Ecodesign Preparatory Study
Lot 8/9/19 Light Sources

1st Stakeholder Meeting

5 February 2015

WELCOME !

Van Holsteijn en Kemna

Vlaamse Instelling voor Technologisch Onderzoek

Agenda

9:30 h	reception	
10:00 h	Welcome, amendment/approval of agenda and announcements	
10:15 h	Presentation:	Introduction (History, Assignment, Study team, Project Schedule, MEErP)
10:45 h	Presentation and Discussion:	Scope of the study (Current scope, Need for Definitions, Special Purpose)
11:45 h	Presentation and Discussion:	Standards and Legislations (Europe in international context)
13:00 h	lunch break	
14:00 h	Presentation and Discussion:	Markets (MELISA model, Sales, Lifetimes, Operating Hours, Installed Stock)
15:00 h	Presentation and Discussion:	Users (Efficacy, Lumen, Power, Energy, Costs, Dimming)
16:30 h	Other topics	
17:30 h	thanks and good bye	

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INTRODUCTION

(Task 0 report)

Leo Wierda

Van Holsteijn en Kemna

Vlaamse Instelling voor Technologisch Onderzoek

Introduction

History of Ecodesign for Lighting

Assignment for the current preparatory study
→ implications for the scope

Structure for study and where we are now (MEErP)

Project details and Study team

Time schedule

Parallel LOT 37 study on lighting systems
→ implications for the scope

History (1)

Date	Document	Short Description
Non-directional Household Lighting		
Oct. 2008	Preparatory Study Lot 19 part 1 (VITO)	Ecodesign Preparatory Study on NDLS for domestic lighting
Mar. 2009	Full Impact Assessment (EC)	EC document accompanying regulation 244/2009
Mar. 2009	**Commission Regulation (EC) No 244/2009**	Main lamp-types regulated: **CFLi, HL, GLS**
Sep. 2009	Commission Regulation (EC) No 859/2009	Amendment on 244/2009 for some UV-requirements
Feb. 2013	CLASP study	Indication of main points for the review of regulation 244/2009
Jun. 2013	Stage 6 Review Study (VHK)	Review of stage 6 requirements of 244/2009 for MV-HL lamps
Apr. 2014	Omnibus Study (VHK)	(Preliminary) Review of regulation 244/2009
Tertiary Lighting		
Jan. 2007	Preparatory Study Lot 9 (VITO)	Ecodesign Preparatory Study on Public Street Lighting
Apr. 2007	Preparatory Study Lot 8 (VITO)	Ecodesign Preparatory Study on Office Lighting
Mar. 2009	Full Impact Assessment (EC)	EC document accompanying regulation 245/2009
Mar.2009	**Commission Regulation (EC) No 245/2009**	Main lamp-types regulated: **LFL, CFLni, HID** incl. related ballasts and luminaires
Apr. 2010	Commission Regulation (EU) No 347/2010	Amendments on regulation 245/2009
Feb. 2013	CLASP study	Indication of main points for the review of regulation 245/2009
Apr. 2014	Omnibus Study (VHK)	(Preliminary) Review of regulation 245/2009

History (2)

Date	Document	Short Description
Directional Lighting		
Nov. 2009	Preparatory Study Lot 19 part 2 (VITO)	Ecodesign Preparatory Study on Directional lamps
Mar. 2011	Follow-up study (ECEEE, DEFRA)	Support study for preparation of regulation on directional lamps
Dec. 2012	Impact Assessment (EC)	EC document accompanying regulation 1194/2012
Dec. 2012	**Commission Regulation (EU) No 1194/2012**	Main lamp-types regulated: **Directional lamps, LEDs** and related equipment
Labelling for Lighting		
Sep. 1992	Directive 92/75/EEC	Framework, legal basis for labelling of light sources (now repealed)
Jan. 1998	Directive 98/11/EC	Labelling of household light sources (now repealed)
May 2010	Directive 2010/30/EU	Framework, legal basis for labelling of light sources (repealing 92/75/EEC)
Jul. 2012	**Commission Delegated Regulation (EU) No 874/2012**	Labelling of electrical lamps and luminaires (repealing 98/11/EC)
Mar. 2014	Commission Delegated Regulation (EU) No 518/2014	Amending 874/2012, information requirements and energy label display for sales on internet

Summaries provided in the Task 0 report

Assignment (1)

- Carry out a study on lighting products for the **preparation of further and/or more advanced ecodesign and/or labelling requirements**.

- Build upon and advance Commission Regulation (EC) No 244/2009, Commission Regulation (EC) No 245/2009, Commission Regulation (EU) No 1194/2012 and Commission Delegated Regulation (EU) No 874/2012, including all amendments and corrigenda thereof.

- **Fulfil the legal review requirements** of Commission Regulation (EU) No 1194/2012 (directional lamps and LEDs) and Commission Delegated Regulation (EU) No 874/2012 (energy labelling).

- Provide a detailed market assessment of directional mains voltage filament lamps, as required by Regulation 1194/2012, Annex III 1.1.

- Aim at setting more ambitious targets for **all lighting products currently regulated** under Ecodesign and Energy Labelling, **including luminaires** (either with or without built-in light sources such as LED modules).

- **Lighting controllers previously not regulated**, either as part of a luminaire or as an independent product, should be **included in the study**.

Assignment (2)

- Carry out an analysis of the **lighting products not yet regulated** (e.g. lamps having a luminous flux above 12.000 lm), identifying other lighting products to be included into this study. **→ Scope !**

- **Review the definitions of special purpose products** should and **propose updates** with a view to minimise the possible misuse while keeping otherwise regulated products for use in special applications exempt from ecodesign and/or labelling requirements. **→ Scope !**

- Explore the feasibility of **unifying all four regulatory measures into one regulation** (or only the three ecodesign regulations into one if this has been identified as the only possible option).

- Take into account the findings of the so-called "Stage-6 Review" and "Omnibus Review" studies.

- Carry out the study following the MEErP, extended in scope if necessary to fulfil the review requirements.

In addition (from kick-off meeting):

- The **projections for past and future lighting energy use have to be harmonized** between the Lots.
  (Lot 8/9/19: Light Sources. Lot 37: Lighting Systems) **→ MELISA model**

MEErP structure used in study

Task 0	First product screening	Draft report
Task 1	Scope (define products, codifications, standards, legislation)	Draft report + Presentation
Task 2	Markets (EU production/import/export, sales, lifetimes, installed stock, market trends, basic economic data)	Draft report + Presentation
Task 3	Users (efficiency, usage parameters, light sources in system, interaction with space heating, end-of-life, infrastructure)	Draft report + Presentation (preliminary)
Task 4	Technologies (existing products, BAT, BNAT, bill-of-material (BOM), packaging/distribution)	Work in progress
Task 5	Environment & Economics (base cases, environmental impact assessment, life cycle costs for consumers)	Future work
Task 6	Design Options (assess design improvement options, least life cycle costs (LLCC))	Future work
Task 7	Scenarios (policy analysis, BAU and ECO scenarios, impact on industry and consumers)	Future work

Project details and Study team

SPECIFIC CONTRACT No ENER/C3/2012-418 LOT1/07/SI2.668526

Implementing Framework Contract No ENER/C3/2012-418-Lot 1

Prepared for the European Commission, DG ENER.C.3, Project officer: Ruben KUBIAK

Main contractor:
Consortium of VITO NV, VHK BV, Viegand & Maagøe ApS, Wuppertal Institute for Climate, Environment and Energy GmbH, ARMINES, represented by VITO

Technical Team Leader: René KEMNA (VHK)
Contract Manager: Caroline LEMEIRE (VITO)

Other Participants:

Roy VAN DEN BOORN, Leo WIERDA (VHK)	Task 0, 1, 2, 3
Stuart JEFFCOTT (external collaboration)	International legislation and standards
Lieven VANHOOYDONCK, Paul VAN TICHELEN (VITO)	Task 4
Wai Chung LAM (VITO, Quality Control)	

Website: http://ecodesign-lightsources.eu/

Planning

Month-Year	Event
January 2014	Start contract
November 2014	Launch website
December 2014/ January 2015	Publication Draft Task Reports 0, 1, 2, 3
5 February 2015	**1st Stakeholder Meeting**
March 2015	Stakeholder comments reports (incl. written)
	2nd edition of Draft Task Reports 0, 1, 2, 3
April 2015	Publication Draft Task Reports 4, 5, 6 and part of 7
May 2015	Consultation Forum on (amongst others) mains-voltage filament lamps;
	2nd stakeholder meeting
June 2015 / July 2015	Stakeholder comments reports (incl. written)
October 2015	**Final report (all tasks 0 to 7)**

Commission foresees a Consultation Forum in the second half of 2015.

Lot 37: Lighting Systems

- **Lot 37 Lighting Systems** preparatory study performed in parallel to the **Lot 8/9/19 Light Sources** study.

- Lot 37 main topics (but not limited to):
  - Occupancy dependent lighting control
  - Daylight dependent lighting control and optimisation of daylight availability
  - Constant illuminance control (dimming in function of degradation with time)
  - Smart task lighting / interactive lighting controls / flexible luminaire systems
  - Design aspects of luminaires, controls, lighting systems

- Same consortium, but: Technical lead by VITO; participation of VHK; collaboration by Paul Waide.

- Longer running time than Light Sources study: Lot 37 final report by December 2016

⇨ Lighting systems, luminaires and controls NOT considered in the Light Sources study, except for some compatibility issues.

→ Scope !

End of Introduction

History of Ecodesign for Lighting
Assignment for the current preparatory study
Structure for study and where we are now (MEErP)
Project details and Study team
Time schedule
Parallel LOT 37 study on lighting systems

Any questions so far ??

Next topic: Scope of the study

Ecodesign Preparatory Study
Lot 8/9/19 Light Sources

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SCOPE

(Task 1 report)

Leo Wierda, René Kemna

Van Holsteijn en Kemna

Vlaamse Instelling voor Technologisch Onderzoek

Scope

Starting points (assignment)

Definition of the Initial Scope

Luminaires and Controls (Lot 37)

Scope Reduction (Ecodesign Directive)

Scope in relation to product Function

Information provided in task 1 report

Scope Decision Table

Definition of lamps by elements

Scope, starting points

- In addition to *all lighting products currently regulated under Ecodesign and Energy Labelling*, the assignment explicitly requests an analysis of *the lighting products not yet regulated*, and *to identify other lighting products to be included into the study*, and to *review the definitions of special purpose products*.

- According to the assignment this also includes *luminaires* (either with or without built-in light sources such as LED modules) and *lighting controllers* (either as part of a luminaire or as an independent product).

- As clarified by the Commission's comments on early drafts of the reports, at least in a first approach: The scope and exemptions of the current regulations, and the wordings currently used to define them, have to be ignored for the purposes of establishing a scope for the study. This is also related to the Commission's request to review the definitions of special purpose lamps and to propose updates.

- In other words: **the scope has to be redefined from scratch and is potentially (very) wide**.

Initial Scope

The study regards all light sources, lamps, ballasts, and lamp control gears according to the definitions provided below:

'*Light source*' means a surface or object designed to emit mainly visible optical radiation produced by a transformation of energy. The term 'visible' refers to a wavelength of 380-780 nm.

'*Lamp*' means a unit whose performance can be assessed independently and which consists of one or more light sources. It may include additional components necessary for starting, power supply or stable operation of the unit or for distributing, filtering or transforming the optical radiation, in cases where those components cannot be removed without permanently damaging the unit.

'*Ballast*' means lamp control gear inserted between the supply and one or more discharge lamps, which, by means of inductance, capacitance or a combination of inductance and capacitance, serves mainly to limit the current of the lamp(s) to the required value.

'*Lamp control gear*' means a device located between the electrical supply and one or more lamps, which provides a functionality related to the operation of the lamp(s), such as transforming the supply voltage, limiting the current of the lamp(s) to the required value, providing starting voltage and preheating current, preventing cold starting, correcting the power factor or reducing radio interference. The device may be designed to connect to other lamp control gear to perform these functions. The term does not include:

- control devices
- power supplies within the scope of Commission Regulation (EC) No 278/2009.

Scope regarding Luminaires and Controls

The initial scope does NOT mention luminaires and controls.

As expressed by the assignment, luminaires and lighting controllers should also be addressed in the study. However, aspects related to **Lighting Systems** and to **Lighting Control** are **excluded from the current study** because they **will be handled in the parallel Lot 37 study**.

This does not exclude that some lighting control aspects are relevant for the current study, in particular as regards the integration of control devices in the lamps (smart lamps), and the compatibility of the lamps with certain types of dimmers or control devices.

Luminaires will predominantly be handled in the Lot 37 study, but integrated LED-luminaires are included in the current study, and the compatibility of retrofit lamps with existing luminaires (lock-in effect) is also in the scope.

Scope reduction (1)

According to the philosophy of the MEErP, the initial scope can be further restricted as the study proceeds and additional information is gathered.

The reasons for further restriction have to be derived from the Ecodesign Directive 2009/125/EC, and in particular from article 15 of this directive that gives the conditions under which a product is eligible for ecodesign measures. Criteria of article 15.2:

a) the product shall represent a significant volume of sales and trade, indicatively more than 200,000 units a year within the Community according to the most recently available figures;
b) the product shall, considering the quantities placed on the market and/or put into service, have a significant environmental impact within the Community, as specified in the Community strategic priorities as set out in Decision No 1600/2002/EC; and
c) the product shall 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 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.

Red text : some information is already available for special lamps

Blue text : would require further study for special lamps

Scope reduction (2)

In addition, if a product is eligible for ecodesign measures according to the above criteria, an implementing measure shall meet the following criteria (article 15.5):

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.

Article 1 sub 3 of the Ecodesign Directive explicitly excludes *means of transport for persons or goods*. However, this exclusion regards only the means themselves and not the products used inside or on those means.
This implies that for example car-lights are not automatically excluded for this reason.

Blue text : would require further study for special lamps

Scope and Function

- Ecodesign study based on: comparison of products that perform the same function.
- Problem: lighting products in the initial scope have a large variety of functions:
  - ‘to make objects and scenes visible’, in general (used in existing regulations, typical functional parameter: luminous flux (lumen) or maintained useful flux density (lux))
  - ‘to make objects and scenes visible’, in a special way (food display, theatres, microscopes),
  - ‘to make objects and scenes visible’, in a special environment (vibration resistant, ovens, explosion proof, marine applications, car-headlights).
  - ‘to make themselves visible’ (traffic lights, exit signs, projector lamps, car-taillights, bill boards).
  - completely different function (grow lights, breeding lights, lamps for UV-treatments, IR lamps for heating, decorative/mood lighting, data-transmission).
- If maintained in the scope: each function requires a separate preparatory study (functional parameters, sales, energy consumption, life, usage characteristics, base-case and BAT technology, availability of standards, scenario analysis, impact on consumers, impact on industry).
- If implemented in a regulation: each function is likely to have its own minimum requirements and label classes.

Information for Scope decision

The Task 1 report provides:

- review of the existing definitions (no new definitions, some issues regarding LEDs).
- survey of parameters used to characterise and distinguish lamps/light sources (many, detailed).
- review of the scope and the exemptions of the current regulations (which types, reasons for exemption)

  → list of lamp types for scope decision.

  - first analysis of all lamp types
  - discussion on inclusion in the scope
  - estimate of sales quantities and energy consumption for many types of special lamps.

- Review highlights a lack of accurate definitions (practical for market surveillance).
- The priority in this moment is to establish these definitions, rather than to decide if a certain type of non-well-defined lamp should be in or out the scope of the current study.
- Work initiated with Task 1 report; should now proceed in cooperation with the stakeholders.

- Task 1 report gives information and considerations: the decision on the scope should be taken by the Commission and by the stakeholders (but implications on amount of work for study team)

List of lamp types for Scope decision (1)

Lamp type description (usually better definition required)	Data for Ecodesign Directive article 15 (Task 1, annex D.15)			(Momentary) Proposal for the scope of the current study			
	Sales M units/y	Energy TWh/y	other legislation	included	excluded	open/ undefined	Notes / comments
Lamps covered by current regulations							
Linear Fluorescent (LFL)				x			All lamps certainly covered by the existing regulations are included in the scope of the study.
Compact Fluorescent, external ballast (CFLni)				x			
Compact Fluorescent, integrated ballast (CFLi)				x			
Halogen Lamps, Mains Voltage (HL-MV)				x			
Halogen Lamps, Low Voltage (HL-LV)				x			
Incandescent Lamps, Mains Voltage (GLS-MV)				x			
Incandescent Lamps, Low Voltage (GLS-LV)				x			
High Intensity Discharge (HID)				x			
Light Emitting Diode (LED, retrofit and dedicated)				x			
Lamps for extreme physical environments	**9.8**	**1.0**					(exclusive 'abused' lamps)
Shock resistant				x			Sales numbers and Environmental impact are significant. No other regulation for energy efficiency. Hence no reason to exclude based on these aspects of Ecodesign Directive art. 15.
Vibration resistant				x			
Shatter resistant				x			
Temperatures below -20˚C				x			
Temperatures above +50˚C				x			
Explosion proof				x			
Non-white lamps		**(2.0)**					TWh: Christmas lighting, fairs, amusement parks
Fixed or variable non-white colour						x	No well defined function. Depends on definition.
Colour-changing-ability including white				x			Important for modern LED lighting
Ultra-Violet lamps	**16.7**	**2.5**					
Tanning	9.4	0.6				x	Large variety of functions. Each function would have to be considered separately.
Waste water treatment	0.6	0.5				x	
Industrial processes	0.5	1.0				x	
Other UV lamps	6.2	0.4				x	

List of lamp types for Scope decision (2)

Lamp type description (usually better definition required)	Data for Ecodesign Directive article 15 (Task 1, annex D.15)			(Momentary) Proposal for the scope of the current study			
	Sales M units/y	Energy TWh/y	other legislation	included	excluded	open/ undefined	Notes / comments
Infrared and collagen lamps	**24.4**	**33.2**					
IR lamps for imaging equipment	11.0	3.4	(yes)		(x)	study	Variety of (heating) functions: each function would have to be considered separately, considering also non-light heating. Some lamps covered by other legislation, but further study required to check details. Collagen could be excluded for low impact, if confirmed; also depends on definition.
IR lamps for electric hobs	0.8	5.4	(yes)		(x)	study	
Zootechnical (raising young animals)	5.0	2.5				x	
Counter-top heaters in restaurants	2.2	10.8				x	
IR for Industrial use	2.2	10.8				x	
Collagen lamps	0.4	0.05			(x)	study	
Therapeutic & Comfort (Sauna's)	2.8	0.2				x	
Signalling and signage lamps	**18.2**	**6.4**					
Exit signs	5.0	4.1		x			Sales numbers and Environmental impact are significant. No other regulation for energy efficiency. Hence no reason to exclude based on these aspects of Ecodesign Directive art. 15.
Traffic lights	8.3	1.0		x			
Neon and (static) billboards	0.3	0.9		x			
Other signalling and signage	4.6	0.4		x			
Appliance integrated lamps	**134**	**9.9**					
Range hoods	12	0.3	yes		x		Excluded because other relevant legislation exists
Aquaria	13	3.5		x			At this stage, no reason to exclude based on Ecodesign Directive art. 15.
Swimming pools	5.4	2.2		x			
Vending machines	6.9	2.6		x			
Other appliance integrated	97	1.3		x			Large number of lamps, each with low energy
Decorative and architectural							
Flood lights for buildings	n/a	n/a		x			NOT considered as Special Purpose: in scope
Decorative	124	2.6				x	Definition needed. Function when included ?
Projection, microscopy, light guides		2.4					
Lamps used in imaging equipment	110	0.9	yes		x		Excluded because other relevant legislation exists
Other projection lamps	11	1.5				x	Definition needed. Function when included ?

