318 | 331 | 267 | 151 | 49 |
| | HL MV X (DLS) | 0 | 366 | 385 | 23 | 0 | 0 |
| | GLS R (DLS) | 303 | 152 | 33 | 0 | 0 | 0 |
| | **DLS (total)** | **334** | **836** | **749** | **290** | **151** | **49** |
| LED | LED retrofit for DLS replacement | 0 | 7 | 137 | 508 | 628 | 709 |
| | LED luminaire for DLS replacement | 0 | 1 | 34 | 162 | 224 | 289 |
| | **LED for DLS (total)** | **0** | **8** | **171** | **670** | **852** | **997** |

| DLS - EU-28 STOCK mln units NON-RESIDENTIAL | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| DLS | HL LV R | 32 | 318 | 330 | 275 | 166 | 57 |
| | HL MV X (DLS) | 0 | 92 | 95 | 6 | 0 | 0 |
| | GLS R (DLS) | 76 | 38 | 8 | 0 | 0 | 0 |
| | **DLS (total)** | **108** | **447** | **433** | **281** | **166** | **57** |
| LED | LED retrofit for DLS replacement | 0 | 1 | 55 | 216 | 341 | 450 |
| | LED luminaire for DLS replacement | 0 | 0 | 13 | 69 | 132 | 217 |
| | **LED for DLS (total)** | **0** | **2** | **69** | **284** | **474** | **666** |

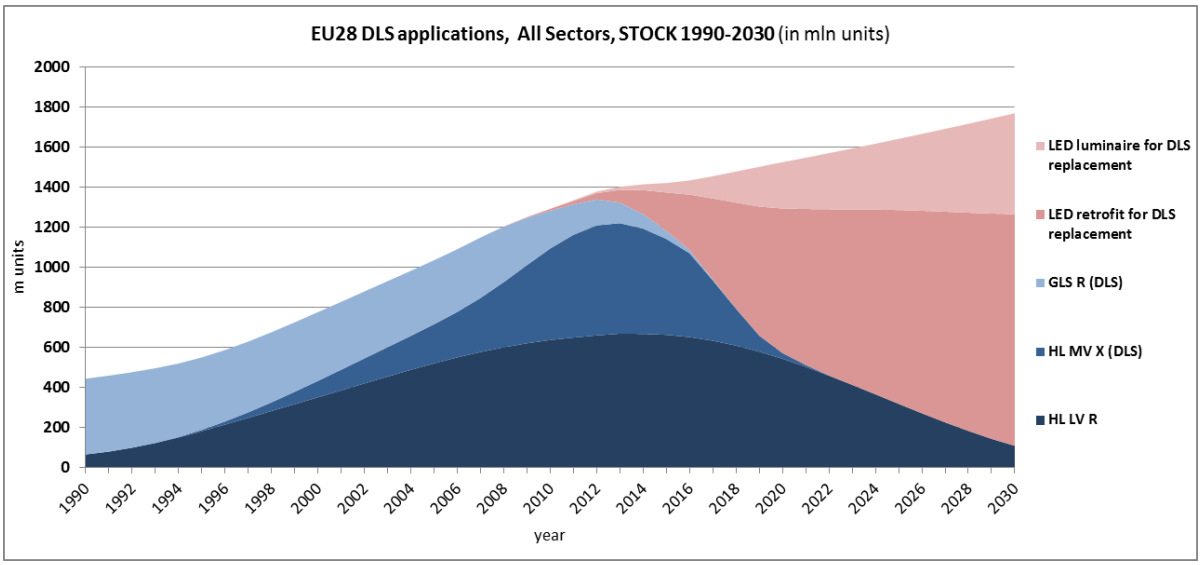



*Figure 0-8 Stock data in mln units for lamp types of the DLS-application group. Per base case, for all sectors (residential + non-residential)*

## Sales and Stock in NDLS application group

*Table 0-9 Sales data in mln units per year for lamp types of the NDLS-application group. Per base case, for all sectors, residential and non-residential*

| NDLS - EU-28 SALES mln units TOTAL, All Sectors | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| NDLS | CFLi | 28 | 480 | 155 | 104 | 30 | 16 |
| | HL MV E (NDLS) | 0 | 172 | 336 | 34 | 0 | 0 |
| | GLS X (NDLS) | 1514 | 624 | 50 | 0 | 0 | 0 |
| | HL LV C (G4,GY6.35) | 52 | 52 | 38 | 18 | 5 | 0 |
| | HL MV C (G9) | 0 | 70 | 60 | 29 | 6 | 0 |
| | HL MV L (R7s) | 15 | 45 | 33 | 12 | 1 | 0 |
| | GLS Storage | 0 | 112 | 187 | 0 | 0 | 0 |
| | HL Storage | 0 | 90 | 124 | 10 | 0 | 0 |
| | **NDLS (total)** | **1609** | **1644** | **983** | **206** | **42** | **17** |
| LED | LED retrofit for NDLS replacement | 0 | 2 | 200 | 647 | 238 | 135 |
| | LED luminaire for NDLS replacement | 0 | 0 | 52 | 283 | 149 | 129 |
| | **LED for NDLS (total)** | **0** | **3** | **252** | **930** | **387** | **264** |

| NDLS - EU-28 SALES mln units RESIDENTIAL | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| NDLS | CFLi | 17 | 288 | 90 | 60 | 17 | 9 |
| | HL MV E (NDLS) | 0 | 138 | 267 | 26 | 0 | 0 |
| | GLS X (NDLS) | 1212 | 500 | 43 | 0 | 0 | 0 |
| | HL LV C (G4,GY6.35) | 26 | 26 | 18 | 7 | 2 | 0 |
| | HL MV C (G9) | 0 | 56 | 48 | 23 | 4 | 0 |
| | HL MV L (R7s) | 12 | 36 | 27 | 10 | 1 | 0 |
| | GLS Storage | 0 | 112 | 187 | 0 | 0 | 0 |
| | HL Storage | 0 | 90 | 124 | 10 | 0 | 0 |
| | **NDLS (total)** | **1266** | **1244** | **803** | **135** | **24** | **9** |
| LED | LED retrofit for NDLS replacement | 0 | 2 | 167 | 451 | 132 | 64 |
| | LED luminaire for NDLS replacement | 0 | 0 | 43 | 198 | 84 | 65 |
| | **LED for NDLS (total)** | **0** | **3** | **210** | **649** | **215** | **129** |

| NDLS - EU-28 SALES mln units NON-RESIDENTIAL | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| NDLS | CFLi | 11 | 192 | 65 | 44 | 13 | 7 |
| | HL MV E (NDLS) | 0 | 34 | 69 | 8 | 0 | 0 |
| | GLS X (NDLS) | 303 | 125 | 8 | 0 | 0 | 0 |
| | HL LV C (G4,GY6.35) | 26 | 26 | 20 | 11 | 3 | 0 |
| | HL MV C (G9) | 0 | 14 | 12 | 6 | 1 | 0 |
| | HL MV L (R7s) | 3 | 9 | 6 | 2 | 0 | 0 |
| | GLS Storage | 0 | 0 | 0 | 0 | 0 | 0 |
| | HL Storage | 0 | 0 | 0 | 0 | 0 | 0 |
| | **NDLS (total)** | **343** | **400** | **180** | **71** | **17** | **8** |
| LED | LED retrofit for NDLS replacement | 0 | 0 | 33 | 196 | 106 | 71 |
| | LED luminaire for NDLS replacement | 0 | 0 | 9 | 86 | 66 | 64 |
| | **LED for NDLS (total)** | **0** | **0** | **42** | **282** | **172** | **135** |

*Table 0-10 Stock data in mln units per year for lamp types of the NDLS-application group. Per base case, for all sectors, residential and non-residential*

| NDLS - EU-28 STOCK mln units TOTAL, All Sectors | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| NDLS | CFLi | 197 | 3109 | 3946 | 3055 | 1345 | 656 |
| | HL MV E (NDLS) | 0 | 402 | 1041 | 398 | 1 | 0 |
| | GLS X (NDLS) | 3315 | 1734 | 152 | 1 | 0 | 0 |
| | HL LV C (G4,GY6.35) | 192 | 230 | 186 | 112 | 41 | 7 |
| | HL MV C (G9) | 0 | 214 | 213 | 127 | 32 | 3 |
| | HL MV L (R7s) | 29 | 103 | 77 | 33 | 4 | 0 |
| | GLS Storage | 0 | 187 | 471 | 6 | 0 | 0 |
| | HL Storage | 0 | 90 | 417 | 126 | 0 | 0 |
| | **NDLS (total)** | **3733** | **6069** | **6502** | **3858** | **1423** | **666** |
| LED | LED retrofit for NDLS replacement | 0 | 4 | 356 | 2777 | 4712 | 5462 |
| | LED luminaire for NDLS replacement | 0 | 0 | 92 | 1006 | 2050 | 2650 |
| | **LED for NDLS (total)** | **0** | **4** | **448** | **3783** | **6761** | **8112** |

| NDLS - EU-28 STOCK mln units RESIDENTIAL | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| NDLS | CFLi | 118 | 1865 | 2362 | 1802 | 769 | 375 |
| | HL MV E (NDLS) | 0 | 322 | 832 | 309 | 1 | 0 |
| | GLS X (NDLS) | 2648 | 1387 | 124 | 1 | 0 | 0 |
| | HL LV C (G4,GY6.35) | 94 | 115 | 91 | 47 | 16 | 3 |
| | HL MV C (G9) | 0 | 171 | 170 | 100 | 25 | 2 |
| | HL MV L (R7s) | 23 | 82 | 62 | 27 | 3 | 0 |
| | GLS Storage | 0 | 187 | 471 | 6 | 0 | 0 |
| | HL Storage | 0 | 90 | 417 | 126 | 0 | 0 |
| | **NDLS (total)** | **2884** | **4219** | **4528** | **2418** | **814** | **380** |
| LED | LED retrofit for NDLS replacement | 0 | 4 | 298 | 2104 | 3297 | 3668 |
| | LED luminaire for NDLS replacement | 0 | 0 | 77 | 753 | 1396 | 1702 |
| | **LED for NDLS (total)** | **0** | **4** | **374** | **2856** | **4693** | **5370** |

| NDLS - EU-28 STOCK mln units NON-RESIDENTIAL | | 1990 | 2010 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|
| NDLS | CFLi | 79 | 1244 | 1584 | 1253 | 576 | 281 |
| | HL MV E (NDLS) | 0 | 80 | 209 | 89 | 0 | 0 |
| | GLS X (NDLS) | 666 | 347 | 29 | 0 | 0 | 0 |
| | HL LV C (G4,GY6.35) | 97 | 115 | 95 | 65 | 25 | 4 |
| | HL MV C (G9) | 0 | 43 | 42 | 26 | 7 | 1 |
| | HL MV L (R7s) | 6 | 21 | 15 | 6 | 1 | 0 |
| | GLS Storage | 0 | 0 | 0 | 0 | 0 | 0 |
| | HL Storage | 0 | 0 | 0 | 0 | 0 | 0 |
| | **NDLS (total)** | **848** | **1849** | **1974** | **1439** | **608** | **286** |
| LED | LED retrofit for NDLS replacement | 0 | 0 | 58 | 673 | 1415 | 1794 |
| | LED luminaire for NDLS replacement | 0 | 0 | 15 | 253 | 653 | 948 |
| | **LED for NDLS (total)** | **0** | **0** | **73** | **926** | **2068** | **2742** |

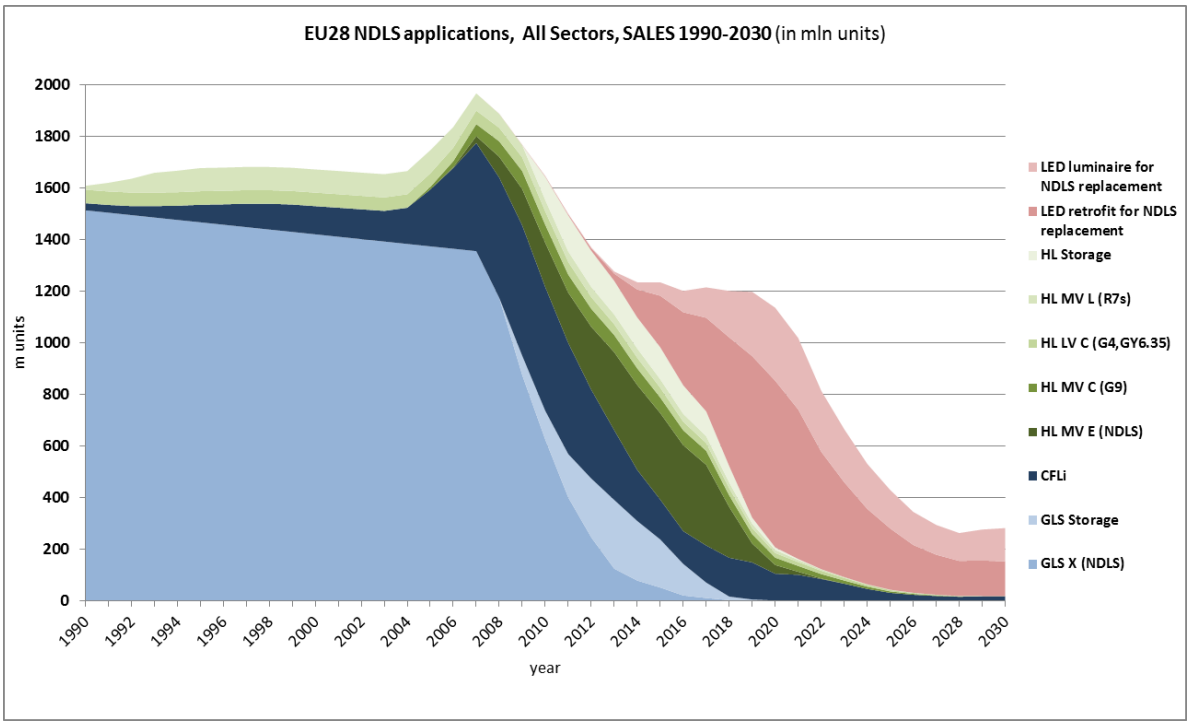



*Figure 0-9 Sales data in mln units per year for lamp types of the NDLS-application group. Per base case, for all sectors (residential + non-residential)*

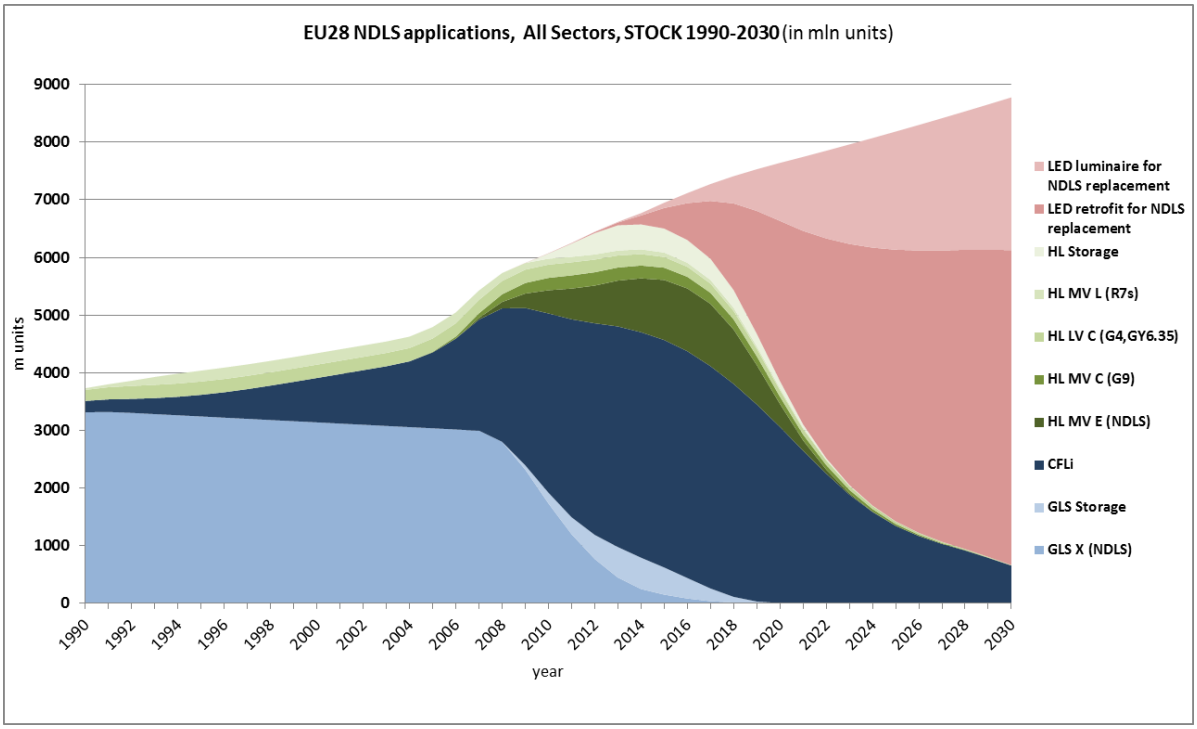



*Figure 0-10 Stock data in mln units for lamp types of the NDLS-application group. Per base case, for all sectors (residential + non-residential)*

# ANNEX D SALES OF BALLASTS AND CONTROL GEARS

The tables and graphs at the end of this annex present the Eurostat data for magnetic and electronic ballast. These data include production, import, export and apparent consumption (sales), expressed in quantities (units) and in values (euros). The presented data are for the following ProdCom codes:

- 27115013 - Inductors for discharge lamps or tubes
  (assumed to represent magnetic ballasts)

- 27115015 - Ballasts for discharge lamps or tubes (excluding inductors)
  (assumed to represent electronic ballasts)

The data can be summarized as follows:

- In 2013 around 600 million **magnetic ballasts** were sold in EU-28, representing a total value of around 165 million euros, for an average value of 0.27 euros/ballast.
  As regards sales quantities there is no clear trend: since 2005 the annual sales go up and down, varying from 600 to 900 million units per year.
  As regards sales values, the last ten years show a downward trend, even if with ups and downs.

- In 2013 around 70 million **electronic ballasts** were sold in EU-28, representing a total value of around 550 million euros, for an average value of 8.11 euros/ballast.
  As regards sales quantities there is a downward trend, from 150 million units in 2006-2007 to 70 million units in 2013.
  As regards sales values, the last ten years show an upward trend, from around 300 million euros in 2003 to around 600 million euros in 2011, with stabilization in the last two years.

For several reasons, these Eurostat data are puzzling and retained unreliable, see remarks in the main text, par. **Error! Reference source not found.**.

*Table 0-11 Eurostat EU-15 data 1995-2002 and EU-28 data 2003-2013, Magnetic ballast (PRC-code 27115013).*

| Magnetic ballast | EU-15 | | | | | | | | EU-28 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| year | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
| Production Quantity (mln units) | 116 | 132 | 143 | 169 | 157 | 202 | 226 | 334 | 498 | 615 | 639 | 782 | 803 | 787 | 635 | 798 | 900 | 672 | 600 |
| Import Quantity (mln units) | 18 | 13 | 16 | 19 | 46 | 50 | 25 | 16 | 114 | 106 | 97 | 193 | 118 | 111 | 60 | 56 | 39 | 39 | 32 |
| Export Quantity (mln units) | 40 | 49 | 57 | 49 | 35 | 43 | 55 | 60 | 48 | 54 | 49 | 47 | 46 | 37 | 29 | 32 | 32 | 33 | 30 |
| Apparent Sales (mln units) | 94 | 96 | 102 | 139 | 168 | 209 | 196 | 290 | 564 | 667 | 687 | 928 | 874 | 860 | 667 | 822 | 907 | 678 | 602 |
| Production Value (mln euro) | 272 | 297 | 335 | 332 | 302 | 404 | 443 | 433 | 380 | 370 | 320 | 339 | 389 | 373 | 271 | 328 | 328 | 263 | 238 |
| Import Value (mln euro) | 6 | 20 | 16 | 20 | 18 | 33 | 35 | 42 | 33 | 34 | 34 | 34 | 44 | 46 | 29 | 50 | 48 | 49 | 34 |
| Export Value (mln euro) | 82 | 100 | 107 | 105 | 74 | 106 | 144 | 112 | 110 | 136 | 112 | 103 | 104 | 101 | 73 | 88 | 110 | 112 | 106 |
| Apparent Sales (mln euro) | 196 | 216 | 243 | 248 | 246 | 331 | 335 | 362 | 303 | 268 | 242 | 270 | 329 | 317 | 227 | 291 | 266 | 200 | 165 |
| Production Value (euro/unit) | 2.34 | 2.26 | 2.35 | 1.96 | 1.93 | 2.01 | 1.96 | 1.30 | 0.76 | 0.60 | 0.50 | 0.43 | 0.48 | 0.47 | 0.43 | 0.41 | 0.36 | 0.39 | 0.40 |
| Import Value (euro/unit) | 0.35 | 1.50 | 0.98 | 1.06 | 0.38 | 0.65 | 1.42 | 2.60 | 0.29 | 0.32 | 0.35 | 0.18 | 0.37 | 0.41 | 0.49 | 0.89 | 1.22 | 1.24 | 1.06 |
| Export Value (euro/unit) | 2.03 | 2.03 | 1.89 | 2.13 | 2.09 | 2.45 | 2.63 | 1.87 | 2.30 | 2.52 | 2.29 | 2.20 | 2.25 | 2.76 | 2.56 | 2.77 | 3.39 | 3.41 | 3.59 |
| Apparent Value (euro/unit) | 2.08 | 2.27 | 2.38 | 1.78 | 1.47 | 1.59 | 1.70 | 1.25 | 0.54 | 0.40 | 0.35 | 0.29 | 0.38 | 0.37 | 0.34 | 0.35 | 0.29 | 0.29 | 0.27 |

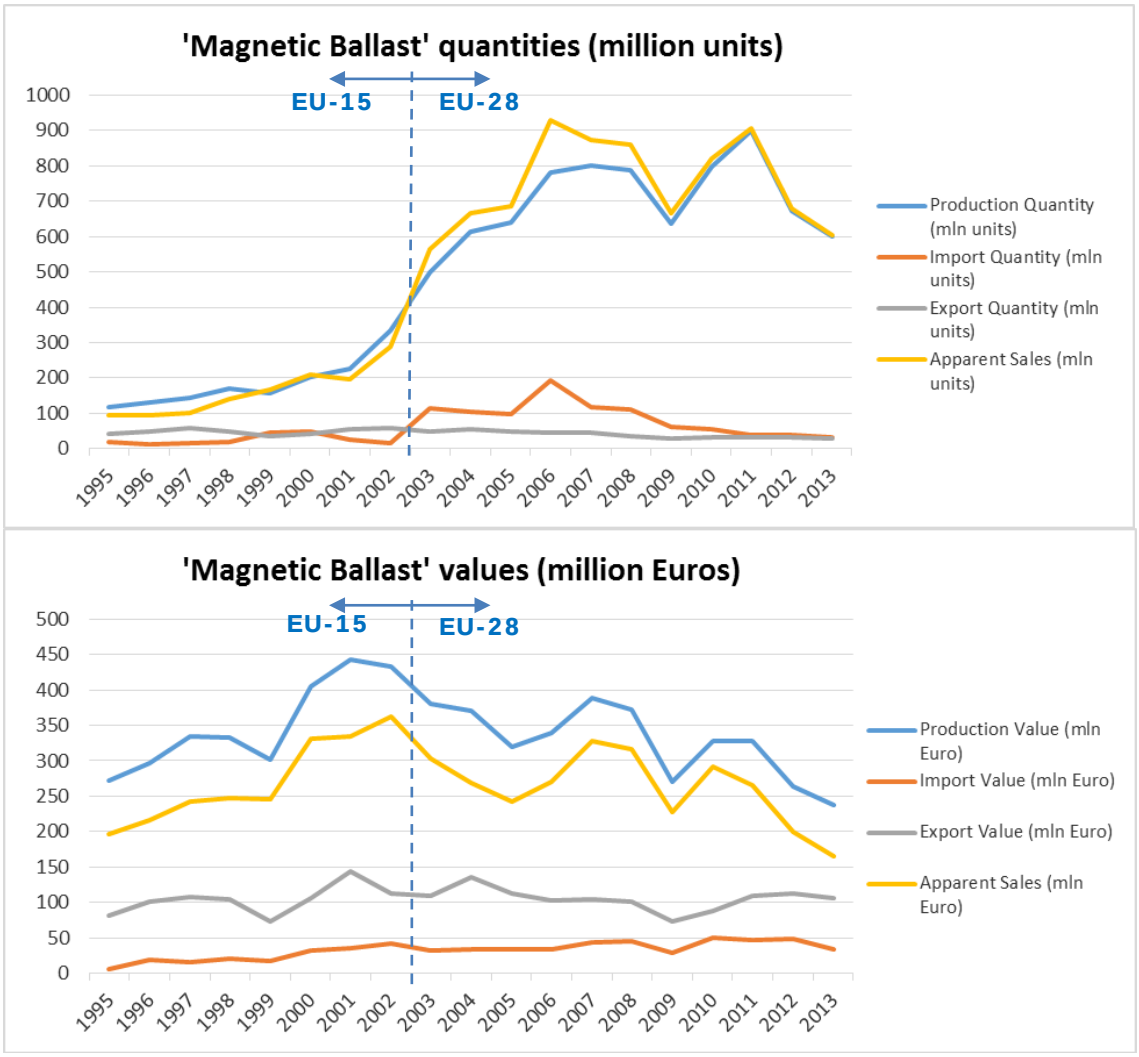



*Figure 0-11: Eurostat EU-15 data 1995-2002 and EU-28 data 2003-2013 for Magnetic ballast. Top: quantities; bottom: monetary value.*

*Table 0-12 Eurostat EU-15 data 1995-2002 and EU-28 data 2003-2013, Electronic ballast (PRC-code 27115015).*

| Electronic ballast | EU-15 | | | | | | | | EU-28 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| year | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
| Production Quantity (mln units) | 15 | 87 | 112 | 121 | 138 | 116 | 112 | 134 | 66 | 66 | 84 | 78 | 81 | 73 | 67 | 69 | 59 | 54 | 46 |
| Import Quantity (mln units) | 38 | 31 | 49 | 46 | 35 | 23 | 26 | 35 | 54 | 66 | 65 | 98 | 98 | 70 | 44 | 62 | 71 | 60 | 54 |
| Export Quantity (mln units) | 13 | 18 | 28 | 28 | 44 | 33 | 30 | 44 | 22 | 27 | 23 | 27 | 30 | 30 | 24 | 28 | 30 | 31 | 31 |
| Apparent Sales (mln units) | 39 | 100 | 133 | 140 | 130 | 106 | 109 | 126 | 98 | 105 | 125 | 149 | 149 | 113 | 87 | 103 | 100 | 82 | 68 |
| Production Value (mln euro) | 208 | 313 | 331 | 395 | 425 | 305 | 307 | 295 | 292 | 374 | 373 | 399 | 432 | 436 | 465 | 535 | 516 | 475 | 461 |
| Import Value (mln euro) | 28 | 40 | 81 | 117 | 119 | 137 | 163 | 189 | 124 | 129 | 141 | 200 | 215 | 240 | 204 | 264 | 330 | 292 | 278 |
| Export Value (mln euro) | 39 | 54 | 69 | 96 | 143 | 162 | 154 | 189 | 162 | 175 | 154 | 208 | 207 | 195 | 159 | 204 | 205 | 195 | 187 |
| Apparent Sales (mln euro) | 196 | 300 | 342 | 416 | 402 | 280 | 315 | 294 | 253 | 328 | 360 | 391 | 439 | 482 | 510 | 595 | 641 | 572 | 553 |
| Production Value (euro/unit) | 14.33 | 3.60 | 2.96 | 3.25 | 3.08 | 2.64 | 2.74 | 2.19 | 4.41 | 5.70 | 4.46 | 5.14 | 5.32 | 5.99 | 6.97 | 7.78 | 8.80 | 8.84 | 10.12 |
| Import Value (euro/unit) | 0.73 | 1.31 | 1.65 | 2.52 | 3.40 | 5.88 | 6.15 | 5.34 | 2.31 | 1.95 | 2.18 | 2.03 | 2.19 | 3.44 | 4.65 | 4.23 | 4.62 | 4.87 | 5.17 |
| Export Value (euro/unit) | 3.05 | 2.96 | 2.48 | 3.46 | 3.28 | 4.85 | 5.15 | 4.30 | 7.46 | 6.61 | 6.59 | 7.59 | 6.89 | 6.55 | 6.68 | 7.17 | 6.92 | 6.22 | 5.97 |
| Apparent Value (euro/unit) | 5.01 | 3.01 | 2.57 | 2.97 | 3.10 | 2.65 | 2.90 | 2.34 | 2.59 | 3.11 | 2.88 | 2.63 | 2.94 | 4.27 | 5.88 | 5.79 | 6.38 | 6.94 | 8.11 |

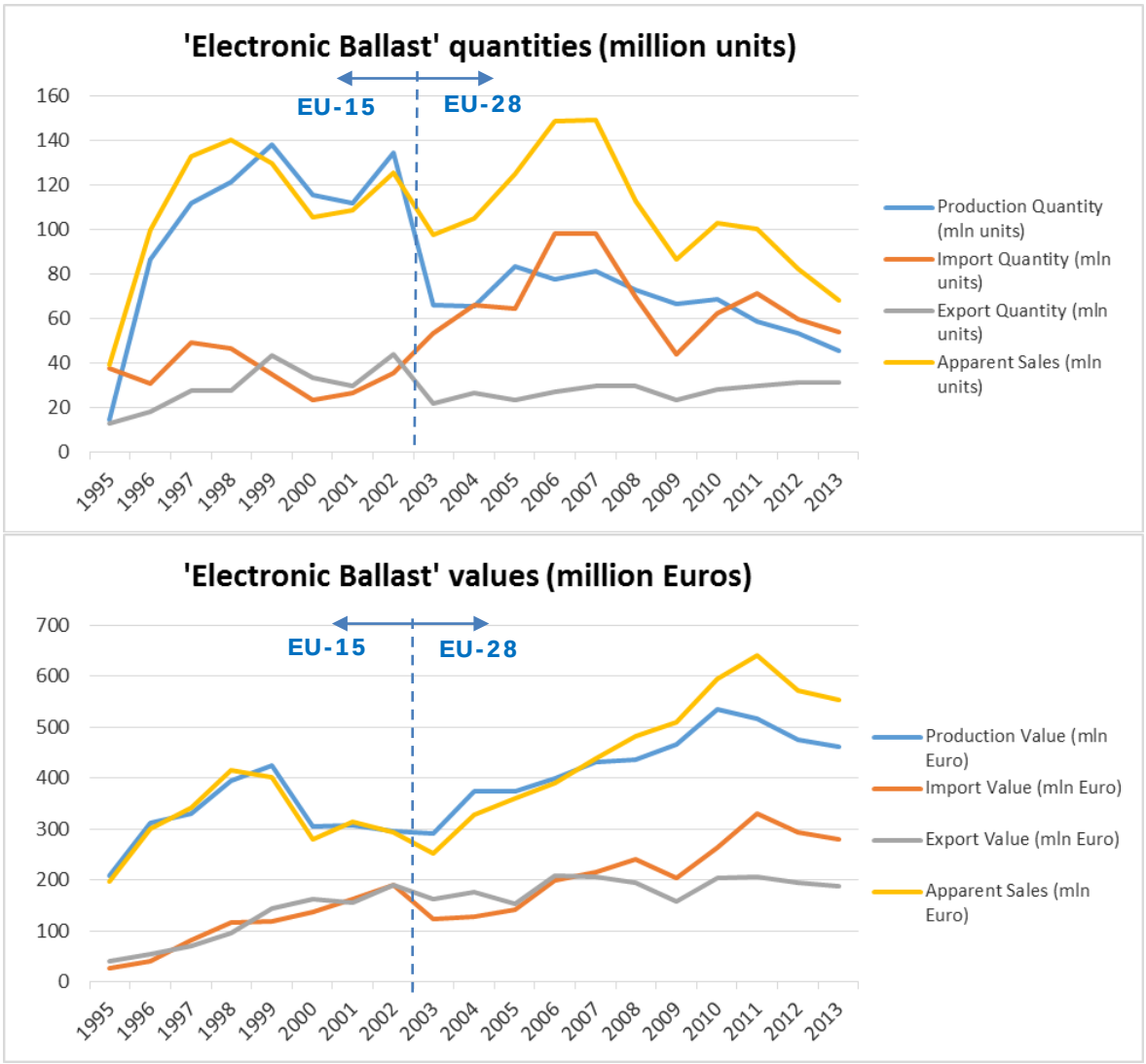



*Figure 0-12: Eurostat EU-15 data 1995-2002 and EU-28 data 2003-2013 for Electronic ballast. Top: quantities; bottom: monetary value.*

# ANNEX E SALES OF LUMINAIRES

*Table 0-13 Eurostat EU-15 data 1995-2002 and EU-28 data 2003-2013, Electric table, desk, bedside or floor-standing lamps (PRC-code 27402200).*

| Desk luminaires etc. | EU-15 | | | | | | | | EU-28 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| year | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
| Production Quantity (mln units) | 24 | 27 | 27 | 25 | 22 | 23 | 25 | 27 | 32 | 25 | 20 | 22 | 22 | 19 | 13 | 14 | 16 | 14 | 16 |
| Import Quantity (mln units) | 12 | 13 | 15 | 14 | 14 | 18 | 18 | 17 | 30 | 29 | 24 | 26 | 31 | 25 | 17 | 23 | 21 | 23 | 23 |
| Export Quantity (mln units) | 7 | 7 | 8 | 7 | 5 | 6 | 6 | 6 | 8 | 7 | 7 | 9 | 8 | 7 | 5 | 6 | 6 | 7 | 8 |
| Apparent Sales (mln units) | 29 | 34 | 34 | 32 | 31 | 35 | 36 | 38 | 54 | 46 | 38 | 39 | 45 | 37 | 25 | 31 | 31 | 30 | 31 |
| Production Value (mln euro) | 420 | 480 | 464 | 551 | 630 | 620 | 669 | 665 | 509 | 446 | 436 | 462 | 453 | 470 | 416 | 396 | 455 | 376 | 401 |
| Import Value (mln euro) | 205 | 228 | 269 | 304 | 410 | 495 | 469 | 429 | 473 | 513 | 527 | 546 | 638 | 615 | 539 | 677 | 611 | 595 | 577 |
| Export Value (mln euro) | 115 | 120 | 143 | 144 | 138 | 163 | 172 | 160 | 125 | 133 | 143 | 182 | 172 | 180 | 155 | 162 | 170 | 187 | 197 |
| Apparent Sales (mln euro) | 510 | 588 | 590 | 710 | 901 | 951 | 966 | 934 | 857 | 826 | 820 | 826 | 918 | 905 | 800 | 912 | 896 | 783 | 782 |
| Production Value (euro/unit) | 17.5 | 17.5 | 17.5 | 22.0 | 28.6 | 27.0 | 26.8 | 24.8 | 16.0 | 17.8 | 21.8 | 21.2 | 20.4 | 24.3 | 31.8 | 29.0 | 29.1 | 26.4 | 25.1 |
| Import Value (euro/unit) | 17.5 | 17.5 | 17.5 | 22.0 | 28.6 | 27.0 | 26.8 | 24.8 | 16.0 | 17.8 | 21.8 | 21.2 | 20.4 | 24.3 | 31.8 | 29.0 | 29.1 | 26.4 | 25.1 |
| Export Value (euro/unit) | 17.5 | 17.5 | 17.5 | 22.0 | 28.6 | 27.0 | 26.8 | 24.8 | 16.0 | 17.8 | 21.8 | 21.2 | 20.4 | 24.3 | 31.8 | 29.0 | 29.1 | 26.4 | 25.1 |
| Apparent Value (euro/unit) | 17.5 | 17.5 | 17.5 | 22.0 | 28.6 | 27.0 | 26.8 | 24.8 | 16.0 | 17.8 | 21.8 | 21.2 | 20.4 | 24.3 | 31.8 | 29.0 | 29.1 | 26.4 | 25.1 |

