European Commission

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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OVERVIEW OF ANNEXES IN THIS DOCUMENT

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

Reference	Title
Lighting in General	
EN 12665:2011	'Light and lighting - Basic terms and criteria for specifying lighting requirements'
CIE S 017/E:2011	'ILV: International lighting vocabulary, new
IEC/TR 60887:2010 (ed3.0)	'Glass bulb designation system for lamps'
EN 61231:2010/ A1:2013	'International lamp coding system (ILCOS)'
CIE 019.21:1981	'An analytic model for describing the influence of lighting parameters upon visual performance, 2nd ed., Vol.1.: Technical foundations'
CIE 019.22:1981	'An analytic model for describing the influence of lighting parameters upon visual performance, 2nd ed., Vol.2.: Summary and application guidelines'
Lamps (excluding LED)	
EN 50285:1999	'Energy efficiency of electric lamps for household use - Measurement methods.'
EN 60064:1995/ A4:2007 A5:2009	'Tungsten filament lamps for domestic and similar general lighting purposes - Performance requirements'.
EN 60081:1998/ A4:2010 A5:2013	'Double-capped fluorescent lamps - Performance specifications.'
EN 60188:2001	'High-pressure mercury vapour lamps - Performance specifications'
EN 60192:2001	'Low pressure sodium vapour lamps - Performance specifications'
EN 60357:2003/ A1:2008 A3:2011	'Tungsten halogen lamps (non-vehicle) - Performance specifications'
EN 60630:1998/ FprA7:2014 (under approval)	'Maximum lamp outlines for incandescent lamps'
IEC 61126:1992/ Am2 ed1.0 :2005	'Procedure for use in the preparation of maximum lamp outlines'
EN 60662:2012	'High-pressure sodium vapour lamps. Performance specifications'
EN 60901:1996/ A4:2008 FprA6:2012 (under approval)	'Single-capped fluorescent lamps – Performance specifications'
EN 60969:1993/ A2:2000 ; FprEN 60969:2013 (under approval)	'Self-ballasted lamps for general lighting services – Performance requirements'
EN 61167:2011	'Metal halide lamps - Performance specifications.'
EN 61228:2008	'Fluorescent ultraviolet lamps used for tanning - Measurement and specification method'
IEC/TR 61341 EN 61341:2011	'Method of measurement of centre beam intensity and beam angle(s) of reflector lamps'

EN 61549:2003/ A3:2012	'Miscellaneous lamps'
EN 62639:2012	'Fluorescent induction lamps - Performance specifications.'
EN 2240-001:2009	'Aerospace series - Lamps, incandescent - Part 001: Technical specification'
CIE 153:2003	'Report on intercomparison of measurements of the luminous flux of high-pressure sodium lamps'
Lamp Caps and Holders	
EN 60061-1:1993/ A41:2009 A50:2014	'Lamp caps and holders together with gauges for the control of interchangeability and safety - Part 1: Lamp caps'
EN 60061-2:1993/ A47:2014	'Lamp caps and holders together with gauges for the control of interchangeability and safety - Part 2: Lampholders'
EN 60061-3:1993/ A48:2014	'Lamp caps and holders together with gauges for the control of interchangeability and safety - Part 3: Gauges'
EN 60061-4:1992/A9:2005	'Lamp caps and holders together with gauges for the control of interchangeability and safety - Part 4: Guidelines and general information'
EN 60238:2004/ A2:2011 ; FprEN 60238:2013 (under approval)	'Edison screw lampholders'
EN 60360:1998	'Standard method of measurement of lamp cap temperature rise'
EN 60399:2004/ A1:2008	'Barrel thread for lampholders with shade holder ring'
EN 60400:2008/ FprA2:2014 (under approval)	'Lampholders for tubular fluorescent lamps and starterholders'
EN 60838-1:2004/ A2:2011 ; FprEN 60838-1:2013 under approval	'Miscellaneous lampholders - Part 1: General requirements and tests'
EN 60838-2-1:1996/ A2:2004	'Miscellaneous lampholders - Part 2-1: Particular requirements - Lampholders S14'
EN 60838-2-2:2006/ A1:2012	'Miscellaneous lampholders - Part 2-2: Particular requirements - Connectors for LED-modules'
Project EN/IEC 60838-2-3 (under approval)	'Miscellaneous lampholders - Part 2-3: Particular requirements - Lampholders for double-capped linear LED lamps'
EN 61184:2008/A1:2011	'Bayonet lampholders'
Luminaires	
EN 16268:2013	'Performance of reflecting surfaces for luminaires'
EN 60598-1:2008/ A11:2009 ; FprEN 60598-1:2014 (under approval)	'Luminaires - Part 1: General requirements and tests'
EN 60598-2-1:1989	'Luminaires - Part 2-1: Particular requirements - Fixed general purpose luminaires'
EN 60598-2-2:2012	'Luminaires - Part 2-2: Particular requirements - Recessed luminaires'
EN 60598-2-3:2003/ A1:2011	'Luminaires - Part 2-3: Particular requirements - Luminaires for road and street lighting'
EN 60598-2-4:1997	'Luminaires - Part 2-4: Particular requirements - Portable general purpose luminaires'
EN 60598-2-5:1998 ; FprEN 60598-2-5:2014 (under approval)	'Luminaires - Part 2-5: Particular requirements – Floodlights.'

EN 60598-2-6:1994/A1:1997	'Luminaires - Part 2-6: Particular requirements - Luminaires with built-in transformers or convertors for filament lamps'
EN 60598-2-7:1989/A13:1997	'Luminaires. Particular requirements. Portable luminaires for garden use.
EN 60598-2-8:2013	'Luminaires - Part 2-8: Particular requirements – Handlamps'
EN 60598-2-9:1989/A1:1994	'Luminaires - Part 2: Particular requirements - Section 9: Photo and film luminaires (non-professional)'
EN 60598-2-10:2003/ corrigendum Aug. 2005	'Luminaires - Part 2-10: Particular requirements - Portable luminaires for children'
EN 60598-2-11:2013	'Luminaires - Part 2-11: Particular requirements - Aquarium luminaires'
EN 60598-2-12:2013	'Luminaires - Part 2-12: Particular requirements - Mains socket-outlet mounted nightlights'
EN 60598-2-13:2006/A1:2012	'Luminaires - Part 2-13: Particular requirements - Ground recessed luminaires'
EN 60598-2-14:2009	'Luminaires - Part 2-14: Particular requirements - Luminaires for cold cathode tubular discharge lamps (neon tubes) and similar equipment'
EN 60598-2-17:1989	'Luminaires - Part 2: Particular requirements - Section 17: Luminaires for stage lighting, television film and photographic studios (outdoor and indoor)'
EN 60598-2-18:1994/A1:2012	'Luminaires - Part 2-18: Particular requirements - Luminaires for swimming pools and similar applications'
EN 60598-2-19:1989/ corrigendum Dec. 2005	'Luminaires - Part 2: Particular requirements - Air-handling luminaires (safety requirements)'
EN 60598-2-20:2010 /corrigendum Sep. 2010 ; FprEN 60598-2-20:2013 (under approval)	'Luminaires - Part 2-20: Particular requirements - Lighting chains'
FprEN 60598-2-21:2013 (under approval)	'Luminaires - Part 2-21: Particular requirements - Sealed lighting chains'
EN 60598-2-22:1998/A2:2008 FprEN 60598-2-22:2014 (under approval)	'Luminaires - Part 2-22: Particular requirements - Luminaires for emergency lighting'
EN 60598-2-23:1996/A1:2000	'Luminaires. Particular requirements - Extra low voltage lighting systems for filament lamps'
EN 60598-2-24:2013	'Luminaires - Part 2-24: Particular requirements - Luminaires with limited surface temperatures'
EN 60598-2-25:1994/A1:2004	'Luminaires. Part 2-25: Particular requirements. Luminaires for use in clinical areas of hospitals and health care buildings.'
EN 62722-1:2016	'Luminaire performance - Part 1: General Requirements'
IEC 62722-2-1:2011	'Luminaire performance - Part 2-1: Particular requirements for LED luminaires'
LED Lighting	
prEN 13032-4:2015	'Light and lighting - Measurement and presentation of photometric data - Part 4: LED lamps, modules and luminaires'
EN 60838-2-2:2006/A1:2012	'Miscellaneous lampholders - Part 2-2: Particular requirements - Connectors for LED-modules'

Project EN/IEC 60838-2-3 (under approval)	'Miscellaneous lampholders - Part 2-3: Particular requirements - Lampholders for double-capped linear LED lamps'
EN 61347-2-13:2006/ corrigendum Dec. 2010 ; FprEN 61347-2-13:2012 under approval	'Lamp controlgear - Part 2-13: Particular requirements for d.c. or a.c. supplied electronic controlgear for LED modules'
EN 62031:2008/ FprA2:2014 (amendment under approval)	'LED modules for general lighting - Safety specifications'
EN 62384:2006/A1:2009	'DC or AC supplied electronic control gear for LED modules. Performance requirements'
EN 62386-207:2009	'Digital addressable lighting interface. Particular requirements for control gear. LED modules (device type 6).'
FprEN 62442-3:2014 (under approval)	'Energy performance of lamp controlgear - Part 3: Controlgear for halogen lamps and LED modules - Method of measurement to determine the efficiency of the controlgear '
FprEN 62504:2014 (under approval)	'General lighting - Light emitting diode (LED) products and related equipment - Terms and definitions'
EN 62560:2012/FprA1:2013 (amendment under approval)	'Self-ballasted LED-lamps for general lighting services by voltage > 50 V - Safety specifications'
EN 62612:2013	'Self-ballasted LED lamps for general lighting services with supply voltages > 50 V - Performance requirements'
FprEN 62663-1:2012 (under approval)	'Non-ballasted LED-lamps - Part 1: Safety specifications'
prEN 62663-2:201X (under drafting)	'Non-ballasted LED lamps - Performance requirements'
IEC 62717 FprEN 62717:2013 (under approval)	'LED modules for general lighting - Performance requirements'
FprEN 62722-2-1:2013 (under approval)	'Luminaire performance - Part 2-1: Particular requirements for LED luminaires'
FprEN 62776:2013 (under approval)	'Double-capped LED lamps for general lighting services - Safety specifications'
prEN 62838:201X (under drafting)	'Semi-integrated LED lamps for general lighting services with supply voltages not exceeding 50 V a.c. r.m.s. or 120V ripple free d.c. - Safety specification'
FprEN 62868:2013 (under approval)	'Organic light emitting diode (OLED) panels for general lighting - Safety requirements'
CIE 127:2007	'Measurement of LED's' (2nd ed.)
CIE 177:2007	'Colour Rendering of White LED Light Sources'
CIE 205:2013	'Review of Lighting Quality Measures for Interior Lighting with LED Lighting Systems'
CIE DIS 024/E:2013	'Light Emitting Diodes (LEDs) and LED Assemblies - Terms and Definitions'
Outdoor Lighting, Workplaces	
EN 12464-2:2014	**'Light and Lighting-Part 2: Lighting of outdoor work places.'**
CIE S015/E:2005	'Lighting of Outdoor Work Places'
CIE S 016/E:2005 (ISO 8995-3:2006)	'Lighting of Work Places - Part 3: Lighting Requirements for Safety and Security of Outdoor Work Places'

CIE 128:1998	'Guide to the lighting for open-cast mines'
CIE 129:1998	'Guide for lighting exterior work areas'
Outdoor Lighting, Streets and External Public Spaces	
BS 5489-1:2003	Code of practice for the design of read lighting – Part 1: Lighting of reads and public amenity areas.
CEN/TR 13201-1:2014 ;	'Road lighting - Part 1:Guidelines on selection of lighting classes.'
EN 13201-2:2016	**'Road lighting - Part 2: Performance requirements.'**
EN 13201-3:2015	'Road lighting - Part 3: Calculation of performance.'
EN 13201-4:2015	'Road lighting - Part 4: Methods of measuring lighting performance.'
EN 13201-5:2015	**'Road lighting-Part 5: Energy performance indicators.'**
prEN 13201-6 (under approval in 2017)	'prEN 13201-6:2015 Road Lighting - Part 6: Tables of the most energy efficient useful utilance, utilance and utilization factor.'
HD 60364-7-714:2012	'Low-voltage electrical installations - Part 7-714: Requirements for special installations or locations - External lighting installations'
CIE 032:197	'Lighting in situations requiring special treatment'
CIE 033:1977	'Depreciation of installations and their maintenance'
CIE 034-1977	'Road lighting lantern and installation data: photometrics, classification and performance'
CIE 047:1979	'Road lighting for wet conditions'
CIE 066:1984	'Road surfaces and lighting (joint technical report CIE/PIARC)'
CIE 093:1992	'Road lighting as an accident countermeasure'
CIE 094:1993	'Guide for floodlighting'
CIE 100:1992	'Fundamentals of the visual task of night driving
CIE 115:2010	**'Lighting of Roads for Motor and Pedestrian Traffic'**
CIE 132:1999	'Design methods for lighting of roads'
CIE 136:2000	'Guide to the lighting of urban areas'
CIE 140:2000	'Road Lighting Calculations (Rev. 2)'
CIE 144:2001	'Road surface and road marking reflection characteristics'
CIE 154:2003	'The maintenance of outdoor lighting systems'
CIE 206:2014	'The Effect of Spectral Power Distribution on Lighting for Urban and Pedestrian Areas'
DIN 13201-1	EN-Norm „Straßenbeleuchtung": „Teil 1: Auswahl der Beleuchtungsklassen"
NBN L 18-004	'Openbare verlichting - Selectie van verlichtingsklassen' (in english Street lighting – selection of Lighting categories)
UNI 11431:2011	

UNI 11248:2007	'Illuminazione stradale - Selezione delle categorie illuminotecniche' (in english Street lighting – selection of Lighting categories)
Outdoor Lighting, Tunnels	
CEN/ CR 14380:2003	'Lighting applications - Tunnel lighting'
EN 16276:2013	'Evacuation Lighting in Road Tunnels'
CIE 061:19	'Tunnel entrance lighting: A survey of fundamentals for determining the luminance in the threshold zone'
CIE 88:2004	'Guide for the lighting of road tunnels and underpasses, 2nd ed.'
CIE 189:2010	'Calculation of Tunnel Lighting Quality Criteria'
CIE 193:2010	'Emergency Lighting in Road Tunnels'
Outdoor Lighting, Traffic Lights	
EN 12352:2006	'Traffic control equipment - Warning and safety light devices'
EN 12368:2015	'Traffic control equipment - Signal heads'
EN 50556:2011	'Road traffic signal systems'
CIE S 006.1/E-1998 (ISO 16508:1999)	'Road traffic lights - Photometric properties of 200 mm roundel signals'
CIE 079:1988	'A guide for the design of road traffic lights'
Outdoor Lighting, Sky Glow and Obtrusive Light	
CIE 001-1980	'Guidelines for minimizing urban sky glow near astronomical observatories (Joint Publication IAU/CIE)'
CIE 126:1997	'Guidelines for minimizing sky glow'
CIE 150:2003	'Guide on the limitation of the effects of obtrusive light from outdoor lighting installations'
Indoor Lighting	
EN 12464-1:2011	**'Light and Lighting-Part 1: Lighting of indoor work places.'**
EN 15193:2007/AC:2010 ; prEN 15193:2016 rev (under drafting)	**'Energy performance of buildings – Energy requirements for lighting'**
DIN V 18599 - 4	'Energy efficiency of buildings - Calculation of the net, final and primary energy demand for heating, cooling, ventilation, domestic hot water and lighting - Part 4: Net and final energy demand for lighting.'
EN 15251:2007	'Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics'
CEN/TC 169 (WI=00169067) (under drafting)	'Energy performance of buildings - Energy requirements for lighting - Part 2: Technical Report to EN 15193-1'
CEN/TS 16163:2014	'Conservation of Cultural Heritage - Guidelines and procedures for choosing appropriate lighting for indoor exhibitions'

HD 60364-5-559:2005/ corrigendum Oct. 2007	'Electrical installations of buildings - Part 5-55: Selection and erection of electrical equipment - Other equipment - Clause 559: Luminaires and lighting installations'
HD 60364-5-559:2012	'Low-voltage electrical installations - Part 5-559: Selection and erection of electrical equipment - Luminaires and lighting installations'
CIE S 008/E:2001 (ISO 8995-1:2002 Cor.1 2005)	'Lighting of Work Places - Part 1: Indoor'
CIE 040:1978	'Calculations for interior lighting: Basic method'
CIE 052:1982	'Calculations for interior lighting: Applied method'
CIE 097:2005	'Maintenance of indoor electric lighting systems'
CIE 161:2004	'Lighting design methods for obstructed interiors'
Sports Lighting	
EN 12193:2007	'Light and lighting - Sports lighting.'
CIE 042:1978	'Lighting for tennis'
CIE 045:1979	'Lighting for ice sports'
CIE 057:1983	'Lighting for football'
CIE 058:1983	'Lighting for sports halls'
CIE 062:1984	'Lighting for swimming pools'
CIE 067:1986	'Guide for the photometric specification and measurement of sports lighting installations'
CIE 083:1989	'Guide for the lighting of sports events for colour television and film systems'
CIE 169:2005	'Practical design guidelines for the lighting of sport events for colour'
Emergency Lighting	
EN 1838:2013	'Lighting applications - Emergency lighting.'
EN 13032-3:2007	'Light and lighting - Measurement and presentation of photometric data of lamps and luminaires - Part 3: Presentation of data for emergency lighting of work places.'
EN 50171:2001 ; prEN 50171:2013 (under approval)	'Central power supply systems.'
EN 50172:2004	'Emergency escape lighting systems.'
CIE S 020/E:2007 (ISO 30061:2007)	'Emergency Lighting'
Gears, Ballasts and Drivers	
EN 50294:1998/A2:2003	'Measurement Method of Total Input Power of Ballast-Lamp Circuits'
EN 50564:2011	'Electrical and electronic household and office equipment - Measurement of low power consumption' (stand-by, no-load)
EN 60155:1995/A2:2007	'Glow-starters for fluorescent lamps'
EN 60730-2-3:2007	'Automatic electrical controls for household and similar use - Part 2-3: Particular requirements for thermal protectors for ballasts for tubular fluorescent lamps'

EN 60730-2-7:2010	'Automatic electrical controls for household and similar use - Part 2-7: Particular requirements for timers and time switches'
EN 60921:2004/A1:2006	'Ballasts for tubular fluorescent lamps – Performance requirements'
EN 60923:2005/A1:2006	'Auxiliaries for lamps. Ballasts for discharge lamps (excluding tubular fluorescent lamps). Performance requirements.'
EN 60925:1991/A2:2001	'D.C. supplied electronic ballasts for tubular fluorescent lamps - Performance requirements'
EN 60927:2007/A1:2013	'Auxiliaries for lamps - Starting devices (other than glow starters) - Performance requirements.'
EN 60929:2011/AC:2011	'AC-supplied electronic ballasts for tubular fluorescent lamps – Performance requirements'
EN 61047:2004	'D.C. or A.C. supplied electronic step-down converters for filament lamps. Performance requirements'.
EN 61048:2006/ FprA1:2013 (amendment under approval)	'Auxiliaries for lamps - Capacitors for use in tubular fluorescent and other discharge lamp circuits - General and safety requirements'
EN 61049:1993	'Capacitors for Use in Tubular Fluorescent and Other Discharge Lamp - Circuits Performance Requirements'
EN 61050:1992/A1:1995	'Transformers for tubular discharge lamps having a no-load output voltage exceeding 1 kV (generally called neon-transformers) - General and safety requirements'
EN 61347-1:2008/FprA3:2013 (amendment under approval)	'Lamp control gear - Part 1: General and safety requirements'
EN 61347-2-1:2001/A2:2014	'Lamp control gear - Part 2-1: Particular requirements for starting devices (other than glow starters)'
EN 61347-2-2:2012	'Lamp control gear - Part 2-2: Particular requirements for d.c. or a.c. supplied electronic step-down convertors for filament lamps'
EN 61347-2-3:2011/AC:2011	'Lamp control gear - Part 2-3: Particular requirements for a.c. and/or d.c. supplied electronic control gear for fluorescent lamps'
EN 61347-2-4:2001/ corrigendum Dec. 2010	'Lamp control gear - Part 2-4: Particular requirements for d.c. supplied electronic ballasts for general lighting'
EN 61347-2-7:2012	'Lamp controlgear - Part 2-7: Particular requirements for battery supplied electronic controlgear for emergency lighting (self-contained)
EN 61347-2-8:2001/ corrigendum Dec. 2010	'Lamp control gear - Part 2-8: Particular requirements for ballasts for fluorescent lamps'
EN 61347-2-9:2013	'Lamp control gear – Part 2-9: Particular requirements for electromagnetic control gear for discharge lamps (excluding fluorescent lamps)'
EN 61347-2-10:2001/A1:2009 corrigendum Dec. 2010	'Lamp controlgear - Part 2-10: Particular requirements for electronic invertors and convertors for high-frequency operation of cold start tubular discharge lamps (neon tubes)'
EN 61347-2-11:2001/ corrigendum Dec. 2010	'Lamp control gear. - Part 2-11: Particular requirements for miscellaneous electronic circuits used with luminaires.'
EN 61347-2-12:2005/A1:2010	'Lamp control gear - Part 2-12: Particular requirements for d.c. or a.c. supplied electronic ballasts for discharge lamps (excluding fluorescent lamps)'

EN 61347-2-13:2006/ corrigendum Dec. 2010 ; FprEN 61347-2-13:2014 under approval	'Lamp controlgear - Part 2-13: Particular requirements for d.c. or a.c. supplied electronic controlgear for LED modules'
EN 62442-1:2011/AC:2012	'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 62442-2:2014	'Energy performance of lamp controlgear - Part 2: Controlgear for high intensity discharge lamps (excluding fluorescent lamps) - Method of measurement to determine the efficiency of controlgear '
IEC 62442-3 FprEN 62442-3:2014 (under approval)	'Energy performance of lamp controlgear - Part 3: Controlgear for halogen lamps and LED modules - Method of measurement to determine the efficiency of the controlgear '
FprEN 62811:2014 (under approval)	'AC and/or DC-supplied electronic controlgear for discharge lamps (excluding fluorescent lamps) - Performance requirements for low frequency squarewave operation'
Lighting Control	
EN 15232:2012 ; prEN 15232 rev (under drafting)	'Energy performance of buildings - Impact of Building Automation, Controls and Building Management.'
EN 50428:2005	'Switches for household and similar fixed electrical installations - Collateral standard - Switches and related accessories for use in home and building electronic systems (HBES)'
EN 50490:2008	'Electrical installations for lighting and beaconing of aerodromes - Technical requirements for aeronautical ground lighting control and monitoring systems - Units for selective switching and monitoring of individual lamps'
EN 50491-3:2009 (and other parts of 50491)	'General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS) - Part 3: Electrical safety requirements'
EN 60669-1:1999/IS1:2009	'Switches for household and similar fixed-electrical installations - Part 1: General requirements'
EN 60669-2-1:2004/A12:2010 FprA2:2013 (under approval)	'Switches for household and similar fixed electrical installations - Part 2-1: Particular requirements - Electronic switches'
EN 60669-2-2:2006	'Switches for household and similar fixed electrical installations Particular requirements. Electromagnetic remote-control switches (RCS)'
EN 60669-2-3:2006	'Switches for household and similar fixed electrical installations. Particular requirements Time-delay switches (TDS)'
EN 60669-2-4:2005	'Switches for household and similar fixed electrical installations - Part 2-4: Particular requirements - Isolating switches'
EN 60669-2-5:2014	'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)'

EN 60669-2-6:2012	'Switches for household and similar fixed electrical installations - Part 2-6: Particular requirements - Fireman's switches for exterior and interior signs and luminaires'
EN 62386-101:2009 ; FprEN 62386-101:2013 (under approval)	'Digital addressable lighting interface - Part 101: General requirements – System.'
EN 62386-102:2009 ; FprEN 62386-102:2013 (under approval)	'Digital addressable lighting interface. General requirements. Control gear.'
FprEN 62386-103:2013 (under approval)	'Digital addressable lighting interface. Part 103. General requirements. Control devices.'
EN 62386-201:2009 ; FprEN 62386-201:2014 (under approval)	'Digital addressable lighting interface. Particular requirements for control gear. Fluorescent lamps (device type 0).'
EN 62386-202:2009	'Digital addressable lighting interface. Particular requirements for control gear. Self-contained emergency lighting (device type 1). '
EN 62386-203:2009	'Digital addressable lighting interface. Particular requirements for control gear. Discharge lamps (excluding fluorescent lamps) (device type 2).'
EN 62386-204:2009	'Digital addressable lighting interface. Particular requirements for control gear. Low voltage halogen lamps (device type 3).'
EN 62386-205:2009	'Digital addressable lighting interface. Particular requirements for control gear. Supply voltage controller for incandescent lamps (device type 4).'
EN 62386-206:2009	'Digital addressable lighting interface. Particular requirements for control gear. Conversion from digital signal into d.c. voltage (device type 5).'
EN 62386-207:2009	'Digital addressable lighting interface. Particular requirements for control gear. LED modules (device type 6).'
EN 62386-208:2009	'Digital addressable lighting interface. Particular requirements for control gear. Switching function (device type 7).'
EN 62386-209:2011	'Digital addressable lighting interface - Part 209: Particular requirements for control gear - Colour control (device type 8).'
EN 62386-210:2011	'Digital addressable lighting interface Particular requirements for control gear. Sequencer (device type 9).'
FprEN 62733:2014 (under approval)	'Programmable components in electronic lamp controlgear - General and safety requirements'
Safety aspects of Lighting	
EN 50102:1995/ A1:1998/ corrigendum Jul. 2002	'Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)'
EN 60432-1:2000/A2:2012	'Incandescent lamps - Safety specifications - Part 1: Tungsten filament lamps for domestic and similar general lighting purposes'
EN 60432-2:2000/A2:2012	'Incandescent lamps - Safety specifications - Part 2: Tungsten halogen lamps for domestic and similar general lighting purposes.'

EN 60432-3:2013	'Incandescent lamps - Safety specifications - Part 3: Tungsten-halogen lamps (non-vehicle)'
EN 60529:1991/ A2:2013	'Degrees of protection provided by enclosures (IP Code)'
EN 60968:2013/A11:201X ; FprEN 60968:2013 (under approval)	'Self-ballasted lamps for general lighting services - Safety requirements.'
EN 61195:1999/ FprA2:2014 (amendment under approval)	'Double-capped fluorescent lamps - Safety specifications'
EN 61199:2011/ FprA2:2014 (amendment under approval)	'Single-capped fluorescent lamps - Safety specifications'
EN 61558-2-9:2011	'Safety of transformers, reactors, power supply units and combinations thereof - Part 2-9: Particular requirements and tests for transformers and power supply units for class III handlamps for tungsten filament lamps'
EN 62031:2008/ FprA2:2014 (amendment under approval)	'LED modules for general lighting - Safety specifications'
EN 62035:2000/ A1:2003 A2:2012 ; prEN 62035:201X (under approval) ; IEC 62035:2014	'Discharge lamps (excluding fluorescent lamps) - Safety specifications.'
EN 62532:2011	'Fluorescent induction lamps - Safety specifications.'
EN 62560:2012/FprA1:2013 (amendment under approval)	'Self-ballasted LED-lamps for general lighting services by voltage > 50 V - Safety specifications'
EN 62471:2008 ; FprEN 62471-5:2014 (under approval)	'Photobiological safety of lamps and lamp systems'
CIE S 009 E:2002 / IEC 62471:2006	'Photobiological safety of lamps and lamp systems '
CIE 138:2000	'CIE Collection in photobiology and photochemistry 2000'
CIE 139:2001	'The influence of daylight and artificial light variations in humans - a bibliography'
CIE 158:2009	'Ocular lighting effects on human physiology and behaviour'
IEC 62321:2008	'Electrotechnical products - Determination of levels of six regulated substances (lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls, polybrominated diphenyl ethers)'
IEC 62321-1:2013	'Determination of certain substances in electrotechnical products - Part 1: Introduction and overview'
IEC 62321-2:2013	'Determination of certain substances in electrotechnical products - Part 2: Disassembly, disjunction and mechanical sample preparation'
IEC 62321-3-1:2013	'Determination of certain substances in electrotechnical products - Part 3-1: Screening - Lead, mercury, cadmium, total chromium and total bromine using X-ray fluorescence spectrometry'
IEC 62321-3-2:2013	'Determination of certain substances in electrotechnical products - 3-2: Screening - Total bromine in polymers and electronics by Combustion - Ion Chromatography'
IEC 62321-4:2013	'Determination of certain substances in electrotechnical products - Part 4: Mercury in polymers, metals and electronics by CV-AAS, CV-AFS, ICP-OES and ICP-MS'
IEC 62321-5:2013	'Determination of certain substances in electrotechnical

	products - Part 5: Cadmium, lead and chromium in polymers and electronics and cadmium and lead in metals by AAS, AFS, ICP-OES and ICP-MS'
EN 62554:2011	'Sample preparation for measurement of mercury level in fluorescent lamps'
FprEN 62663-1:2012 (under approval)	'Non-ballasted LED-lamps - Part 1: Safety specifications'
FprEN 62776:2013 (under approval)	'Double-capped LED lamps for general lighting services - Safety specifications'
IEC/TR 62778: 2012	'Application of IEC/EN 62471 for the assessment of blue light hazard to light sources and luminaires (Technical report)'
prEN 62838:201X (under drafting)	'Semi-integrated LED lamps for general lighting services with supply voltages not exceeding 50 V a.c. r.m.s. or 120V ripple free d.c. - Safety specification'
FprEN 62868:2013 (under approval)	'Organic light emitting diode (OLED) panels for general lighting - Safety requirements'
CEN/TC 169, (WI=00169063) (under drafting, expected 2015)	'Eye mediated non visual effects of light on humans - Measures of neurophysiological and melanopic photosensitivity'
Emission aspects of Lighting	
EN 14255-1:2005	'Measurement and assessment of personal exposures to incoherent optical radiation - Ultraviolet radiation emitted by artificial sources in the workplace'
EN 14255-2:2005	'Measurement and assessment of personal exposures to incoherent optical radiation - Visible and infrared radiation emitted by artificial sources in the workplace'
EN 14255-4:2006	'Measurement and assessment of personal exposures to incoherent optical radiation - Terminology and quantities used in UV-, visible and IR-exposure measurements'
EN 55015:2013 ; FprA1:2014 (under approval)	'Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment'
EN 55103-1:2009/A1:2012	'Electromagnetic compatibility - Product family standard for audio, video, audio-visual and entertainment lighting control apparatus for professional use - Part 1: Emissions'
EN 55103-2:2009/IS1:2012	'Electromagnetic compatibility - Product family standard for audio, video, audio-visual and entertainment lighting control apparatus for professional use - Part 2: Immunity'
EN 60335-2-27:2013	'Household and similar electrical appliances - Safety - Part 2-27: Particular requirements for appliances for skin exposure to ultraviolet and infrared radiation'
EN 61000-3-2:2006 ; FprA3:2013 (under approval)	'Electromagnetic compatibility (EMC) Limits. Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)'
EN 61000-3-3:2013	'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 61000-4-1:2007	'Electromagnetic compatibility (EMC) - Part 4-1: Testing and measurement techniques - Overview of EN 61000-4 series'

EN 61000-4-6:2014	'Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields'
EN 61000-4-15:2011	'Electromagnetic compatibility (EMC) - Part 4-15: Testing and measurement techniques - Flickermeter - Functional and design specifications'
EN 61547:2009	'Equipment for general lighting purposes - EMC immunity requirements'
EN 62493:2010	'Assessment of lighting equipment related to human exposure to electromagnetic fields'
Colour and Colour Rendering	
CIE 013.3:1995	'Method of measuring and specifying colour rendering properties of light sources'
CIE 015:2004	'Colourimetry, 3rd edition'
CIE S004/E-2001	'Colours of light signals'
CIE S 014-1/E:2006 (ISO 11664-1:2007)	'CIE Standard Colourimetric Observers'
CIE S 014-2/E:2006/ (ISO 11664-2:2007(E))	'CIE Standard Illuminants for Colourimetry'
CIE S 014-3/E:2011 (ISO 11664-3:2012)	'Colourimetry - Part 3: CIE Tristimulus Values'
CIE S 014-4/E:2007 (ISO 11664-4:2008)	'Colourimetry - Part 4: CIE 1976 L*a*b* Colour Spaces'
CIE S 014-5/E:2009 (ISO 11664-5:2009)	'Colourimetry - Part 5: CIE 1976 L*u*v* Colour Space and u', v' Uniform Chromaticity Scale Diagram'
ISO/CIE 11664-6:2014(E)	'Colourimetry – Part 6: CIEDE2000 Colour-Difference Formula'
CIE 177:2007	'Colour Rendering of White LED Light Sources'
IEC/TR 62732:2012	'Three-digit code for designation of colour rendering and correlated colour temperature'
Light Measurement and Photometry	
EN 13032-1:2004+A1:2012	'Light and lighting — Measurement and presentation of photometric data of lamps and luminaires — Part 1: Measurement and file format.'
EN 13032-2:2004/AC:2007	'Light and lighting - Measurement and presentation of photometric data of lamps and luminaires - Part 2: Presentation of data for indoor and outdoor work places.'
EN 13032-3:2007	'Light and lighting - Measurement and presentation of photometric data of lamps and luminaires - Part 3: Presentation of data for emergency lighting of work places'
prEN 13032-4:201X (under approval in 2014)	'Light and lighting - Measurement and presentation of photometric data - Part 4: LED lamps, modules and luminaires'
IES TM-25-13	'Ray File Format for the Description of the Emission Property of Light Sources.'
CIE 102:1993	'Recommended file format for electronic transfer of luminaire photometric data'
CIE S 010/E:2004 (ISO 23539:2005)	'Photometry - The CIE system of physical photometry'

CIE 018.2:1983	'The Basis of Physical Photometry, 2nd ed.'
CIE 041:1978	'Light as a true visual quantity: Principles of measurement'
CIE 043:1979	'Photometry of floodlights'
CIE 063:1984	'The spectroradiometric measurement of light sources'
CIE 067:1986	'Guide for the photometric specification and measurement of sports lighting installations'
CIE 070:1987	'The measurement of absolute luminous intensity distributions'
CIE 084:1989	'Measurement of luminous flux'
CIE 121:1996	'The photometry and goniophotometry of luminaires'
CIE 194:2011	'On Site Measurement of the Photometric Properties of Road and Tunnel Lighting'
Glare	
CIE 031-1976	'Glare and uniformity in road lighting installations'
CIE 055:1983	'Discomfort glare in the interior working environment'
CIE 112:1994	'Glare evaluation system for use within outdoor sports and area lighting'
CIE 117:1995	'Discomfort glare in interior lighting'
CIE 146:2002	'CIE Equations for Disability Glare'
CIE 147:2002	'Glare from Small, Large and Complex Sources'
CIE 190:2010	'Calculation and Presentation of Unified Glare Rating Tables for Indoor Lighting Luminaires'
Others	
prEN 50625-2-1 (under drafting)	'Collection, logistics & Treatment requirements for WEEE - Part 2-1: Treatment requirements for lamps'
EN 61995-1:2008	'Devices for the connection of luminaires for household and similar purposes - Part 1: General requirements'
EN 61995-2:2009	'Devices for the connection of luminaires for household and similar purposes - Part 2: Standard sheets for DCL'
HD 60364-7-715:2012	'Low-voltage electrical installations - Part 7-715: Requirements for special installations or locations - Extra-low-voltage lighting installations'
prHD 60364-7-719:2011 (under approval)	'Low-voltage installations - Part 7-719: Requirements for special installations or locations - Lighting installations for advertising signs with a rated output voltage not exceeding 1 000 V, which are illuminated by hot-cathode-fluorescent-lamps, luminous-discharge tubes (neon-tubes), inductive discharge lamps, light emitting diodes (LED) and/or LED modules'
EN ISO 24502:2010	'Ergonomics - Accessible design - Specification of age-related luminance contrast for coloured light (ISO 24502:2010)'
CIE 123:1997	'Low vision - Lighting needs for the partially sighted'
CIE 196:2011	'CIE Guide to Increasing Accessibility in Light and Lighting'

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 AND STOCK OF LIGHT SOURCES

The data in this annex have been taken from the MELISA model (see par. 2.1 of the main text) that was used for the scenario analyses in Task 7 of the Light Sources study [1].
Data have been taken from the July 2016 updated version of MELISA and might therefore differ from those reported in the Light Sources study.
Only data for the LFL-, HID- and CFLni-application groups are shown, as only these are potentially relevant for the Lighting Systems study.
These data are for the BAU-scenario as defined in Task 7 of the Light Sources study.

Sales in LFL application group

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	180	138	90	58
	T5 new (14 - 80w) including Circular	0	64	64	63	42	27
	T5 old (4 - 13W), Special FL, Others	21	30	19	20	13	6
	LFL (total)	**252**	**365**	**263**	**221**	**146**	**90**
LED	LED retrofit for LFL replacement	0	0	8	26	41	46
	LED luminaire for LFL replacement	0	0	3	22	73	134
	LED for LFL (total)	**0**	**0**	**11**	**48**	**114**	**180**

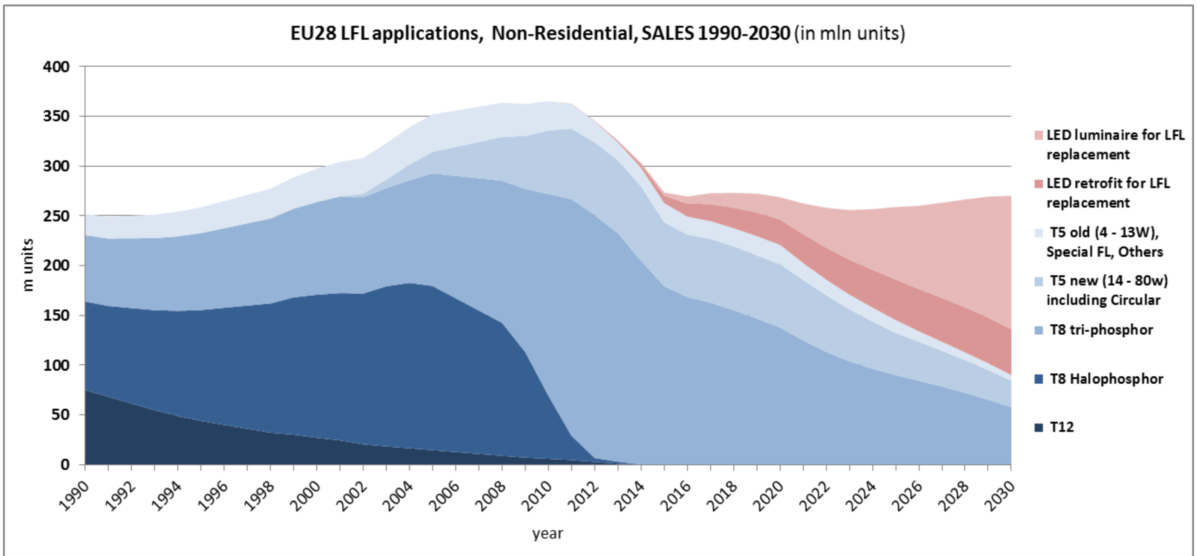


Figure 1 Light source sales in mln units per year for lamp types of the LFL-application group. Per base case, for the non-residential sector (source: MELISA July 2016)

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

Stock in LFL application group

	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	362	851	1252	1248	1154	899
	T5 new (14 - 80w) including Circular	0	261	518	599	573	462
	T5 old (4 - 13W), Special FL, Others	100	168	102	93	75	40
	LFL (total)	**1030**	**1698**	**1880**	**1939**	**1801**	**1402**
LED	LED retrofit for LFL replacement	0	0	13	113	281	478
	LED luminaire for LFL replacement	0	0	5	79	329	848
	LED for LFL (total)	**0**	**0**	**18**	**192**	**610**	**1326**

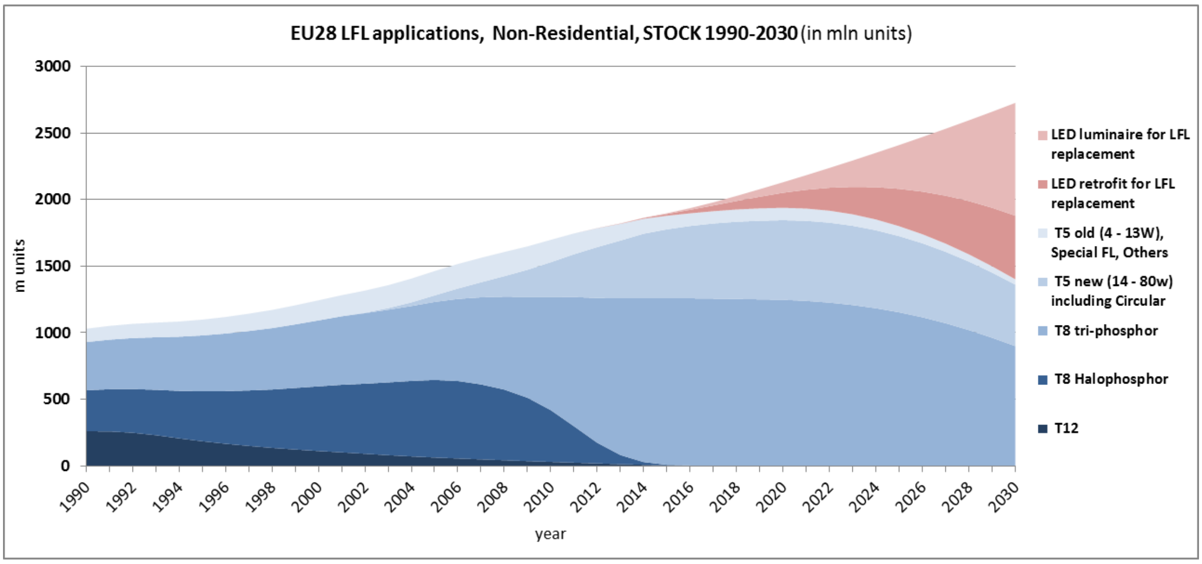


Figure 2 Light source installed stock in mln units for lamp types of the LFL-application group. Per base case, for the non-residential sector (source: MELISA July 2016)

Sales in HID application group

	HID - EU-28 SALES mln units TOTAL, NON-RESIDENTIAL	1990	2010	2015	2020	2025	2030
HID	HPM	8	5	2	0	0	0
	HPS	7	15	11	7	5	2
	MH	2	21	16	10	6	2
	HID (total)	**17**	**41**	**29**	**17**	**11**	**4**
LED	LED retrofit for HID replacement	0	0	1	1	3	3
	LED luminaire for HID replacement	0	0	4	6	10	14
	LED for HID (total)	**0**	**0**	**5**	**7**	**13**	**17**

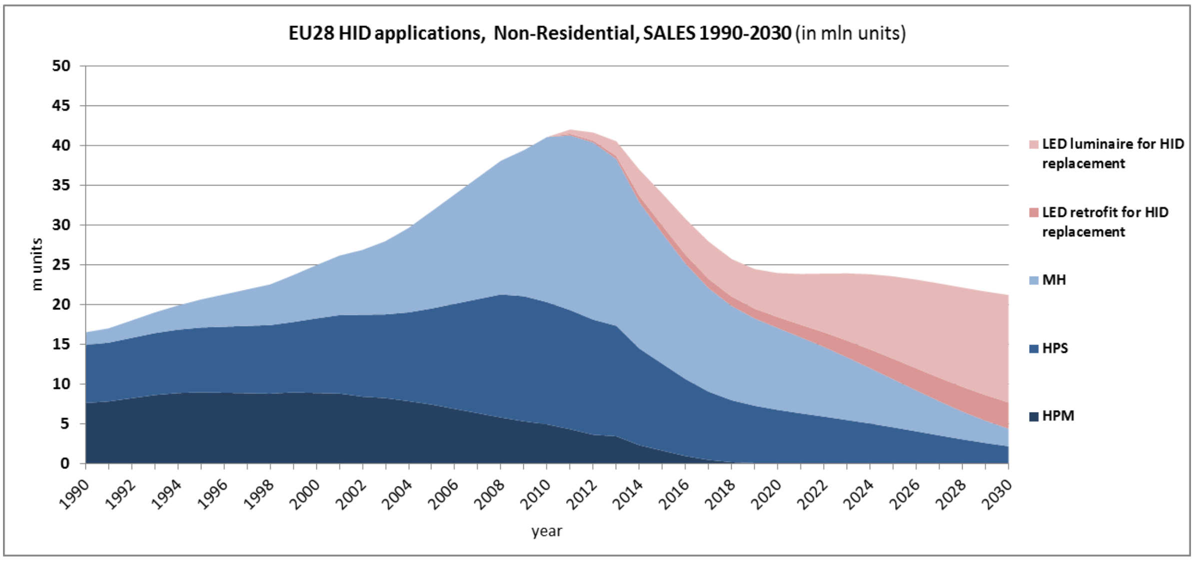


Figure 3 Light source annual sales in mln units for lamp types of the HID-application group. Per base case, for the non-residential sector (source: MELISA July 2016)

Stock in HID application group

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	46	42	38	30	17
	MH	3	39	45	41	27	11
	HID (total)	**40**	**95**	**91**	**79**	**57**	**29**
LED	LED retrofit for HID replacement	0	0	3	8	16	25
	LED luminaire for HID replacement	0	0	12	33	63	100
	LED for HID (total)	**0**	**0**	**15**	**41**	**79**	**125**

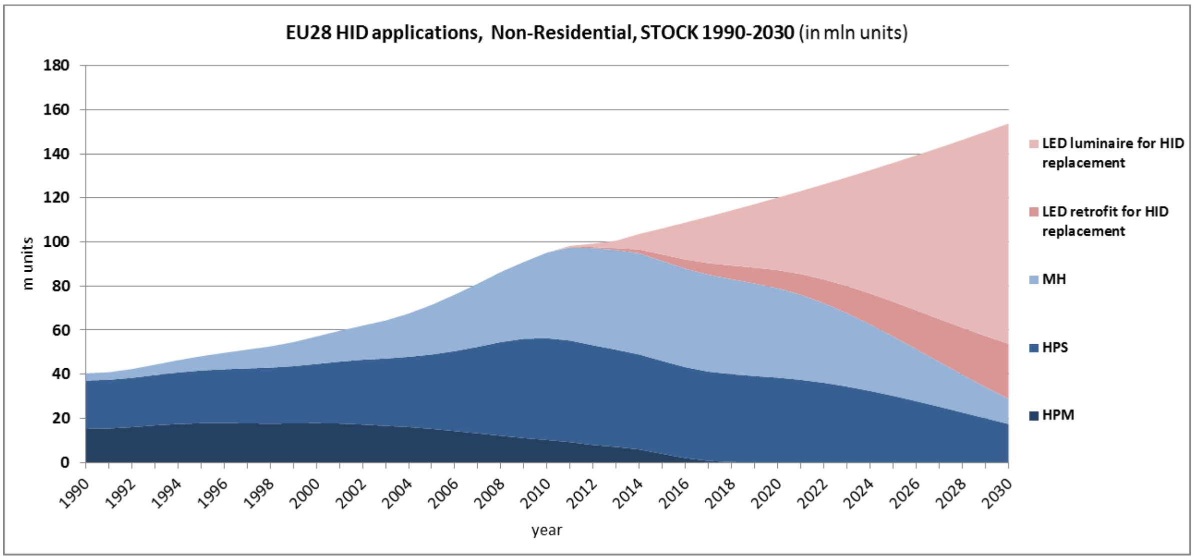


Figure 4 Light source installed stock in mln units for lamp types of the HID-application group. Per base case, for the non-residential sector (source: MELISA July 2016)

Sales in CFLni application group

	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**

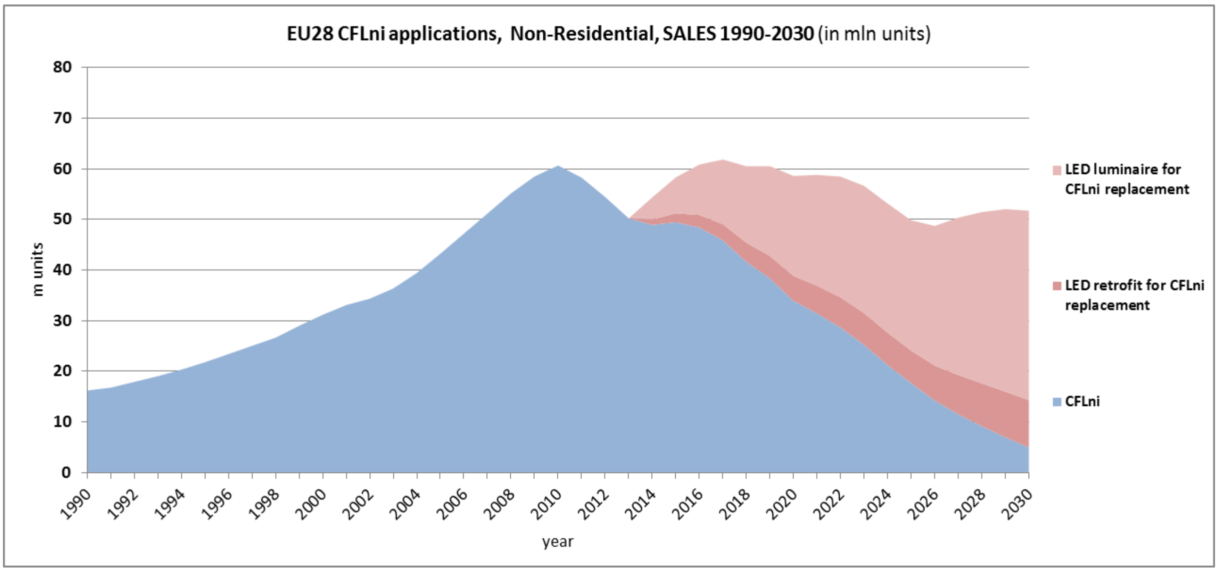


Figure 5 Light source annual sales in mln units for lamp types of the CFLni-application group. Per base case, for the non-residential sector (source: MELISA July 2016)

Stock in CFLni application group

	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**

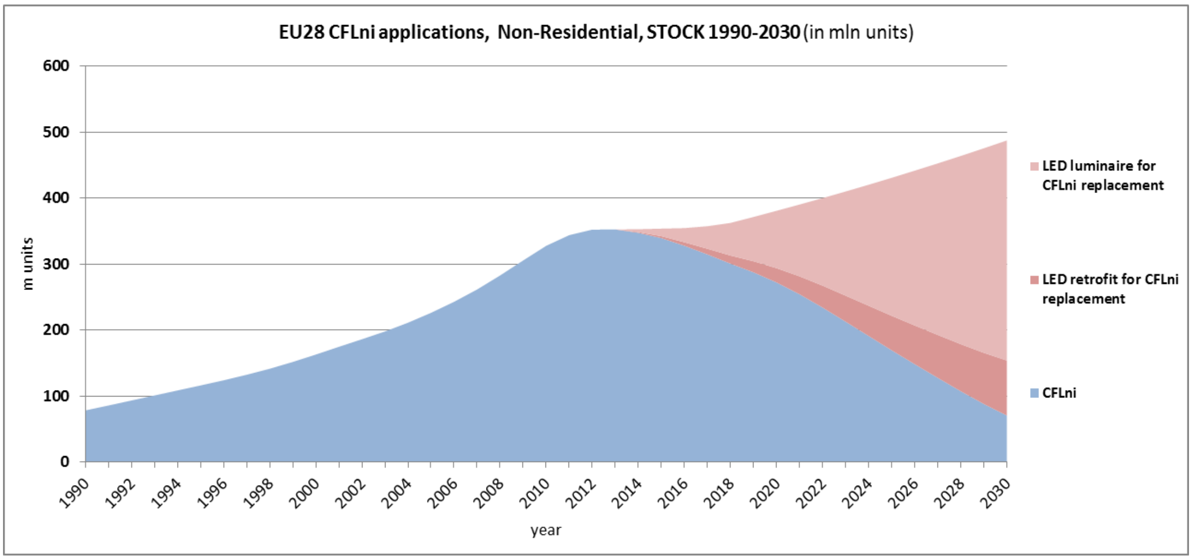


Figure 6 Light source installed stock in mln units for lamp types of the CFLni-application group. Per base case, for the non-residential sector (source: MELISA July 2016)

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:

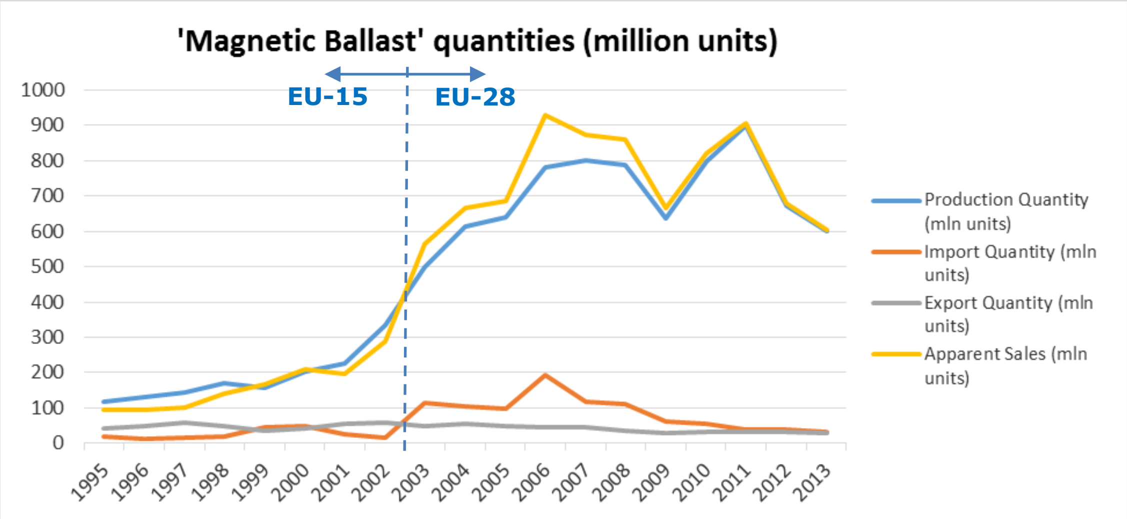
- In 2013 around 600 million **magnetic ballasts** were sold in EU-28, representing a total value of around 165 million euros, for an average value of 0.27 euros/ballast.
  As regards sales quantities there is no clear trend: since 2005 the annual sales go up and down, varying from 600 to 900 million 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. 2.2.3.