List of lamp types for Scope decision (3)

Lamp type description (usually better definition required)	Data for Ecodesign Directive article 15 (Task 1, annex D.15)			(Momentary) Proposal for the scope of the current study			
	Sales M units/y	Energy TWh/y	other legislation	included	excluded	open/ undefined	Notes / comments
Movie/TV or photo studio/theatre/event	**163**	**2.5**					Many > 12,000 lm: requested to be studied
TV/video/film studio lamps	1.1	1.4		x			
Outdoor stadium lamps	0.6	0.2		x			
Photographic flash tubes	160	0.0			(x)	(x)	Could be excluded for low environmental impact
Other in this category	1.3	0.9		x			
Backlighting for displays	**1736**	**58.5**	**yes**		**x**		Excluded because other relevant legislation exists
Grow lights (greenhouses)	**6.9**	**5.2**		x			No reason for exclusion. Definition! Function!
Food display lights	**27**	**1.1**		x			No reason for exclusion. Definition! Function!
Scientific lights	**0.02**	**0.01**			x		Excluded for low sales and low impact. Definition?
Transport lights	**956**	**12.7**					
Motor vehicles, categories M, N, O			yes		x		Excluded because other relevant legislation exists (exception might be interior lights)
Motor cycles, category L			yes		x		
Aeroplanes	0.3	0.02			x		Excluded for low impact. Definition?
Ships, specific lighting	0.08	0.0			x		Excluded for low sales and low impact. Definition?
Trains, specific lighting	0.1	0.04			x		Excluded for low sales and low impact. Definition?
Ships, trains, busses, interior lighting	(11)	(2)		x			Include also interior lighting for cars, trucks, vans ?
Bicycles				x			Consider as battery-operated
Other Mobile Lighting	**25**	**0.03**				x	Not a well defined group, see battery and non-elec
Data-communication and (other) lasers							Definition ?
Signal transmission between instruments			some		x	(x)	Consensus expected on exclusion. Exact reason?
Dashboard and indicator lamps	2000	0.15				x	Excluded for low impact? Definition?
Industrial process lasers					x	(x)	Consensus expected on exclusion. Exact reason?
Laser-diodes for general lighting				x			Could be BAT, BNAT: do not exclude
Emergency lighting				x			Light sources used in emergency are not specific
Battery operated				x			No valid reason found for exclusion

List of lamp types for Scope decision (4)

Lamp type description (usually better definition required)	Data for Ecodesign Directive article 15 (Task 1, annex D.15)			(Momentary) Proposal for the scope of the current study			Notes / comments
	Sales M units/y	Energy TWh/y	other legislation	included	excluded	open/ undefined	
Non-electric lamps					x		Consensus expected on exclusion. Exact reason? (exception: self-luminous exit signs)
Lamps with more than 12,000 lumen				x		study	These lamps are now explicitly exempted from at least one of the regulations. The assignment for the study explicitly requests to reconsider this. Further information is needed to enable an inclusion/exclusion decision, but assistance by stakeholders is necessary.
Lamps with less than 60 lumen				x		study	
Double capped fluorescent lamps with diameter 7 mm (T2) or less				x		study	
Double capped fluorescent lamps with diameter 16 mm (T5) and power ≤ 13 W				x		study	
Double capped fluorescent lamps with diameter 16 mm (T5) and power > 80 W				x		study	
Double capped fluorescent lamps with diameter 38 mm (T12) and special characteristics (see Task 1, par. 1.4.2.25)				x		study	
Double capped fluorescent lamps with diameter 38 mm (T12) and external ignition strip				x		study	
Single capped fluorescent lamps with diameter 16 mm (T5) and special characteristics (see Task 1, par. 1.4.2.27)				x		study	
HID lamps with Tc > 7000 K				x		study	
HID lamps not having lamp cap E27, E40, PGZ12				x		study	
OLED lighting				x			Could be BAT, BNAT: do not exclude

Scope: conclusions

- **Scope of the study is still very wide**, including different functions; **problem** for the study team.

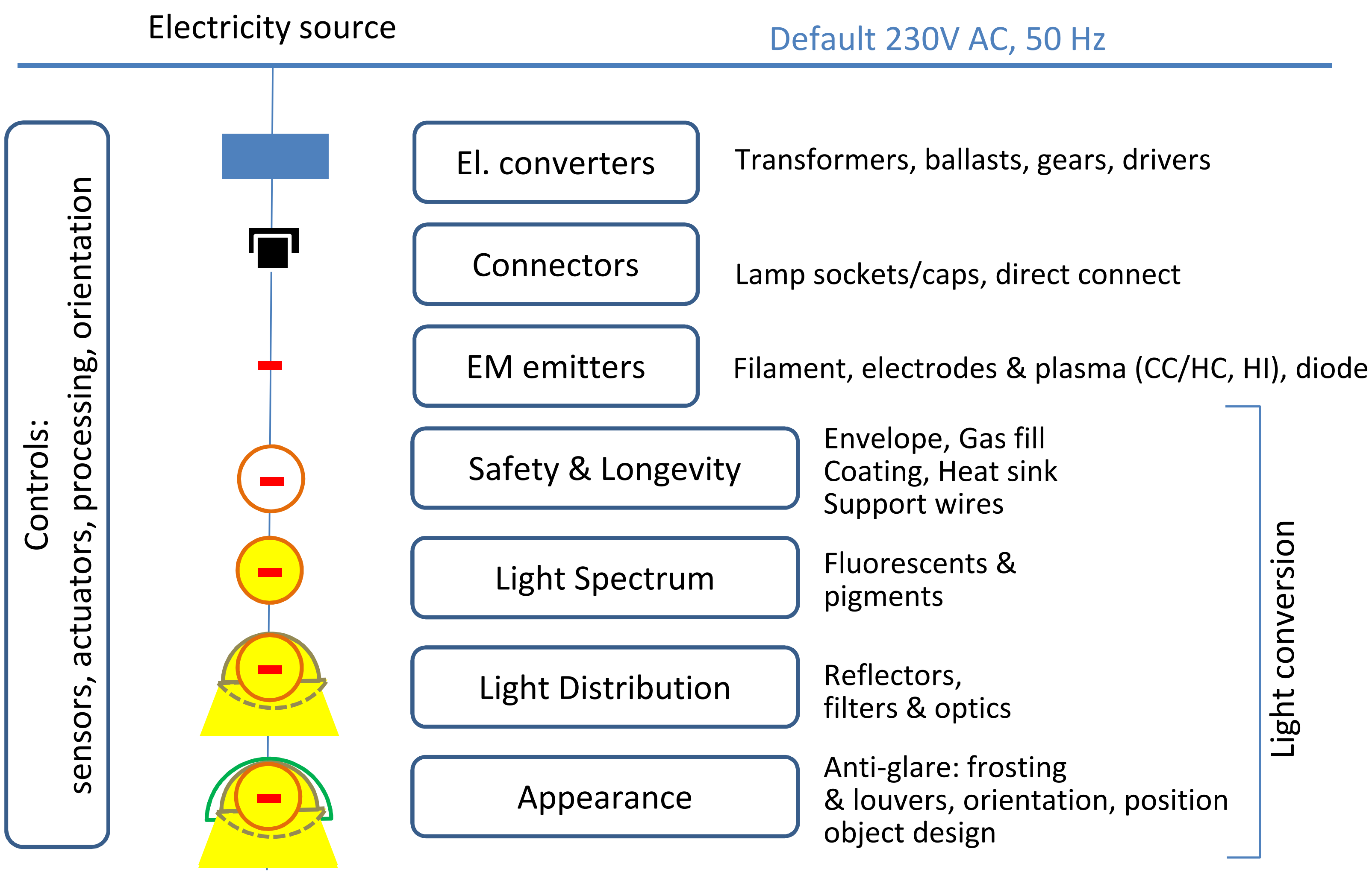
- Ecodesign Directive → guidelines for scope reduction.
- Task 1 report → information/analysis useful for scope decision
- Task 1 report → first scope reduction mainly based on existence of other relevant regulation

- **First: better definitions** (Assistance by Stakeholders; practical for Market Surveillance)
  Then: decision on inclusion/exclusion scope

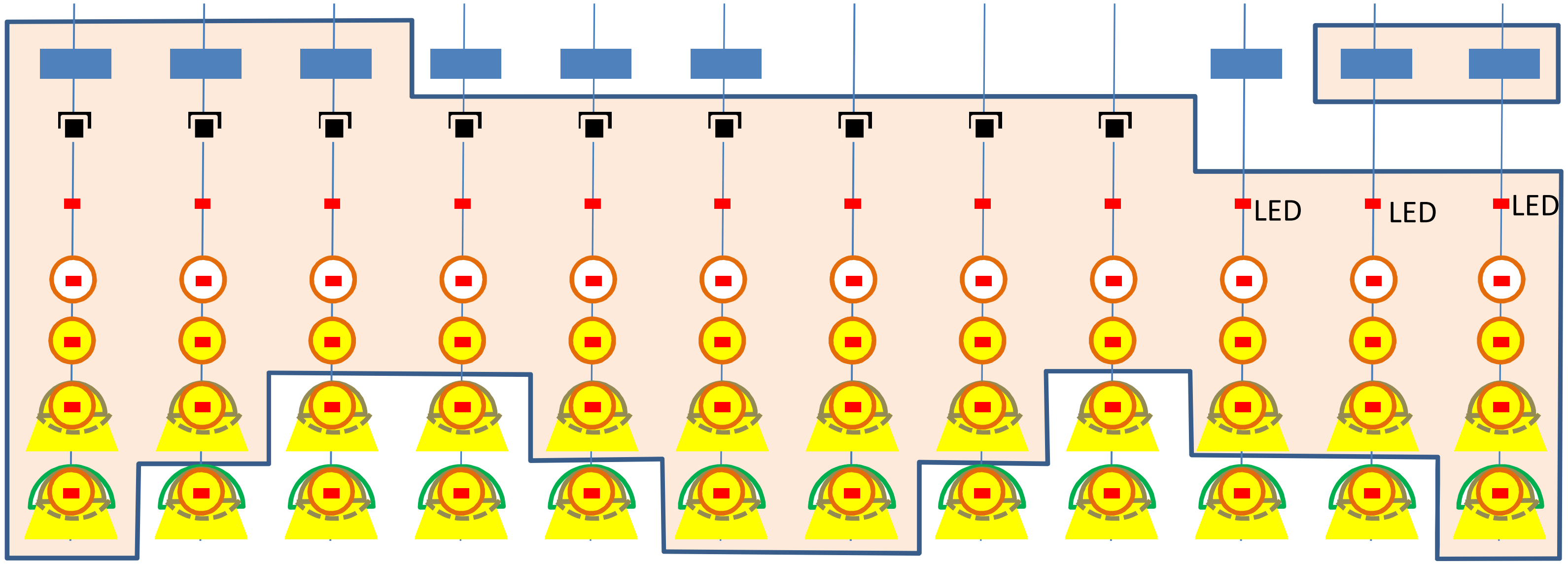
- **Commission and Stakeholders** → Indications regarding scope.

To conclude: **'Lamp' definition by elements**, by René Kemna (not in Task reports)

Lamp elements (1)



‘Lamp’: Definition by elements (2)



HL-LVi-R LED lamp retrofit	CFLi-R LED lamp retrofit	CFLi HL-LVi	LFL HL-LV CFLni HID	HID-R HL-LV-R LEDlinear	CFLni ‘Globe’ etc.	GLS- ‘Globe’ etc.	GLS-R HL-MV-R	GLS HL-MV	LED package	LED module	LED Lamp/ fixture (non- retrofit)

Ecodesign Preparatory Study
Lot 8/9/19 Light Sources

1st Stakeholder Meeting

5 February 2015

STANDARDS and LEGISLATION

(Task 1 report)

Stuart Jeffcott

Van Holsteijn en Kemna

Vlaamse Instelling voor Technologisch Onderzoek

Standards and Legislation

Test methods Comparison

Test methods under Development

Other possible Problems with Test methods

Outline of Mandates to ESO's

Legislative Comparison EU ↔ non-EU

Labelling Regulation Comparison EU ↔ non-EU

Standards and Legislation

The Task 1 report and annexes contain an extensive survey of both European and non-European lighting-related (testing) standards and legislation.

Analysis of the current state of (and ongoing developments in) the international arena to highlight areas where amending current EU practice (or adopting new practice) *may* enhance the standards and regulatory processes within Europe, and where existing issues may remain.

Analysis examines:

- Primary differences between European and non-European test methods for lighting-related parameters, and minimum (and other) performance requirements of those parameters.
- Ongoing or new developments regarding standards and legislation

Core analysis limited to major trade partners and/or countries/regions/ organisations leading standards and/or technology developments (47 countries/standards organisations studied)

    - Australia, Canada, China, India Korea, Japan, Taiwan and USA

Inter-relationship/cross-over of test and regulatory issue varies between countries/regions – in discussion issues dealt with in most appropriate section

Test methods comparison (1)

Primary and Secondary Functional Performance Parameters

Parameter	**Europe**	**Outside Europe**	**Additional Comment**
Luminous flux (directional lamps)	Measurement in angle of 90˚ or 120˚ - Requires full goniophotometer test = more expensive	Measurement in angle of 180˚ (typical) - Allows use of integrating sphere = cheaper	Current EU approach = Higher cost for enforcement testing and barrier for SME development testing
Lumen Maintenance (CFL) Lumen Maintenance for (LED)	Ageing using cycles: 2h 45m on, 15 m off IEC: ageing 6000 hours	Ageing using cycles: 3h 00m on, 20 m off *(North America)* IES: ageing 6000 hours (but 3000 h for luminaires) ISA proposal: ageing 2000 hours with predictive algorithm	No public data on effect of cycle-differences Not known which test is superior, trade-off between speed/cost and uncertainty; discussion ongoing
Colour related parameters	CIE 15 (X/Y space) and CIE 13.3 (Colour Rendering Index, CRI) used everywhere		Research ongoing for LEDs (with possible application to other light sources) Refer new test methods

Test methods comparison (2)

Parameter	Europe	Outside Europe	Additional Comment
Power/ Power Factor	Well established, little variation geographically Recent IEC standard more sophisticated (split into displacement factor and distortion factor)		IEC/EN approach leads the world
Warm-up time (CFL)	Time to reach 60% of initial flux	Time to reach 80% of initial flux	Current EU approach potentially less advantageous for consumer acceptance
Rapid switching withstand (CFLi) Rapid switching withstand (LED)	1 min. on, 3 min. off	5 min. on, 5 min. off (US MEPS) LED: 2 min. on, 2 min. off (US Energy Star)	Difference not obviously linked to consumer requirement Implications for testing time/costs. Research of cycle on (CFL) lifetime ongoing – indications significant impact
UV-radiation	Almost identical when applied		
Compatability/ Dimmability	Subject of ongoing IEC	US Energy Star recent introduction for some LED/dimming products	Issues exist, especially for with newer lamp types. Limited testing solutions that are *broadly* applicable.
Ballast efficiency	Subtle differences in approach between EU/IEC and others		EU adoption of alternative approach unlikely to yield benefits

Test methods comparison (3)

Parameter	Europe	Outside Europe	Additional Comment
Luminaire light output	Subtle differences in approach between EU/IEC and others		EU adoption of alternative approach unlikely to yield benefits
(Luminaire utilisation factor)	Universally applied		
Resource use	No lighting specific test methods (other than mercury content in CFLs)		Potentially need for measurement methods for end of life “recyclability/re-usability” and non-mercury hazardous substances
Safety (flammability, electrical, … etc.)	IEC and CISPR are the key originators of safety and EMS standards globally (although some differences at national levels)		EU adoption of alternative approach unlikely to yield benefits
Noise & vibrations	No requirement in EU	Exists elsewhere (Energy Star)	Simple adoption of ISO standard possible if required

Test Methods Under Development (1)

Test Method		Additional Comment
CIE for LED Lamps, Modules and Luminaires	- Luminous flux, colour, CRI, colour uniformity,… - Guidance on tolerances for rated claims	Likely to become reference document for LEDs (and likely OLEDs) in the future. However, close cooperation between development bodies including IEC means likely little impact from EU perspective.
CIE test method for CRI	- CRI not well suited as a measure for LEDs - New proposed measures likely to be based on spectral distribution analysis	Proprietary issues may cause delay. CRI likely to remain a barrier to 'technology neutral' specifications.
IEA-4E-SSL test method guidance for LEDs	- Rationalises number of international test specifications under one umbrella (excluding light engines, modules and packages) - Rationalises tolerances to most stringent requirement	Not test method in its own right, but adoption of combined approach has potential benefits from cross-regional harmonisation
Array of IEC standards for LEDs	- Extensive development underway - Majority based on underlying CIE methods - Pass/fail requirements (on rated vs measured) has potential to indirectly impact on EU regulation	Potential caution required when adopted into EN standard to ensure intent of any technology neutral regulation is not undermined by the implicit pass/fail criteria defined in the IEC standards
Array of North American (IES/NEMA/ANSI) standards for LEDs	- Extensive development programme underway for suite of products/components	No apparent impact on EU as IEC/CIE likely to capture relevant requirements

Test Methods Under Development (2)

Test Method		Additional Comment
IEC standards for CFLi	- Imminent revision of IEC 60969, likely to be referenced by EU regulation - Revised version extends parameters tested but also alters pass/fail criteria and tolerances	Potential direct and indirect impact the EU regulatory framework
Energy Star "Recommended Practice" for Flicker	- Specific approach to dimmable lamps – limited applicability	Flicker not currently addressed by EU but potentially important area for consumer acceptance, No generic protocol across lamp types, particularly when paired with control devices – potential consumer acceptance issue

Other Possible Problems with Test Methods

Issue		**Additional Comment**
Lamp lifetime	- Currently most methods use 50% survival rate (median life) - Addressed for CFLs in EU by regulation, but IEC 60969 test softens requirement. - Test methods under ideal laboratory conditions (eg voltage, temperature, …), real world likely to shorten lamp life (potentially considerably).	Potential consumer dissatisfaction with claims verses actual performance.
Use of IEC "type test" standards	- Most IEC lamp performance standards state only suitable only for 'type testing' (typically production over an extended period).	Under existing regime, potential issue of "non-compliant" manufacturers appealing compliance decisions based on statistical possibility. Alternative "zero-tolerance" regime risks (occasional) compliant manufacturer failing to meet requirement.
IEC pass/fail requirements incorporated into test methods	- IEC/EN standards typically include pass/fail requirements, eg "initial reading of the luminous flux of a lamp shall be not less than 92% of the rated value."	Effectively devolves some regulatory control to IEC/EN Standard. Issue potentially compounded by regulatory reference to "rated values" vs "tested values".
Network-connected smart lamps	- Network connected lamps currently are not adequately addressed for most of their functionality (colour adjustment, none peak power, "standby")	Has the potential to severely offset saving benefits if appropriate test methods not developed rapidly (possibility of technology leading standards)

Outlines of Mandates to the ESOs

- Lamp luminous flux: address current situation for directional lamps which requires goniophotometer testing of light output within 90° or 120° cone.
- LED lumen maintenance: address differences in approach between the IEC and other test methods, and across product types.
- Lifetime: generate approaches to define lifetime in a consistent manner across product types and in line with consumer understanding.
- Rapid switching withstand: address differences in switching cycle times between the IEC and other test methods, and across lamp types.
- Warm-up (run-up) time: address subtle differences in run-up performance definitions within test methods to ensure compatibility across lamp types.
- Colour, in particular CRI: engage with the evolving measurements approaches for CRI to attempt to ensure compatibility across lamp types.
- Dimmability: continue to address testing for compatibility between dimmers and light sources.
- Noise: potential adoption of existing international test methods, should noise be deemed appropriate for EU regulation.
- Consolidation of test methods: consider consolidating photometric (and colourimetric) testing methods into a single standard for all lamp types with differing, lamp-specific, set-up requirements.
- Network-connected "smart lamps": devise appropriate test methods for functionality and network standby power consumption.