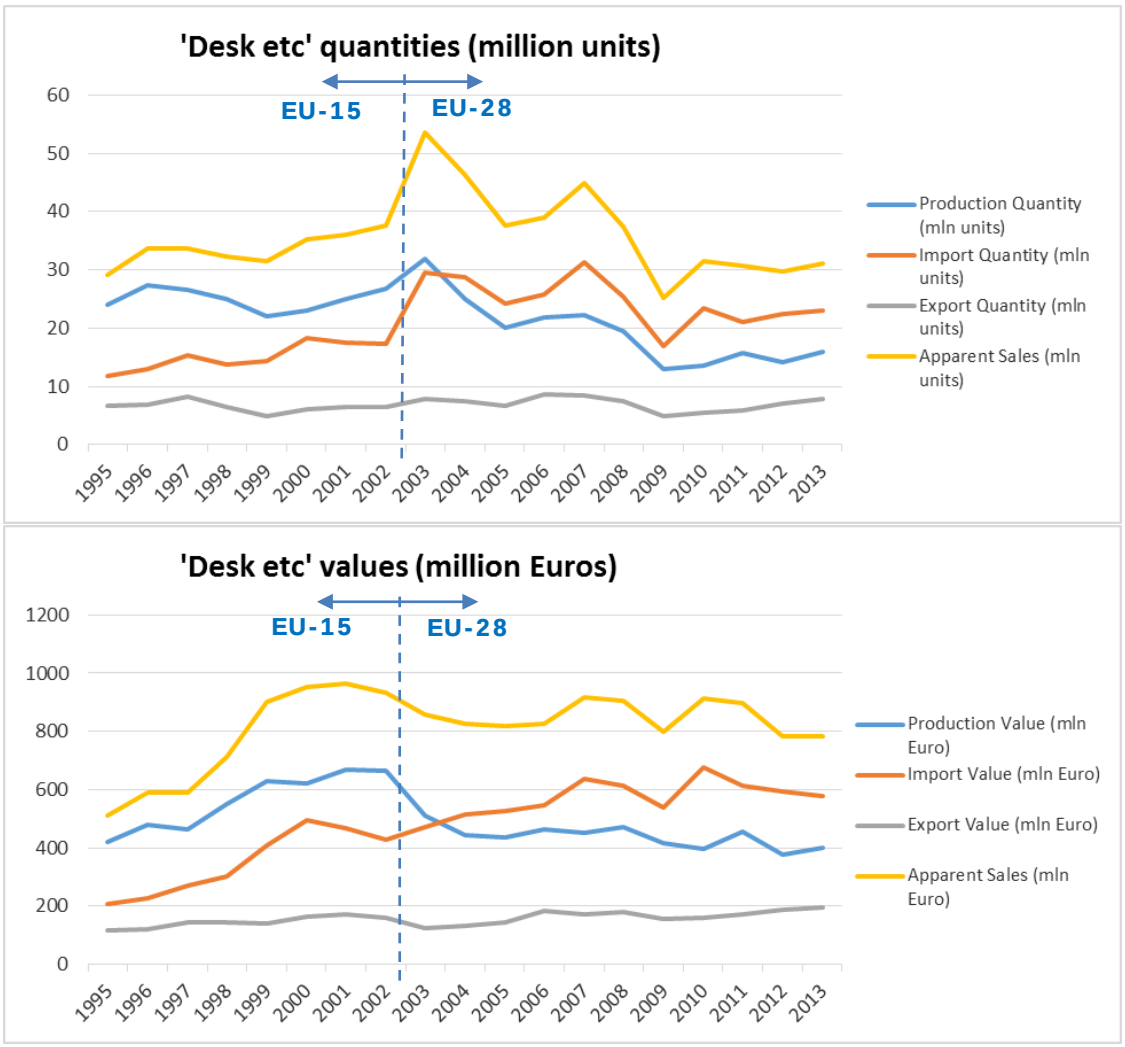



*Figure 0-13: Eurostat EU-15 data 1995-2002 and EU-28 data 2003-2013 for Electric table, desk, bedside or floor-standing lamps. Top: quantities; bottom: monetary value.*

*Table 0-14 Eurostat EU-15 data 1995-2002 and EU-28 data 2003-2013, Chandeliers and other electric ceiling or wall lighting fittings (excluding those used for lighting public open spaces or thoroughfares) (PRC-code 27402500).*

| Chandeliers etc. | EU-15 | | | | | | | | EU-28 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| year | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
| Production Quantity (mln | 186 | 300 | 252 | 307 | 285 | 232 | 237 | 328 | 361 | 342 | 344 | 321 | 327 | 288 | 160 | 200 | 160 | 180 | 180 |
| Import Quantity (mln units) | 13 | 21 | 22 | 27 | 34 | 37 | 39 | 51 | 46 | 56 | 63 | 64 | 71 | 63 | 38 | 59 | 45 | 59 | 57 |
| Export Quantity (mln units) | 32 | 52 | 53 | 55 | 56 | 51 | 47 | 59 | 47 | 53 | 58 | 59 | 62 | 60 | 34 | 43 | 38 | 51 | 55 |
| Apparent Sales (mln units) | 166 | 269 | 221 | 279 | 262 | 218 | 229 | 321 | 359 | 345 | 349 | 326 | 335 | 291 | 165 | 216 | 167 | 188 | 183 |
| Production Value (mln euro) | 297 | 317 | 321 | 404 | 360 | 360 | 400 | 441 | 515 | 466 | 468 | 488 | 536 | 531 | 429 | 466 | 495 | 483 | 504 |
| Import Value (mln euro) | 204 | 227 | 279 | 354 | 423 | 576 | 660 | 689 | 650 | 762 | 859 | 974 | 116 | 116 | 103 | 136 | 137 | 157 | 160 |
| Export Value (mln euro) | 516 | 554 | 674 | 721 | 713 | 787 | 797 | 791 | 669 | 722 | 786 | 901 | 102 | 110 | 910 | 100 | 116 | 135 | 152 |
| Apparent Sales (mln euro) | 265 | 285 | 281 | 367 | 331 | 338 | 386 | 431 | 513 | 470 | 475 | 495 | 550 | 537 | 441 | 503 | 516 | 505 | 511 |
| Production Value (euro/unit) | 16.0 | 10.6 | 12.7 | 13.2 | 12.6 | 15.5 | 16.9 | 13.5 | 14.3 | 13.6 | 13.6 | 15.2 | 16.4 | 18.4 | 26.8 | 23.3 | 30.9 | 26.8 | 28.0 |
| Import Value (euro/unit) | 16.0 | 10.6 | 12.7 | 13.2 | 12.6 | 15.5 | 16.9 | 13.5 | 14.3 | 13.6 | 13.6 | 15.2 | 16.4 | 18.4 | 26.8 | 23.3 | 30.9 | 26.8 | 28.0 |
| Export Value (euro/unit) | 16.0 | 10.6 | 12.7 | 13.2 | 12.6 | 15.5 | 16.9 | 13.5 | 14.3 | 13.6 | 13.6 | 15.2 | 16.4 | 18.4 | 26.8 | 23.3 | 30.9 | 26.8 | 28.0 |
| Apparent Value (euro/unit) | 16.0 | 10.6 | 12.7 | 13.2 | 12.6 | 15.5 | 16.9 | 13.5 | 14.3 | 13.6 | 13.6 | 15.2 | 16.4 | 18.4 | 26.8 | 23.3 | 30.9 | 26.8 | 28.0 |

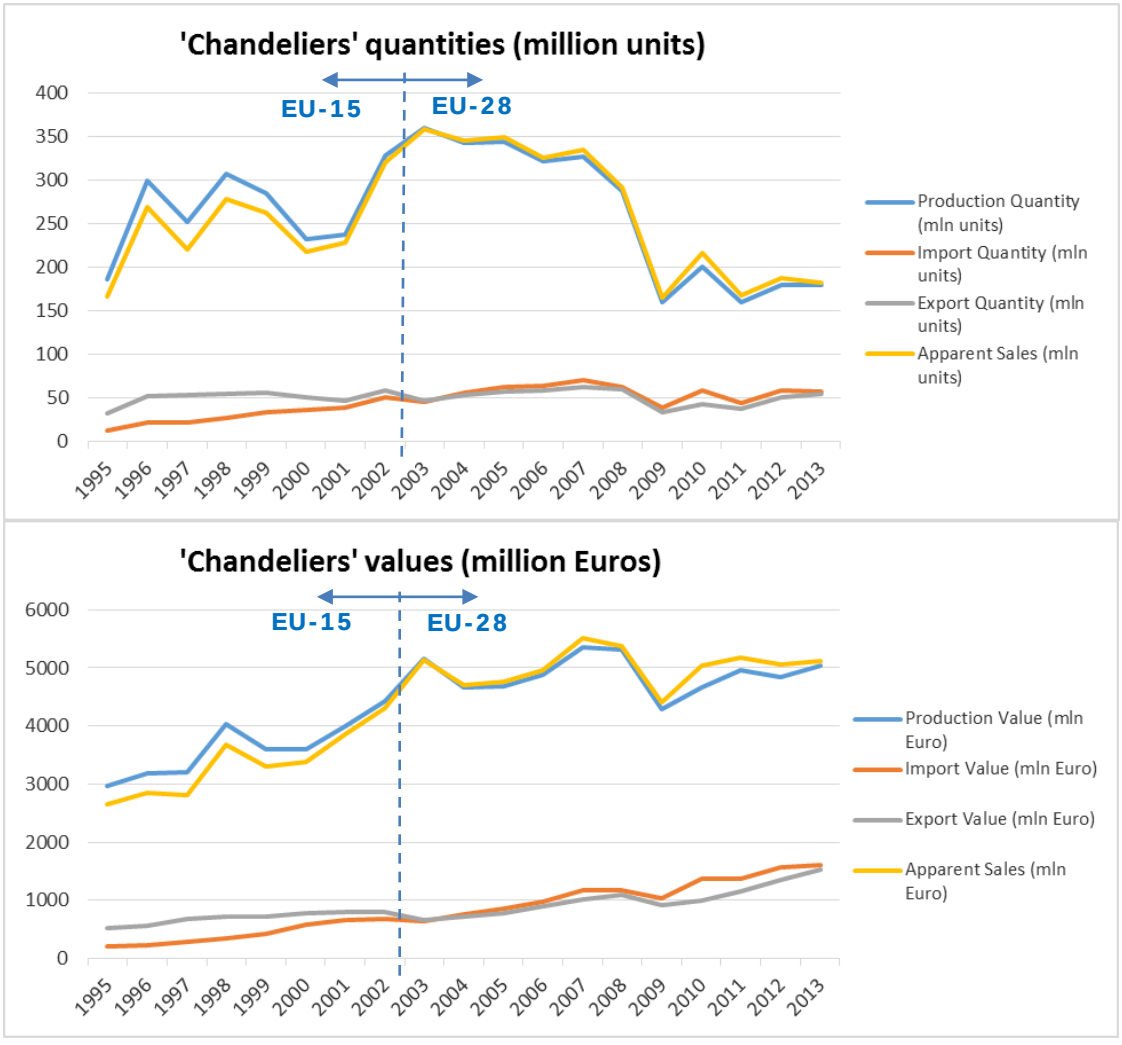



*Figure 0-14: Eurostat EU-15 data 1995-2002 and EU-28 data 2003-2013 for Chandeliers and other electric ceiling or wall lighting fittings (excluding those used for lighting public open spaces or thoroughfares). Top: quantities; bottom: monetary value.*

*Table 0-15 Eurostat EU-15 data 1995-2002 and EU-28 data 2003-2013, Electric lamps and lighting fittings, of plastic and other materials, of a kind used for filament lamps and tubular fluorescent lamps (PRC-code 27403930).*

| Luminaires for LFL and filam. | EU-15 | | | | | | | | EU-28 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| year | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
| Production Quantity (mln | 48 | 80 | 91 | 108 | 98 | 76 | 73 | 68 | 108 | 82 | 72 | 67 | 84 | 131 | 109 | 104 | 88 | 86 | 79 |
| Import Quantity (mln units) | 5 | 8 | 11 | 15 | 14 | 13 | 16 | 15 | 24 | 21 | 23 | 22 | 27 | 43 | 36 | 48 | 42 | 50 | 55 |
| Export Quantity (mln units) | 12 | 21 | 26 | 29 | 21 | 17 | 21 | 18 | 21 | 16 | 15 | 15 | 19 | 33 | 29 | 28 | 24 | 27 | 27 |
| Apparent Sales (mln units) | 42 | 67 | 76 | 94 | 91 | 72 | 68 | 65 | 111 | 87 | 79 | 74 | 92 | 141 | 117 | 124 | 106 | 109 | 106 |
| Production Value (mln euro) | 130 | 144 | 147 | 160 | 197 | 220 | 180 | 199 | 203 | 217 | 211 | 226 | 272 | 261 | 230 | 250 | 295 | 297 | 283 |
| Import Value (mln euro) | 144 | 140 | 175 | 226 | 274 | 369 | 395 | 427 | 450 | 554 | 661 | 751 | 868 | 862 | 760 | 114 | 140 | 173 | 197 |
| Export Value (mln euro) | 314 | 378 | 420 | 430 | 424 | 493 | 522 | 521 | 391 | 412 | 441 | 519 | 624 | 666 | 600 | 677 | 800 | 932 | 986 |
| Apparent Sales (mln euro) | 113 | 120 | 122 | 139 | 182 | 207 | 167 | 190 | 209 | 231 | 233 | 249 | 296 | 281 | 246 | 296 | 356 | 378 | 382 |
| Production Value (euro/unit) | 27.1 | 18.0 | 16.2 | 14.8 | 20.1 | 28.9 | 24.7 | 29.4 | 18.8 | 26.5 | 29.3 | 33.9 | 32.2 | 20.0 | 21.1 | 24.0 | 33.5 | 34.7 | 36.0 |
| Import Value (euro/unit) | 27.1 | 18.0 | 16.2 | 14.8 | 20.1 | 28.9 | 24.7 | 29.4 | 18.8 | 26.5 | 29.3 | 33.9 | 32.2 | 20.0 | 21.1 | 24.0 | 33.5 | 34.7 | 36.0 |
| Export Value (euro/unit) | 27.1 | 18.0 | 16.2 | 14.8 | 20.1 | 28.9 | 24.7 | 29.4 | 18.8 | 26.5 | 29.3 | 33.9 | 32.2 | 20.0 | 21.1 | 24.0 | 33.5 | 34.7 | 36.0 |
| Apparent Value (euro/unit) | 27.1 | 18.0 | 16.2 | 14.8 | 20.1 | 28.9 | 24.7 | 29.4 | 18.8 | 26.5 | 29.3 | 33.9 | 32.2 | 20.0 | 21.1 | 24.0 | 33.5 | 34.7 | 36.0 |

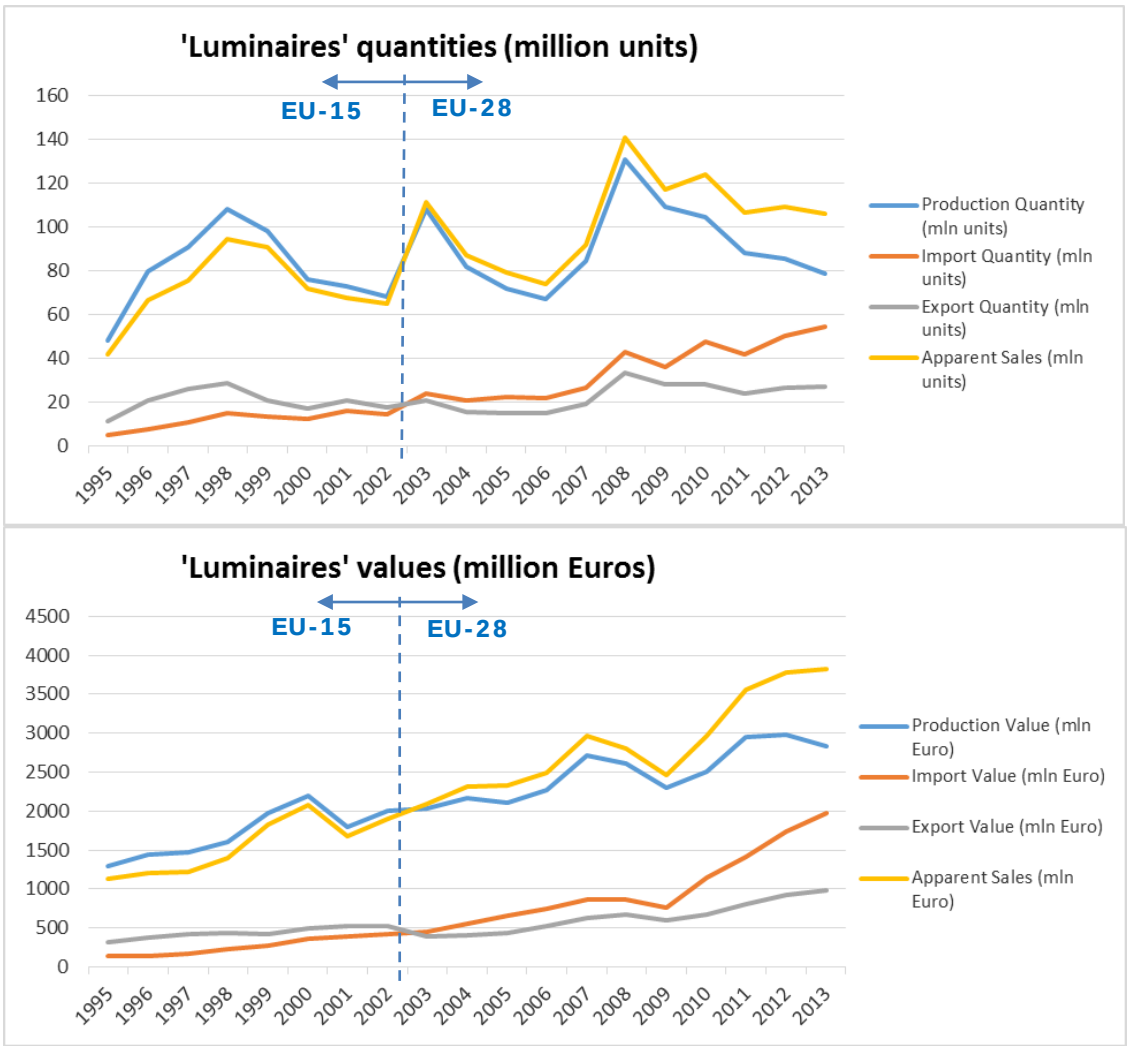



*Figure 0-15: Eurostat EU-15 data 1995-2002 and EU-28 data 2003-2013 for Electric lamps and lighting fittings, of plastic and other materials, of a kind used for filament lamps and tubular fluorescent lamps. Top: quantities; bottom: monetary value.*

# ANNEX F NON-RESIDENTIAL BUILDINGS AND ROOMS

## F1 Introduction

This annex regards lighting in EU-28 non-residential buildings. It handles the following major topics:

- Determination of the areas per building type (sector) and per room type (activity), based on data in the 'Building heat demand report' 2 (chapter E2).
- Determination of the total required lighting (lux) at task level, by multiplication of the building/room areas with the lighting requirements from standards, mainly from EN 12464-1 (chapter E3).
- Determination of the corresponding total installed lighting power, by multiplication of the total required lux with the Pjlx (W/m2/lux) values proposed in EN 15193 (chapter E4).
- Determination of the effective operating hours per building type/room type, considering the potential hours and occupancy-related factors proposed in EN 15193, and estimates for the daylight-related factors (chapter E5).
- Determination of the corresponding lighting energy consumption, by multiplication of the installed powers and the operating hours (chapter E6).

The results are compared to the 2013-values from the MELISA model.

## F2 Determination of Building Areas

### F2.1 Sources

The reference areas for lighting in buildings have been derived starting from the report on EU-28 Building Heat Demand [2]. In particular the following tables from that report have been mainly used:

- Table 13: provides the % of area that is typical for a given type of building (sector) and the % of area occupied by some types of secondary spaces (activities) such as circulation areas, toilets, meeting rooms, technical service areas, etc. [3].
- Table 15: EU-28 total areas in M $m^2$, for primary and secondary sector buildings
- Table 16: EU-28 total areas in M $m^2$, for tertiary sector buildings
- Table 17: EU-28 total areas in M $m^2$, for public and community sector buildings

### F2.2 References for required area subdivisions

[2] "Average EU building heat load for HVAC equipment", final report, René Kemna (VHK) for the European Commission, August 2014 (chapter 4, volumes and surfaces)

[3] It is not specified that the numbers in this table apply to areas in terms of m2, and in some cases there are some doubts on this, but the numbers anyway provide a good indication of the subdivision of the building area over the various activities.

The proposed standard EN 15193 [4] has been used as a main reference for the building area subdivision that would be necessary. This standard distinguishes the building types (or sectors) shown in Table 0-16 (in this case for the definition of default annual operating hours).

As regards the types of rooms / activity types inside these buildings, the most relevant subdivisions are those used for the definition of occupancy factors (or absence factors) and for the required illumination levels. Table 0-17 shows an example of room types being distinguished in prEN 15193-1 for the definition of absence factors.

Required illumination levels (in terms of lux in the task area or in the immediately surrounding area) are defined in EN 12464 (indoor lighting of workplaces) and EN 12193 (sports facilities). An indication for the level of illumination in residential buildings is provided in prEN 15193.

The room types / activity types in EN 12464 and EN 12193 are very detailed and not reported here. It would be impossible to determine the illuminated areas in terms of $m^2$ for all these room types.

*Table 0-16 Building types distinguished for the definition of operation hours (from EN 15193-1 table B.3.3.2)*

| **Building type** | **Default annual operating hours** | | |
|---|---|---|---|
| | $t_D$ | $t_N$ | $t_{tot}$ |
| Domestic buildings | 1 820 | 1 680 | 3 800 |
| Offices | 2 250 | 250 | 2 500 |
| Education buildings | 1 800 | 200 | 2 000 |
| Hospitals | 3 000 | 2 000 | 5 000 |
| Hotels | 3 000 | 2 000 | 5 000 |
| Restaurants | 1 250 | 1 250 | 2 500 |
| Sports facilities | 2 000 | 2 000 | 4 000 |
| Wholesale and retail services | 3 000 | 2 000 | 5 000 |
| Manufacturing factories | 2 500 | 1 500 | 4 000 |

[4] prEN 15193-1:2014 Energy performance of buildings - Module M9 – Energy requirements for lighting - Part 1: Specifications,
and Draft prCEN/TR 15193-2 "Energy performance of buildings Energy requirements for lighting - Part 2: Technical Report to EN 15193-1" (under approval)

*Table 0-17 Room types distinguished for the definition of Absence Factors FA (from EN 15193-1 table E.2)*

| Overall building calculation | | Room by room calculation | | |
|---|---|---|---|---|
| **Building type** | $F_A$ | **Building type** | **Room type** | $F_A$ |
| **Domestic buildings** | 0,00 | **Domestic buildings** | Living room | 0,30 |
| | | | Bedroom | 0,40 |
| | | | Room for children or retired persons | 0,30 |
| | | | Dining room | 0,70 |
| | | | Kitchen | 0,60 |
| | | | Bathroom | 0,80 |
| | | | Toilet | 0,90 |
| | | | Entrance hall | 0,80 |
| | | | Corridor, stairs | 0,70 |
| | | | Storeroom | 0,90 |
| | | | Cellar | 0,95 |
| | | | Laundry | 0,98 |
| | | | Larder | 0,98 |
| | | | Workroom | 0,60 |
| | | | Home workshop | 0,80 |
| | | | Garage | 0,95 |
| **Offices** | 0,20 | **Offices** | Cellular office 1 person. | 0,40 |
| | | | Cellular office 2-6 persons. | 0,30 |
| | | | Open plan office >6persons sensing/30m$^2$ | 0,00 |
| | | | Open plan office >6persons sensing/10m$^2$ | 0,20 |
| | | | Corridor (dimmed) | 0,40 |
| | | | Entrance hall | 0,00 |
| | | | Showroom/Expo | 0,60 |
| | | | Bathroom | 0,90 |
| | | | Rest room | 0,50 |
| | | | Storage room/Cloakroom | 0,90 |
| | | | Technical plant room | 0,98 |
| | | | Copying/Server room | 0,50 |
| | | | Conference room | 0,50 |
| | | | Archives | 0,98 |
| | | | | |
| **Educational buildings** | 0,20 | **Educational buildings** | Classroom | 0,25 |
| | | | Room for group activities | 0,30 |
| | | | Corridor (dimmed) | 0,60 |
| | | | Junior common room | 0,50 |
| | | | Lecture hall | 0,40 |
| | | | Staff room | 0,40 |
| | | | Gymnasium/Sports hall | 0,30 |
| | | | Dining hall | 0,20 |
| | | | Teachers' staff common room | 0,40 |
| | | | Copying/storage room | 0,40 |
| | | | Kitchen | 0,20 |
| | | | Library | 0,40 |
| | | | | |
| **Hospitals** | 0,00 | **Hospitals** | Wards/Bedroom | 0,00 |
| | | | Examination/Treatment | 0,40 |
| | | | Pre-Operation | 0,40 |
| | | | Recovery ward | 0,00 |
| | | | Operating theatre | 0,00 |
| | | | Corridors | 0,00 |
| | | | Culvert/conduct/(dimmed) | 0,70 |
| | | | Waiting area | 0,00 |
| | | | Entrance hall | 0,00 |
| | | | Day room | 0,20 |
| | | | Laboratory | 0,20 |
| | | | | |
| **Manufacturing factory** | 0,00 | **Manufacturing factory** | Assembly hall | 0,00 |
| | | | Smaller assembly room | 0,20 |
| | | | Storage rack area | 0,40 |
| | | | Open storage area | 0,20 |
| | | | Painting room | 0,20 |

| | | | | |
|---|---|---|---|---|
| **Hotels and restaurants** | 0,00 | **Hotels and restaurants** | Entrance hall/Lobby<br>Corridor (dimmed)<br>Hotel room<br>Dining hall/cafeteria<br>Kitchen<br>Conference room<br>Kitchen/storage | 0,00<br>0,40<br>0,60<br>0,00<br>0,00<br>0,40<br>0,50 |
| | | | | |
| **Wholesale and retail service** | 0,00 | **Wholesale and retail service** | Sales area<br>Store room<br>Store room, cold stores | 0,00<br>0,20<br>0,60 |
| | | | | |
| | | **Other areas** | Waiting areas<br>Stairs (dimmed)<br>Theatrical stage and auditorium<br>Congress hall/Exhibition hall<br>museum/ Exhibition hall<br>Library/Reading area<br>Library /Archive<br>Sports hall<br>Car parks office - Private<br>Car parks - Public | 0,00<br>0,20<br>0,00<br>0,50<br>0,00<br>0,00<br>0,90<br>0,30<br>0,95<br>0,80 |

## F2.3 Subdivision of building areas

It would be ideal to subdivide the total building areas from the source document (par. E2.1) according to the building and room types of Table 0-16 and Table 0-17. In that case required illumination levels and absence factors would be readily available. The information from the source document (see par. E2.1) does not always allow such a subdivision, but an attempt has been made to get as close as possible.

Table 0-18 shows the derived detailed subdivision of the total EU-28 Non-Residential Building Area over the various building types and room types.

Table 0-19 provides a summary per building type. The new estimated total EU-28 non-residential building area of 11773 M $m^2$ is approximately twice as large as previously estimated in Task 0 based on Waide(2013)[5] (see also Task 1 report, par. 1.6.3).

Table 0-20 provides a summary per room type. Note that there are still some building types in this table (under Entertainment and Miscellaneous), for which a subdivision in room types would be preferable, but there is no reference information for this.
As regards the Manufacturing sector, some further subdivision of 'production area' would be helpful, and it is a bit strange that the source documents do not provide a 'storage/ warehouse/shipment' area here (counted as part of the Retail/trade sector ?).

[5] Waide (2013): 'The scope for energy and CO2 savings in the EU through the use of building automation technology', http://www.leonardo-energy.org/

*Table 0-18 Subdivision of the total EU-28 non-residential building area over building types and room types (VHK, 2015). Areas are given in M $m^2$ ($10^6$ $m^2$)*

| Area data derived from report on Building Heat Demand | | |
|---|---|---|
| | % of area | EU-28 total area M $m^2$ |
| **Total Manufacturing / Industry** | **100.0%** | **2461** |
| Production Area | 60% | 1476 |
| Reception / Circulation Areas | 10% | 246 |
| Common toilets, showers, wardrobes | 10% | 246 |
| Offices | 10% | 246 |
| Technical Service Rooms | 10% | 246 |
| | | |
| **Total Retail & Wholesale / Trade** | **100.0%** | **2382** |
| Shops < 30 m2 | 27% | 643 |
| Shops > 30 m2 | 17% | 402 |
| Reception / Circulation Areas | 19% | 450 |
| Common toilets and wardrobes | 5% | 113 |
| Storeroom / Warehouse | 32% | 774 |
| | | |
| **Hotel & Restaurant (total)** | **100.0%** | **754** |
| Rooms (excl. toilet/shower) | 18% | 138 |
| Toilet/Shower in rooms | 4% | 34 |
| Common toilets/wardrobes | 4% | 27 |
| Reception/ Circulation areas | 7% | 49 |
| Breakfast / Eating areas | 38% | 285 |
| Coffee-shops, Bars, Discotheques | 10% | 78 |
| Offices | 2% | 11 |
| Meeting Rooms | 4% | 33 |
| Kitchen | 8% | 60 |
| Technical areas | 5% | 40 |
| | | |
| **Education Total** | **100.0%** | **1302** |
| Crèche, play area | 2% | 24 |
| (Pre-)Primary resting area | 5% | 63 |
| Class Rooms | 34% | 440 |
| Meeting Rooms | 12% | 160 |
| Library | 3% | 45 |
| Teacher's Room | 2% | 25 |
| Computer education area | 3% | 45 |
| Reception/ Circulation Area | 17% | 225 |
| Common toilets / wardrobes | 5% | 69 |
| Standard Offices | 10% | 134 |
| Technical Service Rooms | 5% | 71 |
| | | |
| **Hospitals/Healthcare Total** | **100.0%** | **907** |
| Wards / Bedrooms | 21% | 191 |
| Dayroom / Eating Room | 7% | 67 |
| Examination / Treatment Rooms | 20% | 180 |
| Waiting Area | 12% | 111 |
| Reception / Circulation Areas | 14% | 129 |
| Common toilets, wardrobes, showers | 9% | 80 |
| Standard offices | 5% | 49 |
| Laboratories | 7% | 66 |
| Technical Service / Production Areas | 4% | 34 |
| | | |

| Area data derived from report on Building Heat Demand | | |
|---|---|---|
| | % of area | EU-28 total area M $m^2$ |
| **Offices Total** | **100.0%** | **2115** |
| Cellular office | 31% | 660 |
| Open Plan Office (Landscape office) | 29% | 609 |
| Reception/ Circulation Area | 20% | 423 |
| Common toilets / wardrobes / showers | 7% | 148 |
| Meeting Rooms | 8% | 169 |
| Copying, Server, Archive, Technical areas | 5% | 106 |
| | | |
| **Sports Total** | **100.0%** | **544** |
| Sports Hall | 44% | 242 |
| Common toilets / wardrobes / showers | 19% | 102 |
| Reception/ Circulation Area | 12% | 66 |
| Mensa, Restaurant, Bar, Resting area | 12% | 66 |
| Offices | 12% | 68 |
| | | |
| **Parking in structures** | **100%** | **290** |
| public access | 90% | 262 |
| private access (offices) | 10% | 28 |
| | | |
| **Stations, Airports, similar (Total)** | **100%** | **107** |
| passenger/client (waiting) area | 40% | 43 |
| reception and circulation areas | 30% | 32 |
| customs and security | 5% | 5 |
| common toilets, wardrobes, etc. | 10% | 11 |
| offices | 15% | 16 |
| | | |
| **Entertainment and news (Total)** | | **617** |
| Video and Movie production and Cinemas | | 152 |
| Radio and TV | | 107 |
| Theatre, Dancing, Amusement park | | 358 |
| | | |
| **Miscellaneous (Total)** | | **294** |
| Prisons | | 34 |
| Fire service activities | | 4 |
| Waste disposal / sewage | | 37 |
| Political and religious (incl. churches) | | 152 |
| Libraries, museums, zoo | | 67 |
| | | |
| **Overall Total Non-Residential** | | **11773** |

*Table 0-19 Summary of areas (M m$^2$) per building type and comparison with data used in the Lot37 exploratory study (VITO, table 1-2 **Error! Bookmark not defined.**)*

| | EU-27 area M m$^2$ | | Share % of total | |
|---|---|---|---|---|
| | Lot 37 | Current | Task 0 | Current |
| sector | VITO | analysis | | analysis |
| | | | | |
| Education | 1001 | 1302 | 17% | 11% |
| Hotels & Restaurants | 648 | 754 | 11% | 6% |
| Hospitals (&HealthCare) | 412 | 907 | 7% | 8% |
| Retail (&Wholesale) | 883 | 2382 | 15% | 20% |
| Offices | 1354 | 2115 | 23% | 18% |
| Sports | 530 | 544 | 9% | 5% |
| Industry | 530 | 2461 | 9% | 21% |
| Other | 530 | 1308 | 9% | 11% |
| | | | | |
| **Total Non-Residential** | **5888** | **11773** | **100%** | **100%** |
| | | | | |
| Residential | 17810 | 21218 | | |

*Table 0-20 Summary of non-residential building areas (M m$^2$) per room type*

| **Subdivision per type of space in Non-Residential buildings** | EU-28 area M m$^2$ | Share % of total |
|---|---|---|
| | | |
| Circulation areas | 1620 | 13.8% |
| Manufacturing area | 1476 | 12.5% |
| Toilets, showers, wardrobes | 829 | 7.0% |
| Storeroom / Warehouse | 774 | 6.6% |
| Offices (cellular) | 660 | 5.6% |
| Shops < 30 m2 | 643 | 5.5% |
| Offices (open space) | 609 | 5.2% |
| Class rooms and similar | 573 | 4.9% |
| Offices (general, small) [6] | 525 | 4.5% |
| Technical / service areas | 502 | 4.3% |
| Eating / drinking areas | 496 | 4.2% |
| Shops > 30 m2 | 402 | 3.4% |
| Meeting rooms | 362 | 3.1% |
| Theatre, Dancing, Amusement park | 358 | 3.0% |
| Parking in structures | 290 | 2.5% |
| Sports Hall | 242 | 2.1% |
| Hospital wards/bedrooms | 191 | 1.6% |
| Examination / Treatment Rooms | 180 | 1.5% |

[6] Offices (cellular) and Offices (open space) are in office buildings. Offices (general, small) are in other building types.

| **Subdivision per type of space in Non-Residential buildings** | EU-28 area M $m^2$ | Share % of total |
|---|---|---|
| Waiting areas | 179 | 1.5% |
| Political and religious (incl. churches) | 152 | 1.3% |
| Video and Movie production and Cinemas | 152 | 1.3% |
| Hotel rooms (excl. toilet/shower) | 138 | 1.2% |
| Libraries, museums, zoo | 112 | 1.0% |
| Radio and TV | 107 | 0.9% |
| Laboratories | 66 | 0.6% |
| Kitchens | 60 | 0.5% |
| Waste disposal / sewage | 37 | 0.3% |
| Prisons | 34 | 0.3% |
| Fire service activities | 4 | 0.0% |
| | | |
| Total non-residential building area | 11773 | 100.0% |

## F3 Determination of Installed Capacity (lumens)

In this chapter, the building/room areas ($m^2$) of chapter E2 are multiplied by the lighting requirements (lux = $lm/m^2$, at task level) from EN 12464-1:2007.

The general lighting scale is 20 - 30 - 50 - 75 - 100 - 150 - 200 - 300 - 500 - 750 - 1000 - 1500 - 2000 - 3000 - 5000 Lux.

Standard EN-12464 distinguishes:

- Task area
- Surrounding area: immediately surrounding the task area, at least 0.5 m wide. Illumination in this area can be 1 scale value less than in the task area, e.g. if the task area requires 500 lux, the surrounding area can have 300 lux [7].
- Background area: at least 3 m around the surrounding area. The minimum light requirement is 1/3 of that in the surrounding area, e.g. 100 lux in the above example [8].

For most building/room types, three lighting requirements have been estimated: Etask , Esurround, and Ebackground (all in lux). In addition an estimate has been made for the subdivision of the total building/room area over these three area types: Wtask, Wsurround and Wbackground (all in percent weight). This permits the calculation of the factor Fca [9]:

Fca = (Etask * Wtask + Esurround * Wsurround + Ebackground * Wbackground) / Etask

and the calculation of an average lighting requirement on the entire building/room area:
Eavg = Fca * Etask

Multiplying this average lux requirement with the corresponding entire EU-28 area for the room type, an estimate of the total required lighting at task level is obtained for the room type:

LMtot (room type) = Eavg (room type) * Area (room type)
in lux*$m^2$ = lm (but at task level).

The contributions of the various room types can be summed to a total 'installed' lighting capacity for the sector, and next the sector totals can be summed to a total for all non-residential buildings.

The above lighting requirement is the one that has to be maintained, also after a degradation of lamps, luminaires and room surfaces with time. The initially installed

[7] According to table C.2 of EN 15193, the surrounding area lighting is equal to the task lighting if the latter is 150 lux or smaller. As stated in some references, in case of spaces with continuous work, 200 lux is a minimum.

[8] prEN 15193 recognizes the existence of the background area but states that it is not feasible to compute possible savings for this area, and consequently does NOT consider it when computing the factor Fca.

[9] See EN 15193, annex C. For calculations of the simplified method in EN 15193, the task lux (Etask) on the entire building/room area is used. The correction factor Fca reflects that a part of the area is lighted to a lower level than Etask. In this note Fca has been adapted to include also the background area.

lighting capacity will therefore be higher by a factor (1/MF). For the tables presented in this note, the Maintenance Factor MF = 0.8, which is the default value in EN 15193.

The computational inputs and outputs are shown in Table 0-21 (full list), Table 0-22 (summary per building type/sector) and Table 0-23 (summary per room/activity type.

Conclusions:

1- The total EU-28 required lighting capacity for non-residential buildings, taking into account the effects of a maintenance factor MF=0.8, is 3648 Glm (at task level). The MELISA model for 2013 gives an installed lighting capacity of 5660 Glm (at lamp level) [10]. This would imply an average utilization factor of 3648/5660 = 64%, a value that could be reasonable.