Table 0-1 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



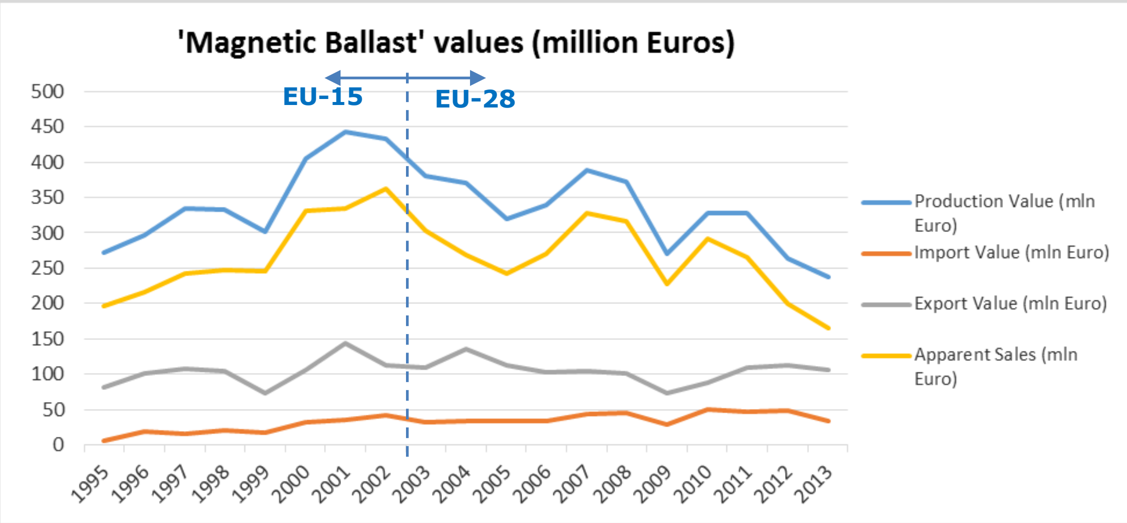
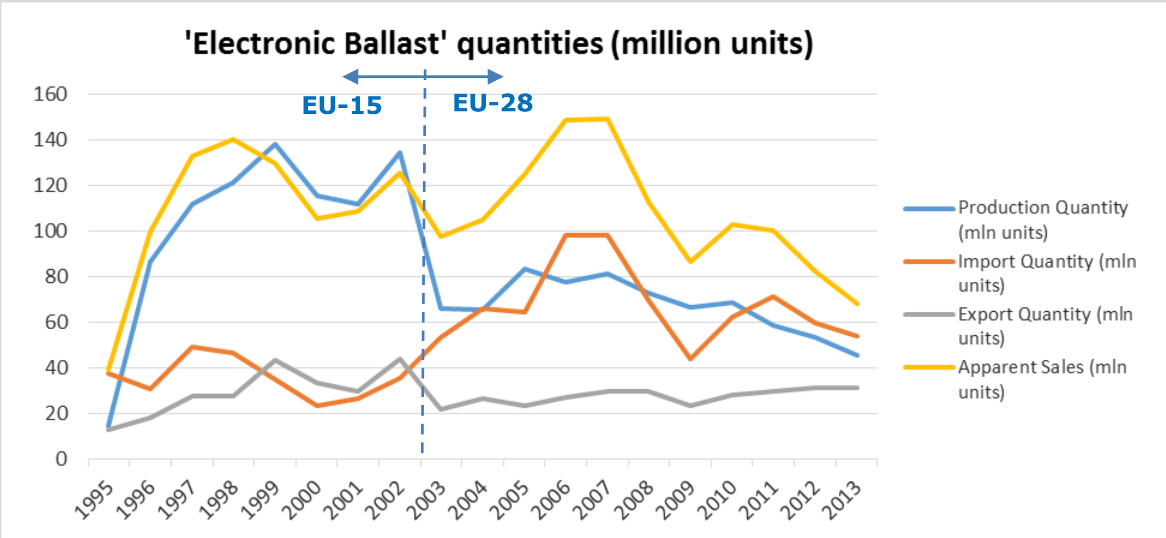


Figure 0-7: Eurostat EU-15 data 1995-2002 and EU-28 data 2003-2013 for Magnetic ballast. Top: quantities; bottom: monetary value.

Table 0-2 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



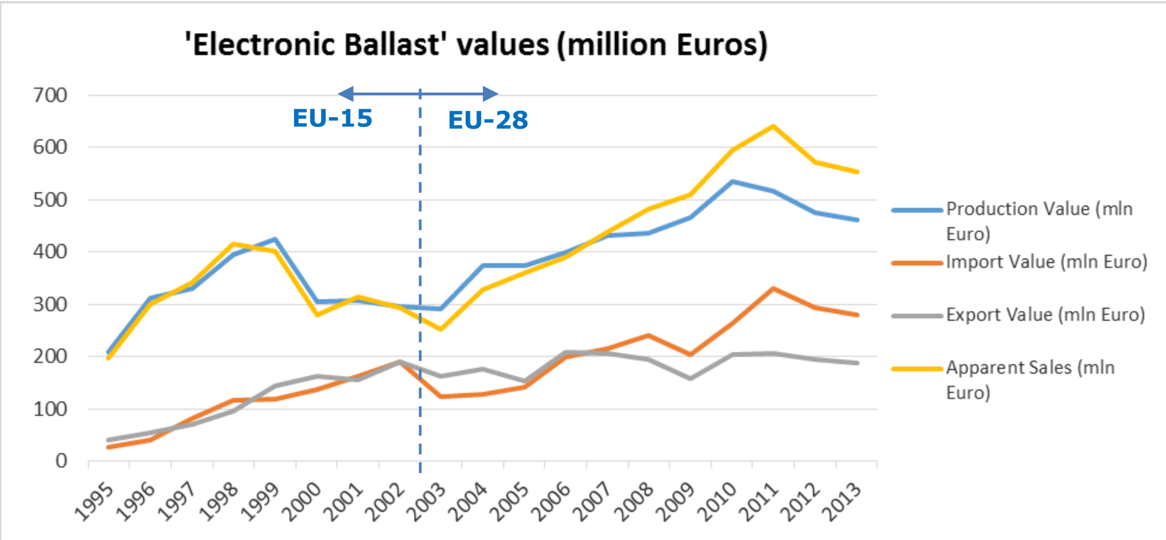


Figure 0-8: Eurostat EU-15 data 1995-2002 and EU-28 data 2003-2013 for Electronic ballast. Top: quantities; bottom: monetary value.

ANNEX E SALES OF LUMINAIRES

Table 0-3 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

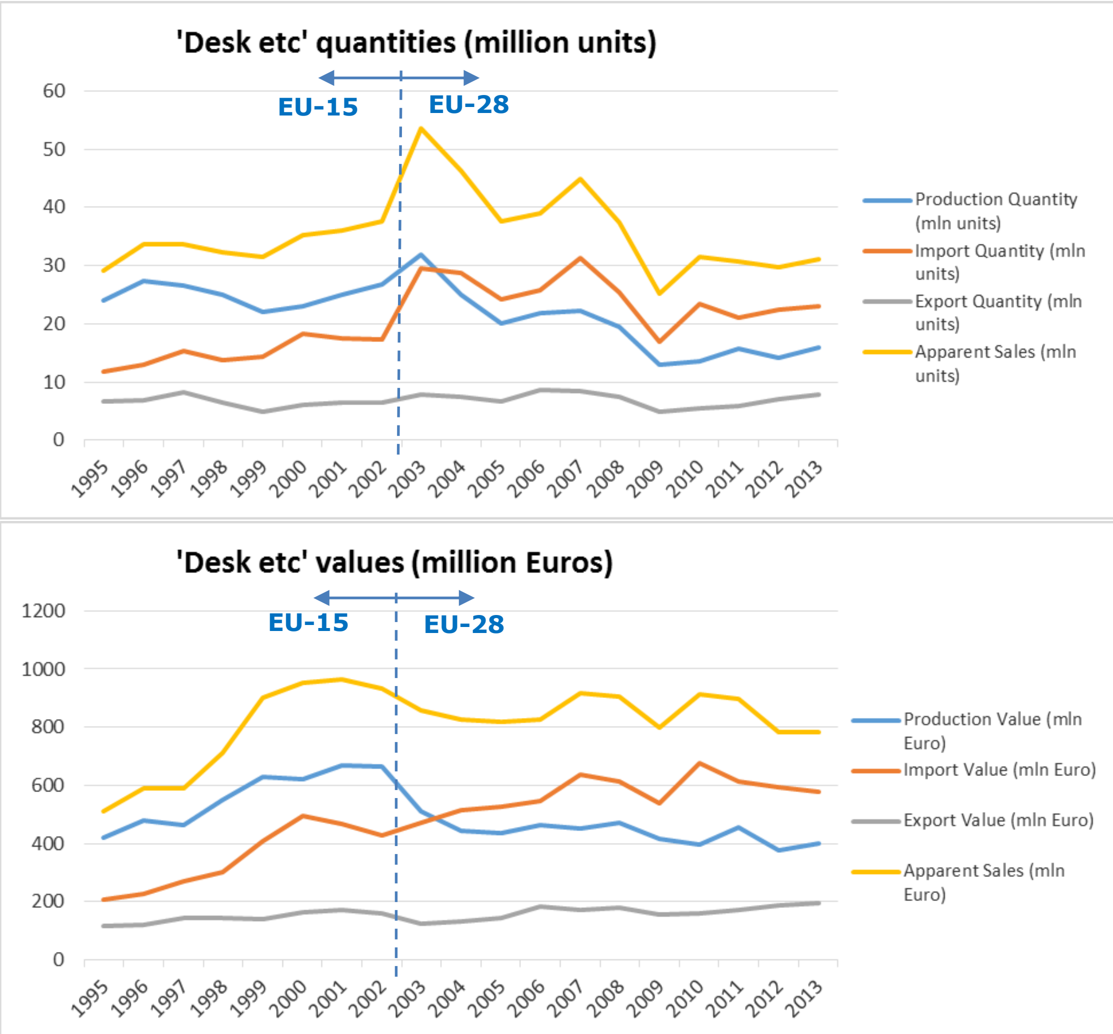


Figure 0-9: Eurostat EU-15 data 1995-2002 and EU-28 data 2003-2013 for Electric table, desk, bedside or floor-standing lamps. Top: quantities; bottom: monetary value.

Table 0-4 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

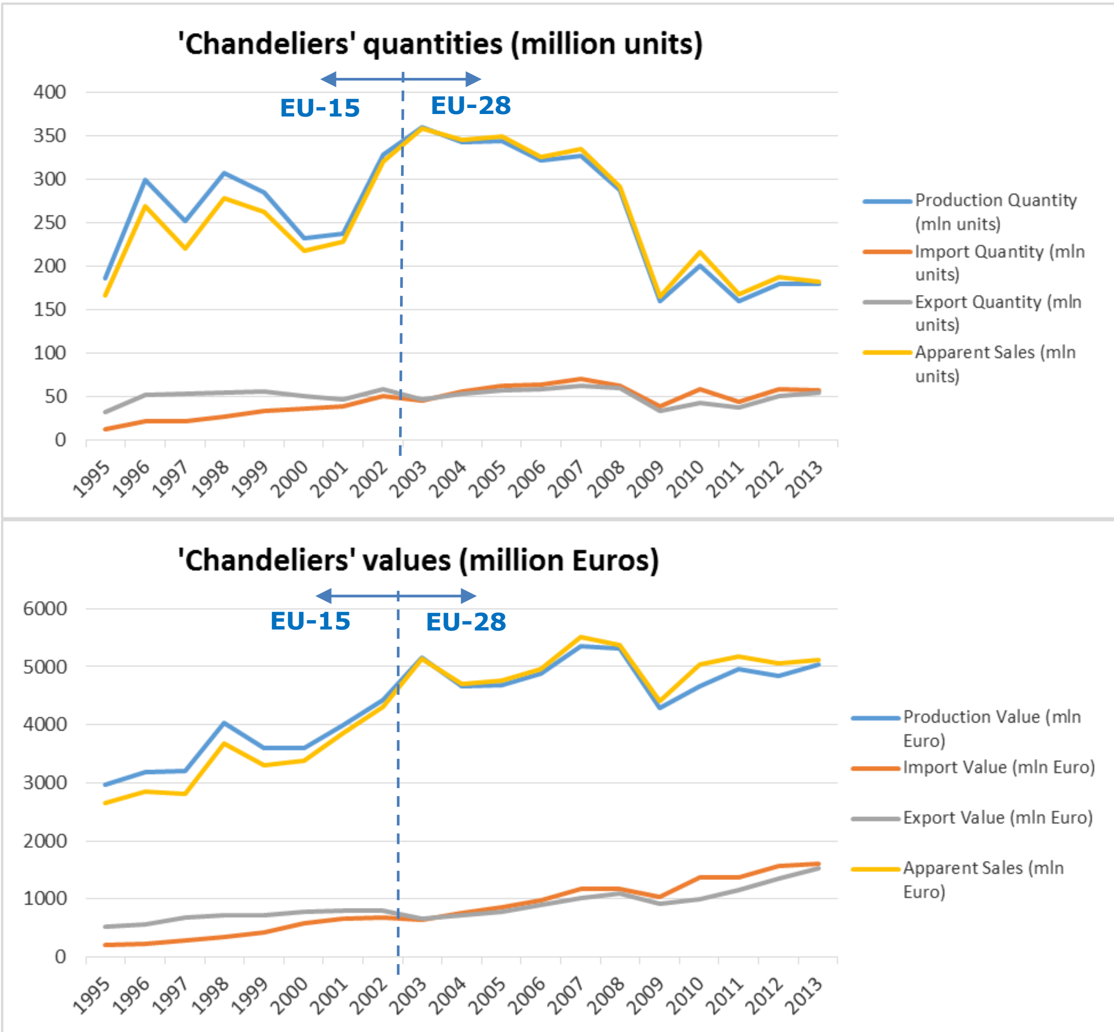


Figure 0-10: Eurostat EU-15 data 1995-2002 and EU-28 data 2003-2013 for Chandeliers and other electric ceiling or wall lighting fittings (excluding those used for lighting public open spaces or thoroughfares). Top: quantities; bottom: monetary value.

Table 0-5 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

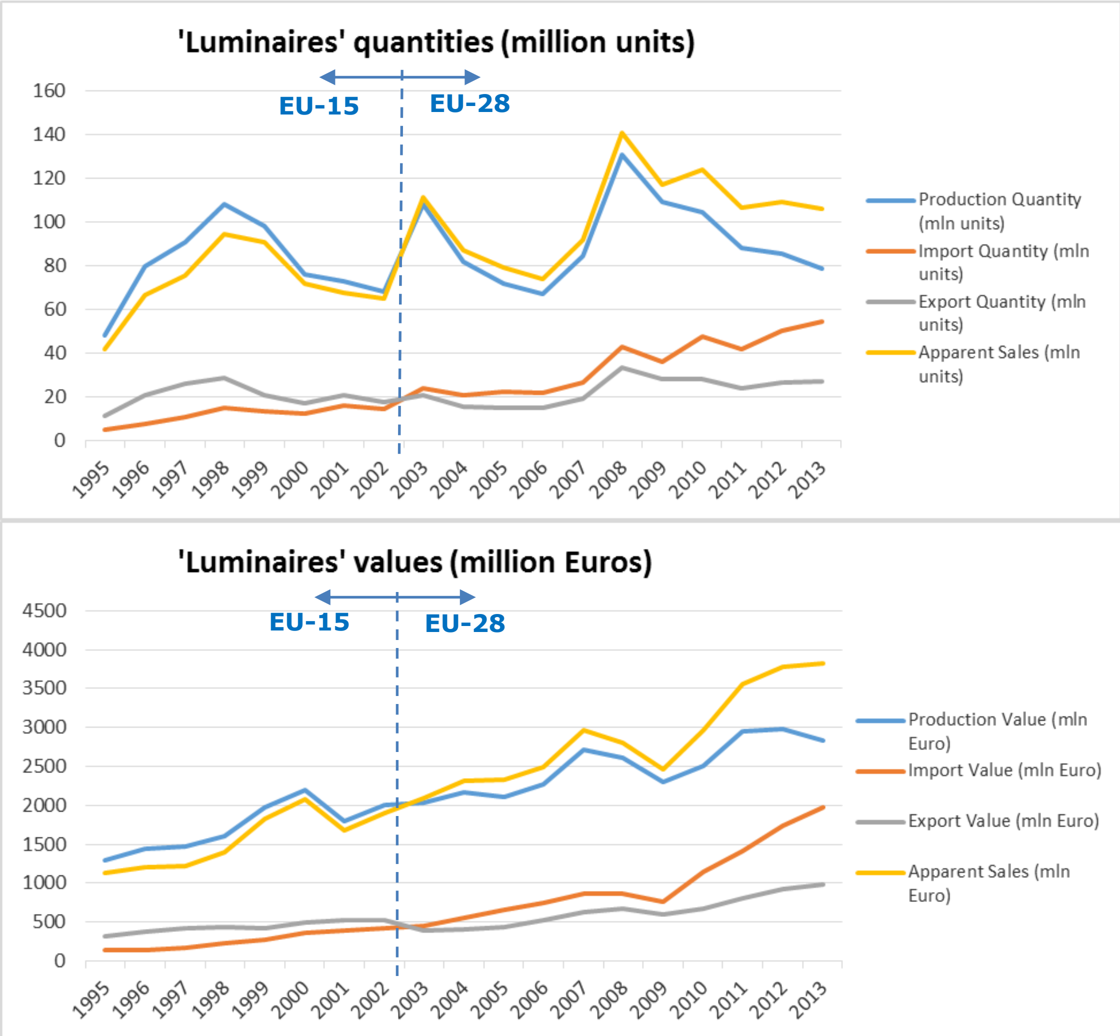


Figure 0-11: Eurostat EU-15 data 1995-2002 and EU-28 data 2003-2013 for Electric lamps and lighting fittings, of plastic and other materials, of a kind used for filament lamps and tubular fluorescent lamps. Top: quantities; bottom: monetary value.

ANNEX F NON-RESIDENTIAL BUILDINGS AND ROOMS

The data in this Annex were developed at an early stage of the study and are not final data. They might not correspond with data developed in later tasks, which should be preferred.
The only purpose of the analysis in this Annex was to verify if the subdivision of the total EU-28 non-residential building area over the various room/space/activity types is compatible with data from the MELISA model.

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 2).
- 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 3).
- Determination of the corresponding total installed lighting power, by multiplication of the total required lux with the Pjlx (W/m^2/lux) values proposed in EN 15193 (chapter 4).

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

[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.

F2.2 References for required area subdivisions

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 0-6 (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 0-7 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 0-6 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 0-7 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 Corridor (dimmed) Hotel room Dining hall/cafeteria Kitchen Conference room Kitchen/storage	0,00 0,40 0,60 0,00 0,00 0,40 0,50
Wholesale and retail service	0,00	**Wholesale and retail service**	Sales area Store room Store room, cold stores	0,00 0,20 0,60
		Other areas	Waiting areas Stairs (dimmed) Theatrical stage and auditorium Congress hall/Exhibition hall museum/ Exhibition hall Library/Reading area Library /Archive Sports hall Car parks office - Private Car parks - Public	0,00 0,20 0,00 0,50 0,00 0,00 0,90 0,30 0,95 0,80

F2.3 Subdivision of building areas

It would be ideal to subdivide the total building areas from the source document (par. 2.1) according to the building and room types of Table 0-6 and Table 0-7. In that case required illumination levels and absence factors would be readily available. The information from the source document does not always allow such a subdivision, but an attempt has been made to get as close as possible.

Table 0-8 shows the derived detailed subdivision of the total EU-28 Non-Residential Building Area over the various building types and room types.

Table 0-9 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 0-10 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 0-8 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 0-9 Summary of areas (M m²) per building type and comparison with data used in Task 0, table 1-2)

	EU-27 area M m²		Share % of total	
sector	Task 0	Current analysis	Task 0	Current 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 0-10 Summary of non-residential building areas (M m²) per room type

Subdivision per type of space in Non-Residential buildings	EU-28 area M m²	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%
Waiting areas	179	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
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 0-11 (full list), Table 0-12 (summary per building type/sector) and Table 0-13 (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 0-11 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			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 %							
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 0-12 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									
	% 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
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 0-13 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**

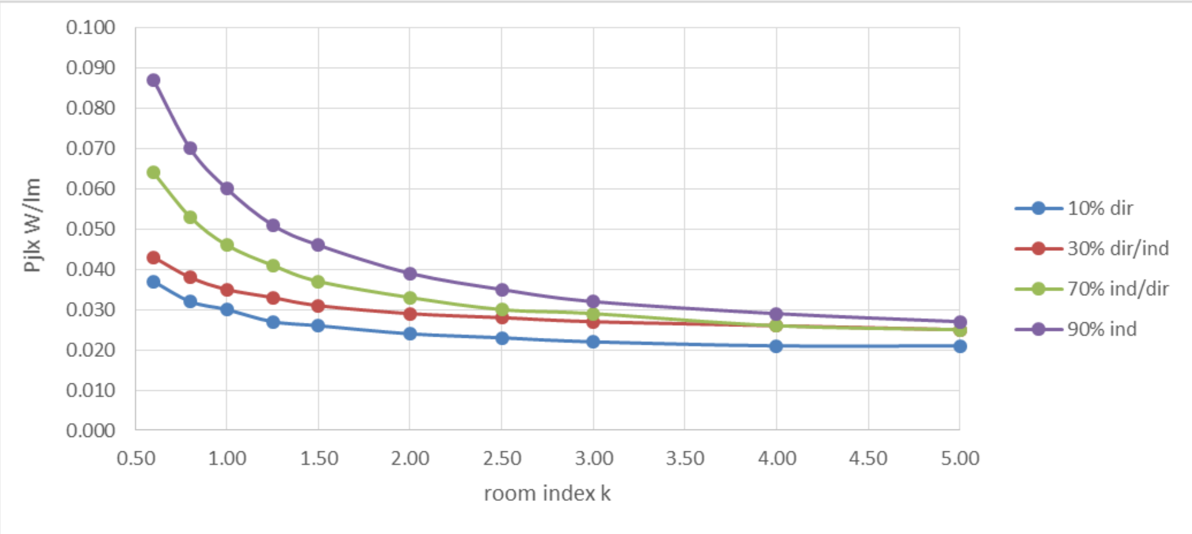
F4 Determination of Installed Power

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 0-14 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 0-16. 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:

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

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 0-15. 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 0-16 (full list), Table 0-17 (summary per building type) and Table 0-18 (summary per room/activity type).

Table 0-15 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 0-15, 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 0-16 Room indexes, Upward flux fractions and estimated Power densities Pjlx ($W/m^2/lux$) according to prEN 15193 table C.1. Last columns show the estimate for the EU-28 installed total lighting power and its density per m^2. (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										
	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)
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										
	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)
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 0-17 Estimate of installed lighting power for non-residential buildings based on building areas, lighting requirements at task level, and Power densities Pjlx (W/m^2/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 m^2. (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 0-18 Estimate of installed lighting power for <u>non-residential rooms/zones</u> based on building areas, lighting requirements at task level, and Power densities Pjlx (W/m^2/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%**

ANNEX G STAKEHOLDER REGISTRATIONS ON THE PROJECT WEBSITE

List of stakeholders that registered on the project website 'http://ecodesign-lightingsystems.eu/' and that agreed that agreed that company/organisation name, my surname and relevant sector is included in the list of stakeholders as presented on this website.

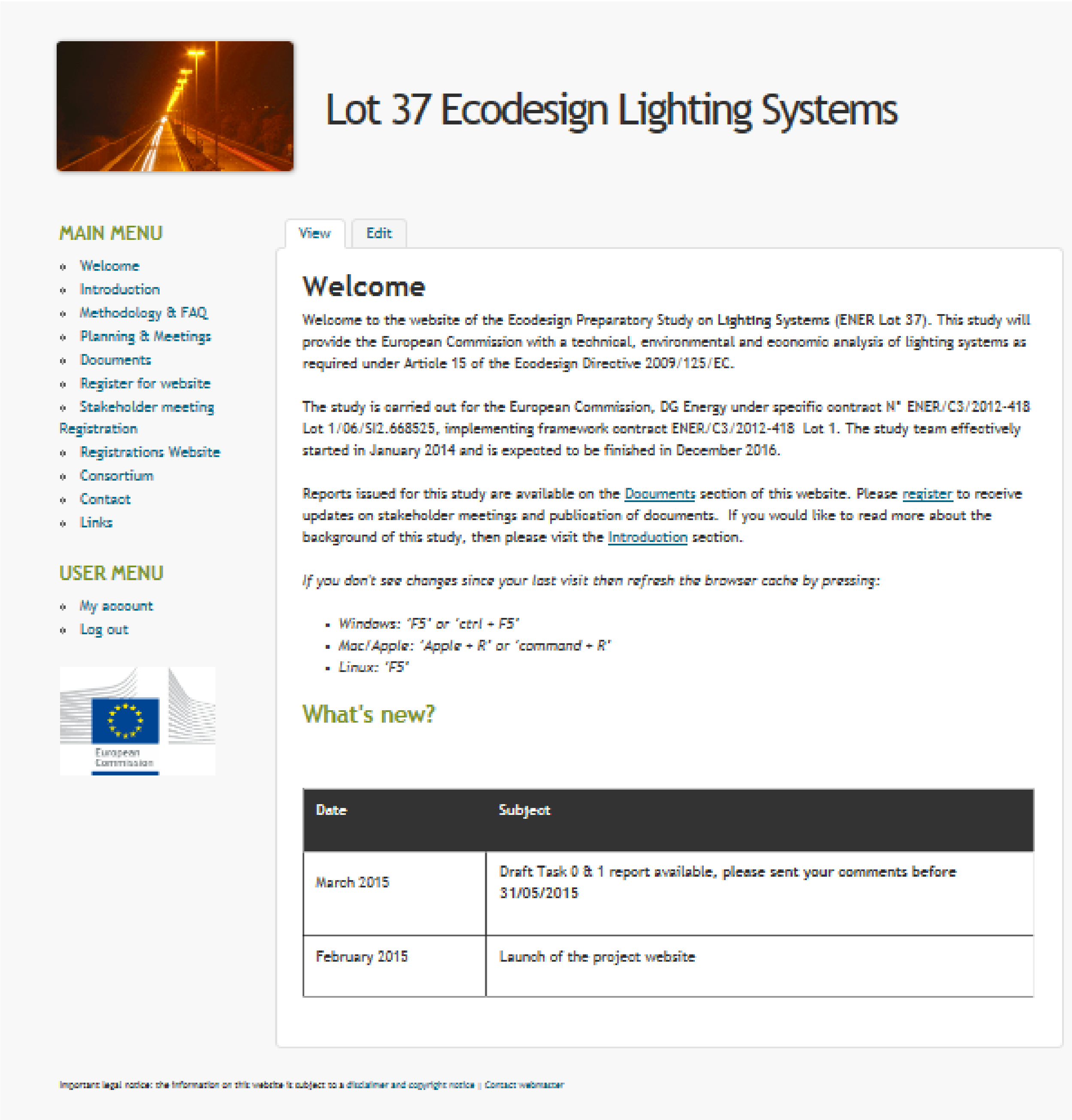
Company / organisation name	Relevant sector		First Name	Surname
ABB Oy	EU manufacturer		Jussi	Aarnivuo
ÅF Lighting / Representing DEA	Other	Mr	Anders Peder	Øbro
Agoria	EU manufacturer		Tim	Hamers
Agoria	Other		Marc	Cumps
AMIRAS C&L IMPEX SRL	EU manufacturer	Mr.	IOAN	DRANGA
ANEC/BEUC	Other		Angeliki	Malizou
ANPCEN	Environmental NGO	Dr	Nicolas	BESSOLAZ
Ballarat Consulting	Consultant		Fiona	Brocklehurst
BAM Federal Institute for Materials Research and Testing	Public official	Dr.	Andrea	Harrer
BEAMA	Other	Mr	Raj	Vagdia
Belgian Administration Environmental Product Policy	Public official	Mr	Bram	Soenen
CLASP	Environmental NGO		Marie	Baton
CLASP	Environmental NGO		Michael	Scholand
CMS	Other		Olivia	Jamison
Compliance and Risks	Other	Ms	Michelle	Walsh
Dark-Sky Slovenia	Environmental NGO	Mr.	Andrej	Mohar

Dept Of Energy and Climate Change	Public official	Mr	Mike	Rimmer
Elektroforeningen (EFO)	Other	Mr.	Per Oyvind	Voie
enea	Researcher		simone tta	fumagalli
Energy Authority, Finland	Public official		Kaisa-Reeta	Koskinen
Energy piano	Consultant	Director	Casper	Kofod
Ensto Oy	EU manufacturer		Maria	Penttilä
ERA Technology Ltd	Consultant	Dr	Chris	Robertson
ETAP Lighting	EU manufacturer	Ing.	Rob	Embrechts
EU Issue Tracker	Other		Dario	Annoscia
EU Issue Tracker	Consultant	Ms	Delia	Harabula
EU Issue Tracker	Consultant	Mr.	Danilo	Gattullo
eu.bac	EU manufacturer	MSc Eng	Andrei	Litiu
European Environmental Citizens Organisation for Standardisation (ECOS)	Environmenta l NGO		Chloe	Fayole
Federal Environment agency	Public official	Dr.	Ines	Oehme
fps Economy	Public official	Mrs	Catheri ne	Grimonpo nt
GE Lighting	EU manufacturer		Gyongy ver	Jakab
German Energy Agency	Consultant	Dr.	Karsten	Lindloff
GIL SYNDICAT DU LUMINAIRE	Public official	Monsieur	JEAN MARIE	CROUE
Hellmann Process Management	Consultant		Jan	Jankord
Helvar Oy Ab	EU manufacturer	Mr.	Markku	Norhio
ICF	Consultant	Mr	Mark	Allington
ICF International	Consultant	Mr	Bizhan	Zhumagali
ICF International	Consultant	Miss	Laura	Pereira
Insta Elektro GmbH	EU manufacturer		Stepha n	Lüling
International Association of Lighting	Other	Mr	Nicolas	Fuentes

Designers (IALD)				Colomer
Intertek	Consultant		Gary	Yu
Intertek Semko AB	Other	Mr.	Mikael	Pettersson
JRC-IPTS	Researcher		Hans	Moons
Kirsti Hind Fagerlund	Public official	Ms	Kirsti Hind	Fagerlund
Korea Testing Certification	Public official	Dr.	JM	Kang
LEGRAND	EU manufacturer	Mrs	Nathalie	Coursiere
LIA	Other		Lawrence	Barling
Licht und Natur e.V.	Environmental NGO	Herr	Harald	Bardenhagen
LightingEurope	EU manufacturer		Diederik	de Stoppelaar
Lysultur/The Norwegian light and lighting association.	Other	Mr.	Kenneth	Hansen
M Frantzell konsult	Consultant		Magnus	Frantzell
Merten	EU manufacturer		Juergen	Kuhnert
NIKO	EU manufacturer	Mr	Rony	Haentjens
NIKO / CECAPI	EU manufacturer	Mr	Rony	Haentjens
Norwegian Water Resources and Energy Directorate	Public official	Ms	Kirsti Hind	Fagerlund
Norwegian Water Resources and Energy Directorate	Public official	Mr.	Bernt	Saugen
Oekopol GmbH	Consultant		Lisa	Roedig
Ökopol	Consultant		Laura	Spengler
Ökopol GmbH	Consultant		Lisa	Rödig
Orgalime	Other	Mr.	Lars	Koch
Philips Lighting	EU manufacturer		Oscar	Deurloo
Philips Lighting / LightingEurope	EU manufacturer	Mr.	Kay	Rauwerdink
Power Integrations	EU		Richard	Fassler

	manufacturer			
Projection.eu	EU manufacturer	Mr.	Thoma s	Van Brantege m
Schneider Electric	EU manufacturer	Ms	Nadine	Bravais
Schneider Electric	EU manufacturer	Dr	Frederi c	VAILLANT
SCHNEIDER-ELECTRIC	EU manufacturer		Philipp e	CARPENTI ER
SEK	Other		Nina	Mylly
SEVEn, The Energy Efficiency Center	Consultant		Michal	Stasa
Siemens	EU manufacturer	Mrs	Bonnie	Brook
SIMON	EU manufacturer		Xavier	Montfort
Society of Light and Lighting	Other	Mr	Brenda n	Keely
Sony	EU manufacturer	Mr.	Lars	Koch
State Office of Legal Metrology of Hessen (Germany)	Public official		Holger	Dickert
SVENSK LJUSFAKTA	Consultant	Lighting Designer	Tommy	Govén
Swedish Energy Agency	Public official		Peter	Bennich
Swiss Federal Office of Energy	Other		Markus	Bleuer
The Netherlands Enterprise Agency	Public official		Hans-Paul	Siderius
Topten	Environmenta l NGO		Eva	Geilinger
Topten	Environmenta l NGO	Mr	Francis co	ZULOAGA
Umweltbundesamt	Public official		Andrea s	Halatsch
Umweltbundesamt (UBA)	Other		Christo ph	Mordziol

ANNEX H IMAGE OF THE MAIN SCREEN OF THE PROJECT WEBSITE



ANNEX I 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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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 ηsystem 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 η_{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 different luminaires, A, B and C. Therefore the systems provide different Average Illuminance and use different System Power.

ÅF - HANSEN & HENNEBERG

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.

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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	ηsystem [lm/W]	B = C better than A

As seen from the three examples only the parameter Lighting System Efficacy, ηsystem 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.

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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)!

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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.

Reaction:
This valuable input has been used for the updated report.

Lighting System Efficiency
ÅF - HANSEN & HENNEBERG\..\Combined

Rev. 0, 24.8.2015

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 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.

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
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 Figures have been updated towards efficacy ofsystem
1	1.3.3.1	11 and 12	The relevant primary parameter is: **"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 stand-**	1. It should be explained that the topic actually is only relevant for 'tertiary lighting systems' where lighting requirements apply. 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. 3. Anyhow the parameter definition and the parameter specifications below the "No-	For 'tertiary' lighting systems designed to meet lighting requirements, the relevant primary parameter is: **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** Notes: The functional unit as [useful lm per W] is: $\sum_{i=1}^{n}(\bar{E}_{i,min}\cdot A_i)/P$	Agreed to clearly define 'the minimum maintained illuminance' as reference (added) Agreed to delete LENI from the notes.

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
			ards Notes: · 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). · For an area where luminance is used instead of illuminance, the following conversion formula is used: · E = L/Q0	tes:" 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. 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. We recommend LENI is left out and is replaced by an explanation.	where $\bar{E}_{i,min}$ is the minimum required average illuminance A_i is the sub-area to which the minimum required average illuminance applies P is the system power of the lighting installation used to light the relevant areas In case of street lighting for an area where luminance is used instead of illuminance, the following conversion formula is appropiate: · $E_{i,min} = L_{i,min}/0,07$ where $L_{i,min}$ is the required minimum average luminance [cd/m²] (Annex B of FprEN 13201-5) For indoor lighting systems the 'Lighting Energy Numer-	

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			where, E is the average illuminance L is the average luminance specified in cd/m² Q0 is the average luminance coefficient (e.g. 0.07 for asphalt)"	5. The conversion of luminance to illuminance should be done in accordance with FprEN 13201-5:2015 Annex B: · E = L/0,07	ical Indicator' (LENI) (kWh/m² per year) (EN 15193).is used as an lighting energy consumption parameter which 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.	1. The following secondary parameters should be added: ▪ **Correction and conversion factor for over lighting and for luminance or hemispherical illuminance based lighting designs C_L** ratio of the luminous flux just sufficient to comply with the lighting requirements received by the reference surface to the (actual) luminous	OK Parameters added Formulas will be updated in line with the reviewed figures and approach

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				Therefore we recommend: 1. To introduce a couple of new parameters: 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. 2. The equations **Functional unit [useful lm/W]** (at the bottom of page 15) is corrected and named "Lighting System Efficacy". For street lighting this is identical to the Installation Luminous Efficacy.	flux received by the reference surface. The luminous flux sufficient to comply with the lighting requirements is: $\bar{E}_{min} * A$ where $\bar{E}_{min}$ is the required minimum average illuminance. For road lighting requirements based on luminance: $\bar{E}_{min} = \bar{L}_{min}/0,07$ For requirements based on hemispherical illuminance: $\bar{E}_{min} = \bar{E}_{hs}/0,65$ ▪ **Useful Utilance U_U** 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 of the luminaires of the installation. The following relation apply:	

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
					$U_U = C_L * U$ 2. Corrected formulas: **The formulas to calculate the functional unit from the secondary lighting system performance parameters (see also Figure 1-1) is:** **Functional unit [useful lm/W] = C_L *U *RSMF* LOR * LMF * η_{lamp} * LLMF * η_{gear} * BGF** Or in the case of an LED luminaire (LOR=1, LMF includes LLMF, η_{ls} * η_{power} = $\eta_{Luminaire}$ and U_U may be known directly): **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 2. The last part "In Annex A on Energy efficiency bench-	1. The text should be based on the standard version, FprEN 13201-5:2015 or later. 2. Please delete the last part starting with: "In Annex A on	Text updated based on the latest version and your input Note: Might need to be updated again when the final is available.

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				marking calculations reference designs are included …" is not appropriate and should be deleted. 3. The standard has a major gap that should be described. For information: Denmark has voted against this standard.	Energy efficiency benchmarking calculations reference designs …" including the Figure 1-12 3. Please describe the major gaps as: Potential gaps in EN 13201-5: The mandatory Annex A of the standard is not appropriate. Neither the PDI or the AECI (ECIy) are real benchmark parameters for efficiency because: PDI does not account for over 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 subareas. Areas of strips for calculation of the edge illuminance ratio are excluded from the calculation of energy performance indicators although	

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Task #	Sec-tion #	Page #	Topic	Comment	Proposed change	Reply study team
					requirements apply to these strips so they should be included. Only the informative annexes B and C are appropriate. 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. It is being developed under the Commission mandate M/485 including a preparatory study 2014-2015. 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** This standard is being developed under the Commission mandate M/485 including also a preparatory study 2014-2015. The standard facilitates	Standard added Functional unit of the study updated in line with the remarks

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Task #	Sec-tion #	Page #	Topic	Comment	Proposed change	Reply study team
					a requirement for product information in the Commission Regulation 245/2009 ANNEX VII (on Street Lighting), 3. LUMINAIRE BENCHMARKS, clause 3.2: "(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)… " 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)*	

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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 #	Sec-tion #	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 Mention the link as a "func-	Not sure understand the suggested change. Please propose specific text and exactly where it should be added.

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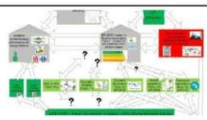
Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
					tion" Most important functional link: BACS determines the use patterns of rooms / zones in buildings – which includes lighting as well.	
1	1.3.1 Figure 1-3	4	Clarification of open questions		Arrows with question marks: (from left to right) - Scheduling, demand and presence functions - Presence detection - Constant light control applications (e.g. together with blinds) o Blinds follow thermal / glare strategy o Light level follows above strategy Add these methods / functions in the context and remove the question marks.	Figure updated taking this comment into account
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	Agree that the EE functions in EN 15232:2012 (and in the M/480-version) will need to be updated with available	Eu.bac comment is included in the revised text to encourage participation

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				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. 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. 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 pres-	technologies and code of practices. Need for update of EN15232 in terms of Light Controls after current work in progress updates.	

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				ence detection in the building (access control) or level of occupancy (number of people in the room; CCTV, people counting e.g. in public buildings, museum, stations) - Easy of reprogramming for the building user to change occupancy modes, avoid fixed programming on a bus - Coupling of shade control with light control like in France - the number of new control technologies available at light point (knx, weblights, PoE) to be considered - 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	Modify in the title of the table: building automated and control systems to building automation and control sys-	The proposed edit has been done. The reason to include BACS within this table is that they are also one of the LS

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				application of efficient light equipment, efficient LS and efficient BACS light control functions (under the base of EN 15232) in new and existing buildings	tems. Both light equipment and BACS norms and efficiency standards need to be integrated in EPBD	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. 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

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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 text updated and also Similar comments from Lighting Europe are taken into account

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. 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	

				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: ***4 Lighting design criteria*** ***4.1 Luminous environment*** *For good lighting practice it is essential that as well as the required illuminances, additional qualitative and quantitative needs are satisfied.*	We would propose including the full design criteria from EN 12464-1:2011 for clarity of intent . These standards also deal with health care related issues: ANSI/IESNA RP-29-06: Lighting for Hospital and Health Care Facilities And CIBSE Lighting Guide 2: Hospitals and healthcare buildings	

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

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				the intrinsic task properties (size, shape, position, colour and reflectance properties of detail and background), *ophthalmic capacity of the person (visual acuity, depth perception, colour perception), intentional-ly improved and designed luminous environment, glare-free illumination, good colour rendering, high* *contrast markings and optical and tactile guiding systems can improve visibility and sense of direc-tion and locality.* *See CIE Guidelines for Accessibility: Visibility and Lighting Guidelines for Older Persons and Persons with* *Disabilities.* *Attention to these factors can enhance visual performance without the need for higher illuminance.*		
0 & 1	1	5	Excluded systems	We would recommend including light art works and light art installations as excluded.	"For example, lighting sys-tems designed to make themselves visible for pur-poses 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	Applicatio n 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 performan ce parameter s	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 They originated from the previous study but will be updated 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 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(2 007)	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. 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. 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 The optional Fcu0&Fce for flexibility will be included in the study. Also after discussion with other stakeholders: Another option is to suggest this factor for EN 15232(buildi 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 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 Will be further done in later tasks.

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Stakeholder comments form

0 & 1	1. 4. 2	3 3	EN 12464- 1	Potential Gap: All the illuminances recommended are based on recommended reflectances ***4.2.2 Reflectance of surfaces*** *Recommended reflectances for the major interior diffuse surfaces are:* *ceiling: 0,7 to 0,9;* *walls: 0,5 to 0,8;* *floor: 0,2 to 0,4.* *NOTE The reflectance of major objects (like furniture, machinery, etc) should be in the range of 0,2 to 0,7.* 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. In respect of good design practice, reconfigurable spaces should be designed with fixed lighting that meets the		We understand the following: Gap: All illuminances are a result o calculations based on recom 'reflectances f mended (this remark is also added in EN 15193 that refers for method 1 to EN 12464) Other text added

Stakeholder comments form

				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

t e x t . i f t e d

0 & 1	1. 6. 6. 7	7 9	Operation and maintenan ce	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 Detailed calculations are sh 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

Organization: LightingEurope	**Name:** Kay Rauwerdink	**Date:** 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.	
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 Isn't it the final? (contacts Steve) 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
5	<u>prEN 15193-1&2</u> 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 t mandate in Task 1 (study will follow metho

gy

#	Question	Answer	Reply study team

		contain worked examples and benchmark indicators. 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 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 adde (despite this the study will attempt to harmoni much as possible)
7	prEN 15193-1&2 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. 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. The new standard will also permit the use of National default values for which templates for the data will be given in Annex A. The standard will not have LENI target values but the TR will give examples. 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. 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 annex part 2 Noted also UK has targets

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#	Question	Answer	Reply study team
8	EN 12464 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 verification procedu be added in EN 12 revision (is a gap) Will be communicat Peter Dehoff
9	EN 15193 We are looking for reference design calculations according to EN 15193, more specific (input from manufacturers is welcome): If possible, identical to the CIE 171 test cases? (to verify if this make sense). 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.: 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) 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) 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. 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. 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 (scheme = define tas surrounding area?) We started our own calculations on selec cases based on the standards 10 / 11

#	Question	Answer	Reply study team
10	EN 13201 We are looking for reference design calculations according to EN 13201, more specific (input from manufacturers is welcome): 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; Type A.5 class P4 (table A5) which is close to category slow traffic in previous lot 9 Type A.4 class M3 (table A4) which is close to category mixed traffic in previous lot 9 Type A.8 class M2 (table A8) which is close to category fast traffic in previous lot 9 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. 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 13 We follow the provided of "/13201 of interest is Annex B installation luminous eff with its decomposition i subsystems. Herein correction factor unclear, does this also illumination classes (P, The issue is (& comme DEA(DK)) to correct for Erequired/Einstalled?

ANNEX J STAKEHOLDER COMMENTS RECEIVED ON SECOND DRAFT TASK 0-4 (2016)

Stakeholder comments form

DG ENER Lot 37: Ecodesign Preparatory Study on Lighting Systems

Organization:	Name:	Date:
CECAPI	Rony Haentjens	15-02-2016

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
0	3	20	Lighting communicatio n network	In most cases this lighting communication network is not a stand-alone system but is part of a building system	Add A lighting communication network can be part of a building communication system (HBES/BACS)	Ok, added
1	*3.*	35	Movement dependent lighting control: uses a sensor to switch the luminaire on or off depending on whether any people are present in the room	There is a difference between a presence and a movement detector	Replace the title by Occupancy dependent lighting control	OK, changed
		37	Combined systems	General remark	Throughout this report use occupancy sensors instead of movement sensors	OK,changed
		37		To be complete	Add Daylight and movement sensors can be combined in one system and the function can be combined in the same sensor	Ok, added
		37		**Dynamic lighting** Dali is only one possibility	Replace (Dali) by (e.g. Dali, RF)	OK, replaced

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
		37		Building management system The definition of building management systems is much broader than the lighting application level	Use the complete definition from EN 15232 or change he title to lighting management system **building management system BMS** products, software, and engineering services for automatic controls (including interlocks), monitoring and optimization, human intervention, and management to achieve energy-efficient, economical, and safe operation of building services equipment	Ok, definition EN 15232 added
			1.3.2.5	Lighting control communication systems This system can be part of the building management system such as KNX, LON BACNET Proprietary solutions In addition it is advised to look at the availability of LEDOTRON as a technology . According to CECAPI this technology is no longer supported by the light industry.	Add a subclause giving examples of building management systems KNX (EN 50090 series) LON BACNET	Ok, added

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
		65	***Safety and EMC standards***	The safety and EMC standards are not listed	Add a bullet point at the end of 15232 The safety and EMC requirements are given in the EN 50491 series	A full list of standards will be included in the annex (will be updated taking this into account)
3			***Residential buildings***	Chapter 3 does not address residential buildings The scope of this work should be made very clear. If residential is not part of this study, then the references to the residential technologies such as phase cut dimming , LEDOTRON , etc should be deleted If the lighting systems study also deals with residential environments, then chapter 3 should be completed especially to address the compatibility issues between control devices and lighting products as these issues are not going to be taken over in the single lighting regulation.	Complete chapter 3 on residential, or address compatibility requirements in the single lighting study.	Should be solved in standards, but we can mention compatibility issues
4			***Main objective***	The main objective of this study should be to give recommendations on how to increase the number of buildings that comprise lighting building management systems in order to achieve the energy saving goals. This is not covered.	This part is focussing primarily on large building and very sophisticated lighting systems, and CECAPI believes that more simple systems should be investigated in small and medium sized buildings with utilisation of schedulers and occupancy detection devices.	Could discuss this in Task 3 on barriers?

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
An ne x	A			The LVD and EMC standards for building management systems are missing	Add EN 50491-3 Safety EN 50491-5 series EMC	OK, to add

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DG ENER Lot 37: Ecodesign Preparatory Study on Lighting Systems

Organization: eu.bac – European Building Automation and Controls Association	Name: Andrei Litiu	Date: 7 March 2016 (wave 1)

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
1 & 0	0.3 + 1.3.1	19 + 28	Smart lighting systems	The term 'smart lighting system' might be misleading considering the ongoing work on Ecodesign Lot 33 Smart Appliances prep study	It could be useful to clarify what is exactly meant by smart lighting systems.	Changed to 'lighting control system ..
1 & 0	3	20	Lighting communication network	In most cases this lighting communication network is not a stand-alone system but is part of a BACS.	Add A lighting communication network is in most cases part of a building communication system (BACS).	Text added
1 & 0	1.3.1	30	Figure 1-3	Arrow with question mark from EN 15232 to "user comfort"	This question mark can be removed. EN 15232 contains a desired occupancy schedule of zones / rooms that directly leads to desired user comfort.	Updated
1 & 0	1.3.2.3.1	35	Movement dependent lighting control	There is a difference between a presence and a movement detector.	Replace the title by occupancy dependent lighting control → this should be applied with consistency throughout the report (e.g. page 19 Movement/presence detection sensor)	OK, updated
1 & 0	1.3.2.3.1	37	Building management system	The text could be misleading by only looking at the lighting component of the BMS.	Make reference to EN 15232 and recall the definition of BMS from there.	Text updated, see CECAPI input
3	Overall	Overall	Residential buildings	Chapter 3 does not address residential buildings.	This should be explained since the occupancy pattern is significantly different (residential stochastic).	See rationale in Task 1 for not addressing residential

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
3	3.5.1	210	1st paragraph - the inclusion of space users / time requirements	Reference to EN 15232 for the design process.	Add reference next to EN 15193 for the case in which BACS is part of the design.	Added When Building Automation Control Systems(BACS) are involved users can also rely on standard EN 15193 for further building system integration
3	3.5.6	214	User acceptance issue / dissatisfaction	It would be beneficial mentioning that in the entire construction process a number of changes usually occur which means that there is a tendency of changes in requirements / use patterns from inception, design, installation, commissioning and operation.	This is – together with the unknown operational concept – one of the significant reasons for frustration of the "users". Please consider "change management and flexibility of operation in design procedures". Include the fact that energy related occupant behaviour in buildings, for example adjusting thermostat for comfort, switching lights, opening/closing windows, pulling up/down window blinds, and moving between spaces, is a key issue for building design optimization, energy diagnosis, performance evaluation, and building energy simulation due to its significant impact on real energy use and indoor environmental quality in buildings. However the influence of occupant behaviour is under-recognized or over-simplified in the design, construction, operation, and retrofit of buildings. Occupant behaviour is complex, stochastic and multi-disciplinary. For more details check the ongoing http://annex66.org/. The use of control systems mitigate the impact of occupant impact.	Indeed A section 'BACS and opportunity for change management and flexibility of operation in design procedures' should be added.