Legislative Comparison

MEPS for Selected Countries

	EU	Australia	Canada	China	Korea	Japan	Taiwan	USA
Incandescent lamps - non-directional	X	X	X	X	X	X	X	X
Incandescent and tungsten halogen lamps - directional	X	X	X	-	-	-	-	X
Compact fluorescent lamps with integrated ballast (CFLi)	X	X	-	X	X	X	X	X
Compact fluorescent lamps without integrated ballast (single-capped fluorescent lamps)	X	-	-	X	-	X	X	-
LED lamps	X	-	-	X	-	X	planned	-
Linear fluorescent lamps	X	X	X	X	X	X	X	X
HID lamps	X	-	-	X	planned	-	-	-
Linear fluorescent ballasts	X	X	X	X	X	X	X	X
HID ballasts	X	-	X	X	planned	-	-	X
Luminaires	-	-	-	-	-	X	-	-

Legislative Comparison - Scope

Type	Observations

Incandescent and Tungsten Halogen lamps	- EU has broadest scope
	- Most countries have exemption for shockproof lamps
	  - US definition very precise
	  - US has a market monitoring system in place – exempted lamps can lose exemption status

CFLi	- EU has broadest scope
CFL (non-integrated)	- EU has similar scope
LED	- EU has broadest scope
linear fluorescent lamp	- EU has broader scope than most countries
HID lamps	- China only other country with regulations (less broad scope than EU) - US eliminating mercury vapour technology using ballast regulations
Scope of "other" lamp types	- EU may consider OLEDs - Induction lamps? Not clear if in scope currently
Fluorescent and HID Ballasts	- EU has broadest scope
Luminaires	- Building standards more widely used – allows more flexibility - EU, Canada and US do regulate HID luminaires (primarily the ballast installed)

Intent of analysis ***is not*** *to imply that new EU legislation should be technology-specific.*

Legislative Comparison – Efficiency (1)

Type	Observations
Non-directional incandescent and tungsten halogen lamps	- Most countries MEPS effectively exclude incandescent but not tungsten halogen lamps - *[New US regulations?]* - Consider power ceiling to ensure increased efficacy results in lower power?
Directional incandescent and tungsten halogen lamps	- Few countries have MEPS - US MEPS allows tungsten halogen directional lamps - Australia has power ceiling for 12V MR16 lamps (37W)
CFLi	- Efficacy requirements of developed countries are similar - Potential to increase EU MEPS efficacy requirement for CFLs by 10+ lm/W
CFL (non-integrated)	- EU has higher efficacy requirement
LED	- EU has higher efficacy requirement
Linear fluorescent lamps	- EU higher but described in terms of rated values - Lamps available with higher efficacies than current EU requirements - Consider power ceiling? (e.g. US has 25W lamps available to replace 32W)

*Intent of the analysis **is not** to imply that new EU legislation should be technology-specific.*

Legislative Comparison – Efficiency (2)

- HID lamps
  - EU efficacy requirements higher than China
  - US phasing-out mercury vapour (via ballasts) - EU could consider this mechanism
  - Could apply to other lamps types
- Linear fluorescent ballasts
  - EU mandates B2 (ferromagnetic)
  - In 2017 EU will mandate electronic
  - (in line with US)
- HID ballasts – see figure --->
  - EU lower than other countries
  - Corrected in stage 3 (2017)
  - (US/Canada just cover metal halide)

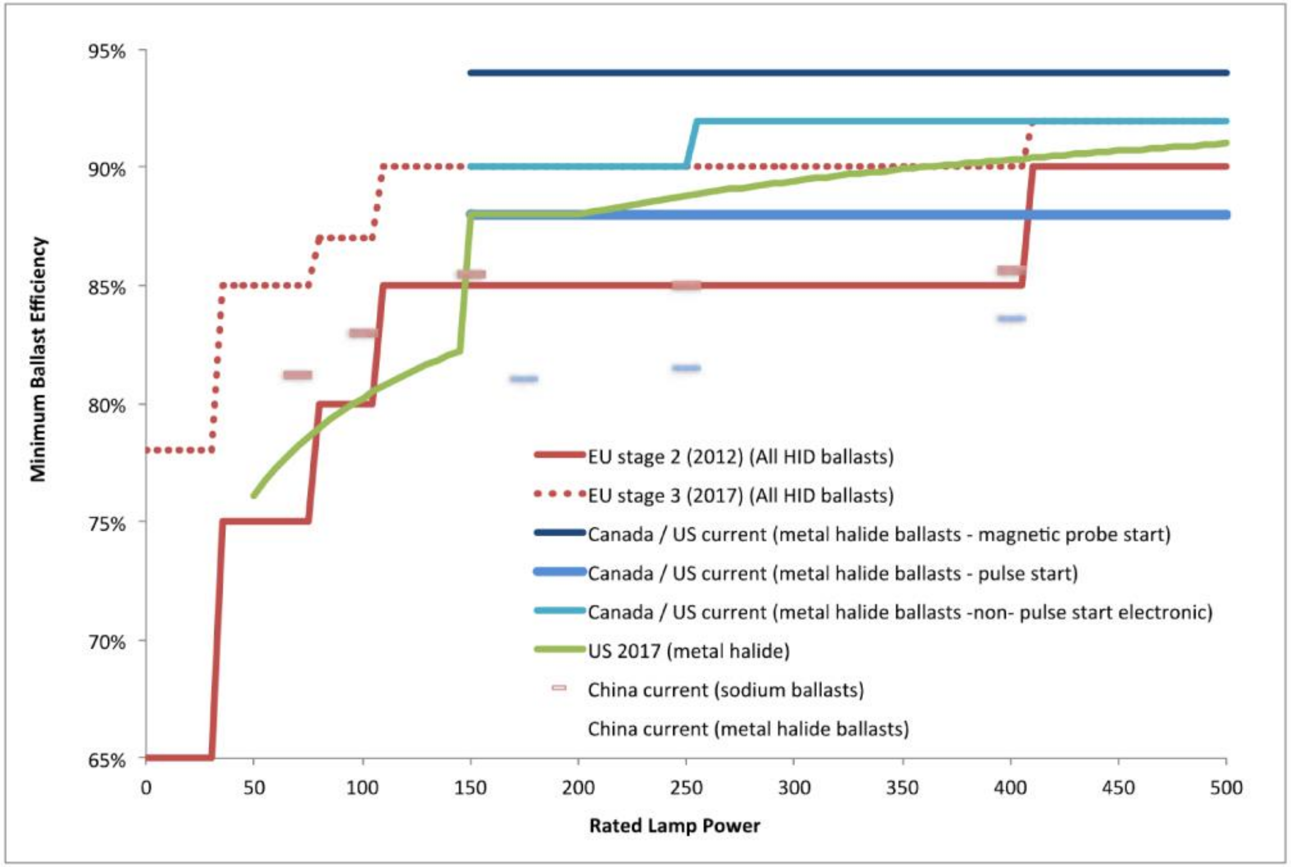


Figure 7 Comparison of MEPS for HID ballasts

Legislative Comparison – Functionality

Type	Observations
Non-directional incandescent and tungsten halogen lamps	- EU requirements broadly in line with other countries - EU does not require CRI as does USA and Canada - *EU adding requirement would not be onerous but of questionable benefit given concerns over CRI as an appropriate measure*
CFLi	- EU requirements typically more stringent than other countries - Exception is rapid cycle switching
LED	- EU significantly more stringent
Linear fluorescent lamps	- EU significantly more stringent
HID Lamps	- EU significantly more stringent

*Intent of the analysis **is not** to imply that new EU legislation should be technology-specific.*

Regulation comparison – labelling (1)

	Incandescent / Tungsten Halogen Lamps		CFLi Lamps		LED Lamps		Fluorescent Lamps		HID Lamps		Fluorescent Ballasts	
	Comp.	End.	Comp.	End.	Comp.	End.	Comp.	End.	Comp.	End.	Comp.	End.
Argentina	Mand		Mand	Vol								
Australia											Mand	
Brazil	Mand		Mand				Mand	Mand			Mand	Mand
Canada	Mand	Vol	Mand	Vol		Vol	Vol	Vol				Vol
Chile							Mand				Mand	
China				Vol		Vol	Mand	Vol				Vol
EU	Mand		Mand	Vol	Mand	Vol	Mand	Vol	Mand		Mand	Vol
Hong Kong			Mand				Vol				Vol	
India			Vol				Mand	Vol			Vol	
Indonesia			Mand				Mand				Prop	
Japan			-				Mand	Vol				
Korea	Mand							Vol			Mand	Vol
Malaysia												
Mexico				Vol			Mand	Vol			Mand	Vol
Philippines			Mand					Prop			Mand	
Russia	Vol		Prop				Vol					
Singapore												
South Africa	Prop		Prop	Mand							Prop	
Taiwan			Mand	Vol		Vol		Vol				
Thailand			Vol	Vol			Vol	Vol			Vol	Vol
USA	Mand		Mand	Vol	Mand	Vol	Mand	Vol			Mand	Vol
Vietnam				Vol				Vol				Vol

Note: Comp = comparison label, End = endorsement label, Mand = mandatory, Vol = voluntary, Prop = proposed

Figure 8 Selection of lamp and ballast labelling currently in place

Regulation comparison – labelling (2)

- For mandatory energy labelling of lamps and ballasts
  - EU covers significantly more lamp types than other countries
  - EU labelling/information requirements are comparatively comprehensive

  - US voluntary LED Lighting Facts label presents
    - Graphical information about LED colour temperature
    - Lumen maintenance
    - Colour accuracy
    - *Potential benefit for consideration by EU*

End of Standards and Regulations

Test methods Comparison

Test methods under Development

Other possible Problems with Test methods

Outline of Mandates to ESO’s

Legislative Comparison EU ↔ non-EU

Labelling Regulation Comparison EU ↔ non-EU

Any questions or remarks on these topics ??

Ecodesign Preparatory Study
Lot 8/9/19 Light Sources

1st Stakeholder Meeting

5 February 2015

MARKETS

(Task 2 report)

Leo Wierda

Van Holsteijn en Kemna

vito vision on technology

Vlaamse Instelling voor Technologisch Onderzoek

Task 2 report (Markets), survey

Model for **E**uropean **Li**ght **S**ources **A**nalysis (MELISA)

(what is this, and why ?)

EU-28 lamp sales (units)
Average lamp prices
→ EU-28 lamp sales (value)

EU-28 lamp sales (units)
Lamp lifetimes
→ EU-28 installed stock (units)

Stakeholders are invited to provide constructive comments on this model.

Eurostat sales data (one of the sources for MELISA)

IEA 4E/GfK 2014 sales data (comparison with MELISA)

McKinsey 2012 derived data (comparison with MELISA)

MELISA, Introduction (1)

- **M**odel for **E**uropean **LI**ght **S**ources **A**nalysis (MELISA) Continuous development by study team

- Now contains:
  - Sales volumes (units)
  - Life & use data (lifetimes, lumens, power, burning hours, efficacies, prices) (averages)
  - Stock for light sources (installed number of units)
  - Installed capacity in terms of lumen (Blue: Task 2 report)
  - Total use in terms of operating hours (Black: Task 3 report)
  - Energy consumption by light sources (TWh/a)
  - Economic data (sales value, industry revenue, energy cost, total consumer expense)

- Data provided for:
  - all lamp technology types (LFL, CFL, HL, GLS, HID, LED, and some further breakdown)
  - period 1990-2013
  - EU-28 total, and split in residential and non-residential sector

- Based on: Eurostat, LightingEurope, literature, study team experience

MELISA, Introduction (2)

- Aims:
  - Harmonise data used in various studies on light sources (Commission request).
  - Create a single stock model for light sources that is accepted by interested parties as the main reference.

- Checks: (mainly Task 3 report)
  - Input data have been checked for reasonability against literature sources
  - Output data have been checked for reasonability, e.g.:
    - Number of lamps installed per household
    - Annual lighting energy consumption per household (kWh/household/year)
    - Power density installed in non-residential buildings (W/m^2)
    - Annual lighting energy density for non-residential buildings (kWh/m^2/year, LENI)
    - Comparison with data from prEN15193 (lighting in buildings) and EN12464-1 (lighting requirements)

- MELISA: use in Light Sources study in MEErP Task 7 for Scenario Analysis
- MELISA: later use in Lighting Systems study, maybe in adapted/extended form.

- Data are preliminary and may be updated as the study proceeds, and following **stakeholders' comments**.

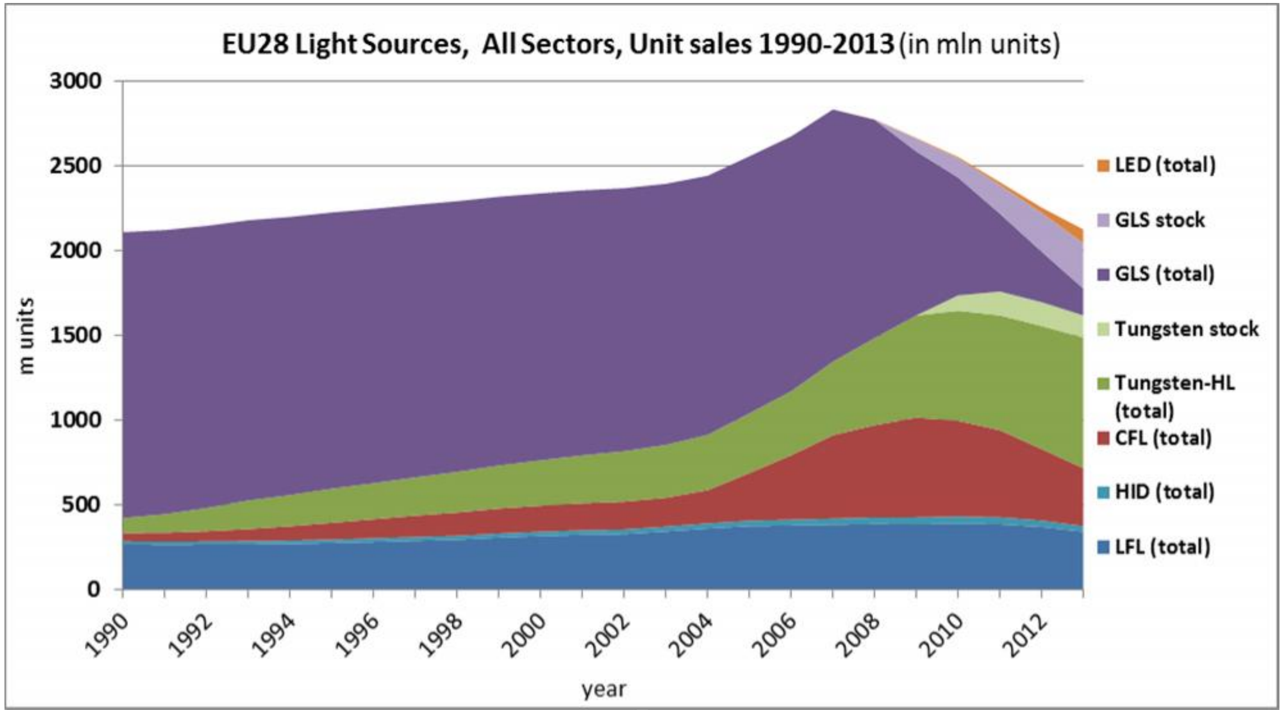
Lamp type subdivision reflects sales data availability from LightingEurope

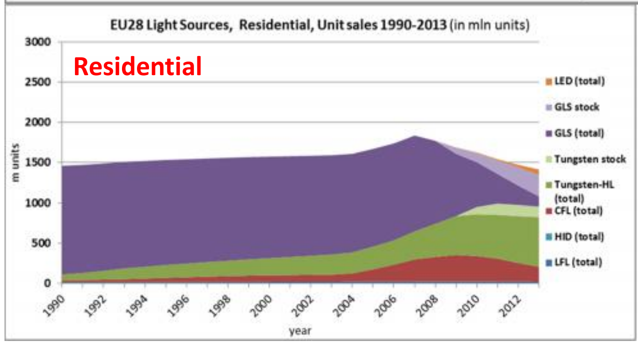
MELISA, Example Table (Sales)

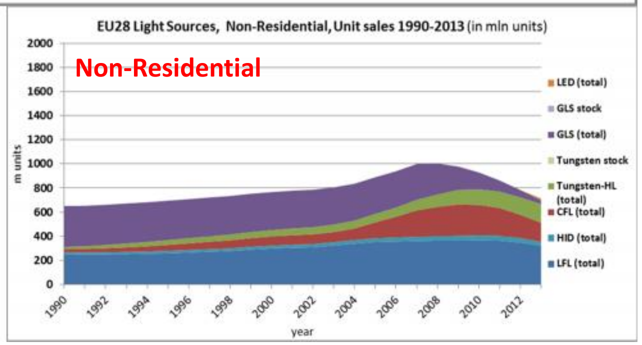
	EU-28 SALES, TOTAL, All Sectors, million units	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013
LFL	T12	80	47	29	16	14	12	10	8	6	5	3	1
	T8 halophosphor	95	119	154	176	165	154	143	113	68	26	4	2
	T8 tri-phosphor	71	83	100	121	131	142	153	175	216	254	261	245
	T5 new (14 - 80w) including circular	0	0	0	23	31	39	47	57	68	76	81	76
	All others (including T5 old types 4 - 13w and special FL)	23	28	36	40	39	38	37	34	32	27	23	19
	LFL (total)	**269**	**276**	**318**	**376**	**380**	**385**	**389**	**387**	**390**	**387**	**372**	**344**
CFL	Retrofit - CFLi	28	68	109	220	313	420	467	506	480	431	345	271
	Non-retrofit - CFLni	23	31	44	62	67	73	79	84	87	83	78	72
	CFL (total)	**51**	**99**	**154**	**282**	**381**	**493**	**545**	**589**	**567**	**514**	**422**	**342**
TUNGSTEN (HL)	Single ended, mirrored (low voltage) [M16, M25 etc.]	20	54	93	130	136	140	144	148	150	151	154	164
	Linear (high voltage) [R7s]	15	90	90	90	80	67	54	47	45	41	40	38
	LV halogen capsule [G4, GY6.35]	52	52	52	52	52	52	52	53	52	49	45	42
	HV halogen capsule [G9]	0	0	0	10	23	47	60	70	70	70	70	67
	Mains halogen (substitute for GLS and reflector)[E14, E27]	0	0	0	0	3	27	81	141	172	196	244	303
	Other mains halogen - PAR 16/20/ 25/30 Hard glass reflectors, GU10 etc.	0	5	32	69	82	101	122	144	162	172	174	158
	Tungsten-HL (total)	**88**	**201**	**268**	**352**	**377**	**433**	**514**	**603**	**650**	**678**	**726**	**772**
GLS	Reflector	173	163	155	144	140	134	115	94	72	61	54	36
	GLS (Including clear/pearl, candles, coloured & decorative)	1514	1468	1421	1375	1365	1356	1174	874	624	400	245	123
	GLS (total)	**1688**	**1631**	**1576**	**1519**	**1506**	**1490**	**1290**	**968**	**697**	**461**	**299**	**159**
HID	All mercury lamps (including mixed)	8	9	9	7	7	6	6	5	5	4	3	2
	All sodium lamps	7	8	9	12	13	14	16	16	15	14	14	14
	Metal halide lamps	2	4	7	12	14	15	17	19	22	23	20	16
	HID (total)	**17**	**21**	**25**	**32**	**34**	**36**	**38**	**40**	**42**	**41**	**37**	**33**
LED	LED directional	0	0	0	0	0	0	1	3	6	11	18	41
	LED non-directional	0	0	0	0	0	0	1	1	3	6	13	41
	LED (total)	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**4**	**8**	**17**	**31**	**82**
	GLS stock	0	0	0	0	0	0	0	75	112	168	228	267
	Tungsten stock	0	0	0	0	0	0	0	0	90	140	140	130
	TOTAL	**2112**	**2228**	**2341**	**2560**	**2677**	**2836**	**2777**	**2592**	**2354**	**2099**	**1889**	**1731**

Not real sales: seem to come to the market from household stocks.