2- Office buildings account for 25% of the required lighting capacity, followed by Manufacturing/Industry (24%), Retail/Wholesale/Trade (15%) and Educational Buildings (12%). All other building types together account for 25%.

3- As regards room/activity types, circulation areas have the largest area share (13.8%), but they have a relatively low lighting requirement and consequently represent 'only' 6.4% of the total required lighting capacity.

4- Manufacturing areas have the highest share (16.2%) of the total required lighting capacity, but this is also due to the fact that this item is not further subdivided.

5- Offices have been split in cellular offices (9.0%), open space offices (9.6%), and general-small offices (7.2%) [11] that together account for 25.8% of the total required lighting capacity.

6- Taking small shops (6.2%) and large shops (3.9%) together, they represent 10% of the total required lighting capacity.

7- Meeting rooms (5.7%), class rooms (5.3%) and toilets/showers/wardrobes (5.3%) have comparable total required lighting capacities.

Notes:

- In some cases the task/surround/background subdivision is not so adequate, and the values in the three columns have a different meaning, as explained in following comments.

- For Production areas (an important item with high influence) the standard gives a large variety of reference values for a large variety of reference tasks. Values above 500 lux are for specific precision tasks and will have a minor associated area. Values of 500 and 300 lux are most common. Some tasks have requirements lower than 300 lux. In this case the task/surround/background columns with values 500, 300, 100 lux have been used to represent different tasks, and their weight is managed through the assigned area percentages.

- For Examination/Treatment rooms in healthcare, the same problem exists as for production areas, and the same approach has been chosen.

[10] The tables in MELISA give 6760 Glm, but this includes outdoor lighting. As a rough estimate, all HID lamps are used outdoor, corresponding to 1100 Glm. This leaves for indoor 6760-1100 = 5660 Glm.

[11] The first two types are inside office buildings, the latter are offices in other buildings.

- For Sports Halls, the most specific reference is EN 12193. Also here there is a wide range of lighting requirements, depending on competition level (classes I, II, III) and type of sport. In general: 500-750 lux, class I (high competition level), 300-500 lux, class II (low competition level), 200-300 lux, class III (recreational, school). In this case the task/surround/background columns with values 500, 300, 200 lux have been used to represent different situations, and their weight is managed through the assigned area percentages.

- The buildings listed under Entertainment and Miscellaneous are not split in room/activity types and therefore no lighting requirement references were available. For a large part these values are (educated) guesses, but their impact on the overall result is relatively small (around 6% in task lumens).

- In principle, special purpose lamps are excluded. For this reason areas for greenhouses and livestock breeding are not listed. Food display lighting in the retail sector is supposed to be excluded. Stage lighting in theatres and studios is also excluded. Emergency lighting is excluded.

- In principle, only indoor lighting is considered, but there are some border areas where this is vague, for example roof-top parking, zoo, amusement park, railway stations, waste disposal/sewage, …

- There may be some issues regarding the distinction between local and general lighting, e.g. reception lighting in entrance halls, local reading lights in a library, spot-lighting in shops and museums, blackboard lighting in class rooms, local table lighting in restaurants. It is vague in how far the local lighting contribution has been grasped with the general task requirements used in this note.

*Table 0-21 Estimate of the 'installed' lighting capacity at task level for non-residential buildings, full list (indoor lighting only, special purpose lamps excluded, source: VHK 2015)*

| | | | | | | | | | | Required, task level | | | Installed, task level | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| cyan fields are inputs, can be changed | Area | | Lighting Requirements | | | Relative Area Weights | | | | | | | | | | |
| | % of total area | EU-28 Area M m2 | Task area lux | Surround area lux | Background area lux | Task area % | Surround area % | Background area % | | Fca | Entire area average req. lux | EU-28 lm required at task level Giga lm | MF | Entire area average inst. lux | EU-28 lm installed at task level Giga lm | % of total lumen |
| **Total Manufacturing / Industry** | **20.9%** | **2461** | 403 | 248 | 83 | 38% | 45% | 16% | | 69% | **279** | **685** | **0.8** | **348** | **857** | **23.5%** |
| Production Area | 12.5% | 1476 | 500 | 300 | 100 | 30% | 50% | 20% | | 64% | 320 | 472 | 0.8 | 400 | 591 | 16.2% |
| Reception / Circulation Areas | 2.1% | 246 | 125 | 75 | 25 | 80% | 20% | 0% | | 92% | 115 | 28 | 0.8 | 144 | 35 | 1.0% |
| Common toilets, showers, wardrobes | 2.1% | 246 | 200 | 150 | 50 | 70% | 30% | 0% | | 93% | 185 | 46 | 0.8 | 231 | 57 | 1.6% |
| Offices | 2.1% | 246 | 500 | 300 | 100 | 60% | 30% | 10% | | 80% | 400 | 98 | 0.8 | 500 | 123 | 3.4% |
| Technical Service Rooms | 2.1% | 246 | 200 | 150 | 50 | 50% | 40% | 10% | | 83% | 165 | 41 | 0.8 | 206 | 51 | 1.4% |
| | | | | | | | | | | | | | | | | |
| **Total Retail & Wholesale / Trade** | **20.2%** | **2382** | 197 | 133 | 44 | 75% | 22% | 4% | | 91% | **179** | **425** | **0.8** | **223** | **532** | **14.6%** |
| Shops < 30 m2 | 5.5% | 643 | 300 | 200 | 67 | 80% | 20% | 0% | | 93% | 280 | 180 | 0.8 | 350 | 225 | 6.2% |
| Shops > 30 m2 | 3.4% | 402 | 300 | 200 | 67 | 80% | 20% | 0% | | 93% | 280 | 113 | 0.8 | 350 | 141 | 3.9% |
| Reception / Circulation Areas | 3.8% | 450 | 125 | 75 | 25 | 80% | 20% | 0% | | 92% | 115 | 52 | 0.8 | 144 | 65 | 1.8% |
| Common toilets and wardrobes | 1.0% | 113 | 200 | 150 | 50 | 70% | 30% | 0% | | 93% | 185 | 21 | 0.8 | 231 | 26 | 0.7% |
| Storeroom / Warehouse | 6.6% | 774 | 100 | 75 | 25 | 50% | 30% | 20% | | 78% | 78 | 60 | 0.8 | 97 | 75 | 2.1% |
| | | | | | | | | | | | | | | | | |
| **Hotel & Restaurant (total)** | **6.4%** | **754** | 255 | 175 | 58 | 52% | 43% | 7% | | 82% | **210** | **158** | **0.8** | **262** | **198** | **5.4%** |
| Rooms (excl. toilet/shower) | 1.2% | 138 | 300 | 200 | 67 | 20% | 60% | 20% | | 64% | 193 | 27 | 0.8 | 242 | 33 | 0.9% |
| Toilet/Shower in rooms | 0.3% | 34 | 200 | 150 | 50 | 70% | 30% | 0% | | 93% | 185 | 6 | 0.8 | 231 | 8 | 0.2% |
| Common toilets/wardrobes | 0.2% | 27 | 200 | 150 | 50 | 70% | 30% | 0% | | 93% | 185 | 5 | 0.8 | 231 | 6 | 0.2% |
| Reception/ Circulation areas | 0.4% | 49 | 125 | 75 | 25 | 80% | 20% | 0% | | 92% | 115 | 6 | 0.8 | 144 | 7 | 0.2% |
| Breakfast / Eating areas | 2.4% | 285 | 200 | 150 | 50 | 50% | 50% | 0% | | 88% | 175 | 50 | 0.8 | 219 | 62 | 1.7% |
| Coffeeshops, Bars, Discotheques | 0.7% | 78 | 200 | 150 | 50 | 30% | 50% | 20% | | 73% | 145 | 11 | 0.8 | 181 | 14 | 0.4% |
| Offices | 0.1% | 11 | 500 | 300 | 100 | 60% | 30% | 10% | | 80% | 400 | 5 | 0.8 | 500 | 6 | 0.2% |
| Meeting Rooms | 0.3% | 33 | 500 | 300 | 100 | 80% | 20% | 0% | | 92% | 460 | 15 | 0.8 | 575 | 19 | 0.5% |
| Kitchen | 0.5% | 60 | 500 | 300 | 100 | 80% | 20% | 0% | | 92% | 460 | 27 | 0.8 | 575 | 34 | 0.9% |
| Technical areas | 0.3% | 40 | 200 | 150 | 50 | 50% | 40% | 10% | | 83% | 165 | 7 | 0.8 | 206 | 8 | 0.2% |
| | | | | | | | | | | | | | | | | |
| **Education Total** | **11.1%** | **1302** | 306 | 193 | 64 | 72% | 24% | 2% | | 88% | **270** | **352** | **0.8** | **338** | **440** | **12.1%** |
| Creche, play area | 0.2% | 24 | 300 | 200 | 67 | 80% | 20% | 0% | | 93% | 280 | 7 | 0.8 | 350 | 8 | 0.2% |
| (Pre-)Primary resting area | 0.5% | 63 | 200 | 150 | 50 | 80% | 20% | 0% | | 95% | 190 | 12 | 0.8 | 238 | 15 | 0.4% |
| Class Rooms | 3.7% | 440 | 300 | 200 | 67 | 80% | 20% | 0% | | 93% | 280 | 123 | 0.8 | 350 | 154 | 4.2% |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Required, task level | | | | Installed, task level | | | |
| cyan fields are inputs, can be changed | Area | | | Lighting Requirements | | | Relative Area Weights | | | | | | | | | | | |
| | % of total area | EU-28 Area M m2 | | Task area lux | Surround area lux | Background area lux | Task area % | Surround area % | Background area % | Fca | Entire area average req. lux | EU-28 lm required at task level Giga lm | | MF | Entire area average inst. lux | EU-28 lm installed at task level Giga lm | | % of total lumen |
| Meeting Rooms | 1.4% | 160 | | 500 | 300 | 100 | 80% | 20% | 0% | 92% | 460 | 73 | | 0.8 | 575 | 92 | | 2.5% |
| Library | 0.4% | 45 | | 500 | 200 | 67 | 30% | 60% | 10% | 55% | 277 | 13 | | 0.8 | 346 | 16 | | 0.4% |
| Teacher's Room | 0.2% | 25 | | 300 | 200 | 67 | 80% | 20% | 0% | 93% | 280 | 7 | | 0.8 | 350 | 9 | | 0.2% |
| Computer education area | 0.4% | 45 | | 300 | 200 | 67 | 80% | 20% | 0% | 93% | 280 | 13 | | 0.8 | 350 | 16 | | 0.4% |
| Reception/ Circulation Area | 1.9% | 225 | | 125 | 75 | 25 | 80% | 20% | 0% | 92% | 115 | 26 | | 0.8 | 144 | 32 | | 0.9% |
| Common toilets / wardrobes | 0.6% | 69 | | 200 | 150 | 50 | 70% | 30% | 0% | 93% | 185 | 13 | | 0.8 | 231 | 16 | | 0.4% |
| Standard Offices | 1.1% | 134 | | 500 | 300 | 100 | 60% | 30% | 10% | 80% | 400 | 54 | | 0.8 | 500 | 67 | | 1.8% |
| Technical Service Rooms | 0.6% | 71 | | 200 | 150 | 50 | 50% | 40% | 10% | 83% | 165 | 12 | | 0.8 | 206 | 15 | | 0.4% |
| | | | | | | | | | | | | | | | | | | |
| **Hospitals/Healthcare Total** | **7.7%** | **907** | | 308 | 178 | 59 | 59% | 32% | 6% | 79% | **242** | **219** | | **0.8** | **303** | **274** | | **7.5%** |
| Wards / Bedrooms | 1.6% | 191 | | 300 | 100 | 33 | 30% | 60% | 10% | 51% | 153 | 29 | | 0.8 | 192 | 37 | | 1.0% |
| Dayroom / Eating Room | 0.6% | 67 | | 200 | 150 | 50 | 50% | 50% | 0% | 88% | 175 | 12 | | 0.8 | 219 | 15 | | 0.4% |
| Examination / Treatment Rooms | 1.5% | 180 | | 500 | 300 | 100 | 60% | 30% | 10% | 80% | 400 | 72 | | 0.8 | 500 | 90 | | 2.5% |
| Waiting Area | 0.9% | 111 | | 200 | 150 | 50 | 80% | 20% | 0% | 95% | 190 | 21 | | 0.8 | 238 | 26 | | 0.7% |
| Reception / Circulation Areas | 1.1% | 129 | | 125 | 75 | 25 | 80% | 20% | 0% | 92% | 115 | 15 | | 0.8 | 144 | 18 | | 0.5% |
| Common toilets, wardrobes, showers | 0.7% | 80 | | 200 | 150 | 50 | 70% | 30% | 0% | 93% | 185 | 15 | | 0.8 | 231 | 19 | | 0.5% |
| Standard offices | 0.4% | 49 | | 500 | 300 | 100 | 60% | 30% | 10% | 80% | 400 | 20 | | 0.8 | 500 | 25 | | 0.7% |
| Laboratories | 0.6% | 66 | | 500 | 300 | 100 | 80% | 20% | 0% | 92% | 460 | 31 | | 0.8 | 575 | 38 | | 1.0% |
| Technical Service / Production Areas | 0.3% | 34 | | 200 | 150 | 50 | 50% | 40% | 10% | 83% | 165 | 6 | | 0.8 | 206 | 7 | | 0.2% |
| | | | | | | | | | | | | | | | | | | |
| **Offices Total** | **18.0%** | **2115** | | 389 | 237 | 79 | 71% | 25% | 4% | 87% | **339** | **718** | | **0.8** | **424** | **897** | | **24.6%** |
| Cellular office | 5.6% | 660 | | 500 | 300 | 100 | 60% | 30% | 10% | 80% | 400 | 264 | | 0.8 | 500 | 330 | | 9.0% |
| Open Plan Office (Landscape office) | 5.2% | 609 | | 500 | 300 | 100 | 80% | 20% | 0% | 92% | 460 | 280 | | 0.8 | 575 | 350 | | 9.6% |
| Reception/ Circulation Area | 3.6% | 423 | | 125 | 75 | 25 | 80% | 20% | 0% | 92% | 115 | 49 | | 0.8 | 144 | 61 | | 1.7% |
| Common toilets / wardrobes / showers | 1.3% | 148 | | 200 | 150 | 50 | 70% | 30% | 0% | 93% | 185 | 27 | | 0.8 | 231 | 34 | | 0.9% |
| Meeting Rooms | 1.4% | 169 | | 500 | 300 | 100 | 80% | 20% | 0% | 92% | 460 | 78 | | 0.8 | 575 | 97 | | 2.7% |
| Copying, Server, Archive, Technical areas | 0.9% | 106 | | 200 | 150 | 50 | 70% | 30% | 0% | 93% | 185 | 20 | | 0.8 | 231 | 24 | | 0.7% |
| | | | | | | | | | | | | | | | | | | |
| **Sports Total** | **4.6%** | **544** | | 362 | 226 | 120 | 38% | 47% | 16% | 73% | **263** | **143** | | **0.8** | **329** | **179** | | **4.9%** |
| Sports Hall | 2.1% | 242 | | 500 | 300 | 200 | 20% | 60% | 20% | 64% | 320 | 77 | | 0.8 | 400 | 97 | | 2.7% |
| Common toilets / wardrobes / showers | 0.9% | 102 | | 200 | 150 | 50 | 70% | 30% | 0% | 93% | 185 | 19 | | 0.8 | 231 | 24 | | 0.6% |
| Reception/ Circulation Area | 0.6% | 66 | | 125 | 75 | 25 | 80% | 20% | 0% | 92% | 115 | 8 | | 0.8 | 144 | 9 | | 0.3% |
| Mensa, Restaurant, Bar, Resting area | 0.6% | 66 | | 200 | 150 | 50 | 70% | 30% | 0% | 93% | 185 | 12 | | 0.8 | 231 | 15 | | 0.4% |
| Offices | 0.6% | 68 | | 500 | 300 | 100 | 60% | 30% | 10% | 80% | 400 | 27 | | 0.8 | 500 | 34 | | 0.9% |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| cyan fields are inputs, can be changed | Area | | | Lighting Requirements | | | Relative Area Weights | | | | Required, task level | | | | Installed, task level | | | | |
| | % of total area | EU-28 Area M m2 | | Task area lux | Surround area lux | Background area lux | Task area % | Surround area % | Background area % | | Fca | Entire area average req. lux | EU-28 lm required at task level Giga lm | | MF | Entire area average inst. lux | EU-28 lm installed at task level Giga lm | | % of total lumen |
| | | | | | | | | | | | | | | | | | | | |
| **Parking in structures** | **2.5%** | **290** | | 75 | 50 | 17 | 60% | 30% | 10% | | 82% | **62** | **18** | | **0.8** | **77** | **22** | | **0.6%** |
| public access | 2.2% | 262 | | 75 | 50 | 17 | 60% | 30% | 10% | | 82% | 62 | 16 | | 0.8 | 77 | 20 | | 0.6% |
| private access (offices) | 0.2% | 28 | | 75 | 50 | 17 | 60% | 30% | 10% | | 82% | 62 | 2 | | 0.8 | 77 | 2 | | 0.1% |
| | | | | | | | | | | | | | | | | | | | |
| **Stations, Airports, similar (Total)** | **0.9%** | **107** | | 238 | 158 | 53 | 71% | 25% | 4% | | 88% | **209** | **22** | | **0.8** | **261** | **28** | | **0.8%** |
| passenger/client (waiting) area | 0.4% | 42.8 | | 200 | 150 | 50 | 80% | 20% | 0% | | 95% | 190 | 8 | | 0.8 | 238 | 10 | | 0.3% |
| reception and circulation areas | 0.3% | 32.1 | | 125 | 75 | 25 | 80% | 20% | 0% | | 92% | 115 | 4 | | 0.8 | 144 | 5 | | 0.1% |
| customs and security | 0.0% | 5.35 | | 500 | 300 | 100 | 60% | 30% | 10% | | 80% | 400 | 2 | | 0.8 | 500 | 3 | | 0.1% |
| common toilets, wardrobes, etc. | 0.1% | 10.7 | | 200 | 150 | 50 | 70% | 30% | 0% | | 93% | 185 | 2 | | 0.8 | 231 | 2 | | 0.1% |
| offices | 0.1% | 16.05 | | 500 | 300 | 100 | 60% | 30% | 10% | | 80% | 400 | 6 | | 0.8 | 500 | 8 | | 0.2% |
| | | | | | | | | | | | | | | | | | | | |
| **Entertainment and news (Total)** | **5.2%** | **617** | | 217 | 159 | 53 | 80% | 20% | 0% | | 95% | **206** | **127** | | **0.8** | **257** | **159** | | **4.3%** |
| Video and Movie production and Cinemas | 1.3% | 152 | | 200 | 150 | 50 | 80% | 20% | 0% | | 95% | 190 | 29 | | 0.8 | 238 | 36 | | 1.0% |
| Radio and TV | 0.9% | 107 | | 300 | 200 | 67 | 80% | 20% | 0% | | 93% | 280 | 30 | | 0.8 | 350 | 37 | | 1.0% |
| Theater, Dancing, Amusementpark | 3.0% | 358 | | 200 | 150 | 50 | 80% | 20% | 0% | | 95% | 190 | 68 | | 0.8 | 238 | 85 | | 2.3% |
| | | | | | | | | | | | | | | | | | | | |
| **Miscellaneous (Total)** | **2.5%** | **294** | | 184 | 123 | 41 | 80% | 20% | 0% | | 93% | **172** | **50** | | **0.8** | **215** | **63** | | **1.7%** |
| Prisons | 0.3% | 34 | | 200 | 150 | 50 | 80% | 20% | 0% | | 95% | 190 | 6 | | 0.8 | 238 | 8 | | 0.2% |
| Fire service activities | 0.0% | 4 | | 200 | 150 | 50 | 80% | 20% | 0% | | 95% | 190 | 1 | | 0.8 | 238 | 1 | | 0.0% |
| Waste disposal / sewage | 0.3% | 37 | | 200 | 150 | 50 | 80% | 20% | 0% | | 95% | 190 | 7 | | 0.8 | 238 | 9 | | 0.2% |
| Political and religious (incl. churches) | 1.3% | 152 | | 125 | 75 | 25 | 80% | 20% | 0% | | 92% | 115 | 17 | | 0.8 | 144 | 22 | | 0.6% |
| Libraries, museums, zoo | 0.6% | 67 | | 300 | 200 | 67 | 80% | 20% | 0% | | 93% | 280 | 19 | | 0.8 | 350 | 23 | | 0.6% |
| | | | | | | | | | | | | | | | | | | | |
| **Total Non-Residential (task level)** | **100.0%** | **11773** | | **305** | **192** | **66** | **59%** | **32%** | **8%** | | **81%** | **248** | **2918** | | **0.8** | **310** | **3648** | | **100.0%** |
| MELISA 2013 non-residential (lamp level) | | | | | | | | | | | | | | | | | 6760 | | |
| MELISA 2013 outdoor (all HID) | | | | | | | | | | | | | | | | | 1100 | | |
| **MELISA 2013 indoor (lamp level)** | | | | | | | | | | | | | | | | | **5660** | | |
| **implied utilization factor** | | | | | | | | | | | | | | | | | **64%** | | |

*Table 0-22 Estimate of the 'installed' lighting capacity at task level for non-residential buildings, summary per building type/sector (indoor lighting only, special purpose lamps excluded, source: VHK 2015)*

| | | | | | | | | | | Required, task level | | | | Installed, task level | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Summary per type of building | Area | | | Lighting Requirements | | | Relative Area Weights | | | Fca | Entire area average req. lux | EU-28 lm required at task level Giga lm | | MF | Entire area average inst. lux | EU-28 lm installed at task level Giga lm | | % of total lumen |
| | % of total area | EU-28 Area M m2 | | Task area lux | Surround area lux | Background area lux | Task area % | Surround area % | Background area % | | | | | | | | | |
| Office buildings | 18.0% | 2115 | | 389 | 237 | 79 | 71% | 25% | 4% | 87% | 339 | 718 | | 0.8 | 424 | 897 | | 24.6% |
| Manufacturing / Industry | 20.9% | 2461 | | 403 | 248 | 83 | 38% | 45% | 16% | 69% | 279 | 685 | | 0.8 | 348 | 857 | | 23.5% |
| Retail & Wholesale / Trade | 20.2% | 2382 | | 197 | 133 | 44 | 75% | 22% | 4% | 91% | 179 | 425 | | 0.8 | 223 | 532 | | 14.6% |
| Educational buildings | 11.1% | 1302 | | 306 | 193 | 64 | 72% | 24% | 2% | 88% | 270 | 352 | | 0.8 | 338 | 440 | | 12.1% |
| Hospitals/Healthcare | 7.7% | 907 | | 308 | 178 | 59 | 59% | 32% | 6% | 79% | 242 | 219 | | 0.8 | 303 | 274 | | 7.5% |
| Hotels & Restaurants | 6.4% | 754 | | 255 | 175 | 58 | 52% | 43% | 7% | 82% | 210 | 158 | | 0.8 | 262 | 198 | | 5.4% |
| Sports buildings | 4.6% | 544 | | 362 | 226 | 120 | 38% | 47% | 16% | 73% | 263 | 143 | | 0.8 | 329 | 179 | | 4.9% |
| Entertainment and news | 5.2% | 617 | | 217 | 159 | 53 | 80% | 20% | 0% | 95% | 206 | 127 | | 0.8 | 257 | 159 | | 4.3% |
| Miscellaneous buildings | 2.5% | 294 | | 184 | 123 | 41 | 80% | 20% | 0% | 93% | 172 | 50 | | 0.8 | 215 | 63 | | 1.7% |
| Stations, Airports, similar | 0.9% | 107 | | 238 | 158 | 53 | 71% | 25% | 4% | 88% | 209 | 22 | | 0.8 | 261 | 28 | | 0.8% |
| Parking in structures | 2.5% | 290 | | 75 | 50 | 17 | 60% | 30% | 10% | 82% | 62 | 18 | | 0.8 | 77 | 22 | | 0.6% |
| | | | | | | | | | | | | | | | | | | |
| **Total Non-Residential (task level)** | **100.0%** | **11773** | | **305** | **192** | **66** | **59%** | **32%** | **8%** | **81%** | **248** | **2918** | | **0.8** | **310** | **3648** | | **100.0%** |
| **MELISA 2013 (lamp level)** | | | | | | | | | | | | | | | | **5660** | | |
| **implied utilization factor** | | | | | | | | | | | | | | | | **64%** | | |

*Table 0-23 Estimate of the 'installed' lighting capacity at task level for non-residential buildings, summary per room/activity type (indoor lighting only, special purpose lamps excluded, source: VHK 2015)*

| Summary per type of space | Area | | | Lighting Requirements | | | Relative Area Weights | | | | Required, task level | | | | Installed, task level | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % of total area | EU-28 Area M m2 | | Task area lux | Surround area lux | Background area lux | Task area % | Surround area % | Background area % | | Fca | Average required lux | EU-28 required Giga lm | | MF | Average installed lux | EU-28 installed Giga lm | % of total lumen |
| manufacturing area | 12.5% | 1476 | | 500 | 300 | 100 | 30% | 50% | 20% | | 64% | 320 | 472 | | 0.8 | 400 | 591 | 16.2% |
| offices (open space) | 5.2% | 609 | | 500 | 300 | 100 | 80% | 20% | 0% | | 92% | 460 | 280 | | 0.8 | 575 | 350 | 9.6% |
| offices (cellular) | 5.6% | 660 | | 500 | 300 | 100 | 60% | 30% | 10% | | 80% | 400 | 264 | | 0.8 | 500 | 330 | 9.0% |
| offices (general, small) | 4.5% | 525 | | 500 | 300 | 100 | 60% | 30% | 10% | | 80% | 400 | 210 | | 0.8 | 500 | 262 | 7.2% |
| circulation areas | 13.8% | 1620 | | 125 | 75 | 25 | 80% | 20% | 0% | | 92% | 115 | 186 | | 0.8 | 144 | 233 | 6.4% |
| Shops < 30 m2 | 5.5% | 643 | | 300 | 200 | 67 | 80% | 20% | 0% | | 93% | 280 | 180 | | 0.8 | 350 | 225 | 6.2% |
| meeting rooms | 3.1% | 362 | | 500 | 300 | 100 | 80% | 20% | 0% | | 92% | 460 | 166 | | 0.8 | 575 | 208 | 5.7% |
| Class rooms and similar | 4.9% | 573 | | 289 | 194 | 65 | 80% | 20% | 0% | | 93% | 270 | 155 | | 0.8 | 338 | 193 | 5.3% |
| toilets, showers, wardrobes | 7.0% | 829 | | 200 | 150 | 50 | 70% | 30% | 0% | | 93% | 185 | 153 | | 0.8 | 231 | 192 | 5.3% |
| Shops > 30 m2 | 3.4% | 402 | | 300 | 200 | 67 | 80% | 20% | 0% | | 93% | 280 | 113 | | 0.8 | 350 | 141 | 3.9% |
| technical / service areas | 4.3% | 502 | | 203 | 152 | 51 | 54% | 38% | 8% | | 85% | 172 | 86 | | 0.8 | 215 | 108 | 3.0% |
| eating / drinking areas | 4.2% | 496 | | 200 | 150 | 50 | 50% | 47% | 3% | | 86% | 172 | 85 | | 0.8 | 215 | 106 | 2.9% |
| Sports Hall | 2.1% | 242 | | 500 | 300 | 200 | 20% | 60% | 20% | | 64% | 320 | 77 | | 0.8 | 400 | 97 | 2.7% |
| Examination / Treatment Rooms | 1.5% | 180 | | 500 | 300 | 100 | 60% | 30% | 10% | | 80% | 400 | 72 | | 0.8 | 500 | 90 | 2.5% |
| Theatre, Dancing, Amusement park | 3.0% | 358 | | 200 | 150 | 50 | 80% | 20% | 0% | | 95% | 190 | 68 | | 0.8 | 238 | 85 | 2.3% |
| Storeroom / Warehouse | 6.6% | 774 | | 100 | 75 | 25 | 50% | 30% | 20% | | 78% | 78 | 60 | | 0.8 | 97 | 75 | 2.1% |
| waiting areas | 1.5% | 179 | | 214 | 157 | 52 | 80% | 20% | 0% | | 95% | 203 | 36 | | 0.8 | 253 | 45 | 1.2% |
| Libraries, museums, zoo | 1.0% | 112 | | 381 | 200 | 67 | 53% | 36% | 4% | | 73% | 279 | 31 | | 0.8 | 348 | 39 | 1.1% |
| Laboratories | 0.6% | 66 | | 500 | 300 | 100 | 80% | 20% | 0% | | 92% | 460 | 31 | | 0.8 | 575 | 38 | 1.0% |
| Radio and TV | 0.9% | 107 | | 300 | 200 | 67 | 80% | 20% | 0% | | 93% | 280 | 30 | | 0.8 | 350 | 37 | 1.0% |
| Hospital wards/bedrooms | 1.6% | 191 | | 300 | 100 | 33 | 30% | 60% | 10% | | 51% | 153 | 29 | | 0.8 | 192 | 37 | 1.0% |
| Video and Movie prod. and Cinemas | 1.3% | 152 | | 200 | 150 | 50 | 80% | 20% | 0% | | 95% | 190 | 29 | | 0.8 | 238 | 36 | 1.0% |
| Kitchens | 0.5% | 60 | | 500 | 300 | 100 | 80% | 20% | 0% | | 92% | 460 | 27 | | 0.8 | 575 | 34 | 0.9% |
| Hotel rooms (excl. toilet/shower) | 1.2% | 138 | | 300 | 200 | 67 | 20% | 60% | 20% | | 64% | 193 | 27 | | 0.8 | 242 | 33 | 0.9% |
| Political and religious (incl. churches) | 1.3% | 152 | | 125 | 75 | 25 | 80% | 20% | 0% | | 92% | 115 | 17 | | 0.8 | 144 | 22 | 0.6% |
| Parking in structures | 2.5% | 290 | | 75 | 50 | 17 | 60% | 30% | 10% | | 82% | 62 | 18 | | 0.8 | 77 | 22 | 0.6% |
| Waste disposal / sewage | 0.3% | 37 | | 200 | 150 | 50 | 80% | 20% | 0% | | 95% | 190 | 7 | | 0.8 | 238 | 9 | 0.2% |
| Prisons | 0.3% | 34 | | 200 | 150 | 50 | 80% | 20% | 0% | | 95% | 190 | 6 | | 0.8 | 238 | 8 | 0.2% |
| Fire service activities | 0.0% | 4 | | 200 | 150 | 50 | 80% | 20% | 0% | | 95% | 190 | 1 | | 0.8 | 238 | 1 | 0.0% |
| | | | | | | | | | | | | | | | | | | |
| **Total Non-Residential (task level)** | **100%** | **11773** | | **305** | **192** | **66** | **59%** | **32%** | **8%** | | **81%** | **248** | **2918** | | **0.8** | **310** | **3648** | **100.0** |

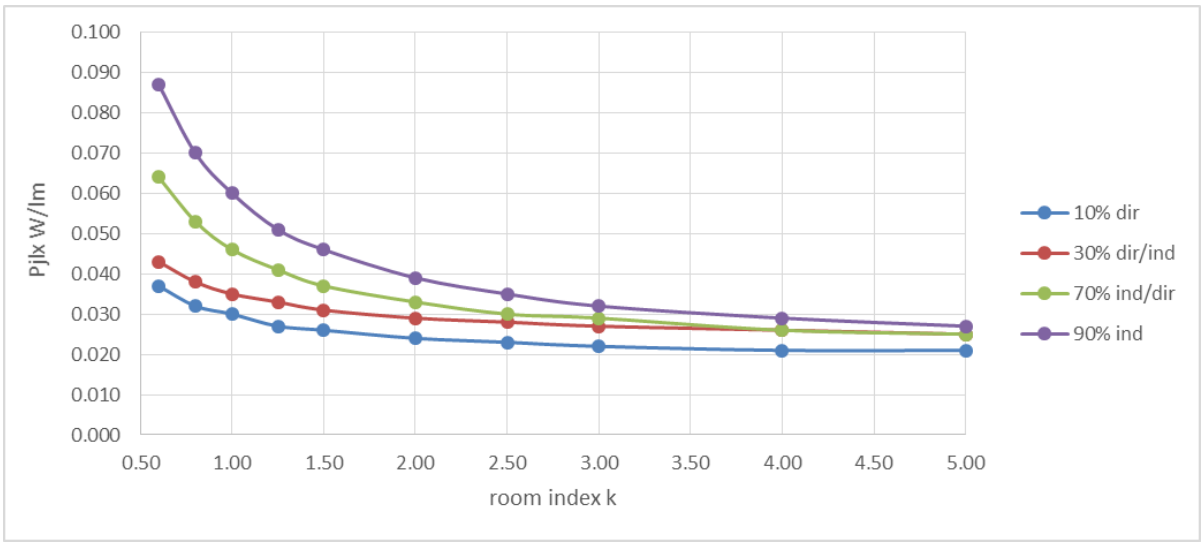
# F4 Determination of Installed Power

## F4.1 Source

The installed lighting power is calculated by multiplying the required lighting capacity (lux*$m^2$ = lm) of chapter E3 by the power density values Pjlx (W/$m^2$/lux = W/lm) suggested in prEN15193-1 table C.1. These values depend on room surface dimensions, the height distance between luminaire and task plane, and the upward flux fractions (UFF) of the luminaires (direct or indirect lighting). For convenience the table is reported below.

*Table 0-24 Power densities Pjlx (W/$m^2$/lux) according to prEN 15193 table C.1. Valid for MF=0.8, 60 luminaire lumens per circuit Watt, reflection coefficients 0.7/0.5/0.2.*

| room index k | | upward flux fraction (UFF) | | | |
|---|---|---|---|---|---|
| | | 10% | 30% | 70% | 90% |
| | | dir | dir/ind | ind/dir | ind |
| | | | | | |
| 0.60 | | 0.037 | 0.043 | 0.064 | 0.087 |
| 0.80 | | 0.032 | 0.038 | 0.053 | 0.070 |
| 1.00 | | 0.030 | 0.035 | 0.046 | 0.060 |
| 1.25 | | 0.027 | 0.033 | 0.041 | 0.051 |
| 1.50 | | 0.026 | 0.031 | 0.037 | 0.046 |
| 2.00 | | 0.024 | 0.029 | 0.033 | 0.039 |
| 2.50 | | 0.023 | 0.028 | 0.030 | 0.035 |
| 3.00 | | 0.022 | 0.027 | 0.029 | 0.032 |
| 4.00 | | 0.021 | 0.026 | 0.026 | 0.029 |
| 5.00 | | 0.021 | 0.025 | 0.025 | 0.027 |




Approximate equations (slightly underestimate Pjlx for k < 0.8):

UFF 10%: Pjlx = $0.0300*k^{-0.266}$, $R^2$=0.95
UFF 30%: Pjlx = $0.0356*k^{-0.246}$, $R^2$=0.96
UFF 70%: Pjlx = $0.0469*k^{-0.440}$, $R^2$=0.97
UFF 90%: Pjlx = $0.0604*k^{-0.553}$, $R^2$=0.98

The Pjlx values of the table are valid for:

- room index k ≥ 0.6; if k > 5, use k=5.
- maintenance factor MF=0.8.
- an efficacy of 60 luminaire lumens per circuit Watt. This is expected to include the power consumption of ballasts/control gears.
- reflection coefficients of ceiling (70%), walls (50%) and floor (20%). This is not explicitly stated, but these values are used as defaults elsewhere in the standard.

The room index k is calculated as k = (L*W) / (hm*(L+W)), where L and W are the room length and width, and hm is the vertical distance between the luminaires and the task level plane (not always identical to the room height).

For given room dimensions (L,W), the room index value k decreases (higher installed power) when height hm is increased.

For a given height hm of the luminaires with respect to the task plane, the room index value k increases (lower installed power) when room dimensions (L,W) are increased.

### F4.2 Estimates for power density

The table for the determination of Pjlx has two entries: upward flux fraction UFF and room index k.

As an EU-28 average, it has been assumed that upward flux fractions vary from 10% (direct lighting) to 30% (direct/indirect lighting). This means that areas with high UFF (50-90%, less efficient) have been assumed to be compensated by areas with low UFF (10-20%, more efficient), so that the average does not exceed UFF=30%.

Even for a specific room/activity type the variety of room dimensions and luminaire heights is practically infinite, so it is not an easy task to estimate an European average. The estimate has been performed by assuming three different sets of typical room dimensions (L, W, hm) for each room/activity type, more or less corresponding to small (low k), medium, and large (high k) and then assigning (guessed) area-weights to these three types. Each of the three variants also has a corresponding UFF value, that has usually been chosen high (30%) for small spaces (low k) and low (10%) for large spaces (high k), in order to create a larger variation in Pjlx values.

For each of the three room variants the Pjlx power density values are derived from the table in prEN 15193 and then weight-averaged.

The assumed room dimensions, room index, upward flux fractions, power densities and average-weighted power density are shown in Table 0-26. The average Pjlx values range from 0.021 W/lm for parkings to 0.035 W/lm for technical service rooms, with an overall average of 0.030 W/lm. The latter average has also been used for the buildings in the Entertainment and Miscellaneous sectors, where no subdivision in room types is available.

