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Preparatory Studies for Product Group in the Ecodesign Working Plan 2012-2014: Lot 6(37)- Lighting systems

07/03/2016

Paul Van Tichelen (Main author will present Tasks 0-1, Vito)

Paul Waide (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

Brussels, 8 March 2016

Agenda

- 10:00-10:10 Welcome
- 10:10-10:20 Short presentation of participants(who is who)
- 10:20-10:30 Short introduction to MEErP & project planning
- 10:30-11:10 Tasks 1, scope + standards & comments
- 11:10-11:40 Tasks 1, EU policy + voluntary initiatives in place (Paul Waide)
- 11:40-12:30 Draft Task 2 + comments
- 12:30-13:30 Break & lunch
- 13:30-14:10 Draft Task 3 + comments
- 14:10-15:00 Draft Task 4 + comments
- 15:00-15:20 Any other business
- 15:20-15:40 Planning stakeholder feedback and finalization

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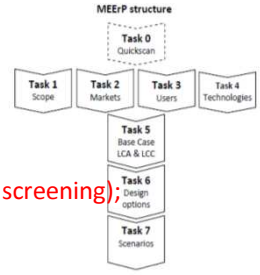
EC policy officer & VITO Study Team

- 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).

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

MEErP in a nutshell



- 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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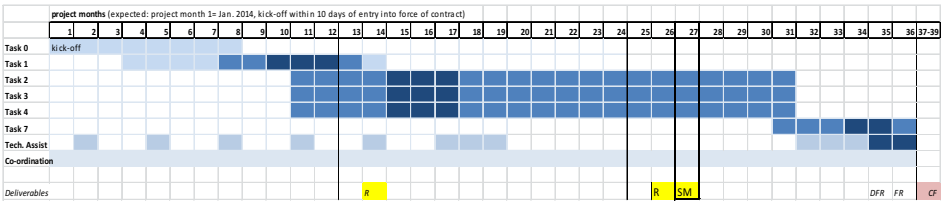
Planning

- **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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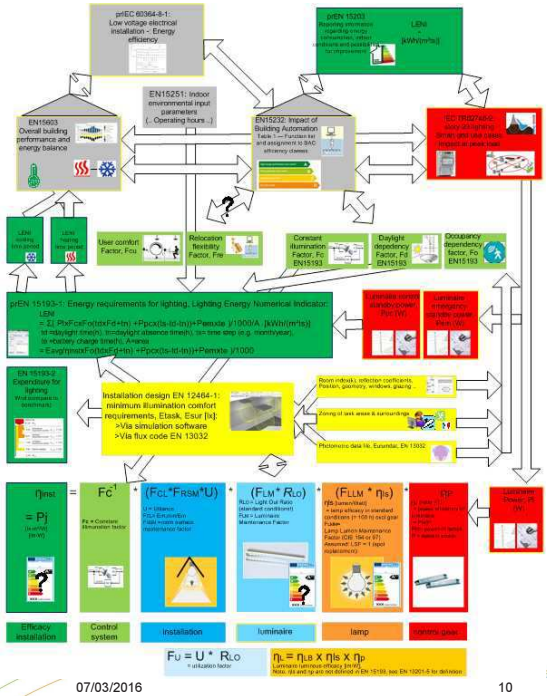
Context indoor lighting



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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)

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]
  - Iluminance uniformity, U0
  - Unified Glare Rating, UGR(indoor) or Threshold Increment, TI (outdoor)
  - Other: CRI, CCT, hemispherical illuminance, *cylindrical illuminance(add?)*

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(?)

Product/system performance parameter

- **lamp/light source parameters:**
  - Luminous efficacy, ηls [lm/W]
  - Lamp Lumen Maintenance Factor, FLLM
  - Lamp Survival Factor, FLS
  - 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, RLO, RLOW (= reference ballast), IP rating, tp

Product/system performance parameter

- **Installation performance**:
  - Utilization factor, F_U (includes R_{LO})
  - 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, C_L (prEN13201-5) or F
  - Room surface maintenance factor, F_{RSM}
  - 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'..