MELISA, Sales (units)







- Sales in 2007: peak of 2.8 billion units
- Sales in 2013: down to 1.7 billion units
- -39% in 6 years, CAGR -8%
- Longer lifetimes -> lower sales volumes

In 2013:

- 59% of sales units is for residential
- average 7.1 lamps/household/year

- Residential sales (2008 -> 2013):

  HL 23% -> 61%
  CFL 17% -> 18%
  GLS 58% -> 13%
  LED 0% -> 7%
  LFL 1% -> 2%

- Non-residential sales (2008 -> 2013):

  LFL 36% -> 45%
  CFL 24% -> 22%
  HL 10% -> 22%
  HID 4% -> 5%
  GLS 26% -> 4%
  LED 0% -> 2%

MELISA, Average prices

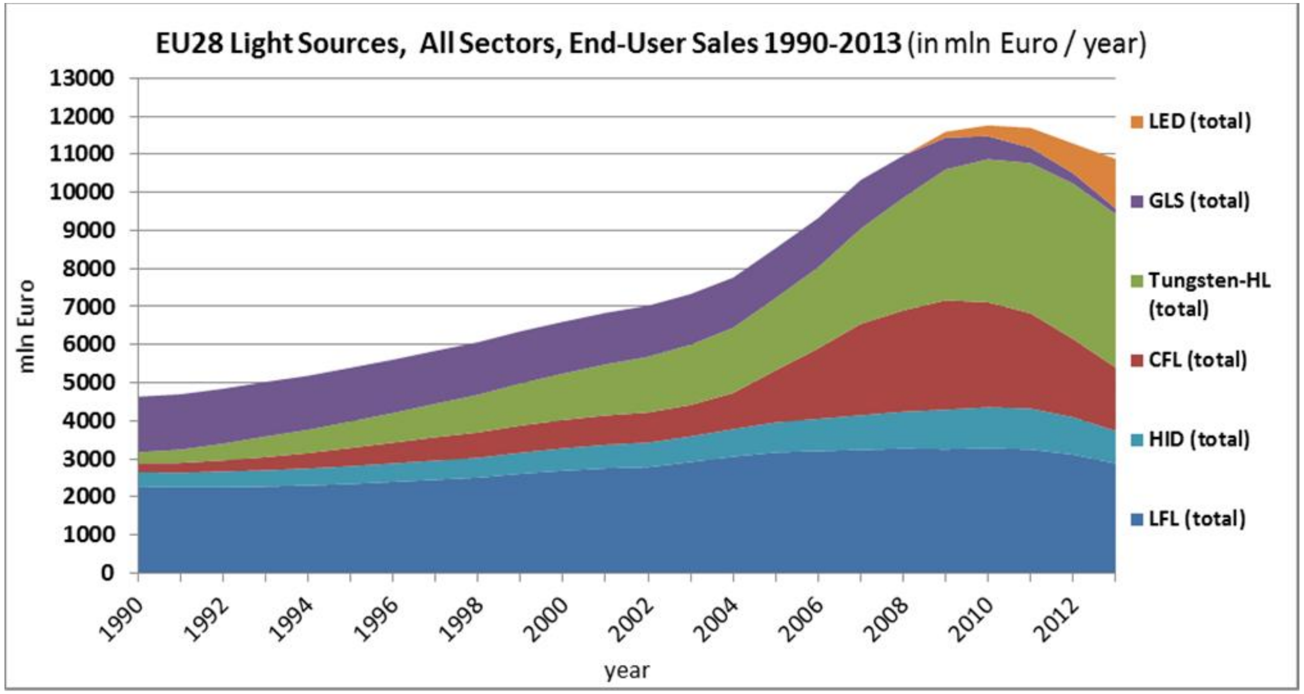
Sales (units) * Average Prices = Sales (value) = Consumer Acquisition Cost

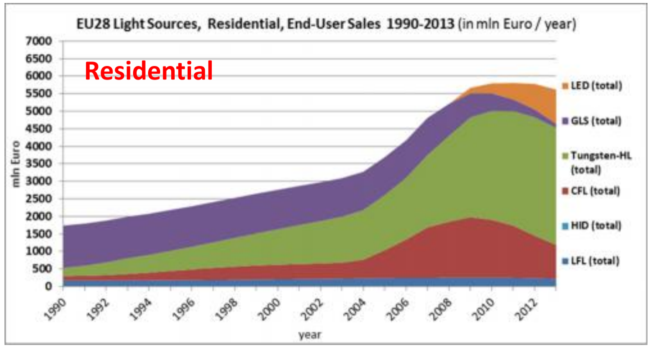
	LFL					CFL		TUNGSTEN						GLS		HID		
MELISA, unit lamp prices in euro/unit fixed euros 2010	T12	T8 Halophosphor	T8 tri-phosphor	T5 new (14 - 80w) including Circular	All others (including T5 old types 4 - 13w and Special Fl.)	Retrofit - CFLi	Non-Retrofit - CFLni	Single Ended, Mirrored (Low voltage) [M16,M25etc]	Linear (High voltage) [R7s]	LV halogen Capsule [G4, GY6.35]	HV halogen Capsule [G9]	Mains halogen (Substitute for GLS and Reflector)[E14, E27]	Other Mains halogen - PAR 16/ 20/25/30 Hard glass reflectors, GU10 etc.	Reflector	GLS (Including clear/pearl, candles, coloured & decorative)	All Mercury Lamps (including mixed)	All Sodium Lamps	Metal Halide Lamps
Reference power (W)	35	32	30	25	12	9.5	12	35	250	35	35	36	35	54	54	250	140	160
Reference efficiency (lm/W)	70	75	80	91	86	55	55	14	12	14	12	12	12	9.5	9.5	40	95	82
Price/unit residential € (incl. VAT)	**10.10**	**10.10**	**10.10**	**9.50**	**9.50**	**5.26**	**5.26**	**3.79**	**3.16**	**3.16**	**3.79**	**2.63**	**14.21**	**1.37**	**0.84**	**20.40**	**32.40**	**32.40**
Price/unit non-residential € (excl. VAT)	**8.42**	**8.42**	**8.42**	**7.92**	**7.92**	**4.39**	**4.39**	**3.16**	**2.63**	**2.63**	**3.16**	**2.19**	**11.84**	**1.14**	**0.70**	**17.00**	**27.00**	**27.00**

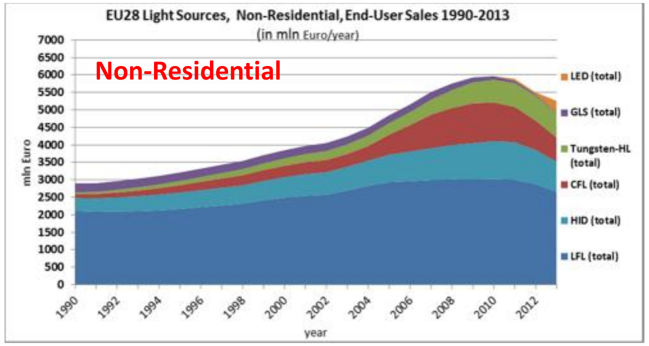
LED price/unit (fixed euros 2010)	**2009**	**2010**	**2011**	**2012**	**2013**
lm / W (for sales in year)	25	30	40	60	80
watt @ 500 lm	20.0	16.7	12.5	8.3	6.3
euro / lumen (source: LightingEurope 2013)	0.056	0.048	0.042	0.034	0.020
euro @ 500 lm (excl. VAT)	**28.00**	**24.00**	**21.00**	**17.00**	**10.00**

Residential incl. 20% VAT
Non-residential excl. VAT

MELISA, Sales (value) = Consumer acquisition cost







- Expense 2010: peak of 11.8 billion euros
- Expense 2013: down to 10.9 billion euros

In 2013:

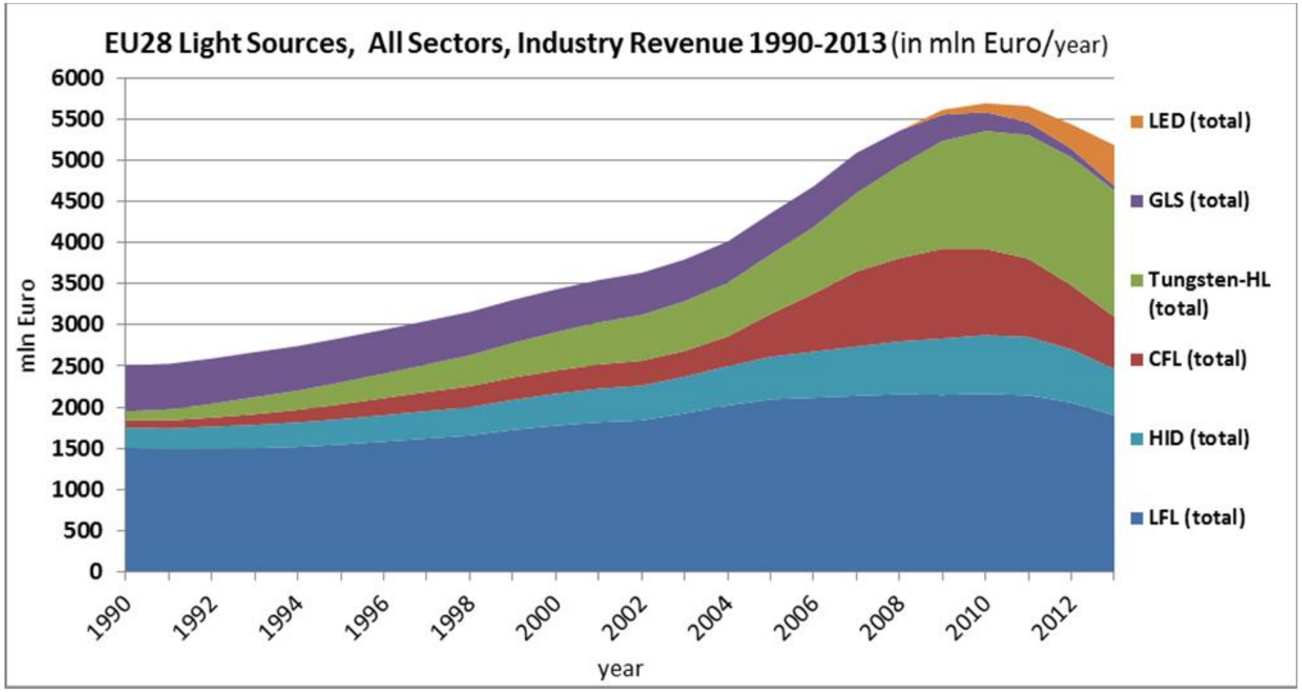
- 52% of consumer expense is residential
- average 28.3 euros/household/year

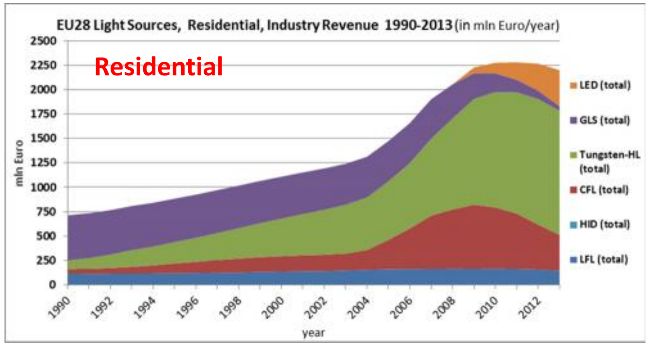
- Residential expense (2008 -> 2013):
  - **HL 47% -> 59%**
  - **CFL 31% -> 17%**
  - **LED 0% -> 17%** (incl. VAT)
  - LFL 5% -> 4%
  - **GLS 18% -> 2%**

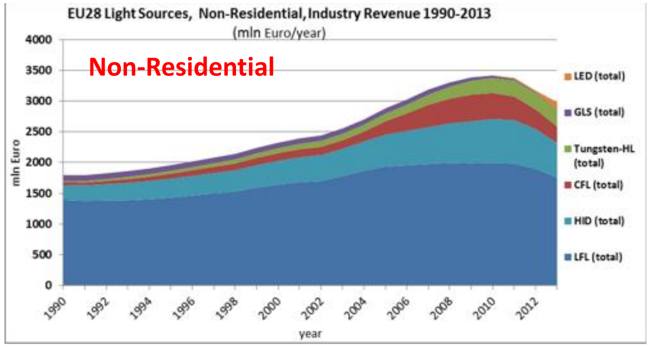
- Non-residential expense (2008 -> 2013):
  - LFL 53% -> 51%
  - HID 17% -> 16%
  - **CFL 18% -> 13%** (excl. VAT)
  - **HL 9% -> 13%**
  - **LED 0% -> 6%**
  - GLS 3% -> 0%

(lamp acquisition cost only, excl. energy cost)

MELISA, Industry Revenue







LFL, HID: revenue is 66% of consumer price
CFL, HL, GLS, LED: 38% (comments!)

- Revenue 2010: peak of 5.7 billion euros
- Revenue 2013: down to 5.2 billion euros

In 2013: 42% of industry revenue is from residential sales

- Residential revenue (2008 -> 2013):
  - **HL 45% -> 58%**
  - **CFL 30% -> 17%**
  - **LED 0% -> 17%**
  - LFL 8% -> 7%
  - **GLS 17% -> 2%**

- Non-residential revenue (2008 -> 2013):
  - LFL 60% -> 59%
  - HID 19% -> 19%
  - **CFL 12% -> 9%**
  - **HL 6% -> 9%**
  - **LED 0% -> 4%**
  - GLS 2% -> 0%

MELISA, Installed Stock, calculation

Stock = Number of light sources installed in EU-28 in a given year (it is NOT the quantity in warehouses)

Stock in year N = $\{ \sum_{year=N-INTlife+1}^{year=N} Sales(year) \} + DEClife * Sales(N - INTlife)$

where INTlife = integer part of the lamp life in years
DEClife = decimal part of the lamp life in years

For example, if the year considered is N=2014 and the life in years for the lamp type has been computed as 3.2 years (INTlife=3 and DEClife=0.2): Stock (2014) = Sales(2014)+Sales(2013)+Sales(2012)+0.2*Sales(2011)

➡ **Installed Stock = Sum of Sales over X preceding years, where X = lamp lifetime**

Lamp lifetime in years depends on:

- lamp life time in hours
- annual operating hours for the lamp

$$Life(years) = \frac{Life\ (hours)}{Operating\ hours\ per\ year}$$

➡ MELISA contains assumptions for Lamp Life (hours) and for Annual Operating Hours (hours/year) (Operating Hours are assumed to be full-power equivalent hours)

MELISA, Lifetimes

Assumed Lamp Life(hours) and Annual Operating Hours (hours/year):

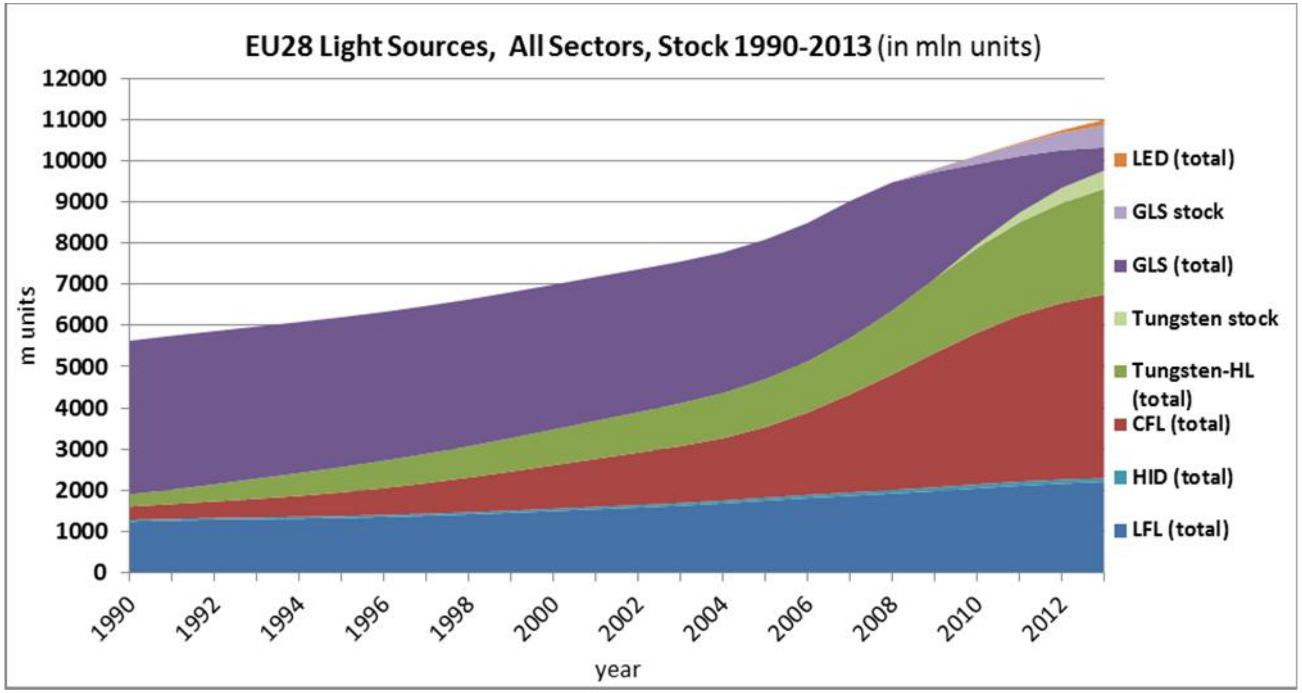
	LFL					CFL		TUNGSTEN						GLS		HID		
Lifetime (hours), operating hours (hours/year) and life (years) per type of light source	T12	T8 Halophosphor	T8 tri-phosphor	T5 new (14 - 80w) including Circular	All others (including T5 old types 4 - 13w and Special Fl.)	Retrofit - CFLi	Non-Retrofit - CFLni	Single Ended, Mirrored (Low voltage) [M16,M25etc]	Linear (High voltage) [R7s]	LV halogen Capsule [G4, GY6.35]	HV halogen Capsule [G9]	Mains halogen (Substitute for GLS and Reflector)[E14, E27]	Other Mains halogen - PAR 16/20/25/30 Hard glass reflectors, GU10 etc.	Reflector	GLS (Including clear/pearl, candles, coloured & decorative)	All Mercury Lamps (including mixed)	All Sodium Lamps	Metal Halide Lamps
Life (hours)	8000	8000	13000	20000	11000	6000	10000	2000	1000	2000	1500	1500	1500	1000	1000	8000	12000	8000
Operating (h/a) residential	700	700	700	700	700	500	700	450	450	450	450	450	450	450	450	*700*	*700*	*700*
Operating (h/a) non-residential	2200	2200	2200	2200	2200	500	1600	450	450	450	450	450	450	450	450	4000	4000	4000
Life (years) residential	**11.4**	**11.4**	**18.6**	**28.6**	**15.7**	**12.0**	**14.3**	**4.4**	**2.2**	**4.4**	**3.3**	**3.3**	**3.3**	**2.2**	**2.2**	***11.4***	***17.1***	***11.4***
Life (years) non-residential	**3.6**	**3.6**	**5.9**	**9.1**	**5.0**	**12.0**	**6.3**	**4.4**	**2.2**	**4.4**	**3.3**	**3.3**	**3.3**	**2.2**	**2.2**	**2.0**	**3.0**	**2.0**

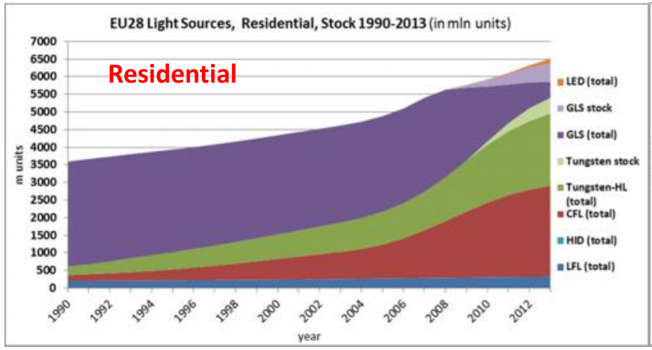
For LED lamps in 2013:

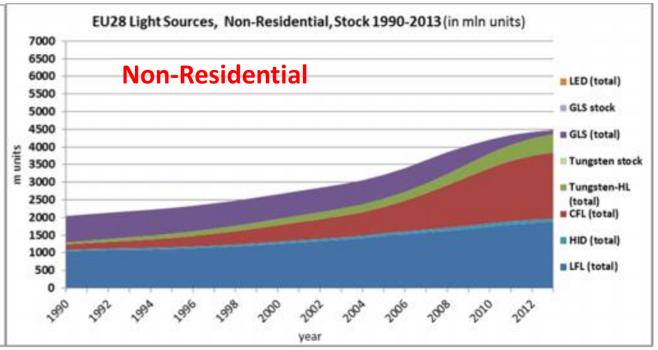
- Life in hours 20,000 h
- Operating hours (residential) 500 h (450 h + rebound)
- Operating hours (NDLS, non-residential) 1500 h (mix of 2200 and 450 h)
- Operating hours (DLS, non-residential) 984 h (mix of DLS and NDLS substituted)

Major uncertainty: average EU-28 Annual Operating Hours in Non-Residential sector

MELISA, Installed Stock







- 1990: stock of 5.6 billion units
- 2013: stock of 11 billion units
- Almost doubled in 23 years

In 2013:

- 59% of stock is in residential sector
- average ≈ 33 lamps/household
  (≈ 13 CFL, ≈ 13 HL)

- Residential stock (2008 -> 2013):
  CFL 28% -> 40%
  HL 22% -> 38%
  GLS 44% -> 15%
  LFL 5% -> 5%
  LED 0% -> 2%

- Non-residential stock (2008 -> 2013):
  LFL 42% -> 42%
  CFL 31% -> 42%
  HL 8% -> 11%
  HID 2% -> 2%
  GLS 16% -> 2%
  LED 0% -> 0%

End of presentation on MELISA sales/stock

Any questions or remarks on this ?

To follow:

Sales data from Eurostat (one of the bases for MELISA)
Comparison of MELISA sales data with GfK / IEA 4E (2014) data
Comparison of MELISA sales data with McKinsey (2012) data

Later, Task 3 presentation: other data from MELISA and comparison with literature data.