### F4.3 Estimates for installed power

The installed power is estimated, according to prEN 15193 simplified method, as:

$$P = \text{Area } (m^2) * \text{Etask (lux)} * \text{Fca (-)} * \text{Pjlx } (W/m^2/lux) * \text{Fmf} \quad \text{(Watt)}$$

The values for Pjlx are reportedly valid for a maintenance factor MF=0.8. It has therefore been assumed that the increase in installed lumen/power due to MF is already

accounted for in the Pjlx values. Consequently the factor (1/MF) is not included in this formula. The data presented here are for MF=0.8, so that the correction factor Fmf = 0.8/MF=1.0.
**The values for Pjlx are valid for an overall efficacy of 60 luminaire lumens per circuit Watt (assumed to include ballast power),** in tables hereafter also referred as 60 LL/W. If light source types are used that lead to a different efficacy, prEN 15193 prescribes the use of a correction factor FL as shown in Table 0-25. Such a correction factor has NOT been applied yet, because it would require deriving a mix of light source types for each room/activity type: this is a time-consuming activity that could be done in a future extension of this study. The factor FL has been taken into account during the comparison with the MELISA values, see 'conclusions'.

The estimated installed lighting power and its density are shown in the last columns of Table 0-26 (full list), Table 0-27 (summary per building type) and Table 0-28 (summary per room/activity type).

*Table 0-25 Values for the efficiency factor FL according to EN 15193-2, table C.10*

| Lamp type | Median value for FL | Range of values for FL |
|---|---|---|
| Metal Halide | 0.99 | 0.93 – 1.10 |
| CFL | 1.56 | 1.32 – 1.93 |
| LED | 0.86 | 0.69 – 0.97 |
| LFL T5 (16 mm) | 0.90 | 0.79 – 1.04 |
| LFL T8 (26 mm) | 0.95 | 0.84 – 1.11 |
| Halogen | 4.49 | 3.27 – 5.39 |
| High Pressure Sodium | 1.01 | 0.94 – 1.06 |
| Incandescent | 6.36 | 6.13 – 6.65 |

Conclusions:

1- The total EU-28 installed lighting power in non-residential buildings, considering a maintenance factor MF=0.8, and an efficacy of 60 luminaire lumens per circuit Watt, is estimated at 87 GW [12]. Using the MELISA mix of lamp types for the non-residential sector [13] and the efficacy correction factors of Table 0-25, a correction factor FL=1.28 results, and the estimate for the installed power would become 87*1.28 = 111 GW. The MELISA model for 2013 gives an installed lighting power of 106 GW [14], which is a very close match.

2- The estimated power density is 7.4 W/m$^2$ (@ 60 lm/W luminaire efficacy), which should be corrected to 7.4*1.28 = 9.5 W/m$^2$ if the MELISA mix of lamp types is assumed. The MELISA value for 2013 is 9.0 W/m$^2$.

3- As regards the building/sector types, the percent shares of total installed lighting power are close to the percent shares of total required lighting capacity at task level. The reason for this is that all power density values Pjlx are estimated to be close to the average of 0.030 W/m$^2$/lux (values vary from 0.029

[12] This is understood to be inclusive ballast/control gear power, but exclusives controls and standby.
[13] excluding HID, assumed for outdoor use
[14] For the entire non-residential sector the MELISA tables give a value of 112 GW, but this is exclusive ballast power. Using the MELISA ballast factors the total inclusive ballast power is 121 GW. This also includes outdoor lighting. As a rough estimate, all HID lamps are used outdoor, corresponding to 16 GW (including ballast). This leaves for indoor 106 GW.

to 0.032, with the exception of parkings that have 0.022). In part this could also be caused by the assumption that all sectors have the same efficacy of 60 luminaire lumens per circuit Watt.

4- As regards entire buildings/sectors, the installed power density is highest for office buildings (9.8 W/m$^2$ @ 60 lm/W luminaire efficacy), followed by Education (8.5 W/m$^2$), Industry (8.1 W/m$^2$) and Sports (7.7 W/m$^2$). By far the lowest density is found for parkings (1.3 W/m$^2$).

5- As regards room/activity types, the spread in Pjlx values is higher, ranging from 0.024 W/m$^2$/lux for open offices to 0.036 for small shops (again, parkings have 0.022). The difference between open offices (0.024) and cellular offices (0.032-0.033) is noteworthy.

6- As regards room/activity types, the installed power density is highest for meeting rooms (13.8 W/m$^2$ @ 60 lm/W luminaire efficacy), small offices (13.4), kitchens (13.0), cellular offices (12.9), laboratories (12.4), examination/treatment rooms (11.6) and open offices (11.1). The smallest values are estimated for parkings (1.3 W/m$^2$ @ 60 lm/W luminaire efficacy), store rooms/warehouses (2.3), churches (3.5), circulation areas (3.7) and hospital wards/bedrooms (4.4).

*Table 0-26 Room indexes, Upward flux fractions and estimated Power densities Pjlx (W/m²/lux) according to prEN 15193 table C.1. Last columns show the estimate for the EU-28 installed total lighting power and its density per m². (Valid for MF=0.8, 60 luminaire lumens per circuit Watt, reflection coefficients 0.7/0.5/0.2; source: VHK 2015).*

| cyan fields are inputs, can be changed | power estimate, reference case 1 | | | | | | | power estimate, reference case 2 | | | | | | | power estimate, reference case 3 | | | | | | | average Pjlx W/m2/lux=W/lm | correction factor Fmf | EU-28 installed power GW (@ 60 lm/W) | installed power density W/m2 (@ 60 lm/W) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | width m | length m | height m | room index k | UFF % | Pjlx W/m2/lux=W/lm | weight (% of area) | width m | length m | height m | room index k | UFF % | Pjlx W/m2/lux=W/lm | weight (% of area) | width m | length m | height m | room index k | UFF % | Pjlx W/m2/lux=W/lm | weight (% of area) | | | | |
| **Total Manufacturing / Industry** | | | | | | | | | | | | | | | | | | | | | | **0.0292** | **1.0** | **20.0** | **8.1** |
| Production Area | 4.0 | 10.0 | 2.0 | 1.4 | 30% | 0.0326 | 20% | 32.0 | 32.0 | 8.0 | 2.0 | 20% | 0.0275 | 50% | 16.0 | 100.0 | 5.0 | 2.8 | 10% | 0.0229 | 30% | 0.0271 | 1.0 | 12.8 | 8.7 |
| Reception / Circulation Areas | 1.8 | 24.8 | 2.8 | 0.6 | 10% | 0.0344 | 30% | 3.0 | 20.0 | 2.8 | 0.9 | 20% | 0.0334 | 40% | 10.0 | 10.0 | 4.0 | 1.3 | 10% | 0.0283 | 30% | 0.0322 | 1.0 | 0.9 | 3.7 |
| Common toilets, showers, wardrobes | | | | 0.6 | 30% | 0.0404 | 20% | 3.0 | 4.0 | 2.0 | 0.9 | 30% | 0.0370 | 40% | 5.0 | 10.0 | 3.0 | 1.1 | 10% | 0.0292 | 40% | 0.0345 | 1.0 | 1.6 | 6.4 |
| Offices | 2.5 | 3.0 | 2.0 | 0.7 | 30% | 0.0391 | 10% | 3.6 | 4.5 | 2.0 | 1.0 | 30% | 0.0356 | 40% | 3.6 | 4.5 | 2.0 | 1.0 | 10% | 0.0300 | 50% | 0.0332 | 1.0 | 3.3 | 13.3 |
| Technical Service Rooms | 2.5 | 3.0 | 2.0 | 0.7 | 30% | 0.0391 | 20% | 3.6 | 4.5 | 2.0 | 1.0 | 30% | 0.0356 | 60% | 5.0 | 10.0 | 3.0 | 1.1 | 10% | 0.0292 | 20% | 0.0350 | 1.0 | 1.4 | 5.8 |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Total Retail & Wholesale / Trade** | | | | | | | | | | | | | | | | | | | | | | **0.0319** | **1.0** | **13.6** | **5.7** |
| Shops < 30 m2 | 4.0 | 4.0 | 2.0 | 1.0 | 30% | 0.0356 | 30% | 3.0 | 6.0 | 2.2 | 0.9 | 30% | 0.0364 | 60% | 4.0 | 7.0 | 2.5 | 1.0 | 10% | 0.0299 | 10% | 0.0355 | 1.0 | 6.4 | 9.9 |
| Shops > 30 m2 | 6.0 | 6.0 | 2.2 | 1.4 | 30% | 0.0330 | 20% | 6.0 | 12.0 | 2.2 | 1.8 | 20% | 0.0282 | 40% | 10.0 | 20.0 | 2.5 | 2.7 | 10% | 0.0231 | 40% | 0.0271 | 1.0 | 3.1 | 7.6 |
| Reception / Circulation Areas | 1.8 | 24.8 | 2.8 | 0.6 | 10% | 0.0344 | 10% | 3.0 | 20.0 | 2.8 | 0.9 | 20% | 0.0334 | 50% | 10.0 | 10.0 | 4.0 | 1.3 | 10% | 0.0283 | 40% | 0.0314 | 1.0 | 1.6 | 3.6 |
| Common toilets and wardrobes | | | | 0.6 | 30% | 0.0404 | 20% | 3.0 | 4.0 | 2.0 | 0.9 | 30% | 0.0370 | 40% | 5.0 | 10.0 | 3.0 | 1.1 | 10% | 0.0292 | 40% | 0.0345 | 1.0 | 0.7 | 6.4 |
| Storeroom / Warehouse | 4.0 | 4.0 | 2.0 | 1.0 | 30% | 0.0356 | 20% | 4.0 | 8.0 | 3.0 | 0.9 | 20% | 0.0338 | 30% | 10.0 | 40.0 | 4.0 | 2.0 | 10% | 0.0249 | 50% | 0.0297 | 1.0 | 1.8 | 2.3 |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Hotel & Restaurant (total)** | | | | | | | | | | | | | | | | | | | | | | **0.0310** | **1.0** | **4.9** | **6.5** |
| Rooms (excl. toilet/shower) | 3.0 | 4.0 | 2.2 | 0.8 | 30% | 0.0379 | 40% | 4.0 | 5.0 | 2.2 | 1.0 | 20% | 0.0327 | 30% | 4.0 | 8.0 | 2.5 | 1.1 | 10% | 0.0295 | 30% | 0.0338 | 1.0 | 0.9 | 6.5 |
| Toilet/Shower in rooms | 2.0 | 3.0 | 2.0 | 0.6 | 30% | 0.0404 | 50% | 2.5 | 4.0 | 2.0 | 0.8 | 20% | 0.0351 | 40% | 3.0 | 5.0 | 2.2 | 0.9 | 10% | 0.0313 | 10% | 0.0373 | 1.0 | 0.2 | 6.9 |
| Common toilets/wardrobes | | | | 0.6 | 30% | 0.0404 | 20% | 3.0 | 4.0 | 2.0 | 0.9 | 30% | 0.0370 | 40% | 5.0 | 10.0 | 3.0 | 1.1 | 10% | 0.0292 | 40% | 0.0345 | 1.0 | 0.2 | 6.4 |
| Reception/ Circulation areas | 1.8 | 24.8 | 2.8 | 0.6 | 10% | 0.0344 | 50% | 3.0 | 20.0 | 2.8 | 0.9 | 20% | 0.0334 | 30% | 10.0 | 10.0 | 4.0 | 1.3 | 10% | 0.0283 | 20% | 0.0329 | 1.0 | 0.2 | 3.8 |
| Breakfast / Eating areas | 4.0 | 6.0 | 2.0 | 1.2 | 30% | 0.0340 | 30% | 5.0 | 8.0 | 2.0 | 1.5 | 20% | 0.0294 | 40% | 6.0 | 10.0 | 2.2 | 1.7 | 10% | 0.0260 | 30% | 0.0298 | 1.0 | 1.5 | 5.2 |
| Coffeshops, Bars, Discotheques | 4.0 | 6.0 | 2.0 | 1.2 | 30% | 0.0340 | 30% | 5.0 | 8.0 | 2.0 | 1.5 | 20% | 0.0294 | 40% | 6.0 | 10.0 | 2.2 | 1.7 | 10% | 0.0260 | 30% | 0.0298 | 1.0 | 0.3 | 4.3 |
| Offices | 2.5 | 3.0 | 2.0 | 0.7 | 30% | 0.0391 | 10% | 3.6 | 4.5 | 2.0 | 1.0 | 30% | 0.0356 | 40% | 3.6 | 4.5 | 2.0 | 1.0 | 10% | 0.0300 | 50% | 0.0332 | 1.0 | 0.2 | 13.3 |
| Meeting Rooms | 4.5 | 3.6 | 2.0 | 1.0 | 30% | 0.0356 | 20% | 9.0 | 7.2 | 2.0 | 2.0 | 20% | 0.0275 | 60% | 9.0 | 7.2 | 2.0 | 2.0 | 10% | 0.0249 | 20% | 0.0286 | 1.0 | 0.4 | 13.2 |
| Kitchen | 4.0 | 6.0 | 2.0 | 1.2 | 30% | 0.0340 | 40% | 16.0 | 16.0 | 2.0 | 4.0 | 30% | 0.0253 | 50% | 16.0 | 16.0 | 2.0 | 4.0 | 10% | 0.0207 | 10% | 0.0283 | 1.0 | 0.8 | 13.0 |

| cyan fields are inputs, can be changed | power estimate, reference case 1 | | | | | | | power estimate, reference case 2 | | | | | | | power estimate, reference case 3 | | | | | | | average Pjlx W/m2/lux=W/lm | correction factor Fmf | EU-28 installed power GW (@ 60 lm/W) | installed power density W/m2 (@ 60 lm/W) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | width m | length m | height m | room index k | UFF % | Pjlx W/m2/lux=W/lm | weight (% of area) | width m | length m | height m | room index k | UFF % | Pjlx W/m2/lux=W/lm | weight (% of area) | width m | length m | height m | room index k | UFF % | Pjlx W/m2/lux=W/lm | weight (% of area) | | | | |
| Technical areas | 2.5 | 3.0 | 2.0 | 0.7 | 30% | 0.0391 | 20% | 3.6 | 4.5 | 2.0 | 1.0 | 30% | 0.0356 | 60% | 5.0 | 10.0 | 3.0 | 1.1 | 10% | 0.0292 | 20% | 0.0350 | 1.0 | 0.2 | 5.8 |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Education Total** | | | | | | | | | | | | | | | | | | | | | | **0.0313** | **1.0** | **11.0** | **8.5** |
| Creche, play area | 4.0 | 6.0 | 2.8 | 0.9 | 30% | 0.0370 | 30% | 5.0 | 8.0 | 2.8 | 1.1 | 20% | 0.0320 | 40% | 6.0 | 10.0 | 2.8 | 1.3 | 10% | 0.0278 | 30% | 0.0322 | 1.0 | 0.2 | 9.0 |
| (Pre-)Primary resting area | 4.0 | 6.0 | 2.2 | 1.1 | 30% | 0.0348 | 30% | 5.0 | 8.0 | 2.2 | 1.4 | 30% | 0.0328 | 40% | 6.0 | 10.0 | 2.2 | 1.7 | 30% | 0.0312 | 30% | 0.0329 | 1.0 | 0.4 | 6.3 |
| Class Rooms | 4.0 | 6.0 | 2.0 | 1.2 | 30% | 0.0340 | 20% | 5.0 | 8.0 | 2.0 | 1.5 | 20% | 0.0294 | 60% | 6.0 | 10.0 | 2.0 | 1.9 | 10% | 0.0254 | 20% | 0.0295 | 1.0 | 3.6 | 8.3 |
| Meeting Rooms | 4.5 | 3.6 | 2.0 | 1.0 | 30% | 0.0356 | 50% | 9.0 | 7.2 | 2.0 | 2.0 | 20% | 0.0275 | 30% | 9.0 | 7.2 | 2.0 | 2.0 | 10% | 0.0249 | 20% | 0.0310 | 1.0 | 2.3 | 14.3 |
| Library | 4.0 | 4.0 | 2.0 | 1.0 | 30% | 0.0356 | 20% | 4.0 | 8.0 | 3.0 | 0.9 | 20% | 0.0338 | 50% | 5.0 | 12.0 | 3.0 | 1.2 | 10% | 0.0287 | 30% | 0.0326 | 1.0 | 0.4 | 9.0 |
| Teacher's Room | 3.0 | 4.0 | 2.0 | 0.9 | 30% | 0.0370 | 30% | 4.0 | 6.0 | 2.0 | 1.2 | 20% | 0.0313 | 40% | 5.0 | 8.0 | 2.0 | 1.5 | 10% | 0.0268 | 30% | 0.0316 | 1.0 | 0.2 | 8.9 |
| Computer education area | 4.0 | 6.0 | 2.0 | 1.2 | 30% | 0.0340 | 20% | 5.0 | 8.0 | 2.0 | 1.5 | 30% | 0.0320 | 60% | 6.0 | 10.0 | 2.0 | 1.9 | 30% | 0.0305 | 20% | 0.0321 | 1.0 | 0.4 | 9.0 |
| Reception/ Circulation Area | 1.8 | 24.8 | 2.8 | 0.6 | 10% | 0.0344 | 10% | 3.0 | 20.0 | 2.8 | 0.9 | 20% | 0.0334 | 70% | 10.0 | 10.0 | 4.0 | 1.3 | 10% | 0.0283 | 20% | 0.0325 | 1.0 | 0.8 | 3.7 |
| Common toilets / wardrobes | | | | 0.6 | 30% | 0.0404 | 10% | 3.0 | 4.0 | 2.0 | 0.9 | 30% | 0.0370 | 40% | 5.0 | 10.0 | 3.0 | 1.1 | 10% | 0.0292 | 50% | 0.0334 | 1.0 | 0.4 | 6.2 |
| Standard Offices | 2.5 | 3.0 | 2.0 | 0.7 | 30% | 0.0391 | 10% | 3.6 | 4.5 | 2.0 | 1.0 | 30% | 0.0356 | 40% | 3.6 | 4.5 | 2.0 | 1.0 | 10% | 0.0300 | 50% | 0.0332 | 1.0 | 1.8 | 13.3 |
| Technical Service Rooms | 2.5 | 3.0 | 2.0 | 0.7 | 30% | 0.0391 | 20% | 3.6 | 4.5 | 2.0 | 1.0 | 30% | 0.0356 | 60% | 5.0 | 10.0 | 3.0 | 1.1 | 10% | 0.0292 | 20% | 0.0350 | 1.0 | 0.4 | 5.8 |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Hospitals/Healthcare Total** | | | | | | | | | | | | | | | | | | | | | | **0.0300** | **1.0** | **6.6** | **7.3** |
| Wards / Bedrooms | 4.0 | 6.0 | 2.0 | 1.2 | 30% | 0.0340 | 20% | 4.0 | 12.0 | 2.0 | 1.5 | 20% | 0.0296 | 40% | 6.0 | 12.0 | 2.2 | 1.8 | 10% | 0.0256 | 40% | 0.0289 | 1.0 | 0.8 | 4.4 |
| Dayroom / Eating Room | 4.0 | 6.0 | 2.0 | 1.2 | 30% | 0.0340 | 20% | 5.0 | 8.0 | 2.0 | 1.5 | 20% | 0.0294 | 40% | 6.0 | 10.0 | 2.2 | 1.7 | 10% | 0.0260 | 40% | 0.0290 | 1.0 | 0.3 | 5.1 |
| Examination / Treatment Rooms | 3.0 | 4.0 | 2.0 | 0.9 | 10% | 0.0313 | 20% | 4.0 | 6.0 | 2.0 | 1.2 | 10% | 0.0286 | 60% | 5.0 | 8.0 | 2.2 | 1.4 | 10% | 0.0274 | 20% | 0.0289 | 1.0 | 2.1 | 11.6 |
| Waiting Area | 3.0 | 4.0 | 2.0 | 0.9 | 30% | 0.0370 | 30% | 4.0 | 6.0 | 2.0 | 1.2 | 20% | 0.0313 | 50% | 5.0 | 8.0 | 2.2 | 1.4 | 10% | 0.0274 | 20% | 0.0322 | 1.0 | 0.7 | 6.1 |
| Reception / Circulation Areas | 1.8 | 24.8 | 2.8 | 0.6 | 10% | 0.0344 | 10% | 3.0 | 20.0 | 2.8 | 0.9 | 20% | 0.0334 | 70% | 10.0 | 10.0 | 4.0 | 1.3 | 10% | 0.0283 | 20% | 0.0325 | 1.0 | 0.5 | 3.7 |
| Common toilets, wardrobes, showers | | | | 0.6 | 30% | 0.0404 | 10% | 3.0 | 4.0 | 2.0 | 0.9 | 30% | 0.0370 | 40% | 5.0 | 10.0 | 3.0 | 1.1 | 10% | 0.0292 | 50% | 0.0334 | 1.0 | 0.5 | 6.2 |
| Standard offices | 2.5 | 3.0 | 2.0 | 0.7 | 30% | 0.0391 | 10% | 3.6 | 4.5 | 2.0 | 1.0 | 30% | 0.0356 | 40% | 3.6 | 4.5 | 2.0 | 1.0 | 10% | 0.0300 | 50% | 0.0332 | 1.0 | 0.7 | 13.3 |
| Laboratories | 4.0 | 6.0 | 2.0 | 1.2 | 10% | 0.0286 | 20% | 5.0 | 8.0 | 2.0 | 1.5 | 10% | 0.0268 | 50% | 6.0 | 10.0 | 2.2 | 1.7 | 10% | 0.0260 | 30% | 0.0269 | 1.0 | 0.8 | 12.4 |
| Technical Service / Production Areas | 2.5 | 3.0 | 2.0 | 0.7 | 30% | 0.0391 | 20% | 3.6 | 4.5 | 2.0 | 1.0 | 30% | 0.0356 | 60% | 5.0 | 10.0 | 3.0 | 1.1 | 10% | 0.0292 | 20% | 0.0350 | 1.0 | 0.2 | 5.8 |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Offices Total** | | | | | | | | | | | | | | | | | | | | | | **0.0290** | **1.0** | **20.8** | **9.8** |
| Cellular office | 2.5 | 3.0 | 2.0 | 0.7 | 30% | 0.0391 | 0% | 3.6 | 4.5 | 2.0 | 1.0 | 30% | 0.0356 | 40% | 3.6 | 4.5 | 2.0 | 1.0 | 10% | 0.0300 | 60% | 0.0322 | 1.0 | 8.5 | 12.9 |

| cyan fields are inputs, can be changed | power estimate, reference case 1 | | | | | | | power estimate, reference case 2 | | | | | | | power estimate, reference case 3 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | width m | length m | height m | room index k | UFF % | Pjlx W/m2/lux=W/lm | weight (% of area) | width m | length m | height m | room index k | UFF % | Pjlx W/m2/lux=W/lm | weight (% of area) | width m | length m | height m | room index k | UFF % | Pjlx W/m2/lux=W/lm | weight (% of area) | average Pjlx W/m2/lux=W/lm | correction factor Fmf | EU-28 installed power GW (@ 60 lm/W) | installed power density W/m2 (@ 60 lm/W) |
| Open Plan Office (Landscape office) | 10.0 | 10.0 | 2.0 | 2.5 | 30% | 0.0284 | 20% | 16.0 | 16.0 | 2.0 | 4.0 | 30% | 0.0253 | 40% | 16.0 | 16.0 | 2.0 | 4.0 | 10% | 0.0207 | 40% | 0.0241 | 1.0 | 6.8 | 11.1 |
| Reception/ Circulation Area | 1.8 | 24.8 | 2.8 | 0.6 | 10% | 0.0344 | 50% | 3.0 | 20.0 | 2.8 | 0.9 | 20% | 0.0334 | 30% | 10.0 | 10.0 | 4.0 | 1.3 | 10% | 0.0283 | 20% | 0.0329 | 1.0 | 1.6 | 3.8 |
| Common toilets / wardrobes / showers | | | | 0.6 | 30% | 0.0404 | 20% | 3.0 | 4.0 | 2.0 | 0.9 | 30% | 0.0370 | 40% | 5.0 | 10.0 | 3.0 | 1.1 | 10% | 0.0292 | 40% | 0.0345 | 1.0 | 0.9 | 6.4 |
| Meeting Rooms | 4.5 | 3.6 | 2.0 | 1.0 | 30% | 0.0356 | 30% | 9.0 | 7.2 | 2.0 | 2.0 | 20% | 0.0275 | 50% | 9.0 | 7.2 | 2.0 | 2.0 | 10% | 0.0249 | 20% | 0.0294 | 1.0 | 2.3 | 13.5 |
| Copying, Server, Archive,Technical areas | 2.5 | 3.0 | 2.0 | 0.7 | 30% | 0.0391 | 20% | 3.6 | 4.5 | 2.0 | 1.0 | 30% | 0.0356 | 60% | 5.0 | 10.0 | 3.0 | 1.1 | 10% | 0.0292 | 20% | 0.0350 | 1.0 | 0.7 | 6.5 |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Sports Total** | | | | | | | | | | | | | | | | | | | | | | **0.0292** | **1.0** | **4.2** | **7.7** |
| Sports Hall | 33.0 | 18.0 | 7.6 | 1.5 | 10% | 0.0268 | 50% | 37.0 | 33.0 | 7.6 | 2.3 | 10% | 0.0241 | 30% | 54.0 | 33.0 | 9.1 | 2.3 | 10% | 0.0242 | 20% | 0.0254 | 1.0 | 2.0 | 8.1 |
| Common toilets / wardrobes / showers | | | | 0.6 | 30% | 0.0404 | 10% | 3.0 | 4.0 | 2.0 | 0.9 | 30% | 0.0370 | 40% | 5.0 | 10.0 | 3.0 | 1.1 | 10% | 0.0292 | 50% | 0.0334 | 1.0 | 0.6 | 6.2 |
| Reception/ Circulation Area | 1.8 | 24.8 | 2.8 | 0.6 | 10% | 0.0344 | 40% | 3.0 | 20.0 | 2.8 | 0.9 | 20% | 0.0334 | 40% | 10.0 | 10.0 | 4.0 | 1.3 | 10% | 0.0283 | 20% | 0.0328 | 1.0 | 0.2 | 3.8 |
| Mensa, Restaurant, Bar, Resting area | 4.0 | 6.0 | 2.0 | 1.2 | 30% | 0.0340 | 40% | 5.0 | 8.0 | 2.0 | 1.5 | 20% | 0.0294 | 50% | 6.0 | 10.0 | 2.2 | 1.7 | 10% | 0.0260 | 10% | 0.0309 | 1.0 | 0.4 | 5.7 |
| Offices | 2.5 | 3.0 | 2.0 | 0.7 | 30% | 0.0391 | 30% | 3.6 | 4.5 | 2.0 | 1.0 | 30% | 0.0356 | 40% | 3.6 | 4.5 | 2.0 | 1.0 | 10% | 0.0300 | 30% | 0.0350 | 1.0 | 0.9 | 14.0 |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Parking in structures** | | | | | | | | | | | | | | | | | | | | | | **0.0216** | **1.0** | **0.4** | **1.3** |
| public access | 15.0 | 25.0 | 2.5 | 3.8 | 30% | 0.0257 | 20% | 15.0 | 50.0 | 2.8 | 4.1 | 20% | 0.0229 | 20% | 30.0 | 50.0 | 2.8 | 5.0 | 10% | 0.0196 | 60% | 0.0214 | 1.0 | 0.3 | 1.3 |
| private access (offices) | 15.0 | 25.0 | 2.5 | 3.8 | 30% | 0.0257 | 30% | 15.0 | 50.0 | 2.8 | 4.1 | 20% | 0.0229 | 40% | 30.0 | 50.0 | 2.8 | 5.0 | 10% | 0.0196 | 30% | 0.0227 | 1.0 | 0.0 | 1.4 |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Stations, Airports, similar (Total)** | | | | | | | | | | | | | | | | | | | | | | **0.0310** | **1.0** | **0.7** | **6.5** |
| passenger/client (waiting) area | 4.0 | 6.0 | 2.2 | 1.1 | 30% | 0.0348 | 20% | 6.0 | 8.0 | 2.2 | 1.6 | 20% | 0.0293 | 30% | 10.0 | 20.0 | 2.8 | 2.4 | 10% | 0.0238 | 50% | 0.0277 | 1.0 | 0.2 | 5.3 |
| reception and circulation areas | 1.8 | 24.8 | 2.8 | 0.6 | 10% | 0.0344 | 10% | 3.0 | 20.0 | 2.8 | 0.9 | 20% | 0.0334 | 60% | 10.0 | 10.0 | 4.0 | 1.3 | 10% | 0.0283 | 30% | 0.0320 | 1.0 | 0.1 | 3.7 |
| customs and security | 2.5 | 3.0 | 2.0 | 0.7 | 30% | 0.0391 | 20% | 3.6 | 4.5 | 2.0 | 1.0 | 30% | 0.0356 | 30% | 5.0 | 10.0 | 3.0 | 1.1 | 10% | 0.0292 | 50% | 0.0331 | 1.0 | 0.1 | 13.2 |
| common toilets, wardrobes, etc | | | | 0.6 | 30% | 0.0404 | 10% | 3.0 | 4.0 | 2.0 | 0.9 | 30% | 0.0370 | 40% | 5.0 | 10.0 | 3.0 | 1.1 | 10% | 0.0292 | 50% | 0.0334 | 1.0 | 0.1 | 6.2 |
| offices | 2.5 | 3.0 | 2.0 | 0.7 | 30% | 0.0391 | 10% | 3.6 | 4.5 | 2.0 | 1.0 | 30% | 0.0356 | 40% | 3.6 | 4.5 | 2.0 | 1.0 | 10% | 0.0300 | 50% | 0.0332 | 1.0 | 0.2 | 13.3 |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Entertainment and news (Total)** | | | | | | | | | | | | | | | | | | | | | | **0.0300** | **1.0** | **3.8** | **6.2** |
| Video and Movie production and Cinemas | | | | | | | | | | | | | | | | | | | | | | 0.03 | 1.0 | 0.9 | 5.7 |
| Radio and TV | | | | | | | | | | | | | | | | | | | | | | 0.03 | 1.0 | 0.9 | 8.4 |

| cyan fields are inputs, can be changed | power estimate, reference case 1 | | | | | | | power estimate, reference case 2 | | | | | | | power estimate, reference case 3 | | | | | | | average Pjlx W/m2/lux=W/lm | correction factor Fmf | EU-28 installed power GW (@ 60 lm/W) | installed power density W/m2 (@ 60 lm/W) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | width m | length m | height m | room index k | UFF % | Pjlx W/m2/lux=W/lm | weight (% of area) | width m | length m | height m | room index k | UFF % | Pjlx W/m2/lux=W/lm | weight (% of area) | width m | length m | height m | room index k | UFF % | Pjlx W/m2/lux=W/lm | weight (% of area) | | | | |
| Theater, Dancing, Amusementpark | | | | | | | | | | | | | | | | | | | | | | 0.03 | 1.0 | 2.0 | 5.7 |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Miscellaneous (Total)** | | | | | | | | | | | | | | | | | | | | | | **0.0300** | **1.0** | **1.5** | **5.2** |
| Prisons | | | | | | | | | | | | | | | | | | | | | | 0.03 | 1.0 | 0.2 | 5.7 |
| Fire service activities | | | | | | | | | | | | | | | | | | | | | | 0.03 | 1.0 | 0.0 | 5.7 |
| Waste disposal / sewage | | | | | | | | | | | | | | | | | | | | | | 0.03 | 1.0 | 0.2 | 5.7 |
| Political and religious (incl. churches) | | | | | | | | | | | | | | | | | | | | | | 0.03 | 1.0 | 0.5 | 3.5 |
| Libraries, musea, zoo | | | | | | | | | | | | | | | | | | | | | | 0.03 | 1.0 | 0.6 | 8.4 |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Total Non-Residential** | | | | | | | | | | | | | | | | | | | | | | **0.0300** | **1.0** | **87** | **7.4** |
| **MELISA 2013 indoor (different lm/W)** | | | | | | | | | | | | | | | | | | | | | | | | **106** | **9.0** |
| **implied factor FL from EN 15193** | | | | | | | | | | | | | | | | | | | | | | | | **1.21** | |

*Table 0-27 Estimate of installed lighting power for non-residential buildings based on building areas, lighting requirements at task level, and Power densities Pjlx (W/m²/lux) according to prEN 15193 table C.1. Last columns show the estimate for the EU-28 installed total lighting power and its density per m². (Valid for MF=0.8, 60 luminaire lumens per circuit Watt, reflection coefficients 0.7/0.5/0.2; source: VHK 2015).*

| **Summary per type of building** | % of total area | EU-28 Area M m2 | Lighting Requirements Task area lux | Fca | EU-28 lm required at task level Giga lm | % of total lumen | average Pjlx W/m2/lux =W/lm | correction factor Fmf | EU-28 installed power GW @60 LL/W | installed power density W/m2 @60 LL/W | % of total power @60 LL/W |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| Offices Total | 18.0% | 2115 | 389 | 87% | 718 | 24.6% | 0.029 | 1.0 | 20.8 | 9.8 | 23.8% |
| Total Manufacturing / Industry | 20.9% | 2461 | 403 | 69% | 685 | 23.5% | 0.029 | 1.0 | 20.0 | 8.1 | 22.9% |
| Total Retail & Wholesale / Trade | 20.2% | 2382 | 197 | 91% | 425 | 14.6% | 0.032 | 1.0 | 13.6 | 5.7 | 15.5% |
| Education Total | 11.1% | 1302 | 306 | 88% | 352 | 12.1% | 0.031 | 1.0 | 11.0 | 8.5 | 12.6% |
| Hospitals/Healthcare Total | 7.7% | 907 | 308 | 79% | 219 | 7.5% | 0.030 | 1.0 | 6.6 | 7.3 | 7.5% |
| Hotel & Restaurant (total) | 6.4% | 754 | 255 | 82% | 158 | 5.4% | 0.031 | 1.0 | 4.9 | 6.5 | 5.6% |
| Sports Total | 4.6% | 544 | 362 | 73% | 143 | 4.9% | 0.029 | 1.0 | 4.2 | 7.7 | 4.8% |
| Entertainment and news (Total) | 5.2% | 617 | 217 | 95% | 127 | 4.3% | 0.030 | 1.0 | 3.8 | 6.2 | 4.4% |
| Miscellaneous (Total) | 2.5% | 294 | 184 | 93% | 50 | 1.7% | 0.030 | 1.0 | 1.5 | 5.2 | 1.7% |
| Stations, Airports, similar (Total) | 0.9% | 107 | 238 | 88% | 22 | 0.8% | 0.031 | 1.0 | 0.7 | 6.5 | 0.8% |
| Parking in structures | 2.5% | 290 | 75 | 82% | 18 | 0.6% | 0.022 | 1.0 | 0.4 | 1.3 | 0.4% |
| | | | | | | | | | | | |
| **Total Non-Residential (indoor)** | **100%** | **11773** | **305** | **81%** | **2918** | **100 %** | **0.030** | **1.0** | **87** | **7.4** | **100%** |
| **MELISA 2013 (different LLm/W)** | | | | | | | | | **106** | **9.0** | |

*Table 0-28 Estimate of installed lighting power for non-residential rooms/zones based on building areas, lighting requirements at task level, and Power densities Pjlx (W/m²/lux) according to prEN 15193 table C.1. (for MF=0.8, 60 Llm/W; source: VHK 2015).*

| Summary per type of room/activity | % of total area | EU-28 Area M m2 | Lighting Requirements Task area lux | Fca | EU-28 required task level Giga lm | % of total lumen | average Pjlx W/m2/lux =W/lm | correction factor Fmf | EU-28 power GW @60 LL/W | power density W/m2 @60 LL/W | % of total power @60 LL/W |
|---|---|---|---|---|---|---|---|---|---|---|---|
| manufacturing area | 12.5% | 1476 | 500 | 64% | 472 | 16.2% | 0.027 | 1.0 | 12.8 | 8.7 | 14.7% |
| offices (open space) | 5.2% | 609 | 500 | 92% | 280 | 9.6% | 0.024 | 1.0 | 6.8 | 11.1 | 7.7% |
| offices (cellular) | 5.6% | 660 | 500 | 80% | 264 | 9.0% | 0.032 | 1.0 | 8.5 | 12.9 | 9.7% |
| offices (general, small) | 4.5% | 525 | 500 | 80% | 210 | 7.2% | 0.033 | 1.0 | 7.0 | 13.4 | 8.0% |
| circulation areas | 13.8% | 1620 | 125 | 92% | 186 | 6.4% | 0.032 | 1.0 | 6.0 | 3.7 | 6.9% |
| Shops < 30 m2 | 5.5% | 643 | 300 | 93% | 180 | 6.2% | 0.036 | 1.0 | 6.4 | 9.9 | 7.3% |
| meeting rooms | 3.1% | 362 | 500 | 92% | 166 | 5.7% | 0.030 | 1.0 | 5.0 | 13.8 | 5.7% |
| Class rooms and similar | 4.9% | 573 | 289 | 93% | 155 | 5.3% | 0.030 | 1.0 | 4.7 | 8.1 | 5.3% |
| toilets, showers, wardrobes | 7.0% | 829 | 200 | 93% | 153 | 5.3% | 0.034 | 1.0 | 5.3 | 6.3 | 6.0% |
| Shops > 30 m2 | 3.4% | 402 | 300 | 93% | 113 | 3.9% | 0.027 | 1.0 | 3.1 | 7.6 | 3.5% |
| technical / service areas | 4.3% | 502 | 203 | 85% | 86 | 3.0% | 0.035 | 1.0 | 3.0 | 6.0 | 3.4% |
| eating / drinking areas | 4.2% | 496 | 200 | 86% | 85 | 2.9% | 0.030 | 1.0 | 2.5 | 5.1 | 2.9% |
| Sports Hall | 2.1% | 242 | 500 | 64% | 77 | 2.7% | 0.025 | 1.0 | 2.0 | 8.1 | 2.3% |
| Examination / Treatment Rooms | 1.5% | 180 | 500 | 80% | 72 | 2.5% | 0.029 | 1.0 | 2.1 | 11.6 | 2.4% |
| Theater, Dancing, Amusementpark | 3.0% | 358 | 200 | 95% | 68 | 2.3% | 0.030 | 1.0 | 2.0 | 5.7 | 2.3% |
| Storeroom / Warehouse | 6.6% | 774 | 100 | 78% | 60 | 2.1% | 0.030 | 1.0 | 1.8 | 2.3 | 2.0% |
| waiting areas | 1.5% | 179 | 214 | 95% | 36 | 1.2% | 0.031 | 1.0 | 1.1 | 6.3 | 1.3% |
| Libraries, musea, zoo | 1.0% | 112 | 381 | 73% | 31 | 1.1% | 0.031 | 1.0 | 1.0 | 8.7 | 1.1% |
| Laboratories | 0.6% | 66 | 500 | 92% | 31 | 1.0% | 0.027 | 1.0 | 0.8 | 12.4 | 0.9% |
| Radio and TV | 0.9% | 107 | 300 | 93% | 30 | 1.0% | 0.030 | 1.0 | 0.9 | 8.4 | 1.0% |
| Hospital wards/bedrooms | 1.6% | 191 | 300 | 51% | 29 | 1.0% | 0.029 | 1.0 | 0.8 | 4.4 | 1.0% |
| Video and Movie production and Cinemas | 1.3% | 152 | 200 | 95% | 29 | 1.0% | 0.030 | 1.0 | 0.9 | 5.7 | 1.0% |
| Kitchens | 0.5% | 60 | 500 | 92% | 27 | 0.9% | 0.028 | 1.0 | 0.8 | 13.0 | 0.9% |
| Hotel rooms (excl toilet/shower) | 1.2% | 138 | 300 | 64% | 27 | 0.9% | 0.034 | 1.0 | 0.9 | 6.5 | 1.0% |
| Political and religious (incl. churches) | 1.3% | 152 | 125 | 92% | 17 | 0.6% | 0.030 | 1.0 | 0.5 | 3.5 | 0.6% |
| Parking in structures | 2.5% | 290 | 75 | 82% | 18 | 0.6% | 0.022 | 1.0 | 0.4 | 1.3 | 0.4% |
| Waste disposal / sewage | 0.3% | 37 | 200 | 95% | 7 | 0.2% | 0.030 | 1.0 | 0.2 | 5.7 | 0.2% |
| Prisons | 0.3% | 34 | 200 | 95% | 6 | 0.2% | 0.030 | 1.0 | 0.2 | 5.7 | 0.2% |
| Fire service activities | 0.0% | 4 | 200 | 95% | 1 | 0.0% | 0.030 | 1.0 | 0.0 | 5.7 | 0.0% |
| **Total Non-Residential (task level)** | **100%** | **11773** | **305** | **81%** | **2918** | **100%** | **0.030** | **1.0** | **87.4** | **7.4** | **100%** |

## F5 Determination of Operating Hours

As regards operating hours for lighting in non-residential buildings, EN 15193 starts from potential hours during which some form of lighting might be necessary, split in daytime hours (tD) and night-time hours (tN), see Table 0-16.