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DG ENER Lot 6 (37): Ecodesign Preparatory Study on Lighting Systems

Draft report of Tasks 0-4 of 10 February 2016

Organization: : Danish Energy Agency, DEA (represented by ÅF Lighting)	Name: Peder Øbro	Date: 02-03--2016

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
General			Figures 1-1, 1-2, 1-3, 3-6 and 3-10 and text on coloured background .	Generally the background coloures are too saturated so the text is difficult to read. This is specially the case when printed on paper.	Make background colours less saturated.	OK, for update
1 and 3			Unreadable text on figures 1-1, 3-6 and 3-10	The text on coloured background is very small and blurred and the saturated colours makes the contrast poor. These texts are almost unreadable both on screen and on paper.	The background colours should be less saturated and the graphics text should be in a vector format instead of a picture, pixel format. The texts on figures 1-2, 1-3 are in vector format making it possible to read the small text on screen after some enlargement and through a magnifier lens on paper, however, the contrast is still poor.	OK, for update
1	1.3 and 1.3.1 Last paragrap h	32	"Are installed lighting systems in buildings or in road lighting products covered in the meaning of the Ecodesign of Energy Related Products Directive (2009/125/EC)?"	The discussion regarding which Directives scope will be best suited for a regulation on lighting systems is important. The DEA will follow this discussion closely.		noted
1	1.3.1	29	*Figure 1-2*	In the large green rectangle reference to EN 13201-6 about PDI and AECI is wrong.	Correct EN 13201-6 to EN 13201-5	OK corrected

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
2	2. - 2.1.2.2	131 - 138	Mentio of Task 5 and 6	Several references to Task 5 and 6, however according to the Project Plan there will be no Task 5 or 6. See Planning & Meetings at http://ecodesign-lightingsystems.eu/planning	Please explain and make alignment.	Agreed to add more guidance on this in the next upgrade Note explaining this is added in the objectives of Task 2
3	3.2.3.4	202	The use of the Lot 9 study	The Lot 9 study was based on 3 road categories Fast, Mixed and Slow. The 3 categories are reused, but now named by the lighting class names M-, C-, and P- of the recent EN 13201-2. This indicates a uniform use of lighting classes throughout the Member States which is not the case.	Insert a note explaining: Differences in the application of lighting classes and reflection tables are found between the member states. Such as C-classes , P-classes or HS-classes used for bicycle and foot ways along motorized roads, HS-classes used for residential roads. N- or C-reflection tables used for luminance calculations.	Agreed to add more info in the next version. (new draft is now available)
4	4.3	233	Discussion of the results for indoor lighting:	The study identifies lacks/gaps in the standards for efficiency of lighting systems (EN 15193 and EN 13201-5) and mends it with supplementary factors included in this study such as "eE (eff. For fitting to minimum requirements)" and the installation efficacy, **η_{inst}** These parameters are indeed useful as they reveal over-lighting.	The study should call for more stringency in the standards(EN 15193 and EN 13201-5) specially concerning energy consumption parameters, efficiency parameters and expenditure factors based on the methods from the study.	noted.
4	4.3	234	Table 4-1 "BATfit", η_{inst}	For the column "BATfit" the useful installation efficacy, ": η_{inst} is not correct. Going from "BATref" to "BATfit" the amount of luminaires is corrected from 3 to 2,44 to fit the lighting requirement. The required useful luminous flux is unchanged, but the power is reduced with a factor of 2,44/3 = 0,813. The useful installation efficacy η_{inst} should be increased by division with the same factor "BATfit": η_{inst} = 88,75/0,813 = 109,16 lm/W	Correct η_{inst} for "BATfit"	Indeed, this needs to be verified and updated

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	4.3	234	Table 4-1 "BATarea"	For the column "BATarea" the useful installation efficacy, η_{inst} = 88,75 is shown as the same as found for "BATref". This is due to the fact that the requirement for illuminance is changed downwards for some of the area. Apparently it has been assumed that both the required useful luminous flux and the power is changed downwards by the same factor, so the ηinst remains the same as in "BATref". The "BATarea" illustrates that a unique relation between η_{inst} and the power consumption only exists for equal requirements and target areas. The LENI serves for showing the actual energy consumption and for comparing unequal requirements and target areas.	The column "BATarea" should be marked with a note on the above making it clear that "BATarea" is based on reduced reruirements for a part of the area.	Indeed, also here should be verified and updated.
4	4.3	234	Table 4-1 eE (eff. For fitting to minimum requirements)	A clear definition of eE is missing. The DEA finds it appropriate that the definition is: The parameter eE is understood as 1/FCL, the reciprocial of the correction factor for over lighting, i.e. for fitting to minimum requirements. Thus eE may be understood ad an additional expenditure factor which is missing in prEN 15193-1:2014. However, in the column "BATdesign01" eE is below 1 (0,91). It is not clear why this is possible(assuming the above, this should not be possible)	Please define and explain the parameter eE and how it can be below unity. (Higher reflectance?)	= E,m(software)/E,m(min. req.) = 1/FCL > .. the value below 1 was for a design that did not fulfill the standard average. Bu agreed that for this reason this design should be replaced.
4	4.3	235	Table 4-2	Explanations for the cases in column "BATcase01" and "BATcase02" are missing. The values of F_{CL} and F_{CLO} seem strange for these columns.	Please explain the cases "BATcase01" and "BATcase02"	Sample designs did not meet the minimum requirements causing the FCL<1. They should be replaced.

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DG ENER Lot 37: Ecodesign Preparatory Study on Lighting Systems

Organization: SLL	Name: Peter Raynham	Date: 19-02-16

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
01	0.3 1.31	pp6 pp3	'Smart' lighting	The buzzword *Smart* is being used but there is no definition of what this means.	Either delete the term or define it	**Note all these and subsequent comments are on an outdated version of the document. The author is informed but had no time to review before the meeting** **Smart = changed to control system**
01	0.3	pp6	Descriptions of system components	I am not sure what the value of this section is and many of the terms are now fairly meaningless. Items such as lamp holders and lamp caps are not used as LEDs are usually integrated into luminaires	Either delete the whole section or only include descriptions of things that are used and their description add value to the document. If there are existing definitions of the terms used in EN 12665 or the EILV (http://eilv.cie.co.at/) these should be used	

Stakeholder comments form

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
01	1.31	pp2	Figure 1-1	This is a very misleading diagram. The principle that it shows that each component in the system has its own set of performance parameters which to some extent are independent of the other factors in the system. The problem that many of the measures break down in practical conditions make the diagram slightly worse than useless. For example the concept that a control system may have a Ballast Gain Factor is totally useless if you are lighting a space without daylight that is continuously occupied	The only proper way to encourage the correct design of energy efficient lighting is by taking a holistic systems approach. Thus the diagram should be replaced by a diagram showing solution optimization starting with a lighting requirement, a list of application factors such as constraints, usage patterns and daylight availability	They are added in Figure 1-3
01	1.31	pp3	Figure 1-2	This has many of the same problems as Figure 1.1 but due to the simpler nature of typical installations the practical problems are not so great	See above	

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
01	1.31	pp4	Figure 1-3	The diagram has a number of problems. It does not quite tie up to the way prEN15193-1 works. Secondly it is a mistake to tie the lighting requirements of EN 12464-1 to the UF method of EN 13032-2. The problem is that EN 12464-1 specifies lighting in terms task illuminance and lighting for the space (Esur, Eb, Ecyl...) thus in any real space uniform lighting is not needed. The UF method of EN 13032-2 only provides information about average illuminance and thus is only really useful when providing uniform light across a whole working plane in a room. This way of lighting would waste a lot of energy and thus it was never included in EN 12464-1	Amend the diagram	More text is added
01	1.3.2 .1	pp6	EN 50172	The reference to this equipment standard is not useful in this section where the document is trying to provide application standard guidance	Either extend the section to cover all product standards (I am aware of over 40 and I am sure there are more) or return the focus to application standards and reference EN 1838	Reference is made to annex
01	1.3.2 .1	pp6	Obtrusive light	The section states EN 12193 give maximum values for obtrusive light. The same is true for EN 12464-2 but this is not mentioned	If the bit about obtrusive light is important add it into the material about EN 12464-2, if not delete the reference	
01	1.3.2 .3.1	pp7	Daylight dependent lighting controls	Last bullet point states: with analogue control of 1-10V or with a DALI-ballast. The text should technology neutral and there are many ways of communicating with dimmable load devices that are not listed in this section	Either delete the bullet point or rewrite it with out reference to a particular technology.	Is updated

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
01	1.3.2 .3.1	pp7	Control systems	Why is there no mention of scene setting?	Add a section of scene setting	OK added
01	1.3.2 .3.1	pp1 2	primary parameter: Notes	The text states that the relevant primary parameter is ... *flux (Φ [lm]) per square meter equal to the required illumination (E [lx])*.. in the notes it then says: *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).* This clearly is nonsense as the units of both all three set of terms are different	Either work out the comparison that the section is trying to make properly or delete the section	Text is updated

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
01	1.3.2 .3.2	pp1 2	The formula to calculate the functional unit from the secondary lighting system performance parameters	The formula provided is the average lumen method which may only be used to calculate the average illuminance across a plane. It can not be used to calculate the illuminance on specific tasks with in a room and thus is of no value in modern lighting design. It certainly can not calculate useful lumens per watt as the whole method ignores the concept of localising the flux to where it is needed. This whole concept is very problematic. Consider a room 6m x 4m x 2.5m. It is a workplace and so it must be designed in accordance with EN 12464-1. The space is an office with two desks. 300 lux is required on the desks which are 1 m^2 each. The area within 0.5 m of the desks must be lit to 200 lx and the rest of the room to 100 lx. The walls must be lit to 75 lx and the ceiling to 50 lx. In addition there must be a cylindrical illuminance of 150 lx across the room at a height 1.2m and probably at 1.6m as well. With this lighting specification how is it possible to come up with a measure of useful luminous flux?	Rethink the concept of useful luminous flux or develop a practical method of calculating it!	Noted Text is updated

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
01	1.4.2	pp2 3 - 26	EN 15193	The final drafts of prEN 15193-1,2 are now available and this section should be updated. In particular the *Identified gaps* section has been dealt with as the CENSE report was used to inform the update of the standard. There is a typo on page 26 where the documents are listed as prEN 15**2**93 and it is assumed that the author is not referring to documents about ethanol used for vehicle fuel. There are good reasons for some of the gaps listed on page 27 • EN 15232 does not provide useful information on lighting control systems and in practice it is rare to integrate lighting controls into other building management systems. • The power to satisfy EN 12464-1 is not a concept that can be easily applied outside of specific conditions, see comment on section 1.3.2.3.2	Rewrite section	CENSE report reference is deleted Typo corrected
01	1.4.2	pp2 6 - 27	EN 15232	EN 15232 does not provide useful information on lighting control systems and in practice it is rare to integrate lighting controls into other building management systems.	Delete section	It is kept for being complete. See also EU.BAC comments

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
01	1.4.2	pp2 7 - 28	EN 13201-5	The standard has now been published	Rewrite section	done
01	1.4.2	pp2 9-30	DIN 18599-4	The tabular method of the DIN standard was studied as part of the development of the new EN 15193 and an improved version of the method was included in the standard as annex C. Thus on publication of EN 15193-1 it will be necessary for DIN 18599-4 to be withdrawn as it will be deemed to be a conflicting standard.	Delete section	noted
01	1.4.2	pp3 1	EN 13032-1	The existing point source model is adequate for most applications and the types of light source listed. This due to the spatially homogenous light distribution and the way that lighting software uses recursive source sub-division	Delete comment	Added: ..However it should be noted that the existing point source model can be adequate for most applications.
01	1.4.2	pp3 1	EN13032-2	The method does not permit the calculation of any meaningful functional unit of light as it only address zones where light is designed to spread uniformly across a plane parallel to the floor of a room	Delete comment	Added: ..It is a simplified method and should be noted that it only address zones where light is designed to spread uniformly across a plane parallel to the floor of a room.
01	1.4.2	pp3 2	EN 12464-1	The document omits mention of the requirements for cylindrical illuminance and illuminance on the room surfaces. Given that in many modern workplaces these requirement are the main drivers of installed flux and hence energy consumption their omission is puzeling.	Add discussion of all requirements of EN 12464-1	More text added (see also other stakeholder comments)

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
01	1.4.2	pp3 4 - 35	EN 13201 series	These standards have just been republished and it is important to check the text of these sections to ensure that they reflect the latest documents	Review sections	updated
01	1.4.3	pp4 0	US Building codes	The section refers to figure 1-15, it should be figure 1-16	Edit text	updated
01	1.4.4	pp4 4	Application of EN 15193	The situation described in this section is very much what was in place till the recast of the EPBD, given the new raft of standards coming into existence as a result of Mandate 480 the ability of EU States to maintain local standards will soon be very limited and national calculation methodologies are also likely to go.	Edit section to reflect changing situation	Mandates are added There is no time for a country update and it is of little added value
01	1.6.6 .2 (and subs que nt secti ons)	pp7 9	Redesign of the building...	This section misses the most obvious opportunity for energy savings in that it odes not ask for a review of lighting need. In many workplaces the visual need of the workers have radically changed, this is particularly true of offices and factories where the move to screen based tasks and automated processes have radically reduced the demand for lighting	Redraft this section to include an assessment of lighting need	Text added..: It should also be noted that over time in many workplaces the visual need of the workers have radically changed, this is particularly true of offices and factories where the move to screen based tasks and automated processes have radically reduced the demand for lighting. This can also justify a complete redesign.

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
01	1.6.6 .7	pp8 1	Reference worst case...	This section provides a further example of the limitation of the concept of the useful lumen. In this case of road lighting it is not clear how the example has been derived. But on a slow traffic route it is likely that the lighting class would be given in table 3 of EN 13201-2:2015 it is not clear what account is taken in the concept for the flux used to provide the vertical and semi-cylindrical illuminance that the standard now requires in areas where there is significant pedestrian use.	Edit this section to use a more realistic example	This section is outdated and reviewed in later tasks (as indicated). It is a raw first screening that therefore will not reviewed.
01	1.6.6 .8	pp8 2	Reference worst case...	Again the concept fails as it is not clear how each of the compared schemes has address the actual needs of the office users.	Edit this section to use a more realistic example	See previous
01	1.6.6 .9	pp8 3	Reference worst case...	This section does give some general principles but misses a very obvious open goal. The simple action of banning luminaires which are designed to accept lamps that have been banned from the market or are going to banned in the next 5 years would be a big improvement over the current situation where luminaires are still being made that can accept GLS lamps and have to be used with sub-optimal retrofit lamps.	Add in the discussion of a ban of luminaires that can accept banned lamps.	See previous

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Comments on draft Tasks 1-4
Preparatory study on Lighting Systems (Lot 37)

VTICHELP
2016-09-05 08:51:01
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note these are late comments therefore we can only taken them into account in the extend possible

Integrating Lighting Systems in the Ecodesign and Energy Labelling framework presents a certain level of complexity, which could require new thinking and innovative approaches to significantly tackle their environmental impact. We believe it is a worthwhile effort as it could open [illegible]ntial energy savings: 610 PJ per year as of 2030, according to the Ecodesign Working Plan 2012-2014. We believe that the ongoing analysis of the point system methods in the implementation of the Ecodesign Directive may provide interesting outcomes that could serve the need of the current study.

- **Reconsidering the suggested study scope limitation**

The study team has decided to focus the scope of their study on "*Lighting systems that provide illumination to make objects, persons and scenes visible wherein the system design is based on minimum quality parameters as described in European standards EN 12464-1 on lighting of indoor work places and EN 13201 for Road lighting*". They thereby exclude residential lighting and many other possible lighting applications from their analysis.

We would like to remind here that the purpose of the preparatory study is to establish a solid evidence base for the whole product group, irrespective of what the focus of possible regulatory measures later on in the process may be. Acknowledging the need to prioritise, we nevertheless want to call on the study team to reconsider this exclusion and the potential impact on the savings at stake. Such exclusions should not be done without strong justifications, as well as an assessment of the potential savings for the excluded product parts.

⇨ **Reconsider the exclusion of residential lighting and potential other areas from the study scope, and provide a strong justification as well as an assessment of the potentially missed savings.**

> Scope has been discussed in the beginning of the study. In Task 7 we will look at how much can be targeted and if extensions can be considered in later policy implementations, if any.

- **Selecting representative reference lighting applications**

In Chapter 3.1.2, reference lighting applications are developed as a basis for the collection and discussion of real (technical and economic) data and will most likely also serve as a starting point for the base cases. We understand that the study team starts with the reference application from Lot 8 (reference office lighting applications) and Lot 9 (reference street lighting applications) and that further reference applications may be added later on during the preparatory study process.

But considering the relevance from an energy consumption perspective of some other sectors of lighting applications identified during the "quick scan" exercise (see Table 1-17 and Table 1-18 on p. 130), it seems surprising that the characteristics of the industrial and retails sectors for example are not included in Tasks 2 to 4 from the start. The surrounding conditions in the industrial sector can be very heterogeneous, with for example much higher temperatures (e.g. metal works), or much lower in cooling rooms, heavy dusts, water spray, etc. The light quality needs also vary greatly – with shopping malls needing a specific light temperature for example. Therefore, all other factors like the technical solutions, the economic situation, and the user behaviour will also differ.

In the current version of the report, we only find a question from the study team regarding more data sources for such sectors, but no clear perspective about how their specific characteristics shall be considered if specific data is not provided by market actors.

⇨ **In order to ensure that the definition of Base Cases and other assessment steps from Tasks 5-7 cover all different lighting situations, we would like the study team to:**
- include a section where the different use conditions (and related technical solutions) are discussed across all sectors of lighting application;
- perform additional assessments on markets, use behaviour and technical solutions for other relevant sectors (at least those with obviously different use conditions)

In the new update they are extended based on task 2 market data and stakeholder input.

- **Addressing standby consumption**

Despite the important debate around the standby energy consumption of lighting solutions in the framework of the "Lighting sources" review process, this aspect is not addressed in detail in Chapter 4 of the current study. 0-Watt standby consumption is assumed for the Worst Case and Mainstream Reference Installations, but installations standby values for BAT are left open.

Given the emergence of the so-called "intelligent lighting systems" and the fact that standby and networked standby consumption could reach a similar importance than the on-mode consumption, we are concerned that standby is treated as part of BAT solutions only, without any further discussions. We therefore ask the study team to include more details on the role of the standby functionality for the different technical solutions. Furthermore, we assume that it is of high importance to explicitly include "System-solutions" with high and low standby needs into the Task 5 and Task 6 research.

⇨ **More attention needs to be given to the standby and network standby consumptions of lighting systems in the first and later tasks of the study**

In the new update this is taken into account

- **Not neglecting non-energy aspects**

At this stage of the study, non-energy aspects of lighting systems are not discussed sufficiently. The rationale is explained on page 124: *"This means that other environmental impacts are neglected in the quick scan, e.g. in street lighting replacing asphalt by concrete to increase the road surface reflection might also impact VOC emission. Also the potential positive impact on outdoor light pollution will not be repeated hereafter (see Lot 9). The main reasons for this decision are the added complexity and/or lack of available data."*

However, little detail is given on how this situation will be solved in the upcoming work. From the perspective of resource use/resource efficiency even quite simple parts like cables, masts, holders, etc. might create relevant impacts if they need to be changed due to a technology shift or a respective regulatory push. These potential impacts need to be thoroughly assessed.

It is not the scope and aim of this study, which primarily focuses on energy aspects of installed lighting systems. For example, any other type of impact of all their individual components for whatever policy would lead us too far into many possible different details. For the aspects mentioned such as resource efficiency production and product oriented policy are more likely to candidates to address these issues, such as IPPC Directive, it can be done in other studies aiming for example resource efficiency in related industry.

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DG ENER Lot 37: Ecodesign Preparatory Study on Lighting Systems

Organization: IALD	Name: Kevan Shaw	Date: 24 /02/2016

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
0	0. 3	18	Definition	The definition of a lighting system has to too much in common with the definition of "Lighting Product" in the draft single lighting regulation. This will result in confusion as to what is the exact scope of each regulation and a high risk of double counting potential energy savings between the proposals.	***In this context a lighting system means a system of devices intended to deliver effective lighting to create a comfortable , functional and safe environment for human habitation , travel, work and leisure activities.***	Thanks, text will be added
0	04	20	Clarification	The statement regarding Quality of light is markedly inaccurate. The cited ENs are predominantly related to lighting quantities and measurements rather than the quality of light, and lighting as experienced by users of specific spaces. It has been repeatedly acknowledged that many of the criteria used such as CRI are not good enough quality descriptors of current lighting equipment and light sources.	***Quality of light & lighting are of primary importance in many applications. Lighting system design is usually based on measurable parameters as described in European standards such as EN 12464 Lighting of work places, EN 12193 Sports lighting and EN 13201 for Road lighting. Important parameters for specifying the lighting and the lighting system are briefly introduced in the next section. Terminology is defined in EN 12665. These standards do not necessarily provide good lighting quality.***	More text will be added

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
0	0. 4. 7	22	Correction	"Photometric Code" is too imprecise in practical lighting systems design	***"Measured Photometric Performance"***	OK, added
0	0. 4. 7	22	Correction	"LED Luminaire Luminous Efficacy (lm/W)" Specifically limiting the scope to LED raises concerns regarding the technology neutrality of the proposal	**"Luminaire Luminous Efficacy (lm/W)"**	OK, modified
1	1. 1	23	Clarification	As above inappropriate use of "quality" in second paragraph ". . . based on minimum maintained ***quality*** parameters as . ."	*". . . based on minimum maintained* ***measurable*** *parameters as . . "*	Suggest to use minimum measurable quality parameters (this does not exclude others and more)
1	1. 1	23	Correction	"on gains from electrical energy conversion to heat ***within*** lighting equipment." This is incorrect. All electrical energy used in lighting equipment is converted to heat. Emitted light is converted to heat when absorbed by surfaces to the extent that it is not reflected to be absorbed and converted elsewhere.	"on gains from electrical energy conversion to heat ***by*** lighting equipment.	OK
1	1. 2	24	Correction	"system design based on minimum ***quality*** parameters" Same comment regarding the inaccurate use of the wording "quality"	"system design based on ***measurable*** parameters"	Suggest to use measurable quality parameters
1	1. 2	24	Correction	"luminaire, LED module, LED control gear," Same comment regarding technological neutrality	***"luminaire, light source module, control gear,"***	OK

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
1	1. 3. 1	27	Definition	The proposal to study the application of lighting cannot at the same time include an individual luminaire and a comprehensive lighting installation as the same thing. The intention of including some luminaires in the draft single lighting regulation has already shown problems: specific applications create requirements for higher or lower efficiencies to achieve specific lighting requirements, therefore it makes more sense that luminaires should only be considered as a component within a lighting system designed for a specific application. "A lighting system can therefore range from simple luminaires to large scale installations with multiple luminaires and intelligent controls such as those used in intelligent street lighting. Lighting systems can be placed on the market either with built-in lamps that are not designed to be changed by the end-user, such as fixed LED modules, or with exchangeable lamps/without lamps. Lighting schemes are plans for a lighting system and allow assessment of the system at the early design stage. 'Smart' lighting systems based on advanced control	***"A lighting system means a system of devices intended to deliver effective lighting to create a comfortable, functional and safe environment for human habitation , travel, work and leisure activities.*** *Lighting schemes are plans for a lighting system and allow assessment of the system at the early design stage. 'Smart' lighting systems based on advanced control systems are also considered in this study."*	Such a text will be added + a clear statement that for example a luminaire, lamps, etc .. are only a component in the system

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				systems are also considered in this study."		
1	1. 3. 1	29	Consistency of wording	"In summary the primary scope of this study is the investigation of lighting systems that provide illumination to make objects, persons and scenes visible wherein the system design based on ***minimum quality*** parameters as described in European standards EN 12464-1 on lighting of indoor work places and EN 13201 for Road lighting."	*In summary the primary scope of this study is the investigation of lighting systems that provide illumination to make objects, persons and scenes visible wherein the system design based on measurable parameters as described in European standards EN 12464-1 on lighting of indoor work places and EN 13201 for Road lighting.*	Suggest to use measurable quality parameters
1	1. 3. 1	29	Omission	EN 12464-2 Lighting for outdoor workplaces provides equivalent measurable parameters to EN 12464-1 . Why are this range of lighting applications omitted from this study?		
1	1. 3. 1	31	Exclusion	For consistency with other lighting regulations theatrical stage and entertainment lighting should be included in the excluded systems	• Lighting systems designed for theatrical, stage, entertainment and similar applications	OK
1	1. 3. 1	32	Clarification	**Rationale and considerations concerning the scope:** The scope indicated above is a clear definition connected to the well-established standards in the field: EN12464 for indoor lighting and the EN 13201 series for road lighting. Therefore lighting systems can be clearly defined, which is useful for any further legislative purpose, and also their		OK, text updated: ..design and/or system technology..

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				performance parameters can be sourced from standards as will be documented later in section 1.4. In the Task 2 study on markets, the Task 0 study on screening and the Task 4 on technologies the scope may be further reduced depending on which lighting systems are relevant and where ***technology is available for improvement.*** Lighting system efficiency can be radically impacted by the design rather than the technology. Focusing on technology alone will fail to achieve best energy efficiency and risk creating conditions where poor design solutions of low efficiency are unwittingly encouraged		
1	1.3.2.1	34	Correction	"The European standards EN 12464-1: 'Light and Lighting – Lighting of indoor workplaces' and EN 12464-2: 'Light and lighting – Lighting of outdoor workplaces' ***impose*** minimum lighting and comfort levels for different task areas. They are applicable in offices, industry halls, education buildings, outdoor workplaces, hospitals and outdoor park places." These standards propose or recommend they do not impose	*"The European standards EN 12464-1: 'Light and Lighting – Lighting of indoor workplaces' and EN 12464-2: 'Light and lighting – Lighting of outdoor workplaces'* ***recommend*** *minimum lighting and comfort levels for different task areas. They are applicable in offices, industry halls, education buildings, outdoor workplaces, hospitals and outdoor park places."*	OK
1	1.3.2.1	37	Unnecessary duplication	**"Fixed dimming** Most lamp types, especially LEDs, lose efficacy over time and dimming systems can compensate for this.	Delete paragraph	OK

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				Dimming also allows the illumination level to be fine-tuned exactly to the minimum required, e.g. to compensate for cases when the exact lamp wattage required was unavailable (e.g. 60 W= 0.85 * 70W)." This is exactly the same as "Constant illumination Control "above		
1	1.3.2.4	38	*Comment*	Accuracy of lighting calculation is dependent on the quality of photometric file provided by manufacturers. There is variable quality and accuracy in supplied data that can significantly impact the accuracy of the calculated output. As no standards exist this is an area of significant risk to design and energy savings.		added in the intro text .. the quality of photometric file provided by manufacturers
1	1.3.3.1	37 =43	Comment	The separation of residential and non residential applications is unsound. Many of the aspects described in the functionality of residential lighting exist in significant commercial applications including high-end retail, hospitality and leisure sectors. Some of this is recognised in EN12464-1 where specific recommendations are not provided. This results in significant potential loopholes or unrealistic regulation.		This is an issue to reconsider in Task 7 when discussing policy However Task 3 should also discuss this aspect 'ambient lighting in non residential applications not following EN 12464-1
1	1.4.2.2.	61	Clarification	EN15193 (2007) "An example of technical aspects still to be addressed is artificial lighting, which is only taken care of in existing buildings in the current version of the standard." We do not understand this. Methods of calculating LENI at the design stage for new lighting schemes		Given the current status of the review text procured from the CENSE project comment will be deleted

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				are clearly indicated in the calculated method for assessment. Obviously the measured assessment can only be carried out on completed projects! There is a simplified method included using standard factors based on tables and schedules. (EN15193 6.2.1 Quick Method) Also there is a method for taking account of lighting controls (EN15193 Annexe H describes approaches to the various control strategies described in the text). A version of LENI is currently incorporated in Building Regulations (England and Wales) Part L 2013 in Table 44 as calculated by the procedure described in Section 12.5. This table provides proposed LENI benchmarks updated from the standard and reflecting the recommendations of EN 14193-1, 2011 and higher target efficiencies in line with good practice and the requirements of continuous improvement of the Building Regulations		
1		62	Typo	Potential gaps in prEN15293-1&2(2014):	Potential gaps in prEN15193-1&2(2014):	Noted depends on the country CEN responsible and how data is shared with members

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
1		62	Information	We do not have access to the draft prEN 15193 1&2 (2014) therefore currently cannot comment this section		
1		72	Comment	EN12464-1 section 4.6 specifies particular minimum illuminances on wall and ceilings. There are also targets for cylindrical illuminance specifically for seeing people. These are totally omitted from your comments. Light energy is required to fulfill these in addition to that provided for the primary task and circulation lighting therefore meeting these specific requirements has an impact on overall lighting energy required.	Include references to these requirements	More text should be added We should say somewhere: LENI is not only
1		73	Comment	Potential Gaps in EN12464-1 " No specific 'short measurement' verification method is included. Section 4.4 defines the illumination grid that is used for calculation, but this would require a large number of measurements per room. " We do not believe there are any practical shortcuts in determining measured illuminance in atypical workplace. A number of measurements similar to the number of points required in a calculation are necessary. Smaller numbers of point measurements will give misleading results and fail to determine if the general distribution of illuminance meets the requirements for uniformity and glare control.	Delete comment	See stakeholder meeting.

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
1	1. 4. 4	86	Comment	We strongly disagree that the current EN 15193 LENI method is too complicated. The presentation and explanation of the formula is very poor in the current standard and essential information such as actual parasitic loads of various elements of lighting equipment are not generally included in technical literature. However the consideration and information gathered to perform a LENI calculation focuses on all the lighting related energy use aspects so results in good low energy use design practice. It is also the only measure that really considers the actual energy used in the operation of a lighting installation which must be the focus of the regulations currently being considered.		Text will be added, because no complementary standard such as EN 15193 or EN 13201-5 exists and the [illegible] with it, but can be discussed in Task 7 (e.g mandates).
2		13 1	Definition	"In this study the 'product' is lighting installations and their designs. This means that the typical market product unit driver is floor or road surface area." We strongly disagree that this is a correct definition. As is stated the delivering the requirements set out in EN12464-1 are the basic design targets and these are much more than any particular measurement of horizontal illuminance as stated here.	In this study the 'product' is lighting installations and their designs. This means that the typical market product unit driver is appropriate volumetric lighting assessed agaonst the floor and/or task surface area serviced by the lighting scheme."	
		13 1	Comment	"When conducting the analyses using the MELISA model and later Tasks 5-7 it will be important to avoid double counting the effect of increased lamp efficacy within lighting stock energy consumption scenarios, because they are already taken into account in the light source study. Therefore, when		Noted. an issue to be kept in mind when working on Task 7. Task 2 is for a first screening only and to select reference designs

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				defining so-called base cases for the system study they should already have this efficacy increase included." We do not believe that this is a realistic approach to assessing variation of energy use according to the specific task requirements. There will be a large variation in luminaire efficiency according to the optical design required for specific applications therefor no single correction factor for light source efficiency will be reliable across this study.		
2	2. 1. 1		Comment	We have already criticised the base data selected for the MELISA model as being unrepresentative of the post 2009 regulation market and practice. We continue to believe that significant basic research is required to develop the data required to make MELISA model reliable.		Noted. Important for scenario's in Task 7
	2. 1. 2	13 5	Comment	The apparent complexity of LENI is identified as a problem earlier in this paper. The approach to MELISA is very significantly more complex and totally divorced from lighting design practice. The number of correction factors being introduced on scant evidence makes it unreliable. There is no way that this can be directly applied to analysis of design or provide significantly meaningful data for practical application	Use an analysis with LENI as the primary measure. If required this can be measured in existing buildings to establish practical and accurate energy use statistics. It is also possible to calculate LENI based on designed or installed lighting systems. This approach will also inform useful target setting in this regulation. LENI is a good design parameter and already has recognition and limited adoption in some National regulation. As this is a known and understood process it is much more useful for market surveillance.	We are aware of this complexity and therefore selected LENI in task 4

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
		13 7 fo ot no te	Comment	"In some LFL applications the directionality of LED tubes also allows to reduce the installed lumens. (assumption from VHK made in MELISA) " This is a dangerous assumption and is very significantly flawed. The problem of directionality specifically affects the lighting quality and appearance by reducing vertical illumination both on surfaces and on people. The result is that use of this kind of substitution can and does result in lighting systems failing to maintain compliance with EN12464-1	Delete and remove this assumption from calculations	a better reference to the other study will be added
		13 8	Comment	"**It is expected that this modelling can be done by adding reference designs with lamp efficacies in line with MELISA and rescale the base cases in Task 5 and improvement options in Task 6 accordingly.**" This seems a complex and not necessarily reliable method of accounting for regulated energy efficiency factors. At a practical level separating efficiency gains from good design and from changes in lighting technology are not clearly seperable.		noted will be a Task 7 issue
	2. 1. 2. 3	13 9	Comment	"in the Light Sources study the same prices were used for LED retrofit lamps and integrated LED luminaires" This is not accurate and delivers poor results. LED luminaires are of a much higher relative price than replacement lamp products. This error must not be repeated here.		noted More accurate price data will be sourced in Task 4.
	2. 1. 2. 3	13 9	Comment	"Costs of control devices, network-communications, timers, dimmers, daylight sensors, occupancy sensors, system installation, management and		noted More accurate controls cost data to be source in Task 4

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				maintenance costs, etc. are not foreseen in MELISA." These form a significant and increasing proportion of lighting systems costs and cannot be ignored or dismissed in this study		
	2. 1. 2. 3	13 9	Footnote 93	This footnote is identifying some of the significant shortcomings and inaccuracies in the MELISSA model. There also seems to be a lack of understanding that LED integrated luminaires are increasingly the normal specification in commercial installations. In respect of 3) the current proposals in the single lighting draft regulation will cause a very large number of conventional technology luminaires to be removed from service before end of life due to non availability of replacement lamps and gear as these will be removed from the market. In respect of 4) price per kLM is a poor measure. Luminaires that use significant optical control by reflectors, lenses , light guides etc. Cost very significantly more per kLM than simple luminaires using direct radiating LEDs for example.		noted More accurate luminaire data to be source in Task 4
		14 0	Comment	"However the additional investments in lighting systems that have to be made to obtain the above energy and cost savings are currently not included in MELISA." This statement indicates the serious and significant shortcomings of the MELISSA model for this study. We urge reconsideration of this approach	Use LENI as basis of measurement for this regulation	noted Will be a Task 7 issue.
	2. 1. 3	14 1	Comment	While we are happy to provide relevant information there are significant problems in fully and completely identifying all the costs associated with	Undertake typical design exercises and have these costed commercially. This will require to be a funded exercise.	noted, see also Task 4.

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				" lighting systems" in building projects. As light sources and luminaires are considered elsewhere what we are looking at here is the entire installation including wiring, switching , lighting (and BMS) control as well as associated costs of builders work for installation. These costs are distributed across building projects in different ways depending on the form of tender for the work. Frequently costs of wiring and power distribution for lighting is included with small power wiring and any attempt to separate the lighting out would at best be intelligent guesswork. Bills of tender are also commercially sensitive and are not generally available nor are clients willing to share this information.		
	2. 2. 1	14 1		"It should be noted that not all type of non-residential area is covered by EN 12464 and EN 13201" As stated above EN12464-1 does not provide definitive requirements for many commercial areas such as hospitality, Museum and gallery, restaurants, high end retail etc.		Noted Also added to task 1
	2. 2. 4			"Consequently the number of luminaires sold was roughly one fifth of the number of light sources. This indicates that the average luminaire lifetime is approximately five times longer than the average light source lifetime," The logic behind this statement is significantly flawed. By 2013 there were a considerable number of LED integrated lighting products being sold into the commercial market. Light source and luminaire are not separated in this case		noted text added in footnote

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				so there is a major error		
	2. 2. 8	14 7	Comment	Cables cannot be omitted from this study as a significant part of the cost of a lighting system. While a well designed cable system should not affect the energy use of the system, the cost and embodied energy and materials are significant in any decision making about the upgrading or replacement of a lighting system.		noted Were part of completed study http://erp4cables.net/ But could be reconsidered in Task 7
	2. 2. 9	15 0	Comment	Cross check 1. We are concerned at the accuracy of this cross check and therefore its conclusion. 1. It is based on task lighting levels set out in EN 12464-1:2007. For the vast majority of small scale and individual business premises the light levels set out in these standards are not generally achieved therefore there is likely an overestimation of installed lighting load. 2. Lighting at task level alone is not a good indicator of required installed luminous flux to achieve an appropriate and acceptable lighting appearance in a space, therefore the effective utilance of lighting energy is misrepresented by these assumptions. 3. We pointed out above that data for lightsources and luminaires sold are likely to be		This was discussed in the stakeholder meeting and afterwards in agreement with the lighting europe market data was cross-checked and new reference designs were added to task 3&4.

Stakeholder comments form

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				unreliable due to the significant market presence of LED integrated luminaires I the commercial market pave from 2010 onwards. 4. The conclusion that "circulation areas" consume such a large proportion of non residential buildings would seem inconsistent with the pressure to ensure that the design of commercial buildings, including offices and retail , to achieve the highest net lettable area i.e. working space. Information should be sought from commercial letting agents on commercially acceptable proportion of lettable to non-lettable areas on commercial buildings in each country of the EU.		
			151	Cross Check 2. We are somewhat concerned at the outcomes of the calculations here in comparison with the realities of current installed systems and current design targets. Typically installed efficiencies for new installations are close to the proposed averages here. UK building regulations have mandated 55 lamp lumens per circuit watt since 2011 therefore an assumption that the average is anywhere near 60Lm/W in 2015 is extremely overoptimistic. This will result in a regulation requiring a much higher systems efficiency and will radically underestimate the effective energy savings deriving from systems	Comprehensive survey of existing lighting installations and existing design practice across the EU28 to determine realistic values for the current installed lighting systems. A comprehensive survey of current design parameters and outcomes. This can be accomplished by an online survey across a wide range of practising lighting designers and engineers.	Noted It was discussed in the meeting and afterwards new designs were added and defined with input from the lighting manufacturers design departments. They will be added in Task 3.

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				based regulations. Similarly the calculated power densities seem overoptimistic. This is based somewhat in the overoptimistic value for efficacy noted above. In general the proposed averages are close to current best design practice rather than a reasonable assumption of the current installed situation		
				Cross check 3, Operating Hours. We are more inclined to believe the results derived from the EN15193 approach. Again this is an issue where real life data should be used to cross check the validity. As EN15193 has been in use for several years and separate lighting circuit metering has also been mandated in some EU states it is reasonable to assume that this data does exist for more recent buildings. The assumption that the lamp technology approach in MELISSA has rendered a more accurate result is flawed. Human behaviour is not determined by lamp type, therefore manual switching patterns would not change. Automatic switching patterns are similarly not dictated significantly by lamp type with the exception that occupancy switching cannot realistically be used with Metal Halide or other discharge lamp types due to the slow warm up characteristics. Ref note 115 it is impractical to determine what lamps are doing what task as the same lamp is used for many different lighting functions in different situations,	Research and acquire real life data for this cross check	noted See previous reply

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				markets and applications. Again we note that the reference efficiency of 60Lm/W is unreasonably high for the existing installed stock of lighting equipment.		
		15 4		" As regards building types/sectors, ... The highest energy density is found for stations/airports (18-31 kWh/m2/a) and for hospital/healthcare (20-28 kWh/m2/a). Excluding parkings, the lowest energy density is found for educational buildings (6-11 kWh/m2/a). " These figures are very considerably lower than the LENI benchmarks in EN15193. While we accept that these benchmarks are out of date for current construction and lighting technology they more closely represent existing installed systems rather than those that are proposed here. There is also a significant risk to basing regulation on overoptimistic figures.		noted Discussed in the meeting and see previous reply. (It was also found that in this analysis HID lamps were not taking into account for indoor lighting resulting in a relative low LENI)
	2. 2. 12	15 9	comment	"Such area's that are therefore excluded from the scope could be found in within hotels, restaurants and shops that use ambient lighting not following EN 12464." The majority of such spaces are referred to in EN12464-1 however do not have specific task levels associated. There is also no discussion with regard to display lighting in shops, museums and galleries that also form a special case where light level is determined by function rather than a specific illuminance.		note agreed that the growth is relative lower as in this draft version. In the course of GPP on street lighting a new enquiry was launched and data was update (annual growth of only 0,33%)

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	2. 2. 13 .3	16 2	Comment	It is very difficult to design a lighting scheme in offices that is fully compliant with EN12646-1 without using direct/indirect luminaires or ceiling systems that have a high proportion of area be light emitting. The latter solution requires significantly higher quantities of luminaires with lower outputs to meet requirements.		Noted an issue to look at in Task 4
	2. 2. 14 .2	16 5	Comment	The assumption that road lighting is increasing may not be accurate as local authorities are taking decisions to reduce the number and time of lighting streets and roads to reduce overall energy consumption.		Noted But in statistics we see roads increasing. It might be that they update inventories?
	2. 4. 1	17 2	Comment	The assumption that lighting design cost is part of luminaire cost is incorrect. While many suppliers include a "design service" this is rarely based on requirements but is only information for purchasers. To impact lighting systems design the focus needs to be on professional design by building services engineers and professional lighting designers who are acting on behalf of the client and will be needed to ensure compliance with any regulation. Omitting the design cost as an identified item sends a strong signal that this service is not required to ensure compliance and best practice. Supplier's "design service" usually excludes lighting controls and wiring that have significant impact on operation and energy in use of la lighting system		This was discussed in the stakeholder meeting Agreed to add the design cost Cost was estimated on typical construction cost data This can be used in later cost estimations.

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Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
	2. 4. 1	17 3	Comment	Table 2-14. In respect of the UK market the rate for labour appears to be relatively flat, however the cost of lighting installations has significantly increased during the period covered. This is the result of significantly higher contractor and wholesaler mark ups on manufacturers prices for lighting equipment. Consideration of such factors in necessary in valuing lighting systems installed costs.		see previous remark. Mark up cost is added in the review.
	2. 5. 2	17 5	Suggestion	In addition to ESCO larger lighting manufacturers with vertical integration and other general service providers who have the scale to achieve financial backing are currently providing lighting systems on a per lumen hour basis. This is more common in street and road lighting than building lighting. It would be sensible to look specifically at this business model and ensure that the regulation addresses this with respect to required escalation of lighting efficiency as technology develops. Failing to specifically address this market area risks stagnation where decisions are taken not to renew or upgrade given adverse economic climate when such upgrade would be due.		Trend to add. Other items are to be looked at in Task 7 when discussing potential policy measures.
3	3. 1. 1	17 7	Comment	We suggest that road lighting has significant impacts on transport energy use. The purpose of road lighting is to facilitate travel. In addition to safety it allows faster and freer traffic flow at night, this can have significant positive impacts on transport efficiency on highways		We could add this as a text but there is few data to build a model on.

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				allowing steady flow without slowing down and speeding up which is energy inefficient. Data will be available for traffic flows on lit and unlit highways.		
	3. 1. 2. 1	17 8	Comment	The models DO NOT COMPLY with EN12464-1. The design is required to provide 500Lux at the task area only. Which needs to be defined in the model.	Define task areas, immediate surrounding areas and background area. Provide model that achieves correct levels for each area. Ensure minimum illuminances on walls and ceilings. Ensure cylindrical illuminances at 1200afl and 1600 afl are achieved	Note: immidiate surrounding area and background area are in Dialux files, but will be added to the text.
	3. 2. 1. 4		Comment	Utilance as defined is not a useful measurement when you are considering the lit environment as a whole. It is clear from the requirements set out in EN 12464-1 that the light on the work surface is only one factor in determining the appropriate lighting for the workspace. In the 1990s we went through a very poor period of lighting design as we came to deal with the requirements for VDU lighting. In the UK we had the requirements for cut off and direct lighting that resulted in fitting specifications to meet a CIBSE standard LG2. The result was all light was directed downward to the work surface and resulted in dark ceilings and walls creating cavern like spaces. Any focus on utilance as described here will result in requirements with effectively similar results. En12464-1 includes recommended ranges for surface reflectances in the workplace. These are not included in	Do not consider Utilance as a measure for this regulation. Do not regulate on the basis of task area lighting alone.	Noted Policy and regulation are Task 7 issues

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				other recommendations therefore are not considered by architects and designers. The impact of surface finish is very high however this would need to be regulated in a place that would impact designers of these spaces.		
	3. 2. 2	19 6	Comment	Temperature effect has the inverse effect on LED i.e. as temperature rises at the junction efficiency and output reduce. This can be a factor when LED systems are installed in voids that get heated such as return air plenums and if the heat sink above the ceiling becomes excessively contaminated with dust and dirt and no longer achieves its intended design performance.		OK, text added
	3. 2. 2	19 6	Comment	Line voltage effect typically has no impact on LED ligtources. The switch mode power supplies used for most of these contain feedback circuit to ensure the outward supply remains at constant voltage or current depending on the LED technology being supplied.		OK, text added
	3. 2. 2	19 7	Comment	Office Hours. The structure of the LENI formula allows specific operating conditions to be used to calculate annual operating hours appropriate to the project. Project briefing needs to include anticipated operating conditions and hours to determine an appropriate LENI. Equally unusual operating hours need to be taken into account to determine appropriate benchmarks for the project.		Such a text will be added
	3. 2. 2	19 7	Conclusion	If you are to neglect these secondary operating conditions, factors and allowances for these must be included in any proposal or outcome of the		noted. Task 7 issue

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				study. Taking such factors into account is good professional practice and should not be ignored in professional lighting design.		
	3. 2. 3. 2. 1	19 9	Comment	"The Expert inquiry of lot 9 (2007) sent out to all stakeholders showed that complete or partial switch off is rarely applied in the 25 EU-countries, and is probably only used for a maximum of up to 5% of the EU's roads." This is significantly out of date. Since 2007 The number of switch off switch down and dim street lighting schemes has very significantly increased due to economic pressure to reduce energy costs. Also there has been significant change over to LED for street lighting that is more easily controlled.		To be discussed in the stakeholder meeting.
	3. 4. 1. 1.	20 6	Question	Lifetime of indoor lighting installations: The current draft single lighting regulation will significantly impact lighting installation life if carried forward with the currently proposed time line. Typically a T5 fluorescent office lighting system installed today (2016) will need to be replaced between 2024 and 2028 as T5 lamps will be removed from the market from 2024. This gives an operating life of 8 to 12 years. Will you include this shortening of operating life in your calculations?		Noted. Can become an issue in Task 7 scenarios (added complexity)
	3. 4. 2	20 7	Comment	Table 3-10. The times allowed would seem unrealistically short for the tasks outlined. Time allowance has to include for erecting and moving access equipment, clearing furniture unpacking product and repacking removed product etc. A revised		To be discussed in the stakeholder meeting. Update enquiry neeeded?

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				assessment for the total time allowed for these tasks should be sought from a number of Facilities Maintenance Companies in different EU states.		
	4. 1. 2. 4		Comment	Design costs do not follow luminaire costs exclusively. Although for some schemes lighting design is provided by luminaire suppliers this does not include design of wiring, distribution and control.		Noted; cost data for design to be discussed in the stakeholder meeting
	4. 1. 3. 5	22 6	Comment	The proposed methodology here represents very poor quality design practice. BAT area specifically would not be calculated by changing a target illuminance. A calculation would be performed with the specific and correct luminaires for the specific requirements.		The purpose was to fit in the spreadsheet. Agreed that more text should be added explaining the area's selected, how design is optimized and the further processing of data fro this study.
	4. 1. 3. 5	22 7	Comment	BAT redefined area: The proposal for change of use as described would not be accommodated by control settings alone. More realistic scenarios are required, for example changing office working are to file storage		see previous remark
	4. 3	23 3	Note	Please be aware that we have not had sight of the spreadsheet and Dialux models while making these comments		More info is in the Dialux files itself
An ne xe C		15	Comment	The expectation for LED retrofit lamps for HID applications is unreliable. There are no genuine products currently available. Replacement of HID requires entire luminaire replacement		Noted. disclaimer for this can be added.

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		18 & 19	Comment	We do not understand the difference between Table 07 and table 08 clarification required.		To do
	F3	37	Comment	The use of en124641-2007 values as assumptions as to installed lighting is unsafe. The standard is not applied across all projects and many lighting schemes are significantly older so were designed to different standards and are also somewhat degraded through poor maintenance. The result will be a significant overstating of the currently installed lighting for many applications. Smaller retail and office premises are rarely designed to any recognizable standard.		Noted. Isue to be discussed in cross-check and Task 3 (rebound effect)
	F4 3		Comment	As before the assumption of an overall efficiency of 60Lm/W would appear to be very high for currently installed lighting systems		Noted

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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 Isn't it the final? (contacts Steve) 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	prEN 15193-1&2 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 (study will follow method 1)

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#	Question	Answer	Reply study team
		contain worked examples and benchmark indicators. 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 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 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. 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. The new standard will also permit the use of National default values for which templates for the data will be given in Annex A. The standard will not have LENI target values but the TR will give examples. 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. 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 Noted also UK has LENI targets

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#	Question	Answer	Reply study team
8	EN 12464 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 verification procedure could be added in EN 12464 revision (is a gap) Will be communicated to Peter Dehoff
9	EN 15193 We are looking for reference design calculations according to EN 15193, more specific (input from manufacturers is welcome): If possible, identical to the CIE 171 test cases? (to verify if this make sense). 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.: 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) 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) 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. 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. 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 (scheme = define task and surrounding area?) We started our own calculations on selected test cases based on the standards

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#	Question	Answer	Reply study team
10	EN 13201 We are looking for reference design calculations according to EN 13201, more specific (input from manufacturers is welcome): 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; Type A.5 class P4 (table A5) which is close to category slow traffic in previous lot 9 Type A.4 class M3 (table A4) which is close to category mixed traffic in previous lot 9 Type A.8 class M2 (table A8) which is close to category fast traffic in previous lot 9 The reference calculations can be either in Dialux, Relux or Ulysse.	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. 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 We follow the provided version of "/13201 of interest is Annex B installation luminous efficacy with its decomposition into subsystems. Herein correction factor Cl is unclear, does this also apply to illumination classes (P,C)? The issue is (& comment DEA(DK)) to correct for Erequired/Einstalled?