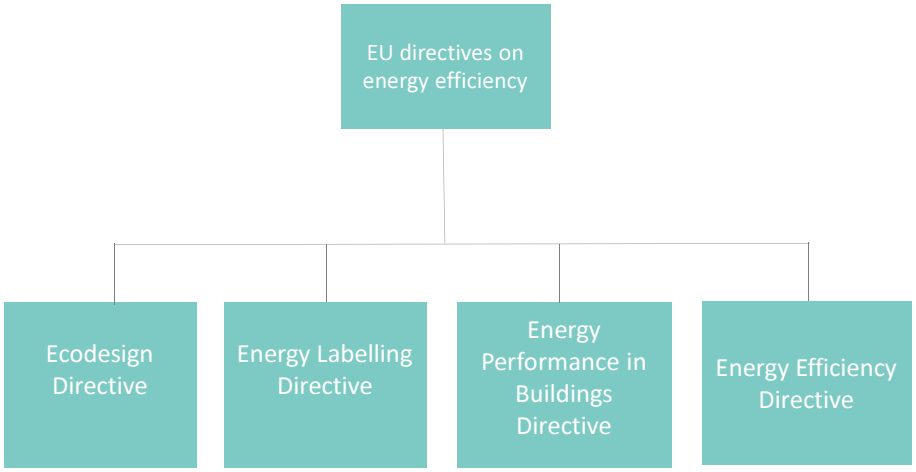
  Short EN 12464-1 measurements missing .. but is there any experience from fully compliant measurements in the field during commissioning of the lighting system?
- CECAPI, EU.BAC, DEA remarks: text corrections
- LE (see AOB powerpoint received):
  - Task 0&1: 'The current report did take into account the majority of the comments submitted by LightingEurope end of May 2015'

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)

Context - The four principal EE Directives



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Task 1: Policies in place – ED/ELD

- Implementing regulations within the ED and ELD are currently applied to:
  - light sources,
  - ballasts,
  - luminaires.
- They are not currently applied to controls and do not address daylight harvesting directly
- The existing regulations only partially addresses luminaire efficiency in that they are not applied to all types and only specify information requirements

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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/

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

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

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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

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

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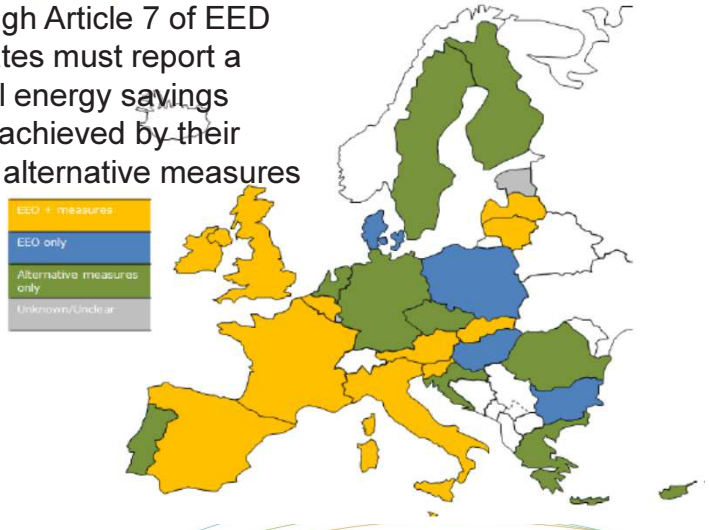
Growing no. of utility energy efficiency obligation (EEO) schemes in the EU