The potential daytime hours (tD) are reduced in function of the availability of daylight, and in function of the presence of control systems that can dim or switch-off lights accordingly. This is expressed by means of the daylight dependency factor Fd.

The potential night-time hours (tN) and the (reduced) daytime hours (tD*Fd) can be further reduced in function of the degree of occupancy of the rooms/buildings considered, and in function of the presence of control systems that can detect the presence/absence, and dim or switch-off lights accordingly. This is expressed by means of the occupancy dependency factor Fo.

As a consequence, the effective operating hours are computed as:

$$t_{oper} = Fo * (Fd*tD + tN) \qquad \text{(hours/year)}$$

In addition prEN 15193 foresees a constant illuminance factor Fc. The installed lighting power has been overdesigned (with respect to requirements) by a factor (1/MF) to account for the degradation of the lighting products (and of the reflection by their surroundings) with time. This implies that initially there would be more light available than required, and consequently lights should be dimmed to the required level to minimise energy consumption. The amount of dimming would then decrease with time, to compensate for the degradation of the lighting system. This could be done automatically by means of 'constant illuminance control'. The average amount of dimming for compensation of degradation is reflected by the factor Fc:

- Fc = 1.0, if no dimming system is installed
- Fc = (1+MF)/2, if there is a dimming system, but no automatic control
- Fc = 1-0.5*Fcc*(1-MF), in case of automatic control with efficiency Fcc.

As the effects of occupancy- and daylight-dimming act on the operating hours, it would be logical to make Fc also act on these hours. Alternatively, Fc could be conceived as reducing the power, as dimming actually does, but dimming effects would then be partially accounted on operating hours and partially on power, which is somewhat confusing.

For the moment the factor Fc has NOT been applied in the values shown in this note, but it is considered when comparing values with those from the MELISA model.

### F5.1 Potential Operating Hours

The potential operating hours have been taken from prEN 15193 table B.2.3.2 (see Table 0-16 of this note). The following remarks can be made regarding these hours:

- The standard explains that: "The values are based on the estimated time people likely to occupy or be in the premises and will require some form of illumination." This seems to assume that if there are no people there is no lighting. This is not always true: in some occasions lights may intentionally be left on, even if at a lower level, for security reasons or for publicity [15].

[15] The impression is that in many shops the window lights remain on longer than the shop opening times, so that people can still see the advertised goods.

- The values in the table are presented as default values, but it is not stated anywhere that they are median or average values. For building types that have more or less defined closure and opening times, such as offices, education buildings, restaurants, sports facilities and (maybe) retail, the table values could be reasonable averages.

- For building types/sectors where a relevant number of buildings never really close completely, this is more doubtful. Many hospitals, hotels and manufacturing factories (continuous processing) never really close, and it is not clear how this has been handled. For hospitals there are even night-time lighting requirements in EN 12464-1 (50 lux for corridors; 5 lux for wards) that do not seem to be captured by the EN 15193 hours.

- In reality, tD and tN could be chosen in any desired way, as long as the occupancy factors Fo correctly consider these periods, e.g. tD+tN = 4000+2000 with Fo=0.5 is the same as tD+tN = 2000+1000 with Fo=1.0.

- The use of the EN 15193 default potential hours as average EU-28 hours, as done in this note, is therefore rather doubtful [16]. Anyway the exercise in this note has been performed, also to satisfy a curiosity.

The following additional remarks apply regarding the use of potential operating hours in this note (see Table 0-29 for reference):

- In prEN 15193, the potential hours for hotels and restaurants are different, while in this note these buildings have been considered together as one category. As shown in Table 0-29, for some room types the hotel-hours have been used, for some the restaurant-hours, and for some an average based on underlying area information.

- For some room/building types no reference information was available for potential operating hours. These have been estimated as specified below.

- For private-parkings (near offices), video and movie production, radio and tv studios, waste disposal, libraries, museums and zoos, the same potential hours have been assumed as for office buildings (2250/250).

- For theatres, dancing, amusement parks, the same potential hours have been assumed as for restaurants (1250/1250).

- For public-parkings, stations and airports, an average 6 hour night-time closure has been assumed, during which lighting is never required. In a rough estimate it has been assumed that on average daytime and night-time are 12 hours/day each, leading to tD=4380 h/a and tN=2190 h/a.

- For prisons and fire service activities, the same potential hours have been assumed as for hotels (3000/2000), respectively with absence factors 0.0 and 0.8.

[16] Additional occupancy pattern reference data are available in prEN 15251:2014, but they are limited to some types of buildings, and too generic for use in this study. In addition they do not correspond with the data in EN 15193, e.g. for restaurants EN 15251 foresees lighting from 7 o'clock in the morning until midnight for all days of the week, including weekends. This would lead to considerably more than the tD+tN = 1250+1250 h/a from EN 15193.

- For political and religious buildings, including 200 000 churches, it is extremely difficult to estimate the potential operating hours. At the end tD/tN = 2500/1500 h/a was decided, with an absence factor of 0.5.

### F5.2 Occupancy dependent factor

The occupancy dependent factor Fo depends on the absence factor Fa and the occupancy control factor Foc.

The absence factor Fa reflects the part of the potential operating hours (NOT the part of the entire year) that a given room is not occupied. These data have mainly been taken from prEN 15193 table E.2 (see Table 0-17 in this note). Other absence factors have been estimated as shown in Table 0-29.

The occupancy control factor Foc reflects how the control system (if present) reacts to the absence of persons in the room. Its value varies from 1.0 for manual control (simple on/off switch) to 0.8 for the best automatic system with presence/absence detection, automatic switch-off and manual switch-on. Both extreme values have been considered.

The occupancy dependent factor 'Fo = 1 – Fa' for the best automatic control system, essentially implies that lights are off when the room is not occupied. For other less efficient control systems, lights will only be dimmed, or they will remain on, even if the room is not occupied. In particular, for the manual control system (on/off switch), for absence factors of 0.2 or below, Fo = 1 and the absence does not have any effect.

In formula: Fo = MIN { 1- [(1-Foc)*Fa/0.2 ; (Foc+0.2-Fa) ; [7-(10+Fa)]*(Fa-1) }

For further information see prEn 15193-1, annex E, figure E.1 and table E.3.

### F5.3 Daylight dependent factor

The daylight dependent factor expresses which part of the lighting requirement can be fulfilled by means of daylight: only the remaining part needs to be integrated with artificial lighting. This means that in the presence of daylight, the artificial lights can be turned-off or dimmed, even during the potential operating hours.

The daylight dependent factor Fd = 1 – Fds*Fdc, where Fds represents the availability of daylight in the room and Fdc represents the reaction of the control system to the presence of the daylight. Note that:

- Fd = 1 means no daylight use (all light is artificial)
- Fd = 0 means all lighting by daylight (no artificial light).

Notwithstanding its name, Fd indicates the part of time that artificial lighting is being used.

For a specific room in a specific building in a specific place in Europe the determination of the daylight dependent factor is not an easy task, see prEN 15193 annex F. It is even more difficult to estimate an EU-28 average daylight contribution for a generic room of a certain type (e.g. circulation area) in a building of a certain type (e.g. office building).

Anyway an attempt has been made, based on the following assumptions [17]:

[17] It is not feasible to explain all details of the daylight contribution calculation here: see prEN 15193 annex F for details.

- daylight availability classification (table F.1): as average for EU, only 'low' (Dca=2-4%) and 'medium' (Dca=4-6%) are considered. For some rooms, 'no daylight availability' has also been considered, but in these cases Fd=1 and no further calculations are required.

- luminous exposure Hdir/Hglob, average for EU : 0.42 (table F.2)
- average latitude for EU-28: 50 degrees (Frankfurt) (45<$\gamma$<60 for some tables)

- average facade orientation: slightly better than east/west; more or less corresponds to random use of all orientations, but slightly more south-oriented.

- average 75% of time no sun shading (SNA), 25% of time sun shading (SA), both for facade and roof-lights

- for Fds in absence of sun-shading system, in tables F.4, F5, F6, used effective glazing transparency (tau-eff) 0.7*0.7*0.9*0.85 = 0.4 (D=0.4*Dca) 'low' (D=1%) 'medium' (D=2%)

- type of shading system: 50% glare protect (1), 20% auto-operated (2), 10% light guides (3), 20% no protection (4)

- roof lights: use 45 degree inclination values

- daylight responsive control: consider 'manual' (worst option) and 'automated, dimmed, no standby losses, no switch-on' (best automated option). For 100 lux use 300 lux Fdc values.

Using the above assumptions, the following values have been derived for Fd:

Facade

Low Daylight availability
manual controls 0.66 0.74 0.81 (for 100, 300, 500 lux)
best auto controls 0.47 0.59 0.67 (for 100, 300, 500 lux)

Medium Daylight availability
manual controls 0.58 0.65 0.76 (for 100, 300, 500 lux)
best auto controls 0.35 0.46 0.60 (for 100, 300, 500 lux)

Roof lights

Low Daylight availability
manual controls 0.52 0.60 0.70 (for 100, 300, 500 lux)
best auto controls 0.25 0.37 0.47 (for 100, 300, 500 lux)

Medium Daylight availability
manual controls 0.46 0.49 0.56 (for 100, 300, 500 lux)
best auto controls 0.17 0.21 0.27 (for 100, 300, 500 lux)

Note that the daylight factors also depend on the required lighting level. Higher lighting requirements typically have higher daylight factors, meaning that artificial lighting is used for a longer time. This is also intuitive: if lighting requirements are low (100 lux), it will be more often possible to satisfy them using only daylight; if lighting requirements are high (500 lux), it will be more often necessary to integrate with artificial lighting.

Regarding the daylight factors reported in Table 0-29, the following explanations are given:

- The reference for the lighting requirement is the Task Area lux (column 4 of Table 0-21):
  - Etask < 200 lux: the daylight factor for 100 lux is used
  - 200 ≤ Etask < 400 lux: the daylight factor for 300 lux is used
  - Etask ≥ 400 lux: the daylight factor for 500 lux is used

- Low availability columns: contain the lowest estimate for daylight availability, i.e. the highest daylight factors (longer time for artificial lighting). For room types that are not exceptionally dark (on average), the Fd values are those reported above for 'low availability', corresponding to Dca 2-4%. For room types that have been considered exceptionally dark (on average) the reported values are a weighted average between Fd=1 ('no daylight availability') and the Fd values reported above for 'low availability'(Fdlow), typically with weight > 50% for Fd=1.

- Medium availability columns: contain the highest estimate for daylight availability, i.e. the lowest daylight factors (shorter time for artificial lighting). For room types that are not exceptionally dark (on average), the Fd values are those reported above for 'medium availability', corresponding to Dca 4-6%. For room types that have been considered exceptionally dark (on average) the reported values are a weighted average between Fd=1 ('no daylight availability') and the Fd values reported above for 'low availability'(Fdlow), typically with weight < 50% for Fd=1.

- 'Manual' and 'best auto' columns: 'manual' reflects the worst option for the daylight responsive control, i.e. a simple on/off switch commanded manually. 'Best auto' : reflects the best option for the daylight responsive control, i.e. 'automated, dimmed, no standby losses, no switch-on'.

- Manufacturing areas: assumed 25% façade lighting and 75% roof lights.

- Reception and circulation areas, shops, video/movie studio, theatre, libraries, museums, prisons: low is 50%*(Fd=1) and 50%*(Fdlow); medium is 0%*(Fd=1) and 100%*(Fdlow).

- Toilets, showers, wardrobes, technical areas, parkings: low is 90%*(Fd=1) and 10%*(Fdlow); medium is 50%*(Fd=1) and 50%*(Fdlow).

## F5.4 Estimate for Operating Hours

Effective operating hours are computed as: $t_{oper} = Fo * (Fd*tD + tN)$ (hours/year)

Table 0-29 (full list), Table 0-30 (summary for building types) and Table 0-31 (summary for room types) report four values for effective operating hours, depending on daylight availability and presence of control systems:

- Low daylight availability
  - manual control system (both for occupancy control and daylight control)
  - best automated control system (both for occupancy control and daylight control)

- Medium daylight availability
  - o manual control system (both for occupancy control and daylight control)
  - o best automated control system (both for occupancy control and daylight control)

Conclusions:

1- Based on the potential lighting operating hours and occupancy factors from prEN 15193, and VHK estimates of daylight dependency factors, the average EU-28 effective lighting operating hours for non-residential buildings are estimated between 2538 and 2739 h/a when manual occupancy and daylight controls are assumed, and between 1858 and 2120 h/a when best automated controls are assumed.

2- The EU-28 average control system for occupancy dependent and daylight dependent lighting is currently expected to be closer to the manual system than to the best automated system. This leads to an estimate between 2300 and 2600 h/a.

3- The above estimates do NOT take into account the beneficial effects of constant illuminance control, that is used to dim the initially over-dimensioned lighting capacity in function of the degree of degradation of the lighting products and room surfaces with time. Assuming that at least half of the installations allow such a dimming (either manual or automatic), a correction factor not higher than Fc= 0.95 [18] can to be applied to the operating hours, leading to an estimate for the average EU-28 effective lighting operating hours for non-residential buildings between 2200 and 2500 h/a (full power equivalent hours).

4- For non-residential indoor lighting (excluding HID lamps, assumed to be used mainly in outdoor lighting) the MELISA model for 2013 shows an installed-power-weighted average operating time of 1467 h/a. This average mainly results from [19]:

| | | | |
|---|---|---|---|
| - | LFL | 57.9 GW | 2200 h/a |
| - | CFLni | 4.4 GW | 1600 h/a |
| - | CFLi | 14.5 GW | 500 h/a |
| - | Halogen lamps | 22.3 GW | 450 h/a |
| - | GLS incandescent lamps | 6.1 GW | 450 h/a |

5- The difference between the two estimates confirms that lighting operating hours for the indoor non-residential sector are among the most difficult lighting parameters to establish.
As stated before, it is not certain that the potential operating hours of EN 15193 (from which the 2200-2500 h/a estimate derives) are EU-28 averages, and their status and background should be further clarified. In addition the occupancy and daylight factors used in the estimate have a high degree of uncertainty.
The MELISA value of 1467 h/a seems to be on the low side, but comparing it with the values from measuring campaigns as reported in the Task 3 report table 42 of the Light Sources study, it seems to be quite reasonable.

[18] If all installations allowed manual dimming, considering that a maintenance factor of MF=0.8 has been assumed, the factor would be Fc=(1+0.8)/2=0.9. The beneficial effect is assumed to be halved, so the factor becomes 0.95.
[19] Installed powers are reported inclusive ballast power.

6- As regards building types, the highest annual operating hours are estimated for stations/airports (2849-4736 h/a), retail sector (3454-4416 h/a) and healthcare sector (2699-3854 h/a). The lowest hours have been found for Education (668-1248 h/a) and Offices (1158-1869 h/a).

7- As regards room/activity types, the highest annual operating hours are estimated for Shops (3770-4610 h/a), Prisons (3770-4610 h/a), Laboratories (3040-4430 h/a) and Hospital wards/bedrooms (3380-4220 h/a). The lowest hours have been found for Technical/Service areas (461-1078 h/a), Class rooms (706-1359), Meeting rooms (855-1499) and Libraries and Museums (871-1581 h/a).

*Table 0-29 Potential operating hours, occupancy factors, estimated daylight factors and effective operating hours, based on prEN 15193. (source: VHK 2015)*

| cyan fields are inputs, can be changed<br>green fields are based on formulas<br>but can be changed if desired | potential daytime hours,tD h/a | potential nighttime hours,tN h/a | absence factor FA | occupancy control factor Foc | | occupancy dependency factor Fo | | Daylight Dependency Factor | | | | effective operating hours (h/a) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | low availability | | medium availability | | low availability | | medium availability | |
| | | | | manual | best auto | manual | best auto | manual control | best auto | manual control | best auto control | manual control | best auto | manual control | best auto control |
| **Total Manufacturing / Industry** | | | | | | | | | | | | **3048** | **2220** | **2806** | **1922** |
| Production Area | 2500 | 1500 | 0.10 | 1.0 | 0.8 | 1.0 | 0.9 | 0.73 | 0.52 | 0.61 | 0.35 | 3319 | 2520 | 3025 | 2143 |
| Reception / Circulation Areas | 2500 | 1500 | 0.20 | 1.0 | 0.8 | 1.0 | 0.8 | 0.83 | 0.74 | 0.66 | 0.47 | 3575 | 2670 | 3150 | 2140 |
| Common toilets, showers, wardrobes | 2500 | 1500 | 0.70 | 1.0 | 0.8 | 0.5 | 0.3 | 0.97 | 0.96 | 0.87 | 0.80 | 1968 | 1169 | 1838 | 1046 |
| Offices | 2500 | 1500 | 0.30 | 1.0 | 0.8 | 0.9 | 0.7 | 0.81 | 0.67 | 0.76 | 0.60 | 3173 | 2223 | 3060 | 2100 |
| Technical Service Rooms | 2500 | 1500 | 0.90 | 1.0 | 0.8 | 0.3 | 0.1 | 0.97 | 0.96 | 0.87 | 0.80 | 1181 | 390 | 1103 | 349 |
| | | | | | | | | | | | | | | | |
| **Total Retail & Wholesale / Trade** | | | | | | | | | | | | **4416** | **4034** | **4034** | **3454** |
| Shops < 30 m2 | 3000 | 2000 | 0.00 | 1.0 | 0.8 | 1.0 | 1.0 | 0.87 | 0.80 | 0.74 | 0.59 | 4610 | 4385 | 4220 | 3770 |
| Shops > 30 m2 | 3000 | 2000 | 0.00 | 1.0 | 0.8 | 1.0 | 1.0 | 0.87 | 0.80 | 0.74 | 0.59 | 4610 | 4385 | 4220 | 3770 |
| Reception / Circulation Areas | 3000 | 2000 | 0.00 | 1.0 | 0.8 | 1.0 | 1.0 | 0.83 | 0.74 | 0.66 | 0.47 | 4490 | 4205 | 3980 | 3410 |
| Common toilets and wardrobes | 3000 | 2000 | 0.50 | 1.0 | 0.8 | 0.7 | 0.5 | 0.97 | 0.96 | 0.87 | 0.80 | 3445 | 2439 | 3227 | 2193 |
| Storeroom / Warehouse | 3000 | 2000 | 0.40 | 1.0 | 0.8 | 0.8 | 0.6 | 0.88 | 0.81 | 0.76 | 0.63 | 3712 | 2663 | 3424 | 2325 |
| | | | | | | | | | | | | | | | |
| **Hotel & Restaurant (total)** | | | | | | | | | | | | **2328** | **1832** | **2211** | **1687** |
| Rooms (excl. toilet/shower) | 3000 | 2000 | 0.60 | 1.0 | 0.8 | 0.6 | 0.4 | 0.74 | 0.59 | 0.65 | 0.46 | 2532 | 1508 | 2370 | 1352 |
| Toilet/Shower in rooms | 3000 | 2000 | 0.90 | 1.0 | 0.8 | 0.3 | 0.1 | 0.97 | 0.96 | 0.87 | 0.80 | 1477 | 488 | 1383 | 439 |
| Common toilets/wardrobes | 1985 | 1565 | 0.50 | 1.0 | 0.8 | 0.7 | 0.5 | 0.97 | 0.96 | 0.87 | 0.80 | 2449 | 1734 | 2304 | 1572 |
| Reception/ Circulation areas | 1985 | 1565 | 0.30 | 1.0 | 0.8 | 0.9 | 0.7 | 0.83 | 0.74 | 0.66 | 0.47 | 2891 | 2117 | 2588 | 1749 |
| Breakfast / Eating areas | 1250 | 1250 | 0.00 | 1.0 | 0.8 | 1.0 | 1.0 | 0.74 | 0.59 | 0.65 | 0.46 | 2175 | 1988 | 2063 | 1825 |
| Coffeeshops, Bars, Discotheques | 1250 | 1250 | 0.00 | 1.0 | 0.8 | 1.0 | 1.0 | 0.74 | 0.59 | 0.65 | 0.46 | 2175 | 1988 | 2063 | 1825 |
| Offices | 1985 | 1565 | 0.40 | 1.0 | 0.8 | 0.8 | 0.6 | 0.81 | 0.67 | 0.76 | 0.60 | 2538 | 1737 | 2459 | 1654 |
| Meeting Rooms | 3000 | 2000 | 0.40 | 1.0 | 0.8 | 0.8 | 0.6 | 0.81 | 0.67 | 0.76 | 0.60 | 3544 | 2406 | 3424 | 2280 |
| Kitchen | 1250 | 1250 | 0.00 | 1.0 | 0.8 | 1.0 | 1.0 | 0.96 | 0.93 | 0.91 | 0.84 | 2453 | 2418 | 2381 | 2294 |
| Technical areas | 1985 | 1565 | 0.98 | 1.0 | 0.8 | 0.1 | 0.0 | 0.97 | 0.96 | 0.87 | 0.80 | 210 | 69 | 198 | 63 |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| **Education Total** | | | | | | | | | | | | **1248** | **787** | **1138** | **668** |

| cyan fields are inputs, can be changed<br>green fields are based on formulas but can be changed if desired | potential daytime hours,tD h/a | potential nighttime hours,tN h/a | absence factor FA | occupancy control factor Foc | | occupancy dependency factor Fo | | Daylight Dependency Factor | | | | effective operating hours (h/a) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | low availability | | medium availability | | low availability | | medium availability | |
| | | | | manual | best auto | manual | best auto | manual control | best auto | manual control | best auto control | manual control | best auto | manual control | best auto control |
| Creche, play area | 1800 | 200 | 0.40 | 1.0 | 0.8 | 0.8 | 0.6 | 0.74 | 0.59 | 0.65 | 0.46 | 1226 | 757 | 1096 | 617 |
| (Pre-)Primary resting area | 1800 | 200 | 0.40 | 1.0 | 0.8 | 0.8 | 0.6 | 0.74 | 0.59 | 0.65 | 0.46 | 1226 | 757 | 1096 | 617 |
| Class Rooms | 1800 | 200 | 0.30 | 1.0 | 0.8 | 0.9 | 0.7 | 0.74 | 0.59 | 0.65 | 0.46 | 1379 | 883 | 1233 | 720 |
| Meeting Rooms | 1800 | 200 | 0.50 | 1.0 | 0.8 | 0.7 | 0.5 | 0.81 | 0.67 | 0.76 | 0.60 | 1161 | 703 | 1098 | 640 |
| Library | 1800 | 200 | 0.40 | 1.0 | 0.8 | 0.8 | 0.6 | 0.81 | 0.67 | 0.76 | 0.60 | 1326 | 844 | 1254 | 768 |
| Teacher's Room | 1800 | 200 | 0.40 | 1.0 | 0.8 | 0.8 | 0.6 | 0.74 | 0.59 | 0.65 | 0.46 | 1226 | 757 | 1096 | 617 |
| Computer education area | 1800 | 200 | 0.30 | 1.0 | 0.8 | 0.9 | 0.7 | 0.74 | 0.59 | 0.65 | 0.46 | 1379 | 883 | 1233 | 720 |
| Reception/ Circulation Area | 1800 | 200 | 0.60 | 1.0 | 0.8 | 0.6 | 0.4 | 0.83 | 0.74 | 0.66 | 0.47 | 1016 | 609 | 833 | 418 |
| Common toilets / wardrobes | 1800 | 200 | 0.70 | 1.0 | 0.8 | 0.5 | 0.3 | 0.97 | 0.96 | 0.87 | 0.80 | 977 | 578 | 883 | 489 |
| Standard Offices | 1800 | 200 | 0.30 | 1.0 | 0.8 | 0.9 | 0.7 | 0.81 | 0.67 | 0.76 | 0.60 | 1492 | 984 | 1411 | 896 |
| Technical Service Rooms | 1800 | 200 | 0.98 | 1.0 | 0.8 | 0.1 | 0.0 | 0.97 | 0.96 | 0.87 | 0.80 | 117 | 39 | 106 | 33 |
| | | | | | | | | | | | | | | | |
| **Hospitals/Healthcare Total** | | | | | | | | | | | | **3854** | **2957** | **3654** | **2699** |
| Wards / Bedrooms | 3000 | 2000 | 0.00 | 1.0 | 0.8 | 1.0 | 1.0 | 0.74 | 0.59 | 0.65 | 0.46 | 4220 | 3770 | 3950 | 3380 |
| Dayroom / Eating Room | 3000 | 2000 | 0.20 | 1.0 | 0.8 | 1.0 | 0.8 | 0.74 | 0.59 | 0.65 | 0.46 | 4220 | 3016 | 3950 | 2704 |
| Examination / Treatment Rooms | 3000 | 2000 | 0.40 | 1.0 | 0.8 | 0.8 | 0.6 | 0.81 | 0.67 | 0.76 | 0.60 | 3544 | 2406 | 3424 | 2280 |
| Waiting Area | 3000 | 2000 | 0.00 | 1.0 | 0.8 | 1.0 | 1.0 | 0.74 | 0.59 | 0.65 | 0.46 | 4220 | 3770 | 3950 | 3380 |
| Reception / Circulation Areas | 3000 | 2000 | 0.00 | 1.0 | 0.8 | 1.0 | 1.0 | 0.83 | 0.74 | 0.66 | 0.47 | 4490 | 4205 | 3980 | 3410 |
| Common toilets, wardrobes, showers | 3000 | 2000 | 0.50 | 1.0 | 0.8 | 0.7 | 0.5 | 0.97 | 0.96 | 0.87 | 0.80 | 3445 | 2439 | 3227 | 2193 |
| Standard offices | 3000 | 2000 | 0.30 | 1.0 | 0.8 | 0.9 | 0.7 | 0.81 | 0.67 | 0.76 | 0.60 | 3987 | 2807 | 3852 | 2660 |
| Laboratories | 3000 | 2000 | 0.20 | 1.0 | 0.8 | 1.0 | 0.8 | 0.81 | 0.67 | 0.76 | 0.60 | 4430 | 3208 | 4280 | 3040 |
| Technical Service / Production Areas | 3000 | 2000 | 0.98 | 1.0 | 0.8 | 0.1 | 0.0 | 0.97 | 0.96 | 0.87 | 0.80 | 295 | 98 | 277 | 88 |
| | | | | | | | | | | | | | | | |
| **Offices Total** | | | | | | | | | | | | **1869** | **1302** | **1745** | **1158** |
| Cellular office | 2250 | 250 | 0.30 | 1.0 | 0.8 | 0.9 | 0.7 | 0.81 | 0.67 | 0.76 | 0.60 | 1865 | 1230 | 1764 | 1120 |
| Open Plan Office (Landscape office) | 2250 | 250 | 0.10 | 1.0 | 0.8 | 1.0 | 0.9 | 0.81 | 0.67 | 0.76 | 0.60 | 2073 | 1582 | 1960 | 1440 |
| Reception/ Circulation Area | 2250 | 250 | 0.30 | 1.0 | 0.8 | 0.9 | 0.7 | 0.83 | 0.74 | 0.66 | 0.47 | 1906 | 1333 | 1562 | 915 |
| Common toilets / wardrobes / showers | 2250 | 250 | 0.50 | 1.0 | 0.8 | 0.7 | 0.5 | 0.97 | 0.96 | 0.87 | 0.80 | 1709 | 1204 | 1545 | 1019 |
| Meeting Rooms | 2250 | 250 | 0.50 | 1.0 | 0.8 | 0.7 | 0.5 | 0.81 | 0.67 | 0.76 | 0.60 | 1451 | 879 | 1372 | 800 |
| Copying, Server, Archive, Technical areas | 2250 | 250 | 0.60 | 1.0 | 0.8 | 0.6 | 0.4 | 0.95 | 0.92 | 0.87 | 0.80 | 1430 | 926 | 1325 | 816 |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| **Sports Total** | | | | | | | | | | | | **3145** | **2307** | **3026** | **2168** |
| Sports Hall | 2000 | 2000 | 0.30 | 1.0 | 0.8 | 0.9 | 0.7 | 0.81 | 0.67 | 0.76 | 0.60 | 3258 | 2338 | 3168 | 2240 |

| cyan fields are inputs, can be changed<br>green fields are based on formulas<br>but can be changed if desired | potential daytime hours,tD h/a | potential nighttime hours,tN h/a | absence factor FA | occupancy control factor Foc | | occupancy dependency factor Fo | | Daylight Dependency Factor | | | | effective operating hours (h/a) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | low availability | | medium availability | | low availability | | medium availability | |
| | | | | manual | best auto | manual | best auto | manual control | best auto | manual control | best auto control | manual control | best auto | manual control | best auto control |
| Common toilets / wardrobes / showers | 2000 | 2000 | 0.50 | 1.0 | 0.8 | 0.7 | 0.5 | 0.97 | 0.96 | 0.87 | 0.80 | 2764 | 1959 | 2618 | 1795 |
| Reception/ Circulation Area | 2000 | 2000 | 0.20 | 1.0 | 0.8 | 1.0 | 0.8 | 0.83 | 0.74 | 0.66 | 0.47 | 3660 | 2776 | 3320 | 2352 |
| Mensa, Restaurant, Bar, Resting area | 2000 | 2000 | 0.00 | 1.0 | 0.8 | 1.0 | 1.0 | 0.74 | 0.59 | 0.65 | 0.46 | 3480 | 3180 | 3300 | 2920 |
| Offices | 2000 | 2000 | 0.40 | 1.0 | 0.8 | 0.8 | 0.6 | 0.81 | 0.67 | 0.76 | 0.60 | 2896 | 2004 | 2816 | 1920 |
| | | | | | | | | | | | | | | | |
| **Parking in structures** | | | | | | | | | | | | **2343** | **1150** | **2179** | **1023** |
| public access | 4380 | 2190 | 0.80 | 1.0 | 0.8 | 0.4 | 0.2 | 0.97 | 0.95 | 0.86 | 0.79 | 2568 | 1268 | 2390 | 1128 |
| private access (offices) | 2250 | 250 | 0.95 | 1.0 | 0.8 | 0.2 | 0.1 | 0.97 | 0.95 | 0.86 | 0.79 | 364 | 119 | 329 | 101 |
| | | | | | | | | | | | | | | | |
| **Stations, Airports, similar (Total)** | | | | | | | | | | | | **4736** | **3267** | **4381** | **2849** |
| passenger/client (waiting) area | 4380 | 2190 | 0.25 | 1.0 | 0.8 | 1.0 | 0.8 | 0.74 | 0.59 | 0.65 | 0.46 | 5160 | 3581 | 4785 | 3154 |
| reception and circulation areas | 4380 | 2190 | 0.25 | 1.0 | 0.8 | 1.0 | 0.8 | 0.83 | 0.74 | 0.66 | 0.47 | 5534 | 4057 | 4827 | 3186 |
| customs and security | 4380 | 2190 | 0.20 | 1.0 | 0.8 | 1.0 | 0.8 | 0.91 | 0.84 | 0.81 | 0.67 | 6154 | 4678 | 5738 | 4100 |
| common toilets, wardrobes, etc. | 4380 | 2190 | 0.50 | 1.0 | 0.8 | 0.7 | 0.5 | 0.97 | 0.96 | 0.87 | 0.80 | 4519 | 3195 | 4200 | 2836 |
| offices | 4380 | 2190 | 0.60 | 1.0 | 0.8 | 0.6 | 0.4 | 0.81 | 0.67 | 0.76 | 0.60 | 3443 | 2050 | 3311 | 1927 |
| | | | | | | | | | | | | | | | |
| **Entertainment and news (Total)** | | | | | | | | | | | | **2208** | **1872** | **2007** | **1596** |
| Video and Movie production and Cinemas | 2250 | 250 | 0.20 | 1.0 | 0.8 | 1.0 | 0.8 | 0.87 | 0.80 | 0.74 | 0.59 | 2208 | 1631 | 1915 | 1262 |
| Radio and TV | 2250 | 250 | 0.20 | 1.0 | 0.8 | 1.0 | 0.8 | 0.74 | 0.59 | 0.65 | 0.46 | 1915 | 1262 | 1713 | 1028 |
| Theatre, Dancing, Amusement park | 1250 | 1250 | 0.00 | 1.0 | 0.8 | 1.0 | 1.0 | 0.87 | 0.80 | 0.74 | 0.59 | 2338 | 2244 | 2175 | 1988 |
| | | | | | | | | | | | | | | | |
| **Miscellaneous (Total)** | | | | | | | | | | | | **2301** | **1666** | **2086** | **1398** |
| Prisons | 3000 | 2000 | 0.00 | 1.0 | 0.8 | 1.0 | 1.0 | 0.87 | 0.80 | 0.74 | 0.59 | 4610 | 4385 | 4220 | 3770 |
| Fire service activities | 3000 | 2000 | 0.80 | 1.0 | 0.8 | 0.4 | 0.2 | 0.74 | 0.59 | 0.65 | 0.46 | 1688 | 754 | 1580 | 676 |
| Waste disposal / sewage | 2250 | 250 | 0.20 | 1.0 | 0.8 | 1.0 | 0.8 | 0.74 | 0.59 | 0.65 | 0.46 | 1915 | 1262 | 1713 | 1028 |
| Political and religious (incl. churches) | 2500 | 1500 | 0.50 | 1.0 | 0.8 | 0.7 | 0.5 | 0.66 | 0.47 | 0.58 | 0.35 | 2205 | 1338 | 2065 | 1188 |
| Libraries, museums, zoo | 2250 | 250 | 0.40 | 1.0 | 0.8 | 0.8 | 0.6 | 0.87 | 0.80 | 0.74 | 0.59 | 1766 | 1223 | 1532 | 947 |
| | | | | | | | | | | | | | | | |
| **Total Non-Residential (indoor)** | | | | | | | | | | | | **2739** | **2120** | **2538** | **1858** |
| **MELISA 2013 indoor** | | | | | | | | | | | | | | **1467** | |

*Table 0-30 Estimate of effective operating hours, per non-residential building type, based on prEN 15193 potential hours and occupancy factors, and VHK-estimated daylight factors. (source: VHK 2015)*

| **Summary per type of building** | | effective operating hours (h/a) | | | |
|---|---|---|---|---|---|
| | | low daylight availability | | medium daylight availability | |
| | | manual control | best auto control | manual control | best auto control |
| Offices Total | | 1869 | 1302 | 1745 | 1158 |
| Total Manufacturing / Industry | | 3048 | 2220 | 2806 | 1922 |
| Total Retail & Wholesale / Trade | | 4416 | 4034 | 4034 | 3454 |
| Education Total | | 1248 | 787 | 1138 | 668 |
| Hospitals/Healthcare Total | | 3854 | 2957 | 3654 | 2699 |
| Hotel & Restaurant (total) | | 2328 | 1832 | 2211 | 1687 |
| Sports Total | | 3145 | 2307 | 3026 | 2168 |
| Entertainment and news (Total) | | 2208 | 1872 | 2007 | 1596 |
| Miscellaneous (Total) | | 2301 | 1666 | 2086 | 1398 |
| Stations, Airports, similar (Total) | | 4736 | 3267 | 4381 | 2849 |
| Parking in structures | | 2343 | 1150 | 2179 | 1023 |
| | | | | | |
| **Total Non-Residential (indoor)** | | **2739** | **2120** | **2538** | **1858** |

*Table 0-31 Estimate of effective operating hours, per non-residential room/activity type, based on prEN 15193 potential hours and occupancy factors, and VHK-estimated daylight factors. (source: VHK 2015)*

| **Summary per type of room** | | effective operating hours (h/a) | | | |
|---|---|---|---|---|---|
| | | low daylight availability | | medium daylight availability | |
| | | manual control | best auto control | manual control | best auto control |
| manufacturing area | | 3319 | 2520 | 3025 | 2143 |
| offices (open space) | | 2073 | 1582 | 1960 | 1440 |
| offices (cellular) | | 1865 | 1230 | 1764 | 1120 |
| offices (general, small) | | 2779 | 1918 | 2677 | 1808 |
| circulation areas | | 3115 | 2579 | 2717 | 2036 |
| Shops < 30 m2 | | 4610 | 4385 | 4220 | 3770 |
| meeting rooms | | 1499 | 930 | 1424 | 855 |
| Class rooms and similar | | 1359 | 867 | 1215 | 706 |
| toilets, showers, wardrobes | | 2303 | 1529 | 2147 | 1363 |
| Shops > 30 m2 | | 4610 | 4385 | 4220 | 3770 |
| technical / service areas | | 1078 | 521 | 1004 | 461 |
| eating / drinking areas | | 2642 | 2302 | 2498 | 2105 |
| Sports Hall | | 3258 | 2338 | 3168 | 2240 |
| Examination / Treatment Rooms | | 3544 | 2406 | 3424 | 2280 |
| Theatre, Dancing, Amusement park | | 2338 | 2244 | 2175 | 1988 |
| Storeroom / Warehouse | | 3712 | 2663 | 3424 | 2325 |
| waiting areas | | 3811 | 3133 | 3548 | 2785 |
| Libraries, museums, zoo | | 1581 | 1063 | 1415 | 871 |
| Laboratories | | 4430 | 3208 | 4280 | 3040 |
| Radio and TV | | 1915 | 1262 | 1713 | 1028 |
| Hospital wards/bedrooms | | 4220 | 3770 | 3950 | 3380 |
| Video and Movie production and Cinemas | | 2208 | 1631 | 1915 | 1262 |
| Kitchens | | 2453 | 2418 | 2381 | 2294 |
| Hotel rooms (excl. toilet/shower) | | 2532 | 1508 | 2370 | 1352 |
| Political and religious (incl. churches) | | 2205 | 1338 | 2065 | 1188 |
| Parking in structures | | 2343 | 1150 | 2179 | 1023 |
| Waste disposal / sewage | | 1915 | 1262 | 1713 | 1028 |
| Prisons | | 4610 | 4385 | 4220 | 3770 |
| Fire service activities | | 1688 | 754 | 1580 | 676 |
| **Total Non-Residential (indoor)** | | **2739** | **2120** | **2538** | **1858** |

## F6 Determination of Lighting Energy

The total EU-28 annual lighting energy for non-residential buildings is computed by multiplication of the total EU-28 installed power (chapter E4) and the annual operating hours (chapter E5). Considering that four estimates have been made for the operating hours, there are also four estimates for the energy, depending on the average quantity of daylight available in the EU buildings (low, medium) and on the type of lighting control for occupancy and daylight dependent lighting (manual, best automated option).