Eurostat trade data (1)

- Eurostat data = one of the sources for the MELISA model

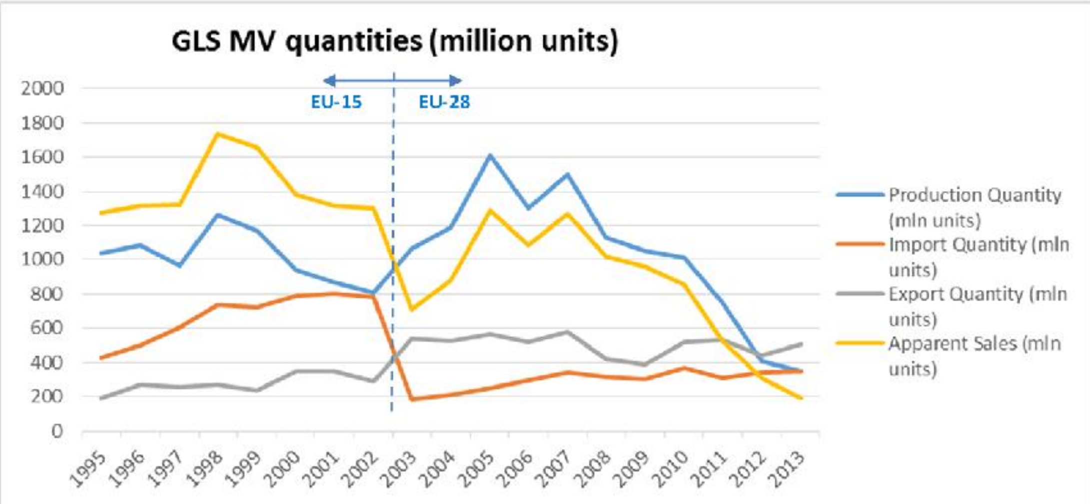
- Sales = Apparent Consumption = Production + Import – Export

- Details on coding systems (Task 1 report)
- Comments on reliability of data and interpretation difficulties (Task 2 report)
- Extensive reporting of Eurostat data (tables, graphs) in Annex C of the Task 2 report

- **Only some examples are presented here, as an illustration of the available data**

Eurostat (2), example of data per lamp type

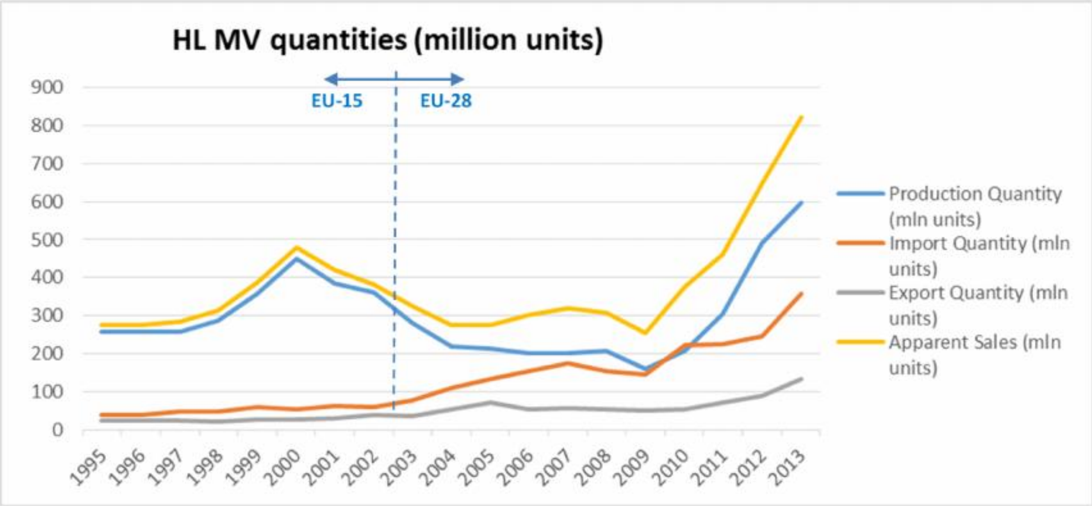
GLS MV <200W	EU-15								EU-28										
year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Production Quantity (mln units)	1040	1085	969	1263	1171	939	867	806	1067	1192	1610	1303	1500	1130	1051	1012	751	407	352
Import Quantity (mln units)	426	502	607	738	725	788	799	784	186	212	248	295	344	313	301	367	311	343	350
Export Quantity (mln units)	193	272	256	267	237	348	350	291	542	525	568	516	576	423	391	522	534	439	509
Apparent Sales (mln units)	1272	1316	1320	1734	1659	1379	1316	1299	711	878	1290	1082	1269	1020	961	857	528	311	192
Production Value (mln euro)	354	340	357	380	365	320	325	313	289	314	377	293	331	346	342	325	221	210	200
Import Value (mln euro)	100	123	142	169	185	204	201	193	49.7	47.7	53.6	61.1	65.7	60.3	62.1	88.4	79.9	83.8	75.3
Export Value (mln euro)	71.1	89.4	99.0	97.9	93.2	117	129	99.1	134	134	116	112	113	95.0	83.8	101	99.3	94.1	104
Apparent Sales (mln euro)	383	374	400	451	457	407	398	407	204	227	315	243	284	311	320	312	202	199	172
Production Value (euro/unit)	0.34	0.31	0.37	0.30	0.31	0.34	0.38	0.39	0.27	0.26	0.23	0.22	0.22	0.31	0.33	0.32	0.29	0.51	0.57
Import Value (euro/unit)	0.24	0.24	0.23	0.23	0.26	0.26	0.25	0.25	0.27	0.23	0.22	0.21	0.19	0.19	0.21	0.24	0.26	0.24	0.22
Export Value (euro/unit)	0.37	0.33	0.39	0.37	0.39	0.34	0.37	0.34	0.25	0.26	0.20	0.22	0.20	0.22	0.21	0.19	0.19	0.21	0.20
Apparent Value (euro/unit)	0.30	0.28	0.30	0.26	0.28	0.30	0.30	0.31	0.29	0.26	0.24	0.22	**0.22**	**0.31**	**0.33**	**0.36**	**0.38**	**0.64**	**0.89**

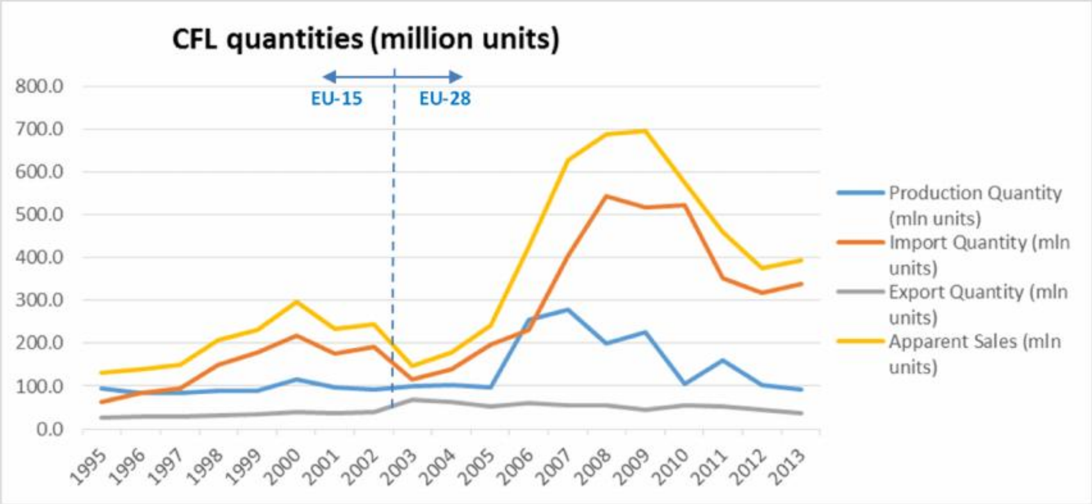


Incandescent MV lamps < 200W:

- clear downward trend from 2007

Eurostat (3), example of data per lamp type

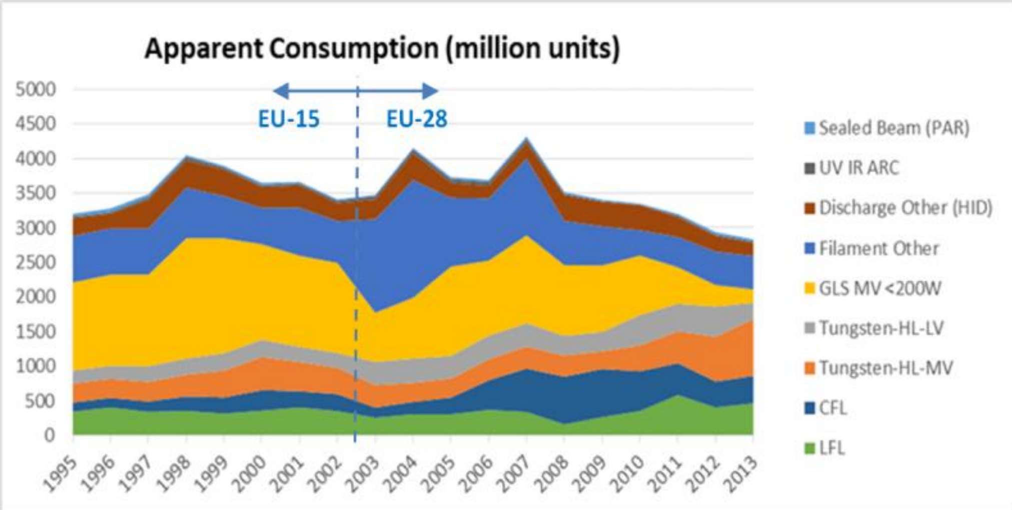


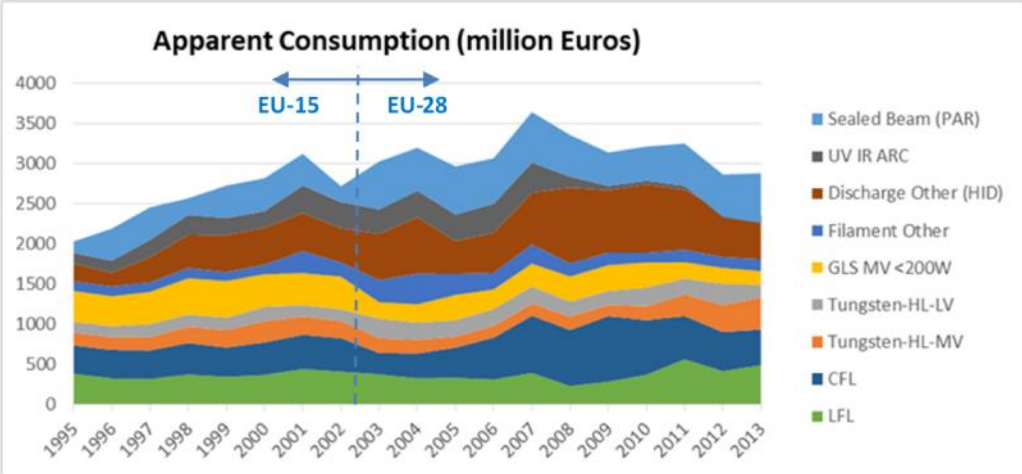


Halogen MV lamps :
- clear upward trend from 2009

Compact Fluorescent Lamps :
- Peak around 2008-2009
- Decrease in sales in recent years

Eurostat (4), example of cumulative totals



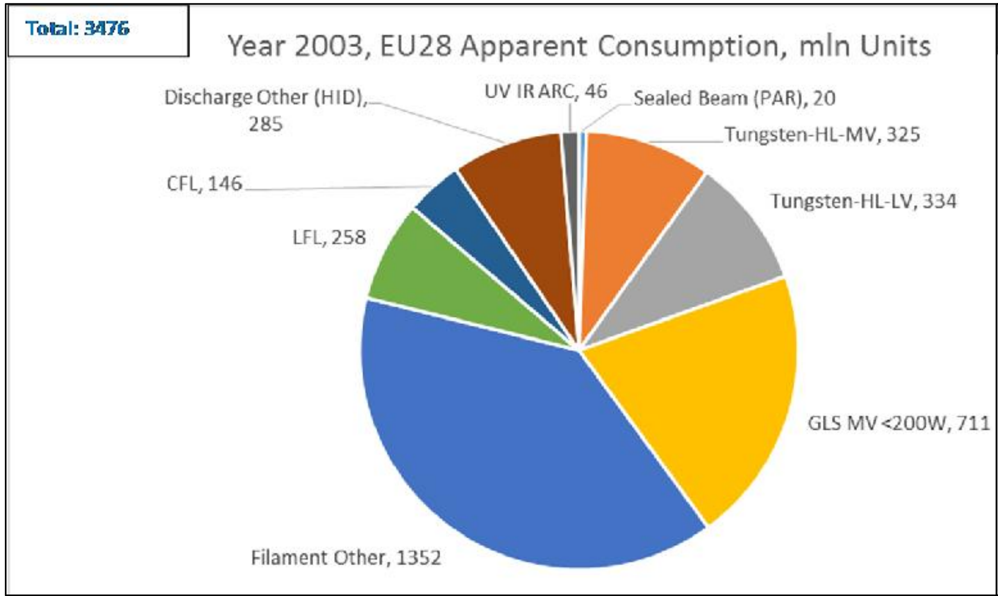


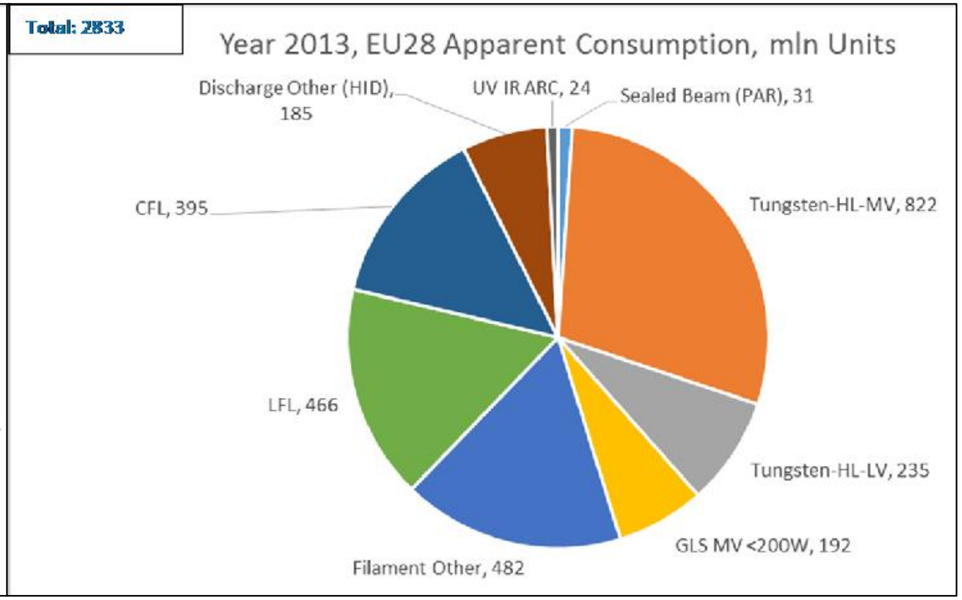
- Data available in:
  - units
  - euros

- Same graphs available for:
  - production
  - import
  - export

- 'Difficult' groups for modelling:
  - Filament Other (GLS LV, GLS MV > 200W)
  - Discharge Other (HID, but also many CCFL's)
  - Sealed Beam (PAR)
  - no group for LEDs

Eurostat (5), example of distributions





From 2003 (first year with EU-28 data) to 2013 (last year with EU-28 data):

- Total apparent sales decrease from 3.5 to 2.8 billion units (includes all Eurostat lamp types)
- Strong decrease in share of incandescent lamps (GLS MV < 200W + Filament other)
- Strong increase in share for Halogen MV, CFL, LFL
- Share of Halogen LV lamps more or less stable

IEA 4E / GfK data (1)

- Gesellschaft für Konsumforschung (GfK), research on **domestic** lamp sales
- Countries covered (average coverage estimated 70%):
  Austria, Belgium, France, Germany, Great Britain, Italy, Netherlands (2007-2013),
  Poland, Spain (2011-2013).

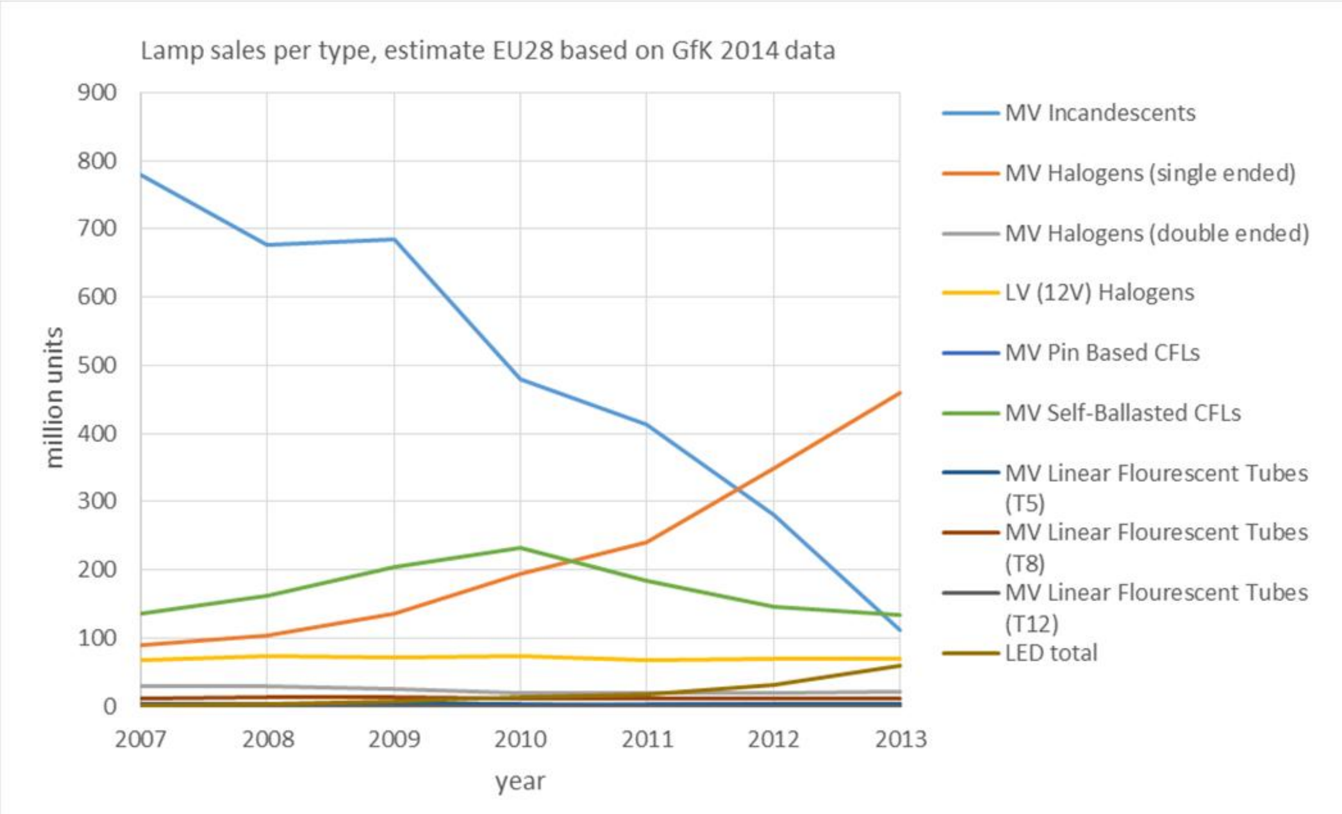
- Data reported by IEA in "4E Mapping Document, European Union, Domestic Lighting" (2014)

- Data extrapolated by study team to EU-28
- **Outcome compared with data in the MELISA residential model**

- GfK/IEA 4E data also include:
  Distribution of the sales over various wattage ranges -> estimate of average lamp powers.
  Sales-weighted average efficacies (lm/W)
  These aspects are further explored in the Task 3 report. Here: focus on sales

- See Annex D of Task 2 report for results extrapolated to EU-28

IEA 4E / GfK data (2)



Lamp sales per lamp type, estimate for EU28 based on GfK 2014 data (millions of units)

	2007	2008	2009	2010	2011	2012	2013
TOTAL all lamp types	**1125**	**1068**	**1149**	**1031**	**959**	**916**	**873**

GfK/IEA 4E data confirm MELISA trends:

- A strong decrease in the sales of incandescent lamps (GLS)
- An increase in the sales of mains voltage halogen lamps (MV-HL)
- An initial increase and following decrease of CFLi sales with a peak around the year 2010.
- A general decrease in the overall quantity of lamp sales.