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DG ENER Lot 37: Ecodesign Preparatory Study on Lighting Systems Tasks 0-1

Organization: LightingEurope	Name: Chiara Briatore	Date: March 22nd 2016

	Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
1	0	3	20	Lighting communication network	In most cases this lighting communication network is not a stand-alone system but is part of a building system	Add A lighting communication network can be part of a building communication system (HBES/BACS)	added
2	0	0.4.7	22	Important technical characteristics	The characteristics are specific to LED technology. They should be generic for all lighting technologies	Change characteristics to be more applicable across all lighting technologies.	LMF & LSF added
3	1	1.2	24	Summary of Tasks 1 and 0	Discussion of LED module and LED control gear is too specific.	Keep generic across all lighting technologies.	modified
4	1	1.3.1	27	Definition of lighting system scope	Figure 1-1 implies a control system only implements constant illuminance. A control system adds many more control functions that are relevant to energy efficiency	Add additional control functions such as presence/absence and daylight controls.	The idea is that presence and daylight are added in the Energy function (right box only), to increase the readability this is added in the
5	1	1.3.1	29	Definition of lighting system scope	Figure 1-2 implies a control system only implements constant light output. A control system adds many more control functions that are relevant to energy efficiency	Add additional control functions such as presence/absence, dimming and daylight controls (as opposed to switching via a time clock).	figure See previous answer
6	1	1.3.1	31	Definition of lighting system scope	Only indoor workplaces and roads are considered. Outdoor workplaces should also be included	Add outdoor workplaces and EN 12464-2.	this could be in a full study but the idea was to build on the lot 8/9 studies& there is not yet a complementary standard on efficiency such as EN 13201-5
7	1	1.3.1	31	Definition of lighting system scope	The inclusion of emergency lighting equipment integrated with general illumination is proposed to be in scope. However this equipment has emergency parasitic loads	Explicitly exclude the power use due to charging of batteries.	added
8	1	1.3.2.1	33	Lighting system at design and installation level	Whilst this must exclude performing maintenance it should include a maintenance plan based upon the lighting design parameters	Add maintenance plan to be taken into account.	added
9	1	1.3.2.1	33	Lighting system at design and installation level	Whilst tunnel lighting is outside the scope of EN 13201 it is covered in CEN CR 14380	Add reference to CR 14380.	added
10	1	3.	35	Movement dependent lighting control	There is a difference between a presence and a movement detector	Replace the title by Occupancy dependent lighting control.	OK replaced
11	1	3	35 and onwards	Combined systems	General remark	Throughout this report, replace movement sensors by occupancy sensors.	OK search and replace done
12	1	3	37	Dynamic lighting	Dali is only one possibility, other protocols exist	Replace (Dali) by (e.g. Dali, RF…)	OK replaced
13	1	3	37	Building management system	The definition of Building management systems is much broader than the lighting application level	Use the complete definition as stated in EN 15232: Building Management System (BMS): Products, software, and engineering services for automatic controls (including interlocks), monitoring and optimization, human intervention, and management to achieve energy-efficient, economical, and safe operation of building services equipment.	OK, added
14	1	3	37	Building management system	"Building management system"	Change the title to "Lighting management system".	changed to Building or Lighting Management System
15	1	1.3.2.3.2	38	For outdoor lighting	No mention is made of simple on/dim/off controls where the lighting is automatically dimmed to a set percentage based around a nominal midnight (midway between on and off)	Add simple dim controls.	OK added
16	1	1.3.2.4	39	Lighting system design and calculation software	CIBSE file format is not commonly used in the UK. Most common formats are eulumdat and IES. CIBSE is only used for a few legacy software.	Remove comment about CIBSE file format being commonly used within the UK.	OK removed
17	1	1.3.2.4	39	Lighting system design and calculation software	Radiosity can simplistically model translucent and transparent materials	Modify comment that radiosity cannot include translucent or transparent surfaces.	OK, comment removed
18	1	1.3.2.5	41	Lighting control	This system can be part of the building	Add a sentence that lighting systems	

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	Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				communication systems	management system such as KNX, LON, BACNET and proprietary solutions	can also be part of a broader building management systems.	Ok added
19	1	1.3.3.1	43	Primary performance parameters	*In the studies on non-residential lighting, the chosen functional unit was the 'provided maintained illuminance (Em[lx]) in one hour of operation' or in particular cases of street lighting the 'provided luminance in one hour of operation'.* It is difficult to understand proposed functional unit 'amount of light per hour operation' in relation to the intended use of lighting controls.	Clarify how energy saving due to lighting controls is considered using this functional unit.	added in the notes: Energy savings of control systems will be modeled taking into account time of use as a secondary parameter ..
20	1	1.3.3.2	45	Secondary performance parameters	For maintained luminance the symbol Lm is used. This is confusing because Lm is also used for lumens.	Consider other symbol for maintained luminance (Lm)	OK replaced by Ē m with 'overline'
21	1	1.3.3.2	45	Secondary performance parameters	Uniformity is Uo, not U0 (with O from Overall)	Replace U0 by Uo.	OK replaced
22	1	1.3.3.2	45	Secondary performance parameters	At the 08/03 stakeholder meeting it has been suggested to add cylindrical illuminance as secondary performance parameter. We support this idea and suggest to add secondary parameters on vertical illuminance of walls and horizontal illuminance of ceilings too.	Add secondary parameters on vertical illuminance of walls, horizontal illuminance of ceilings and cylindrical illuminance of objects/faces.	OK more text added
23	1	1.3.3.2	45	Secondary performance parameters	*Installation luminous efficacy , ηinst [lm/W]* Using lm/W as installation luminous efficacy to compare good and bad lighting installations is risky because it neglects most of the Light Quality parameters used in lighting designs based on EN12464-1.	Clarify how Light Quality parameters are considered when using this functional unit.	More text explaining this is added 'In lighting design the primary design parameter ...'
24	1	1.3.3.2	46	Secondary performance	*Luminous efficacy of a light source used in the installation, ηls*	In case of luminaires: assess lm/W at luminaire level and not at light source	OK, added

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	Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				parameters	*[lm/W]* For apple-to-apple (fair) comparison it is better to assess lm/W at luminaire level and not at light source level.	level.	
25	1	1.3.3.2	46	Secondary performance parameters	CIE general colour rendering index may be R_8 or R_{14}, not R_{20}	Change R_{20} to R_{14}	corrected
26	1	1.3.3.2	50	Secondary performance parameters	Fy is poorly defined. Highlight that Fy is a combination of By and Cz. LF is commonly used to indicate the lifetime of consumer (LED) lamps.	Remove LF parameter. For the professional market 2 separate parameters LB and LC are widely used to indicate lumen depreciation and abrupt failures of a LED based luminaire at a certain point in time.	modified
27	1	1.3.3.2	50	Secondary performance parameters	*Utilance of an installation for a reference surface, U* Using Utilance is risky because it neglects most of the Light Quality parameters used in lighting designs based on EN 12464-1.	Explain how in combination with Utilance other secondary parameters like vertical illuminance of walls, horizontal illuminance of ceilings and cylindrical illuminance of objects/faces are considered.	Text will be added that this is indicative for a single parameter (horizontal illuminance) while also other criteria are often involved.
28	1	1.4.2.1	64	EN 15232	To be cautious with the gaps between this standard and EN 15193	Add outdoor workplaces and EN 12464-2.	modify
29	1	1.4.2.1	65		EN 13201-5 is published	To review this clause taking into account the standard.	OK, included
30	1	1.4.2.5	78	Examples of performance standards on parts of the system	Compatibility between LED and phase cut dimmers is not mentioned	Add IEC/TR 63037 Ed. 1: "Electrical interface specification for self-ballasted lamps and control gear in phase cut dimmed lighting systems".	OK added

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DG ENER Lot 37: Ecodesign Preparatory Study on Lighting Systems Task 2

Organization: LightingEurope	Name: Chiara Briatore	Date: March 29th 2016

	Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
1	2	summary	131	Markets	EN 12464 is only mentioned with respect to indoor workplaces. EN 12464 consists of part 1 (indoor) and part 2 (outdoor).	Include EN 12464-2 and outdoor workplaces	OK added
2	2	2.1.1	132	Introduction of the Melisa model	For calculation of a lighting system only typical luminaire date of wattage and light output are relevant for calculation. The calculation can be different if based on light source data	Please clarify what Fsales factor will be applied for non-residential and street lighting. How will luminaire light output and wattage be corrected by the Fsales factor?	This is an issue for task 7 and Fsales might even not be used, threrefore a note is added: 'Note: the factor is described here but later in Task 7 it will be decided if Fsales will be used for this study or not.'
3	2	2.1.2.1	135	Sales and stock volumes and sales factor	It would be completely wrong calculation if lighting system data will be calculated on sales of light sources. May be it could function conventional light sources but not with LED modules. For LED based luminaires the Fsales factor will be different.	Consider to introduce 2 Fsales factors: one for conventional luminaires and one for LED based luminaires. For new solutions it would be practical to consider LED based luminaires only.	see previous note.
4	2	2.1.2.1	135	Sales and stock volumes and sales factor	The calculation for the lighting systems based upon the sales of light sources will be incorrect. However based upon current data availability it is considered that this will give the best result within the bounds of possible accuracy.		noted
5	2	2.1.2.1	135	Sales and stock volumes and sales factor	*Improvements in the design of lighting systems can lead to a reduction of the number of installed light sources,* When a conventional luminaire will be	Please clarify what is meant here: reduction of light sources or reduction of light points?	added. MELISA is basically a light source or lamp stock and sales model based on the stock of installed light sources and lamps including lamp saels for replacement and new projects.I

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					replaced by a LED based luminaire, it is difficult to think in terms of 'reduction of number of installed light sources'. Including lighting controls and improved lighting design will not automatically result in fewer luminaires. Optimization can in limited cases lead to less light points. But very often this will not be the case, because the geometry of the space does require a certain positioning of the luminaires to secure uniformity and prevent glare.		agreed that changes in installed stock are unlikely. Some improved deisgns used a higher amount of lower wattage lamps.
6	2	2.1.2.2	137	Power, capacity, operating ours and factors ……..	It is unclear whether this Fphi factor considers improved optical performance resulting in fewer luminaires or the use of controls to provide constant lumen output through life. This needs to be clarified.	Please clarify what is meant here.	constant illuminance controls are mentioned at Fhour
7	2	2.1.2.2	137	Power, capacity, operating ours and factors ……..	Again is mentioned that clear calculation of energy consumption in a lighting system only can be done via lighting planning tool (software assisted). Than with data and calculation tools in EN 15193 the annual energy consumption is available. Especially with led luminaires with integrated led modules, light output and luminaire wattage depends on individual adjustments of current in the modules, which could specific for the application	Do not reflect on existing data with conventional light sources, perhaps as from Melisa. As mentioned above it should be calculated on LED-luminaire data. The best and most clear way would be by calculating via EN 15193 or EN 13201-5 and use typical figures from LED-luminaires.	noted and text added: . When the factors LENI or AECI are used in Tasks 3&4, it will be important to define corresponding factors Fhi & Fhour in Task 7 for scenario calculations.

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	Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
8	2	2.1.2.2	137	Power, capacity, operating ours and factors ……..	see note 90: *For example when low CRI HPS lamps are substituted by higher CRI LED it is probably possible to install less LED lumens than the HPS lumens before. In some LFL applications the directionality of LED tubes also allows to reduce the installed lumens. (assumption from VHK made in MELISA)* This is a dangerous suggestion, there is no difference in LED lumens and HPS lumens.	Please remove sentence.	agreed text deleted
9	2	2.1.2.3	139	Cost information	In this respect MELISA data for lighting system calculation are not usable. We could agree with the proposed option 2 to account for these deficiencies.		noted
10	2	2.1.3	141	Determination of MELISA's system parameters	*The 'involved' shares should be determined based on trends in lighting system 'sales' and on trends in the type of systems installed (i.e. influence is on sales, flux or hours).* This type of information can probably only be provided by professionals working in the sector, any information from stakeholders is welcome).	Fsales: The calculation for the lighting systems based upon the sales of light sources will be incorrect. However based upon current data availability it is considered that this will give the best result within the bounds of possible accuracy. Fphi: Optimization can in limited cases lead to less light points. But very often this will not be the case, because the geometry of the space does require a certain positioning of the luminaires to secure uniformity and prevent glare.	noted
11	2	2.2	141	general	Data 'light sources' (Annex C) and 'ballast and control gear' (Annex D) have been checked against LightingEurope Pooling data. For luminaires there is no such pooling data available.		noted

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	Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
12	2	2.2.1	141	Introduction	The lighting system consideration should only be focused on prof. application in office, industrial and street lighting. To cover the residential at the moment should avoided.		noted
13	2	2.2.1	141	Introduction	The scope of this study should be very clear: are lighting systems for residential buildings part of this study or not?	If out and to avoid confusion, to delete information related to residential buildings (e.g. 2.2.10)	no , residential systems are not in the scope.
14	2	2.2.6	147	Sales and stock of dimmers and other control devices	*It should be noted that these light control sales figures cannot directly be linked to the scope as defined in Task 1, for example those for residential application are not within the scope.* Any additional sales information on lighting controllers provided by professionals within the sector, is welcome.	Our estimation of stock (= today's park): 5-10% of lighting in non-residential buildings is controlled and 5-7% of street lighting is controlled.	Thanks added
15	2	2.2.9	149	Table 2-4	In general it seems difficult to get a realistic figure of EU-28 non-residential building area. Available market research studies show different results. It is also difficult to compare different studies without having clarity on the definitions belonging to the different categories. However when comparing 'Task 0' and 'Current' analysis with industry own estimations, we consider the 'Task 0' figures (6Gm2) as too low. We recognize that market size of industry ≈ retail ≈ offices. As a result we believe the 'Current Analysis' (12Gm2) reflects better the market estimation.	Use 'Current analysis' market estimation figures as basis for further calculations.	Thanks added
16	2	2.2.9	150	Table 2-5	It is difficult to check the subdivision	Consider to add definitions, this will	

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					without having clarity on the definitions belonging to the different types of space.	simplify comparison with other data sources.	
17	2	2.2.9	150	Cross check 1	EN 12464-1:2007 does not exist. This has to be 2002 or 2011.	Please change accordingly.	corrected (2011)
18	2	2.2.9	150	Cross check 1	When considering the required lighting capacity (lm) at task level only: there is a serious risk that the vertical illuminance of walls, horizontal illuminance of ceilings and cylindrical illuminance of objects/faces are neglected. From a lighting design perspective this is highly undesirable.	Going forward please consider to introduce a correction factor: 1,4 for cell office and 1,25 for open plan office.	noted This is for cross chening only.
19	2	2.2.9	151	Cross check 2	Going forward the installed lighting power (W/m2) completely neglects the effect of lighting controls, which is the core of the lighting system study.	Please clarify how this is integrated in both Fphi and Fhours factors?	Note: control are added later. This is for MELISA cross checking
20	2	2.2.9	151	Cross check 2	MF needs to linked to lifetime (0.8 is roughly based L90 for LED) – 60 lm/W is okay for installed (TL) base but rather low for new technologies.	Going forward please consider 2 options: MF + lm/W values for TL solutions and MF + lm/W values for LED based solutions.	For further scenario's and hence LED we will not use his approach any further
21	2	2.2.9	153	Cross check 3	*Establishing the operating hours for each room/space type: EN 15193 ≠ MELISA.*	Please follow/refer to the EN 15193-1 standardized operating hour values. Adjust the MELISA values accordingly.	Cross check is updated
22	2	2.2.11	158	Table 2-1	Table number is inconsistent: 2.8 – 2.1 – 2.9	Change numbering of tables.	corrected
23	2	2.2.11	158	Table 2-1	There seems some inconsistencies between table 2-1, table 2-13 and the table in the original ERS file. Trigger is that we believe that the type 'other roads' is 70 to 80% of EU total road network, which is not the case in Table 2-1. (EU-28 calculations based on original ERS file results in Motorways 1% -	Please double-check data table 2-1, table 2-13 with data original ERS file.	tables will be updated

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					Main roads national 5% - Secondary/regional roads 25% - Other roads 69%)		
24	2	2.2.11	158	Table 2-1	Linking European Road Federation classification to EN 13201 lighting classes in as proposed is too quick.	We believe that some further refinement between 'secondary' and 'other' roads is required. See proposal under chapter 3 comments.	This data will be updated with input for Task 3
25	2	2.2.12	159	Generic economic and MELISA model data conclusion	More accurate building stock data from stakeholders is welcome.	Individual companies do have market estimations too but are hesitating to share details since the business model of 3rd party market research is that parties pay for the data. You could also check the NEEAP reports on building renovations: https://ec.europa.eu/energy/en/topics/energy-efficiency-directive/buildings-under-eed Quick and dirty cross-check can be that you calculate m2 per inhabitant for a set of countries where you trust your data and then multiply this with # EU28 inhabitants?	The referred report is the one that was used in Task 0 (6Gm²), which is low.
26	2	2.2.13.1	161	2007 installed base lighting control (lot 8)	What is never mentioned is that optimised lamps and luminaires already reduce the energy demand of a lighting system to a rather low level and that in turn the automatic control gear also requires some power (usually for 8760h/a), which at least partly offsets the energy savings achieved during office hours.	Adding controls to lighting typically reduces energy consumption by about 30%, due to reducing light when daylight is available and switching off when nobody is present. However the controls consume some energy. As worst case average number about 1W per luminaire can be used (see reference data below). Assume a 30W office luminaire (high end LED lighting) operated for 10	text updated This data is also useful for taks 3.

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	Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
						hours a day = 300W/hrs * 5days a week = 1500W/hrs Energy saving in office application is about 30% = 90W/hrs * 5 days a week = 450W/hrs Standby losses in case luminaires are powered 24/7 will be 12 hours a day = 14W/hrs * 5 days a week + weekend = 118W/hrs Adding controls will result in 22% additional energy saving (instead of the initial 30%) when taking into account stand-by losses of controls. We have to be aware that In many indoor applications the power is switched off during the night and weekend, so energy saving will be higher. For many outdoor applications the lighting is often switched centrally, so these installations are not powered during the day and as a consequence do not have standby losses. Typical data: Indoor controls: - Controls embedded in luminaire typically have 1W standby losses. - Standalone controls controlling multiple luminaire are in the order of 2-4W. For 4 luminaires controlled by one controller this would mean 1W standby per luminaire. Outdoor controls:	

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	Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
						- As said outdoor lighting is often switched centrally, so these installations are not powered during the day and as a consequence do not have standby losses.	
27	2	2.2.13.1	162	2007 installed base lighting control (lot 8)	*The data sources on control gear are old (1999-2007) and it is likely that the current situation changed to higher degrees of automation.* Any new source of information on the current status is welcome.	We don't have more recent figures that show penetration of controls.	notred
28	2	2.3.1.2.2	169	Impacts of GPP on	It seems that the implication of the GPP for lighting systems was not so surprising on the other hand there was no led in it. In this respect the GPP now will be revised.		noted
29	2	2.4.2	174	Disposal and dismantling cost	To consider: extra material for luminaires? Light poles?	We suggest to await current running Circular Economy Package discussions with the European Commission.	noted. In this study no further elements will be incorporated.
30	2	2.5.2	175	Barriers and opportunities from economical / commercial perspective	*The added complexity of lighting system design can provide an incentive or added value for energy service companies (ESCO's) when they combine technical knowledge with financial capacities. The ESCO business model could become a one-stop shop including lighting systems that enable builders, developers, owners, operators and occupants of buildings to purchase energy efficient light. An ESCO might be well placed to offer a single-point access to a full range of services from product sourcing to design, financing and installation.* Any other suggestions from stakeholders is welcome.	We believe this area is not exclusive to ESCO's. Please change proposed text: The added complexity of lighting system design *and lack of budget for energy efficient lighting systems* can provide an incentive or added value *not only* for energy service companies (ESCO's) *but for lighting producers too* when they combine technical knowledge with financial capacities. The ~~ESCO~~ *They* could become a one-stop shop including lighting systems that enable builders, developers, owners, operators and occupants of buildings to purchase energy efficient light. *Lighting producers and/or* ESCO's might be well placed to offer a single-point access to a full range of services *from lighting*	text updated

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	Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
						audits, to design, financing, installation, operation, maintenance and end-of contact management of the installation (circular economy).	
31	Annex C+D			general	Data of 'light sources' and 'ballast and control gear' have been checked against LightingEurope Pooling data. For luminaires there is no such pooling data available. Forecast of lamps and ballasts markets is based on market models that calculate the market size based on the replacement markets (installed base x lifetime x burning hours) + the initial market based on estimated luminaires sales.		noted
32	Annex C		11	general	We see the European Prof conventional Lamps market (TL, HID, CFLni) show a decline of 15-20% per year; and it looks like the decline is accelerating.	There might be no market for conventional lamps in 2025 – maybe some very special purpose lamps that cannot be replaced by LED (e.g. high temp. environments).	MELISA is updated after consulting Lighting Europe
33	Annex C		11	Table 0-1	VITO/LightingEurope Pooling T8 tri-phosphor – 204M/148M T5 New – 67M/57M T5 Old 21M/11M	Given estimated high coverage of LightingEurope Lamps pooling, we think that the consultant's estimate is rather high but not completely off.	noted
34	Annex C		11	Table 0-1	VITO/LightingEurope Pooling LED Tubes – 9M/8M	Seems in line.	noted
35	Annex C		14	Table 0-3	VITO/LightingEurope Pooling HID HPM – 2M/3.5M HID HPS – 13M/12M HID MH – 20M/16M	Seems in line.	noted
36	Annex C		14	Table 0-3	VITO/LightingEurope Pooling LED HID lamps replacement is hardly there yet.	1M looks high.	noted
37	Annex C		16	Table 0-5	VITO/LightingEurope Pooling CFLni – 66M/62M	Seems in line.	noted

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	Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
38	Annex C		16	Table 0-5	LED CFLni lamps was not/hardly available in 2015.	Seems about zero market.	
39	Annex C		16	Table 0-5	CFLni is not really a residential market – mostly prof	16M for residential looks high.	
40	Annex D		24	Table 0-11	Magnetic ballasts 2013 EU-28: 602M LE pooling: 2013 sales of ballasts (excluding those in luminaires) is 30M since most EM-ballasts are banned.	This is a big difference, please double check.	
41	Annex D		25	Table 0-12	Electronic ballast 2013 EU-28: 68M this figure is in line with LightingEurope Pooling data.	Seems in line with remark that market is declining at an increasing pace as LED takes over.	

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DG ENER Lot 37: Ecodesign Preparatory Study on Lighting Systems Tasks 3-4

Organization: LightingEurope	Name: Chiara Briatore	Date: April 8th 2016

#	Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
1	3	3.1.2	178	Reference lighting system designs and lighting schemes for use in this study	*If considered necessary, depending on the outcomes of later Tasks 2 and 4 new reference applications can be added in a later version of this report, for example if some innovations or impact cannot be covered with the current selection.* Stakeholders are also invited to present additional sources of data.	See comments below: LightingEurope is proposing an alternative set of reference designs and WC-MS-BAT-BNAT scenarios for both indoor and outdoor situations. We believe this alternative set much better / more significant reflect the current practice. We suggest to plan a meeting with the objective to agree upon a final set of reference designs and scenarios. Based on the final set we could offer support in verifying/tweaking/adding different assumptions and parameters used.	adapted A meeting with LE was planned, as a result of that the reference designs and options were reviewed. LE provided Dialux design files for the BC and improvement options
2	3	3.1.2	178	Selection of reference designs for indoor	Based on table 2-5 (chapter 2) we suggest to add one reference design to the office application. This will further improve the impact of the chosen reference designs.	Add following reference design to office application: **Office** Circulation area/corridors - Downlights (size: 14.4 * 2.4*2.8m)	adapted New reference designs are used
3	3	3.1.2	178	Selection of reference designs for indoor	Based on EU-28 m2 table 2-4 (chapter 2) we suggest to further improve the impact of the chosen reference designs by adding 2 more applications: retail and industry.	Add following applications / reference designs: **Retail:** - Fashion store – e.g. spots on track (size: 10*30*4m) - Hypermarket (high space) – e.g. trunking cross aisles (size:	Those reference designs were used (except the Fashion store because good quality lighting design cannot be quantified with EN 12464-1 and is outside the scope)

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#	Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
						80*100*6.5) - Supermarket mid height – e.g. trunking in aisles (size: 30*40*4m) - DIY stores – e.g. high/mid bay luminaires (size: 80*100*6.5m) **Industry:** - Warehouse (high racks) – e.g. trunking (size: 70*100* 14m) - Open space high– e.g. high bay luminaires (size: 56*112*12m) Open space mid height– e.g. waterproof luminaires (size: 56*28*7m)	
4	3	3.1.2	178	Selection of reference designs for outdoor	In general linking European Road Federation 'road type' classification to EN 13201 'lighting classes' seems a good approach. However the proposal reflected in table 2-13 of chapter 2 requires some further refinement including small tweaks in the proposed lighting classes.	We believe some further refinement in the road types 'Secondary or regional roads' and 'Other roads' is required in order to select the right set of impactful reference designs for outdoor. Split 'Secondary or regional roads' into - 'Rural streets' - 'Streets with mixed traffic' Split 'Other roads' into - 'Streets with mixed traffic' - 'Residential streets' See ANNEX I for matrix with tweaked road types / lighting classes.	adopted
5	3	3.1.2.1	179	DIALux	For indoor lighting design DIALux 4.xx is still the standard, not DIALux evo.	Revert reference design calculations to Dialux 4.12.	agreed, moved to Dialux 4.12 for indoor lighting designs
6	3	3.1.2.1	179	Reference designs	There seems inconsistency between parameters mentioned in chapter 3 text and the ones used in the DIALux files (e.g. maintenance factor).	Please remove inconsistencies.	maintenance factor will not be used in this section and a single reference will be used as much as possible
7	3	3.1.2.1	179	Primary functional unit	A primary functional unit (see definition in Task 1) of 500 lx per hour is mentioned. How does this relate to	Please clarify.	this is reviewed, zones per reference design are introduced.

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#	Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
					controls/zoning etc?		
8	3	3.1.2.1	179	Space Height Ration	A Space Height Ration (SHR) of 1 implies fixed spacing, is this the case?	Please clarify.	Agreed and deleted
9	3	3.1.2.1	179	Luminaire spacing	There seems a discrepancy in luminaire spacing between study fig 3-2 and DIALux calculation (4 vs 6 luminaires)	Please check.	this is an illustrative Figure but not fixed
10	3	3.1.2.3	180	Daylight calculations	Window seems not very representative w.r.t. daylight calculations.	Please check if this impacts final calculations.	this section is updated, nevertheless daylight is difficult to quantify but has a large impact
11	3	3.1.2.5	181>	Reference designs	Outdoor reference designs should be based on EN 13201-2:2015. Current calculations are based on DIALux evo5.	Please use DIALux evo6 that will be launched soon and includes 2015 revision of EN 13201.	Reviewed
12	3	3.1.2.5	181>	Reference designs	There seems inconsistency between parameters mentioned in chapter 3 text and the ones used in the DIALux files (e.g. mounting height).	Please remove inconsistencies.	All designs are reviewed and recalculated with input from LE
13	3	3.1.2.5	181>	Reference designs	Some parameters used in the DIALux files are missing in chapter 3 text (e.g. overhang and tilt angle).	Please add these to the chapter 3 text.	see previous
14	3	3.1.2.5	181	Motorized road traffic class M3	*EIR (Edge Illumination Ratio on edge 3.5 m width) (edge illumination ratio): 0.5* (Should this be applied to the emergency lane?) *Requirements on the emergency lane (TBD)* With regards to the emergency lane and EIR the proposal is: C4 class lighting on the emergency lane (3 metre width) Because there are C4 class requirements on the emergency lane no EIR (=0) requirements are needed. The benefit of this approach is that UF data of the lot 9 study can be used. *Note: we are aware that different approaches are used in Member States but think this is a reasonable working compromise for this study.*	EIR should be applied to the emergency lane. EIR indicates the visibility of objects off the main roadway. Defining the emergency lane as class C4 does not negate this requirement although it potentially makes it easier to achieve the correct EIR value. A person may be present within the emergency lane and has to be suitably visible from the main carriageway.	all requirements are updated

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15	3	3.1.2.5	181	Motorized road traffic class M3	For luminance calculations (example M3) R3 road surface model has been used.	We propose to calculate with C2 road surface model (with Q0=0.07) which is more widely used over Europe.	agreed, adapted
16	3	3.1.2.5	181	Motorized road traffic class M3	*UF data of lot 9 study can be used.* Be aware that the Utilsation Factor (UF) is heavily under discussion. In CEN/TC 169 the EN 13021-6 on how to apply the UF is under development. The European Commission have published M485 asking to propose a table of energy efficient utilization factors (UF) for different roads.	Make a statement that both these activities have to be strongly aligned.	Noted statement on EN 13201-6 added
17	3	3.2.1.1	184	Energy of indoor lighting systems according to EN 15193	Figure 3-6 implies a control system only implements constant illuminance. A control system adds many more control functions that are relevant to energy efficiency	Add additional control functions such as presence/absence and daylight controls	picture has been updated and hopefully this function are more highlighted
18	3	3.2.1.2.3	190	Daylight dependency factor	Note that DIALux does not necessarily calculate this factor identically to the standard EN 15193 as DIALux calculates according to the actual configuration and orientation of the space and its windows.		noted. Velux Vizualizer software will be used that complies with the standard.
19	3	3.2.1.2.4	190	CLO	Constant Light Output has been implemented in the new EN 15193.	Consider to mention the concept in the study.	this is added in the text and Task 4 calculations
20	3	3.2.1.3	191	LF	LF=LB+LC For professional applications LF is not a usual metric to express lifetime.	Please take out LF and refer to LB in case of gradual degradation and LC for abrupt failures.	corrected
21	3	3.2.1.3	193	Influence of maintenance factors	*Sometimes manufacturers only supply a single value per luminaire, e.g. L80F50 is 50000 h, and therefore tables or tools are needed to extrapolate values for the application.* Stakeholders are invited to supply such tools.	IEC standards do not allow to make interpolation between 2 values. In practice, linear interpolation between 0 hours (100%) and Lx at YY hours is used but we are not favour of interpolation, because the values are product (luminaire level) specific.	noted

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						We propose to take the values that are published per product, e.g. L70B50, L80B50 and L90B50. Often project specific values will be calculated on request.	Task 4 will use typical per product data
22	3	3.2.1.4	193	Utilance	Utilance ignores all benefits of vertical illuminance. So this is not a very good indicator of luminaire efficiency. Having LENI, how many alternative indicators do we need?	Please only refer to LENI.	Noted: A paragraph is added on meaning and limitations of Utilance.
23	3	3.2.1.4	193	Figure 3-9	Size of open plan 3x cell (but rotated). Cell and open plan often extensions of each other and still modular, so the window should be on the same side. In other words, x3 in both directions in not relevant.	Multiply x4 in window direction, x2 in other direction (resulting in 14.4x10.8 (now they use half modules)	discussed in a meeting on defining the reference designs. (consistency with past lot 8 was selected)
24	3	3.2.1.4	194	Use parameters influencing the lighting system utilance Table 3.6	In general current modern offices may be assumed to have reflectances of ceiling: 80% and walls 60%. The values of 70% and 50% are historical but office environments are cleaner and materials, especially ceiling tiles, tend to be lighter. Whilst a 20% floor reflectance is low it has least impact of all the reflecting surfaces and is the common value used across all reflectance combinations in standard tables.		noted and text updated
25	3	3.2.1.5	195	Over-dimensioning task areas with high illuminance requirements	In a study by Barry Wilde Associates for office spaces it was shown that primary reference plane tasks (desks) occupied typically less than 25% of total floor space with secondary reference plane tasks (filing, etc.) occupying less than 8%. The rest of the space was circulation, etc.	Increase the estimation for dimming to 50% (there will be some overlap where specific luminaires are lighting both primary and secondary tasks and circulation space)	noted. The areas are now more precisely defined in the new reference designs and are also more in line with these findings
26	3	3.2.2	196	Temperature effect	Temperature effects for TL is already	Consider not to include this	

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#	Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
					corrected in photometry (LOR). For LED temperature effects are completely different.	parameter.	
27	3	3.2.2	197	Energy consumption of indoor lighting system in the use phase not yet covered in prEN 15193	*Conclusions and values used for this study:* It is proposed to neglect conduct of an assessment within this study of the losses associated with deviations in the operating conditions of luminaires from those specified in the standard discussed because more precise data and evidence is missing and also taking these effects into account is not common practice.	Agreed. For indoor these may be safely ignored – do not over complicate the discussion.	noted
28	3	3.2.2	198	Energy consumption of indoor lighting system in the use phase not yet covered in EN 15193	*With respect to the assumptions regarding the working or operating hours, however, a sensitivity analysis could be done in Task 7 to assess the impact on Life Cycle Cost.* Although data for this is still missing.		noted
29	3	3.2.2	198	Energy consumption of indoor lighting system in the use phase not yet covered in EN 15193	*Weather conditions, currently taken from Frankfurt (Lattitude 50,0°), can also be modified to Stockholm (Lattitude 59.7°) and Athens(Lattitude 37.9°) in a sensitivity analysis to be done in Task 7.* Do stakeholders agree?	We don't have a clear opinion here, sensitivity analysis would make sense.	noted
30	3	3.2.3.1	198	Energy of road lighting system according to EN 13201	Figure 3-10 implies a control system only implements constant light output. A control system adds many more control functions that are relevant to energy efficiency	Add additional control functions such as presence/absence, dimming and daylight controls (as opposed to switching via a time clock)	Figure is updated
31	3	3.2.3.1	198	Energy of road lighting systems according to EN 13201	The indicator AECI comes from the EN13201:2015 part 5. It is important to Understand that the AECI shouldn't be used alone, but next to the other indicator PDI (Power Density Indicator) also mentioned in part 5.	Make sure AECI is always used in combination with Lighting Power Density.	Text and figure are updated and it should be more clear now.

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Stakeholder comments form

#	Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
					The AECI is Wh per m² per year. If you don't connect it to the power density (W per m² per lux), which gives the correlation with the application, then it can say everything. Basically, just take a minimum of watts and you will have the lowest possible AECI.		
32	3	3.2.4	205	Mesopic vision and MOVE project	The MOVE project and TC1-58 have both finished a long time ago. Conclusion of the research on the practical applicability of mesopic photometry is that in areas equipped with road lighting, the user is never adapted so 'deep' into the mesopic region, to make these effects practically relevant. Where it could be relevant, the user still needs to be able to accomplish his foveal eye tasks (those performed while looking directly at something) and these do not profit from a mesopic effect, as there are no rods in the fovea, only cones.	Change conclusion: ~~As a consequence, at low light levels or so called 'mesopic view conditions' photometric values such as lamp efficacy or luminance could be corrected.~~ Conclusion of the research on the practical applicability of mesopic photometry is that in areas equipped with road lighting, the user is never adapted so 'deep' into the mesopic region, to make these effects practically relevant.	noted
33	3	3.2.4	205	Energy consumption of road lighting in the use phase that is not yet covered EN 13201-5	*Weather conditions: TBW.* *Traffic density: TBW.* (Input required: might be related to EN 13201-1?)	Weather conditions: this brings in additional complexity so we suggest for the purpose of this study to neglect these parameters. Traffic density is already part of the road class determination.	agreed and deleted
34	3	3.2.4	205	Energy consumption of road lighting in the use phase that is not yet covered EN 13201-5	*Conclusions and values used for this study:* It is proposed to neglect in this study the losses due to deviations in operating conditions of luminaires and light colour from the standard conditions, as discussed, because more precise data and evidence is missing	Agreed. Also consider with car headlamps that on high speed roads the lit distance is generally less than the stopping distance without additional road lighting. On slower roads the mixed traffic can mean some users are not in	text added

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Stakeholder comments form

#	Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
					and also taking these effects into account is not a common practice.	a car and do not benefit from having headlamps. Therefore the use of car headlamps for road lighting is difficult and the decision should be to light or not light a road based upon a risk assessment and irrespective of car headlamps.	
35	3	3.3.1	205	Heat replacement effect in buildings	*TBW* (An example/reference building with full EN 15193 calculation and a monthly energy balance would be welcome).	Not available.	noted and therefore will not be considered.
36	3	3.3.2	205	Impact on the cooling loads in buildings	*TBW* (An example/reference building with full EN 15193 calculation and a monthly energy balance would be welcome).	Not available.	noted and therefore will not be considered.
37	3	3.4.1.1	206	Economic lifetime of indoor lighting installations	For LED luminaires the calculation will be different and therefore the typical lifetime of an installation may be different. However for an office an assumed 50,000 hours life 20 years is approximately correct.	To note.	note added
38	3	3.4.1.2	206	Economic lifetime of road lighting installations	30 years average is mentioned which is true for conventional technology. LED based outdoor luminaires have been designed for 12.5K years (50K hrs.) to 25 years (100K hrs.)	Change 30 years into 25 years for outdoor luminaires.	text added and expected economic life time of 22,5 years introduced for LED road lighting installations.
39	3	3.4.4	208	tspot	**tspot** = is the period for a spot replacement of a lamp or an abrupt failure of an LED luminaire.	Be aware that **tspot** will be a different value for lamp, LED, ballast or driver.	corrected and increased to 10 minutes because LED is most relevant for this study

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40	3	3.4.4	209		In this study a Ballast Failure Rate (BFR) of 0.2 % is used for electronic ballasts. With expected lifetimes of 50 to 100K hours for LED based luminaires this 0.2% BFR seems rather low.	0.1% per 1000hrs seems more realistic and in line with LED driver specs.	added
41	3	3.4.4	209	LED driver	The lifetime of electronic ballasts or control gear decreases strongly if the working temperature exceeds the indicated working temperature in reality.	It should be mentioned that the opposite is valid too: the lifetime increases at lower working temperature. This is often the case for outdoor luminaires.	added
42	3	3.5.1	210	EN 15193	The intent of EN 15193 is not to optimize energy savings, as the highest energy saving is not by definition the best lighting installation. The standard even states that "This standard does not cover lighting requirements, the design of lighting systems, the planning of lighting installations, the characteristics of lighting equipment (lamps, control gear and luminaires) and systems used for display lighting, desk lighting or luminaires built into furniture."	Maybe obsolete to say: please do not optimize based on energy efficiency alone!	noted
43	3	3.5.9	215	Light pollution and sky glow	*Supposed trend in preventing light pollution by using high (> 3000K) CCT lights.* People are concerned about using blue-rich outdoor lighting, because they fear it may impact their biological clock or while it provides more scatter in the atmosphere than lower CCT lighting. People also experience more discomfort from high CCT lights. There seems also to be a trend in	Light pollution is a discussion that still has a lot of open issues. Be careful with adding supposed trends.	noted

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					certain countries to use low CCT (2000 K) or amber LED lighting mimicking the old HPS feel.		
44	3	3.5.12	218	Non visual	Non visual effects might be a part of the update of EN12464-1 (NWIP)	To note.	noted
45	3	3.6	218	Recommendations	This chapter seems to be most important and should be mainly driven by LE. Finally the commissioners will mainly decide on that.	This is to be underlined and VITO should focus on that.	noted and issue for Task 7.
46	4	intro	219	Best	*Best is highest environmental performance of the product.* On what level? Highly efficient does not mean best installation.	Please add sentence: *Lighting designs are according to minimum EN 12464-1 and/or EN 13201-1 requirements.*	Such a statement is added
47	4	4.1.1-4	221>	Indoor WC-MS-BAT-BNAT	current use cases WC: T8 EM – no controls MS: T8/T5 EL – no controls BAT: LED – controls There is quite a gap between proposed MS and BAT use cases. We propose further refinement. For a clear reference we also added a category <u>current base</u> reflecting todays installed base. We believe the alternative set of improvement scenarios (use cases) much better / more significant reflect the current practice.	Consider alternative use cases: **Office** - <u>Current base: T8</u> - WC: T5 - MS: LED - BAT: LED + controls (occupancy + daylight) - BNAT: LED + controls + non-lighting data connected <u>Non-lighting data connected</u>: linked to e.g. BMS so further synergies/savings based on adjacent sector data can be achieved.	in consultation with LE new use cases were introduced. Current base case BATLED .. (see update)
48	4	4.1.1-4	221>	Indoor WC-MS-BAT-BNAT	In case proposed reference designs for additional applications (see comment #3) are accepted, further improvement scenarios (use cases) are needed.	Consider following use cases: **Retail** - <u>Current base</u>: T8/halogen	see previous (new applications are also introduced accordingly)

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#	Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
					For a clear reference we also added a category current base reflecting todays installed base.	- WC: T5/CDM - MS: LED - BAT: LED + controls (occupancy + daylight) - BNAT: LED + controls + non-lighting data connected **Industry** - Current base: T8/HPS - WC: T5/CDM - MS: LED - BAT: LED + controls (occupancy + daylight) - BNAT: LED + controls + non-lighting data connected Non-lighting data connected: linked to e.g. BMS so further synergies/savings based on adjacent sector data can be achieved.	
49	4	4.1.5-7	227>	Outdoor WC-MS-BAT-BNAT	current use cases WC: HPS - IP2x MS: HPS - IP5x BAT: LED - IP6x Some further refinement of scenarios is required to improve reflectance of market situation. We believe the alternative set of improvement scenarios (use cases) much better / more significant reflect the current practice.	**Road lighting** - Current base: HPS/CFLni - WC: HPS/CDM/CFLni - MS: LED + luminaire based controls - BAT: LED + remote controls and monitoring (CMS) control monitoring system - BNAT: LED + controls + non-lighting data connected Non-lighting data connected: further synergies/savings based on adjacent sector data can be achieved.	see previous taken into account in the update
50	4	4.1.3.1	225	BATref control system level indoor	*The expected impact on product price for BAT control system following the definitions of EN 15193.* Stakeholders are invited to provide input.	We suggest first agree on final set of reference designs and scenarios before we dig into the details.	Noted

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51	4	4.1.3.1	225	BATref control system level indoor	*Special systems such as light guides or others sensors can be discussed in a separate section. Light guides, as opposed to louvres, will contribute to more daylight and could therefore be seen as part of the lighting system.* Stakeholders can provide input on this.	The calculation of energy performance of lighting with respect to dynamic facades (such as automatic louvres) is extremely complex and difficult for a standardised methodology. Typically this would be modelled for a specific building and location using more specialised daylighting software.	noted no text added
52	4	4.1.3.2	225	BATref control gear or ballast indoor	*The expected impact on product price of this solution.* Stakeholders are invited to provide input.	We suggest first agree on final set of reference designs and scenarios before we dig into the details.	a separate meeting was set up to agree on a final set of applications, prices were sourced as explained in the study
53	4	4.1.3.3	226	BATref luminaire and lamp efficacy indoor	*The expected luminaire price for this solution is:* *Suspended: 250 + X euro* *Ceiling mounted: 250 + X euro* (This price includes design services)	We suggest first agree on final set of reference designs and scenarios before we dig into the details.	a separate meeting was set up to agree on a final set of applications, prices were sourced as explained in the study
54	4	4.1.3.5	227	Bat area	In many office spaces it is not necessary to light the circulation spaces as the task lighting to the task(s) provides enough overspill to light the circulation areas sufficiently.	To note.	noted, taken into account in the optimized designs as much as possible
55	4	4.1.3.5	227	Other BAT options at installation level indoor	*BAT design01:* *This is an individual design with high grade LED luminaires and higher reflecting wall surfaces that has been calculated with Dialux software. Afterwards the Dialux results were entered in the spreadsheets. In the spreadsheet there is an option to work with calculated illuminance values.* Stakeholders are invited to supply similar Dialux design solutions, to be discussed in the stakeholder meeting.	We suggest first agree on final set of reference designs and scenarios before we dig into the details.	a separate meeting was set up to agree on a final set of applications and BAT designs were developed accordingly
56	4	4.1.4	227	BNAT or low energy using indoor lighting systems	*Approach: In this section on BNAT or low energy use systems we are discussing the best systems that are under development but not on a stage*	Non-lighting data connected: further synergies/savings based on adjacent sector data can be achieved. See scenarios.	in the final version text has been updated taking this into account.

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					of development which allows market introduction. They could also be used in later sections for modelling the impact of any future policy measures, to be considered if another category needs to be introduced for this in the event that this is deemed relevant and that data is available. Stakeholders are invited to provide input such as ideas or calculated reference designs.		
57	4	4.1.5.2	228	WC luminaire and lamp efficacy outdoor	So far poles are not included.	That is correct since the replacement cycle of poles ≠ luminaires.	noted and text updated
58	4	4.1.6.2	230	MAINSTREAM luminaire and lamp efficacy outdoor	So far poles are not included.	That is correct since the replacement cycle of poles ≠ luminaires.	noted
59	4	4.1.7.1	231	BATref control system and control gear level outdoor	*The expected impact on product price:* 50 euro per luminaire?	For luminaire based controls this seems realistic rule of thumb.	
60	4	4.1.7.2	231	BATref luminaire and lamp efficacy outdoor	*The expected luminaire price for this solution is: Road class M: 1000 euro (excl. VAT) Road class C: 750 euro (excl. VAT) Road class P: 500 euro (excl. VAT)* It is assumed that this price includes the design and calculation service.	We don't recognise that the cost for a lighting design are included in the price of the luminaire.	OK, adopted
61	4	4.1.7.3	232	BATref installation outdoor	*The Utilance (U) will be based on software calculations. A Dialux file with the reference design will be available for this purpose, calculated average maintained illuminance for the areas can be introduced in the project spreadsheet.* Stakeholder can provide input.	We suggest first agree on final set of reference designs and scenarios before we dig into the details.	a separate meeting was set up to agree on a final set of applications, text has been updated accordingly
62	4	4.1.7.4	232	BAT other installation	*BAT case01 for application Motorized Road M3: In this application a specific street lighting design was calculated*	We suggest first agree on final set of reference designs and scenarios before we dig into the details.	a separate meeting was set up to agree on a final set of applications, text has been updated accordingly

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#	Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
					with Dialux based on LED luminaires and entered in the spreadsheet. Stakeholders are invited to supply similar Dialux design solutions, to be discussed in the stakeholder meeting.		
63	4	4.1.7.5	232	BNAT outdoor installation	*Other solutions under development can be proposed herein.* Stakeholders are invited to supply information.	Non-lighting data connected: further synergies/savings based on adjacent sector data can be achieved. See scenarios.	a separate meeting was set up to agree on a final set of applications and improvement scenarios, text has been updated accordingly
64	4	4.2	233	Production, distribution and End of Life	*Much of the design work is does not consume materials and has to be done by local designers and installers with little need for transport. Lighting Systems are not disposed of as a whole but is related to disposal of the components. Therefore it is assumed that this is covered by the MELISA model from the Light Sources study.* This means that other factors will be neglected, such as wall painting, light poles, cabling, etc.	Agreed – do not over complicate the discussion.	noted
65	4	4.3	233	Summary of lighting system technical solutions and technical improvement options	*Table 4-1 also includes some expenditure factors sourced from prEN15193 and supplementary factors included in this study. These expenditure factors can provide insight into how far sublevels are optimised compared to the benchmark. This could be further elaborated and documented in the final version.* Is this useful?	It can be for those who understand expenditure factors. We have to be aware that these values are calculated rather than measured. However expenditure factors are compared to a nominal BAT configuration. Therefore there is a risk that the comparison system parameters become better than the reference system which is not a problem but needs user comprehension.	Noted. But in order to not useless overcomplicate the study this data is not included in the final version.
66	4	4.3	234	Light source efficacy	This improvement is not only related to the improvement of the light source efficacy but is due to a combination of several improvement options.	It is good to mention that next to light source efficacy following parameters are relevant: thermal- and optical losses of the luminaire, quality of the light distribution, (for outdoor) optimised installation parameters	noted. stressed again in the final version.

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#	Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
						optimization (overhang-tilt), lighting class selection for lighting design.	
67	4	4.3 Summary	234	Table 4-1	This table with the values must be checked carefully by experts. It is essential for further considerations	More to involve stakeholders or figures from the market. It could be that from authorities responsible for buildings statistic could be contacted by VITO.	noted. Review was done based in design inputs from LE. However accurate non-residential buidling statistics still could contribute to increased quality of results and future efforts for colllecting this could be encouraged in Task 7.
68	4	4.3 Summary	235	Table 4-2	This table is difficult to understand and the values must be checked carefully by experts. It is essential for further considerations	Consider to simplify this table. More to involve stakeholders or figures from the market. It could be that from authorities responsible for buildings statistic could be contacted by VITO.	Table is reviewed and simplified graphics are added to illustrate the outcomes of Task 4 in the summary.

Stakeholder comments form

ANNEX I Matrix road types / lighting classes TWEAKED

VITO	Motorways	Main or national roads	Secondary or regional roads		Other roads	
	68.251 km	281.095 km	1.410.180 km		3.543.979 km	
	M3	M3	C3		P3	
Lighting Europe	**Motorways**	**Motorized traffic roads**	**Rural roads**	**Streets with mixed traffic**	**Streets with mixed traffic**	**Residential streets**
length	68.251 km	281.095 km	846.108 (60%)	564.072 (40%)	1.417.592 (40%)	2.126.387 (60%)
	M2 central arrangement 2 x 3 lanes	M3 single-side arrangement 2 lanes	M4 single-side arrangement 2 lanes	C3 (20%) opposite arrangement 2x3 lanes M4 (80%) single-side arrangement 2 lanes	P2 single-side arrangement 2 lanes	P4 (50%) staggered arrangement 2 lanes+kerbs M5 (50%) single-side arrangement 2 lanes

VITO reply: Thanks for providing this input. This table has served to update the market data in Task 2 and select the new reference designs in the review of Task 4.

ANNEX K MINUTES OF THE STAKEHOLDER MEETING

Distribution: General

Date :	9/03/2016	Ref.	Final version
From :	Dominic Ectors	Annex(es):	- Presentation stakeholder meeting - Draft report of Tasks 0 – 4 (see http://ecodesign-lightingsystems.eu/documents)
To :	Ruben Kubiak; ENER Lot 37 Stakeholders		
Copy :	Paul Van Tichelen, Dominic Ectors, Marcel Stevens, Paul Waide		

Minutes of stakeholder meeting for the ecodesign preparatory study Lot 37 – Lighting systems

CCAB Building, Brussels, March 8, 2016

Present	Name	abbr.
European Commission		
DG ENERGY	Ruben Kubiak	RK
Project Team		
VITO	Paul Van Tichelen	PVT
Paul Waide Consulting	Paul Waide	PW
VITO	Dominic Ectors	DE
VITO	Marcel Stevens	MS
Stakeholders		
Anec/BEUC		AB
Belgium		BE
CECAPI		CEC
CLASP		CLA
Denmark		DK
ECOS		ECO
Eu.bac		EUB
Germany		DE
IALD		IAL
ICF		ICC
Italy		SE
LightingEurope		LE
Society of Light and Lighting (CIBSE)		CIB
Sony Europe		SON
Sweden		SE
The Netherlands		NL

Final version
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Distribution: General

Topten International Services	TOP
United Kingdom	UK
VOLTA	VOL

Objective of the meeting

Stakeholder consultation in the framework of a study with regard to Ecodesign of Lighting Systems (Lot 37) accomplished under the authority of DG Enterprise of the European Commission (EC), under specific contract N° ENER/C3/2012-418 Lot 1/06/SI2.668525, within the multiple framework service contract N° ENER/C3/2012-418 Lot 1, preparatory studies and related technical assistance on specific product groups.

The main objective was to discuss the technical aspects related to the study (Task 0-4 report) and to present the next steps of the study.