The results are shown in Table 0-32 (full list), Table 0-33 (summary per building type) and Table 0-34 (summary per room/activity type). All results are inclusive ballasts, but exclusive special purpose lamps, controls and standby. Effects of factors Fc (dimming for over-design) and FL (average efficacy) are NOT included in the table values, see comments below. The following conclusions can be drawn:

1- Based on data from prEN 15193 and VHK estimates, the annual energy for indoor lighting of EU-28 non-residential buildings is estimated between 222 and 240 TWh/a when manual occupancy and daylight controls are assumed, and between 162 and 185 TWh/a when best automated controls are assumed.

2- The EU-28 average control system for occupancy dependent and daylight dependent lighting is currently expected to be closer to the manual system than to the best automated system. This leads to an energy estimate between 200 and 230 TWh/a.

3- The above estimates do NOT take into account the beneficial effects of constant illuminance control. Considering a factor Fc=0.95 (see conclusions in E5.4), the estimate for the EU-28 annual lighting energy for non-residential buildings is between 190 and 220 TWh/a.

4- The above estimate is valid for an efficacy of 60 luminaire lumen per circuit Watt. As explained in E4.3, if the MELISA mix of lamp types is considered (with lower average efficacy), the installed power would be FL=1.28 times higher and consequently the annual energy would be 240-280 TWh/a.

5- For non-residential indoor lighting (excluding HID lamps, assumed to be used mainly in outdoor lighting) the MELISA model for 2013 shows an annual lighting energy of 155 TWh/a (inclusive ballasts; exclusive special purpose lamps, controls and standby).

6- The overall average energy density (LENI) for EU-28 non-residential buildings is 14-20 kWh/m$^2$/a (not corrected for Fc and FL). The corresponding 2013-value from MELISA is 13 kWh/m$^2$/a.

7- The difference between the two estimates derives almost entirely from a difference in operating hours, see remarks in E5.4.

8- As regards building types/sectors, the highest lighting energy is estimated for manufacturing/industry (38-61 TWh/a), for the retail sector (47-60 TWh/a) and for office buildings (24-39 TWh/a). The highest energy density is found for stations/airports (18-31 kWh/m$^2$/a) and for hospital/healthcare (20-28 kWh/m$^2$/a). Excluding parkings, the lowest energy density is found for educational buildings (6-11 kWh/m$^2$/a).

9- As regards room/activity types, the highest annual lighting energy is estimated for manufacturing areas (27.5-42.5 TWh/a), although this is exceeded if the three office types are taken together ( 31.9-49.4 TWh/a). The highest energy density is found for laboratories (38-55 kWh/$m^2$/a), small shops (38-46 kWh/$m^2$/a) and examination/treatment rooms (26-41 kWh/$m^2$/a). Low density values are found for parkings (1-3 kWh/$m^2$/a), technical/service areas (3-6), political activities/churches (4-8) and warehouses (5-9).

*Table 0-32 Installed power (GW), Operating hours (h/a), Annual lighting energy (TWh/a) and Energy density (kWh/m2/a, LENI), EU-28 totals for non-residential buildings (indoor), based on data in prEN 15193 and VHK estimates. Power and Energy are valid for MF=0.8 and 60 luminaire lumens per circuit Watt. Ballasts and control gears are included. Special purpose lamps, controls and standby are excluded. (source: VHK 2015)*

| **Full list** | EU-28 installed power GW @60 LL/W | installed power density W/m2 @60 LL/W | effective operating hours (h/a) | | | | annual lighting energy (Twh/a) @60 LL/W | | | | lighting energy density (kWh/m2/a) @60 LL/W) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | low daylight availability | | medium daylight availability | | low daylight availability | | medium daylight availability | | low daylight availability | | medium daylight availability | |
| | | | manual control | best auto control | manual control | best auto control | manual control | best auto control | manual control | best auto control | manual control | best auto control | manual control | best auto control |
| **Total Manufacturing / Industry** | **20.0** | **8.1** | **3048** | **2220** | **2806** | **1922** | **60.9** | **44.4** | **56.1** | **38.4** | **24.8** | **18.0** | **22.8** | **15.6** |
| Production Area | 12.8 | 8.7 | 3319 | 2520 | 3025 | 2143 | 42.5 | 32.3 | 38.8 | 27.5 | 28.8 | 21.9 | 26.3 | 18.6 |
| Reception / Circulation Areas | 0.9 | 3.7 | 3575 | 2670 | 3150 | 2140 | 3.3 | 2.4 | 2.9 | 1.9 | 13.2 | 9.9 | 11.6 | 7.9 |
| Common toilets, showers, wardrobes | 1.6 | 6.4 | 1968 | 1169 | 1838 | 1046 | 3.1 | 1.8 | 2.9 | 1.6 | 12.6 | 7.5 | 11.7 | 6.7 |
| Offices | 3.3 | 13.3 | 3173 | 2223 | 3060 | 2100 | 10.4 | 7.3 | 10.0 | 6.9 | 42.1 | 29.5 | 40.6 | 27.8 |
| Technical Service Rooms | 1.4 | 5.8 | 1181 | 390 | 1103 | 349 | 1.7 | 0.6 | 1.6 | 0.5 | 6.8 | 2.3 | 6.4 | 2.0 |
| **Total Retail & Wholesale / Trade** | **13.6** | **5.7** | **4416** | **4034** | **4034** | **3454** | **60.0** | **54.8** | **54.8** | **46.9** | **25.2** | **23.0** | **23.0** | **19.7** |
| Shops < 30 m2 | 6.4 | 9.9 | 4610 | 4385 | 4220 | 3770 | 29.5 | 28.1 | 27.0 | 24.1 | 45.9 | 43.6 | 42.0 | 37.5 |
| Shops > 30 m2 | 3.1 | 7.6 | 4610 | 4385 | 4220 | 3770 | 14.1 | 13.4 | 12.9 | 11.5 | 35.0 | 33.3 | 32.0 | 28.6 |
| Reception / Circulation Areas | 1.6 | 3.6 | 4490 | 4205 | 3980 | 3410 | 7.3 | 6.8 | 6.5 | 5.6 | 16.2 | 15.2 | 14.4 | 12.3 |
| Common toilets and wardrobes | 0.7 | 6.4 | 3445 | 2439 | 3227 | 2193 | 2.5 | 1.8 | 2.3 | 1.6 | 22.0 | 15.6 | 20.6 | 14.0 |
| Storeroom / Warehouse | 1.8 | 2.3 | 3712 | 2663 | 3424 | 2325 | 6.6 | 4.7 | 6.1 | 4.1 | 8.6 | 6.1 | 7.9 | 5.4 |
| **Hotel & Restaurant (total)** | **4.9** | **6.5** | **2328** | **1832** | **2211** | **1687** | **11.4** | **9.0** | **10.8** | **8.3** | **15.1** | **11.9** | **14.4** | **11.0** |
| Rooms (excl. toilet/shower) | 0.9 | 6.5 | 2532 | 1508 | 2370 | 1352 | 2.3 | 1.4 | 2.1 | 1.2 | 16.5 | 9.9 | 15.5 | 8.8 |
| Toilet/Shower in rooms | 0.2 | 6.9 | 1477 | 488 | 1383 | 439 | 0.3 | 0.1 | 0.3 | 0.1 | 10.2 | 3.4 | 9.6 | 3.0 |
| Common toilets/wardrobes | 0.2 | 6.4 | 2449 | 1734 | 2304 | 1572 | 0.4 | 0.3 | 0.4 | 0.3 | 15.6 | 11.1 | 14.7 | 10.0 |
| Reception/ Circulation areas | 0.2 | 3.8 | 2891 | 2117 | 2588 | 1749 | 0.5 | 0.4 | 0.5 | 0.3 | 10.9 | 8.0 | 9.8 | 6.6 |
| Breakfast / Eating areas | 1.5 | 5.2 | 2175 | 1988 | 2063 | 1825 | 3.2 | 3.0 | 3.1 | 2.7 | 11.3 | 10.4 | 10.7 | 9.5 |
| Coffeeshops, Bars, Discotheques | 0.3 | 4.3 | 2175 | 1988 | 2063 | 1825 | 0.7 | 0.7 | 0.7 | 0.6 | 9.4 | 8.6 | 8.9 | 7.9 |
| Offices | 0.2 | 13.3 | 2538 | 1737 | 2459 | 1654 | 0.4 | 0.3 | 0.4 | 0.3 | 33.7 | 23.0 | 32.6 | 21.9 |
| Meeting Rooms | 0.4 | 13.2 | 3544 | 2406 | 3424 | 2280 | 1.5 | 1.0 | 1.5 | 1.0 | 46.6 | 31.7 | 45.0 | 30.0 |
| Kitchen | 0.8 | 13.0 | 2453 | 2418 | 2381 | 2294 | 1.9 | 1.9 | 1.8 | 1.8 | 32.0 | 31.5 | 31.1 | 29.9 |
| Technical areas | 0.2 | 5.8 | 210 | 69 | 198 | 63 | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | 0.4 | 1.1 | 0.4 |

| Full list | EU-28 installed power GW @60 LL/W | installed power density W/m2 @60 LL/W | effective operating hours (h/a) | | | | annual lighting energy (Twh/a) @60 LL/W | | | | lighting energy density (kWh/m2/a) @60 LL/W) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | low daylight availability | | medium daylight availability | | low daylight availability | | medium daylight availability | | low daylight availability | | medium daylight availability | |
| | | | manual control | best auto control | manual control | best auto control | manual control | best auto control | manual control | best auto control | manual control | best auto control | manual control | best auto control |
| **Education Total** | **11.0** | **8.5** | **1248** | **787** | **1138** | **668** | **13.8** | **8.7** | **12.6** | **7.4** | **10.6** | **6.7** | **9.6** | **5.7** |
| Creche, play area | 0.2 | 9.0 | 1226 | 757 | 1096 | 617 | 0.3 | 0.2 | 0.2 | 0.1 | 11.1 | 6.8 | 9.9 | 5.6 |
| (Pre-)Primary resting area | 0.4 | 6.3 | 1226 | 757 | 1096 | 617 | 0.5 | 0.3 | 0.4 | 0.2 | 7.7 | 4.7 | 6.9 | 3.9 |
| Class Rooms | 3.6 | 8.3 | 1379 | 883 | 1233 | 720 | 5.0 | 3.2 | 4.5 | 2.6 | 11.4 | 7.3 | 10.2 | 5.9 |
| Meeting Rooms | 2.3 | 14.3 | 1161 | 703 | 1098 | 640 | 2.6 | 1.6 | 2.5 | 1.5 | 16.6 | 10.0 | 15.7 | 9.1 |
| Library | 0.4 | 9.0 | 1326 | 844 | 1254 | 768 | 0.5 | 0.3 | 0.5 | 0.3 | 12.0 | 7.6 | 11.3 | 6.9 |
| Teacher's Room | 0.2 | 8.9 | 1226 | 757 | 1096 | 617 | 0.3 | 0.2 | 0.2 | 0.1 | 10.9 | 6.7 | 9.7 | 5.5 |
| Computer education area | 0.4 | 9.0 | 1379 | 883 | 1233 | 720 | 0.6 | 0.4 | 0.5 | 0.3 | 12.4 | 7.9 | 11.1 | 6.5 |
| Reception/ Circulation Area | 0.8 | 3.7 | 1016 | 609 | 833 | 418 | 0.9 | 0.5 | 0.7 | 0.4 | 3.8 | 2.3 | 3.1 | 1.6 |
| Common toilets / wardrobes | 0.4 | 6.2 | 977 | 578 | 883 | 489 | 0.4 | 0.2 | 0.4 | 0.2 | 6.0 | 3.6 | 5.5 | 3.0 |
| Standard Offices | 1.8 | 13.3 | 1492 | 984 | 1411 | 896 | 2.7 | 1.8 | 2.5 | 1.6 | 19.8 | 13.1 | 18.7 | 11.9 |
| Technical Service Rooms | 0.4 | 5.8 | 117 | 39 | 106 | 33 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 0.2 | 0.6 | 0.2 |
| | | | | | | | | | | | | | | |
| **Hospitals/Healthcare Total** | **6.6** | **7.3** | **3854** | **2957** | **3654** | **2699** | **25.4** | **19.5** | **24.1** | **17.8** | **28.0** | **21.5** | **26.5** | **19.6** |
| Wards / Bedrooms | 0.8 | 4.4 | 4220 | 3770 | 3950 | 3380 | 3.6 | 3.2 | 3.3 | 2.9 | 18.7 | 16.7 | 17.5 | 15.0 |
| Dayroom / Eating Room | 0.3 | 5.1 | 4220 | 3016 | 3950 | 2704 | 1.4 | 1.0 | 1.3 | 0.9 | 21.4 | 15.3 | 20.0 | 13.7 |
| Examination / Treatment Rooms | 2.1 | 11.6 | 3544 | 2406 | 3424 | 2280 | 7.4 | 5.0 | 7.1 | 4.7 | 40.9 | 27.8 | 39.6 | 26.3 |
| Waiting Area | 0.7 | 6.1 | 4220 | 3770 | 3950 | 3380 | 2.9 | 2.6 | 2.7 | 2.3 | 25.8 | 23.1 | 24.2 | 20.7 |
| Reception / Circulation Areas | 0.5 | 3.7 | 4490 | 4205 | 3980 | 3410 | 2.2 | 2.0 | 1.9 | 1.6 | 16.8 | 15.7 | 14.9 | 12.7 |
| Common toilets, wardrobes, showers | 0.5 | 6.2 | 3445 | 2439 | 3227 | 2193 | 1.7 | 1.2 | 1.6 | 1.1 | 21.3 | 15.1 | 19.9 | 13.6 |
| Standard offices | 0.7 | 13.3 | 3987 | 2807 | 3852 | 2660 | 2.6 | 1.8 | 2.5 | 1.7 | 52.9 | 37.2 | 51.1 | 35.3 |
| Laboratories | 0.8 | 12.4 | 4430 | 3208 | 4280 | 3040 | 3.6 | 2.6 | 3.5 | 2.5 | 54.8 | 39.7 | 53.0 | 37.6 |
| Technical Service / Production Areas | 0.2 | 5.8 | 295 | 98 | 277 | 88 | 0.1 | 0.0 | 0.1 | 0.0 | 1.7 | 0.6 | 1.6 | 0.5 |
| | | | | | | | | | | | | | | |
| **Offices Total** | **20.8** | **9.8** | **1869** | **1302** | **1745** | **1158** | **38.8** | **27.1** | **36.3** | **24.1** | **18.4** | **12.8** | **17.1** | **11.4** |
| Cellular office | 8.5 | 12.9 | 1865 | 1230 | 1764 | 1120 | 15.9 | 10.5 | 15.0 | 9.5 | 24.1 | 15.9 | 22.7 | 14.4 |
| Open Plan Office (Landscape office) | 6.8 | 11.1 | 2073 | 1582 | 1960 | 1440 | 14.0 | 10.7 | 13.2 | 9.7 | 23.0 | 17.5 | 21.7 | 16.0 |
| Reception/ Circulation Area | 1.6 | 3.8 | 1906 | 1333 | 1562 | 915 | 3.0 | 2.1 | 2.5 | 1.5 | 7.2 | 5.0 | 5.9 | 3.5 |
| Common toilets / wardrobes / showers | 0.9 | 6.4 | 1709 | 1204 | 1545 | 1019 | 1.6 | 1.1 | 1.5 | 1.0 | 10.9 | 7.7 | 9.9 | 6.5 |
| Meeting Rooms | 2.3 | 13.5 | 1451 | 879 | 1372 | 800 | 3.3 | 2.0 | 3.1 | 1.8 | 19.6 | 11.9 | 18.6 | 10.8 |
| Copying, Server, Archive, Technical areas | 0.7 | 6.5 | 1430 | 926 | 1325 | 816 | 1.0 | 0.6 | 0.9 | 0.6 | 9.3 | 6.0 | 8.6 | 5.3 |

| Full list | EU-28 installed power GW @60 LL/W | installed power density W/m2 @60 LL/W | effective operating hours (h/a) | | | | annual lighting energy (Twh/a) @60 LL/W | | | | lighting energy density (kWh/m2/a) @60 LL/W) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | low daylight availability | | medium daylight availability | | low daylight availability | | medium daylight availability | | low daylight availability | | medium daylight availability | |
| | | | manual control | best auto control | manual control | best auto control | manual control | best auto control | manual control | best auto control | manual control | best auto control | manual control | best auto control |
| **Sports Total** | **4.2** | **7.7** | **3145** | **2307** | **3026** | **2168** | **13.1** | **9.6** | **12.6** | **9.1** | **24.1** | **17.7** | **23.2** | **16.6** |
| Sports Hall | 2.0 | 8.1 | 3258 | 2338 | 3168 | 2240 | 6.4 | 4.6 | 6.2 | 4.4 | 26.5 | 19.0 | 25.8 | 18.2 |
| Common toilets / wardrobes / showers | 0.6 | 6.2 | 2764 | 1959 | 2618 | 1795 | 1.7 | 1.2 | 1.7 | 1.1 | 17.1 | 12.1 | 16.2 | 11.1 |
| Reception/ Circulation Area | 0.2 | 3.8 | 3660 | 2776 | 3320 | 2352 | 0.9 | 0.7 | 0.8 | 0.6 | 13.8 | 10.5 | 12.5 | 8.9 |
| Mensa, Restaurant, Bar, Resting area | 0.4 | 5.7 | 3480 | 3180 | 3300 | 2920 | 1.3 | 1.2 | 1.2 | 1.1 | 19.9 | 18.2 | 18.9 | 16.7 |
| Offices | 0.9 | 14.0 | 2896 | 2004 | 2816 | 1920 | 2.7 | 1.9 | 2.7 | 1.8 | 40.5 | 28.0 | 39.4 | 26.9 |
| **Parking in structures** | **0.4** | **1.3** | **2343** | **1150** | **2179** | **1023** | **0.9** | **0.4** | **0.8** | **0.4** | **3.1** | **1.5** | **2.9** | **1.4** |
| public access | 0.3 | 1.3 | 2568 | 1268 | 2390 | 1128 | 0.9 | 0.4 | 0.8 | 0.4 | 3.4 | 1.7 | 3.2 | 1.5 |
| private access (offices) | 0.0 | 1.4 | 364 | 119 | 329 | 101 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 0.2 | 0.5 | 0.1 |
| **Stations, Airports, similar (Total)** | **0.7** | **6.5** | **4736** | **3267** | **4381** | **2849** | **3.3** | **2.3** | **3.0** | **2.0** | **30.7** | **21.1** | **28.4** | **18.4** |
| passenger/client (waiting) area | 0.2 | 5.3 | 5160 | 3581 | 4785 | 3154 | 1.2 | 0.8 | 1.1 | 0.7 | 27.1 | 18.8 | 25.2 | 16.6 |
| reception and circulation areas | 0.1 | 3.7 | 5534 | 4057 | 4827 | 3186 | 0.7 | 0.5 | 0.6 | 0.4 | 20.3 | 14.9 | 17.7 | 11.7 |
| customs and security | 0.1 | 13.2 | 6154 | 4678 | 5738 | 4100 | 0.4 | 0.3 | 0.4 | 0.3 | 81.5 | 61.9 | 75.9 | 54.3 |
| common toilets, wardrobes, etc. | 0.1 | 6.2 | 4519 | 3195 | 4200 | 2836 | 0.3 | 0.2 | 0.3 | 0.2 | 27.9 | 19.8 | 26.0 | 17.5 |
| offices | 0.2 | 13.3 | 3443 | 2050 | 3311 | 1927 | 0.7 | 0.4 | 0.7 | 0.4 | 45.7 | 27.2 | 43.9 | 25.6 |
| **Entertainment and news (Total)** | **3.8** | **6.2** | **2208** | **1872** | **2007** | **1596** | **8.4** | **7.1** | **7.6** | **6.1** | **13.6** | **11.5** | **12.4** | **9.8** |
| Video and Movie production and Cinemas | 0.9 | 5.7 | 2208 | 1631 | 1915 | 1262 | 1.9 | 1.4 | 1.7 | 1.1 | 12.6 | 9.3 | 10.9 | 7.2 |
| Radio and TV | 0.9 | 8.4 | 1915 | 1262 | 1713 | 1028 | 1.7 | 1.1 | 1.5 | 0.9 | 16.1 | 10.6 | 14.4 | 8.6 |
| Theatre, Dancing, Amusement park | 2.0 | 5.7 | 2338 | 2244 | 2175 | 1988 | 4.8 | 4.6 | 4.4 | 4.1 | 13.3 | 12.8 | 12.4 | 11.3 |
| **Miscellaneous (Total)** | **1.5** | **5.2** | **2301** | **1666** | **2086** | **1398** | **3.5** | **2.5** | **3.2** | **2.1** | **11.9** | **8.6** | **10.7** | **7.2** |
| Prisons | 0.2 | 5.7 | 4610 | 4385 | 4220 | 3770 | 0.9 | 0.8 | 0.8 | 0.7 | 26.3 | 25.0 | 24.1 | 21.5 |
| Fire service activities | 0.0 | 5.7 | 1688 | 754 | 1580 | 676 | 0.0 | 0.0 | 0.0 | 0.0 | 9.6 | 4.3 | 9.0 | 3.9 |
| Waste disposal / sewage | 0.2 | 5.7 | 1915 | 1262 | 1713 | 1028 | 0.4 | 0.3 | 0.4 | 0.2 | 10.9 | 7.2 | 9.8 | 5.9 |
| Political and religious (incl. churches) | 0.5 | 3.5 | 2205 | 1338 | 2065 | 1188 | 1.2 | 0.7 | 1.1 | 0.6 | 7.6 | 4.6 | 7.1 | 4.1 |
| Libraries, museums, zoo | 0.6 | 8.4 | 1766 | 1223 | 1532 | 947 | 1.0 | 0.7 | 0.9 | 0.5 | 14.8 | 10.3 | 12.9 | 8.0 |
| **Total Non-Residential (task level)** | **87** | **7.4** | **2739** | **2120** | **2538** | **1858** | **240** | **185** | **222** | **162** | **20.3** | **15.7** | **18.8** | **13.8** |
| MELISA 2013 non-residential (lamp level) | 121 | | | | | | 218 | | | | | | | |
| MELISA 2013 outdoor (all HID) | 16 | | | | | | 63 | | | | | | | |
| **MELISA 2013 indoor (lamp level)** | **106** | **9.0** | **1467** | | | | **155** | | | | **13.1** | | | |

*Table 0-33 Building Summary, Installed power (GW), Operating hours (h/a), Annual lighting energy (TWh/a) and Energy density (kWh/m2/a, LENI), EU-28 totals for non-residential buildings (indoor), based on data in prEN 15193 and VHK estimates. Power and Energy are valid for MF=0.8 and 60 luminaire lumens per circuit Watt. Ballasts and control gears are included. Special purpose lamps, controls and standby are excluded. (source: VHK 2015)*

| **Summary per type of building** | EU-28 installed power GW @60 LL/W | installed power density W/m2 @60 LL/W | effective operating hours (h/a) | | | | annual lighting energy (Twh/a) @60 LL/W | | | | lighting energy density (kWh/m2/a) @60 LL/W | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | low daylight availability | | medium daylight availability | | low daylight availability | | medium daylight availability | | low daylight availability | | medium daylight availability | |
| | | | manual control | best auto control | manual control | best auto control | manual control | best auto control | manual control | best auto control | manual control | best auto control | manual control | best auto control |
| Office buildings | 20.8 | 9.8 | 1869 | 1302 | 1745 | 1158 | 39 | 27 | 36 | 24 | 18 | 13 | 17 | 11 |
| Manufacturing / Industry | 20.0 | 8.1 | 3048 | 2220 | 2806 | 1922 | 61 | 44 | 56 | 38 | 25 | 18 | 23 | 16 |
| Retail & Wholesale / Trade | 13.6 | 5.7 | 4416 | 4034 | 4034 | 3454 | 60 | 55 | 55 | 47 | 25 | 23 | 23 | 20 |
| Educational buildings | 11.0 | 8.5 | 1248 | 787 | 1138 | 668 | 14 | 9 | 13 | 7 | 11 | 7 | 10 | 6 |
| Hospitals/Healthcare | 6.6 | 7.3 | 3854 | 2957 | 3654 | 2699 | 25 | 19 | 24 | 18 | 28 | 21 | 27 | 20 |
| Hotels & Restaurants | 4.9 | 6.5 | 2328 | 1832 | 2211 | 1687 | 11 | 9 | 11 | 8 | 15 | 12 | 14 | 11 |
| Sports buildings | 4.2 | 7.7 | 3145 | 2307 | 3026 | 2168 | 13 | 10 | 13 | 9 | 24 | 18 | 23 | 17 |
| Entertainment and news | 3.8 | 6.2 | 2208 | 1872 | 2007 | 1596 | 8 | 7 | 8 | 6 | 14 | 12 | 12 | 10 |
| Miscellaneous buildings | 1.5 | 5.2 | 2301 | 1666 | 2086 | 1398 | 3 | 3 | 3 | 2 | 12 | 9 | 11 | 7 |
| Stations, Airports, similar | 0.7 | 6.5 | 4736 | 3267 | 4381 | 2849 | 3 | 2 | 3 | 2 | 31 | 21 | 28 | 18 |
| Parking in structures | 0.4 | 1.3 | 2343 | 1150 | 2179 | 1023 | 1 | 0 | 1 | 0 | 3 | 2 | 3 | 1 |
| **Total Non-Residential** | **87** | **7.4** | **2739** | **2120** | **2538** | **1858** | **240** | **185** | **222** | **162** | **20** | **16** | **19** | **14** |
| **MELISA 2013** | **106** | **9.0** | **1467** | | | | **155** | | | | **13.1** | | | |

*Table 0-34 Room Summary, Installed power (GW), Operating hours (h/a), Annual lighting energy (TWh/a) and Energy density (kWh/m2/a, LENI) (source: VHK 2015)*

| Summary per type of room | EU-28 installed power GW @60 LL/W | installed power density W/m2 @60 LL/W | effective operating hours (h/a) | | | | annual lighting energy (Twh/a) @60 LL/W | | | | lighting energy density (kWh/m2/a) @60 LL/W | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | low daylight availability | | medium daylight availability | | low daylight availability | | medium daylight availability | | low daylight availability | | medium daylight availability | |
| | | | manual control | best auto control | manual control | best auto control | manual control | best auto control | manual control | best auto control | manual control | best auto control | manual control | best auto control |
| manufacturing area | 12.8 | 8.7 | 3319 | 2520 | 3025 | 2143 | 42.5 | 32.3 | 38.8 | 27.5 | 29 | 22 | 26 | 19 |
| offices (open space) | 6.8 | 11.1 | 2073 | 1582 | 1960 | 1440 | 14.0 | 10.7 | 13.2 | 9.7 | 23 | 18 | 22 | 16 |
| offices (cellular) | 8.5 | 12.9 | 1865 | 1230 | 1764 | 1120 | 15.9 | 10.5 | 15.0 | 9.5 | 24 | 16 | 23 | 14 |
| offices (general, small) | 7.0 | 13.4 | 2779 | 1918 | 2677 | 1808 | 19.5 | 13.4 | 18.8 | 12.7 | 37 | 26 | 36 | 24 |
| circulation areas | 6.0 | 3.7 | 3115 | 2579 | 2717 | 2036 | 18.7 | 15.5 | 16.3 | 12.2 | 12 | 10 | 10 | 8 |
| Shops < 30 m2 | 6.4 | 9.9 | 4610 | 4385 | 4220 | 3770 | 29.5 | 28.1 | 27.0 | 24.1 | 46 | 44 | 42 | 38 |
| meeting rooms | 5.0 | 13.8 | 1499 | 930 | 1424 | 855 | 7.5 | 4.7 | 7.1 | 4.3 | 21 | 13 | 20 | 12 |
| Class rooms and similar | 4.7 | 8.1 | 1359 | 867 | 1215 | 706 | 6.3 | 4.0 | 5.7 | 3.3 | 11 | 7 | 10 | 6 |
| toilets, showers, wardrobes | 5.3 | 6.3 | 2303 | 1529 | 2147 | 1363 | 12.1 | 8.0 | 11.3 | 7.2 | 15 | 10 | 14 | 9 |
| Shops > 30 m2 | 3.1 | 7.6 | 4610 | 4385 | 4220 | 3770 | 14.1 | 13.4 | 12.9 | 11.5 | 35 | 33 | 32 | 29 |
| technical / service areas | 3.0 | 6.0 | 1078 | 521 | 1004 | 461 | 3.2 | 1.6 | 3.0 | 1.4 | 6 | 3 | 6 | 3 |
| eating / drinking areas | 2.5 | 5.1 | 2642 | 2302 | 2498 | 2105 | 6.7 | 5.8 | 6.3 | 5.3 | 14 | 12 | 13 | 11 |
| Sports Hall | 2.0 | 8.1 | 3258 | 2338 | 3168 | 2240 | 6.4 | 4.6 | 6.2 | 4.4 | 27 | 19 | 26 | 18 |
| Examination / Treatment Rooms | 2.1 | 11.6 | 3544 | 2406 | 3424 | 2280 | 7.4 | 5.0 | 7.1 | 4.7 | 41 | 28 | 40 | 26 |
| Theatre, Dancing, Amusement park | 2.0 | 5.7 | 2338 | 2244 | 2175 | 1988 | 4.8 | 4.6 | 4.4 | 4.1 | 13 | 13 | 12 | 11 |
| Storeroom / Warehouse | 1.8 | 2.3 | 3712 | 2663 | 3424 | 2325 | 6.6 | 4.7 | 6.1 | 4.1 | 9 | 6 | 8 | 5 |
| waiting areas | 1.1 | 6.3 | 3811 | 3133 | 3548 | 2785 | 4.3 | 3.5 | 4.0 | 3.1 | 24 | 20 | 22 | 18 |
| Libraries, museums, zoo | 1.0 | 8.7 | 1581 | 1063 | 1415 | 871 | 1.5 | 1.0 | 1.4 | 0.8 | 14 | 9 | 12 | 8 |
| Laboratories | 0.8 | 12.4 | 4430 | 3208 | 4280 | 3040 | 3.6 | 2.6 | 3.5 | 2.5 | 55 | 40 | 53 | 38 |
| Radio and TV | 0.9 | 8.4 | 1915 | 1262 | 1713 | 1028 | 1.7 | 1.1 | 1.5 | 0.9 | 16 | 11 | 14 | 9 |
| Hospital wards/bedrooms | 0.8 | 4.4 | 4220 | 3770 | 3950 | 3380 | 3.6 | 3.2 | 3.3 | 2.9 | 19 | 17 | 17 | 15 |
| Video and Movie production and Cinemas | 0.9 | 5.7 | 2208 | 1631 | 1915 | 1262 | 1.9 | 1.4 | 1.7 | 1.1 | 13 | 9 | 11 | 7 |
| Kitchens | 0.8 | 13.0 | 2453 | 2418 | 2381 | 2294 | 1.9 | 1.9 | 1.8 | 1.8 | 32 | 32 | 31 | 30 |
| Hotel rooms (excl. toilet/shower) | 0.9 | 6.5 | 2532 | 1508 | 2370 | 1352 | 2.3 | 1.4 | 2.1 | 1.2 | 17 | 10 | 15 | 9 |
| Political and religious (incl. churches) | 0.5 | 3.5 | 2205 | 1338 | 2065 | 1188 | 1.2 | 0.7 | 1.1 | 0.6 | 8 | 5 | 7 | 4 |
| Parking in structures | 0.4 | 1.3 | 2343 | 1150 | 2179 | 1023 | 0.9 | 0.4 | 0.8 | 0.4 | 3 | 2 | 3 | 1 |
| Waste disposal / sewage | 0.2 | 5.7 | 1915 | 1262 | 1713 | 1028 | 0.4 | 0.3 | 0.4 | 0.2 | 11 | 7 | 10 | 6 |
| Prisons | 0.2 | 5.7 | 4610 | 4385 | 4220 | 3770 | 0.9 | 0.8 | 0.8 | 0.7 | 26 | 25 | 24 | 21 |
| Fire service activities | 0.0 | 5.7 | 1688 | 754 | 1580 | 676 | 0.0 | 0.0 | 0.0 | 0.0 | 10 | 4 | 9 | 4 |
| **Total Non-Residential** | **87.4** | **7.4** | **2739** | **2120** | **2538** | **1858** | **240** | **185** | **222** | **162** | **20** | **16** | **19** | **14** |

# ANNEX G MEERP GUIDELINE TASK 4

The MEErP [20] prescribes the following topics to be addressed in Task 4, Technologies:
Identify, retrieve and analyse data, report on

Technical product description

illustrated with data on performance, price, resources/emissions impact of

4.1.1 Existing products (working towards definition of Base Cases)
4.1.2 Products with standard improvement (design) options
4.1.3 Best Available Technology BAT (best of products on the market)
4.1.4 Best Not yet Available Technology BNAT (best of products in field tests, labs, etc.)