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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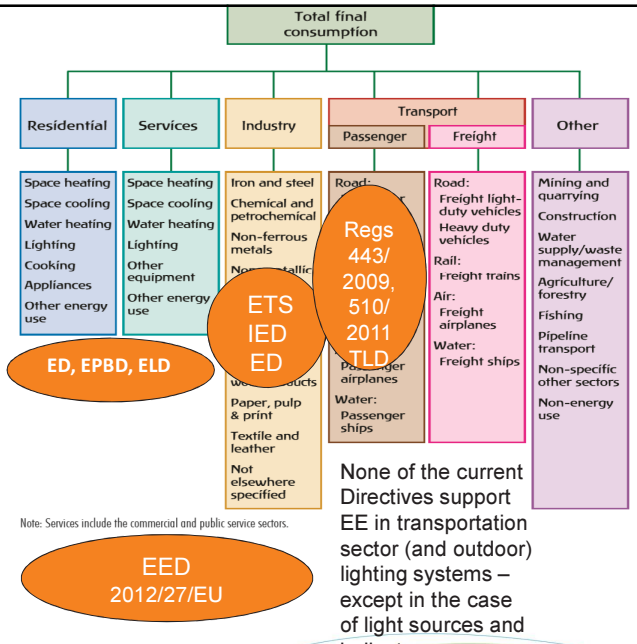

None of the current Directives support EE in transportation sector (and outdoor) lighting systems – except in the case of light sources and ballasts

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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.

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.

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

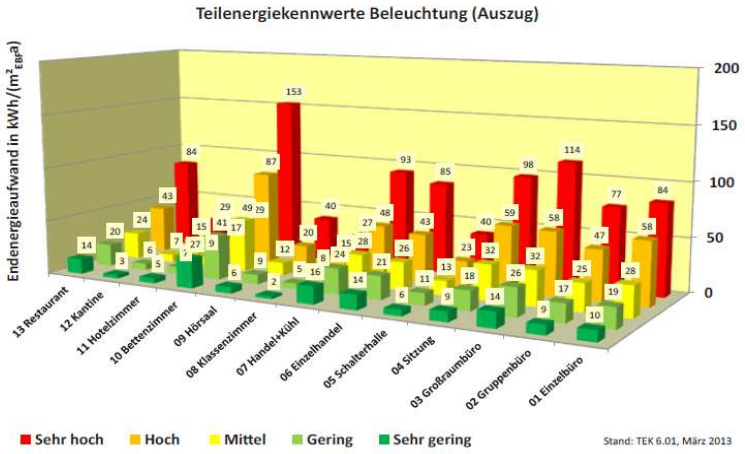
- Sub metering for the lighting circuit (art. 23) (art. 31);
- Light levels can be controlled in each room manual or automatic as a function of presence in non-residential buildings (art. 37);
- A minimum requirement for windows area in residential buildings;
- A requirement for central lighting controllers 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).

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.m^2) 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.

Task 1: EPBD implementation - Germany

- TEK tool



Task 1: EPBD implementation - UK

» The UK Building regulations Part L include compliance guides for domestic and non-domestic buildings that specify lighting energy efficiency requirements that must be satisfied independently of the whole building performance.

	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.

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.)

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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

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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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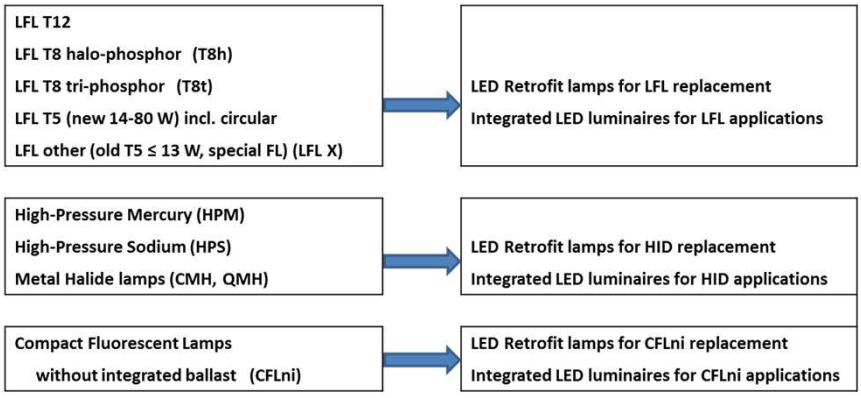
Task 2: MELISA base cases and scenarios