Note: complementary to this minutes of the meeting the meeting powerpoint presentation can be consulted

Agenda

- Welcome
- Short presentation of participants
- Short introduction to the MEErP & project planning
- Task 1, scope + standards & comments
- Task 1, EU policy + voluntary initiatives in place (Paul Waide)
- Draft Task 2 + comments
- Break &lunch
- Draft Task 3 + comments
- Draft Task 4 + comments
- Any other business
- Planning stakeholder feedback and finalization

Minutes

- **Short presentation of participants (all)**

After all participants presented themselves, RK gave a short overview where the study is heading at. VITO and Paul Waide are main contractors on this study. This is not a full preparatory study, because the lighting systems are complex topic. Tasks 0, 1, 2 , 3, 4 and partially 7 as indicated by the MEErP will be delivered. By the end of the year the study must be finished. The EC will then decide to go ahead or not based upon the study and to figure out the best way to use the study. Is Ecodesign the right policy tool, or is it energy labelling or EPBD (Energy performance of Buildings Directive) or something completely new? Or do we wait a bit longer to see how the technology develops?
Next RK gives some details on what's going on in the Ecodesign preparatory study on lighting products. There was a consultation forum on the beginning of December 2015. The EC received a lot of comments. The impact assessment process is started, which will run from 6 to 12 months, but the process might be slower than previously anticipated, because)the Commission is waiting for the energy labelling regulation to be agreed on by council and parliament, and the energy efficiency unit is stretched on resources.

abbr.	Comment/answer

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SE	Five years ago we discussed lighting system legislation. Have you draw anything from what was discussed then (using system legislation or EPBD)?
RK	It is related. The outcomes of these discussions were the background to decide to have a dedicated study on the topic. It is a very complex topic and that's why the preparatory study will take a long time. And we hope when the study has finished that we have a better idea how to tackle it.

- **Short introduction to the ecodesign directive MEErP (PVT)**

See stakeholder meeting presentation slides 4 till 7

abbr.	Comment/answer
LE	Slide 6: Can you clarify application data ?
PVT	That are the calculations based upon reference designs.

- **Task 1 (PVT)**

See stakeholder meeting presentation slides 8 till 21

abbr.	Comment/answer
PVT	Slide 10: The focus of this study is on automation (lighting control) and design.
BE	Slide 12: What is the difference between control gear and controls?
PVT	Control gear is the hardware that drives the lamp. The controls are the lighting controls or control systems. It is how you control the lighting.
LE	Slide 14: You said you didn't use the full set of parameters for the lighting quality indoor. Why didn't you for instance consider cylindrical illuminance? In certain cases it gives you the need to install mode power to avoid shades on faces like in class rooms. So at the end of the study you may have too low level of benchmark values not considering the proper level for quality in certain applications.
PVT	I will consider it in the updated version. Agreed that the flux code (from data in the past) is a simplification unable to have this quality parameters.
LE	That is the key point of the story. Once you are designing a lighting scheme and you are not considering these kind of parameters then you can have a low level of power consumption, having a certain illuminance on a horizontal level. Once you have to create the proper level of illuminance in the vertical plane you need also to improve the quality of the product.
PVT	I will include it in the update. It is important t cross check this parameter and it is now possible to calculate cylindrical illuminance in the Dialux software.
IAL	There is a semantic problem. What we are talking about is not lighting 'quality' but lighting quantities these are things with different natures. Lighting quality is more than quantity and we don't have a specific method of measuring quality. I have a problem talking about lighting quality. If people are going to get an expectation about that what's going to be delivered, and all we are now dealing with these lighting quantities.
PVT	Indeed. It is important that there are 'measureable lighting requirements' which is not necessarily the same as 'lighting quality'. People can have a different level of interpretation regarding 'lighting quality'. I have noted it from your comments(IALD comments received)..
IALD	Slide 14: The majority of the lighting studies is done for horizontal illuminance , however this is a bad measure for quality of light in an architectural sense. Even here (the meeting room) all the walls are dark. If we regulate for only horizontal illuminance, we will end up regulating in a way it is easy to make very bad lighting and difficult to make good lighting.
PVT	We have noted it. And it is a topic that have to be taken into account in task 7 policy measures: that there should be enough margin and that we should check that there is no collateral damage from policy.

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CLASP	Slide 15: Why did you deviated from the standards? You used different terminology or definitions? When you started today you said you would try to harmonize and be as consistent as possible with the standards.
PVT	I don't deviate in a deep way from the standards. What I use are the draft standard proposals. I copy this terminology from these standards, but they are not finished and not all standards are updated. I also try to keep consistency between indoor and outdoor standards. In any case with the definitions in task 1 they are traceable to the standards and the things that may different are symbols and acronyms (reason: in the European standards these were changed and in the revision process that runned parallel to this study).
LE	Slide 17: To inform you: in working group 12 we agreed to keep the useful utilance (UU) out of the draft standard propasal(EN13201-part 6).(reason: the standard should not overlap with the contents of EN13201-part 5). Once you have a standard with a calculation method for the energy efficiency of the system, then that standard should be the only one. The useful utilance is part of the literature in the lighting sector and is ok to have it in your study.
PVT	We include in the study as much as possible. For the end value it is not so relevant, but for the understanding and the analyses and the decomposition of improvement options that are useful ideas I would like to maintain in the study.
DK	S17: to my opinion EN13201-part 6 of the standard is no longer in coherence with the mandate of the standard. We identified a need for tackling overlighting but it is compensated by the CL parameter(EN 13201-5), a factor for fitting to the requirements. Part 6 is mandate for the regulation 245 for a most efficient utilization factor. We defined this Useful Utilance as the most energy efficient utilization factor to be used for documentation according to regulation 245.
PVT	Indeed. We discussed the mandates in task 1. There is a mandate for the utilance. It is already partially incorporated the factor CL in part 5 of the standard.
PVT	Slide 18: Measurement standards: there is a standard specifying the requirements for lighting of indoor work places: 12464-1. But it specifies a measurement method that requires a lot of work having to perform many point-to-point measurements on a grid. Paul is wondering if this is done in the field, or that in practice just a few points are measured?
IAL	We as designers had to prove in several occasions the performance of our systems to whatever standard asked for and the only way to do this a grid of point-by-point measurements. Standards for that exist, currently there is no better way of doing this. Digital photography could be an option but this will give us not illuminance data, but luminance data and that would require resetting the standards to luminance based. We would be in favour of this, but that is a long way down the road. For now we have to use point by point on a grid as defined.
PVT	That is much work. I doubt many people do that. A simple way could be to check a minimum value, e.g. if the average should be 500 lx with 60 % uniformity check only for a minimum of 300 lux for instance in a few points.
IAL	That really doesn't work. You cannot just check a few points. You cannot go for a minimum, this is not practical. To get the minimum you have to check a lot of points to get the minimum. We cannot shortcut this at the moment with the current technology and the current measures. We have to follow what the industry standards are, which are grid measurements. This will give problems for people who are looking for compliance. It happens a lot more in emergency lighting than in normal lighting. Because emergency lighting tends to be checked for conformance to statutes and regulation in a lot of countries.
CIB	Sometimes the scheme will not meet the criteria and the only way finding out what the reason is, is by doing some common sense methods; are the luminaires delivering the expected? are the designs correct? But I agree they are not used that often.

Final version
4

Distribution: General

vito
vision on technology

- **Task 1 (PW): Policies**

See stakeholder meeting presentation slides 22 till 61. Paul Waide explains the policies in place, the EU legislation and the voluntary initiatives.

abbr.	Comment/answer
PW	Slide 61: concerning street lighting design regulation or guidelines we are aware of a Royal decree in Spain, a guideline the Netherland and a standard in Italy, but there may be other regulations or guidelines we haven't heard of. Appeal to the stakeholder group: if you are aware of other regulations of guidelines we haven't mention, please inform us so we can include it in Task1.

- **Task 0 (PVT): screening**

See stakeholder meeting presentation slide 62. Also included is a Task 0: a first screening. The outcome was that the focus is on non-residential and specific application areas. Depending on the figures in task 2 we may add additional reference designs when a certain application area is important. This is a rough calculation and the figures will be updated later.

- **Task 2 (PVT): Market**

See stakeholder meeting presentation slides 62 till 75. Task 2 collects the market data.

abbr.	Comment/answer
PVT	Slide 67 – 72 : cross-checks: the most obvious way to do this is by multiplying the LENI value by the area (m²) and this will result in a certain amount of TWh per year. For roads one can use the road length and road width to obtain the area. Eurostat does not provide the non-residential area data, and these values have to be estimated. We see a substantial difference between the BPIE and the VHK data on the amount of area. So this can be one of the parameters that have to be evaluated. Using the large value (11773 Mm²) the outcome is 13kWh/(m².y) and this figure is very low. Compared with the TEK tool this would mean that on average we are in the green zone. Also compared to what is required with the UK building legislation this would mean that the stock on average is in line with their requirements. So this has to be checked. Parameters (see slide 72) to be checked are (see slide 72): operating hours, stock area, total power consumption, stock illumination level, area estimates, and combination with Daylight factor. We are open for more input data.
IAL	Obviously this data is insufficient to perform this task properly. Maybe we can ask the commission to find some funding to do some proper surveys to find out what is installed now. Otherwise if we go forward with so much uncertainty there is no likelihood of getting good regulations at the end.
RK	Thanks for the suggestion but points out that this is not usually done, because of the very high costs involved and time needed for a survey to cover the whole EU. Further, the modelling approach is a common and accepted methodology in policy making..
PVT	We could add a recommendation to Eurostat to collect and process such data. Of course some uncertainty will always be present and should not stop us from continue the study or deciding on policy. We work with the data that we have, but if you can help us

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	increasing the accuracy of the data is very welcome.
PW	If some stakeholders have national data, while it is only national, this would be useful to perform crosschecks. So please share this kind of information.
SE	We did that kind of audits in 2005-2008, statistically correct, and is was very expensive (10MUero). We are considering updating this data doing a quick assessment doing some enquiries. I agree, the data should not prevent us from doing something.
TOP	The stock area data seems to have the most influence on the final result. Do you have more information on the difference between these 2 figures? Are there other sources to verify this?
PVT	In the past study the stock is calculated from the sales, lifetime and operational hours. Changing the operational hours has also an impact on the payback time, ROI will take longer. It is quite a substantial change, so we don't like to change it (operational hours parameter) too much. The main input is the sales, average wattage and the lifetime of the lamp. There might be a relation between these parameters and the stock area data. Now more field data is needed, and in task 7 we can see how to react on this.
DK	There might be uncertainty in the data, but the data may still be quite useful anyhow, because the important thing is to identify the potentials. Which part of the lighting system has to highest potential for energy savings. It doesn't need to be so accurate. Most of the parameter are relative correct to each other. In task 7 there will be a sensitivity analysis to take this uncertainty in this data into account.
PVT	Indeed, the sensitivity analysis will take this uncertainty into account, of course I want to limit this uncertainty as much as possible.
SE	Checking the reports there was a wide spread in operational hours from 500 hours till 4000. That is quite large uncertainty.
PVT	You sometimes finds explanations why the operational hours can be lower. People may use daylight more than calculated in the standard way. Or the light may be switched on at a lower level.
SE	We checked buildings with the same technical installations and areas and we found large variations. In many times it was due to the building management. The management awareness is really important.
IAL	Slide 75 comments: I think there is a problem using LENI and regulation on lamp efficiency. If we are looking at systems, LENI is the systems measure. The lamp efficiency is going to run on its own. If we are targeting something to measure and to regulate on at system level, it has to be on a LENI basis. Making it more complicated than that, is going to make the regulations make no sense to anybody.
PVT	The regulation is more related to LENI. The figures and cross-check are more about background, impact accounting, bookkeeping for the Commission. We don't have to mix both aspects. It is now about impact on 155 TWh for non-residential lighting out of 3500TWh total consumption for Europe..
IAL	This gives me concern, giving the inaccuracy in the accounting process we have here .This could easily get to a situation where we are setting targets which are not achievable within lighting system.
PVT	There are many parameters that can impact the policy measures.
RK	This is not the time to decide if we are going to use LENI, or anything else, in a regulatory measure. But we need consistency with other studies. It is bookkeeping. It is for us important to understand how much can be saved. We do not want to double count. We need to have accurate information for a policymaker to take the right policy decisions. If LENI is the appropriate tool to be used we will do that in the regulation. This is separate from the bookkeeping. I agree we should get the data as good and right as possible to

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	form decisions later on in the policy process. We are on the right track. Also acknowledging that we will never have perfect information, we always have to estimate. Hence, the purpose of this stakeholder meeting is to get as much information as possible.
IAL	We have the lamp regulation 245/2009. What we don't have is a follow up to measure exactly what has happened. All what has happened is not measurement, but statistical or other expectation what the effect might have been. When we get to this stage with this degree of uncertainty, we need to get to position where you have a good, reliable sound basis to make regulation or recommendations. If we create regulation on a basis that isn't correct, and that regulation can't be made to work then we have a problem. We must do proper research on what the current situation is and what has happened since the regulation245/2009.
SE	I disagree with IAL. There are methods to estimate what was before and to evaluate what has happened since 245/2009. You can check the market. You can do an assessment what is in the stock, how it is used.
PVT	Agreed that the impact of 245/2009 will interfere with this study and result in added complexity Of course more price data is welcome, cost of design. Maybe we can do a small enquiry. If you have that or references please apply this to us.

- **Task 3 (PVT): Users**

See stakeholder meeting presentation slides 76 till 96.

abbr.	Comment/answer
CIB	Slide 77: With respect to the references you should add a combination of ceiling mounted luminaires and suspended luminaires. A lot of offices are lit that way.
PVT	Indeed. They reference designs could be merged into a single one.
IAL	S78: Colour of reflecting surfaces. This is mentioned in EN12464-1 recommendations. In practice architects and interior designers are not aware of those recommendations. Changing reflectivity has a huge impact on the overall efficiency of a lighting scheme. Given the way the regulation is going, is there any way foreseen that we could get the people doing the surface finishes think about that? How could those get regulated in?
PVT	The first thing is to demonstrate this impact in our calculation and I think I have that (reflection and also daylight) on board in the spreadsheet. Reflection has indeed an enormous impact on artificial lighting energy use and on daylight.
IAL	The other areas to incorporate are the cylindrical illuminance and illuminance of surfaces. There are specific requirements in the standard now for minimum lighting level at the ceiling and at the walls. These need to be captured as part of the total energy use….
DK	It is possible to count all the flux needed for all the surfaces of the room. So they will be part of the target area, weighted by the requirement of each surface. Further on the cylindrical illuminance, this works like a kind of spatial uniformity. This cannot be counted as spatial flux needed, it is really something about the direction of the light. Of course that will tend to decrease the illumination on task area. However, it is just the same as a requirement of uniformity. … Only if we calculate the annual energy consumption based on the floor area, it is different from the total room surface area (floor, ceiling, walls). That is actual possible to do. It is a new approached we haven't seen before and it is not in the standards.
PVT	We cannot add all the complexity in the study. The cylindrical illuminance parameter is a secondary parameter, a criteria like uniformity. …We should have this story on board..
IAL	Slide 80: Practical application of LENI. There are set values in the LENI document. But there

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	is nothing preventing you from using the correct values for the particular situation you are working in. If we apply LENI we look specifically at what is happening in the particular project in terms of hours of use, patterns of use, patterns of occupation, preset settings and so on. It is a matter of applying the thing properly and doing the work required to do that. If you base it on standards it is a loose standard, but in terms optimizing energy use you should apply it on a case by case basis, which is what the designer should be doing.
PVT	Indeed, you can change the parameters in EN 15193, because there is nothing mentioned in the standard indicating that is not allowed. It is something to add to the study.
CIB	Slide 81: useful daylight index. We seem all be heading away from this as a metric. It has got huge limitations.
PVT	There are indeed many more advanced designs and calculations and the standard heavily simplifies daylight. But nevertheless it gives guidance. It gives you a standard method to compare yourselves to.
IAL	Slide 83:About dimming. We have to design to an end-of-life situation. Everything we design that meets the standard is over-lighting by a significant amount. If we look at a maintenance factor of 0,7 which is probably correct for a 50000 hour LED solution. Then your initial lighting level, initial lighting equipment and initial energy use is going to be monstrous, unless you have control system that corrects this. This is something that has to be mandated, rather than ignored. It does interplay with daylight as well. We need to think how this can be integrated in the rules.
PVT	OK, noted. (it is in factor Fclo in the study)
SE	Regarding outdoor lighting I got a similar comment from a colleague at traffic agency regarding over illuminating to begin with. The consumption was quite high. He was thinking about either having a self reporting system that can measure much more accurate or having more requirements on the lumen maintenance so the slope is less. They noticed that the consumption was higher than expected because of the compensation they introduce in the beginning. Maybe something alike can be introduced here. Some self reporting systems. So control systems could help.
PVT	In the current regulation for HID lamp there are lamp lumen maintenance, that is something to think about. Therefore it is also connected to the other study "light sources".
LE	Slide 86: Question about the weather. The metrological visibility, cloudy.
PVT	The standard simplifies this and assumes overcast sky in the case solar blinds are used, therefore weather has little impact We could simulate this. The figures are rough. When solar blinds are used, direct sunlight is assumed not to be relevant in the standard. (because of shielding)
CIB	Is that not a fundamental mistake? The scenario with an overcast sky is very rare thing. So if we look at how energy is going to be used or the impact of solar gain, we are not starting at the right place to get at the right finish line. If we don't use climate based daylight modelling we are not getting real appreciation on how that space is going to react (things like objects in its view). The daylight factor is brilliant because it is so simple, so intuitive, but it is significantly wrong.
PVT	That is also our experience with daylight systems. We can add more on this in task 3&4.
CIB	A final note: in the UK is now using climate based daylight modelling in all schools, because it is giving them more useful information.
PVT	Slide 90: indirect impact of the use phase - indoor only. What do we do with it in the calculation?
SE	It is very complicated, because it dependents on latitude so much. We try to do it in window labeling, and it is very tricky. Maybe it is out of the scope here. Maybe it easier to have requirements on LENI level and installed power per square meter. There is also the Technology Corporation Project (TCP). They treated the daylight

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	contribution to heating and cooling. Maybe you can consult them.
PVT	For heating and cooling the direct sunlight has more impact. A LENI value on a annual basis is not enough for the people making the energy balance of a building. There are tables in the standard to split up the annual LENI values using the standard weighting factors into monthly basis.
IAL	Slide 91: End-of-Life. This is a typically concern of ours working out effectively this time, and certainly the cost to EoL. If the current draft of the single lighting regulation goes forward, we are going to take a lot of equipment out of use much earlier than would normally be because the lamps will no longer be available. We have a timeline on that regulation for now. Can't you incorporate that timeline into the thinking for the EoL?
PVT	This is a typical scenario issue. We can take that on board when we discuss scenario's in task 7. We should mention it here. ...
LE	Slide 93: Installation times That are a couple of aspects that have to be considered here. First what is the impact of LED technology? Specially in relation to road lighting, you could imagine that there would be no relamping during the lifetime of the product. Indoor: it is not always the EoL of the product that makes that renovation takes place. It's much more linked to the application. For instance in case of hotels or restaurants they will more often renovate their complete installation to make it more modern or better looking and that will not change because we go to LED technology.
PVT	In the past we assumed that Luminaire cleaning might still be needed for outdoor lighting, because it was combined with lamp replacement. Maybe we have to add more repair/cleaning/replacement cases, times and periods. Also the failure of electronic control gear is now assumed as spot replacement and this might be more complex. Maybe more differentiation can be made here.
IAL	Slide 94: Ballast failure. Ballast life isn't any longer connected to the operating life of the lamp. If we have control gear in it, something like DALI, then the ballast is always on. It is hours of life, not hour of lamp operation that need to be taken into account in determining the number of failures that occur over system life
PVT	Yes, that makes it more complicated. Technically speaking the electrolytical capacitor is the weakest component and that is related to the power and not to the control gear. In this case we could keep the simple formula. We can of course mention it. We have the parameter on board and can do such a calculation if we could get good data.
ECO	Slide 96: comments. Question: when you defined the reference lighting applications have you considered integrating the industry and retail sector, which will have very different surrounding conditions and that may influence the economic situation and user behaviour.
PVT	Yes. There is a grey area in the retail sector, and we are aware of that. Not all retail, restaurants do not follow the standard because their objective is to design for what we call ambient lighting, design for atmospheric or artistic lighting. We are aware that we will miss specific areas. It is so specific for each project that we cannot have a good metric for it. We will look in task 7 what we can do with it. This is indeed a grey application area that is non-residential and that is not following what we are doing here.
SE	You didn't touch the new possibilities in the new lighting systems. That is unexplored territory. I'm a bit scared that we are limiting ourselves to too much about the actual applications. We want to put some kind of cap that we don't spend too much normalized to the function, the service it provides. It would be ok for me to actually increase the energy use for lighting if in the same time we provide more services with benefits like security, safety, ambience or cosiness. It would be a mistake if we put a cap on that without considering the new applications and services. It would be a threat towards innovation and new business models we see. It is not a rebound effect.

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PVT	I hope all the ingredients are captured here, and we can see different possibilities.
SE	We must remember that the standards we are working with here are for lighting systems. They are not market requirements. The methods used here take the requirements from the standards, but they might take as well the requirements elsewhere. The methods are proved to work here. We can make some major conclusions from it for identifying improvement potentials. Every lighting system can be put into some requirement that apply for it, and then it can be evaluated in the meaning of efficiency. It is not limited to these standards. It is a general approach that could be used anywhere.
PVT	Noted and to be remind for in task 7.
IAL	Comment: good lighting, good lighting design does not mean high energy consumption. You need to think more carefully about the application, how you use equipment. In a lot of cases it means more equipment and more potential connected load with a higher use of controls to deliver the right light in the right place at the right time. It is important as we go on with this to be careful not to limit potential flexibility which is achieved by say putting twice as much lighting you need but only using half of it at a time. That is important when it comes to flexible retail or office areas. If we want to get to a point where we can discriminate between task area and surrounding area it will make a huge difference in energy use. It is an important thing to think about lighting quality in relation to energy use, not in relation to equipment connected.

- **Task 4 (PVT): Technologies**

See stakeholder meeting presentation slides 97 till 104.

abbr.	Comment/answer
LE	Slide 104: we will also check the concept of Useful Utilance. Utilance is a technical parameter. The approach cannot be the same indoor as outdoor. Indoor is much more difficult, because you have to meet the requirements for the luminance on the wall and the balance of the luminance in some application, which is much more than to lit a task area alone.
PVT	There are indeed limitation with the method that is connected to the floor area, when considering also walls and the ceilings.
LE	The concept that arises from this mathematical and technical parameters is the human centric lighting concept. The human, the people need to be in the proper lighting environment for better activity or well-being. It is much more than to lit the surface.
PVT	Indeed. But an indicator for system efficiency is always difficult. Is there an alternative? We will not mandate a certain utilance. It is a dashboard, an insight that you will have.
DK	Comment on Useful Utilance. It has nothing to do with the light quality as such. It has to do with when you have some requirements set it shows you how efficient the luminance flux from the luminaires are used to meet the requirements.
LE	It is easier for outdoor lighting. It is much more difficult for indoor, because the reference surface is not clear enough.
DK	It can be connected to any surface where there is a requirement. And at the same time supplementary requirements as cylindrical illuminance and uniformities are met. Of course they can only be compared for different installations meeting the same requirements. That is true.
IAL	We agree that utilance numbers are very useful in lighting design to determine what is good and what even is energy efficient. The issue about lighting the surfaces rather than the work target area itself is one that part of the change in the last EN 12464-1. We must not lose sight of the fact that in regulation we are looking at the room space and not just at the task area. It may be even better to ignore the task area in some circumstances and looking at the background lighting level as the target level in designing office spaces and

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	the like. Then it is very easy to add task lighting as a task light to achieve the higher task lighting levels. If we do that we've got immediately one third energy saving, if we change that target, if we change the culture and expectations of people living in offices of having the background level of light and supplementing that with task lighting rather than lighting the whole area to task level.
PVT	Indeed, it is about meeting requirements. The simplification of utilance is only connected to one parameter and one area. If you have more than one design criteria and more than one area, the single value might not be enough to reflect that. Of course it can be indicative for the primary parameter and primary floor area requirement. It is complex to measure how to match multiple criteria with a single performance indicator parameter. Nevertheless we could calculate it based on the main parameter and area?
BE	Question. This is very complex. Is there any straightforward way that any of the knowledge we are building here can be translated into an eco-design measure? From what I see now there is something called lighting systems which may be manufactured by one or more companies. Several component, including manual dimmers, occupancy detectors, the luminaires, you can input in for example the Dialux model and evaluate what illuminance you get on say a horizontal surface in a standard office layout. This illuminance should meet certain requirements for that task or office layout and then you can model the energy efficiency for that. Or should a system be tested in a test lab; and surveillance authorities should redo the test to verify compliance? In the real world there will be different configurations, difficult to capture in one test. A goal might be that every system at least offers the opportunity to either have occupancy detection or good dimming qualities. I guess these are the kind of results we want to have to lower cost and consumption?
PVT	That is an issue for task 7. It is not the goal of this stakeholder meeting to discuss this, but any idea for task 7 can submitted to us.
RK	We are not even sure what the right policy tool will be, if any tool , to regulate lighting systems. We are using the MEErP methodology, based on ecodesign, because this is a tested methodology and appears to be the most proper way to do it. We have to look for the most appropriate policy tool in task 7, but probably also at later stages.

- **Task 7 (PVT):**

See stakeholder meeting presentation slide 106.

abbr.	Comment/answer
-	-

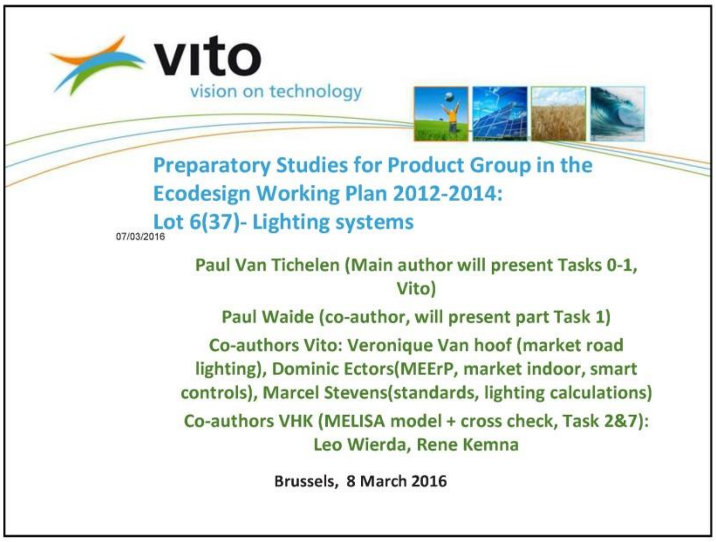
- **Planning (PVT):**

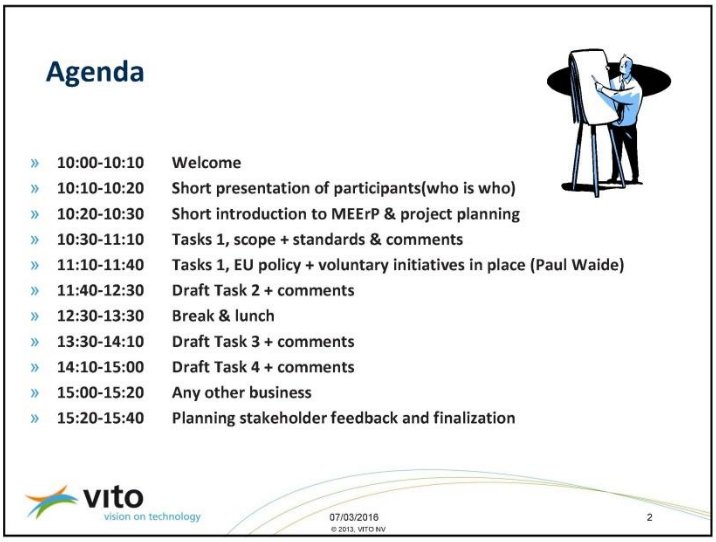
See stakeholder meeting presentation slide7 & 107.

abbr.	Comment/answer
IAL	We probably want to go over our comment submission again and with your comments against it, we will simplify a bit these comments.
ECO	Is the lot number lot 37 or is it lot 6?
RK	It is lot 37. 6 is the number of the contract under our framework contract.

ANNEX L POWERPOINT PRESENTATION OF THE STAKEHOLDER MEETING

07/03/2016





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EC policy officer & VITO Study Team

- EC policy officer: **Ruben Kubiak**
- VITO Preparatory Study Team:
  - **Arnoud Lust**: Contract Manager: FC DG ENER Lot 1
  - **Paul Van Tichelen** (Main author will present Tasks 0-1, Vito)
  - **Paul Waide**, WSE (co-author, will present part Task 1)
  - Co-authors Vito: **Veronique Van hoof** (market road lighting), **Dominic Ectors**(MEErP, market indoor, smart controls), **Marcel Stevens**(standards, lighting calculations)
  - Co-authors VHK (MELISA model + cross check, Task 2&7): **Leo Wierda, Rene Kemna**
  - Website: **Karel Styns** (webmaster).

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Introduction Ecodesign Directive

- Background is the Ecodesign Directive 2009/125/EC:
  - Framework Directive
  - binding requirements through 'Implementing Measures' (EC Regulation ..)
  - For products but it is possible to introduce information requirements for components and sub-assemblies
  - Product groups are first identified in a Working Plan, e.g. in the 2nd working plan year 2012-2014
  - **A preparatory study provides the necessary information to prepare for the next phases in the policy process, a.o.: impact assessment, the consultation forum, ..)**
  - Approach of preparatory study is well defined in the Methodology for the Ecodesign of Energy-related Products (MEErP)
  - Further info: http://ec.europa.eu/enterprise/policies/sustainable-business/ecodesign/index_en.htm

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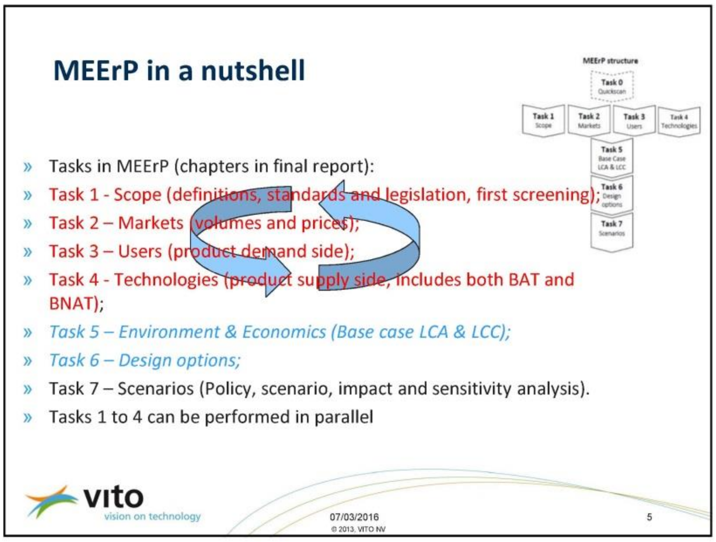
MEErP in a nutshell
MEErP structure
Task 0
Quickscan
Task 1
Scope
Task 2
Markets
Task 3
Users
Task 4
Technologies
Task 5
Base Case
LCA & LCC
Task 6
Design
options
Task 7
Scenarios
» Tasks in MEErP (chapters in final report):
» Task 1 - Scope (definitions, standards and legislation, first screening);
» Task 2 – Markets (volumes and prices);
» Task 3 – Users (product demand side);
» Task 4 - Technologies (product supply side, includes both BAT and BNAT);
» Task 5 – Environment & Economics (Base case LCA & LCC);
» Task 6 – Design options;
» Task 7 – Scenarios (Policy, scenario, impact and sensitivity analysis).
» Tasks 1 to 4 can be performed in parallel
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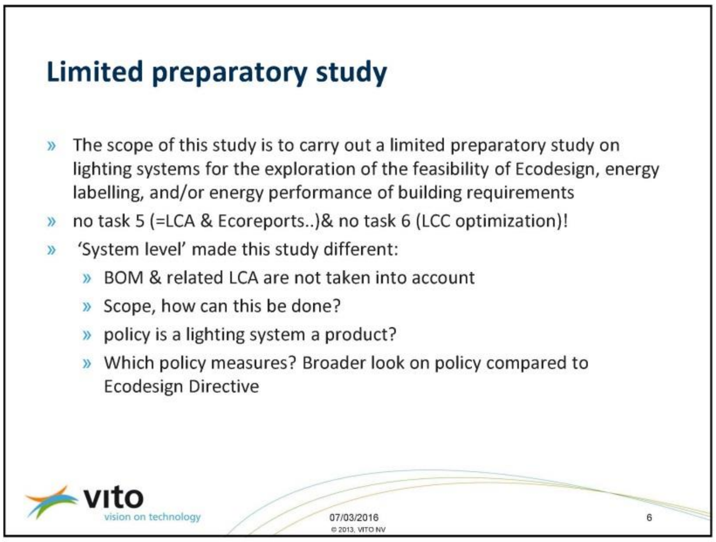
Limited preparatory study
» The scope of this study is to carry out a limited preparatory study on lighting systems for the exploration of the feasibility of Ecodesign, energy labelling, and/or energy performance of building requirements
» no task 5 (=LCA & Ecoreports..)& no task 6 (LCC optimization)!
» 'System level' made this study different:
» BOM & related LCA are not taken into account
» Scope, how can this be done?
» policy is a lighting system a product?
» Which policy measures? Broader look on policy compared to Ecodesign Directive
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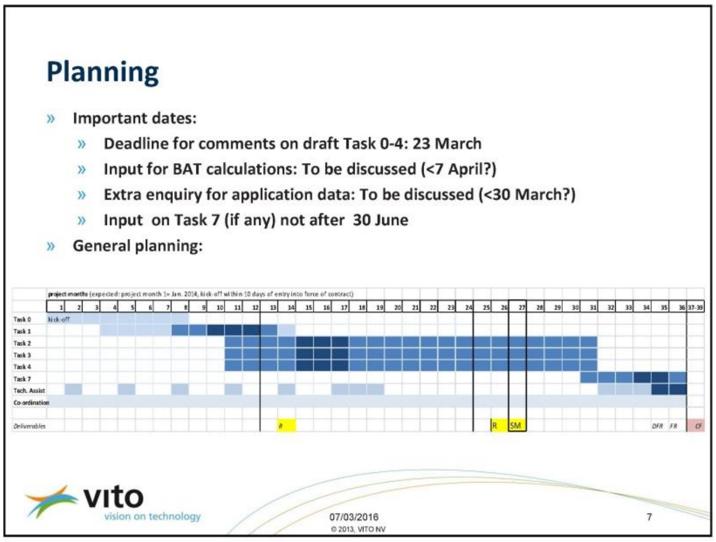
Planning
» Important dates:
» Deadline for comments on draft Task 0-4: 23 March
» Input for BAT calculations: To be discussed (<7 April?)
» Extra enquiry for application data: To be discussed (<30 March?)
» Input on Task 7 (if any) not after 30 June
» General planning:
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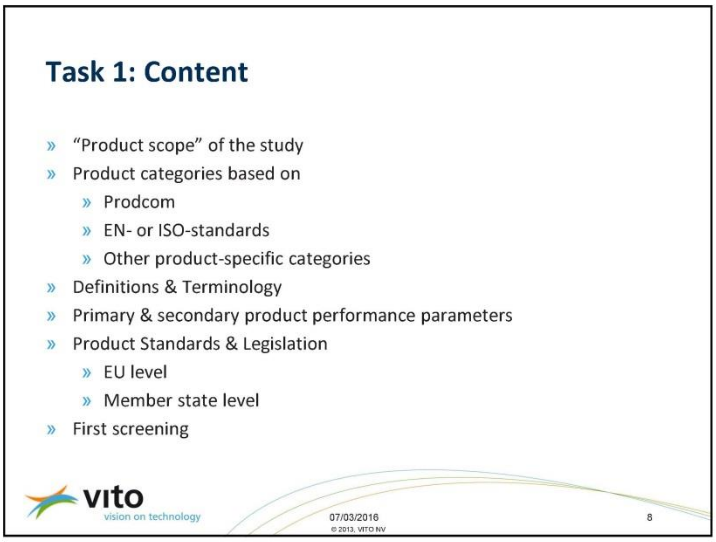
Task 1: Content
» "Product scope" of the study
» Product categories based on
» Prodcom
» EN- or ISO-standards
» Other product-specific categories
» Definitions & Terminology
» Primary & secondary product performance parameters
» Product Standards & Legislation
» EU level
» Member state level
» First screening
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Task 1: Product scope

- **SCOPE: lighting systems that provide illumination to make objects, persons and scenes visible wherein the system design is based on minimum quality parameters as described in European standards EN 12464-1 on lighting of indoor work places and EN 13201 for Road lighting.**

  Excludes:
  - residential, signage & displays (.. works of arts, ..), emergency lighting
  - power cable: because completed lot 8 + should be part IEC(prEN) 60364-1

  pro:
  - A framework of standards is available (EN 12464-1 + EN 15193, EN13201-2 +5)
  - Energy metrics are available, LENI & AECI kWh/(y.m²)

  However:
  - Does not include all area's of light source consumption
  - Unclear how much non-residential area to day really applied EN 12464-1
  - Uncertainties in some EN 15193 reference data estimates (Task 2 & 7)

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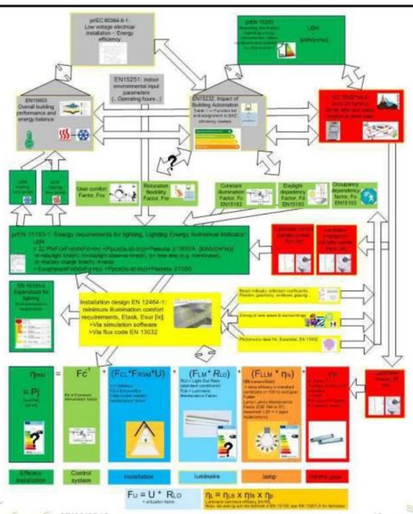
Context indoor lighting



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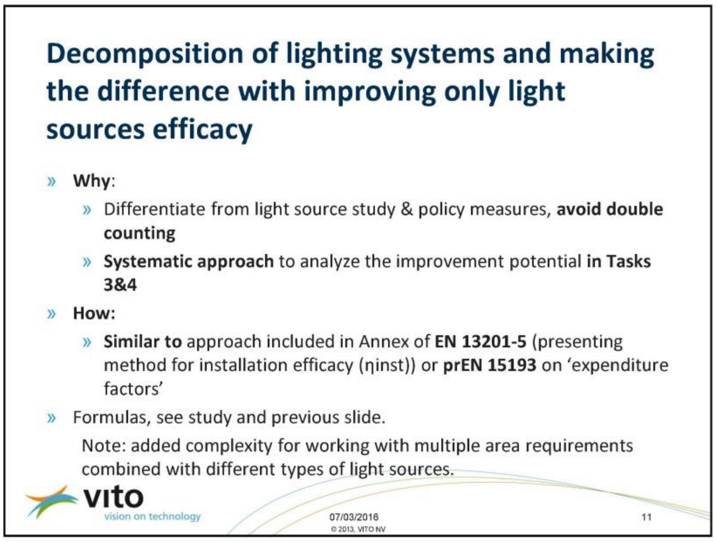
Decomposition of lighting systems and making the difference with improving only light sources efficacy
» Why:
» Differentiate from light source study & policy measures, avoid double counting
» Systematic approach to analyze the improvement potential in Tasks 3&4
» How:
» Similar to approach included in Annex of EN 13201-5 (presenting method for installation efficacy (ηinst)) or prEN 15193 on 'expenditure factors'
» Formulas, see study and previous slide.
Note: added complexity for working with multiple area requirements combined with different types of light sources.
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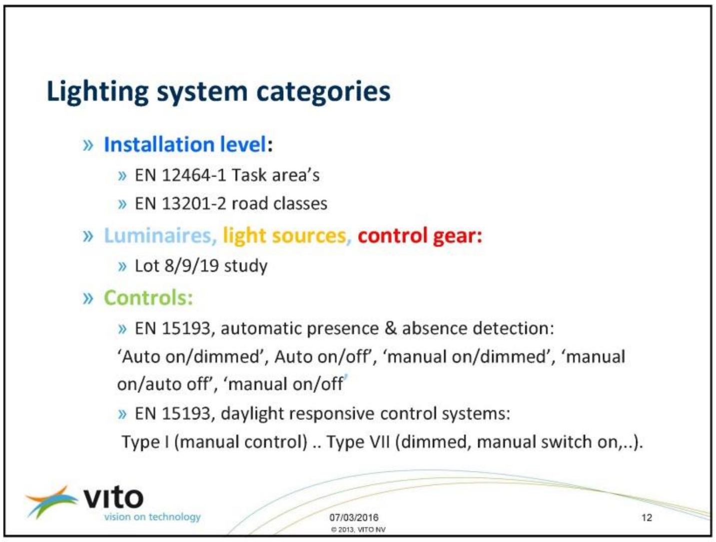
Lighting system categories
» Installation level:
» EN 12464-1 Task area's
» EN 13201-2 road classes
» Luminaires, light sources, control gear:
» Lot 8/9/19 study
» Controls:
» EN 15193, automatic presence & absence detection:
'Auto on/dimmed', Auto on/off', 'manual on/dimmed', 'manual on/auto off', 'manual on/off'
» EN 15193, daylight responsive control systems:
Type I (manual control) .. Type VII (dimmed, manual switch on,..).
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Lighting system categories

- » **Controls:**
  - » Constant illumination control (EN 15193, EN 13201-5)
  - » = Compensates for maintenance factors **+ over illumination compared to the requirement levels**
- » **Lighting systems design and calculation software:**
  - » Software
  - » Software vs flux code EN 13032
  - » File format
- » Communication systems
- » Retrofittable components for luminaires: (see lot 8/9/19)

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Task 1: Product/system performance parameter

» Primary product (circuit) performance paramater or "Functional unit":
minimum required maintained average illumination(Em,min [lx]) as calculated with secondary performance parameters as defined in standards in 1 hour of operation
(alternatively:

- » Secondary for **lighting design requirements**:
  - » Maint. illuminance, Em [1 lx] or Maint. luminance, Lm [1 Cd/m²]
  - » lluminance uniformity, U0
  - » Unified Glare Rating, UGR(indoor) or Threshold Increment, TI (outdoor)
  - » Other: CRI, CCT, hemispherical illuminance, *cylindrical illuminance(add?)*

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Product/system performance parameter

- **Energy performance:**
  - Lighting Energy Numeric Indicator, **LENI [kWh/m²year]** (EN 15193)
  - Annual Energy Consumption Indicator, **AECI or PE [kWh/m²year]**(EN 13201-5)
  - Installation luminous efficacy , η_{inst} [lm/W] (EN 13201-5) in this study extended to indoor similar to proposal for expenditure factors (EN 15193)
  - Lighting power density indictor, PDI or DP[W/(lx.m²) = W/lm
- **Control gear performance**: Maximum luminaire power, Pl [W], Power efficiency of luminaires ηp , Ballast Reliability, BR(?), Ballast gain factor, BGF(?), Ballast maintenance factor, FBM(?)

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Product/system performance parameter

- **lamp/light source parameters:**
  - Luminous efficacy, ηls [lm/W]
  - Lamp Lumen Maintenance Factor, F_{LLM}
  - Lamp Survival Factor, F_{LS}
  - LED module/luminaire rated life, Lx
  - LED module failure fraction, Fy
  - LED luminaire gradual failure fraction, By
  - LED luminaire catastrophic failure rate, Cz
    - How to convert LxFy to FLLM & FLS, tables tools needed?
  - light sources: CRI, CCT, CIE x,y coordinates, SDCM, LGF(keep?)
  - Luminaires: I (light distribution, photometric file), flux code, R_{LO}, R_{LOW} (= reference ballast), IP rating, tp

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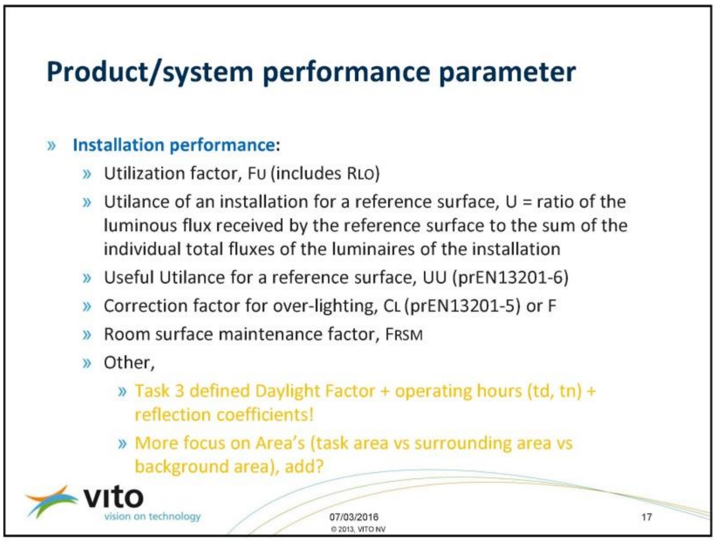
Product/system performance parameter
» Installation performance:
» Utilization factor, FU (includes RLO)
» Utilance of an installation for a reference surface, U = ratio of the luminous flux received by the reference surface to the sum of the individual total fluxes of the luminaires of the installation
» Useful Utilance for a reference surface, UU (prEN13201-6)
» Correction factor for over-lighting, CL (prEN13201-5) or F
» Room surface maintenance factor, FRSM
» Other,
» Task 3 defined Daylight Factor + operating hours (td, tn) + reflection coefficients!
» More focus on Area's (task area vs surrounding area vs background area), add?
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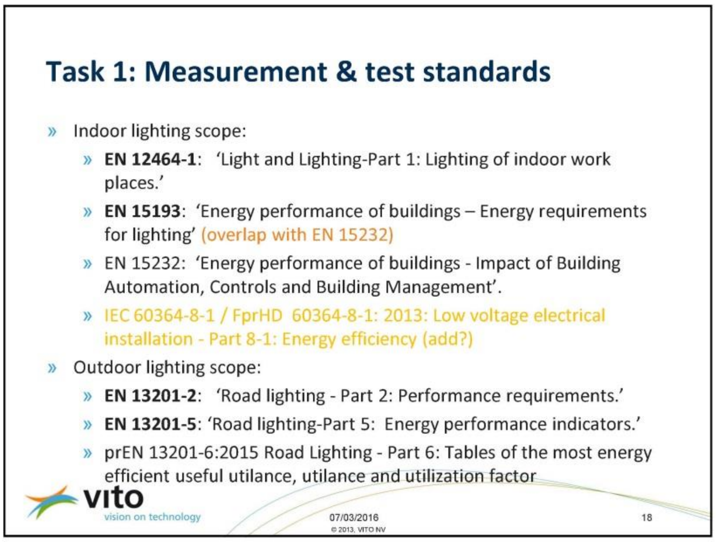
Task 1: Measurement & test standards
» Indoor lighting scope:
» EN 12464-1: 'Light and Lighting-Part 1: Lighting of indoor work places.'
» EN 15193: 'Energy performance of buildings – Energy requirements for lighting' (overlap with EN 15232)
» EN 15232: 'Energy performance of buildings - Impact of Building Automation, Controls and Building Management'.
» IEC 60364-8-1 / FprHD 60364-8-1: 2013: Low voltage electrical installation - Part 8-1: Energy efficiency (add?)
» Outdoor lighting scope:
» EN 13201-2: 'Road lighting - Part 2: Performance requirements.'
» EN 13201-5: 'Road lighting-Part 5: Energy performance indicators.'
» prEN 13201-6:2015 Road Lighting - Part 6: Tables of the most energy efficient useful utilance, utilance and utilization factor
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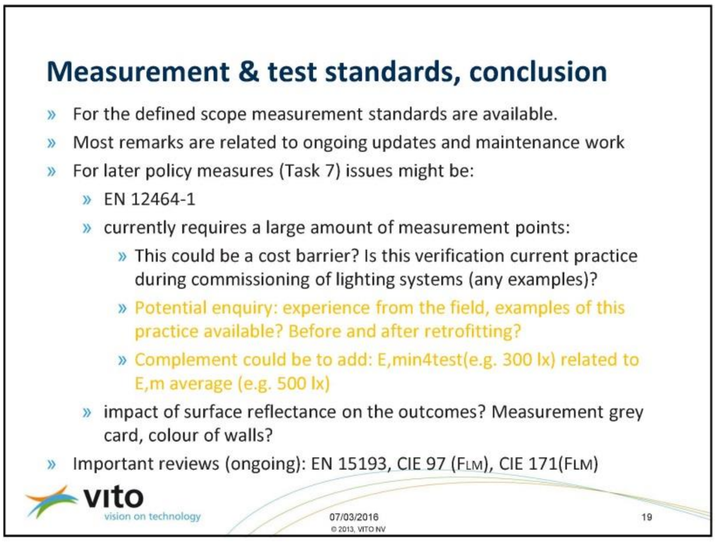
Measurement & test standards, conclusion
» For the defined scope measurement standards are available.
» Most remarks are related to ongoing updates and maintenance work
» For later policy measures (Task 7) issues might be:
» EN 12464-1
» currently requires a large amount of measurement points:
» This could be a cost barrier? Is this verification current practice during commissioning of lighting systems (any examples)?
» Potential enquiry: experience from the field, examples of this practice available? Before and after retrofitting?
» Complement could be to add: E,min4test(e.g. 300 lx) related to E,m average (e.g. 500 lx)
» impact of surface reflectance on the outcomes? Measurement grey card, colour of walls?
» Important reviews (ongoing): EN 15193, CIE 97 (FLM), CIE 171(FLM)
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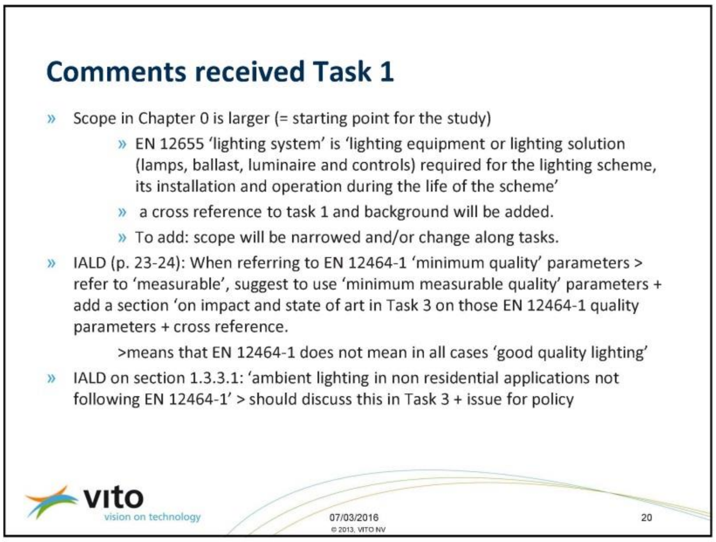
Comments received Task 1
» Scope in Chapter 0 is larger (= starting point for the study)
» EN 12655 'lighting system' is 'lighting equipment or lighting solution (lamps, ballast, luminaire and controls) required for the lighting scheme, its installation and operation during the life of the scheme'
» a cross reference to task 1 and background will be added.
» To add: scope will be narrowed and/or change along tasks.
» IALD (p. 23-24): When referring to EN 12464-1 'minimum quality' parameters > refer to 'measurable', suggest to use 'minimum measurable quality' parameters + add a section 'on impact and state of art in Task 3 on those EN 12464-1 quality parameters + cross reference.
>means that EN 12464-1 does not mean in all cases 'good quality lighting'
» IALD on section 1.3.3.1: 'ambient lighting in non residential applications not following EN 12464-1' > should discuss this in Task 3 + issue for policy
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Comments received Task 1

- IALD (p. 72+73): Add more parameters and info from EN 12464-1 'Mean cylindrical illuminance requirement'..

Short EN 12464-1 measurements missing .. but is there any experience from fully compliant measurements in the field during commissioning of the lighting system?