Production, distribution and end-of-life

specifically regarding

4.2.1 Product weight and Bills-of-Materials (BOMs), preferably in EcoReport format (see Task 5)
4.2.2 Assessment of the primary scrap production during sheet metal manufacturing
4.2.3 Packaging materials
4.2.4 Volume and weight of the packaged product
4.2.5 Actual means of transport employed in shipment of components, sub-assemblies and finished products
4.2.6 Materials flow and collection effort at end-of-life (secondary waste), to landfill/ incineration/ recycling/ re-use (industry perspective)
4.2.7 Technical product life (time-to-failure of critical parts)

Recommendations

for

4.3.1 refined product scope from the technical perspective (e.g. exclude special applications for niche markets)
4.3.2 barriers and opportunities for Ecodesign from a technical perspective
4.3.3 the typical design cycle for this product and thus approximately appropriate timing of measures

[20] MEErP 2011, Methodology for Ecodesign of Energy-related Products, part 1: Methods and part 2: Environmental policies and data, René Kemna (VHK) November 28th 2011

# ANNEX H STAKEHOLDER COMMENTS RECEIVED ON FIRST DRAFT TASK 0-1 (2015)

DANISH ENERGY AGENCY

European Commission
DGENER
att. Mr. Paul van Tichelen

24. August 2015
Ref. SFC
Building and Energy Efficiency

By e-mail

The Danish Energy Agency (DEA) regrets it has not been possible before now to comment the Task 1 of the Lot 37 Ecodesign Preparatory Study on Lighting Systems. We hope that the comments will be useful for the study team anyway.

Please find the Stakeholder comments form (20150824_DEA Comments Lot37 Task 1 Comment Form.pdf) and the technical note "Lighting System Efficiency" (4785int033-Lighting_System_Efficiency.pdf)

Our comments primarily concern is issues of in-coherence between the definition of the relevant primary parameter, the functional unit and its mathematical expression.

The main source of in-coherence between the three is a lack of clear distinction between the required illuminance being the primary parameter and the actual illuminance in the mathematical expressions of the functional unit. The technical note "Lighting System Efficiency" illustrates the differences and points to the coherent mathematical definition and method.

ÅF Lighting et al. did a development work in 2014-2015 for DIN under the Commission mandate M/485 to elaborate a method for a "most energy efficient Utilization Factor" to be used for product benchmark information on road lighting luminaires according to regulation 245/2009. This work has convinced us that a parameter based on the minimum required average illuminance is the only possibility for a good lighting system efficiency parameter.
A NWIP for EN 13201-6 "Tables of the most energy efficient useful utilance, utilance and utilization factor" has been drafted in CEN TC 169 WG12 and should be included in the list of standards.

We look forward to see the next draft task reports.

Prepared by Peder Øbro poe@afhh.dk , ÅF Lighting/ÅF – Hansen & Henneberg for The Danish Energy Agency, DEA

Yours sincerely

Signe Friis Christensen

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# DG ENER Lot 37: Ecodesign Preparatory Study on Lighting Systems

| Organization: Danish Energy Agency, DEA (represented by ÅF Lighting) | Name: Peder Øbro | Date:24-08-2015 |
|---|---|---|

| Task # | Section # | Page # | Topic | Comment | Proposed change | Reply study team |
|---|---|---|---|---|---|---|
| 1 | General Chapter 1 1.1 to 1.3 | 2-17 | Energy efficiency of lighting systems | The basic definition of the relevant primary parameter for 'tertiary lighting systems' is "the required illumination (E [lx])" (illuminance). We agree with this definition. We find in inconsistent though that the definition of the functional unit and other efficiency parameters are based on the actual illuminance as the "actual illuminance" ≥ "required illuminance". Due to this a functional unit like the Lighting Power Density LPD is not uniquely related to the power consumption of the system and this is not appropriate. Please see the explanatory note "Lighting System Efficiency" <4785int033-Lighting_System_Efficiency.pdf> accompanying these comments. | Define the functional units e.g. the Lighting System Efficacy as is done for the Installation Efficacy in Annex B of FprEN 13201-5:2015 based on the required illuminance. | Agreed<br>Has been done in the extend possible, taking into account differences in terminology in current drafts between prEN 13201-5 and EN15193 and aiming at a unified approach. |
| 1 | 1.3.1 | 2-5 | Figure 1-1, 1-2 and 1-3 | When changing the definition of the functional unit to be Lighting System Efficacy or Installation Efficacy the figures are not valid any longer. | Revise the figures according to the change of definition of the functional unit. | Agreed<br>Figures have been updated towards efficacy ofsystem |

| Task # | Section # | Page # | Topic | Comment | Proposed change | Reply study team |
|---|---|---|---|---|---|---|
| 1 | 1.3.3.1 | 11 and 12 | The relevant primary parameter is:<br>**"The functional or useful luminous flux (Φ [lm]) per square meter equal to the required illumination (E [lx]) as calculated with secondary performance parameters as defined in standards**<br>Notes:<br>· This functional unit is equivalent to the so-called 'Lighting Power Density' (LPD) [W/(m².lx)] (Pr EN 13201-5) or 'Lighting Energy Numerical Indicator' (LENI) (kWh/m² per year) (EN 15193).<br>· For an area where luminance is used instead of illuminance, the following conversion formula is used:<br>· E = L/Q0<br><br>where,<br>E is the average illuminance<br>L is the average luminance specified in cd/m²<br>Q0 is the average | 1. It should be explained that the topic actually is only relevant for 'tertiary lighting systems' where lighting requirements apply.<br>2. It is very appropriate and stringent to base the definition (in bold) on "the required illumination (E [lx]) …" (our underlining). We interpret this as the illuminance required in a standard, code or regularion for the task or relevant area.<br>3. Anyhow the parameter definition and the parameter specifications below the "Notes:" are not coherent as neither of the parameters are based on or dependent on the required illuminance. The Lighting Power Density (called Power Density Indicator [W/(m²·lx)] in FprEN 13201-5:2015) is based on the actual illuminance which often is larger than the required illuminance. This parameter should not be used because it makes installations look more efficient than they really are. Instead the Installation Luminous Efficacy [lm/W] (FprEN 13201-5:2015 Annex B) should be used.<br>The LENI [W/m²] according to EN 15193 is not dependent on the illuminance at all, so it is not related to the relevant primary parameter but is a power or energy consumption parameter. | For 'tertiary' lighting systems designed to meet lighting requirements, the relevant primary parameter is:<br>**The functional or useful luminous flux (Φ [lm]) per square meter equal to the required illumination (E [lx]) as calculated with secondary performance parameters as defined in standards**<br>Notes:<br>The functional unit as [useful lm per W] is:<br>$\sum_{i=1}^{n}(\bar{E}_{i,min} \cdot A_i)/P$<br>where<br>$\bar{E}_{i,min}$ is the minimum required average illuminance<br>$A_i$ is the sub-area to which the minimum required average illuminance applies<br>$P$ is the system power of the lighting installation used to light the relevant areas<br>In case of street lighting for an area where luminance is used instead of illuminance, the following conversion formula is appropiate:<br>· $E_{i,min} = L_{i,min}/0,07$<br>where $L_{i,min}$ is the required minimum average luminance [cd/m²] (Annex B of FprEN 13201-5)<br>For indoor lighting systems the 'Lighting Energy Numerical Indicator' (LENI) (kWh/m² per year) (EN 15193).is used as an lighting energy consumption parameter which | Agreed to clearly define 'the minimum maintained illuminance' as reference (added)<br>Agreed to delete LENI from the notes. |

| Task # | Section # | Page # | Topic | Comment | Proposed change | Reply study team |
|---|---|---|---|---|---|---|
| | | | luminance coefficient (e.g. 0.07 for asphalt)" | We recommend LENI is left out and is replaced by an explanation.<br>5. The conversion of luminance to illuminance should be done in accordance with FprEN 13201-5:2015 Annex B:<br>· E = L/0,07 | is not equivalent to the functional unit. | |
| 1 | 1.3.3.2 | 15 | secondary performance parameters | The equations **Functional unit [useful lm/W]** (bottom of page 15) are not coherent with the relevant primary parameter (page 11-12) as the equations are not based on the required but on the actual illuminance. This is inappropriate as the actual illuminance in practice is often higher than the required illuminance.<br>Therefore we recommend:<br>1. To introduce a couple of new parameters:<br>The correction factor $C_L$ from FprEN 13201-5:2015 and the Useful Utilance from prEN 13201-6:2015 being developed under the Commission mandate M/485 by CEN TC 169 WG12.<br>2. The equations **Functional unit [useful lm/W]** (at the bottom of page 15) is corrected and named "Lighting System Efficacy".<br>For street lighting this is identical to the Installation Luminous Efficacy. | 1. The following secondary parameters should be added:<br>▪ **Correction and conversion factor for over lighting and for luminance or hemispherical illuminance based lighting designs $C_L$**<br>ratio of the luminous flux just sufficient to comply with the lighting requirements received by the reference surface to the (actual) luminous flux received by the reference surface.<br>The luminous flux sufficient to comply with the lighting requirements is:<br>$\bar{\mathbf{E}}_{\mathbf{min}} * \mathbf{A}$<br>where<br>$\bar{\mathbf{E}}_{\mathbf{min}}$ is the required minimum average illuminance.<br>For road lighting requirements based on luminance:<br>$\bar{\mathbf{E}}_{\mathbf{min}} = \bar{\mathbf{L}}_{\mathbf{min}}/\mathbf{0,07}$<br>For requirements based on hemispherical illuminance:<br>$\bar{\mathbf{E}}_{\mathbf{min}} = \bar{\mathbf{E}}_{\mathbf{hs}}/\mathbf{0,65}$<br>▪ **Useful Utilance $U_U$**<br>ratio of the luminous flux just sufficient to comply with the lighting requirements received by the reference surface to the sum of the individual total fluxes | OK<br>Parameters added<br>Formulas will be updated in line with the reviewed figures and approach |

| Task # | Section # | Page # | Topic | Comment | Proposed change | Reply study team |
|---|---|---|---|---|---|---|
| | | | | | of the luminaires of the installation. The following relation apply:<br>$\mathbf{U_U = C_L * U}$<br><br>2. Corrected formulas:<br>**The formulas to calculate the functional unit from the secondary lighting system performance parameters (see also Figure 1-1) is:**<br>**Functional unit [useful lm/W] = $C_L$ *U *RSMF* LOR * LMF * $\eta_{lamp}$ * LLMF * $\eta_{gear}$ * BGF**<br>Or in the case of an LED luminaire (LOR=1, LMF includes LLMF, $\eta_{ls} * \eta_{power} = \eta_{Luminaire}$ and $U_U$ may be known directly):<br>**Functional unit [useful lm/W] = $U_U$ *RSMF*LMF * $\eta_{Luminaire}$ * BGF** | |
| 1 | 1.4.1 | 27-28 | Description of prEN 13201-5: 'Road lighting-Part 5: Energy performance indicators.' | 1.The description is not based on the latest standard: FprEN 13201-5:2015<br>2. The last part "In Annex A on Energy efficiency benchmarking calculations reference designs are included …" is not appropriate and should be deleted.<br>3. The standard has a major gap that should be described.<br><br>For information: Denmark has voted against this standard. | 1. The text should be based on the standard version, FprEN 13201-5:2015 or later.<br>2. Please delete the last part starting with: "In Annex A on Energy efficiency benchmarking calculations reference designs …" including the Figure 1-12<br>3. Please describe the major gaps as:<br>Potential gaps in EN 13201-5:<br>The mandatory Annex A of the standard is not appropriate.<br>Neither the PDI or the AECI (ECIy) are real benchmark parameters for efficiency because:<br>PDI does not account for over | Text updated based on the latest version and your input<br>Note: Might need to be updated again when the final is available. |

| Task # | Section # | Page # | Topic | Comment | Proposed change | Reply study team |
|---|---|---|---|---|---|---|
| | | | | | lighting or good/bad adaption between the luminaire intensity distribution and the reflection table. Further the PDI and the AECI does not include all the reference sub-areas. Areas of strips for calculation of the edge illuminance ratio are excluded from the calculation of energy performance indicators although requirements apply to these strips so they should be included. Only the informative annexes B and C are appropriate.<br>The mandatory parts of FprEN 13201-5:2015 are considered to be in conflict with the requirement in Commission Regulation 245/2009 for tables of most energy efficient utilization factors, UF and in conflict with Commission Mandate M/485 for facilitating the ecodesign regulation 245/2009 in this respect. | |
| 1 | 1.4.1 | 27-28 | prEN 13201-6:2015 Road Lighting - Part 6: Tables of the most energy efficient useful utilance, utilance and utilization factor | Description of this standard should be inserted.<br>It is being developed under the Commission mandate M/485 including a preparatory study 2014-2015.<br>The development of the standard is going on in CEN TC 169 WG12. | **prEN 13201-6:2015 Road Lighting - Part 6: Tables of the most energy efficient useful utilance, utilance and utilization factor**<br>This standard is being developed under the Commission mandate M/485 including also a preparatory study 2014-2015.<br>The standard facilitates a requirement for product information in the Commission Regulation 245/2009 ANNEX VII | Standard added<br><br>Functional unit of the study updated in line with the remarks |

| Task # | Section # | Page # | Topic | Comment | Proposed change | Reply study team |
|---|---|---|---|---|---|---|
| | | | | | (on Street Lighting), 3. LUMINAIRE BENCHMARKS, clause 3.2:<br>"(b) Utilisation Factor values for standard road conditions in tabular form for the defined road class. The table contains the most energy efficient UF values for different road widths, different pole heights, maximum pole distances, luminaire overhang and inclination, as appropriate for the given road class and luminaire design; (c)…"<br><br>The standard and the preparatory study (M/485) are coherent with the Annex B of FprEN 13201-5:2015 and with the functional unit as defined in 1.3.3.2. *(Editorial: After the correction of 1.3.3.2 as explained above)* | |

# Lighting System Efficiency

## Review of ecodesign functional unit for Lighting Systems

## Technical note supporting comments to the ENER Lot 37 Ecodesign Preparatory Study Task 1

by Peder Øbro, ÅF Lighting on behalf of the Danish Energy Agency

### Lighting energy efficiency parameters

For an energy efficiency parameter to be used as the functional unit in ecodesign it is a crucial condition that it is uniquely related to the power consumption of the system considered.

A functional unit for energy efficiency must be [service_performance to power] or [(service_performance × time) to energy]. The reciprocal may also be used as for instance [power to service_performance]

For lighting the functional unit is [useful lm per W].

The Lighting Power Density, LPD have been proposed as a reciprocal functional unit in the Lot 37 Ecodesign Preparatory Study Task 1. It is defined in FprEN 13201-5:2015 4. but as demonstrated below the LPD is not uniquely related to the power consumption of the system. The reason is that any lighting level above the required level is considered as useful if the LPD is used as functional unit.

A parameter based on the required average illuminance should be used instead. It may be called Installation Luminous Efficacy as in Annex B of FprEN 13201-5:2015, but it may also be called Lighting System Efficacy or Useful Efficacy. The symbol $\eta_{system}$ is used here. By using this parameter, only the required lighting level is considered as useful.

The mathematical definitions of the two parameters for a simple case with only one relevant area are shown in the Table 1 below together with examples illustrating essential properties of the parameters.

The two parameters are <u>not</u> reciprocal as indicated in Figure 1-2 of the Preparatory Study on Lighting Systems - Lot 37 Task 1 report, but they are related as:

$$\eta_{system} = \frac{\bar{E}_{min}}{E_{av}} \cdot \frac{1}{LPD}$$

where

$\bar{E}_{min}$ is the required minimum average illuminance on the relevant area
$E_{av}$ is the actual (calculated) average illuminance on the relevant area

Only the units of the two parameters are reciprocal as: [W/lm] and [lm/W]

The definition of a $\eta_{system}$ may easily be extended to more complex cases with several relevant areas (surfaces) being subject to lighting requirements

### Illustrating examples

Consider three examples of lighting systems for the same relevant area (in a rectangular room) all optimized to comply with the same lighting requirement. The systems have differ-

ent luminaires, A, B and C. Therefore the systems provide different Average Illuminance and use different System Power.

3 rows of luminaires are found to be the optimal choice for all the three luminaires. Differences are demonstrated in the Table 1 below.

**Table 1 Examples of 3 lighting systems with different luminaires, A, B and C for the same room and the same lighting requirements**

| **Area and lighting requirements** | | | | |
|---|---|---|---|---|
| Relevant area [m²] | A | 90 | | |
| Required avarage illuminance [lx] | Emin | 300 | | |
| Required uniformity | U0min | 0,4 | | |
| Minimum maintained luminous flux required | Φmin = Emin*A | 27000 | | |
| **Installation and performance** | | | | |
| Luminaire – Lighting system | | A | B | C |
| Luminaire power [W] | Pl | 32 | 32 | 32 |
| Luminaire luminous flux [lm] | Φl | 3250 | 3500 | 3250 |
| Luminaire Efficacy [lm/W] | ηl = Φl/Pl | 101,6 | 109,4 | 101,6 |
| Maintenance Factor | N | 18 | 15 | 15 |
| Number of luminaires | MF = LMF*LLMF | 0,8 | 0,8 | 0,8 |
| System power [W] | P = N*Pl | 576 | 480 | 480 |
| Actual average illuminance [lx] | Eav | 365 | 315 | 303 |
| Actual uniformity | U0 | 0,4 | 0,5 | 0,4 |
| Utilance | U = Eav*A/(N*Φl) | 0,702 | 0,675 | 0,699 |
| Useful Utilance | $U_U$ = Emin*A/(N*Φl) | 0,577 | 0,643 | 0,692 |
| Lighting Power Density [W/(m²·lx)] = [W/lm] | LPD =P/(Eav*A) | 0,0175 | 0,0169 | 0,0176 |
| Power Density [W/m²] | PD = P/A | 6,40 | 5,33 | 5,33 |
| Lighting System Efficacy alias Installation Luminous Efficacy alias Usefull Efficacy [lm/W] | ηsystem = Emin*A/P | 46,88 | 56,25 | 56,25 |

Luminaire A:
The luminous intensity distribution is too narrow and not optimal for the uniformity so 6 luminaires are required in each row making 18 luminaires where B and C only need 15 luminaires. Based on the LPD, the efficiency of A seems just as good as that of C but that is not true because the System Power and the Power Density of A are higher than those of C.

Luminaire B:
The luminaire efficacy [lm/W] is the highest of the three but the intensity distribution is wider so more light is spilled outside the relevant area. To obtain the required average illuminance 15 luminaires are needed (5 in each row). Based on the LPD, the efficiency of B is

better than that of C but that is not true because the system Power and the Power Density are not lower than those of C.

Luminaire C:
The luminaire luminous flux and the intensity distribution balance both the average luminance and the uniformity with good accuracy on the required values. Based on the LPD, the efficiency of C is a bit worse than that of A but that is not true because the system Power and the Power Density are lower than that of A.

A true efficiency parameter that can be used as the functional unit for ecodesign must be able to rank different solutions for the same case unambiguously in the same order as ranked according to lowest system power.

The Table 2 below illustrates that the Lighting Power Density does not comply with this requirement.

**Table 2 Analysis of ranking order according to different parameters**

| Ranking order of the lighting systems A, B and C according to - | | |
|---|---|---|
| lowest System Power | P [W] | B = C better than A |
| lowest Power Density | PD [W/m²] | B = C better than A |
| lowest Lighting Power Density | LPD [W/(m²·lx] | B better than A being better than C |
| highest Lighting System Efficacy | $\eta_{system}$ [lm/W] | B = C better than A |

As seen from the three examples only the parameter Lighting System Efficacy, $\eta_{system}$ follows the system power and the power density accurately (however reciprocally). Therefore only the Lighting System Efficacy should be used as functional unit for lighting systems.

The problem with the LPD is that is does not reveal the power consumption caused by over lighting.

Further the Lighting Power Density does not reveal the savings from dimming or from adjustment of the average illuminance to the required illuminance! This is illustrated by the following examples.

**Examples with adjustable lighting level**

If the luminaires are adjustable then the average illuminance can be adjusted to exactly meet the required value: $E_{av} = E_{avd} = \bar{E}_{min}$.

The Table 3 shows the results when the three systems A, B and C are adjusted down to provide exactly the required illuminance.

Note: This adjustment is not the same as dimming in cases where dimming is implied by a temporary change of the required illuminance, $\bar{E}_{min}$.

**Table 3 Examples of the 3 lighting systems with flux adjusted to just meet the required average illuminance. For clarity the luminaire efficacy is assumed to be constant.**

| **Area and lighting requirements** | | | | |
|---|---|---|---|---|
| Relevant area [m²] | A | 90 | | |
| Required avarage illuminance [lx] | Emin | 300 | | |
| Required uniformity | U0min | 0,4 | | |
| Minimum maintained luminous flux required | Φmin = Emin*A | 27000 | | |
| **Installation and performance – adjusted luminous flux and power** | | | | |
| Luminaire – Lighting system | | A | B | C |
| Luminaire power [W] | Pl | 26 | 26 | 26 |
| Adjusted luminaire power | Pld | 26,30 | 30,48 | 31,68 |
| Adjusted Luminaire luminous flux [lm] | Φld | 2671,2 | 3333,3 | 3217,8 |
| Luminaire Efficacy [lm/W] | Etald=Φld/Pld | 101,6 | 109,4 | 101,6 |
| Number of luminaires | N | 18 | 15 | 15 |
| Maintenance factor | MF = LMF*LLMF | 0,8 | 0,8 | 0,8 |
| Adjusted System power [W] | Pd | 473,42 | 457,14 | 475,25 |
| Actual average illuminance [lx] | Eavd | 300,00 | 300,00 | 300,00 |
| Actual uniformity | U0 | 0,4 | 0,5 | 0,4 |
| Utilance | U = Eavd*A/(N*Φld) | 0,562 | 0,540 | 0,559 |
| Useful Utilance | $U_U$ = Emin*A/(N*Φld) | 0,562 | 0,540 | 0,559 |
| Lighting Power Density [W/(m²·lx)] = [W/lm] | LPDd =Pd/(Eavd*A) | 0,0175 | 0,0169 | 0,0176 |
| Power Density [W/m²] | PDd = Pd/A | 5,26 | 5,08 | 5,28 |
| Lighting System Efficacy alias Installation Luminous efficacy alias Usefull efficacy [lm/W] | ηsystem,d = Emin*A/Pd | 57,03 | 59,06 | 56,81 |

Comparing the two tables Table 1 and Table 3 it is seen that the Lighting Power Density, LPD does not change when the luminaire flux is adjusted although the system power goes down, so the LPD does not reveal the savings by adjustment (or dimming)!

The Lighting System Efficacy, ηsystem goes up reciprocally to the system power going down when the luminaire flux is adjusted downwards, and it still ranks the systems A, B and C in the same order as ranked according to lowest system power. This shows that The Lighting System Efficacy serves as a better efficiency parameter as shown in Table 4.

**Table 4 Analysis of ranking order according to different parameters for the 3 lighting systems with flux adjusted to just meet the required average illuminance. For clarity the luminaire efficacy is assumed to be constant.**

| Ranking order of the lighting systems A, B and C according to - | | |
|---|---|---|
| lowest System Power | Pd [W] | B better than A being better than C |
| lowest Power Density | PDd [W/m²] | B better than A being better than C |
| lowest Lighting Power Density | LPD [W/(m²·lx] | B better than A being better than C |
| highest Lighting System Efficacy | ηsystem [lm/W] | B better than A being better than C |

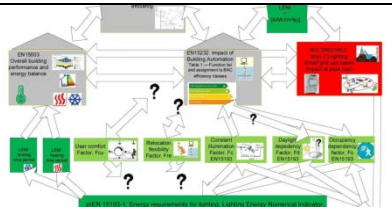
## Concluding remarks

Using the LPD as functional unit implies that lighting above the required level is regarded as useful. This makes a bias in the efficiency rating of lighting systems making poorly designed systems look just as efficient as optimally designed systems just meeting the requirements.

Only a parameter as the ηsystem has appropriate properties for a fair and accurate functional unit.

# DG ENER Lot 37: Ecodesign Preparatory Study on Lighting Systems

| Organization: | Name: | Date: |
|---|---|---|
| **eu.bac – European Building Automation and Controls Association** | **Andrei Litiu** | **29 May 2015** |

| Task # | Section # | Page # | Topic | Comment | Proposed change | Reply study team |
|---|---|---|---|---|---|---|
| 1 | 1.1 | 1 | Building users | Buildings, users in buildings and type of activity in buildings set the requirements for the conditions (especially important for lighting is the "activity"). | Add "activity" and "building". | done |
| 1 | 1.1 | 1 | Role of blinds | Effect of blinds in regard to lighting and light comfort is "glare protection". | Mention "glare protection" and an important example (in this context). | Not sure understand the suggested change |
| 1 | 1.3.1 Figure 1.2 | 2 | Role of an interlink with Building Automation / Controls systems | The integration of lighting functions with the operational system in a building increases EE significantly (see EN 15232). | Add an interface function that links lighting applications with systems that drive building operations – e.g. Building automation system-functions (like in EN 15232) – BACS<br>Mention the link as a "function"<br>Most important functional link: BACS determines the use patterns of rooms / zones in buildings – which includes lighting as well. | Not sure understand the suggested change. Please propose specific text and exactly where it should be added. |
| 1 | 1.3.1 Figure 1-3 | 4 | Clarification of open questions |  | Arrows with question marks: (from left to right)<br>- Scheduling, demand and presence functions<br>- Presence detection<br>- Constant light control applications (e.g. together with blinds)<br>o Blinds follow thermal / | Figure updated taking this comment into account |

| Task # | Section # | Page # | Topic | Comment | Proposed change | Reply study team |
|---|---|---|---|---|---|---|
| | | | | | glare strategy<br>o Light level follows above strategy<br>Add these methods / functions in the context and remove the question marks. | |
| 1 | 1.4.2 | 26 | EN 15232 | EN 15232 is currently undergoing a revision under the mandate M/480 however the lighting applications are not really taken into account since the contribution of those expert groups are little – and in the TC 247 / TC 371 little expertise in lighting is available.<br>Would be great if lighting systems experts could join either M/480 activities and/or TC 247 maintenance work – including calculation methods in referenced standards.<br><br>New Light controls functions to be taken into considerations: Development of advanced lighting controls functions in BAcs: mostly the last developments are around adapting the light intensity to occupancy, Unoccupied/ standby/ occupied functions with either dimming or partial light switch off: this typically with standby occupancy with presence detection in the building ( access control) or level of occupancy ( number of people in the room; CCTV, | Agree that the EE functions in EN 15232:2012 (and in the M/480-version) will need to be updated with available technologies and code of practices.<br><br>Need for update of EN15232 in terms of Light Controls after current work in progress updates. | Eu.bac comment is included in the revised text to encourage participation |

| Task # | Section # | Page # | Topic | Comment | Proposed change | Reply study team |
|---|---|---|---|---|---|---|
| | | | | people counting e.g. in public buildings, museum, stations)<br>- Easy of reprogramming for the building user to change occupancy modes, avoid fixed programming on a bus<br>- Coupling of shade control with light control like in France<br>- the number of new control technologies available at light point ( knx, web-lights, PoE) to be considered<br>- The integration of monitoring functions of light control ratio ( % of light switched off or dimmed during the year) in the Bacs | | |
| 1 | 1.5.1.1 Table 1-2 | 47 | BACS – EN 15232 reference | It is not clear why LS and BACS are placed in the same table. EPBD should integrate the application of efficient light equipment, efficient LS and efficient BACS light control functions (under the base of EN 15232) in new and existing buildings | Modify in the title of the table: building automated and control systems to building automation and control systems.<br>Both light equipment and BACS norms and efficiency standards need to be integrated in EPBD | The proposed edit has been done. The reason to include BACS within this table is that they are also one of the LS improvement options but they are often treated as a separate issue within EPBD regs. |
| 1 | 1.4.5 | 45 | List of standards with gaps | EN 15232 should be mentioned. | Put EN 15232 in the list. | Now added |
| 1 | 1.6.6.10 | 84 | Reference to EN 15232 | Old reference used.<br>EN 15232 is being edited right now in the M/480 and in roughly 8 months from now we'll be having a new version. | Update reference to EN 15232: 2012 | New section discussing mandates added + reference |

Stakeholder comments form

# DG ENER Lot 37: Ecodesign Preparatory Study on Lighting Systems

| Organization: | Name: | Date: |
|---|---|---|
| IALD | NICOLÁS FUENTES COLOMER | 29 May 2015 |

| Task # | Section # | Page # | Topic | Comment | Proposed change | Reply study team |
|---|---|---|---|---|---|---|
| 0 & 1 | 1. 1 | 1 | OBJECTIVE | As a general comment, the members of the IALD would like to emphasise that the Study should completely address Lighting quality, especially the interplay of lighting and human factors. Energy efficiency, eco-design and lighting quality should together in shaping effective energy policy. Lighting quality's goal is to achieve the optimum balance between practical and aesthetic issues, taking into account human needs, the environment and building-related issues such as safety, energy codes and style. With this overarching idea, we have addressed several aspects of the study from the point of view of the profession of independent lighting designers. | | noted<br>text updated and also<br>Similar comments from<br>Lighting Europe are taken<br>into account |

| | | | | | | |
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| 0 & 1 | 1. 1 | 1 | OBJECTIVE | The importance of light within the built environment is entirely described from the energy use point of view. | "Lighting provides a significant contribution to the experience of buildings. As well as basic requirements to fulfil tasks, the general lighting of buildings provides visibility, orientation and wayfinding. Current research shows that lighting has specific non–visual effects that influence mood, attention and wakefulness. These need to be considered in lighting system design to ensure the wellbeing of building users." | |
| | 1. 1 | 1 | OBJECTIVE | The effects of outdoor lighting are not fully addressed.<br><br>In outdoor lighting, quality (and quantity of light) differs vastly by age and culture/nationality. Comfort levels for young adults may differ entirely from elder people. For northern people an under lit almost atmospheric park or outdoor area is totally acceptable both in terms of security and comfort. This is not | "Outdoor lighting must provide effective illumination relevant to the task. These include place-making, orientation and wayfinding . Consideration of visual comfort is important as is avoiding unnecessary upward lighting, light trespass and | |

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| | | | | the case in Southern European countries. | glare. Consideration of the non visual effects of light are also necessary not only for humans but for the effect on the ecology of the area where light is used." | |
| 0 & 1 | 1 | 4 | Reference s to EN12464-1:2011 | The suggestion that target levels in this standard should be the basis has some risks associated with it. The greatest risk being over illumination and therefore considerable energy wastage. This is particularly common in buildings designed before a final user or tenant is known. Under these circumstances there has been practice to light entire floor plates to task lighting levels as positions of workstations are not known at the design stage. Also, EN 12464-1 has detailed tables see below for healthcare lighting. Please also note design criteria from EN12464-1:2011:<br><br>***4 Lighting design criteria***<br>***4.1 Luminous environment***<br>*For good lighting practice it is essential that as well as the required illuminances, additional qualitative and*<br>*quantitative needs are satisfied.* | We would propose including the full design criteria from EN 12464-1:2011 for clarity of intent .<br><br>These standards also deal with health care related issues:<br><br>ANSI/IESNA RP-29-06: Lighting for Hospital and Health Care Facilities<br><br>And CIBSE Lighting Guide 2: Hospitals and healthcare buildings | |

| | | | | | | |
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| | | | | *Lighting requirements are determined by the satisfaction of three basic human needs:*<br>*visual comfort, where the workers have a feeling of well-being; in an indirect way this also contributes to a*<br>*higher productivity level and a higher quality of work;*<br>*visual performance, where the workers are able to perform their visual tasks, even under difficult circumstances and during longer periods;*<br>*safety.*<br>*Main parameters determining the luminous environment with respect to artificial light and daylight are:*<br>*luminance distribution;*<br>*illuminance;*<br>*directionality of light, lighting in the interior space;*<br>*variability of light (levels and colour of light);*<br>*colour rendering and colour appearance of the light;*<br>*glare;*<br>*flicker.*<br>*Values for illuminance and its uniformity, discomfort glare and colour rendering index are given in Clause 5;*<br>*other parameters are described in Clause 4.*<br>*NOTE In addition to the lighting there are other visual ergonomic parameters which influence visual performance,*<br>*such as:* | | |

| | | | | | | |
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| | | | | *the intrinsic task properties (size, shape, position, colour and reflectance properties of detail and background),*<br>*ophthalmic capacity of the person (visual acuity, depth perception, colour perception),*<br>*intentionally improved and designed luminous environment, glare-free illumination, good colour rendering, high*<br>*contrast markings and optical and tactile guiding systems can improve visibility and sense of direction and locality.*<br>*See CIE Guidelines for Accessibility: Visibility and Lighting Guidelines for Older Persons and Persons with*<br>*Disabilities.*<br>*Attention to these factors can enhance visual performance without the need for higher illuminance.* | | |
| 0<br>&<br>1 | 1 | 5 | Excluded systems | We would recommend including light art works and light art installations as excluded. | "For example, lighting systems designed to make themselves visible for purposes of signage or displays including works of art that are self illuminating or relay on specific illumination to achieve the artists required outcome" | Agreed, text added. |

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| 0 & 1 | 1. 3. 2. 1 | 5 | Application areas | We would recommend including Building identity Lighting in outdoor non-public lighting as a specific application | | |
| 0 & 1 | 1. 3. 3. 1 | 1 1 | Primary and secondary performance parameters | The described parameters relate to luminaires rather than the overall lighting system as described above. Performance parameters should include user satisfaction and wellbeing in addition to quantification of illuminance. No account is taken of the system design including controls and switching that are core elements of the system as described above. The ability of luminaires to be controllable as part of the system is an essential element. | | Agreed<br>They originated from the previous study but will be updated<br>note: control system parameters are included, will be aligned with EN 15193 |
| 0 & 1 | 1. 4. 2 | 2 1 | CIE 97(2005) | Calculation of Maintenance Factors remains an area where the experience of the lighting designer could provide a more comprehensive solution. The values stated are not necessarily conservative. In use the majority of lighting installations do not receive adequate maintenance and cleaning. Current marketing trends suggesting that LED luminaires require little or no maintenance could potentially contribute to worsening the situation. Currently recommended lighting levels are based on the end of life performance of a | Consider including maintenance and operation of lighting systems after being placed in use to ensure they are operated according to the design intent and achieve designed energy use in operation. Considering mandating systems maintenance according to assumptions or | This remark is added<br>Keep the suggested policy measure in mind for later Task 7. |

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| | | | | lighting system. This results in over dimensioning when the lifetime of the system is expected to be very long. | decisions used to inform the design process. | |
| 0 & 1 | 1. 4. 2 | 2 1 | CIE 154(2003) | Same considerations as above for CIE 97(2005) | | See previous |
| 0 & 1 | 1. 4. 2 | 2 3 | EN15193(2007) | We would recommend LENI for assessing actual energy use for lighting. It would be appropriate for LENI to form the base measure for the efficiency of lighting systems.<br>Issues remain about setting benchmark standards for design. The current benchmarks (2007) are behind best current practice and best achievable. Keeping these values updated would require frequent review in line with technology , practice and other standards development.<br>Adding additional factors (Fcu0 & (Fre) are likely to increase apparent complexity and therefore increase resistance to uptake of the calculation. An additional flexible factor | | Scope figures are updated in line with LENI as suggested<br>The optional Fcu0&Fce for flexibility will be included in the study.<br>Also after discussion with other stakeholders:<br>Another option is to suggest this factor for EN 15232( building automation only) |

| | | | | | | |
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| | | | | could be provided to be used by designers in specific appropriate cases much as the factors for scene setting exist in the current calculation method. | | |
| 0 & 1 | 1. 4. 2 | 2 7 | EN 15232 | Lighting control system development is currently outpacing the ability of standards to keep up with the potential. Mandating adherence to standards such as these risks inhibiting new developments and consequent energy savings. Using a measure such as LENI allows for a technologically blind assessment of energy used | | Noted<br>Statement added to the text |
| 0 & 1 | 1. 4. 2 | 2 8 | EN 13201-5 | Different models and standards are used to calculate un-metered lighting supplies for street and road lighting in different countries. As these will be the basis for investment decisions, and closely match actual energy used, a full study of these would be necessary to understand the real effects and impacts of regulation in this area. | | Noted<br>Will be further done in later tasks. |

| | | | | | | |
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| 0 & 1 | 1. 4. 2 | 3 3 | EN 12464-1 | Potential Gap: All the illuminances recommended are based on recommended reflectances<br><br>***4.2.2 Reflectance of surfaces***<br>*Recommended reflectances for the major interior diffuse surfaces are:*<br>*ceiling: 0,7 to 0,9;*<br>*walls: 0,5 to 0,8;*<br>*floor: 0,2 to 0,4.*<br>*NOTE The reflectance of major objects (like furniture, machinery, etc) should be in the range of 0,2 to 0,7.*<br><br>Architects and interior designers are not required to meet these requirements. The effect of lighting measured in illuminance will vary according to the reflectances of surfaces with the result that the illuminances in the standard can be either too low or too high to meet the visual requirements of the workplace or other space.<br><br>In respect of good design practice, reconfigurable spaces should be designed with fixed lighting that meets the | | We understand the following:<br>Gap:<br>All illuminances are a result of calculations based on recommended reflectances<br>(this remark is also added in EN 15193 that refers for method 1 to EN 12464)<br>Other text added |