IEA 4E / GfK data (3)

Relative values: GfK-derived data / MELISA residential data (%)							
	2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
MV incandescent lamps	65%	65%	88%	86%	112%	117%	87%
MV halogens (single ended)	65%	49%	48%	60%	69%	89%	109%
MV halogens (double ended)	57%	71%	70%	57%	60%	61%	68%
LV (12V) halogens	44%	47%	45%	46%	42%	44%	42%
MV pin based CFLs (CFLni)	9%	9%	10%	9%	13%	15%	17%
MV self-ballasted CFLs (CFLi)	54%	58%	67%	81%	71%	71%	82%
MV LFL tubes (all types)	64%	62%	64%	61%	57%	63%	69%
LED total		262%	193%	152%	110%	108%	89%
TOTAL all lamp types	61%	60%	71%	72%	78%	83%	86%

Conclusions:

- **MELISA residential sales are compatible with GfK/IEA 4E data**
- **MELISA HL-LV residential sales may be too high: consider moving a part of HL-LV sales to non-residential sector**

GfK/IEA 4E extrapolated EU-28 lamp sales **compared to MELISA (residential):**

- Good match for GLS
- Good match for MV-HL (single-ended)
- Good match for CFLi
- Good match for LED
- Good match for total lamp sales

- No good match for HL-LV: GfK sales are lower than LightingEurope sales and LE has only a share of the market, but LE sales are for all sectors; GfK sales only for residential.

- Moderate match for MV-HL (double-ended, R7s), but low sales quantities

- CFLni and LFL: are not typical lamps for residential use; low quantities.

Data derived from McKinsey (1)

- McKinsey's report "Lighting the Way ...." (2012) (update of similar 2011 report)

  - annual sales volumes (quantities) and market values
  - for new installations (fixtures, containing light sources) and for replacement of light sources
  - subdivided per sector (residential, office, industrial, shop/retail, hospitality, outdoor, architectural)
  - subdivided per light source technology type (incandescent, halogen, HID, LFL, CFL, LED retrofit, LED full)
  - data provided for years 2011 and 2012 with forecasts for 2016 and 2020
  - most data are provided on a **global level**, i.e. for the entire world.

- Regional breakdown only in terms of market value (not in quantities)
- McKinsey's 'Europe' not exactly defined, but larger than EU-28
  -> *data elaboration performed to convert to EU-28 market value (assumptions)*
- Light sources value: part is explicit (retrofit), part hidden (light sources sold with luminaires)
  -> *market value conversion from 'general lighting' to 'light sources only' (assumptions)*
- McKinsey's ASP's (global average €/unit) not exactly defined and not representative for EU-28
  -> *assumed €/unit for EU-28 to convert market value to quantities (assumptions)*
- Details in Task 2 report Annex E

Data derived from McKinsey (2), Entire lighting market

Estimate for EU-28		2011	2012	2016	2020	2011	2012	2016	2020
total general lighting market	**m €**	**12964**	**13730**	**15696**	**16308**				
excl. lighting control systems	m €	12434	13102	14508	14141				
incandescent	*m €*	*1914*	*1533*	*303*	*0*	*15%*	*12%*	*2%*	*0%*
halogen	*m €*	*2039*	*2148*	*1952*	*893*	*16%*	*16%*	*13%*	*6%*
HID	*m €*	*1859*	*1958*	*1608*	*669*	*15%*	*15%*	*11%*	*5%*
LFL	*m €*	*3053*	*3026*	*2559*	*1787*	*25%*	*23%*	*18%*	*13%*
CFL	*m €*	*2421*	*2420*	*1292*	*521*	*19%*	*18%*	*9%*	*4%*
LED	*m €*	*1149*	*2017*	*6793*	*10272*	***9%***	***15%***	***47%***	***73%***
Luminaire market	m €	10107	10655	12246	12637	78%	78%	78%	77%
Light Source replacement market	m €	2327	2447	2263	1504	**18%**	**18%**	**14%**	**9%**
Control system market	m €	530	629	1188	2166	**4%**	**5%**	**8%**	**13%**

Share of market value per lamp type,
comparison 2012->2020

- LED 15% -> 73%
- Retrofit 18% -> 9%
- Controls 4% -> 13%

Estimate for EU-28		2011	2012	2016	2020	2011	2012	2016	2020
	m €	**12964**	**13730**	**15696**	**16308**				
Residential	m €	6360	6547	7135	7225	**49%**	**48%**	**45%**	**44%**
Hospitality	m €	878	941	1035	1078	7%	7%	7%	7%
Outdoor	m €	1242	1354	2008	2080	**10%**	**10%**	**13%**	**13%**
Office	m €	1686	1872	2219	2582	**13%**	**14%**	**14%**	**16%**
Architectural	m €	556	594	654	729	4%	4%	4%	4%
Shop/retail	m €	1123	1243	1380	1303	9%	9%	9%	8%
Industrial	m €	1122	1179	1264	1309	9%	9%	8%	8%

Share of market value per sector,
comparison 2012->2020

- Residential 49% -> 44%
- Outdoor 10% -> 13%
- Office 13% -> 16%

Data derived from McKinsey (3), Light sources, value

EU-28 market for light sources/lamps/modules, as derived by the study team from McKinsey data. Sum of all sectors. Values in million euros

EU-28 Light Sources Market		2011	2012	2016	2020
Based on McKinsey, All Sectors	**m €**	**3237**	**3576**	**3940**	**3439**
incandescent	*m €*	*502*	*420*	*82*	*0*
halogen	*m €*	*536*	*591*	*531*	*204*
HID	*m €*	*461*	*507*	*423*	*181*
LFL	*m €*	*820*	*859*	*736*	*493*
CFL	*m €*	*643*	*675*	*357*	*123*
LED	*m €*	***275***	***523***	***1809***	***2439***
Light source NEW	m €	909	1128	1678	1935
Light source REPLACEMENT	m €	2328	2447	2262	1504

Industry revenue 2012 from light sources (million euros):

- McKinsey (derived) 3576
- Eurostat 2415 - 2865
- MELISA 5439

Only residential (not in table):

- McKinsey (derived) 1769
- MELISA 2268

Industry revenue conclusion:

- MELISA value (5439 mln euros) is much higher than value derived from McKinsey data (3576 mln euros)
- This is mainly due to differences in the non-residential sector
- Value reported by LightingEurope is less than the other sources because LE covers only part of market, but their value could be compatible with value derived from McKinsey.
- For MELISA, consider reducing the part of consumer price that is industry revenue (**stakeholders ?**)

Data derived from McKinsey (4), Light sources, units

EU-28 sales quantities for light sources/lamps/modules, as derived by the study team from McKinsey market value data and for two sets of assumed unit prices. Sum of all sectors, in million units.

Light Source unit price (€/unit)	High price set					Low price set			
	2011	**2012**	**2016**	**2020**		**2011**	**2012**	**2016**	**2020**
incandescent	0.28	0.28	0.31	0.33		0.21	0.21	0.24	0.25
halogen	1.00	1.03	0.98	0.83		0.88	0.91	0.86	0.73
HID	9.67	9.44	8.27	7.10		7.31	7.14	6.25	5.37
LFL	1.30	1.27	1.16	1.07		0.87	0.85	0.78	0.72
CFL	2.01	1.92	1.57	1.28		1.60	1.53	1.25	1.02
LED	**11.67**	**9.06**	**5.53**	**4.79**		**7.85**	**6.10**	**3.72**	**3.22**
Light Sources sold in EU-28 (million units / year)	**3351**	**3211**	**2045**	**1336**		**4431**	**4248**	**2749**	**1875**
incandescent	1789	1497	261	0		2377	1989	347	0
halogen	538	573	544	245		612	651	618	279
HID	48	54	51	25		63	71	68	34
LFL	633	678	634	460		943	1010	944	685
CFL	320	351	228	96		402	441	286	121
LED	**24**	**58**	**327**	**510**		**35**	**86**	**486**	**757**
Light sources NEW	*926*	*997*	*853*	*733*		*1223*	*1318*	*1144*	*1022*
Light sources REPLACEMENT	*2426*	*2214*	*1192*	*603*		*3208*	*2930*	*1605*	*853*

Sales quantities 2012 of light sources (million units):

- McKinsey (derived) 3211 - 4248
- Eurostat 2883 - 2937
- MELISA 1889

Sales quantity conclusion (2012):

- The MELISA total sales quantity is far less than the quantity derived from McKinsey data.
- The difference derives for a large part from GLS sales:
  - McKinsey (derived) 1497 - 1989
  - MELISA & Eurostat ≈300
- LightingEurope data for GLS are in line with MELISA and Eurostat data.

→ McKinsey (derived) sales quantities for GLS are much too high.

End of presentation of Task 2 report

Any questions or remarks on sales/stock ?

Task 3 presentation will follow:

Other data from MELISA and comparison with literature data
Compatibility between light sources and dimmers

Ecodesign Preparatory Study
Lot 8/9/19 Light Sources

1st Stakeholder Meeting

5 February 2015

USERS

(Task 3 report)

Leo Wierda

Van Holsteijn en Kemna

Vlaamse Instelling voor Technologisch Onderzoek

Task 3 report (Users), survey 1st part

MELISA continued:

EU-28 installed stock
Average lamp power → EU-28 total installed power

EU-28 installed stock
Average lamp lumen → EU-28 total installed lumen

Average lamp efficacy

EU-28 installed stock
Average lamp hours → EU-28 total operating hours

EU-28 total hours
Average lamp power → EU-28 total lighting energy

EU-28 lighting energy
Electricity costs → EU-28 total energy cost

Stakeholders are invited to provide constructive comments on this model.

At each step:

MELISA inputs
↔
Literature data

MELISA outcomes
↔
Literature data

Quantities/household
Quantities/m^2

Task 3, 2nd part:
Heat aspects of Lighting
Health aspects
End-of-Life aspects
Dimming

MELISA Power (1), Average lamp power

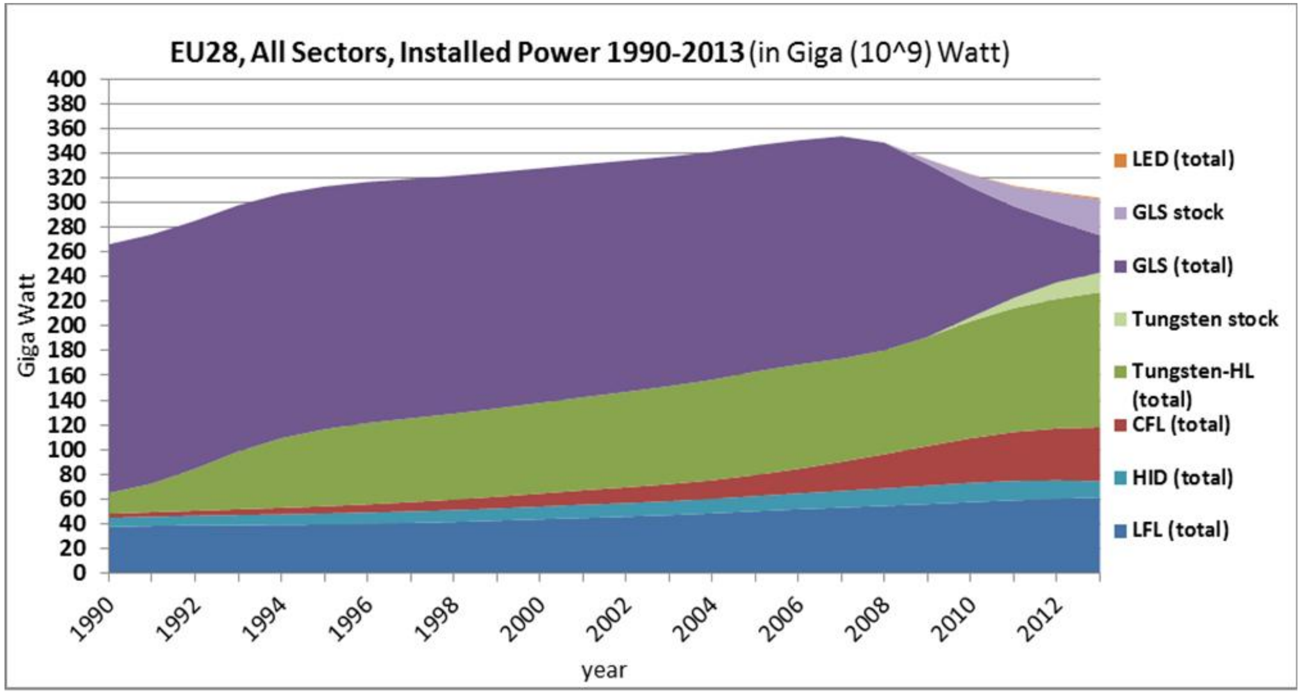
MELISA assumptions on average lamp powers, compared with CLASP 2013, VITO 2009, GfK/IEA 4E (2013)

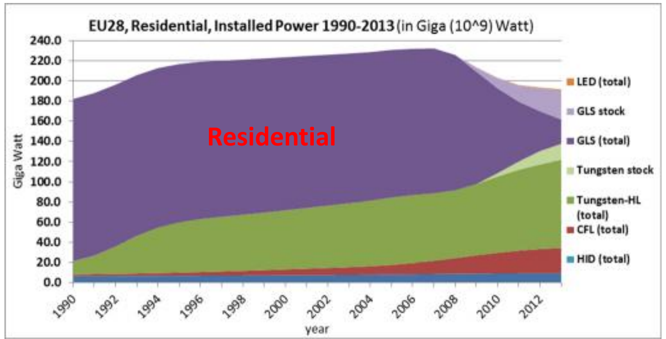
Average lamp power (W)	LFL					CFL		HL							GLS		HID		
For LEDs see later presentation sheet	T12	T8 halophosphor	T8 tri-phosphor	T5 new (14 - 80w) including circular	All others (including T5 old types 4 - 13w and special FL)	Retrofit - CFLi	Non-retrofit - CFLni	Single ended, mirrored (low voltage) [M16, M25 etc.]	Linear (high voltage) [R7s]	LV halogen Capsule [G4, GY6.35]	HV Halogen capsule [G9]	Mains halogen (substitute for GLS and reflector)[E14, E27]	Other mains halogen - PAR 16/20/ 25/30 hard glass reflectors, GU10 etc.	Reflector	GLS (including clear/pearl, candles, coloured & decorative)	All mercury lamps (including mixed)	All sodium lamps	Metal halide lamps
MELISA	**35**	**32**	**30**	**25**	**12**	**9.5**	**12**	**35**	**250**	**35**	**35**	**36**	**35**	**54**	**54**	**250**	**140**	**160**
CLASP 2013	35	32	28-30	25	12	13	9.5-11.5	35	100	35	52	52	52	60	60	250	120-140	150-225
VITO 2009						13		30	300	30	40	40	40	54	54			
GfK/IEA 4E 2013			*33-35*			≈14		≈35	200-240	≈35	38-40			40-45				

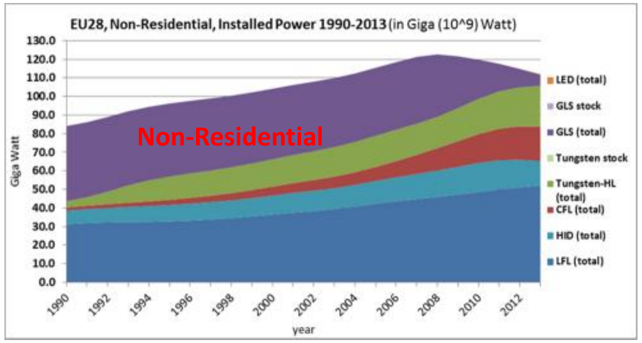
Main conclusions:

- MELISA CFLi power seems on the low side (Swedish measurements: 9.5W; implications for lumen!)
- MELISA HL R7s power seems slightly high (small influence)
- MELISA MV-HL power seems slightly low
- MELISA GLS power seems too high (phase out: (1) high powers phased out first (2) less relevant for future)

MELISA, Power (2), Total installed in EU-28







- Power 2007: peak of 354 GW
- Power 2013: down to 304 GW

In 2013:

- 63% of power installed in residential
- average 966 W/household
  (of which 521 W for halogen lamps)

- Residential power (2008 -> 2013):
  - **HL 30% -> 54%**
  - **GLS 60% -> 28%**
  - **CFL 7% -> 13%**
  - LED 0% -> 1%
  - LFL 4% -> 5%

- Non-residential power (2008 -> 2013):
  - **LFL 37% -> 47%**
  - **HL 14% -> 20%**
  - **CFL 10% -> 17%**
  - HID 12% -> 12%
  - **GLS 27% -> 5%**
  - LED 0% -> 0%

MELISA Power (3), Residential

Source	Number of lamps per household	Average installed lighting power per household (W)	Lighting power density for households (W/m²)
MELISA 2013	**33**	**966**	**11**
MELISA 2007	**28**	**1198**	
MELISA 2000	**23**	**1184**	
MELISA 1990	**21**	**1062**	
United Kingdom 2012	34	1362	24
Sweden 2009, houses	55	1618	13
apartments	31	829	11
REMODECE 2008 (12 countries)	26	1060	
IA 2009, data for 2007	19		
JRC, Bertoldi, 2006	22		
IEA, 2006 (7 countries)	10 - 40		6 - 16
France 2003	28	1578	15
EURECO 2002 (4 countries)	10 - 24	675 - 883	6 – 9
Delight, 1994-1997	24		
GPP Indoor Residential			9 - 11
Residential communal spaces			5 - 6
prEN15193, standard (15 lm/W)		920 - 1380	15 - 17
optimised (60 lm/W)		330 - 535	≈ 6

Comparison of installed powers for lighting in **residential buildings** between the MELISA model and various literature sources.

MELISA Residential 2013:

- 33 lamps / household
- 966 W installed / household
- Average 11 W/m²

Values seem reasonable considering comparison with literature sources

MELISA Power (4), Non-Residential

Source	Room/zone type	Lighting power density for non-residential buildings (W/m²)
MELISA 2013	**Average of all buildings**	**8.7**
EL-Tertiary project 2008 (3 values are 25%, 50%, 75% quartiles)	Offices (82)	6 – 13 – 21
	Conference rooms (20)	12 – 14 – 18
	Classrooms (40)	5 – 8 – 12
	Toilets, sanitary (40)	7 – 12 – 18
	Circulation areas (108)	4 – 7 – 13
	Service, tech, archives (42)	6 – 8 – 12
	Gymnasium, sports (14)	6 – 7 – 12
Office buildings (FR,2005) (average of 49 buildings)	Entire building, original	19
	After proposed improvements	10
Office building (FR,2005) (1 large building)	Corridors	15
	Offices (ceiling lamps)	13
	Entrance hall	7
	Conference rooms	32
	Offices (desk lamps)	5
IEA, 2006	commercial buildings	15-16
GPP Indoor	Various building types	7 - 14
prEN15193-2	Circulation areas	29 (existing), 8 (standard)
	Personal offices	35-43 (existing), 12-14 (efficient)
	Conference room	12 (efficient)
	Open floor office	27 (existing), 11 (efficient)
	Kitchen in non-residential building	33 (existing), 12 (efficient)
	Manufacturing hall	34 (existing), 7-13 (efficient)

Comparison of installed power densities (W/m^2) for lighting in **non-residential buildings** between the MELISA model and various literature sources.

MELISA Non-Residential 2013 (exclusive outdoor lighting):

- Average 8.7 W/m^2 installed power (on entire EU-28 heated building area)

Value seems reasonable considering comparison with literature sources

Large variability in data due to different building types, to different uses of the spaces, and to different degrees of lighting optimisation.
Further research in Lot37 study.