- CECAPI, EU.BAC, DEA remarks: text corrections
- LE (see AOB powerpoint received):
  - Task 0&1: 'The current report did take into account the majority of the comments submitted by LightingEurope end of May 2015'

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Task 1: Policies in place – EU legislation + voluntary initiatives

There are four EU Directives that could influence the energy efficiency of lighting systems:

- The Ecodesign Directive (ED)
- The Energy Labelling Directive (ELD)
- The Energy Performance in Buildings Directive (EPBD)
- The Energy Efficiency Directive (EED)

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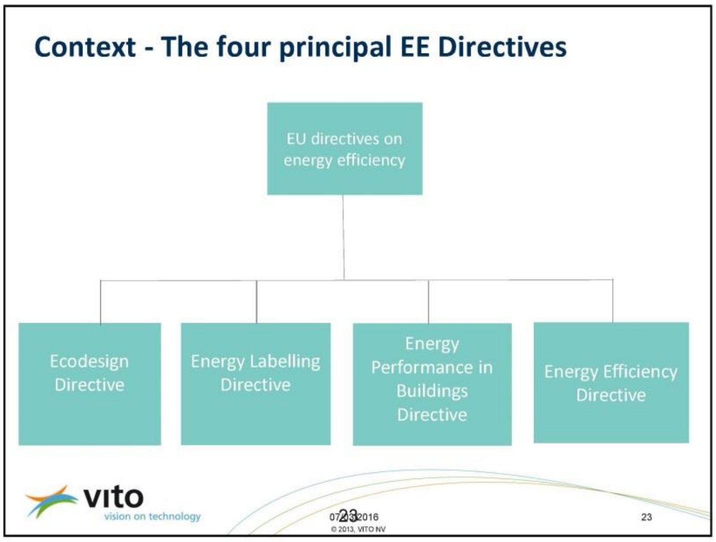

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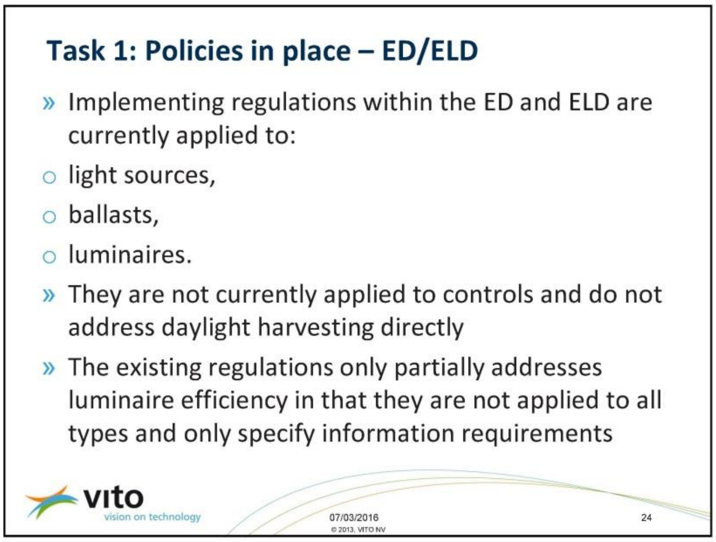

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Task 1: Policies in place – ED/ELD

» Note: In parallel with this study a preparatory study specifically focused on light sources has been conducted

» This should be consulted for more light source product-related information, see:

http://ecodesign-lightsources.eu/

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Task 1: Policies in place – EPBD

Requires:

» Whole-building energy performance standards to be set for new-build and major renovations in both residential and tertiary sector buildings

» These are to be set at a level not weaker than is implied by an assessment of cost-optimality over the building life-cycle

» Whole building energy performance should include the assessment of lighting energy performance within it

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Task 1: Policies in place – EPBD

'major renovation' means the renovation of a building where:

- (a) the total cost of the renovation relating to the building envelope or the technical building systems is higher than 25 % of the value of the building, excluding the value of the land upon which the building is situated; or
- (b) more than 25 % of the surface of the building envelope undergoes renovation;

Note – new build rates are v. low in the EU. Major renovations are more frequent but would still require a long time to affect the installed based of EU lighting systems

Task 1: Policies in place – EPBD Article 8

On Technical Systems (including lighting) requires:

- Member States to set system requirements in respect of the overall energy performance, the proper installation, and the appropriate dimensioning, adjustment and control of the technical building systems which are installed in existing buildings.
- Member States may also apply these system requirements to new buildings.
- System requirements shall be set for new, replacement and upgrading of technical building systems and shall be applied in so far as they are technically, economically and functionally feasible.

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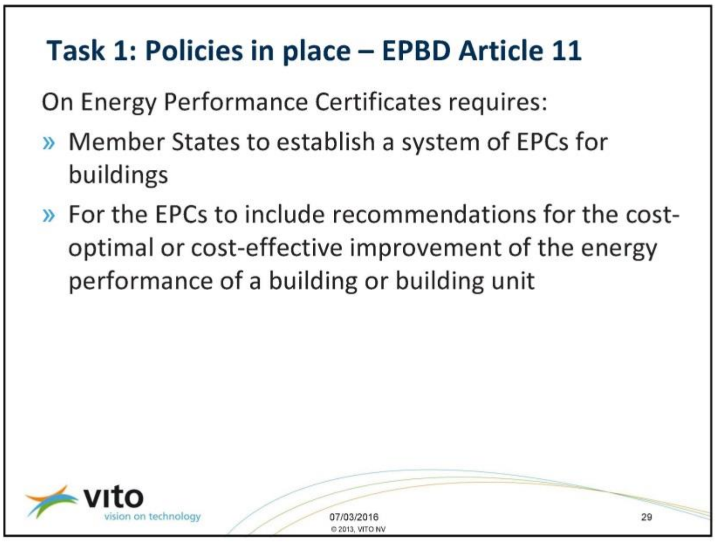
Task 1: Policies in place – EPBD Article 11
On Energy Performance Certificates requires:
» Member States to establish a system of EPCs for buildings
» For the EPCs to include recommendations for the cost-optimal or cost-effective improvement of the energy performance of a building or building unit
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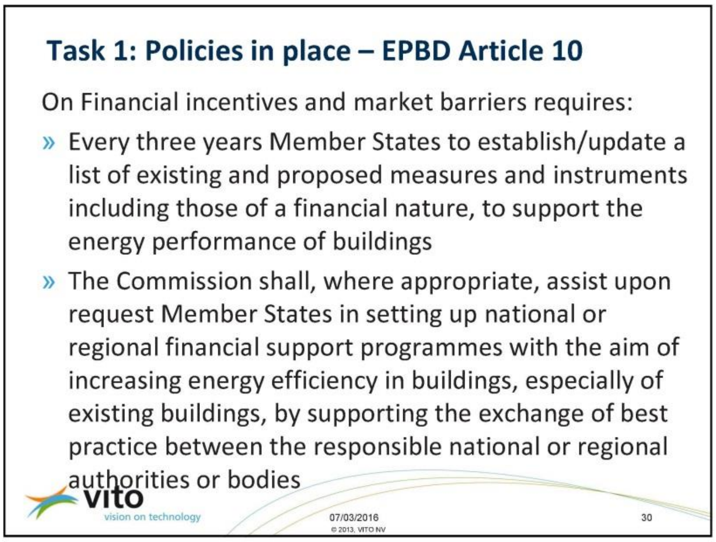
Task 1: Policies in place – EPBD Article 10
On Financial incentives and market barriers requires:
» Every three years Member States to establish/update a list of existing and proposed measures and instruments including those of a financial nature, to support the energy performance of buildings
» The Commission shall, where appropriate, assist upon request Member States in setting up national or regional financial support programmes with the aim of increasing energy efficiency in buildings, especially of existing buildings, by supporting the exchange of best practice between the responsible national or regional authorities or bodies
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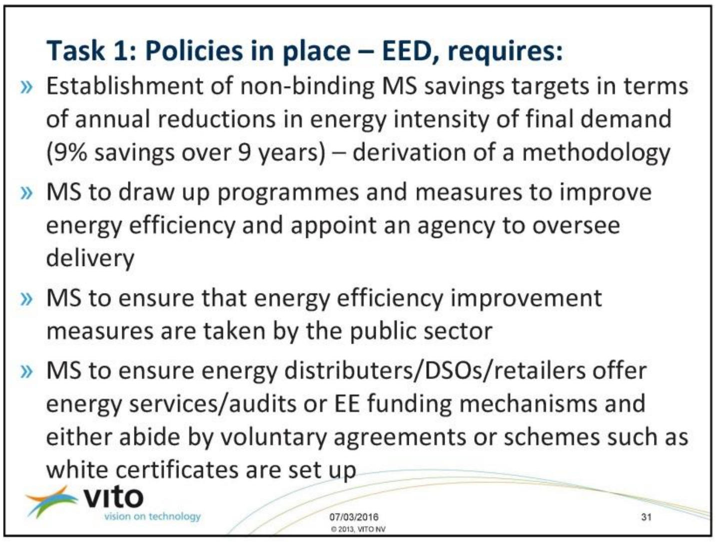
Task 1: Policies in place – EED, requires:
» Establishment of non-binding MS savings targets in terms of annual reductions in energy intensity of final demand (9% savings over 9 years) – derivation of a methodology
» MS to draw up programmes and measures to improve energy efficiency and appoint an agency to oversee delivery
» MS to ensure that energy efficiency improvement measures are taken by the public sector
» MS to ensure energy distributers/DSOs/retailers offer energy services/audits or EE funding mechanisms and either abide by voluntary agreements or schemes such as white certificates are set up
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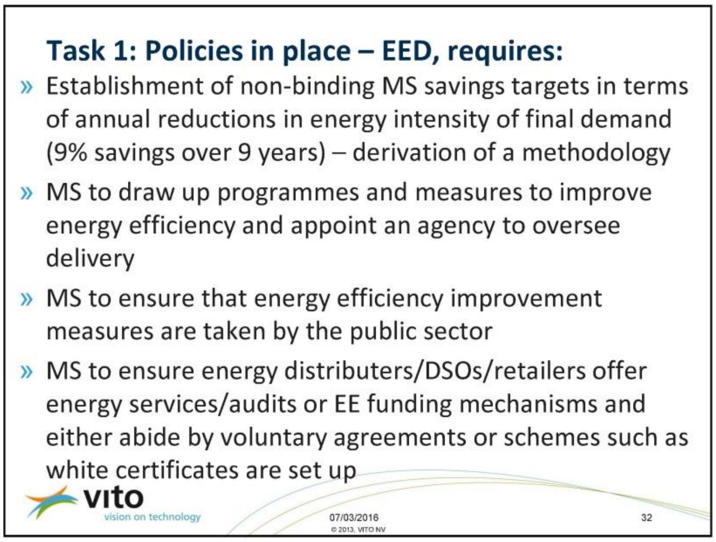
Task 1: Policies in place – EED, requires:
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Article 4 - Building renovation strategy

Provisions:

- MS shall ***establish a long-term strategy for mobilising investment in the renovation of the national building stock***
- This strategy shall encompass:
- (a) an overview of the national building stock based, as appropriate, on statistical sampling;
- (b) identification of cost-effective approaches to renovations relevant to the building type and climatic zone;
- (c) policies and measures to stimulate cost-effective deep renovations of buildings, including staged deep renovations;
- (d) a forward-looking perspective to guide investment decisions of individuals, the construction industry and financial institutions;
- (e) an evidence-based estimate of expected energy savings and wider benefits
- To be published by end April 2014

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Article 5 - Exemplary role of public bodies' buildings

Provisions:

- MS shall ensure from 1 January 2014, ***3 % of the total floor area of heated and/or cooled buildings owned and occupied by its central government is renovated each year*** to meet at least EPBD minimum code levels
- The 3 % rate shall be calculated on the total floor area of occupied buildings with a total useful floor area over 500 m^2 (250 m^2 from 2015) and not meeting the EPBD levels
- MS may opt for an alternative approach whereby they take other measures, including deep renovations and measures for behavioural change of occupants, to achieve equivalent savings in central government buildings by 2020
- MS shall encourage public bodies, inc. at regional and local level, and social housing bodies governed by public law to: adopt energy efficiency plans; implement energy management; use ESCOs/EPCs to finance renovations and implement EE plans

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Article 6 - Purchasing by public bodies

MS shall:

- ***ensure that central governments purchase only products, services and buildings with high energy-efficiency performance***, insofar as that is consistent with cost-effectiveness, economical feasibility, wider sustainability, technical suitability, as well as sufficient competition, as referred to in Annex III
- encourage public bodies, including at regional and local levels, to follow the exemplary role of their central governments to purchase only products, services and buildings with high energy-efficiency performance
- encourage public bodies, when tendering service contracts with significant energy content, to assess the possibility of concluding long- term energy performance contracts that provide long-term energy savings

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Article 7 – Energy efficiency obligation schemes

Member states:

- ***shall set up an energy efficiency obligation scheme*** to ensure that energy distributors and/or retail energy sales companies achieve a cumulative end-use energy savings target by 31 December 2020, *at least* ***equivalent to achieving new savings each year from 1 January 2014 to 31 December 2020 of 1.5 % of the annual energy sales*** to final customers of all energy distributors or all retail energy sales companies by volume, averaged over the most recent three-year period prior to 1 January 2013
- may exclude from the calculation all or part of the sales, by volume, of energy used in industrial activities listed in Annex I to Directive 2003/87/EC; and transport fuels
- may allow savings achieved in the energy transformation, distribution and transmission sectors, including efficient DH/C infrastructure, or due to individual actions implemented since 31 December 2008 to count towards the target's attainment
- shall publish the energy savings achieved by each obligated party annually

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Article 7 – EEOs continued

- The amount of energy savings to fulfil the obligation shall be achieved by the obligated parties among final customers, either designated by the MS or through certified savings stemming from other parties
- *MS shall put in place* ***measurement, control and verification systems*** under which at least a statistically significant proportion and representative sample of the energy efficiency improvement measures put in place by the obligated parties is verified. To be conducted independently of the obligated parties.
- As an alternative to EEOs *MS may opt to take other policy measures to achieve energy savings among final customers* providing the overall savings target is met or use a hybrid EEO/alternative savings route
- These could include: energy or CO2 taxes; financing schemes, fiscal incentives, regulations or voluntary agreements that lead to the application of energy-efficient technology or techniques; standards and norms that aim at improving the energy efficiency of products and services; labelling; training and education – providing these are additional to obligations under EU law – double counting is prohibited

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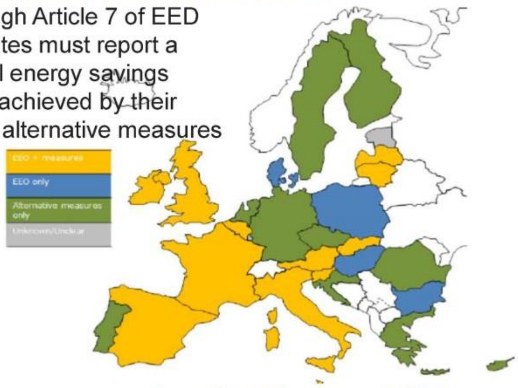
Growing no. of utility energy efficiency obligation (EEO) schemes in the EU

Driven through Article 7 of EED
Member States must report a 1.5% annual energy savings target to be achieved by their EEO and/or alternative measures to 2020



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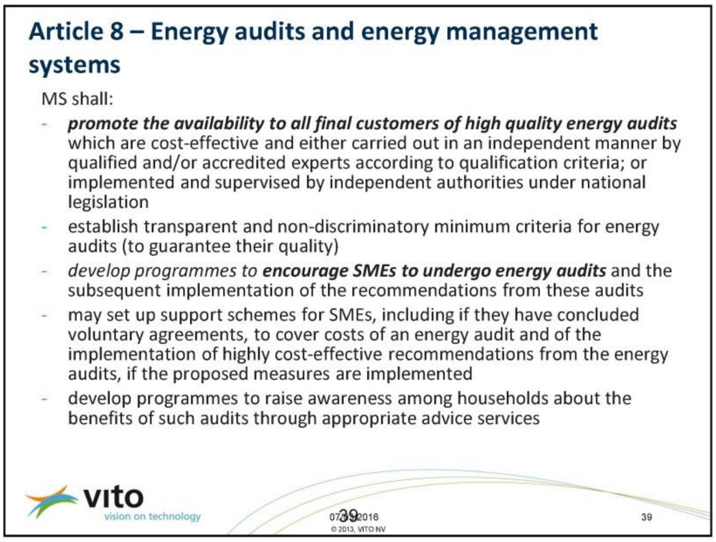
Article 8 – Energy audits and energy management systems
MS shall:
- promote the availability to all final customers of high quality energy audits which are cost-effective and either carried out in an independent manner by qualified and/or accredited experts according to qualification criteria; or implemented and supervised by independent authorities under national legislation
- establish transparent and non-discriminatory minimum criteria for energy audits (to guarantee their quality)
- develop programmes to encourage SMEs to undergo energy audits and the subsequent implementation of the recommendations from these audits
- may set up support schemes for SMEs, including if they have concluded voluntary agreements, to cover costs of an energy audit and of the implementation of highly cost-effective recommendations from the energy audits, if the proposed measures are implemented
- develop programmes to raise awareness among households about the benefits of such audits through appropriate advice services
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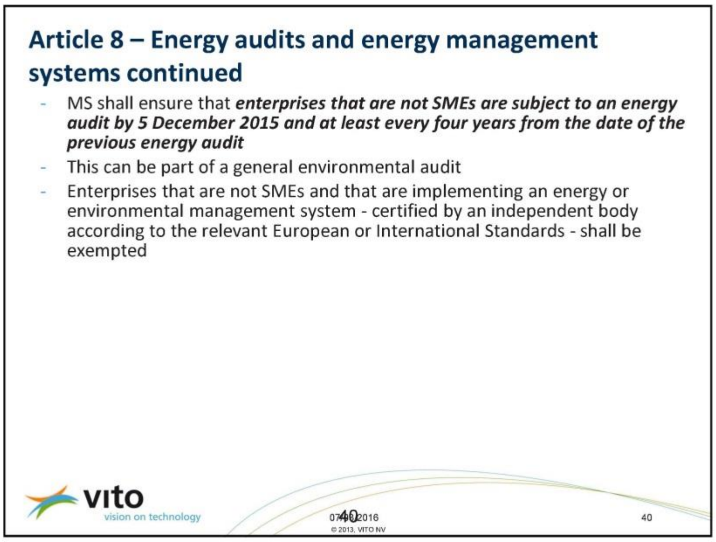
Article 8 – Energy audits and energy management systems continued
- MS shall ensure that enterprises that are not SMEs are subject to an energy audit by 5 December 2015 and at least every four years from the date of the previous energy audit
- This can be part of a general environmental audit
- Enterprises that are not SMEs and that are implementing an energy or environmental management system - certified by an independent body according to the relevant European or International Standards - shall be exempted
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Article 20 - Energy Efficiency National Fund, Financing and Technical Support

- MS shall facilitate the ***establishment of financing facilities, or use of existing ones, for energy efficiency improvement measures*** to maximise the benefits of multiple streams of financing.
- The Commission shall, where appropriate, directly or via the European financial institutions, assist Member States in setting up financing facilities and technical support schemes with the aim of increasing energy efficiency in different sectors
- The Commission shall facilitate the exchange of best practice between the competent national or regional authorities or bodies
- MSs may set up an ***Energy Efficiency National Fund***. The purpose of this fund shall be to support national energy efficiency initiatives
- ***Obligated parties under EEOs may donate to these funds*** by way of meeting their obligations
- MS ***may use their revenues from annual emission allocations*** under Decision No 406/2009/EC for the development of innovative financing mechanisms to give practical effect to the ***objective*** in Article 5 ***of improving the energy performance of build***ings

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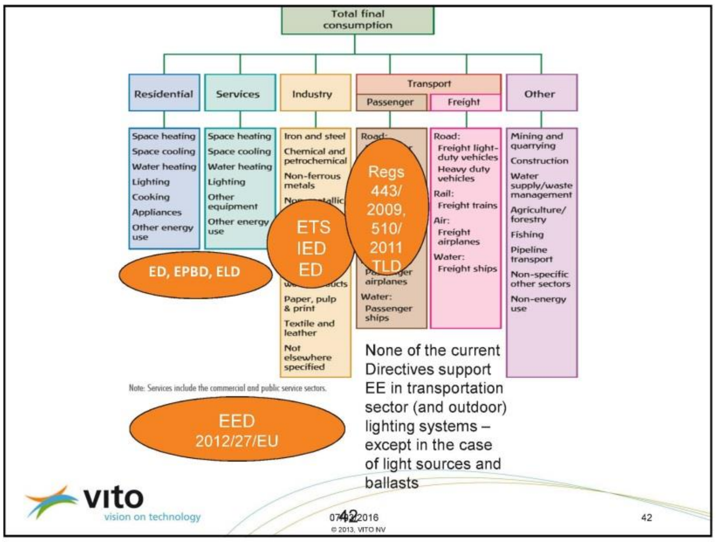

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Task 1: Policies in place – Summary

- Overall existing EU policy frameworks contain plenty of levers and opportunities that could be applied to the promotion of energy efficient lighting systems;
- however, the application of these is variable and generally not targeted at lighting systems per se.

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Task 1: Policies in place – EPBD summary

- European building energy performance codes all include the impact of the lighting system but relatively few have specific targeted requirements for lighting systems – most simply include lighting as an input into the overall building energy target.
- Building EPCs include lighting within the rating system but only some give specific targeted advice on the performance of the lighting system relative to its potential performance.
- The situation for building automated controls (which can be used to reduce lighting energy wastage) is similar except that they have even less requirements specified.

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Task 1: Policies in place – EPBD implementation

- EE of lighting is explicitly addressed as a subject, mainly for non-residential sector. 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'

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Task 1: EPBD implementation - Belgium

- Implemented at the regional level in regional decrees but the method is harmonised between the regions. The decrees limit the maximum primary energy per year and per m² together with a set of other performance requirements that need to be calculated (relative energy level, relative insulation level, etc.).
- Lighting energy efficiency is taken into account in non-residential buildings. Daylight control systems and presence detectors are taken into account, but the method is considerably simplified compared to EN 15193. Calculations are done on a monthly basis and take seasonal changes in daylight into account.
- For presence detection the highest benefit is for manual on and automatic off implemented per area of a maximum of 30 m² (30 % saving).

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Task 1: EPBD implementation - Belgium

- For daylight responsive dimming savings of up to 40 % are possible depending on the area of luminaires that are controlled together. The highest saving is for a control area of a maximum of 8 m². The method is simplified compared to EN 15193 because orientations of windows and type of shading devices are not taken into account. The calculation software to prove compliance is free.
- In the Flemish region there are also specific system requirements for renovated non- residential buildings.
- They limit the maximum installed lighting power per m² (W/m²) depending on the task area with corrections for presence detectors, daylight control and dimming. For example the upper limit (W/m²) for an individual office with presence detectors and a daylight responsive dimmer is 15/(0.7x0.8x0.9) or 29.8 W/m² or 15 W/m² without automatic controls.

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Task 1: EPBD implementation - France

- The EPBD in France is regulated within local decrees and limits the maximum primary energy per year and m² together with a combination of other minimum performance requirements to be calculated.
- Calculation software to prove compliance needs to be purchased. This software needs to be validated before it is commercialised. The calculation method also takes daylight and presence detection into account.
- The RT 2012 also has a set of specific requirements for lighting installations, for example:
  - Public spaces in residential buildings need presence detectors (art. 27);
  - Parking places need presence detectors (art. 28) (art. 40);

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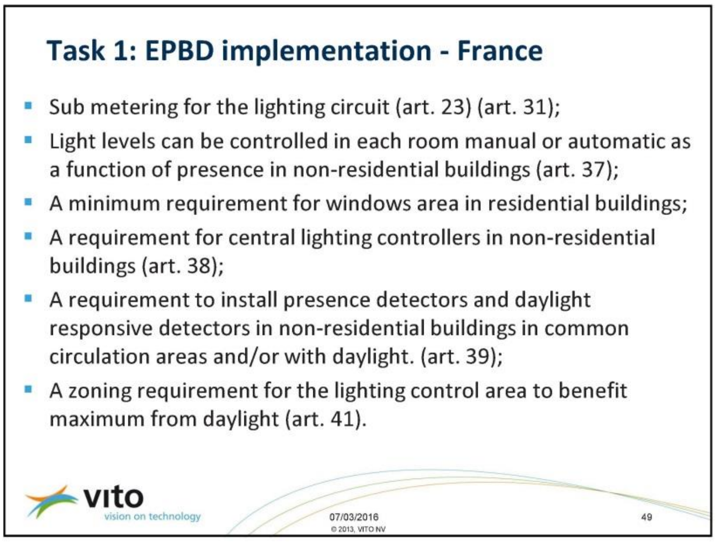
Task 1: EPBD implementation - France
Sub metering for the lighting circuit (art. 23) (art. 31);
Light levels can be controlled in each room manual or automatic as a function of presence in non-residential buildings (art. 37);
A minimum requirement for windows area in residential buildings;
A requirement for central lighting controllers in non-residential buildings (art. 38);
A requirement to install presence detectors and daylight responsive detectors in non-residential buildings in common circulation areas and/or with daylight. (art. 39);
A zoning requirement for the lighting control area to benefit maximum from daylight (art. 41).
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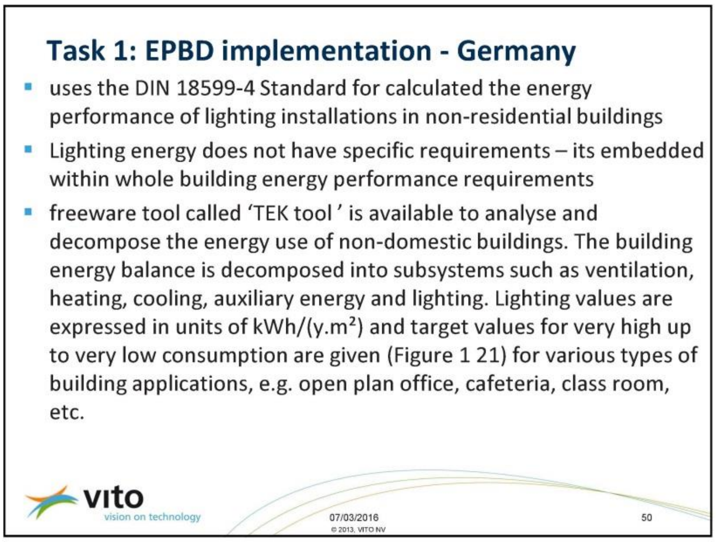
Task 1: EPBD implementation - Germany
uses the DIN 18599-4 Standard for calculated the energy performance of lighting installations in non-residential buildings
Lighting energy does not have specific requirements – its embedded within whole building energy performance requirements
freeware tool called 'TEK tool ' is available to analyse and decompose the energy use of non-domestic buildings. The building energy balance is decomposed into subsystems such as ventilation, heating, cooling, auxiliary energy and lighting. Lighting values are expressed in units of kWh/(y.m²) and target values for very high up to very low consumption are given (Figure 1 21) for various types of building applications, e.g. open plan office, cafeteria, class room, etc.
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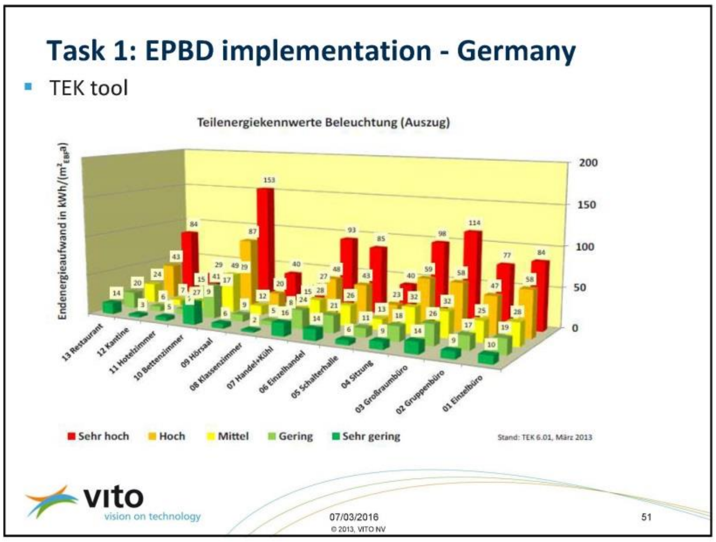

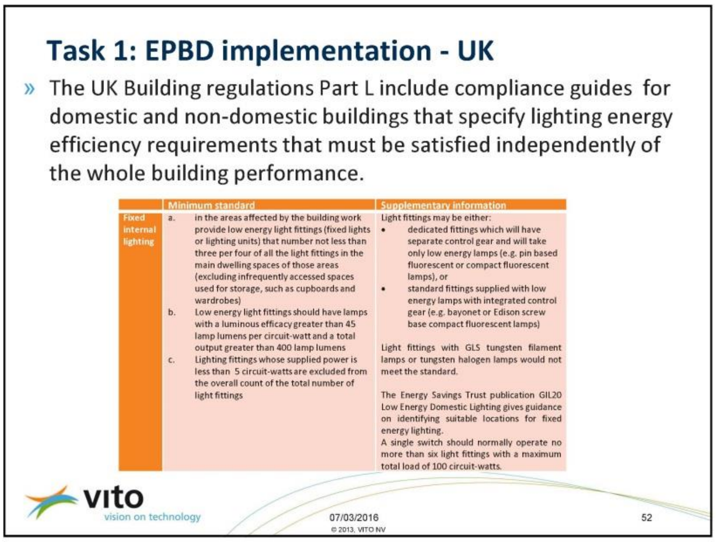

	Minimum standard	Supplementary information
Fixed internal lighting	a. in the areas affected by the building work provide low energy light fittings (fixed lights or lighting units) that number not less than three per four of all the light fittings in the main dwelling spaces of those areas (excluding infrequently accessed spaces used for storage, such as cupboards and wardrobes) b. Low energy light fittings should have lamps with a luminous efficacy greater than 45 lamp lumens per circuit-watt and a total output greater than 400 lamp lumens c. Lighting fittings whose supplied power is less than 5 circuit-watts are excluded from the overall count of the total number of light fittings	Light fittings may be either: • dedicated fittings which will have separate control gear and will take only low energy lamps (e.g. pin based fluorescent or compact fluorescent lamps), or • standard fittings supplied with low energy lamps with integrated control gear (e.g. bayonet or Edison screw base compact fluorescent lamps) Light fittings with GLS tungsten filament lamps or tungsten halogen lamps would not meet the standard. The Energy Savings Trust publication GIL20 Low Energy Domestic Lighting gives guidance on identifying suitable locations for fixed energy lighting. A single switch should normally operate no more than six light fittings with a maximum total load of 100 circuit-watts.

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Task 1: EPBD implementation - UK

	Minimum standard	Supplementary information
Fixed external lighting	Where fixed external lighting is installed, provide light fittings with the following characteristics: a. Either: I. lamp capacity not greater than 100 lamp-watts per light fitting, and II. all lamps automatically controlled so as to switch off after the area lit by the fitting becomes unoccupied, and III. all lamps automatically controlled so as to switch off when daylight is sufficient b. Or: I. lamp efficacy greater than 45 lumens per circuit-watt, and II. all lamps automatically controlled so as to switch off when daylight is sufficient, and III. light fittings controllable manually by occupants.	

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Task 1: EPBD implementation - UK

» In the case of non-domestic buildings the requirements specify that the lighting system should meet minimum standards for:

a) efficacy (averaged over the whole area of the applicable type of space in the building) and controls as set out in Table 1.5 3

OR

» the LENI values as set out in Table 1.5 4;

» b) The lighting should be metered to record its energy consumption in accordance with minimum requirements as set out in Table 1.5 5;

» c) Lighting controls in new of existing buildings should follow the guidance in BRE Digest 498 Selecting Lighting Controls. Display lighting, where provided, should be controlled on dedicated circuits that can be switched off at times when people will not be inspecting exhibits or merchandise or being entertained.

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Task 1: EPBD implementation - UK

Table 1 4: Recommended minimum lighting efficacy with controls in new and existing non domestic buildings, UK Building regulations, Part L

General lighting in office, industrial and storage spaces		Initial luminaire lumens/circuit-watt
		60
Controls	Control factor	Reduced luminaire lumens/circuit-watt
a. daylit space with photo-switching with or without override	0.90	54
b. daylit space with photo-switching and dimming with or without override	0.85	51
c. unoccupied space with auto on and off	0.90	54
d. unoccupied space with auto on and off	0.85	51
e. unoccupied space with auto on and off	0.90	54
a + c	0.80	48
a + d	0.75	45
b + c	0.75	45
b + d	0.70	42
e + c	0.80	48
e +d	0.75	45
General lighting in other types of space		The average initial efficacy should be not less than 60 lamp lumens per circuit-watt
Display lighting		The average initial-efficacy should be not less than 22 lamp lumens per circuit-watt

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Task 1: EPBD implementation - UK

Table 1 5: Recommended maximum LENI (kWh/m2/year) in new and existing non domestic buildings, UK Building regulations, Part L

Hours			Illuminance (lux)								Display Lighting	
Total	Day	Night	50	100	150	200	300	500	750	1000	Normal	Shop window
1000	821	179	1.11	1.92	2.73	3.54	5.17	8.41	12.47	16.52	10.00	
1500	1277	223	1.66	2.87	4.07	5.28	7.70	12.53	18.57	24.62	15.00	
2000	1726	274	2.21	3.81	5.42	7.03	10.24	16.67	24.70	32.73	20.00	
2500	2164	336	2.76	4.76	6.77	8.78	12.79	20.82	30.86	40.89	25.00	
3000	2585	415	3.31	5.72	8.13	10.54	15.37	25.01	37.06	49.12	30.00	
3700	3133	567	4.09	7.08	10.06	13.04	19.01	30.95	45.87	60.78	37.00	
4400	3621	779	4.89	8.46	12.02	15.59	22.73	37.00	54.84	72.68	44.00	96.80
5400	4184	1216	6.05	10.47	14.90	19.33	28.18	45.89	68.03	90.17	54.00	
6400	4547	1853	7.24	12.57	17.89	23.22	33.87	55.16	81.79	108.41	64.00	
8760	4380	4380	10.26	17.89	25.53	33.16	48.43	78.96	117.12	155.29	87.60	192.72

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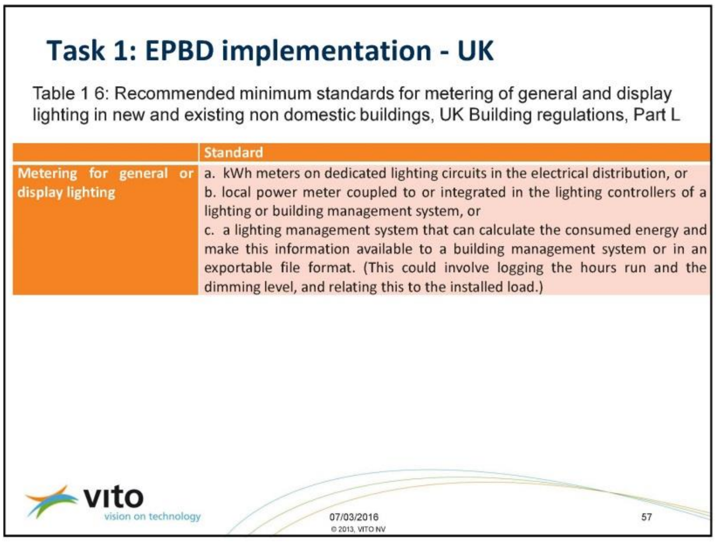
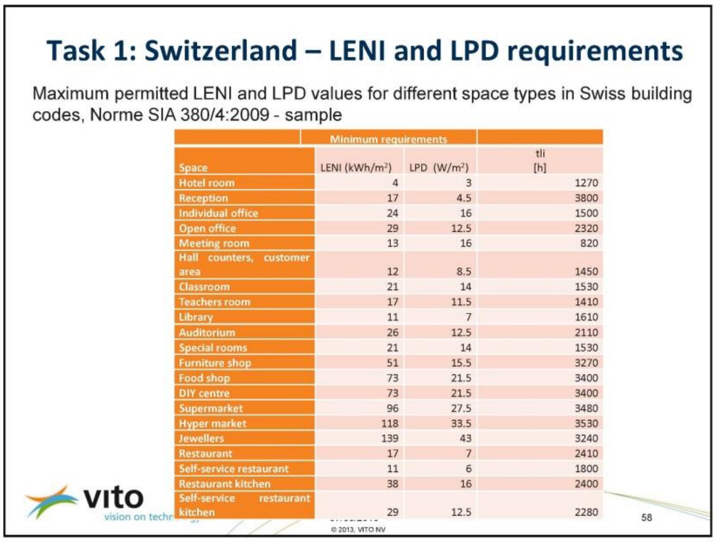


Task 1: EPBD implementation - UK

Table 1 6: Recommended minimum standards for metering of general and display lighting in new and existing non domestic buildings, UK Building regulations, Part L

	Standard
Metering for general or display lighting	a. kWh meters on dedicated lighting circuits in the electrical distribution, or b. local power meter coupled to or integrated in the lighting controllers of a lighting or building management system, or c. a lighting management system that can calculate the consumed energy and make this information available to a building management system or in an exportable file format. (This could involve logging the hours run and the dimming level, and relating this to the installed load.)



Task 1: Switzerland – LENI and LPD requirements

Maximum permitted LENI and LPD values for different space types in Swiss building codes, Norme SIA 380/4:2009 - sample

	Minimum requirements		
Space	LENI (kWh/m²)	LPD (W/m²)	tli [h]
Hotel room	4	3	1270
Reception	17	4.5	3800
Individual office	24	16	1500
Open office	29	12.5	2320
Meeting room	13	16	820
Hall counters, customer area	12	8.5	1450
Classroom	21	14	1530
Teachers room	17	11.5	1410
Library	11	7	1610
Auditorium	26	12.5	2110
Special rooms	21	14	1530
Furniture shop	51	15.5	3270
Food shop	73	21.5	3400
DIY centre	73	21.5	3400
Supermarket	96	27.5	3480
Hyper market	118	33.5	3530
Jewellers	139	43	3240
Restaurant	17	7	2410
Self-service restaurant	11	6	1800
Restaurant kitchen	38	16	2400
Self-service restaurant kitchen	29	12.5	2280

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Task 1: Policies in place – EED summary

- The EED includes several general provisions that could be applied in ways that would have an influence on lighting system energy efficiency but that is entirely dependent on how the measures are actually put into effect at MS level
- Provisions such as the utility energy efficiency obligations, national energy efficiency funds, energy audits, building renovations and certification and accreditation measures could all in principle be applied in ways that promoted energy savings in lighting systems but there is little evidence that this has been done

Task 1: Examples of Street lighting design regulation

Royal Decree 1890/2008 in Spain

- The energy efficiency regulations in street lighting installations, approved by Royal Decree 1890/2008, of 14th November, aims at improving the energy efficiency and saving, and therefore, decreasing greenhouse gas emissions;
- it provides the necessary feasibility conditions for both car drivers and pedestrians to have their security guaranteed as well as the one of the goods in the vicinity; it provides city life with a pleasant visual night time atmosphere; and curbs nightlight brightness or light pollution, reducing intrusive or unpleasant light.

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Task 1: Examples of Street lighting design regulation

Guideline for Public Lighting 'ROVL 2011' in the Netherlands

» This guideline assists in selecting the road classes according to EN 13201-2 taking traffic density and possibilities for dimming into account.

Italian standard UNI 11431 Applicazione in ambito stradale dei dispositive regolatori di flusso luminoso

» This standard assists in the application of dimming in public lighting.

Italian decree of the 23th December 2013

» This decree on public lighting, including sports lighting, refers to the European regulations and gives guidance for design and tendering.

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Task 0: First screening

» **Note: these values are updated in later chapters!**

» Focus in tasks 2-4 on non-residential and specific application areas

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Task 2: Market, Content

- **2.1 Generic economic data**
- **2.2 Market and stock data**
  - **2.2.1 Sales data**
  - **2.2.2 Stock data**
- **2.3 Market trends**
- **2.4 Consumer expenditure base data**
- **2.5 Recommendations**

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Task 2: Linking to MELISA (lot 8/9/19 study on light sources)

- MELISA = 'Model for European Light Sources Analysis'
- Developed in lot 8/9/19
- aim to harmonize the data for the two related preparatory studies on lighting, why:
  - have only one energy consumption for lighting
  - avoid double counting of potential energy savings
- MELISA
  - derives stock of light sources from data on the annual sales and on the average useful lifetimes of light sources.
  - combined with average unit power (W) and annual operating hours results in electricity consumption per base case (TWh/a).

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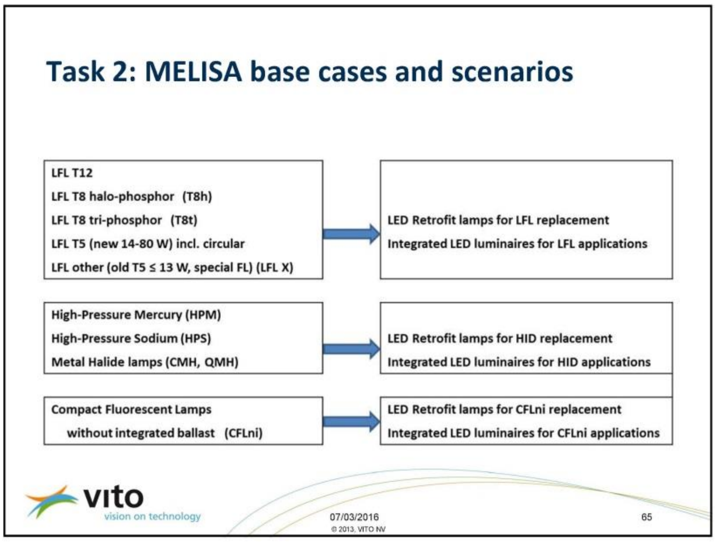
Task 2: MELISA base cases and scenarios
LFL T12
LFL T8 halo-phosphor (T8h)
LFL T8 tri-phosphor (T8t)
LFL T5 (new 14-80 W) incl. circular
LFL other (old T5 ≤ 13 W, special FL) (LFL X)
LED Retrofit lamps for LFL replacement
Integrated LED luminaires for LFL applications
High-Pressure Mercury (HPM)
High-Pressure Sodium (HPS)
Metal Halide lamps (CMH, QMH)
LED Retrofit lamps for HID replacement
Integrated LED luminaires for HID applications
Compact Fluorescent Lamps
without integrated ballast (CFLni)
LED Retrofit lamps for CFLni replacement
Integrated LED luminaires for CFLni applications
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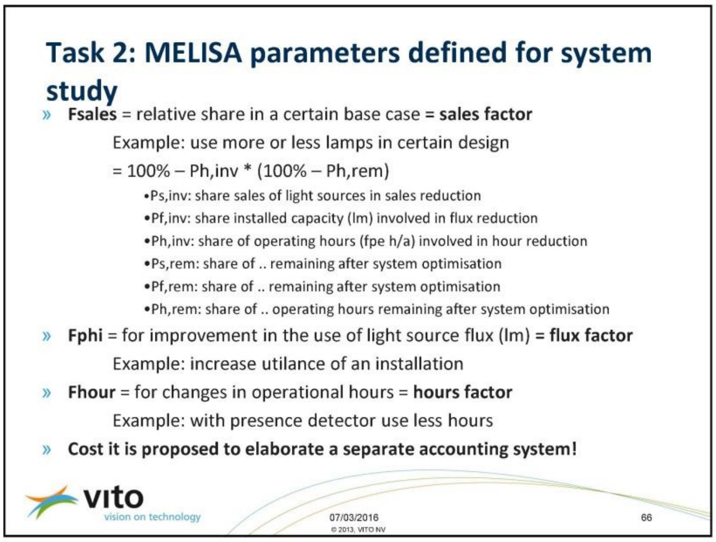
Task 2: MELISA parameters defined for system study
» Fsales = relative share in a certain base case = sales factor
Example: use more or less lamps in certain design
= 100% – Ph,inv * (100% – Ph,rem)
•Ps,inv: share sales of light sources in sales reduction
•Pf,inv: share installed capacity (lm) involved in flux reduction
•Ph,inv: share of operating hours (fpe h/a) involved in hour reduction
•Ps,rem: share of .. remaining after system optimisation
•Pf,rem: share of .. remaining after system optimisation
•Ph,rem: share of .. operating hours remaining after system optimisation
» Fphi = for improvement in the use of light source flux (lm) = flux factor
Example: increase utilance of an installation
» Fhour = for changes in operational hours = hours factor
Example: with presence detector use less hours
» Cost it is proposed to elaborate a separate accounting system!
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Linking the energy units of lighting systems (Task 1) to MELISA and cross checking data

- **Obvious** and standardized **energy units** in lighting systems are:
  - Indoor: **LENI [kWh/(m².y)]** > Market and sales model is area(m²)
  - Outdoor: **AECI [kWh/(m².y)]** > Market and sales model is area(m²) or road length(km) x typical road with(m)
- **> In principal indoor area and road area are the primary market parameters to be combined with LENI and AECI**
- **Cross checking an fitting this to MELISA:**
  - **LENI(EU28) [kWh/(m².y)] x area(EU28) = total TWh/y**
  - **AECI (EU28) [kWh/(m².y)] x road length x width (EU28) = total TWh/y**
- Also: analyse area's statistics with default area operational hours and E,m(lux)

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Non-residential area as a market parameters

based on two sources of data (VHK, EU-28 building heat demand) vs BPIE report

	EU-27 area M m²		Share % of total	
	BPIE	VHK	BPIE	VHK
sector				
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%
m² per capita EU		21218		

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Task 2: Market data cross-checks

- MELISA lumen & power requirement, see study (fits in realistic assumptions) (5560 Glm/87 GW = 64 lm/W)
  - 5660 Glm/11773 Mm² = **480 lm/m²**
  - 87 GW/11776 Mm² = **7,4 W/m²**
- MELISA LENI cross-check
  - 155 TWh/11773 Mm² = **13 kWh/(m².y)**

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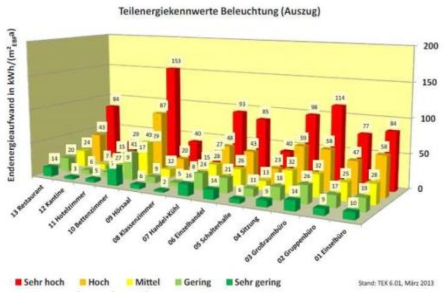
Task 2: Is a LENI of 13 kWh/(m².y) realistic?

- Sources: TEK tool (IWU.de)
- on average all is green?
- Task 4 (500 lx, 2500 h), LENI: WC = 55, Mainstream = 27, BATref = 9,8



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Task 2: Is an average LENI of 13 kWh/(m^2.y) realistic?

- Sources: LENI in UK Building regulation part L
- Task 4 (500 lx, 2500 h), LENI: WC = 55, Mainstream = 27, BATref = 9,8
-

hours			Illuminance (lux)							
Total	Day	Night	50	100	150	200	300	500	750	1000
1000	821	179	1.11	1.92	2.73	3.54	5.17	8.41	12.47	16.52
1500	1277	223	1.66	2.87	4.07	5.28	7.70	12.53	18.57	24.62
2000	1726	274	2.21	3.81	5.42	7.03	10.24	16.67	24.70	32.73
2500	2164	336	2.76	4.76	6.77	8.78	12.79	20.82	30.86	40.89
3000	2585	415	3.31	5.72	8.13	10.54	15.37	25.01	37.06	49.12
3700	3133	567	4.09	7.08	10.06	13.04	19.01	30.95	45.87	60.78
4400	3621	779	4.89	8.46	12.02	15.59	22.73	37.00	54.84	72.68
5400	4184	1216	6.05	10.47	14.90	19.33	28.18	45.89	68.03	90.17
6400	4547	1853	7.24	12.57	17.89	23.22	33.87	55.16	81.79	108.41
8760	4380	4380	10.26	17.89	25.53	33.16	48.43	78.96	117.12	155.29

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Task 2: Market data & cross-checks, conclusion

- Market cross-check in LENI of 13 kWh/(m^2.y) is relative low, could be an indication for:
  - **Operating hours** overestimate in LENI following defaults EN 15193 (Fa factor(absence), illumination level & D(daylight),..)?
    MELISA: hours↓ + sales= + stock↑ > TWh= + W/m^2↑ + lm/m^2↑?
  - Overestimating stock **area**? 5,8 vs 11,8 G m^2? LENI↑ + W/m^2↑
  - Underestimating in TWh in MELISA: average wattage, h/y, lifetime, annual sales? TWh↑ (However should fit in total EU28 impact accounting)
  - Overestimating stock **illumination level** following EN 12464-1 + area estimates + combination with Daylight factor? LENI should reflect lower reference value? High amount of low spec areas (circulation, storage, ..).. Risk for EN 12464-1 rebound effect?
  - MELISA related to **share** of non-residential **area within the scope** of Task 1?
  - MELISA related to **share** of **lamp stock within the scope** of Task 1? E.g. Halogen lamps?

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Task 2: Market data & cross-checks, sourcing data

- Experience from designers in the field (LENI, illumination levels before and after retrofit, operating hours)?
  - Query for:
    - EN 12464-1 compliance for existing stock before retrofitting? (illumination levels)
    - Lamp technology for area's in the scope?
    - LENI levels before and after renovating?
    - Relative share of EN 12464-1 area's within typical buildings?
    - Typical operating hours (used, measured)? Life time of installations before renovating (see task 3)? Any stock data??
    - Design cost? Euro/m² (per country)? Hours/m²? Included or markup (%) on luminaire prices?
    - Based on market data, add some other reference applications in taks 3: Industry? Retail?
    - Combined with other Task 3 issues: installation time, cleaning, etc..

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Other Task 2 issues

- Important for Task 3&4:
    - Will be finalized in task 7, more data is welcome!
    - Avoid double counting with efficacy increase of light sources > decompose LENI
    - If so, should we model an EN 12464-1 rebound effect comparing WC to BAT? (because stock data seems not te reflect WC LENI.)
    - Parameter fitting and/or simplification for MELISA scenarios .. Will be done considered in Task 7. Use LENI x Area scenarios and rescale MELISA?

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Task 2: comments

- IALD (definition): 'This means that the typical market product unit driver is appropriate volumetric lighting assessed against the floor and/or task surface area serviced by the lighting scheme'.
- IALD (section 2.1.1 + 2.1.2 + p.140): MELISA inaccurate for this purpose, *use LENI.* Noted: we are aware of this complexity, is a Task 7 issue (MELISA relies much on lamp sales data)
- IALD (2.1.2.3 several): noted. More accurate price data (controls, luminaires, ..) to be source in Task 4
- IALD (P. 141): As stated above EN12464-1 does not provide definitive requirements for many commercial areas such as hospitality, Museum and gallery, restaurants, high end retail etc = 'ambient lighting' > Separate section in Task 3 needed
- IALD (p. 150-159) (cross-check accuracy): see previous slides

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Task 3 Users

- **Systems aspects of the use phase for ErPs with direct/indirect impact**
  - Definition of the User and context
  - Energy parameters directly related to the lighting system itself
  - Other functional parameters
  - Formulas used for power losses in cables
  - Standard vs non standard conditions
- **End of Life behaviour**
- **Local infrastructure (barriers & opportunities), e.g. cable bending**
- **Recommendations**

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Task 3 Users: Approach

- **Based on selected reference designs:**
  1 st selection building on lot 8&9 but **can be extended**, e.g. to illustrate better some BAT and/or to be more representative for the proposed scope and/or some design requirements
- Current reference lighting applications:
  - Cellular office with ceiling mounted luminaires
  - Cellular office with suspended luminaires
  - Open plan office with ceiling mounted luminaires
  - Open plan office with suspended luminaires
  - Motorized road with fast traffic class M3 (EN 13201)
  - Conflict road with mixed traffic class C3 (EN 13201)
  - Pedestrian area road with slow traffic class P3 (EN 13201)
- **Reference designs are available in Dialux evo + calculation spreadsheet that allow stakeholders to contribute!**

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Task 3 Users: MEErP and Product vs System?