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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 Mm^2 = **480 lm/m²**
  - 87 GW/11776 Mm^2 = **7,4 W/m²**
- MELISA LENI cross-check
  - 155 TWh/11773 Mm^2 = **13 kWh/(m².y)**

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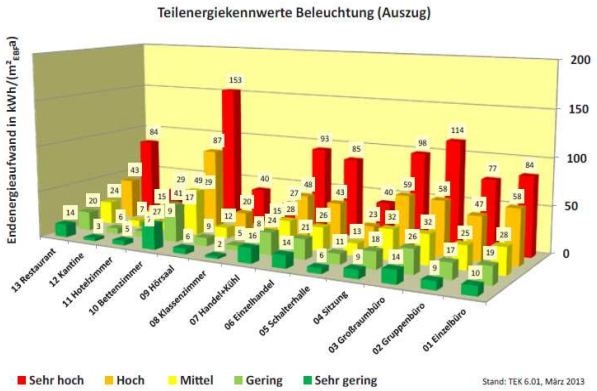
Task 2: Is a LENI of 13 kWh/(m².y) realistic?

- 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/(m².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/(m².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/m²↑ + lm/m²↑?
  - Overestimating stock **area**? 5,8 vs 11,8 G m²? LENI↑ + W/m²↑
  - 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

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**

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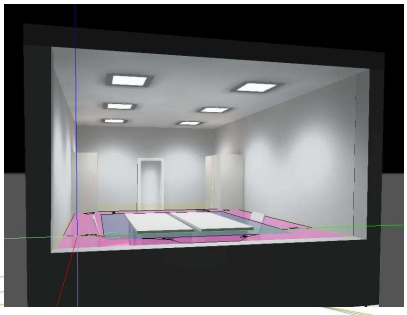
Task 3 Users: Example, reference design 'cellular office'

- 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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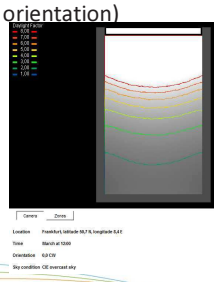
Task 3 Users: Energy calculation indoor EN 15193

- **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



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

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	10 000	15000	20 000	25 000	30 000	35 000***
L95 @ 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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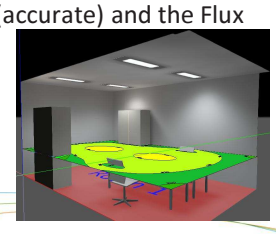
Task 3 Users: Energy calculation indoor EN 15193

- 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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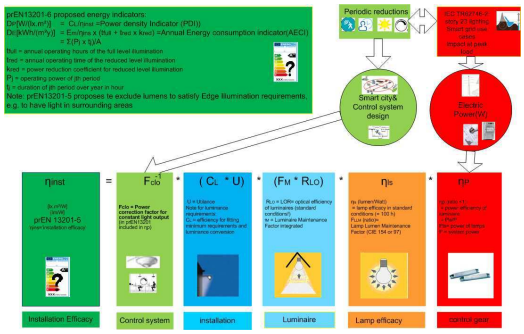
Outdoor lighting EN 13201-5

- 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



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

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?

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 1O K =1OO 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?

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?

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

» **Lamp consumption:**

» $N_y = 1 / t_{group} + (1 - FLS) / t_{group}$

» **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?

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

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, ..)**

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 BATfit	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 = fB (power efficiency of luminaire)	0,76	0,84	1,00	1,00	1,00	1,00	1,00
4	CIE flux code N5(R_{LO}) (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 nSV	VIII: nSB nSV	VIII: nSB nSV	VIII: nSB nSV	VIII: nSB nSV
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	eLC (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	93,58	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
filuxme 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
DP (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) = Pw(tfull+kredxtred)xFclo/A (excl. edges area) (annual energy)	kWh/(m².y)	5,036	2,772	0,83	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, ηinst . 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.

Task 4: comments

- DEA (p. 234): 'ηinst <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

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

Conclusion

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