MELISA Lumen (1), Average lamp lumen

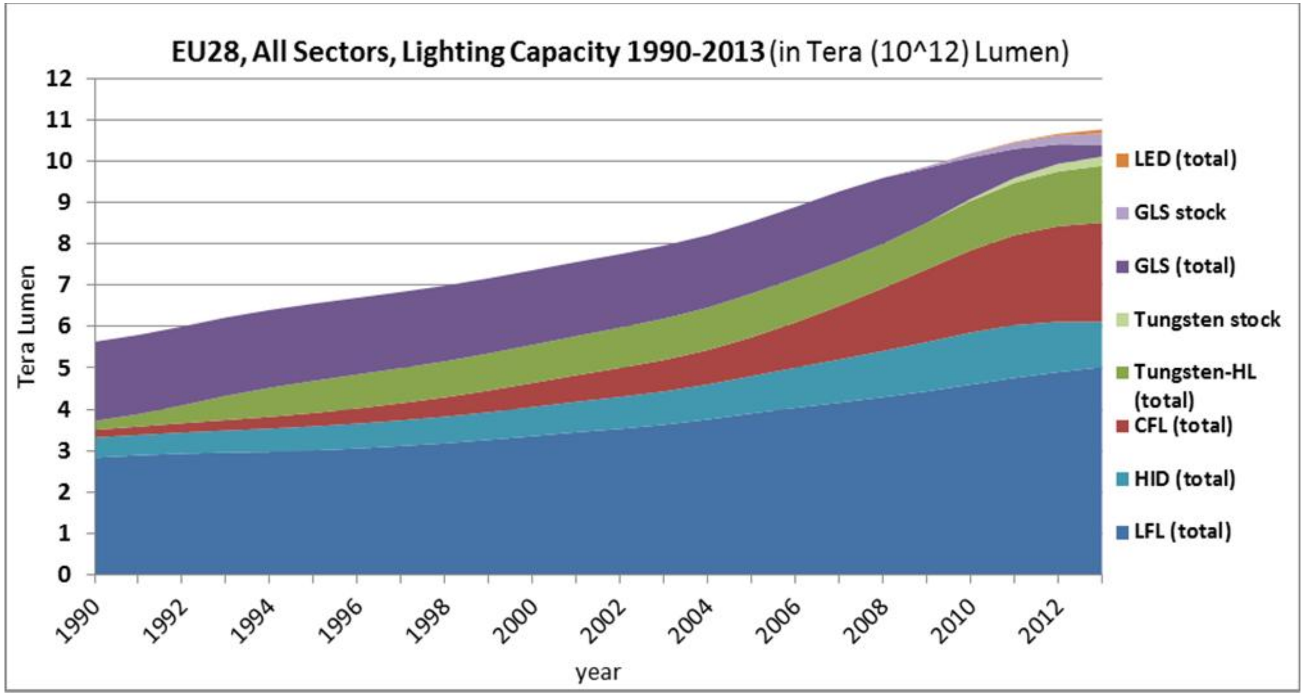
MELISA assumptions on average lamp lumens, compared with CLASP 2013, VITO 2009, GfK/IEA 4E (2013)

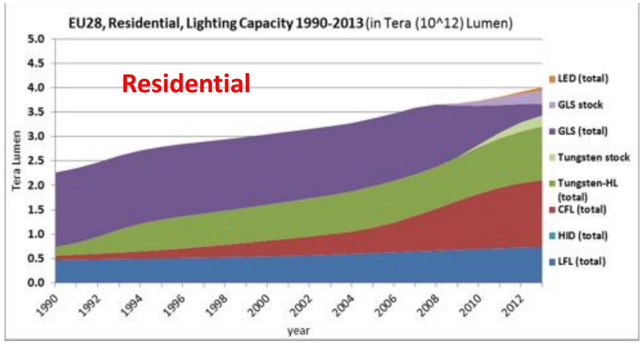
Average Flux (lm)	LFL					CFL		HL							GLS		HID		
For LEDs see later presentation sheet	T12	T8 halophosphor	T8 tri-phosphor	T5 new (14 - 80w) including circular	All others (including T5 old types 4 - 13w and special FL)	Retrofit - CFLi	Non-retrofit - CFLni	Single ended, mirrored (low voltage) [M16, M25 etc.]	Linear (high voltage) [R7s]	LV halogen Capsule [G4, GY6.35]	HV Halogen capsule [G9]	Mains halogen (substitute for GLS and reflector)[E14, E27]	Other mains halogen - PAR 16/20/25/30 hard glass reflectors, GU10 etc.	Reflector	GLS (including clear/pearl, candles, coloured & decorative)	All mercury lamps (including mixed)	All sodium lamps	Metal halide lamps
MELISA	**2450**	**2400**	**2400**	**2275**	**1032**	**523**	**633**	**490**	**3000**	**490**	**420**	**432**	**420**	**513**	**513**	**10000**	**13300**	**13120**
CLASP 2013	2450	2400	2352-2400	2275	1032		617-632									10000	13300	13500-14625
VITO 2009						559		392	5177	435	480 (DLS:315)			258	572-594			
GfK/IEA 2013 min-max			2200-3600			790-860		430-630	3800-4500	430-630	530-600			380-490				

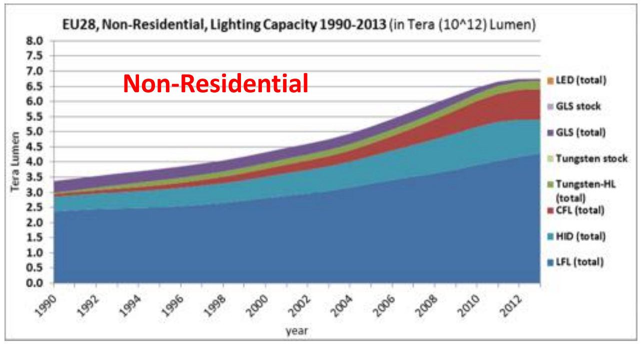
Main conclusions:

- MELISA CFLi lumen seems on the low side (power was also low; are 500 lm GLS replaced by 800 lm CFLi ?)
- MELISA HL R7s lumen seems low (power was slightly high -> efficacy difference, small impact)
- MELISA MV-HL lumen seems low (power was also slightly low; lower lumen lamps replaced by LEDs ?)
- MELISA GLS lumen seems slightly high (power was also slightly high)

MELISA, Lumen (2), Total in EU-28







- 1990: 5.6 Tlm; 2013: 10.8 Tlm
  (sun, zenith, clear, on same area: 3200 Tlm)

In 2013:

- 37% of lumen installed in residential
- average 20200 lm/household
  (7000 lm CFL, 6700 lm HL)

- Residential lumen (2008 -> 2013):
  - **CFL 24% -> 34%**
  - **HL 23% -> 33%**
  - LFL 18% -> 18%
  - **GLS 35% -> 13%** LED 0% -> 2%

- Non-residential lumen (2008 -> 2013):
  - LFL 61% -> 63%
  - HID 19% -> 16%
  - CFL 11% -> 15%
  - HL 4% -> 4%
  - GLS 5% -> 1% LED 0% -> 0%

Residential 190 lm/m²
Non-Residential 500 lm/m² see Lot37
(light source level, not task level)

MELISA Efficacy

MELISA assumptions on average lamp efficacy, compared with CLASP 2013, VITO 2009, GfK/IEA 4E (2013)

Average Efficacy (lm/W)	LFL					CFL		HL						GLS		HID		
For LEDs see later presentation sheet	T12	T8 halophosphor	T8 tri-phosphor	T5 new (14 - 80w) including circular	All others (including T5 old types 4 - 13w and special FL)	Retrofit - CFLi	Non-retrofit - CFLni	Single ended, mirrored (low voltage) [M16, M25 etc.]	Linear (high voltage) [R7s]	LV halogen Capsule [G4, GY6.35]	HV Halogen capsule [G9]	Mains halogen (substitute for GLS and reflector)[E14, E27]	Other mains halogen - PAR 16/20/ 2 5/30 hard glass reflectors, GU10 etc.	Reflector	GLS (including clear/pearl, candles, coloured & decorative)	All mercury lamps (including mixed)	All sodium lamps	Metal halide lamps
MELISA	**70**	**75**	**80**	**91**	**86**	**55**	**55**	**14**	**12**	**14**	**12**	**12**	**12**	**9.5**	**9.5**	**40**	**95**	**82**
CLASP 2013	70	75	80-84	91	86		55-65									40	95-110	65-90
VITO 2009						43		10	17	14	12			5	11			
GfK/IEA 4E 2013			77-80	*89-91*		60	*70-76*	17.8	18.9	17.8	14.2			10.7-11.5				

Main conclusions:

- MELISA CFLi efficacy seems on the low side
- MELISA HL R7s efficacy seems too low
- MELISA LV-HL efficacy seems too low; MV-HL seem slightly low
- MELISA GLS efficacy seems slightly low (less important for future scenarios)

MELISA, Power, Lumen, Efficacy of LEDs (1)

	Year	2009	2010	2011	2012	2013
LED General	**lm/W (for sales in year)**	25	30	40	60	**80**
	Watt @ 500 Lm	20.00	16.67	12.50	8.33	**6.25**
LED-NDLS Residential Use	**Lumen to Fit (NDLS)**	500	550	600	600	**600**
	lm/W (average for stock)	25	28	35	49	68
	Watt to Fit (avg. NDLS stock)	20.00	19.37	17.03	12.13	8.83
LED-NDLS Non-Residential Use (incl. LFL replacement)	**Lumen to Fit (NDLS)**	1800	1800	1800	1800	**1800**
	lm/W (average for stock)	25	30	40	49	76
	Watt to Fit (avg. NDLS stock)	72.00	60.00	45.00	36.38	23.58
LED- DLS Residential Use	**Lumen to Fit (DLS)**	600	600	600	600	**600**
	lm/W (average for stock)	25	28	35	47	63
	Watt to Fit (avg. DLS stock)	24.00	21.15	17.34	12.83	9.55
LED- DLS Non-Residential Use	**Lumen to Fit (DLS)**	600	600	600	600	**600**
	lm/W (average for stock)	25	30	40	53	74
	Watt to Fit (avg. DLS stock)	24.00	20.00	15.00	11.33	8.08

LEDs in MELISA for 2013:

- General for LEDs: 80 lm/W implies: 6.25 W for 500 lm lamp
- Basic principle: lumens of LED lamps should match the lumens of the lamps that they replace + some rebound ('Lumen-to-Fit').
  This gives different values for Residential and Non-Residential, for NDLS and DLS.
- Lumen-to-Fit / (80 lm/W) -> Watt-to-Fit
- **Efficacy changes with years** -> in a given year the average efficacy of the installed stock is smaller than the average efficacy of the lamps sold in the same year

MELISA, Power, Lumen, Efficacy of LEDs (2)

Derived by study team from GfK/IEA 4E data (**RESIDENTIAL**)

Retrofit LED Lamps	average estimated wattage (W)		Efficacy (lm/W)	average estimated lumen	
Countries AT, BE, FR, DE, UK, IT, NL	MAX	MIN		MAX	MIN
2007	1.7	1.2	37.2	62	45
2008	1.6	1.2	40.9	67	48
2009	1.8	1.3	45.5	82	58
2010	2.2	1.7	50.9	114	85
2011	3.2	2.5	57.4	184	141
2012	5.0	3.9	64.9	324	254
2013	**6.5**	**5.2**	**72.6**	**473**	**381**
Countries ES, PL					
2011	3.6	2.7	57.4	206	158
2012	4.3	3.3	63.7	274	212
2013	5.8	4.6	71.7	419	333

Dedicated LED Lamps	average estimated wattage (W)		Efficacy (lm/W)	average estimated lumen	
Countries AT, BE, FR, DE, UK, IT, NL	MAX	MIN		MAX	MIN
2007	1.6	1.1	46.3	73	52
2008	1.6	1.2	51.0	83	60
2009	1.8	1.3	56.9	105	76
2010	2.4	1.8	63.2	150	112
2011	2.9	2.2	70.6	207	156
2012	4.1	3.1	79.5	327	249
2013	**4.9**	**3.7**	**88.4**	**430**	**330**
Countries ES, PL					
2011	3.7	2.8	71.5	262	199
2012	3.9	3.0	78.9	311	238
2013	4.8	3.7	88.0	419	322

- Average LED power, efficacy, and thus lumen, are rapidly increasing each year
- Dedicated LED lamps (integrated LED luminaires) are more efficient than LED retrofit lamps. In 2013:
  - retrofit LED 73 lm/W
  - dedicated LED 88 lm/W

In MELISA Residential for 2013:

- 80 lm/W
  -> in agreement with GfK/IEA 4E
- 600 lm, 7.5 W (2013 sales)
  -> high compared to GfK/IEA 4E

-> LEDs are currently replacing the lower lumen HL and GLS, while for higher lumen people still buy HL ? Could explain why average lumen for sold HL is higher than expected.

MELISA, Operating Hours (1) Residential

Reference information from literature:

Residential Measurement campaign	Operating hours per year
United Kingdom 2012	394
Sweden 2009 houses apartments	515 567
REMODECE 2008 average 12 countries nordern countries southern countries France	 459 637-752 209-529 295
France 2003	224
EURECO 2002 3 countries (excl. PT)	 425 – 576

MELISA:

- HL and GLS: 450 h/a
- LFL and CFLi: 700 h/a
- LED: 500 h/a

- Average all types: 492 h/a (2013)

MELISA residential annual operating hours seem reasonable considering literature reference data.

MELISA, Operating Hours (2) Non-Residential

Reference information from literature:

Non-Residential Measurement campaign	Type of building or room/zone type	Operating hours per year
EL-Tertiary project 2008 (3 values are 25%, 50%, 75% quartiles)	Offices (60)	750 – 850 – 1080
	Conference rooms (16)	150 – 200 – 250
	Classrooms (20)	480 – 870 – 2000
	Toilets, sanitary (32)	150 – 280 - 600
	Circulation areas (80)	180 – 800 - 1370
	Service, tech, archives (42)	50 -80 -100
	Gymnasium, sports (11)	650 – 1350 - 1550
Supermarket (FR, 2001)	Entire building	3984
High-school (FR, 2003)	Entire building	1018
Office building (FR, 2005)	Entire building	2226
IEA 2006 (data 2000)	Commercial buildings	1781

Non-Residential Measurement campaign	Type of building or room/zone type	Operating hours per year
Office buildings (FR, 2005) (average of 49 buildings)	Single offices	1155
	Open offices	2513
	Floor lamps near desks	767
	Desk lamps	489
	Corridors	2740
	Stairs	1125
	Archives	1053
	Printing/copying rooms	1970
	Service rooms	1443
	Canteens/restaurants	1653
	Kitchen zones	538
	Conference rooms	530
	Sanitary, toilets	669-711
	Sanitary, washbasins	1084
	Entire building (average)	1383

MELISA:

HID: 4000 h/a
LFL: 2200 h/a
CFLni: 1600 h/a
CFLi: 500 h/a
HL, GLS: 450 h/a

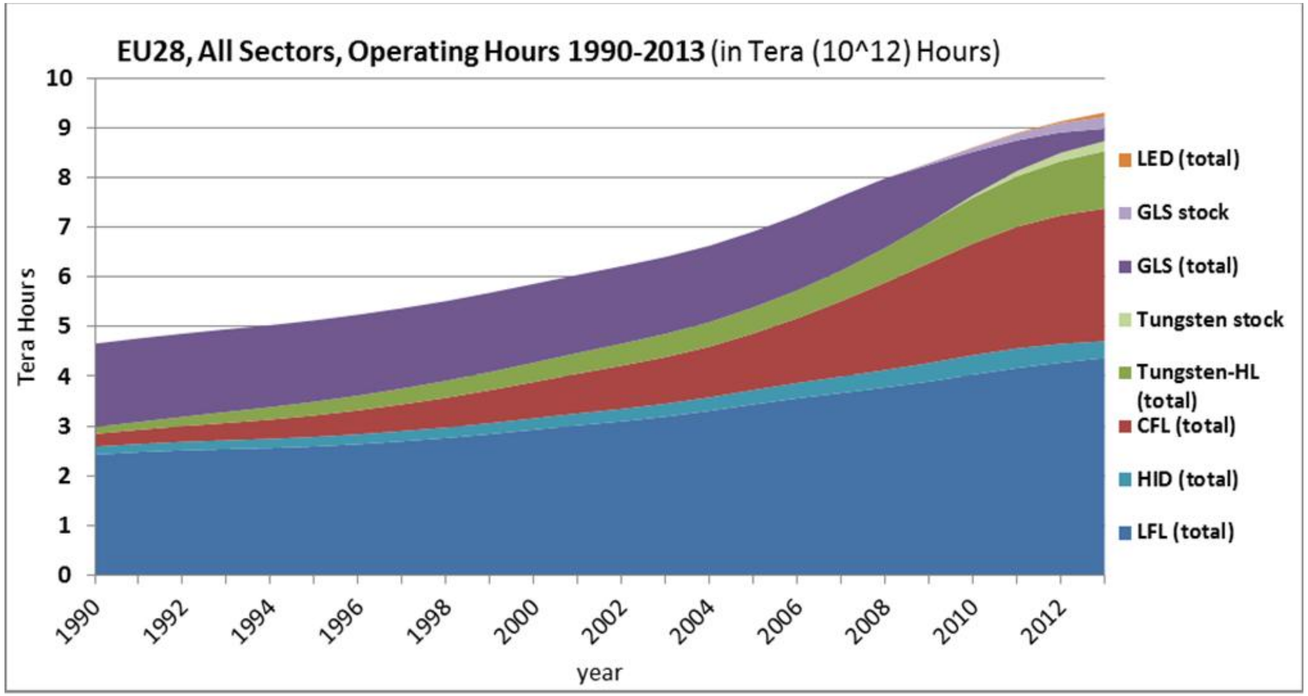
MELISA (2013):

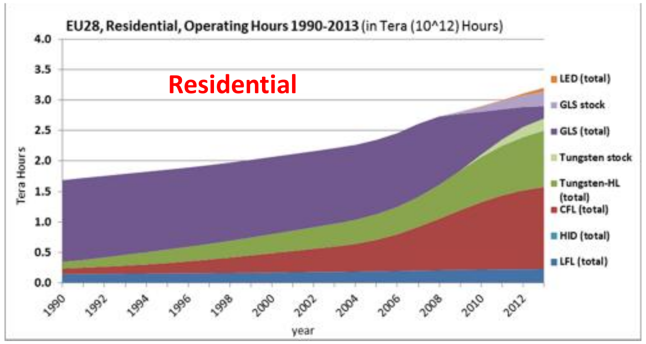
LED NDLS: 1500 h/a
LED DLS: 984 h/a

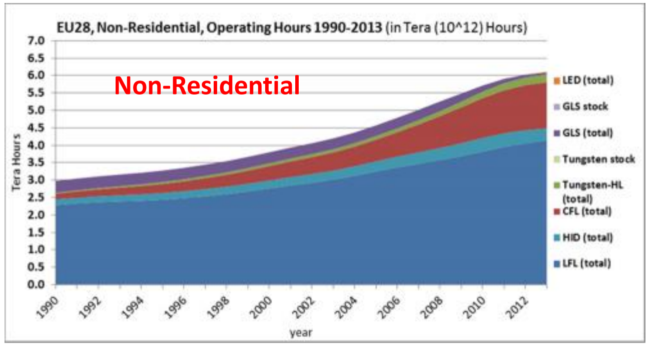
Average all types (2013): 1360 h/a

Difficult to judge if MELISA non-residential average annual operating hours (1360) are reasonable, but corresponds well to FR,2005 average of 49 office buildings (1383).

MELISA, Operating Hours (3), EU-28 totals







- 1990: 4.7 Th; 2013: 9.3 Th
  (9.3 TeraHours ≈ 1 billion years)

In 2013:

- 34% of hours made in residential
- average 44 lamp-hours/household/day
- average 1.3 hours/household lamp/day

- Residential hours (2008 -> 2013):
  - **CFL 31% -> 42%**
  - **HL 20% -> 35%**
  - LFL 8% -> 7%
  - **GLS 41% -> 14%** LED 0% -> 2%

- Non-residential hours (2008 -> 2013):
  - LFL 68% -> 68%
  - CFL 17% -> 22%
  - HID 7% -> 6%
  - HL 3% -> 4%
  - GLS 5% -> 1% LED 0% -> 0%

MELISA hours are Full-Power Equivalent Hours

End of MELISA, Power, Lumen, Efficacy, Hours

Any questions or remarks on this part ?