- The lighting system within the scope will be considered as a product and follow the MEErP as much as possible:
  - **The lighting system 'product'** is a system or installation that is composed of luminaires, lamps, sensors and controls to satisfy lighting requirements according to EN 12464 or EN 13201
  - A lighting system in this study forms part of the building or road infrastructure
  - In this study the **'MEErP system aspects' of a lighting system** are the building or road infrastructure such as walls, ceiling, road surface, ducts, lighting poles or supports, connectors, power cables, etc.

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Task 3 Users: Example, reference design 'cellular office'

- Em (minimum maintained average illuminance): 500 lx
- UGR (glare): ≤ 19
- U0 (uniformity): ≥ 0.6
- Ra (CRI): ≥ 80
- Task area: whole floor area + optimisation in Task 4
- Ecyl?

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Task 3 Users: Energy calculation indoor EN 15193

- **= LENI** + decomposition (a.o. needed to avoid double counting + can serve for systematic approach in Task 4)
- Day time, night time and occupied period
  - Standard uses default values that are downwards corrected afterwards.
- **Occupancy Dependency Factor (Fo)**
  - calculated from an **absence factor (Fa)**, as defined for different types of reference rooms (cellular office, open plan office, etc..), and an **occupancy control factor (Foc)**, as defined for different types of control (centralised control, presence detector, etc.).
  - Reference values of absence factor? (unrented space, lower annual work hours, etc..)

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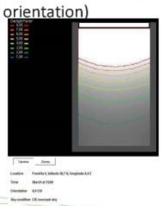
Task 3 Users: Energy calculation indoor EN 15193

» **Daylight Dependency Factor (Fd)**

- Daylight Dependency Factor (Fd) is calculated from the daylight dependent control factor (Fd,c) and the daylight supply factor (Fd,s) with the following formula: Fd = 1 - Fd,c x Fd,s
- Values depend on the Daylight Factor (D), ratio of the light level inside a structure due to daylight versus the light level outside the structure (i.e. 10000 lux), as a consequence 2 % means 200 lx. (free software available)
- Table for sun shading activated Fd,s (independent of orientation)

	Classification of daylight availability			
control type	None	Low	Medium	Strong
	D<2%	2%≤D<4%	4%≤D<6%	D≥6%
MO	0	0,1	0,2	0,3
Auto	0	0,2	0,43	0,55
Guided		0,3	0,65	0,8
None		0,3	0,65	0,8



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Task 3 Users: Energy calculation indoor EN 15193

» Correction factor Fd,c to account for the effect of daylight-responsive control systems in a zone n, as a function of the maintained illuminance Ēm and the daylight supply classification:

Daylight availability		Low	Medium	Strong
Ēm(illuminance)		500 lx	500 lx	500 lx
System	Type of system			
Manual	I	0,47	0,52	0,57
On/off	II	0,59	0,63	0,66
On/off in stages	III	0,7	0,73	0,75
Daylight responsive off	IV	0,7	0,73	0,75
Stand-by losses, switch-on, dimmed	V	0,7	0,73	0,75
No stand-by losses, switch-on, dimmed	VI	0,74	0,78	0,81
Stand-by losses, no switch-on, dimmed	VII	0,77	0,8	0,83
No stand-by losses, no switch-on, dimmed	VIII	0,81	0,86	0,89

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Task 3 Users: Energy calculation indoor EN 15193

- **Constant illuminance Factor (Fc)**, to model the impact of smart dimming control designed to constantly match the illuminance to the required minimum
- Why:
  - Technique, **compensate for lumen depreciation**:
    EN 12646 specifies the task illuminance in terms of maintained illuminance, such a system can compensate for this.
    Standard proposes to compensate for FLM
  - Can also work to **compensate for over-lighting** due to fit of amount of luminaires, changes in reflection coefficients…
  - **Often combined with daylight responsive dimming**
- **Note: Dimming is also useful when no daylight is available!**

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Task 3 Users: Energy calculation indoor EN 15193

- **Influence of maintenance factors (FLM, FLLM, FRSM)**
  - Why: EN 12464 standard series specifies requirements in terms of 'Maintained illuminance'
  - FM = FLM x FLLM x FRSM
  - For lamps such data is know from the current regulation 245/2009
  - However **for LED luminaires** should be **derived from: LxFy data**
  - **More input welcome for Task 4! Methods & tools!**
  - e.g. Zumtobel:

Lamp luminous flux maintenance factor (LLMF) and lamp survival factor (LSF)

LED luminous flux classes* with the following specific values		Service life given in hours 1000	5000	10000	15000	20000	25000	30000	35000***
L96 @ 50,000 h	LLMF	1.00	1.00	0.99	0.99	0.98	0.98	0.97	0.97
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
L90 @ 50,000 h	LLMF	1.00	0.99	0.98	0.97	0.96	0.95	0.94	0.93
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
L85 @ 50,000 h	LLMF	1.00	0.99	0.97	0.96	0.94	0.93	0.91	0.90***
	LSF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

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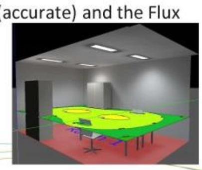
Task 3 Users: Energy calculation indoor EN 15193

- The **Utilance** (U) =ratio of the luminous flux received by the reference surface to the sum of the individual total fluxes of the luminaires of the installation

  U = Em/(Φ x A)

  (note: summing might be needed in complex designs!)
- Impact of office room area size and light point location
- Impact of room surface reflection
- calculated with **lighting design software**(accurate) and the Flux code(inaccurate)



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Task 3 Users: Energy calculation indoor EN 15193 not covered or deviating from standard conditions

- T (°C)
- Line voltage fluctuations, PQ issues
- Colour and vision not yet covered in EN 12464-1?
- **Spreading in user preferences?** E.g. some users could fit with 300 lx instead of 500 lx? (could explain lower operating hours with daylight)
- Weather (for daylight)
- **Working hours (Fa (absence in some work places)** different from the assumptions in the standard)? (E.g. unrented, storage, ..)
- = see also Task 2 finding of the cross check:
  - In Task 7 scenarios correct base line values vs sensitivity analysis? Exclude some task area's?
  - Change existing factors and/or add a new one (BMF)?

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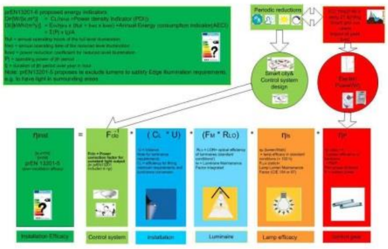
Outdoor lighting EN 13201-5

- Follows a similar approach
- For decompositions parts of this standard are also calculated for indoor
- Lighting design criteria are different, e.g. road class M uses Luminance



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EN 13201-5 road lighting

- Not yet covered very similar to EN 13201-5, but also:
  - Scotopic vision (because only at low light levels)
  - Colour vision, light pollution (trend to require 3000 K?) versus playing around with CIE YX colour coordinates to increase efficacy
  - Impact of new developments in car headlights

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Task 3 Users: Indirect impact of the use phase (indoor only)

- **Heat replacement effect** in buildings
  - During the heating period: depends much on building design, other internal heat gains (e.g. occupants, ICT, ..) and climate
  - EN 15193 provides method for monthly LENI data and EN 15603 provides method for overall building performance and energy balance
  - Trend for reduced heating periods due to increased insulation and air tightness requirements?
- **Impact on the cooling loads**
  - During the cooling period, can be calculated see heating period
  - Often related to solar heat gains
  - could fit with photovoltaics?

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Task 3 Users: Indirect impact of the use phase (indoor only)

- Should we add efficacy of daylight in the scenarios? E.g. D= 5% (500 lx) on 19,44 m² (9720 lm) versus window energy loss of 3,6x2,8m² x 1 W/(m².K) x 10 K =100 Watt resulting in 97 lm/Watt? But in an energy balance 80 Watt is about to be equivalent to one person heating. Remarkable is that LED luminaires could start to compete with daylight in our reference design?
- **Options:**
  - **Neglect** in this study because both effects (heat replacement, cooling load) exists?
  - Add a reference building? Any suggestions or opinion for this?

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Task 3 Users: End-of-Life

» Indoor: 20 y +/- 10 y

» Outdoor:

	Road class M			Road class C			Road class P		
	min.	avg.	max	min.	avg.	max	min.	avg.	max
life time (y)	25	30	35	25	30	35	15	30	35

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Task 3 Users: End-of-Life , installation, maintenance

» Indoor: 20 y +/- 10 y

» Outdoor:

	Road class M			Road class C			Road class P		
	min.	avg.	max	min.	avg.	max	min.	avg.	max
life time (y)	25	30	35	25	30	35	15	30	35

» Indoor maintenance :

Time required for installing one luminaire (t-luminaire install)	**20 min.**
Time required for group lamp replacement (t-group relamping)	**3 min.**
Time required for spot lamp replacement (t-spot relamping)	**20 min.**
Time required for luminaire cleaning (in addition to time for group lamp replacement) (t-luminaire cleaning)	**1.5 min.**

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Task 3 Users: End-of-Life , installation, maintenance

- Outdoor:

Time required for installing one luminaire (t-luminaire install)	20 min.
Time required for group lamp replacement (t-group relamping)	3 min.
Time required for spot lamp replacement (t-spot relamping)	20 min.
Time required for luminaire cleaning (in addition to time for group lamp replacement) (t-luminaire cleaning)	1.5 min.

Time required for installing one luminaire (group installation)	20 min.
Time required for lamp replacement (group replacement)	10 min.
Time required for lamp replacement (spot replacement)	20 min.
Time required for maintenance including ballast replacement	30 min.

- Add time and/or markup for lighting design, e.g. + 7 % of total cost?

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Task 3 Users: End-of-Life , installation, maintenance

- **Lamp consumption:**
  - $N_y = 1 / t_{group} + (1 - F_{LS}) / t_{group}$
- **Ballast/control gear consumption:**
  - Nb = BFR/100x toperating /1000h x Nbal

    BFR = ballast failure rate per 1000 h with the ballast tc point @ 70 °C.

    Nbal = number of ballasts per luminaire.
  - BFR =0,2 % .. But more recent data for LED drivers welcome?
  - The percentage of LED luminaires that have a catastrophic failure or failed completely by the end of rated life 'Lx' (e.g. L80) is expressed by 'Cz'. For example C10 means 10 % catastrophic failures at rated life (e.g. 16000 h) with L80.
  - In this study it will be assumed that FLS = Cz for LED luminaires, for example C10 results in FLS = 0,10. Does this overlap with BFR?

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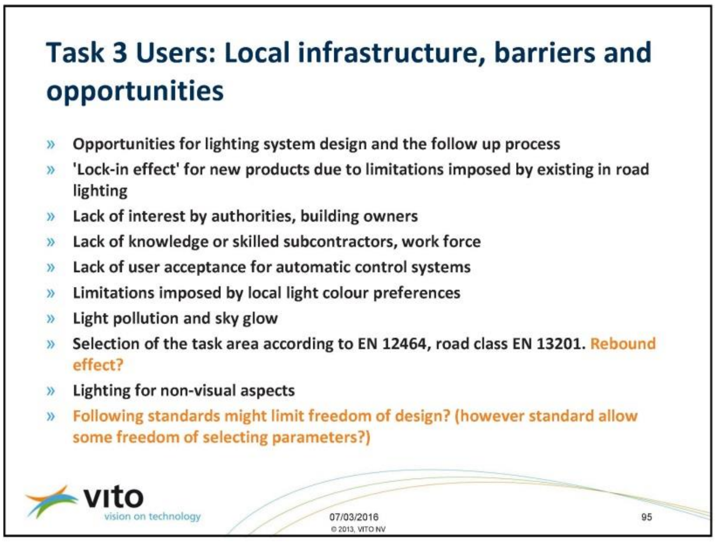
Task 3 Users: Local infrastructure, barriers and opportunities
» Opportunities for lighting system design and the follow up process
» 'Lock-in effect' for new products due to limitations imposed by existing in road lighting
» Lack of interest by authorities, building owners
» Lack of knowledge or skilled subcontractors, work force
» Lack of user acceptance for automatic control systems
» Limitations imposed by local light colour preferences
» Light pollution and sky glow
» Selection of the task area according to EN 12464, road class EN 13201. Rebound effect?
» Lighting for non-visual aspects
» Following standards might limit freedom of design? (however standard allow some freedom of selecting parameters?)
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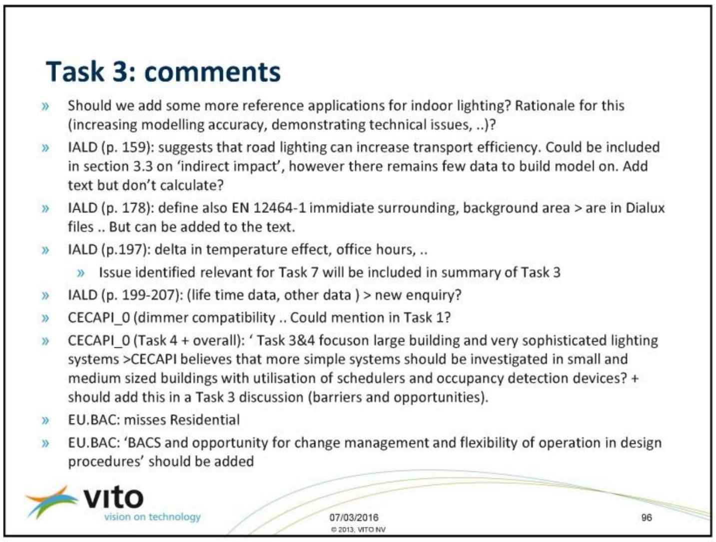
Task 3: comments
» Should we add some more reference applications for indoor lighting? Rationale for this (increasing modelling accuracy, demonstrating technical issues, ..)?
» IALD (p. 159): suggests that road lighting can increase transport efficiency. Could be included in section 3.3 on 'indirect impact', however there remains few data to build model on. Add text but don't calculate?
» IALD (p. 178): define also EN 12464-1 immidiate surrounding, background area > are in Dialux files .. But can be added to the text.
» IALD (p.197): delta in temperature effect, office hours, ..
» Issue identified relevant for Task 7 will be included in summary of Task 3
» IALD (p. 199-207): (life time data, other data) > new enquiry?
» CECAPI_0 (dimmer compatibility .. Could mention in Task 1?
» CECAPI_0 (Task 4 + overall): ' Task 3&4 focuson large building and very sophisticated lighting systems >CECAPI believes that more simple systems should be investigated in small and medium sized buildings with utilisation of schedulers and occupancy detection devices? + should add this in a Task 3 discussion (barriers and opportunities).
» EU.BAC: misses Residential
» EU.BAC: 'BACS and opportunity for change management and flexibility of operation in design procedures' should be added
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Task 4: Technologies

- **BAT: Best Available Technologies**
- BNAT: Best Not yet Available technologies = not on scale for large deployment = barriers should be discussed (e.g. Cost, IP, R&D)
- Production, distrubution and End of Live (see also Task 3) > in principle is covered with Light source study modelling in MELISA (waste, volumes, etc, ..)
- Improvement options & recommendations
- Not so evident .. It is not only about increasing the light source efficacy (lm/w), therefore the proposal is to follow

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Task 4: Technologies -approach

- Context:
  - Not so evident .. It is not only about increasing the light source efficacy (lm/w) because many parameters and/or methods are involved.
  - In Task 7 we should avoid double counting with improvements from light source study (MELISA model)
- Therefore the proposed approach is:
  - **Follow the decomposition proposed in previous tasks** with parameters sourced from standards
  - **Compare** for the selected reference applications designs improvement on **LENI or AECI** will be grouped into **categories: worst case(WC), mainstream(MS), BATxx, BNATxx, ..)**

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Task 4: Technologies -approach

- Data sourcing and processing:
  - The reference designs (Task 3) are available in Dialux EVO & Velux daylight visualizer
  - **Dialux evo** is used to calculate lighting design parameters (also D(daylight))
  - Spreadsheet also includes EN 13032 flux code calculation .. only be used for Worst Case or Mainstream design modelling (because not refined)
  - **Spreadsheet to calculate EN 15193 (LENI), EN 13201-5(AECI) + other parameters (please verify)**
  - Spreadsheet also includes LCC (TCO) calculations for each design
  - Open issue: how to deal with refined selection of area requirements >> add the moment feed averages to the spreadsheet
  - Spreadsheet available for verification. Sample EN 15293 calculations are welcome!
  - **BAT & BNAT samples are welcome in Dialux!**

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Task 4: Draft results – indoor – ex. Cellular office

- See spreadsheet and Dialux: LENI = 55; 39; 9,8; 8 ; 6,4; 8,4; 12,4 kWh/m².y

Related Task	Reference design	lot 37 WC	lot 37 Mainstream	lot 37 BATref	lot 37 BATlit	lot 37 BATarea	lot 37 BATdesign01	lot 37 BAT cel_samp01
4	lamp replacement period(tgroup)(y)	3,80	7,60	15,20	15,20	15,20	20,00	20,00
4	ηls (lm/W) – ηL (25°C standard conditions)	75,00	86,00	140,00	140,00	140,00	110,94	97,10
4	FLLM (lamp lumen maintenance f) (~f(t-lamp replacement period))	0,90	0,90	0,80	0,80	0,80	0,80	0,80
4	FLS (lamp survival f) (~f(t-lamp replacement period))	0,90	0,90	0,99	0,99	0,99	0,99	0,99
4	ηp (power efficiency of luminaire)	0,76	0,84	1,00	1,00	1,00	1,00	1,00
4	CIE flux code N5(RLO) (Luminaire light output ratio)	0,47	0,68	1,00	1,00	1,00	1,00	1,00
4	FLM (Luminaire Maintenance Factor)	0,91	0,91	1,00	1,00	1,00	1,00	1,00
3	FRSM (Room Surface Maintenance Factor)	0,96	0,96	0,96	0,96	0,96	0,96	0,96
4	Task Area reduction Factor	1	1	1	1	1	1	1
4	constant illumination control(EN 15193)	n	n	y	y	y	y	y
4	occupancy control type(EN 15193)	Man. On/Off	Auto On/Off	presence det.	presence det.	presence det.	presence det.	presence det.
4	room type absence (EN 15193)	Cellular 2-6 p.	Cellular 2-6 p.	Cellular 2-6 p.	Cellular 2-6 p.	Cellular 2-6 p.	Cellular 2-6 p.	Cellular 2-6 p.
4	type of daylight control (Table F.16) (EN 15193)	I: Manual	I: Manual	VIII: nSB nSW	VIII: nSB nSW	VIII: nSB nSW	VIII: nSB nSW	VIII: nSB nSW
4	type of blinds control (annex F 3.2.4) (EN 15193)	MO	MO	Auto	Auto	Auto	Auto	Auto
3	MF = LLMF x MF x RSMF (spot replacement LSF=1)	0,786	0,786	0,768	0,768	0,768	0,768	0,768
4	U (utilance) = ηR (software or flux code)	0,64	0,74	0,74	0,74	0,74	0,81	0,84
4	**Fc (constant illumination factor)**	1,00	1,00	0,90	0,90	0,90	0,90	0,90
4	**Fo (formula E.1) (occupancy)**	0,9	0,8	0,85	0,85	0,85	0,85	0,85
4	**Fd (formula 9) (daylight)**	0,896	0,896	0,6302	0,6302	0,6302	0,6302	0,6302
4	eL,C (eq. 18) part. expend. 4 const. illum. control	1,00	1,00	1,01	1,01	1,01	1,01	1,01
4	eL,O (eq. 19) part. expend. 4 occupancy control	1,29	1,14	1,21	1,21	1,21	1,21	1,21
4	eL,D (eq. 19) part. expend. 4 daylight dep. control	1,11	1,11	1,09	1,09	1,09	1,09	1,09
4	eE (eff. For fitting to minimum requirements	1,23	1,23	1,23	1,00	1,00	0,91	1,21
4	eL,ES, del (eq. 19) part. expend. 4 delivery of light	1,12	0,97	0,97	0,97	0,97	0,88	0,86
4	eL,ES, dis (eq. 19) part. expend. 4 distrub. of light	2,13	1,48	1,00	1,00	1,00	1,00	1,00
4	eL,ES, gen (eq. 19) part. expend. 4 generation of light	1,42	1,37	1,00	1,00	1,00	1,26	1,44
4	eLES (eq. 19) part. Expend. 4 lighting system	3,39	1,96	0,97	0,97	0,97	1,12	1,24
4	**LENI (kWh/m²Y) (f 15)**	55,8	39,1	9,8	8,0	6,4	8,4	12,4
4	ηinst-u (usefull installation efficacy) (lm/W)	13,56	28,63	88,75	88,75	88,75	76,95	69,22
4	Fhour-s (=(Fox(Fdxtd+tn)/(td+tn))	0,82	0,73	0,57	0,57	0,57	0,57	0,57

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Task 4: Draft results outdoor – ex. Highway class M3

» See spreadsheet and Dialux: AECI =5,0; 2,8 ; 0,63 ; 0,73; 0,97 kWh/m².y

		WC	Mainstream	BATref	case LED1	case HPS1
pole height	m	14,00	14,00	14,00	11,00	14,00
FLLM		0,90	0,95	0,80	0,80	0,95
LSF (lamp survival f)		0,95	0,62	0,99	0,99	0,94
ηp		0,90	0,90	0,94	1,00	0,90
ηls (calculated from Pls and Lamp lumen)	lm/W	105,00	105,00	140,00	93,56	116,67
IP (ingress)		2x	5x	6x	66	65
FLM		0,51	0,86	0,89	1,00	0,89
fM=MF = LMF*LLMF=FLM*FLLM		0,46	0,82	0,71	0,80	0,85
CIE flux code N5(LOR) = ηLB=RLO		0,70	0,73	1,00	0,76	0,82
t full (annual operating time at full illumination)	h/y	2000	2000	2000	2000	2000
t red (annual operating time at reduced illumination)	h/y	2000	2000	2000	2000	2000
k red (reduction coefficient for the illumination level)		1,00	1,00	0,70	0,70	0,70
BGF (ballast gain factor) = fred = (tfull+tred)/(tfull+tredxkred)		1,00	1,00	1,18	1,18	1,18
FU (UF) software from lot 9		0,33	0,48	0,70	NA	NA
E average from FU (UF) lot 9	lx	18,0	25,7	14,3	#VALUE!	#VALUE!
E ave as calculated from software (@fM)	lx	NA	NA	NA	13,00	15,44
further use data based on UF lot 9 or Eave software		use UF	use UF	use UF	use E	use E
Fu from selected method		0,33	0,48	0,70	0,64	0,44
E average maintained hor. illuminance selected	lx	18,0	25,7	14,3	13,0	15,4
U (Utilance) from selected method		0,47	0,66	0,70	0,84	0,54
FCL = correction for not fitting minimum requirements		0,79	0,56	1,00	1,10	0,93
filename software					clM3_ex02	clM3_ex02
CLO regulation	y/n	n	n	y	y	y
Fclo =(1-(1-Fm)/2)xCL		1,00	1,00	0,85	0,99	0,85
ηinst	lm/W	11,3	20,6	76,6	53,0	42,4
ρP (PDI) (no FCLO & no CL) (lighting power density)	W/(m².lx)=W/lm	0,070	0,027	0,015	0,021	0,026
DE (AECI) =Px(tfull+kredxtred)xFclo/A (excl. edges area) (annual energy)	kWh/(m².y)	5,036	2,772	0,63	0,73	0,97
P per km road	W per km	12589	6931	2187	2180	3333
Annual Energy per km road	kWh/y per km	101	55	13	15	19
Fhour-abs =(td + kredxtred)/(td+tred)		1,000	1,000	0,850	0,850	0,850

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Task 4: comments

- Reference designs are welcome!
- Address more lighting design requirements Ecyl?
- Verify calculation, reference calculations EN 15193&EN13201-5
- Method for processing refined area requirements: e.g. one light source could be used for multiple area's EN 12464-1 requirements ..
- prEN15193 expenditure factors, see spreadsheet, useful?
- Data for luminaire prices .. Especially road lighting, prices for LED luminaires found in catalogues are still very high (> 1000 euro)?
- Including the design cost:
  - Assuming this is included in the luminaire price?
  - Markup on total installation cost, e.g. 7 %?
  - Cost per m²?

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Task 4: comments

- IALD (p. 226-227): optimize area's and how to process them. Text update needed. More info in the Dialux sample designs.
- DEA (p. 233): The study identifies lacks/gaps in the standards for efficiency of lighting systems (EN 15193 and EN 13201-5) and mends it with supplementary factors included in this study such as "eE (eff. For fitting to minimum requirements)" and the installation efficacy, $\eta inst$. These parameters are indeed useful as they reveal over-lighting.

note: eE is in part covered with CLO in EN 15193 (constant illumination control) .. However this requires dimming! A solution will be worked out in the spreadsheet.

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Task 4: comments

- DEA (p. 234): '$\eta inst$ <1' > designs not aligned with minima, but will be replaced by better designs + area correction method should be verified.
- LE on Tasks 2-4(see ppt): LightingEurope started to evaluate:
  - market data and calculation model used;
  - proposed reference designs for both indoor and outdoor lighting;
  - calculations of energy saving potential for the different scenarios.

LightingEurope aims to submit the final comments by April 8th 2016

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Task 7 structure

- Stakeholders input (if any) – to be provided before 30 June
- Policy options
- Scenarios, issues:
  - Avoid double counting with light sources, set efficacy for new projects on target values (80/120 lm/W)?
  - Sensitivity on some parameters: Fa(absence), Em + D(daylight)
  - Scaling up selected references to EU28 totals
- Socio-economic Impact
- Sensitivity analysis
  - However: will be limited because no task 5&6
  - To be decided by the EC if and how to complete it

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Conclusion

- Planning (see slide 7)
- AOB
- Thank you for participating and contributing!

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Presentation from Lighting Europe at the end of the meeting:

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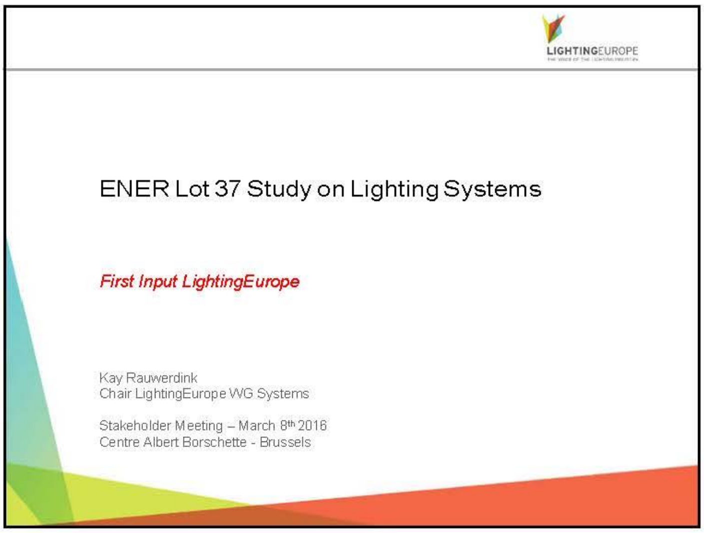

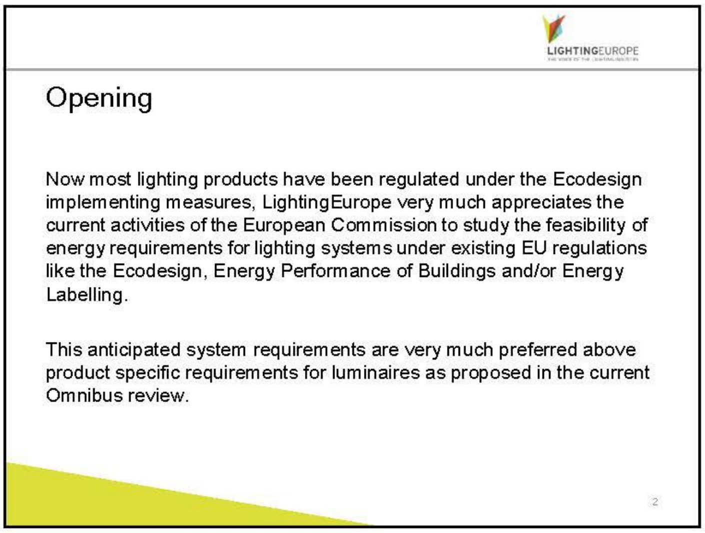

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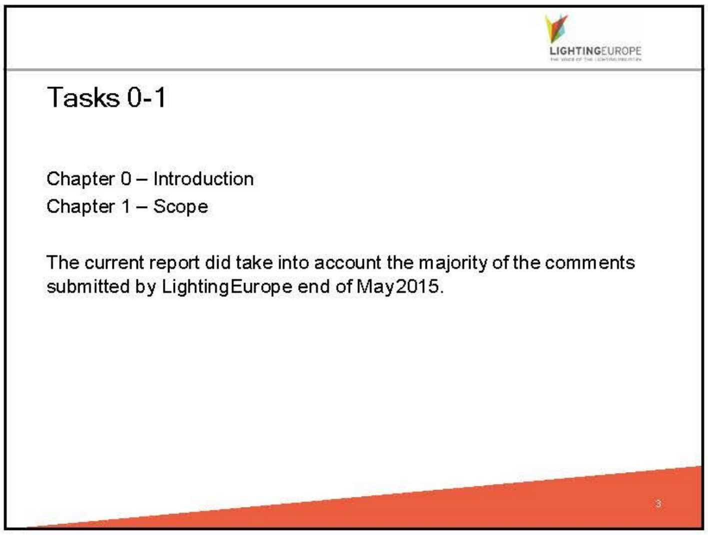
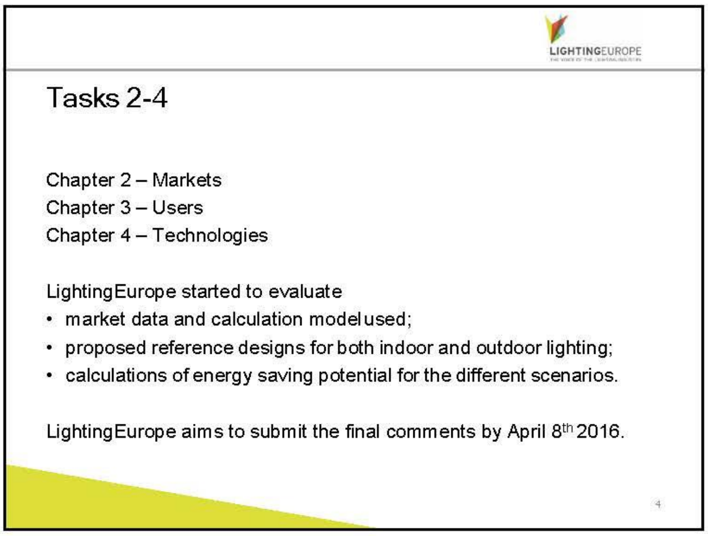

LIGHTINGEUROPE
Tasks 0-1
Chapter 0 – Introduction
Chapter 1 – Scope
The current report did take into account the majority of the comments submitted by LightingEurope end of May 2015.
3


LIGHTINGEUROPE
Tasks 2-4
Chapter 2 – Markets
Chapter 3 – Users
Chapter 4 – Technologies
LightingEurope started to evaluate
• market data and calculation model used;
• proposed reference designs for both indoor and outdoor lighting;
• calculations of energy saving potential for the different scenarios.
LightingEurope aims to submit the final comments by April 8th 2016.
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ANNEX M TASK 0- QUICK SCAN

Objective:

Important note: The findings presented in the discussion below are indicative and made only for the purpose on an initial screening exercise. They will thus be updated in the course of conducting the later Tasks. Therefore this section is mainly printed in grey and will not be updated in revisions of this Task 0.

According to the MEErP: "Task 0 is an optional task for the case of large or inhomogeneous product groups, where it is recommended to carry out a first product screening, considering the environmental impact and potential for improvement of the products as referred to in Article 15 of the Ecodesign Directive. The objective is to re-group or narrow the product scope, as appropriate from an ecodesign point of view, for the subsequent analysis in Tasks 1-7."

This preparatory study on lighting systems follows from the request for services ENER/C3/2012-418 LOT1/05. The Quickscan is an initial screening, based on available information from previous studies and other sources. The objective is to re-group or narrow the product scope, as appropriate from an Ecodesign point of view, for the subsequent analysis. This is done by gathering initial data for the study tasks in order to allow scrutiny against the Article 15 criteria of the Ecodesign Directive 2009/125/EC. Accordingly, the structure of the Quickscan is based on the three major criteria in Article 15, paragraph 2, as explained in section 3.1.1.

According to paragraph 2 of Article 15 of Ecodesign Directive 2009/125/EC energy-related products such as lighting systems have to:

1. represent a significant volume of sales and trade, indicatively more than 200 000 units a year within the Community to the most recently available figures;
2. have a significant environmental impact within the Community – as specified in the Community strategic priorities as set out in Decision No 1600/2002/EC – considering the quantities placed on the market and/or put into service;
3. present significant potential for improvement in terms of its environmental impact without entailing excessive costs, taking into account in particular:
   i. the absence of other relevant Community legislation or failure of the market forces to address the issue properly; and
   ii. a wide disparity in the environmental performance of products available on the market with equivalent functionality.

These three criteria will be addressed in the Quickscan as guiding principles to determine the potential of possible Ecodesign, energy labelling, and/or energy performance of buildings requirements.

Additionally, the provisions of the Ecodesign Directive 2009/125/EC require consideration of the (entire) life cycle of the product and all its significant environmental aspects (including energy efficiency during the use phase of the product) (article 15, paragraph 4, item (a)). Furthermore, implementing measures shall meet the following criteria (article 15, paragraph 5):

a) there shall be no significant negative impact on the functionality of the product, from the perspective of the user;
b) health, safety and the environment shall not be adversely affected;

c) there shall be no significant negative impact on consumers in particular as regards the affordability and the life cycle cost of the product;
d) there shall be no significant negative impact on industry's competitiveness;
e) in principle, the setting of an Ecodesign requirement shall not have the consequence of imposing proprietary technology on manufacturers; and,
f) no excessive administrative burden shall be imposed on manufacturers.

This chapter gives an overview of the Quickscan to provide an insight into the economic and environmental importance of lighting systems and to define potential environmental improvement actions. The results from the Quickscan will identify the most relevant issues for determining whether lighting systems should be included under the "priority list" of products covered by the Second Working Plan on Ecodesign.

So far 'Lighting systems' are not exactly defined as 'traded products' for which a commonly agreed 'unit sold' and product code is available in official product sales statistics such as PRODCOM. Therefore checking significance compared to 200 000 units sold is more complex than for some product groups. Nonetheless it seems clear that considerably more than 200000 lighting systems are installed each year across the EU.

In addition, the potential for energy savings are comfortably above 2 TWh per year and hence can be considered to be significant within the terms applied for the Ecodesign Directive.

Data sources used

The data sources used are:

- Commission Staff Working Document (3009/324): 'Accompanying document to the Commission Regulation implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps, and repealing Directive 2000/55/EC of the European Parliament and of the Council' full impact assessment.
- Commission Staff Working Document (3009/327): 'Commission Staff Working Document (3009/324): 'Accompanying document to the Commission Regulation implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps, and repealing Directive 2000/55/EC of the European Parliament and of the Council' full impact assessment.
- Commission Staff Working Document: Annex 1 working document on possible measures targeting the energy efficiency of lighting in the tertiary sector Presented by the Directorate General for Energy for consultation of the Consultation Forum running from 6 July to 15 September 2010.
- Lighting preparatory studies on lot 8, lot 9, lot 19 (www.eup4light.net).
- Road network statistics from Eurostat (length of roads).
- Building stock statistics from Buildings Performance Institute Europe (BPIE) (surface areas per sector).

- Waide et al., 'The scope for energy and CO2 savings in the EU through the use of building automation technology', Final report August 2013. (Note, this processed BPIE building stock data).
- Typical lighting operational hours and power density (W/m²) per sector/building type according to standard EN 15193.
- Outdoor lighting estimate for non-public lighting as found in literature[15].
- Building construction and renovation statistics from literature[16].
- VHK (2011), Study on Amended Working Plan under the Ecodesign Directive: Final Report, commissioned by the European Commission, version 16 December 2011. This study identifies traffic lights and lighting controls.
- VHK (2013), Omnibus Review Study on Cold Appliances, Washing Machines, Dishwashers, Washer-Driers, Lighting, Set-top Boxes and Pumps, draft interim report (available through www.eup-network.de).

Lighting Installation stock data rough estimate

Important note: These are indicative for a first screening only and will be updated in later Tasks. Therefore this section is mainly printed grey and will not be updated in revisions of this Task 0.

In the literature there is data available concerning the size of the existing building stock17 which can be combined with indicative operational hours of lighting and power density in typical sectors; this results in an estimate to allocate the EU27 power consumption per sector (Table 0-19).

15 http://www.milieurapport.be/Upload/main/AG2007_2%207c_9%20met%20voorblad.pdf

16 Ecofys (2011): 'Panorama of the European non-residential construction sector'-Final report

17 Waide et al., 'The scope for energy and CO2 savings in the EU through the use of building automation technology', Final report August 2013

Table 0-19: Relative indoor lighting power consumption per sector

sector	EU 27 area (million m²)	Share of total area %	time (h/y)	W/m²	% TWh
Education	1001	17%	2000	20	10%
Hotels & restaurants	648	11%	3750	22,5	13%
Hospitals	412	7%	5000	23	11%
Retail	883	15%	5000	25	27%
Offices	1354	23%	2500	20	16%
Other	1590	27%	2980	20	23%
other (% sports)	not available	assumption 1/3	4000	20	10%
other (% industry)	not available	assumption 1/3	4000	20	10%
other (% any other)	not available	assumption 1/3	1000	20	3%
households	17810	not applicable	630	NA	NA
	source: Waide et al. Data (8/2013)		source: EN 15193		estimate

Lot 9 contained an estimate of the energy consumption of street lighting in the EU. Little data is available on other outdoor applications, however, an estimate of the share of outdoor lighting energy use by application derived according to the literature18 can be found in Table 0-20.

Table 0-20: Estimated share in outdoor lighting power consumption per sector

sector	%
public lighting	55,6
industry sector outdoor	8,6
service & recreational sector	23,4
households	2,9
agriculture green houses	9,5

Reference Total energy consumption of the lighting stock in 2007 (rough estimate) (TWh)

Savings are relative to the energy consumption of the lighting stock, therefore this section contains a rough estimate of the lighting stock in 2020, see Table 0-21.
The upper part of Table 0-21 subdivides the data according to the regulation from which they have been derived, i.e. 245/2009 (Tertiary), 244/2009 (NDLS) and 1194/2012 (DLS).

[18] Van Tichelen, Bossuyt, Mira-2007 'Achtergronddocument Thema hinder: lichthinder', www.milieurapport.be

The lower part of the table attempts an alternative subdivision, of the same total values, into an outdoor share, an indoor-residential share and an indoor-non-residential share.

Notes about this 2020 estimate:

- This energy estimate is limited to the scope of existing EU policy measures and therefore does not include, for example, special purpose lamps (estimated to consume 58 TWh in 2007) and/or some types of controls.
- The 2020-data in the table have been derived from Impact Assessment reports that in their turn depended heavily on the data collected and derived for the Preparatory Studies during the years 2005-2007. The clear impression is that the progress, development and market-introduction of LED lamps is much faster than was assumed in those years and also therefore that this estimate is inaccurate.
- This estimate neglects interactive effects with the building energy balance as illustrated in **Error! Reference source not found.**, for example energy savings in lighting could also reduce the building cooling energy demand.

In the context of this quick scan it is not feasible to develop a new and more refined models for the lighting stock, for the corresponding total energy consumption, and for the energy savings related to the Eco-design and –labelling measures which have already been implemented.

Table 0-21: Rough estimate of Electrical Energy Consumption of the EU27 lighting stock based on the data of the Impact Assessment reports associated with the Regulations regarding the Ecodesign measures.

Source	Main Lamp Types	TWh base year[19]	TWh BAU[20] 2020	TWh ECO[21] 2020	TWh ECO 2020 – base year	TWh Savings ECO 2020 – BAU 2020
245/2009[22] (Tertiary)	LFL, CFLni, HID	200	260	222	+22	-38
244/2009[23] (NDLS)	GLS, CFLi, HL, (LED)	112	135	84	-28	-51
1194/2012[24] (DLS)	GLS-R, HL-R, (LED)	30	50	26	-4	-24
Total	**All above**	**342**	**445**	**332**	**-10**	**-113**
Estimated Outdoor/Indoor Subdivision compatible with above totals						
Outdoor	HID	65	84	72	+7	-12
Indoor Residential	GLS, CFLi, HL, (LED)	109	131	82	-27	-49
Indoor Non-Residential	LFL, CFLni (LED)	168	230	178	+10	-52
Total	**All above**	**342**	**445**	**332**	**-10**	**-113**

Link between reference energy consumption and installation stock

At the moment we can only provide an educated guess based on perception; to our knowledge lamp manufacturers have no accurate data concerning where lamps are used or don't want to disclose it for commercial reasons. The assumption on the relation between sector and lamp technology is summarised in the next table:

19 Differs from source to source, year 2005 or 2007
20 Business As Usual, based on state and trends of 2005 or 2007
21 ECO includes the effect of measures as specified in the source
22 Impact Assessment 2009-0324, for Regulation 245/2009, sub-option 2 of Annex II
23 Impact Assessment 2009-0327, for Regulation 244/2009, does not contain full energy data for BAU and ECO scenarios. Data have been taken from Preparatory study Lot 19; figure 8-6 for BAU; figure 8-36 2b for ECO.
24 Impact Assessment 2012-0419, for Regulation 1194/2012; para 2.5.4 for BAU; para 5.2.1 for Lbl Min II (stage 3 at EEI=0.95 applied) for ECO

Table 0-22: Estimated share of lamp technology per sector indoor

	LFL&HID	NDLS	DLS
sector	%	%	%
Education	100%	0%	0%
Hotels & restaurants	34%	33%	33%
Hospitals	90%	5%	5%
Retail	40%	20%	40%
Offices	100%		
Other			
other (% sports)	90%	5%	5%
other (% industry)	90%	5%	5%
other (% any other)	90%	5%	5%

Combining these assumptions with the rough estimate of the lighting stock energy consumption in 2020 results in the following estimate per indoor sector (Table 0-23):

Table 0-23: Estimated annual power consumption of indoor lighting stock per sector (2007)

sector	TWh
Education	17,2
Hotels & restaurants	23,5
Hospitals	20,3
Retail	47,3
Offices	29,0
Other	
other (% sports)	18,0
other (% industry)	18,0
other (% any other)	4,6
households	82,0

For outdoor lighting the data on energy consumption per sector from Table 0-21 and Table 0-23 can be combined to derive the values in (Table 0-24).

Table 0-24: Estimated annual power consumption of outdoor lighting stock per sector (2007)

sector	TWh
public lighting	40,1
industry sector outdoor	6,2
service & recreational sector	16,9
households	2,1
agriculture green houses	6,8
Total outdoor	72,0

Lighting system related improvement options

Introduction to lighting system improvement options

The focus of the improvement options discussed in this section is on improving energy efficiency. This means that other environmental impacts are neglected in the quick scan, e.g. in street lighting replacing asphalt by concrete to increase the road surface reflection might also impact VOC emission. Also the potential positive impact on outdoor light pollution will not be repeated hereafter (see Lot 9). The main reasons for this decision are the added complexity and/or lack of available data. It is suggested to look at those impacts in a full preparatory study for selected and relevant improvement options only. Improvement options related to increases in lamp efficacy, e.g. to A+, will not be discussed hereafter. They are discussed in the OMNIBUS review.

The focus is therefore on system level improvement options that are only related to energy efficiency and that were not dealt with in existing legislation.

The parameters and the related system components that are used in the quick scan are explained in Task 1.

In the following sections five levels of system related improvement options are discerned:

1. *Redesign the building*/room or street;
2. *Change the luminaire and lighting control system* and maintain the other surrounding infrastructure (poles, light point locations, …);
3. *Change the luminaire but not the lighting control system;*
4. *Retrofit lamp, ballast and optic*
5. *Retrofit lamp and ballast*

The highest level, e.g. 1 'Redesign the building', can always be combined with a lower level, e.g. 'Change the luminaire'.

Redesign the building/room or street improvement option

In this case the redesign includes:

- lighting and building energy balance calculation with optimisation;
- choosing windows for daylight entrance;
- building the lighting infrastructure i.e. cables, suspension or poles;
- choosing and placing luminaires;
- choosing and placing lamps or light sources;
- choosing and placing ballasts or drivers;
- installing the lighting control system;
- choosing appropriate surface reflection requirements;

- 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.

Luminaires, lamps and ballasts were selected to be the best available products on the market and moreover ballasts or drivers are dimmable, electronic ones. The dim ability, coupled to a lighting control system, allows energy savings accordingly to the traffic density (street lighting) or daylight (offices and indoor lighting).

It should also be noted that over time in many workplaces the visual need of the workers have radically changed, this is particularly true of offices and factories where the move to screen based tasks and automated processes have radically reduced the demand for lighting. This can also justify a complete redesign.

Change the luminaire and the external lighting control system improvement option

This option saves the basic infrastructure and only replaces:

- luminaires;
- lamps or light sources;
- ballasts or drivers;
- lighting control system.

Luminaires, lamps and ballasts were selected to be the best available products on the market.

Ballasts or drivers shall be dimmable and electronic ones and play an important role in this option. Dimming also enables close matching of the illumination to the lighting requirements for non-domestic lighting as defined in standards EN 12464-1&2 and EN 13201-2 and therefore provides energy saving. Otherwise, there is an initial over-illumination in projects where the maintenance factor is taken into account; a constant illumination control system such as defined in EN 15193 can therefore provide additional savings.

Change the luminaire but not an external lighting control system improvement option

In existing installations of the previous option where no lighting control system can be installed, it is possible to just replace luminaires.

In this case dimming can also be useful e.g. when dimming can be done to fine tune matching with the minimum illumination requirements taking into account real local conditions such as reflections and the available lamp wattages. It is also possible to have an integrated light or presence sensor to control the light output.

Retrofit lamp, ballast and optic improvement option

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.

Retrofit lamp and ballast improvement option

See the Omnibus study.

More frequent operation and maintenance of the lighting system according to the design

This can reduce calculated maintenance factors and therefore initial and total energy in use for the life of the lighting system.

Also in existing designs it can provide savings when constant illumination control systems are implemented, see 0.

Reference Worst Case (WC) 2020 compared to BAT 2020 for street lighting (outdoor)

The calculation shown in table 1-15 below is made for a street in a slow traffic area in line with the Lot 9 Preparatory Study for Public Street Lighting.
The base case already takes into account the Ecodesign requirements for 2017 as published in Commission Regulation 245:

- the lamp type is an HPS with enhanced xenon-pressure and non-dimming magnetic ballast;
- the luminaire is a luminaire without optics and with ingress protection IP45 as the regulation does not impose any requirement for luminaires; and,
- low performing optics and installation (UF).

The BAT 2017 uses:

- an improved MH-lamp of the new generation;
- improved UF;
- a dimmable, electronic ballast with appropriate control system;
- a luminaire with BAT optic, IP65 and self-cleaning glass and thus high LMF.

The BAT 2020 LED has:

- LED light source with assumed efficiency of 120 lm/W as forecast by Lighting Europe;
- a dimmable electronic driver with appropriate control system;
- improved UF, it assumes that LED enables better control of the light distribution;
- a luminaire with high LMF.

Table 0-25: Worst Case with existing legislation compared to BAT 2020 at system level for street lighting

	HPS-70W	MH-60W	LED
	Worst Case 2017, Slow Traffic	MH BAT 2020 2017, Slow Traffic	LED BAT 2020 2017, Slow Traffic
ballast type	elecronic	electronic, dim	electronic, dim
IP(ingress)	45	65	65
ηgear	0,90	0,90	0,90
BGF	1	1,6	1,6
ηlamp(lm/w)	94	120	120
LLMF	0,95	0,95	0,80
LOR	0,5	0,75	1,00
LMF	0,84	0,90	1,00
U	0,22	0,67	0,80
LPDi(W/100 lm)	13,43	1,35	0,90

Conclusion:

This street lighting example, illustrates that the energy consumption per year and per useful lumen when comparing the Worst Case projected for 2017 with the BAT can drop from 13.43 W per 100 functional lumens to 0.9 W per 100 functional lumens, i.e. **an energy saving of over 93%.**

Reference Worst Case (WC) 2020 compared to BAT 2020 for office lighting (indoor)

The calculated example in the table below is made for a cellular office with luminaires with direct light output, in line with the lot 8 Preparatory Study for Office Lighting.

The base case assumes a T8-LFL, a non-dimmable electronic ballast with a directional light source luminaire (CIE flux code N2>0.8) and relatively poor optics (LOR) in line with the 2017 legislation.

The BAT case uses the improved T5-LFL and a dimmable, electronic ballast with lighting control i.e. presence detection and daylight responsive dimming (BGF).

The LED solution assumes an efficiency of 120 lm/W and also a dimmable, electronic driver with lighting control i.e. presence detection and daylight responsive dimming.

Table 0-26: Worst Case with existing legislation compared to BAT 2020 at system level for office lighting

	BC2020	BATLED	BAT_T5
Room length (window)	3,6	3,6	3,6
Room depth	5,4	5,4	5,4
distance lum-work plane	2	2	2
SHR	1	1	1
Reflectance ceiling	0,7	0,7	0,7
Reflectance Walls	0,5	0,5	0,5
Reflectance floor cavity	0,2	0,2	0,2
annual operating hours(ref)	2250	2250	2250
ηballast (T8 corrected for HF operation)	1,03	0,9	0,9
BGF (ballast gain factor)	1	2,26	2,26
ηlamp (lm/W) (T8 on magnetic)	93,06	120,00	103,00
LLMF (lamp lumen maintenance f)	0,90	0,70	0,90
luminaire type	**reflector**	**LED**	**reflector**
CIE flux code N1(41,4°)	0,76	0,79	0,65
CIE flux code N2(60°)	0,99	0,99	0,99
CIE flux code N3(75,5°)	0,99	0,99	0,99
CIE flux code N4(DFF)	1,00	1,00	1,00
CIE flux code N5(LOR)	0,66	1,00	0,90
LMF	0,85	1,00	0,80
LER (functional lumen/W)	63,3	108,0	83,4
RSMF	0,96	0,96	0,96
U (utilance)	0,84	0,86	0,79
LPDi (W/(m².100lx) or W/100 f-lm)	2,55	0,71	0,98
LENI (kWh/(m².y)	5,74	1,60	2,20

Conclusion:

This office lighting example illustrates that the energy consumption per year and per useful lumen, when comparing the Worst Case projected for 2017 with the BAT, can drop from 5.74 kWh/(m².y) to 1.60 kWh/(m².y), **i.e. an energy saving of 62 %**. The main improvement comes from control systems in conjunction with a higher LER for the LED luminaire. More refined analysis will be done in later tasks 4-6.

Reference Worst Case (WC) 2020 compared to BAT 2020 related to changing domestic luminaire design (indoor)

In domestic lighting and some other similar lighting applications there are no strict illumination requirements imposed via standards, as opposed to typical non-domestic lighting applications. This has an impact on the functional unit (see Task 1) and therefore also on system improvement options.