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| | | | | requirements for background area or immediately surrounding area depending on the size and nature of the space with task lighting provided separately related to furnishing. This would reduce the practice of over lighting entire floor plates to task level and result in very considerable energy savings. | | |
| 0 & 1 | 1. 4. 2 | 3 5 | EN 12193 | In large venues and stadia lighting levels are determined by requirements for televising. These are increasing significantly to allow for High Definition and instant slow motion replay. Lighting to achieve these levels is frequently installed permanently, therefore control systems and management are required to ensure lower levels are used whenever possible. | | Text added |
| 0 & 1 | 1. 6. 6. 2 | 7 9 | Redesign Option | Regarding design targets, a maximum of +5% over the design target still results in over lighting at switch on and for the majority of the project life by over 25% when maintenance factor is incorporated and there is no control system tasked with maintaining specific illuminances. | | Text in line with this remark is added in option for control system |

| | | | | | | |
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| 0 & 1 | 1. 6. 6. 7 | 7 9 | Operation and maintenance | Propose adding an option for mandating operation and maintenance of lighting system according to the design intent for the installation. This can reduce calculated maintenance factors and therefore initial and total energy in use for the life of the lighting system | | This option is added in the text. Detailed calculations are shifted to task 4. |
| 0 & 1 | 1. 6. 7 | 8 4 | Conclusion | Typically Hospitals and public education establishments are designed with a high priority placed on energy efficiency in lighting. It is challenging that the proposed energy savings would be achieved by regulation as these are already being designed in for new build and refurbishment projects. Commercial developments, office and retail show the largest opportunity for system level savings as prime cost rather than cost in use drives these projects. Hotels and Restaurants require lighting system design to focus on the aesthetic qualities of light with style and fashion dictating much of the design trend. Systems regulation on maintenance and operation would be most effective here. | | Thanks added to the text |

# Additional questions to DG ENER Lot 37 on Lighting Systems

| Organization: | Name: | Date: |
|---|---|---|
| LightingEurope | Kay Rauwerdink | July 27th 2015 |

| # | Question | Answer | Reply study team |
|---|---|---|---|
| 1 | *Could you ask the convenor of EN 15193-1 & 2 to send us the latest working version on which we can build our work (if possible <1/8)?* | Convenor is Lou Bedocs: will be able to release to you the recast draft standard prEN15193-1 by end of July but the Technical report and Spreadsheet will not be available till September as they require major restructuring and content improvements. The recast will include the responses to comments from enquiry. | OK, done |
| 2 | *Could you ask the convenor of EN 12464 to send us the latest working version on which we can build our work (if possible <1/8)?* | Convenor is Peter Dehoff: WG 2 has just started to work on NWIP (new work item proposals) and is waiting for a further new work item to start revising EN 12464-1. | noted, our gaps will be sent |
| 3 | *Could you ask the convenor of EN 13201-5 to send us the final voted versions on which we can build our work (if possible <1/8)?* | As the Convenorship of Steve Austin for WG 12 is formally not decided yet, Sohéil Moghtader (chair of CEN/TC-169) enclosed the latest document of FprEN 13201-5. He asks to strictly limit the access for other experts than Vito or EC. Please be aware that during the Formal Vote some editorial comments were received which still needs to be discussed and decided whether to be included in the document. Therefore this document is not the final EN 13201-5 but the most current document available. | Received<br>Isn't it the final?<br>(contacts Steve)<br>CL definition OK? |
| 4 | It would be nice having gaps in above mentioned EN standards already included in your comments (31/5), e.g. there is a gap.. in EN .. and there is work in progress on .. | It is of little use to document the potential gaps in the prEN standards as the working documents are changing in structure and content in response to comments and inputs received from enquiry and WG members. To follow development need to join the WG. | noted, but the study contract requires this also |
| 5 | <u>prEN 15193-1&2</u><br>It is useful to have several examples for verification, is it possible to look at CIE 171 on 'Test Cases for Assessment of Accuracy of Lighting Computer Programs'? | Please note the EU mandate on EPB matters demands the production of software to support the implementation of these standards and to show the fulfilment of the EPB requirements. Already there is an established task group and are busy in the development of the software. With the software there will be test cases but not exclusive to lighting. There will be a spreadsheet on lighting energy estimation but only to cover method 2. The TR will | Noted, we should add the mandate in Task 1<br>(study will follow method 1) |

| # | Question | Answer | Reply study team |
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| | | contain worked examples and benchmark indicators.<br>The EPB software process will have nothing to do with CIE 171 as lighting will only be a small part. Similarly the lighting spreadsheet is only required to prove the workings of the calculation methods. | |
| 6 | prEN 15193-1&2<br>When comparing EN 15193 with EN 13201-5 it would be useful to see how parameters, definitions and acronyms can be streamlined as much as possible between prEN 15193-1&2 and EN 13201-5. Can this be done? | Unfortunately the prEN13201-5 recently rejected the LENI route for energy requirement estimation of road lighting and the TG invented its own terms. However, the process is very similar and just needs conversion of the new terminology. In TC169 the WGs work independently so any plans for alignment is a matter CEN/TC169 to resolve. CELMA produced a LENI calculation procedure for outdoor lighting but was rejected by the CEN/TC169WG12 part 5 TG and NSBs have accepted the difference. | noted text will be added (despite this the study will attempt to harmonize as much as possible) |
| 7 | prEN 15193-1&2<br>Is it possible to have the experimental data that is behind the factors? IHMO: it is worth elaborating the measurement method with a more detailed analysis (e.g. to derive FD, FO, ..). | The new standard will still only specify the methodology for calculating the energy requirements for lighting. It will not define or specify the lighting design process and will not specify targets or limits for energy for lighting.<br>The CEN default data were obtained from studies made in several countries and the results were published in various publications. Most of the publications will be listed in the bibliography of the TR.<br>The new standard will also permit the use of National default values for which templates for the data will be given in Annex A.<br>The standard will not have LENI target values but the TR will give examples.<br>The Technical Report will also give some information on lighting design process and considerations. It will also give examples of default data and generate LENI values for some building types.<br><br>This revised standard will be part of the family of standards that specify methods to calculate the energy requirements of buildings for the EPB Certification. The standard will indicate its relationship with the OAS and other Technical services standards. The standards will not give target values as these specifications are Member states responsibility. | OK we consult the references in annexes of part 2<br>Noted also UK has LENI targets |

| # | Question | Answer | Reply study team |
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| 8 | <u>EN 12464</u><br>Progress and field experience is welcome related to verification procedures. In section 6.2 (illuminance) is stated 'When verifying conformity to the illuminance requirements the measurement points shall coincide with any design points or grids used', how much points and how much work is related to this? Is this sometimes done in the field? Can fast screening methods with a more limited set of measurements be considered? | The number and distance of grid points is defined in section 4.4 Illuminance grid. As the distance is related to room size it is already optimised. This is the basis for field measurements. To reduce the measurement points means to reduce accuracy of measurement data. No "short measurement" is considered in the standard. But it can be done "for orientation" in the field, but not for verifying the calculation. | noted<br>verification procedure could be added in EN 12464 revision (is a gap)<br>Will be communicated to Peter Dehoff |
| 9 | <u>EN 15193</u><br>We are looking for reference design calculations according to EN 15193, more specific (input from manufacturers is welcome):<br><br>If possible, identical to the CIE 171 test cases? (to verify if this make sense).<br><br>Some new reference calculations for offices in line with the previous office lighting study(lot 8) but the best solution available today and EN 15193 data, i.e.:<br><br>Cellular office L=5.4 m, B =3.6 m (one side with window), 2.8 m ceiling height, 0.8m work plane height, window height 2 m from ceiling(oriented SE), reflectances (ceiling 0.7, wall 0.3, floor 0.2)<br><br>Open plan office L= 16.2 m (one side with window), B =10.8 m, 2.8 m ceiling height, 0.8m work plane height, window height 2 m from ceiling(oriented SE), reflectances (ceiling 0.7, wall 0.3, floor 0.2)<br><br>The reference calculations can be either in Dialux or Relux. | EN12464-1 provides design criteria for indoor lighting schemes. There is no standard that defines how lighting scheme design is carried out. This lack is a hot topic of discussion in TC169. EN15193 assumes that the lighting scheme has been designed to fulfil the requirements of EN12464.<br><br>EN15193 gives the calculation method to estimate the energy required by the designed lighting scheme when operated with lighting controls built into luminaires. The proposals made in lot8 and here are not part of the work item for WG9 as such calculations can be made by any individuals.<br><br>The crucial parameters of Occupancy, Daylight availability and Lighting Control system are specific to an installation and cannot be standardised. The new EU software will enable all calculations on EPB to be made at concept stage, comprehensive design stage and post installation. | Noted<br>(scheme = define task and surrounding area?)<br>We started our own calculations on selected test cases based on the standards |

| # | Question | Answer | Reply study team |
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| 10 | EN 13201<br>We are looking for reference design calculations according to EN 13201, more specific (input from manufacturers is welcome):<br><br>Is it possible to have some benchmark calculations (Best Available) from several manufacturers(>2) in accordance with 'Annex A on Energy efficiency benchmarking calculations' for;<br>Type A.5 class P4 (table A5) which is close to category slow traffic in previous lot 9<br>Type A.4 class M3 (table A4) which is close to category mixed traffic in previous lot 9<br>Type A.8 class M2 (table A8) which is close to category fast traffic in previous lot 9<br><br>The reference calculations can be either in Dialux, Relux or Ulyssse. | The prCENTR 15193-2 will give sample calculations for areas and buildings to guide the user of the standard. There will also be an Excel spreadsheet to help with the calculation steps.<br>It is important to understand that EN15193 is not a specification standard. It only gives standardised methods for estimating the energy requirements for lighting. | question was on EN 13201<br>We follow the provided version of "/13201<br>of interest is Annex B<br>installation luminous efficacy with its decomposition into subsystems.<br>Herein correction factor CI is unclear, does this also apply to illumination classes (P,C)?<br>The issue is (& comment DEA(DK)) to correct for Erequired/Einstalled? |

# DG ENER Lot 37: EcoDesign Preparatory Study on Lighting Systems

| **Organization:** LightingEurope | **Name:** VITO | **Date:** 19 October 2015 |
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| Task # | Section # | Page # | Topic | Comment | Proposed change | Reply study team |
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| Chapter 0 **#1** | 0.3 | Page 18 | Second paragraph | "*... used for the production of artificial lighting from the power supply in household lighting and tertiary lighting.*" Tertiary sector of economy deals with application such as Office, school but not INDUSTRY and Agriculture, so a different term should be used to avoid misunderstanding | to be replaced by:<br><br>""*... used for the production of artificial lighting from the power supply in residential lighting and non-residential lighting.*"<br><br>Note: because residential means household and other similar applications.<br><br>This is the terminology to be used within the revision of EN 15193 | Agreed that 'Tertiary' should be replaced.<br>For discussion: ' the UK building regulation part L defines 'domestic' and 'non-domestic' to be compared with 'residential? |
| LightingEurope would prefer 'residential' and 'non-residential'. The problem with 'domestic' and 'non-domestic' is that applications such as residential homes for students or senior citizens are not really domestic but neither are they non-domestic. They are residential however. | | | | | | agreed, modified where possible |
| Chapter 0 **#2** | 0.3 | Page 18 | Luminaire description | An apparatus which distributes, filters or transforms the light transmitted from one or more lamps..... | An apparatus which distributes, filters or transforms the light transmitted from one or more light sources<br><br>Proposal from (FP):<br>Clarity may help, so please use the complete definition (with note) from EN 60598-1: | Agreed, work in progress<br><br>Note: are standards aligned with the IEC online terminology service: http://www.electropedia.org? |

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| | | | | | **1.2.1 luminaire**<br>apparatus which distributes, filters or transforms the light transmitted from one or more lamps and which includes all the parts necessary for supporting, fixing and protecting the lamps, but not the lamps themselves, and where necessary, circuit auxiliaries together with the means for connecting them to the supply<br><br>Note 1 to entry: A luminaire with integral non-replaceable lamps is regarded as a luminaire, except that the tests are not applied to the integral lamp or integral self ballasted lamp. | |
| The first working draft of prEN12665 (Light and lighting. Basic terms and criteria for specifying lighting requirements) has been circulated to CEN/TC 169 WG1. It generally aligns with the CIE international lighting vocabulary with a few exceptions. Furthermore, CIE / IEC are currently doing an update process to align the documents from each organisation (CIE S 017:2011 is the newer document). Example: luminaire description under proposed change. | | | | | | noted |
| Chapter 0<br>**#3** | 0.3 | Page 18 | | ~~What other descriptions to be taken into account?~~ | | Further updates are welcome |
| We remove this comment. | | | | | | OK |
| Chapter 0<br>**#4** | 0.3 | 18 | | General use of the terms lamps and light sources is confused and should be corrected | | Further updates are welcome |

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| Due to the increasing use of LED technology the terms lamp and light source are no longer interchangeable.<br><br>CIE DIS 024/E:2015 defines:<br>- LED lamp – LED light source incorporating one or more LED package(s) or LED module(s) and provided with one or more cap(s)<br>- LED light source – electric light source based upon LED technology<br><br>EN 62504:2014 defines<br>- LED lamp as LED light source provided with (a) cap(s) incorporating one or more LED module(s) and possibly including one or more of the following; electrical, optical, mechanical, and thermal components, interfaces and controlgear<br>- It also includes the note A LED lamp is designed so that it can be replaced by an ordinary person (as defined in IEC 60050-826, 826.18.03)<br><br>So the main differentiator is the cap and ease of replacement. | | | | | | added to text |
| Chapter 0<br>**#5** | 0.4 | Page 19 | | Implement quality parameters for LED e.g. CRI, CCT, SDMC…. | Should be added to the document. Ideally follow the IEC performance standard and mention this standard in the text. | Agreed intro text added + more parameters of the standards will be added. |
| With reference to IEC 62722-2-1 Luminaire performance Part 2-1 Particular requirements for LED luminaires and EN 13032-4 data in question are:<br>- Photometric code<br>- Rated input luminaire power (W)<br>- Rated Luminaire Luminous Flux (lm)<br>- LED Luminaire Luminous Efficacy (lm/W)<br>- Correlated Color Temperature, CCT (K)<br>- Color Rendering Index, CRI (Ra 8) - initial/maintained<br>- Chromaticity tolerance (CDCM) - within steps of MacAdam ellipses - initial/maintained<br>- Rated life (h) and the related lumen maintenance factor ($L_x$)<br>- Failure fraction ($B_y$) corresponding to rated life<br>- Useful Nominal lifetime ($L_xB_y$/hours)<br>- Rated ambient temperature ($t_a$)<br>- Luminous Intensity Distribution (cd/1000lm) | | | | | | added to text |

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| Chapter 1<br>**#6** | 1.1 | Page 21 | OBJECTIVE | Description product category and the system boundaries of the playing field for ecodesign for lighting systems and this from a functional, technical and environmental point of view. | This in principle describes the scope of the EBDP.<br>Our task should be only to focus on the savings by lighting system<br>Do we address the whole building or only lighting systems? | The focus is the lighting system taking the interaction into account, text updated e.g.:<br>..This study focuses on the lighting system but will take for buildings energy related interactions with other building systems into account. ..<br>. |
| Yes that's true. Illumination could support heating during heating period. Otherwise during summertime cooling must compensate illumination heating energy. So far this is intended to be regulated by the relevant standards construction and exactly that's the problem, because interaction between EN 15193 and the other relevant standards is not solved yet. | | | | | | noted |
| Chapter 1<br>**#7** | 1.3.1 | Page 25 | Products excluded | ~~Exit signs are excluded, what about other emergency lighting luminaires part as exit signs of emergency lighting systems. LightingEurope Emergency Lighting WG to give its comments by April 24th~~<br><br>~~*Lighting systems designed for other purposes than providing illumination. For example, lighting systems designed to make themselves visible for purposes of signage or displays (e.g. traffic lights, exit signs, television sets, tablets, ..).*~~<br><br>~~luminous signs for advertisement? All types or back lighted boxes are in the scope? Christmas lighting chain?~~ | ~~Exit signs are excluded but what about other emergency lighting luminaires, that are a part, as exit signs, of emergency lighting systems.~~<br><br>~~Please specify the intention for excluding (or not) luminous signs for advertisement (all types or back lighted boxes only), Christmas lighting chain, ...~~ | Text modified and added:<br>..Please note that emergency lighting equipment directly related to illumination in buildings are proposed to be within the scope, see also EN 15193. |
| Emergency lighting should be treated carefully with respect to energy efficiency. Whilst there is no excuse for inefficient | | | | | | noted |

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| systems it is a safety critical system so should not be legislated into problems.<br><br>Revised comments & proposed changes:<br><br>Comment:<br>Exit signs are excluded but all other emergency lighting luminaires should also be excluded. Revert to http://ec.europa.eu/energy/en/topics/energy-efficient-products/lighting<br>"Lighting products are subject to EU energy labelling and ecodesign requirements. ..... Emergency lighting and some LEDs designed for very specific uses and sold in very small quantities per year (less than 200), are excluded from these regulations."<br><br>Proposed Change:<br>To clearly stated that emergency lighting luminaires are excluded.<br><br>Comment:<br>What's about luminous signs for advertisement, all types of back lighted boxes, Christmas lighting chains?<br><br>Proposed Change:<br>To clearly specify the intention for excluding (or not) luminous signs for advertisement (all types of back lighted boxes only), Christmas lighting chains,... | | | | | | text and figures updated |
| Chapter 1<br>**#8** | 1.3.1 | Page 25 | Paragraph after Fig 1-1 | *"In this study it is the intention to look at the application level of lighting. ....."*<br><br>Repetition; nearly the same as in chapter 0.3 | | Noted, but the document structure requires such repetition. To be kept in mind that they are kept in line. |
| No further comments. | | | | | | OK |

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| Chapter 1<br>**#9** | 1.3.1 | Page 25 | Paragraph before Fig 1-2 | Tertiary sector of economy deals with application such as Office, school but not INDUSTRY and Agriculture, so a different term should be used to avoid misunderstanding | Replace the term "*tertiary*" to read:<br>" *In non-residential lighting, system design is often based on minimum performance levels sourced from standards.* " | Agreed to replace Tertiary. Maintain where reference is made to existing regulation. Choice between 'Nor-residential' or 'Non-domestic'? |
| See also comment under #1. No further comments. | | | | | | OK |
| Chapter 1<br>**#10** | 1.3.2.1 | Page 26 | | There should be a clear differentiation between street lighting and traffic route lighting. The inclusion of tunnel lighting implies that traffic route lighting is included but this is not indicated | | Agreed to do, is it possible to have more detailed definition of traffic route versus street lighting? |
| Traffic route lighting is where motorised traffic is the predominant user with little or no pedestrians / cyclists / etc. Typically associated with lighting class M from PD CEN/TR 13201-1:2014.<br><br>Street lighting is residential or amenity lighting where traffic is significantly mixed or predominantly non-motorised. Typically associated with lighting class P from PD CEN/TR 13201-1:2014. | | | | | | text added |
| Chapter 1<br>**#11** | 1.3.2.2 | Page 26 | Luminaire description | ~~An apparatus which distributes, filters or transforms the light transmitted from one or more lamps.....~~<br><br>~~"*The first sentence is not understood: The luminaire level of the lighting system is denoted by the light blue in Figure 1-1 or by orange when the light source is fixed and integrated into the luminaire.*"~~ | ~~An apparatus which distributes, filters or transforms the light transmitted from one or more light sources~~<br><br>~~Further to this, please add the NOTE:~~<br><br>~~Note~~<br>~~A luminaire with integral non-replaceable lamps is regarded as a luminaire, except that the tests are not applied to the integral lamp or integral self ballasted lamp~~ | The luminaire level of the lighting system is denoted by the light blue in Figure 1 -1.<br>A "luminaire" is defined as an "apparatus which distributes, filters or transforms the light transmitted from one or light sources.". Note: A luminaire with integral non-replaceable lamps is regarded as a luminaire, except that the tests are not applied to the integral lamp or integral self ballasted lamp? |
| We prefer a better clarification what you mean with these luminaire types and also what standard to test against. | | | | | | figures and text updated |

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| Revised comments & proposed changes:<br><br>Comment:<br>The first sentence is not understood:<br>“The luminaire level of the lighting system is denoted by the light blue in Figure 1-1 or by orange when the light source is fixed and integrated into the luminaire."<br><br>Proposed change:<br>To clarify the meaning and also what standard to test against.<br><br>Comment:<br>A “luminaire” is defined.....<br><br>Proposed change:<br>Revert to the comment for Chapter 0, section 0.3, Page 18, Some descriptions of system components. | | | | | | |
| Chapter 1<br>**#12** | 1.3.2.3 | Page 27 | Constant illumination level | Constant illumination level also adjusts to the levels of daylight, dimming or switching off the lighting when sufficient daylight is available | | To verify & discuss (definitions of EN 15193 should be introduced? Fco covers close fitting to the minimum required setting? (accoding to prEN 15193) |
| Because constant illumination controls monitor the light on the task they cannot differentiate between the source of the light, e.g. artificial or natural light. | | | | | | added |
| Chapter 1<br>**#13** | 1.3.2.3.1 | Page 26 – Page 28 | Examples of lighting control system for indoor lighting | To review the descriptions of the different control systems | | Under consideration: can and should we use those of prEN 15193 & 13201? |
| Yes, please refer as much as possible to definitions used in prEN12665, prEN15193 and EN13201. | | | | | | done |

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| Chapter 1 **#14** | 1.3.2.4 | Page 29 | DIALux | Description of DIALux and RELUX to possibly recommendation for system calculation | State parameters software needs to address | OK, will be more documented (could refer to future Task 3) |
| This is not so difficult. Software from DIAL can already calculate lighting energy consumption according to EN 15193, but not in interaction with the other energy consumption equipment in the building. | | | | | | added |
| Chapter 1 **#15** | 1.3.2.5 | Page 30 | | Short description of Lighting Control Systems like DALI, DMX512, ZigBee and LEDOTRON | As well known in the meantime more systems will be implemented | Make sure the document is future-proofed.<br>Text added:<br>This is a relative new area wherein also often new technologies and standards are introduced to the market |
| We can refer to well established tools for Germany DIALux or Relux. Calculations with lighting can be performed with quick software tools. Examples are available, made in existing buildings. | | | | | | see previous |
| Chapter 1 **#16** | 1.3.3.2 | Page 35 | Formula for explaining maintenance factor | Formula to calculate the functional unit (Wartungsfaktor) from the secondary lighting system | To note | Noted<br>Under consideration to add MF in accordance with ZVEI, which is more in line with LED |
| The German national lighting association ZVEI will not publish a MF document. A new ZVEI Guide for planning LED will be published in short time and will be translated into English. For detailed calculations on MF the guide refers to calculation tables in the German LiTG report. There is also a Swedish proposal. | | | | | | noted |
| Chapter 1 **#17** | 1.3.3.2 | Page 35 | Formulae | The formulae should either use UF and LOR or U without LOR. The use of U and LOR accounts for the LOR twice.<br><br>LMF does not account for LLMF in formula 2. LMF accounts for date and aging of reflective materials within the luminaire. LLMF accounts for the | | Formulae to be checked<br><br>Note: UF= UxLOR (therefore only accounted once). Nevertheless we will move to new aronyms for LOR and U based on the most recent standards prEN15193, |

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| | | | | effects of aging of the light source. Formula 2 is not for the case of LED, it is for the case of absolute photometry. A LED luminaire presented as relative photometry would have to use equation 1.<br><br>The use of different efficiency factors between the equations confuses them. The difference between equation 1 and equation 2 should essentially be the LOR. However equation 1 could still be applicable for absolute photometry as the LOR=1 will have no effect. | | EN13201-6(2015), EN12665(2011) (ηR, ..). Figures will be updated accordingly |
| The IEC defines utilance as "ratio of the luminous flux received by the reference surface to the sum of the individual output fluxes of the luminaires of the installation". Because it is the individual fluxes of the luminaires it implicitly includes the LOR. | | | | | | OK |
| Chapter 1<br>**#18** | 1.3.3.2 | Page 36 | Other units in draft PrEN 15193 must be converted | EN 15193 and EN 13201-5 in principle use similar functional units<br><br>Comment (TG)<br>Add LED Luminaires and absolute photometry (lm/W)<br>Implement quality parameters for LED<br>Add SDMC (Mac Adam ellipses) | To note | SDMC + other definitions are welcome |
| Reference to EN 13032-4 *Rating and tolerance of LED-luminaire data*: In most LED luminaires the LED light sources cannot be separated from the luminaire. Therefore, LED luminaires are measured in so called "absolute photometry". Output data of an LED luminaire measurement are raw data at laboratory test conditions and are corrected and reported for standard test conditions (see clause 4). Other definitions see also remarks under point # 5.<br><br>Within the German national lighting association ZVEI a special guide for using absolute photometry within LED illumination is finalized and will be published in due time. All ZVEI Guides can be free downloaded from the ZVEI website. | | | | | | please provide when available |

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| Chapter 1 **#19** | 1.3.3.2 | Page 36 | Operational lifetime | The use of the F factor confuses the issue regarding LED. The use of B and C would be more precise. | Consider ZVEI LED guide. Use LxBy as standard | To do, add more text and discriminate LED, for other light sources formulas procured from lot 8&8 = similar to economic model in CIE 115 (to check) |
| F failure factor related to 'group' or 'spot' replacement as mentioned in the CIE 115. So linked to the cost model. Please check against new IEC lifetime metric for LED based products mentioned in IEC 62717 Ed. 1.0 ANNEX C Explanation of recommended LED product lifetime metrics. | | | | | | LED parameters from this standard added |
| Chapter 1 **#20** | 1.4.2 | Page 41 | CIE (97)2005 | Identified gap:<br>The example values included are conservative, which results in over dimensioning lighting systems. Updates might be needed for LED luminaires which were not detailed in this guideline (2005)<br>~~ZVEI has a 'Guide to Reliable Planning with LED Lighting Terminology, Definitions and Measurement Methods: Bases for Comparison' where also the Lamp Survival Factor (LSF) is taken into account for lighting systems using multiple LED sources. This could be included in an update.~~ | ~~It is of little use to document potential gaps in the prEN standards as the documents are changing in response to comments received during enquiry.~~ | Is there a revision ongoing? |
| We remove comment … *it is of little use* … since it is not appropriate here. CIE 97:2005 is on the list of CIE Division 3 as requiring an update but currently is not being worked upon. Revision is foreseen in ISO/TC-274. | | | | | | OK |
| Chapter 1 **#21** | 1.4.2 | Page 42 | CIE (154)2003 | Identified gap: Updates might be needed for LED luminaires which were not detailed in this guideline (2007). ~~ZVEI has a 'Guide to Reliable Planning with LED Lighting Terminology, Definitions and Measurement Methods: Bases for Comparison' where also the Lamp Survival~~ | ~~It is of little use to document potential gaps in the prEN standards as the documents are changing in response to comments received during enquiry.~~ | idem |

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| | | | | ~~Factor (LSF) is taken into account for lighting systems using multiple LED sources. This could be included in an update.~~ | | |
| We remove comment … *it is of little use* … since it is not appropriate here. CIE 154:2003 is on the list of CIE Division 4 as requiring an update but currently is not being worked upon. Revision is foreseen in ISO/TC-274. | | | | | | added |
| Chapter 1 **#22** | 1.4.2 | Page 51 | EN 13032-1 | Identified gaps: Despite of this accepted European standard, in practice the sector often uses another similar file format (EULUMDAT, IES, CIBSE, ..). A photometry file reduces a luminaire to a point source which can be inaccurate to model a distributed light source such as a large LED panel luminaire (e.g. OLED), therefore more sophisticated file formats are being developed (e.g. IES TM-25-13). | | **Please specify** |
| Some programs use specific file formats to overcome this. Dialux (ULD files) and Relux (ROLF files) allow the photometry to be attached to a model of the luminaire, ensuring the correct position of the luminous emitting areas within the luminaire geometry.<br><br>For basic photometric file formats the photometry is spread over the luminous area specified within the file, centred upon the centre of the luminaire dimensions. So, for example, a street lantern with the light source positioned at the end of a body containing control gear, spigot mounting mouldings, etc. would have the luminous aperture positioned central to the full body which would be somewhere over the gear compartment. This is because the photometric file conveys the size of the luminaire and the size of the luminous aperture but not any geometric relationship between the two. | | | | | | added |

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| Chapter 1<br>**#23** | 1.4.2 | Page 53 | EN 12464-1 | Potential gaps in EN 12464-1: Reference could be made to EN 15232 and that task areas and their surrounding areas can change over the life time of a building, therefore a building management system could reconfigure flexible the illumination levels and provide additional savings. It is unclear if and how these savings are modelled. Areas where much changes can be expected over the building life time could be identified (e.g. open plan office) and a recommendations for building management systems could be included. | ~~It is of little use to document potential gaps in the prEN standards as the documents are changing in response to comments received during enquiry.~~ | To be verified if there is a review planned |
| We remove comment … *it is of little use* … since it is not appropriate here. There is a revision of EN 12464 planned in CEN/TC 169 for 2015/2016. | | | | | | |
| Chapter 1<br>**#24** | 1.5.1.1 | Page 67 | Table 1-2: Summary of current EU policy instruments as they are and could be applied to lighting systems (LS) and building automated control systems (BACS) | Good overview about existing systems Overall it is clear that the existing EU policy framework contains plenty of levers and opportunities that could be applied to the promotion of energy efficient lighting systems however that the application of these is variable and generally not targeted at lighting systems per se | This table is very difficult to understand and is confusing | We are considering ways to make the table clearer and welcome suggestions |
| It should be selected that only that levers and opportunities are listed which could apply to lighting systems. At the moment it is completely overloaded. | | | | | | |
| Chapter 1<br>**#25** | 1.5.1.6 | Page 73 | Certification: 'Member States shall ensure that an energy performance | ~~Certification refers mainly to following articles of the recast EPBD21: - Article 11 'Energy Performance Certificates';~~ | ~~This should be watched carefully. Behind this cost intensive structures of certification schemes could be set in force. This would be profitable market~~ | Certification is a very important topic as it will drive industry and project practice. This needs careful definition as to who is responsible and who is |

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| | | | certificate is issued for (a) buildings or building units which are constructed, sold or rented out to a new tenant; and (b) buildings where a total useful floor area over 500 m 2 is occupied by a public authority and frequently visited by the public. On 9 July 2015, this threshold of 500 m² shall be lowered to 250 m². ‘ | ~~- Article 12 ‘Issue of Energy Performance Certificates’;~~<br>~~- Article 13 ‘Display of Energy Performance Certificates’.~~<br>~~The issuing of EPCs has an important role in the transformation of the building sector. By providing information, potential buyers and tenants can compare buildings/building units. Also recommendations are provided for a cost-effective improvement, encouraging home owners to refurbish their building to a better energetic standard.~~ | ~~for certification companies and at least hamper the actual project.~~ | liable. Not clear there is any need to change the text here though |
| We remove this comment. | | | | | | OK |
| Chapter 1<br>**#26** | 1.5.1.6 | Page 74 | Cost-optimal methodology: | ‘Member States shall calculate cost-optimal levels of minimum energy performance requirements using the comparative methodology framework established in accordance with paragraph 1 of the recast EPBD and relevant parameters, such as climatic conditions and the practical accessibility of energy infrastructure, and compare the results of this calculation with the minimum energy performance requirements in force.’ | This is to be understood that each member state can implement their own system | Yes, although within the constraint that MS should demonstrate their building code requirements are derived using the cost-optimal approach within their specific national circumstances. Is there a proposal to change the text here? |
| No this has to be considered as an observation, every member state implementing its own system is a possible route. | | | | | | |
| Chapter 1<br>**#27** | 1.5.1.6 | Page 75 | Impacts of EPBD on lighting systems: | The energy efficiency of lighting is explicitly addressed as a subject, mainly for the non-residential sector, in the 2010 recast of the Energy Performance | If following the EPBD rules for lighting than each member state can implement their own system. In principle what we have today. | Again they can do so providing it complies with the methodological cost-optimality requirements in the Directive. It is an open question how |

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| | | | | of Buildings Directive (EPBD)24. Annex I point 3 stipulates that 'The methodology shall be laid down taking into consideration at least the following aspects: …(e) built-in lighting installation (mainly in the non-residential sector);'.Annex I point 4 stipulates that 'The positive influence of the following aspects shall, where relevant in the calculation, be taken into account: .. (d) natural lighting.'. The EPBD recast also explicitly formulates that 'Member States should use, where available and appropriate, harmonized instruments, in particular testing and calculation methods and energy efficiency classes developed under measures implementing Directive 2009/125/EC'.25<br><br>Comment (TG)<br>1.5.1.12 Green Public Procurement (GPP) – LENI criteria should be implemented (simplified calculation model, see 1.3.1) | | much this is the case currently. Again not sure that there's any need to revise the text here? |
| We believe the text is suitable, however it will not in all case possible to rule the EPBD in all buildings all over Europe in the same way due to different building forms, climate, building history, etc.<br><br>Please find some examples from Sweden: updated THE NATIONAL AGENCY FOR PUBLIC PROCUREMENT'S PROCUREMENT CRITERIA FOR INDOOR LIGHTING. To be sure you have the latest versions of the criteria, visit;<br>www.upphandlingsmyndigheten.se/gid/1082/9.<br>www.upphandlingsmyndigheten.se/11013/2. | | | | | | |
| Chapter 1<br>**#28** | 1.5.1.6 | Page 75 | Examples of country implementations on EPBD related to | -Simple system used in Belgium<br>-System in France<br>-System in Germany and Luxemburg | noted and again as mentioned above, that only a simple system would be accepted | The object in this task is to list who specifies what but not to comment on the appropriateness of these measures |

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| | | | lighting: | DIN V 18599<br>-Building regulation in UK<br>1.5.1.12 Green Public<br><br>Comment (TG)<br>1.5.1.12 Procurement (GPP) – LENI criteria should be implemented (simplified calculation model, see Swedish model on public procurement based on standard room conditions calculated from the comprehensive method 1.3.1) | | at this stage. Therefore we will happily add more details on national specifications in EU MS and welcome any details stakeholders can provide on these |
| The publication "Implementing the Energy Performance of Buildings Directive" October 2013 is useful for this. It is available electronically (www.epbd-ca.eu ).<br><br>There is also more information about The National Agency for Public Procurement´s procurement criteria on the website. Please contact our helpdesk if you have any questions, upphandlingsstod@uhmynd.se.<br><br>UHM_indoor-lighting_20150911_102212.pd UHM_indoor-lighting_20150911_102212.pd Appendix_LENI-calculations_EN.pdf | | | | | | |
| Chapter 1<br>**#29** | 1.6.6.1 | Page 99 | system related improvement options are discerned: | 1. Redesign the building/room;<br>2. Change the luminaire and lighting control system and maintain the other surrounding infrastructure, …);<br>3. Change the luminaire but not the lighting control system;<br>4. Retrofit lamp, ballast and optic<br>5. Retrofit lamp and ballast | It seems the most effective combination would solution 1 and 2. But at least solution 2 should be implemented | This may not be the right place for the text to comment on the most effective solution |
| Might be, but it must be declared and stated anywhere to give the most effective solution for the architect and planner of the building. | | | | | | is a task 6 issue, reference is made to later tasks |
| Chapter 1 | 1.6.6.2 | Page 99 | Redesign the building | In this case the redesign includes: | | The comment reiterates the |

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| **#30** | | | | • Lighting and building energy balance calculation with optimization;<br>• Choosing windows for daylight entrance;<br>• building the lighting infrastructure i.e. cables, suspension or poles;<br>• choosing and placing luminaires;<br>• choosing and placing lamps or light sources;<br>• choosing and placing ballasts or drivers;<br>• installing the lighting control system;<br>• choosing appropriate surface reflection requirements;<br>• iterative redesign steps to have a close fit to lighting requirements for tertiary lighting as defined in standards EN 12464-1&2 and EN 13201-2, e.g. fit to maximum +5 % above the requirement of 500 lx | | existing text – please explain the intended point and if any changes in text are required |
| For the first step the explanations in the text under the different intends seems sufficient. Maybe the study is not the appropriate place go more in detail. | | | | | | See previous<br>Reference is made to later tasks |
| Chapter 1<br>**#31** | 1.6.6.5 | Page 100 | Retrofit lamp, ballast and optic improvement option | Not recommended | | The text says: "If the luminaires in an installation are equipped with poor optics, only lamps, ballasts and optics can be replaced. In this option the lamp is replaced by a directional light source that partially bypasses the luminaire optics. This is useful in existing luminaires with poor optical efficiency. Replacing a fluorescent lamp by a retrofit LED lamp can be an example of this solution." |

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| | | | | | | Does this address the comment? |
| With the addition that when using 'retrofit lamp sources' this must be strictly follow the requirements laid down in regulation (EU) 1194/2012. | | | | | | OK noted |
| Chapter 1 **#32** | 1.6.6.6 | Page 100 | Retrofit lamp and ballast improvement option | Not recommended | | Same as above |
| With the addition that when using 'retrofit lamp sources' this must be strictly follow the requirements laid down in regulation (EU) 1194/2012. | | | | | | OK noted |