In the Preparatory Study for Domestic Lighting, several improvement options were discussed at 'system level' that can also be applied in other lighting applications.
Note: in Lot 19 the luminaire was part of the system environment.

Improvement options related to lamp efficacy improvements:

- avoid the lock-in effect into low efficiency lamps of class C or lower;
- design luminaires that create a positive lock-in effect into efficient lighting;
- use coloured LEDs to create coloured light.

Options for the design of luminaires with appropriate and efficient control electronics:

- luminaires that incorporate or are compatible with dimmers;
- luminaires with motion sensors incorporated where appropriate;
- outdoor luminaires with day/night sensors incorporated;
- eliminate standby losses when power supplies are incorporated in luminaires;
- use electronic control gear instead of magnetic (conventional) control gear for CFLni and low voltage halogen.

Options to increase the optical efficiency of luminaires:

- use material with increased light transmittance for visible parts that are transparent / translucent;
- use materials with increased reflectance for invisible parts that are not transparent/translucent;
- use the correct category of luminaire for the correct application and provide appropriate user information.

Other luminaire related improvement options:

- design outdoor luminaires with photovoltaic panels;
- use a reflector lamp or an LED-luminaire instead of a luminaire with reflector for downlighters.

Conclusion:

Annex I of lot 19 included estimates on Luminaire improvement options **which can results in cumulative savings up to 80 %,** on the assumption that they are all relevant and applicable. More refined analysis will be done in later tasks 4-6.

Reference Worst Case (WC) 2020 compared to BAT 2020 for the building energy balance related to lighting

As shown in sections **Error! Reference source not found.** and **Error! Reference source not found.**, lighting systems are specified by different characteristics. Taking into account all these characteristics makes it difficult to compare different lighting systems. When looking at lighting systems within the context of a whole building energy performance approach, this becomes even more difficult, since windows also need to be considered.

Windows are generally the weakest link in the building envelope from an insulation point of view (e.g. U=0.24 W/m²K for walls and roofs versus 1.1 W/m²K for windows), but provide natural daylight and solar heat gains. Heat losses and solar heat gains, as well as daylight provision are all characterised by different aspects of the window and its surroundings (e.g. shades, etc.).

Daylight is considered a crucial aspect in sustainable building, as shown by the BREEAM rating system, where in the section of health and well-being credits can be awarded for daylit rooms.

Also, windows play an important role in the perception of space and often contribute to the architectural qualities of a building, especially in office buildings.

Conclusion:

There is no ready to use data for the quick scan, however the impact of modelling is included in standard DIN EN 15232:2007-11, and therefore it is recommended to reconsider this in the subsequent tasks.

Input received from field experience of lighting designers on target application area's

Note the following input was received from IALD**Error! Bookmark not defined.**:

"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."

Conclusions on scope

As already can be concluded, savings at system level can be very significant and can reach up to 90% when comparing the worst case implementation permitted according to the existing legislation after 2017 with the best available techniques.

Therefore the statement made in a working document of the consultation of September 2010 on lighting is still a realistic estimate; it states that 'addressing lighting at system level would contribute to 90 TWh[25] for the whole non-domestic sector'[26]. Of course, all TWh consumed in lighting can only be saved once. This means that when light sources become more efficient, the total impact from other system related improvement options will become proportionally less. Subsequent tasks will analyse this in more detail, with more categories, more representative base cases and consider more improvement options.

[25] Of Annual Energy Savings in lighting installations (2005 reference)
[26] The 90TWh refers to estimated annual energy savings in 2020

The estimated energy consumption (2007) per sector and rough first estimates of the maximum savings found are summarised in Table 0-27 and Table 0-28. The findings in these tables imply that the remaining tasks should specially focus on indoor lighting systems in the sectors of: education, hotel & restaurants, hospitals, retail, offices, sports and industry. For outdoor lighting the focus should be on street lighting and the public & recreational sector. In task 2 the screening of application areas will continue and might reveal new areas of importance. Also lighting designers pointed out that interesting application areas are commercial developments, office and retail.

Table 0-27: Annual indoor lighting energy consumption per sector and maximum savings identified

sector	TWh	saving up to %
Education	17,2	70%
Hotels & restaurants	23,5	70%
Hospitals	20,3	70%
Retail	47,3	70%
Offices	29,0	70%
Other		70%
other (% sports)	18,0	70%
other (% industry)	18,0	70%
other (% any other)	4,6	NA
households	82,0	80%

Table 0-28: Annual outdoor lighting energy consumption per sector and maximum savings identified

sector	TWh	saving up to %
public lighting	40,1	90%
industry sector outdoor	6,2	90%
service & recreational sector	16,9	90%
households	2,1	90%
agriculture green houses	6,8	unknown
Total outdoor	72,0	

ANNEX N SUMMARY OF LOT (8/9/19) STUDY ON LIGHT SOURCES

This study, assigned by the European Commission, prepares for a comprehensive review of the four existing ecodesign and energy labelling regulations for Light Sources ('Lot 8/9/19') in the European Union [27]. It aims at setting more ambitious targets, removing flaws and possibly unifying the existing regulations into one or two improved pieces of legislation.

The study ran from January 2014 to October 2015, and was structured according to the MEErP [28] methodology with 8 Tasks (0 to 7). Stakeholders have been consulted during two meetings and their information and comments have been taken into account.

Task 0: Assignment, Methodology and First screening

A summary of the context is provided, including a description of the existing regulations regarding Light Sources. The assignment, project structure, planning and team for the study are presented. In the first screening, the initial scope of the study is chosen very wide: "*The study regards all light sources, lamps, ballasts and lamp control gears according to the definitions provided in the Task 0 report* ".

Task 1: Scope, Standards and Legislation

Typology of light sources on the EU-market and relevant parameters are presented. Special Purpose Lamps and other exemptions have been analysed. They account for 70-80 TWh/a [29] of EU-28 electricity consumption in 2013. The lack of accurate, verifiable definitions is identified as a barrier for effectiveness of market surveillance. The initial scope is slightly reduced (Figure 12), mainly on the basis of the eligibility criteria of art. 15 of the Ecodesign Framework Directive 2009/125/EC, and a proposal for further reduction is presented to the stakeholders and the Commission.

A study of the many available standards related to lighting products (measurement, safety, other) led to the identification of several potential issues for mandates to European Standardization Organisations, such as:

- accelerated testing for lumen maintenance & life,
- dimmer compatibility (ongoing, expected 2018),
- colour rendering metrics across lamp types,
- cost-effective solutions for testing of directional lamps,
- practical tests for special purpose lamps and other exemptions,
- generally accepted methods for testing and calculation of flickering.

[27] Commission Regulation (EC) No 244/2009 of 18 March 2009, OJ L76/3, 24.3.2009 (non-directional household lamps)
Commission Regulation (EC) No 245/2009 of 18 March 2009, OJ L76/17, 24.3.2009 (fluorescent lamps without integrated ballast, high intensity discharge lamps, ballasts and luminaires able to operate such lamps)
Commission Regulation (EU) No 1194/2012 of 12 December 2012, OJ L342/1, 14.12.2012 (directional lamps, light emitting diode lamps and related equipment)
Commission Delegated Regulation (EU) No 874/2012 of 12 July 2012, OJ L258/1, 26.09.(energy labelling of electrical lamps and luminaires)
as amended by successive regulations

[28] 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

[29] Excluding lighting on means of transport, backlighting for electronic displays, and lamps integrated into products that are already subject of separate ecodesign measures.

Minimum efficacy requirements exist in almost all parts of the world. An international comparison concludes that the EU has the broadest scope, is the most stringent and covers most lamp types, while energy labels and information requirements for light sources are very comprehensive. Yet, most recently, Japan has announced more ambitious targets.

Task 2: Markets

In 2013 a total of 2.1 billion light sources was sold in EU-28 (Figure 13)of which 62% in the residential sector and 38% in the non-residential sector. The installed stock in 2013 was around 11 billion units and is continuously increasing (Figure 14). The total consumer expense for lighting in 2013 was around 65 billion euros [30], corresponding to 0.4% of the EU-28 GDP.
Data regarding ballasts show a > 60% sales share for electronic ballasts in 2010.

Together with the parameters from Task 3, all data have been collected and processed in the very comprehensive 'Model for European LIght Sources Analysis' (MELISA) (Figure 16). Model input and output have been extensively checked against other available data sources.

Task 3: Users

Task 3 reports annual operating hours, useful lifetimes, installed power (W) and capacity (lm), and efficacy. In 2013 the installed lighting capacity was 10.8 Tlm and the total installed power 304 GW [31], estimated to correspond to 11 W/m^2 in the residential sector and 8.7 W/m^2 in the indoor non-residential sector.

Electric energy consumption for lighting amounted to 382 TWh/a in 2013 (including ballasts, controls, standby and special purpose lamps), which is around 14% of the EU-28 total. The share of the residential sector is 93 TWh/a (24%), with energy density estimated in 467 kWh/household/a or 4.3 $kWh/m^2/a$. The non-residential sector accounts for 289 TWh/a (76%) with an estimated energy density of 13.4 $kWh/m^2/a$ for the indoor applications.

Other issues addressed in Task 3 are:

- More efficient lighting (LED) is estimated to lead (on average) to 0.1°C colder rooms in 2020 due to the lower heating contribution of light sources.
- As regards health aspects of light sources, in general there is no reason for concern, but in some cases there are reports on issues related to blue-light hazard, glare and photo-biological safety.
- At end-of-life, according to European waste handling statistics, 30% of the discharge lamps and 5% of the other lighting equipment is separately collected, of which 75-80% is recycled or re-used. All other lighting products end up in the main waste stream.
- There are problems with dimming of 'dimmable' LED lamps, but data lack as regards the size of the problem. A cautious estimate is that 50% of the households has on average 1 phase-cut dimmer installed, and some of these may encounter problems. A new dimmer-lamp compatibility standard is expected by 2018.

Task 4: Technology

[30] Fixed 2010 euros, including 20% VAT for the residential sector. Total expense for acquisition, installation, use (electricity cost) and maintenance. Excluded: special purpose lamps, lighting controls and standby.

[31] Tlm = Tera-lumen (10^12), GW = Giga-Watt (10^9)

The technological aspects of all types of lamps are discussed, with a focus on LED technology. The 2014/2015 LED lighting products have an average efficacy of 89 lm/W and an average price of 23 euros/klm. The future projections up to 2030 for LED efficacy and LED prices are shown in Figure 17 and Figure 18. LED prices are rapidly coming down, efficacies are still going up, and quality is improving. These developments, and the penetration of LEDs in the light source market, are much faster than could be expected in 2007-2009 when the studies for the current regulations were made.

LED retrofit lamps are available for most classical lamp types. Some (partial) exceptions are LEDs to replace LFL T5, high capacity HID-lamps and CFLni. Some LED-retrofits for halogen lamps with G9 or R7s cap may encounter lock-in problems in existing luminaires.

Task 4 also discusses OLED-lighting, Laser-diode lighting, Induction lighting, Plasma lighting and Smart lamps, but these have not been considered as separate base cases. In addition the packaging and material resources (bill-of-materials) are addressed.

Task 5: Environment & Economics (base case LCA and LCC)

Using the EcoReport-tool, the life cycle costs (LCC) and the environmental impacts (Figure 19) for all light source types have been determined. The LCC for average 2013 LED lighting products is 3.4 euros/Mlmh [32], which is 5 to 7 times lower than for filament lamps and 2 times lower than for CFL. In 2020 the LCC for LED is expected to decrease to 1.3 euros/Mlmh, i.e. significantly lower than for linear fluorescent and high-intensity discharge lamps.

The electricity consumption of light sources in 2013 was 265 TWh (excluding ballasts, controls, standby and special purpose lamps), which is 9.5% of the EU-28 total. Greenhouse gas emissions due to lighting products were 103 MtCO_2eq. (2% of EU-28 total). Mercury emissions due to the generation of electricity for lighting were 4.2 ton in 2013 (5.3% of EU-28 total). The mercury contained in lamps that reached their end-of-life in 2013 was around 2.1 ton (2.7% of EU-28 total).

Task 6: Design Options (Least Life-Cycle Costs and payback times)

The payback time for an investment in LED lighting products is 1-4 years [33]. These values are reached in 2015 for substitution of filament lamps (GLS, HL) by LEDs, and are projected to be reached in 2020 for substitution of discharge lamps (LFL, CFL, HID) (Figure 20).

Task 7: Scenario Analysis (Policy Options)

The Business-as-Usual (BAU) scenario includes the future effects of existing regulations and the expected trends in LED sales, efficacy and prices. It leads to 110 TWh/a of electric energy savings in 2030 as compared to 2015 (Figure 21, Figure 22).

The ECO-scenarios aim at a single new ecodesign regulation, technology neutral, with a single energy efficiency criterion for all types of lighting products (light source + control gear + other related devices if integrated). The scope is further clarified in Figure 12, Figure 23 and Figure 24).

The required energy efficiency is expressed as a maximum allowed power (Figure 25) that includes a bonus for low lumen lamps and for lamps with high colour rendering

[32] Considering that different light sources have different lifetimes, for honesty of comparison, the life-cycle costs and energies have been normalized to a total light output of a million lumen-hours (Mlmh)

[33] In some cases payback times can be less than one year.

index (CRI). The target efficacy in this formula (70, 80 or 120 lm/W) is based on the LLCC criterion, while the timing of measures considers the expected development of the affordability of LED lighting products, the ongoing work on the dimmer compatibility standard (2018), the need for recent investors in high-intensity discharge (HID) lamps and high-frequency T5 linear fluorescent lamps (LFL T5) to recuperate investments, and time for industry to prepare for the new requirements.

The proposal is completed with requirements regarding standby power, suitability for general purpose lighting, dimmability, power factor and colour consistency. Improvement of Market Surveillance is enabled, speeding up test procedures and removing ambiguities.

The ecodesign measures are combined with an improved energy labelling for lighting products (indicated as '+LBL' below), aimed mainly at increasing the visibility of the label (Figure 26).

The ECO-scenarios that have been analysed are:

- ECO70+LBL: P(on) ≤ (2 + Ø/ 70)*((CRI+240)/320) in 2020
- ECO80+120 (+LBL): P(on) ≤ (2 + Ø/ 80)*((CRI+240)/320) in 2020 (stage 1)
P(on) ≤ (2 + Ø/120)*((CRI+240)/320) in 2024 (stage 2)
- ECO120+LBL [34]: P(on) ≤ (2 + Ø/120)*((CRI+240)/320) in 2020

The ECO120+LBL scenario is an approximate reference for the maximum savings that could be theoretically obtained, but its technical feasibility is uncertain. The ECO80+120+LBL has been selected by the European Commission for its draft regulation proposal to the Ecodesign Consultation Forum of December 2015.

The additional savings of the ECO-scenarios with respect to the BAU-scenario in 2030 are provided in Figure 21 and Figure 22. The ECO80+120+LBL scenario saves additional 61 TWh/a of electricity and 21 MtCO_2eq of greenhouse gas emissions. Without energy label improvement these savings drop to 43 TWh/a and 14 MtCO_2eq.

To obtain these savings, an investment in LED lighting products is required, leading to a peak in EU-28 total acquisition costs around 2020. This peak is higher when the measure is more ambitious (Figure 27): 19 billion euros for BAU and 26 billion euros for the ECO80+120+LBL scenario (+7 bn euros, +36%).
As a consequence, the EU-28 total annual consumer expense for lighting is higher for the ECO-scenarios than for the BAU-scenario up to 2022 (Figure 28). After that year the consumer reaps the benefits of the investments due to lower energy costs: in 2030 the total expenses are 76 billion euros in BAU and 62 billion euros for the ECO80+120+LBL scenario (-14 bn euros per year, -18%).

All documentation regarding the Light Sources study can be found on the project website http://ecodesign-lightsources.eu/documents .

[34] This is an approximate reference scenario for the maximum savings that could be theoretically obtained, but the technical feasibility of this scenario is uncertain.

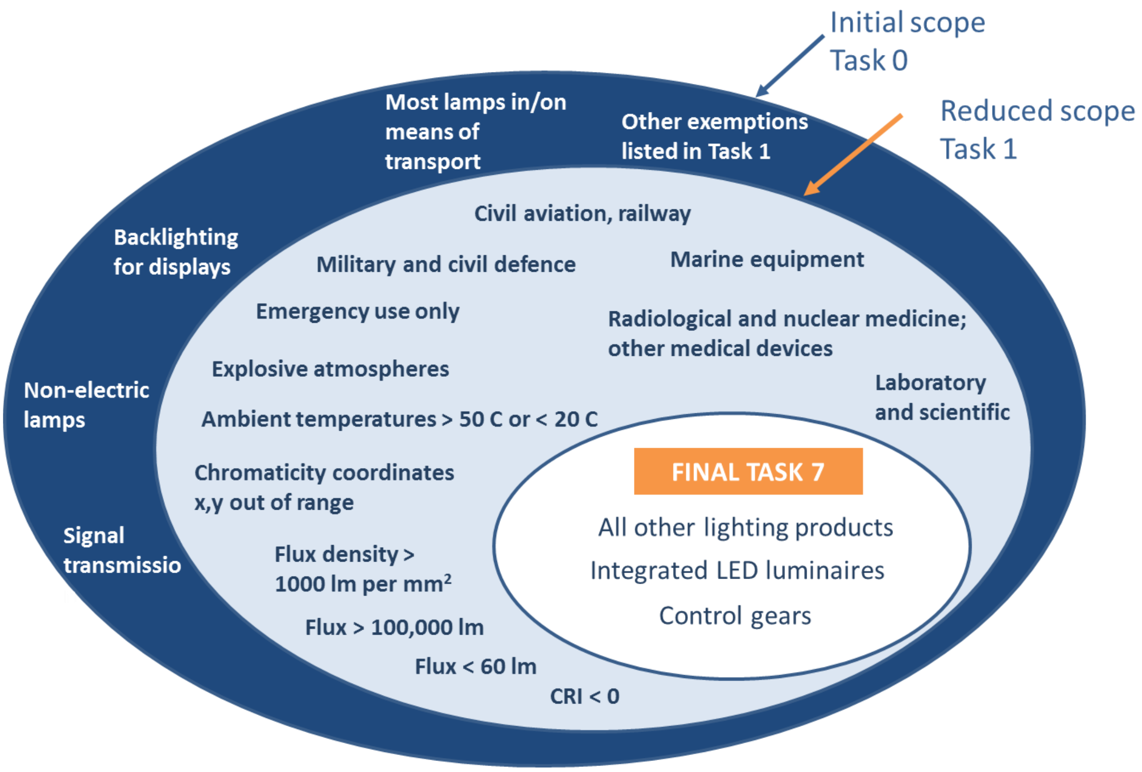


Figure 12 Reduction of the scope during the study. The final (Task 7) scope proposed for the new regulation regards all lighting products not exempted in the two outer ellipses.

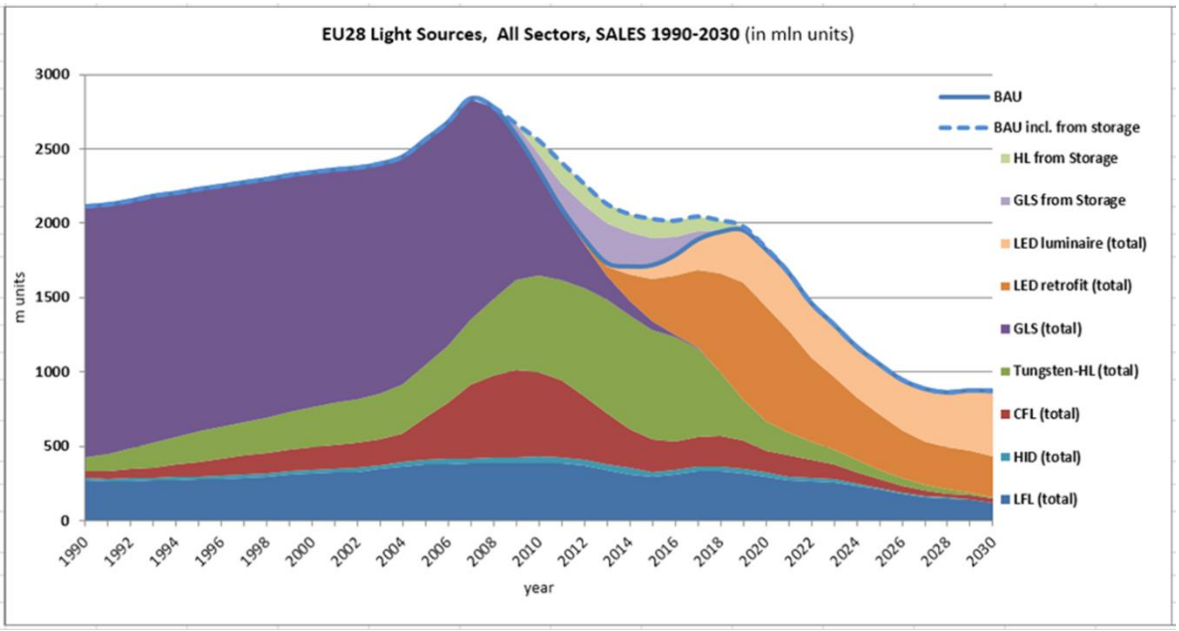


Figure 13 Sales volumes of light sources from the MELISA model, EU-28 totals over the period 1990-2030 (millions of units). In 2013 a total of 2.1 billion units were sold in EU-28 of which 62% in the residential sector. In 2030 this is predicted to decrease to 0.9 billion (Business-as-Usual scenario).

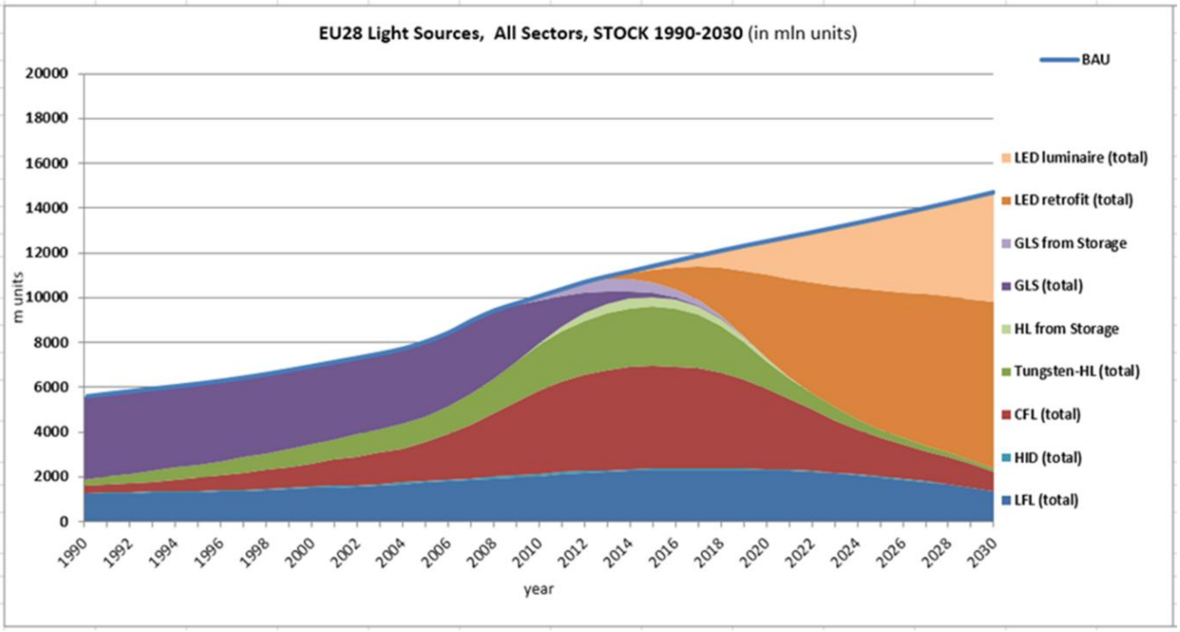


Figure 14 Installed Stock of light sources from the MELISA model, EU-28 totals over the period 1990-2030 (millions of units). In 2013 a total of 11 billion units were installed in EU-28 of which 60% in the residential sector. In 2030 this is predicted to increase to 15 billion (Business-as-Usual scenario).

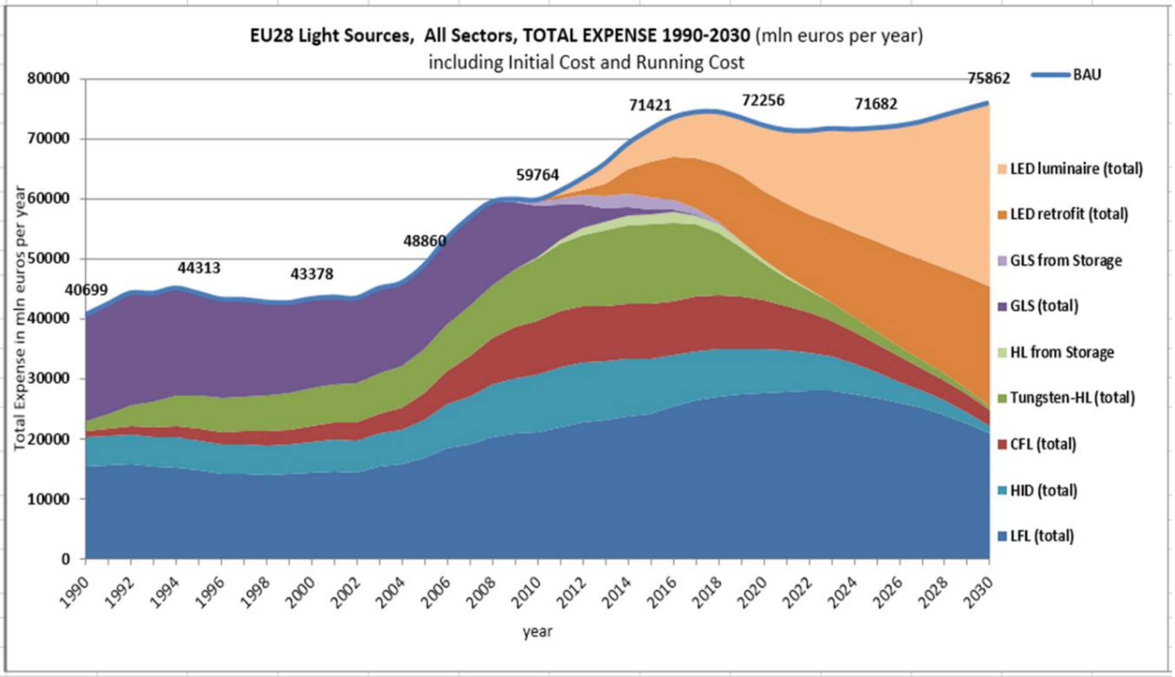


Figure 15 Annual Total Consumer Expenditure for the acquisition, installation and operation of light sources, from the MELISA model, EU-28 totals over the period 1990-2030 (millions of fixed 2010 euros, incl. VAT). Special purpose lamps, controls and

standby are excluded. In 2013 the total expenditure was around 65 billion euros, or 0.4% of the EU-28 GDP. The residential share was 43%, i.e. 118 euros/household/year. (Business-as-Usual scenario for 2013-2030).

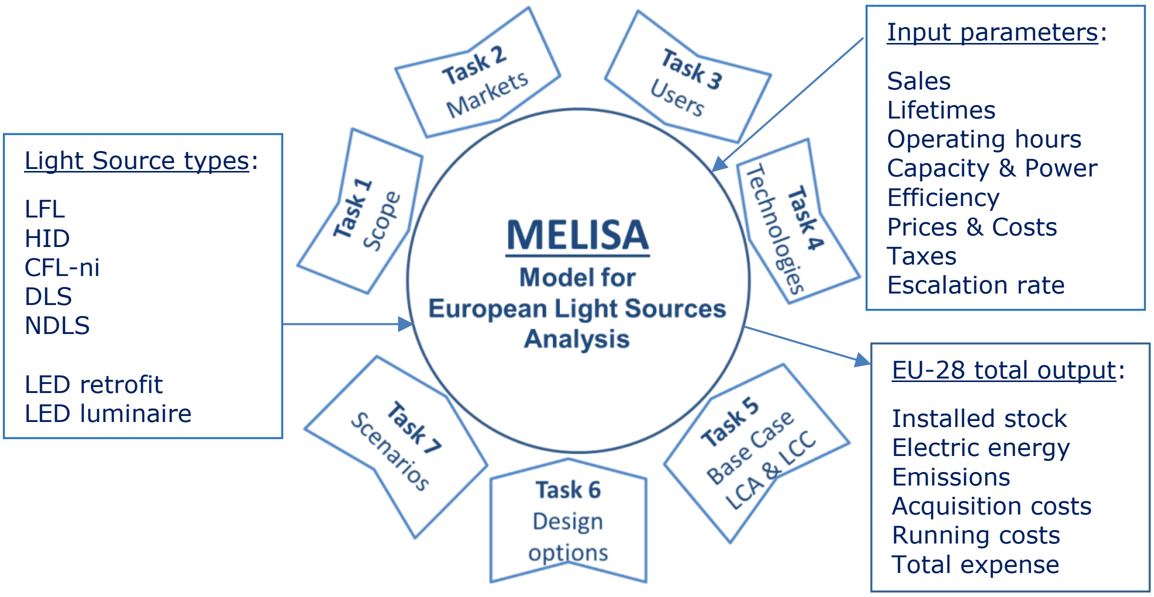
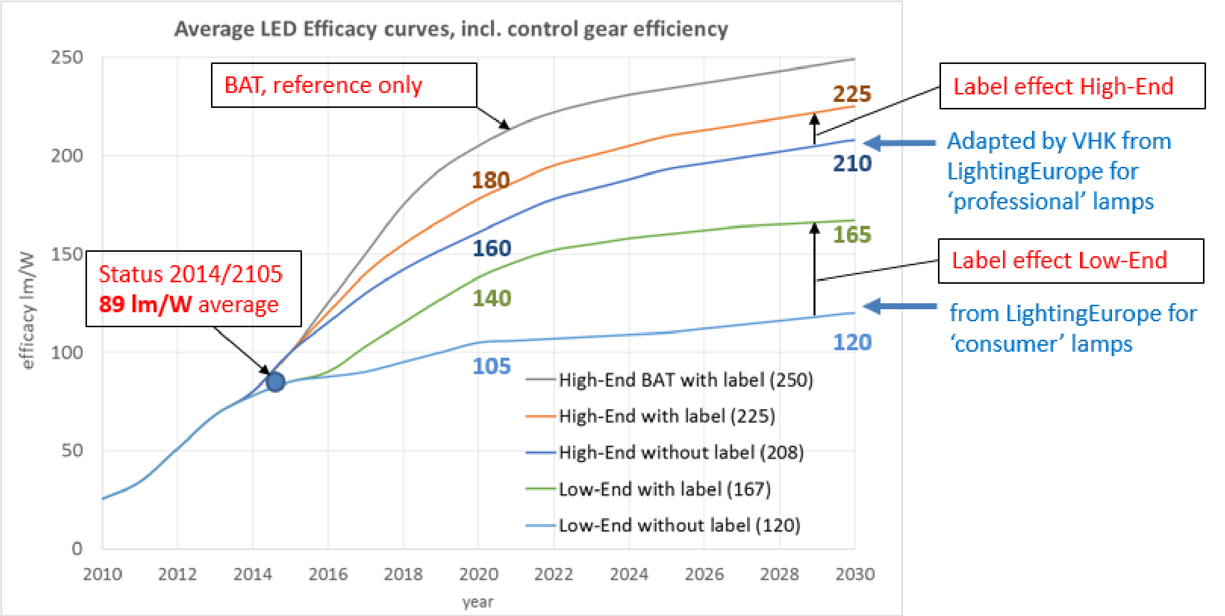
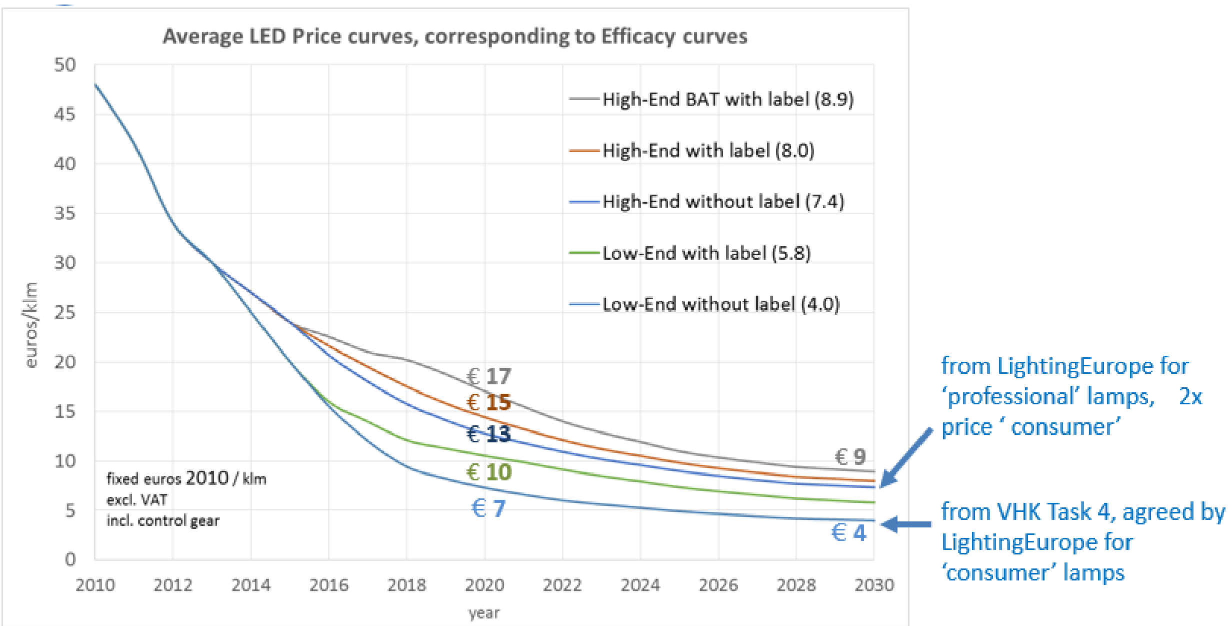


Figure 16 Model for European Light Sources Analysis (MELISA). Covers all general purpose light source types over the period 1990-2030. This model was originally developed and presented in Task 2 and further developed in Task 7 for the scenario analyses. LFL= linear fluorescent lamp; HID = high-intensity discharge lamp; CFL = compact fluorescent lamp with ('i') or without ('ni') integrated ballast; DLS = directional light source (incandescent or halogen filament lamps); NDLS = non-directional light source (filament lamps and CFLi); LED = light-emitting diode



High-End = LED replacing LFL, CFLni, HID-lamps in non-residential sector.
Low-End = LED replacing GLS, HL, CFLi in all sectors and LFL, CFLni in residential.

Figure 17 Current status and projection up to 2030 for the efficacy (lm/W) of LED lighting products. These curves have been used in Task 7 for the scenario analysis



Price curves apply to efficacy curves with same name, i.e. price increases linearly with efficacy

Figure 18 Current status and projection up to 2030 for the prices (euros/klm) of LED lighting products. These curves have been used in Task 7 for the scenario analysis and are applied to LED products with the efficacy of the corresponding curve in Figure 17.

Parameter	**EU-28 lamp-related**	**Share of EU-28 total (%)**
Electricity	265 TWh *	9.5 % *
→ Primary Energy	2398 PJ	3.2 %
GHG emissions	103 Mt CO_2 eq.	2 %
Acidifying agents emission	455 kt SO_2 eq.	2 %
Other emissions to air		< 0.6 %
Emissions to water		< 0.1 %
Non-energy resources		< 0.1 %
End-of-Life Hg emissions	2.1 ton (end-of-life lamps)	
Use-phase Hg emission	4.2 ton (power plants)	
Total lamp-related Hg	6.3 ton (total lamp-related)	8 % (declining)
Critical raw materials	158 tons Sb equivalent	1.4 %
End-of-Life Lamp Waste	96 kt (light sources)	1 % of WEEE
	78 kt (packaging)	
Use-phase Lamp Waste	1.2 Mt (power plants solid waste)	
Total lamp-related Waste	1.4 Mt	0.04%

*Figure 19 EU-28 Environmental Impacts of lighting products, as derived from the EcoReports in Task 5, compared to the EU-28 total impact of all products. * Excluded: impacts from ballasts/control gears, special purpose lamps, lighting controls and standby. Including those, electricity would be 382 TWh (44% higher). GHG = greenhouse gas emission; Hg = mercury; WEEE = Waste Electric & Electronic Equipment*

Application Group (analysis conditions)	Available option with **lowest LCC/Mlmh**	Available option with **lowest kWh/Mlmh**	**Payback** for LED **2015** vs. best classic technology (years)	**Payback** for LED **2020** vs. best classic technology (years)
Linear fluorescent lamps (LFL) (approx. 2400 lm, 1400-2200 h/a)	Classic technology	LED 2015	maybe never	**3-4**
Compact fluorescent lamps (CFLni) (630 lm, 1200 h/a)	LED 2015	LED 2015	no pay back in CFLni life	**3.5**
High-intensity discharge lamps (HID) (12000-13000 lm, 4000 h/a)	Classic technology	Classic technology	maybe never	**1-2.5**
Directional (filament) lamps (DLS) (450 lm, 450 h/a)	LED 2015	LED 2015	**2**	**0-1**
Non-directional lamps (NDLS, incl. CFLi) (420-500 lm, 450 h/a) (3000 lm for R7s)	LED 2015	LED 2015	**3.5-4 (GLS, HL) >12 (CFLi)**	**0-2**

Figure 20 Least life-cycle cost design options and payback times for LED lighting products in 2015 and 2020. Results are valid only for the analysed conditions (reference lumen, operating hours per year), under the assumptions made, and for

the prices and costs considered. NOT valid for every lighting situation, but indicative for the average EU-28 situation. LCC = Life-cycle cost; Mlmh = million lumen-hours of light output; kWh is kiloWatt-hour of electricity consumption

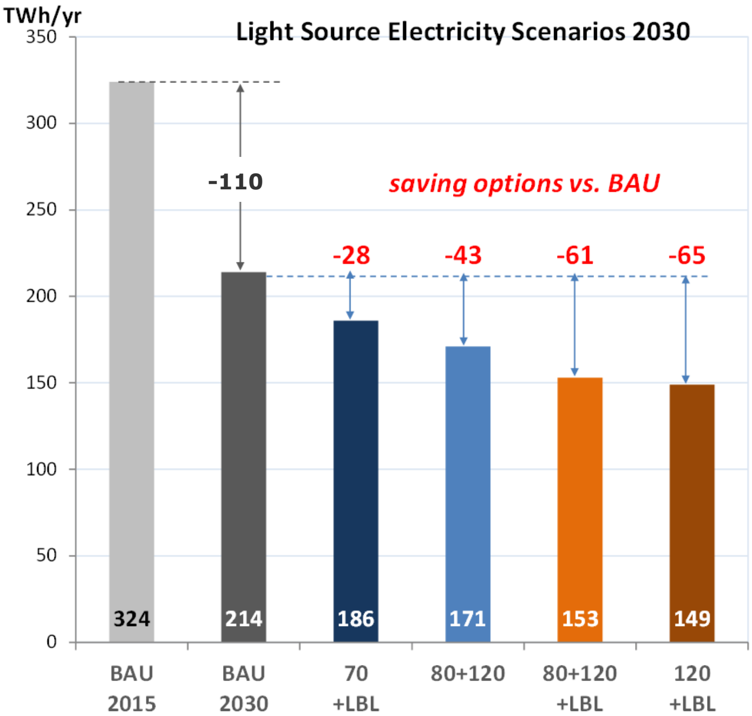


Figure 21 Annual electric energy savings (TWh/a) in the BAU-scenario between 2015 and 2030, and possible additional savings in 2030 depending on new Ecodesign and Energy Labelling measures.

(ECO)70, -80 and -120 indicate the target minimum efficacy requirement (Eff) in the maximum power requirement formula P_{on} < (2+flux/Eff)((CRI+240)/320). ECO120 is an approximate reference for highest savings that could be theoretically obtained but technical feasibility of this scenario is uncertain. '+LBL' indicates introduction of label improvements (visibility, size) in addition to the ecodesign measure.*

impact	unit	absolute		relative vs. BAU 2030			
		BAU 2015	BAU 2030	ECO70+ LBL	ECO80+ 120	ECO80+ 120+LBL	ECO120 +LBL
Electricity	TWh/yr	324	214	-28	-43	-61	-65
GHG emissions	Mt CO_2 eq.	128	73	-10	-14	-21	-22
Acquisition costs	bn. euros	18.2	14.4	+0.8	-0.3	+1.1	+1.1
Energy costs	bn. euros	53.2	61.5	-7.4	-9.9	-14.9	-15.9
Total expenditure	bn. euros	71.4	75.9	-6.6	-10.2	-13.8	-14.7
Business revenu	bn. euros	10	8.6	+0.9	+0.2	+1.3	+1.3
Jobs (in+out EU)	000 jobs	199	172	+18	+4	+26	+26

Figure 22 Survey of savings in the BAU-scenario between 2015 and 2030, and possible additional savings in 2030 depending on new Ecodesign and Energy Labelling measures. (see Figure 21 for explanation of ECO-options)

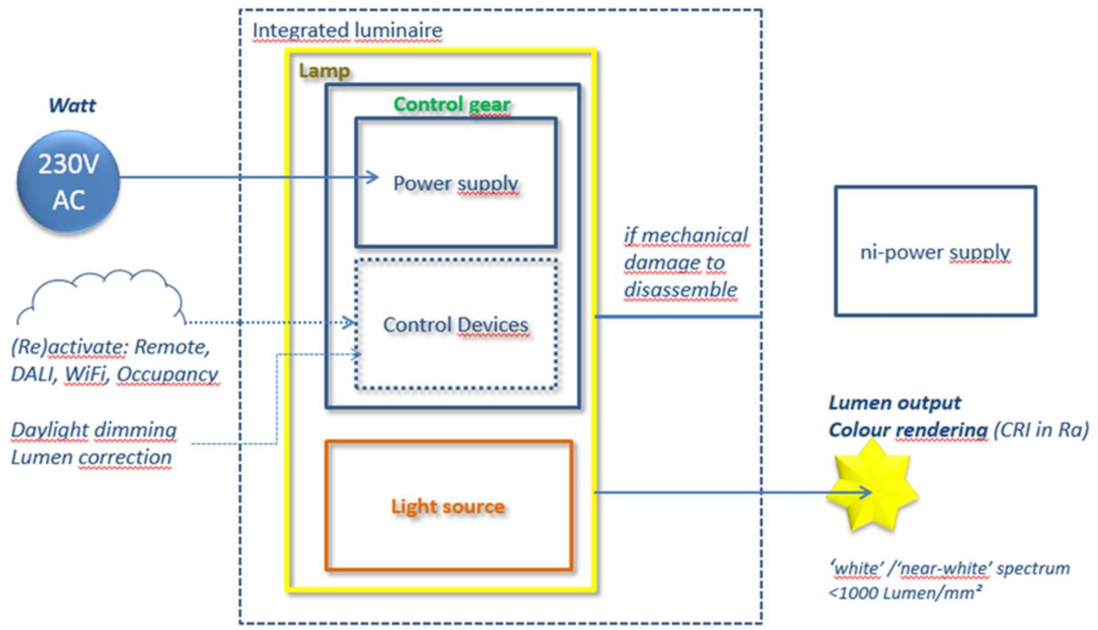


Figure 23 The subject of ecodesign measures is the mains-operated 'lighting product', intended as the combination of light source, ballast/control gear, and other integrated devices for control and communication where applicable. The scope is limited to products emitting 'white' or 'near white' light (Figure 24), with a flux between 60 and 100 000 lm, an emitter density below 1000 lm/mm^2, and a positive CRI. Products covered by other legislation, or related to safety and health, are excluded from the scope, see Figure 12.

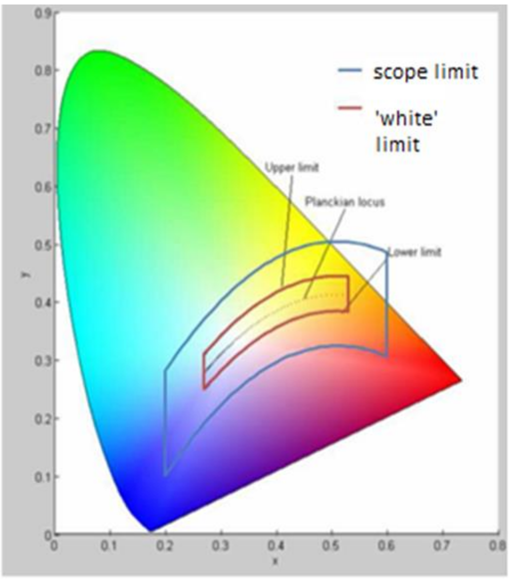


Figure 24 To be in the scope of the new proposed regulation, emitted light must satisfy:

$0,200 < x < 0,600$ and $-2,3172\ x^2 + 2,3653\ x - 0,2800 < y < -2,3172\ x^2 + 2,3653\ x - 0,1000$.

To be suitable for general purpose indoor lighting, emitted light must satisfy:

$0,270 < x < 0,530$ and $-2,3172\ x^2 + 2,3653\ x - 0,2199 < y < -2,3172\ x^2 + 2,3653\ x - 0,1595$.

This provides an easy to measure criterion for Market Surveillance and gives manufacturers the possibility to exclude IR (red, gold), UV (blue), grow lights (purple), collagen (pink), etc.

Maximum power requirement formula:

Power (on) ≤ (Constant + Flux/Target Efficacy)* CRI correction

- Flux is total luminous flux (not in cone) in Lumen Output
- Target Efficacy in Lumen Output / Mains Watt Input
  (for Lighting Product, including control gear)
- Constant = 2 W (proposed)
- Account for parasitic power of control- and network devices
- Account for fixed electrode losses in discharge lamps
- Allow lower efficacy for lower lumen lamps
- Makes result similar to square-root formula for EEI
- CRI-correction = (CRI+240)/320 (proposed)
- Bonus for high CRI lamps; penalty for low CRI lamps
- CRI=80→ 1.0; CRI=90→ 1.03; CRI=60→ 0.94; CRI=25→0.83

Figure 25 Explanation of the maximum power requirement formula that is used as the basis for the ECO-scenarios. Target efficacies of 70, 80 and 120 lm/W and combinations thereof have been analysed.

Figure 26 Increasing the effectiveness of the energy label for lighting products by requiring (at least) a coloured arrow with the label class to be directly visible to the consumer.

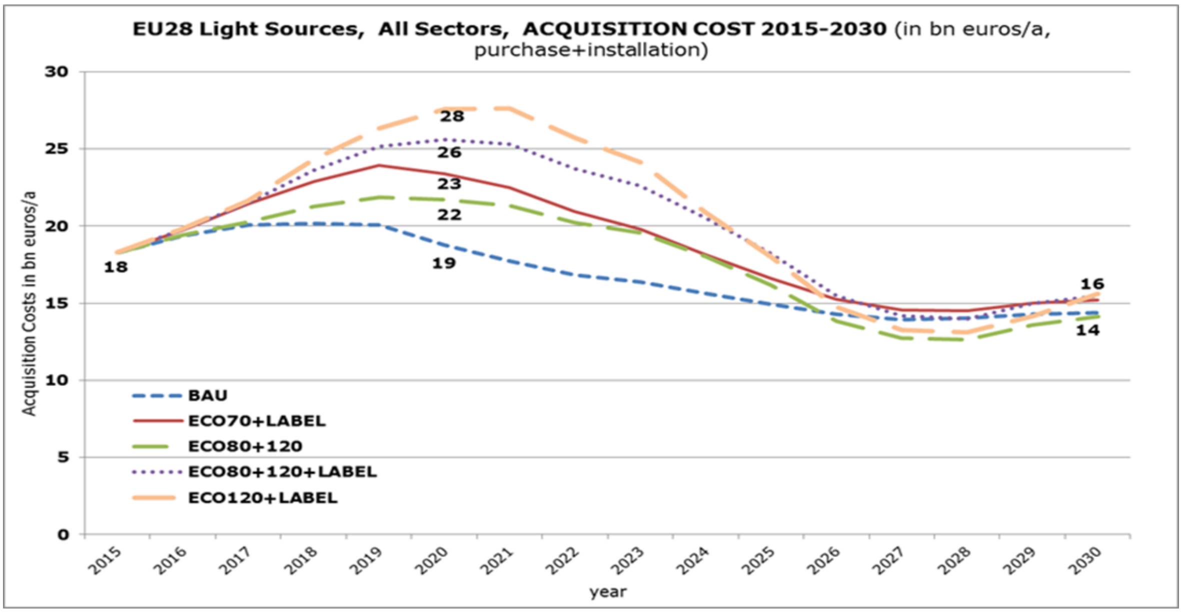


Figure 27 To obtain the savings of Figure 21 and Figure 22, an investment in LED lighting products is required. This leads to a peak in acquisition costs around 2020, that is higher when the measure is more ambitious.

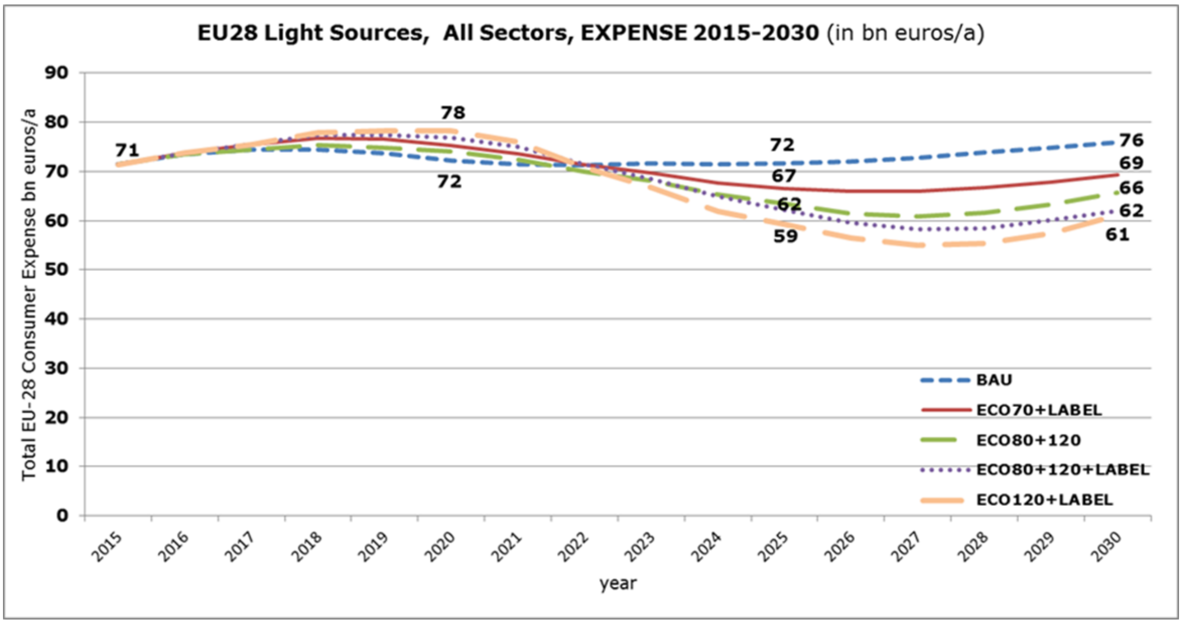


Figure 28 The total consumer expense for the ECO-scenarios is higher than the BAU scenario up to 2022 due to higher investments in LED lighting. After that year the lower energy costs related to LEDs become dominant and the consumer receives the benefits of its investment.