Next topics of 1st part of Task3:

MELISA, Lighting energy consumption
Lighting energy cost

MELISA, Energy Consumption (1)

For non-special lamps (as presented so far):

$$\text{Energy} = \frac{\text{Total Hours} * \text{Average Power}}{\text{Control gear efficiency}}$$

Control gear efficiency:

- 80% (T12, T8 halophosphor)
- 83% (T5old, other LFL, HID)
- 91% (T8 triphosphor, T5, CFLni, LED)
- 94% (HL-LV)
- 100% (HL-MV, GLS, CFLi)

\+

Energy of Special Purpose Lamps:

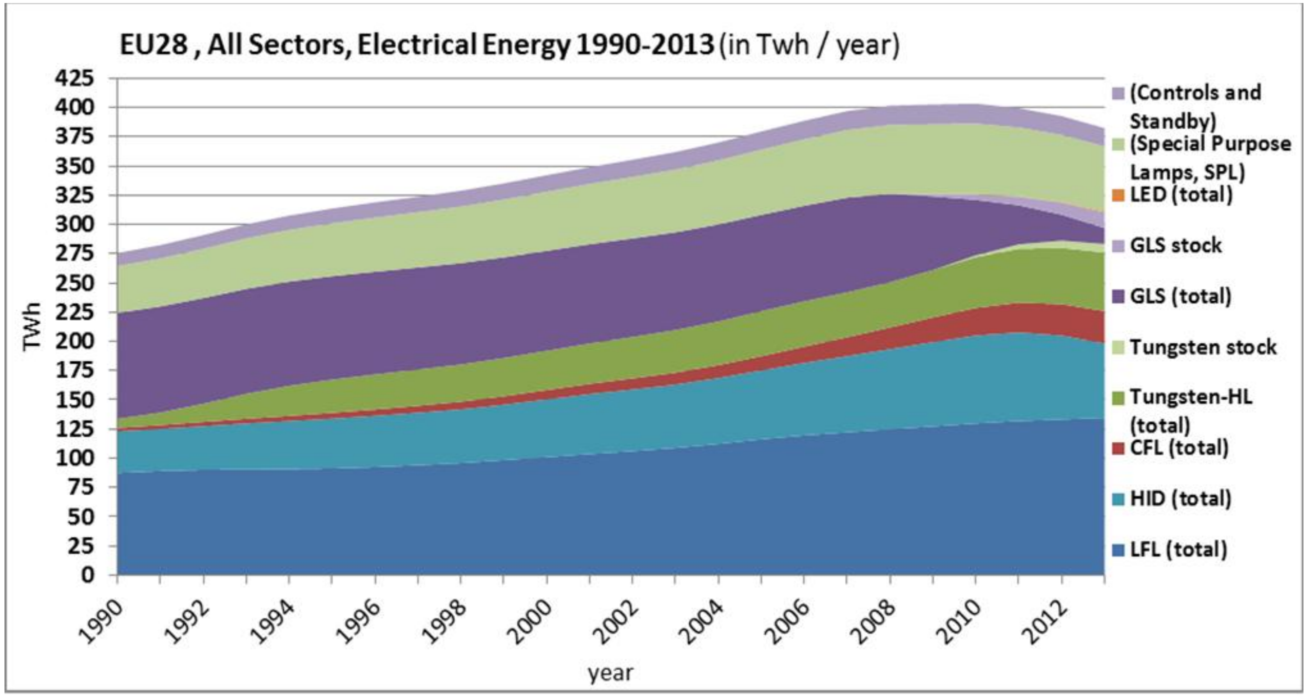
- as presented in Task 1 report (Scope)
- without automotive and backlighting
- estimated 56 TWh in 2013

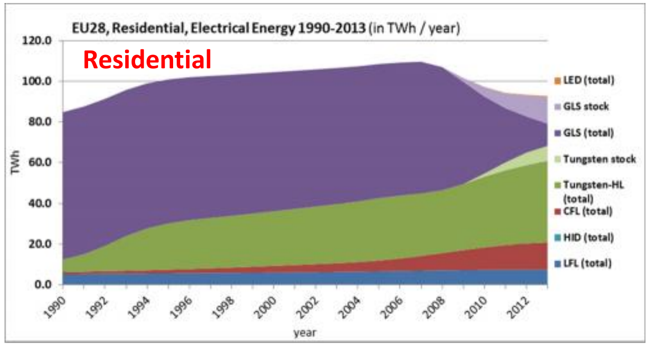
Energy of Controls and Standby:

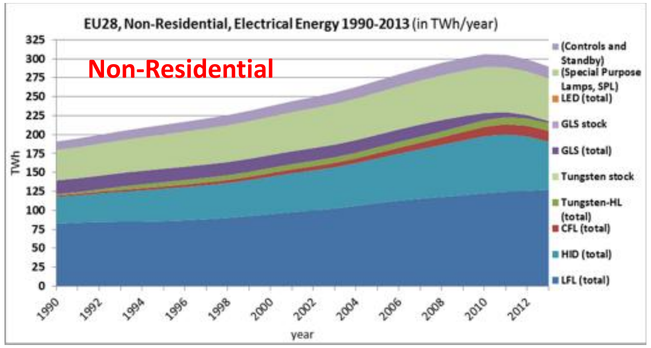
- preliminary rough estimate
- to be detailed in Lot 37 study
- estimated 16 TWh in 2013

Note: average lamp power does NOT include control gear power, unless integrated in lamp (CFLi)

MELISA, Energy Consumption (2)







1990: 276 TWh (225 excl. SPL, Control & SB)
2010: 403 TWh (328 excl. SPL, Control & SB)
2013: 383 TWh (322 excl. SPL, Control & SB)

In 2013:

- 24% of energy used in residential
- average 467 kWh/household/year
  (240 kWh for HL; 120 kWh for GLS)

- Residential energy (2008 -> 2013):
  - **HL 29% -> 51%**
  - **GLS 57% -> 26%**
  - **CFL 8% -> 14%**
  - LFL 7% -> 8% LED 0% -> 1%

- Non-residential energy (excl. SPL, Control & SB) (2008 -> 2013):
  - LFL 54% -> 58%
  - HID 31% -> 29%
  - CFL 5% -> 7%
  - HL 4% -> 5%
  - GLS 7% -> 1% LED 0% -> 0%

MELISA, Energy Consumption (3), Residential

Reference information from literature:

Source	Annual energy consumption for lighting per household (kWh/hh/year)	Lighting energy density for households (kWh/m^2)
MELISA 2013	**467**	**4.3**
MELISA 2007	**565**	
MELISA 2000	**553**	
MELISA 1990	**494**	
United Kingdom 2012	537	10
The Netherlands 2011	464	
Sweden 2009, houses apartments	646-937 240-691	6.7
REMODECE 2008 (12 countries)	487	
JRC, Bertoldi, 2006 (EU-28)	498	
IEA, 2006 (7 countries)	375-775	3.3-9.3
France 2003	354	3.7
EURECO 2002 (4 countries)	375-426	3.3-4.0
France 2000, CIEL	500	
Delight, 1994-1997 (19 countries)	569	3.4-12.1

Comparison of energy consumption for lighting in **residential buildings** between the MELISA model and various literature sources.

MELISA Residential 2013:

- 467 kWh/household/year
- 966 W installed / household
- Average 4.3 kWh/m^2
  (on entire EU-28 heated residential area)

Values seem reasonable considering comparison with literature sources

MELISA, Energy Consumption (4), Non-Residential

Reference information from literature:

Source	Building type or Room/zone type	Lighting energy density (kWh/m²/year)
EL-Tertiary project 2008 (buildings: 2 values are median – average) (rooms: 3 values are 25%, 50%, 75% quartiles)	Office buildings (10)	21 - 25
	School buildings (11)	5 - 10
	Hotel buildings (4)	28
	Offices (82)	7 – 20 – 30
	Conference rooms (20)	3 – 6 – 9
	Classrooms (40)	0 – 4 – 12
	Toilets, sanitary (40)	1 – 5 – 25
	Circulation areas (108)	4 – 13 – 22
	Service, tech, archives (42)	1 – 2 – 7
	Gymnasium, sports (14)	1 – 5 – 15
Office buildings (49) (FR, 2005)	Average of 49 buildings Original -> Optimised	26.7 -> 17.6
Office building (1) (FR,2005)	Entire building (1) Original -> Optimised	28.1 -> 6
IEA, 2006	commercial buildings	27.7
Recent office building (FR,2009)	Entire building (1) Original -> Optimised	6.2 -> 3.9

Source	Building type or Room/zone type	Lighting energy density (kWh/m²/year)
IWU (Germany 2014)	93 non-residential buildings	23 (average), 15 (median)
	10 public buildings	13 (average), 7 – 24 (range)
	140 offices (single & open)	19
	50 class rooms	15
	13 hotel rooms	12
	128 circulation areas	11
prEN15193-2	Circulation areas	26 (existing), 4.3-6.8 (standard)
	Personal offices	31-39 (existing), 6-13 (efficient)
	Conference room	10-15 (efficient)
	Open floor office	58 (existing), 19-23 (efficient)
	Kitchen in non-residential building	68 (existing), 19-24 (efficient)
	Manufacturing hall, with roof lights without roof lights	8.5 (existing), 1.8-3.3 (efficient) 132 (existing), 27-51 (efficient)

Comparison of energy consumption for lighting in **non-residential buildings** between the MELISA model and various literature sources.

MELISA Non-Residential 2013:
Average **13.4 kWh/m²** (LENI)
(on entire EU-28 heated non-residential area)
(not considering Outdoor, SPL, Controls, SB)

Large variability in reference values: difficult to judge if MELISA values are reasonable

MELISA, Lighting Energy Cost (1)

Cost of electricity:

Residential prices of electricity (fixed euros 2010), in euros/kWh, incl. VAT									
1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
0.178	**0.188**	**0.195**	**0.188**	**0.188**	**0.181**	**0.176**	**0.173**	**0.168**	**0.163**
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0.162	**0.158**	**0.156**	**0.155**	**0.153**	**0.153**	**0.158**	**0.167**	**0.169**	**0.167**
2010	2011	2012	2013						
0.170	**0.177**	**0.184**	**0.191**						

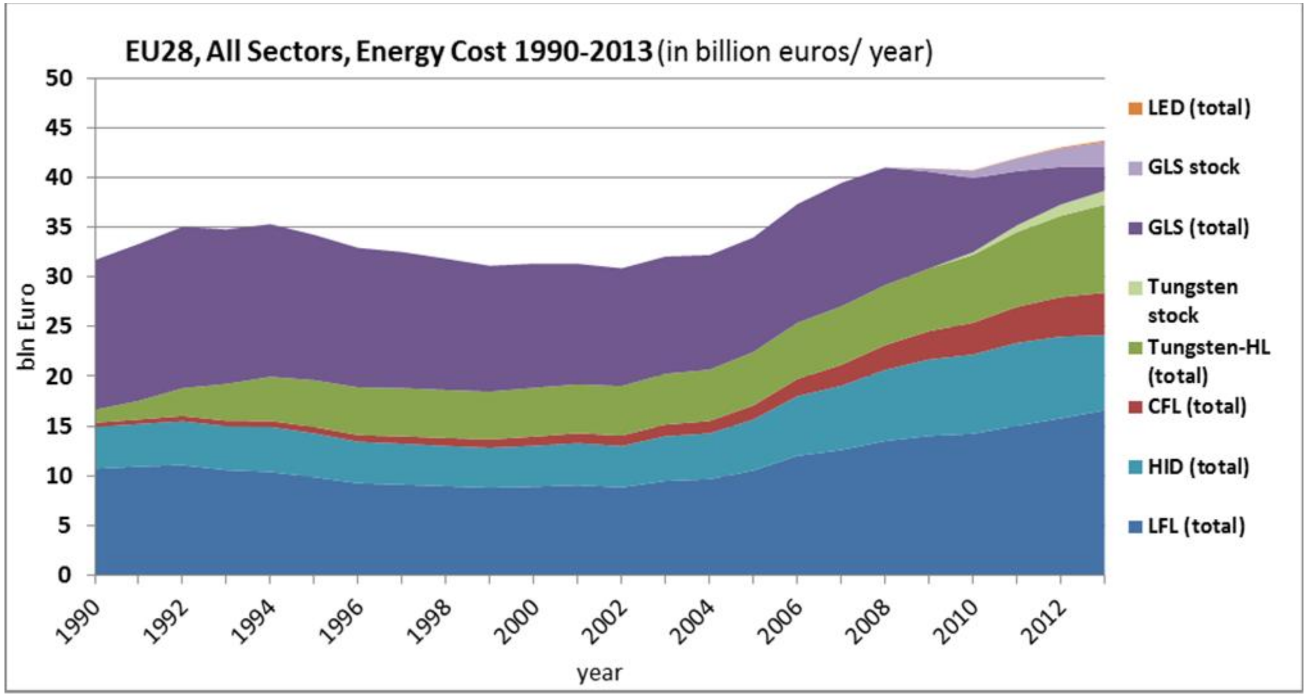
For residential these prices are based on Eurostat tariff group Dc: “annual consumption of 3 500 kWh among which 1 300 kWh overnight (standard dwelling of 90m²)”.

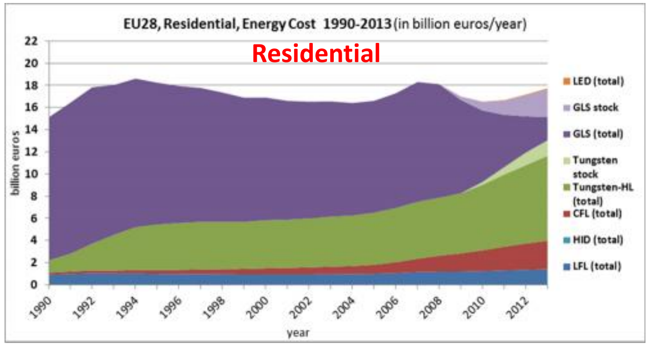
Non-residential prices of electricity (fixed euros 2010), in euros/kWh, excl. VAT									
1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
0.119	**0.119**	**0.118**	**0.112**	**0.110**	**0.103**	**0.095**	**0.092**	**0.088**	**0.085**
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0.084	**0.083**	**0.079**	**0.083**	**0.082**	**0.087**	**0.097**	**0.099**	**0.105**	**0.107**
2010	2011	2012	2013						
0.106	**0.110**	**0.115**	**0.119**						

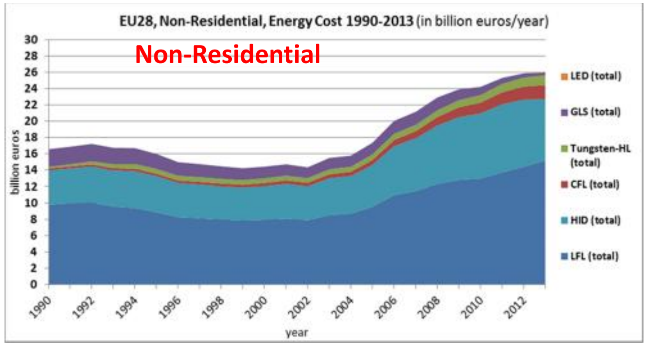
For non-residential the reference was tariff group Ie: “annual consumption of 2 000 MWh, maximum demand of 500kW and annual load of 4 000 hours”.

These tariff group definitions are according to the old (2007) methodology.

MELISA, Lighting Energy Cost (2)







1990: 32 billion euros
2013: 44 billion euros (0.33% of EU-28 GDP)
(excl. SPL, Control & SB)

In 2013:

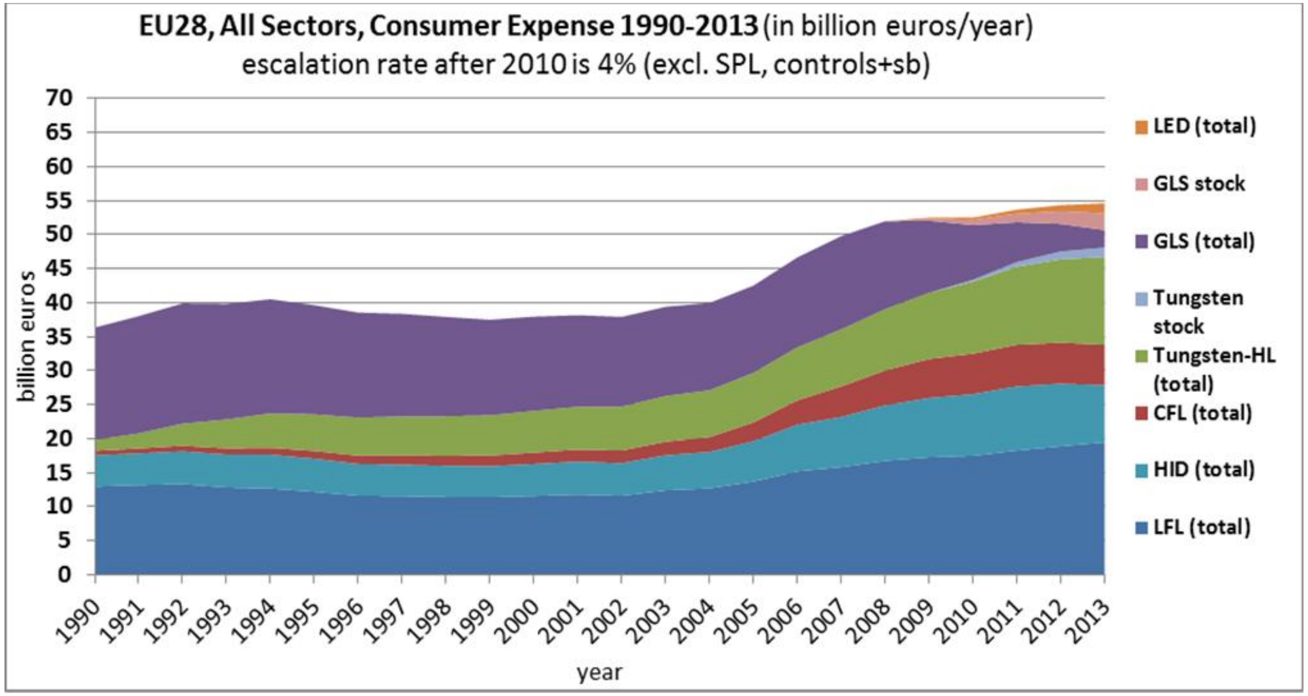
- 40% of expenses made for residential
- average 89.3 euros/household/year

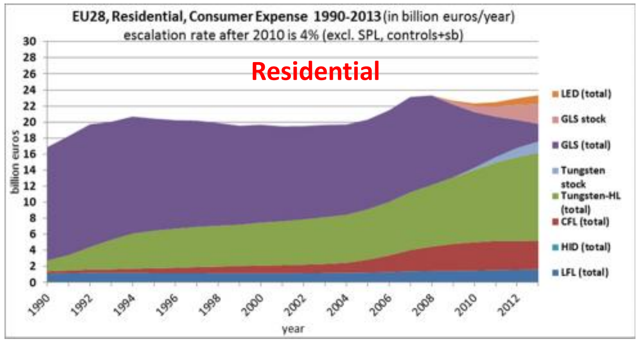
- Residential energy cost (2008 -> 2013):
  - HL 29% -> 51%
  - GLS 57% -> 26%
  - CFL 8% -> 14%
  - LFL 7% -> 8% LED 0% -> 1%

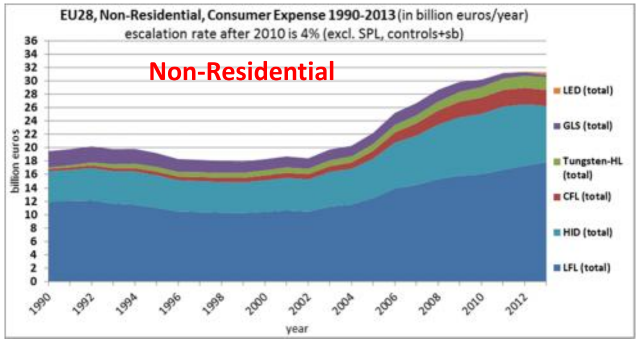
- Non-residential energy cost (excl. SPL, Control & SB) (2008 -> 2013):
  - LFL 54% -> 58%
  - HID 31% -> 29%
  - CFL 5% -> 7%
  - HL 4% -> 5%
  - GLS 7% -> 1% LED 0% -> 0%

Residential: almost constant since 1992
Non-residential: increase after 2004

MELISA, Total Consumer Expense







Light source Acquisition + Energy cost

1990: 36 billion euros (5 acq + 32 nrg)
2013: 55 billion euros (11 acq + 44 nrg)
(excl. SPL, Control & SB)

In 2013:

- 43% of expenses made for residential
- average 117.6 euros/household/year

- Residential expense (2008 -> 2013):
  - **HL 33% -> 53%**
  - **GLS 48% -> 20%**
  - CFL 13% -> 15%
  - LFL 6% -> 7% **LED 0% -> 5%**

- Non-residential expense (excl. SPL, Control & SB) (2008 -> 2013):
  - LFL 54% -> 57%
  - HID 28% -> 27%
  - CFL 7% -> 8%
  - HL 5% -> 6%
  - GLS 6% -> 1% LED 0% -> 1%

MELISA, Additional verification

Non-residential buildings: different method to estimate Power, Lumen, Hours and Energy

(work performed in the context of the Lot37 study; NOT in Task 3 report)

- Report Building Heat Demand (VHK,2014) -> EU-28 heated floor area per type of non-residential building
- Building areas further subdivided per room/activity types (circulation areas, offices, toilets, ….)

- Multiplied these areas with corresponding lighting requirement (lux) from EN-12464-1 (indoor lighting)
  -> 3648 Glm at task level
  MELISA: 5660 Glm at lamp level (implied average utilization factor of 64% **could be reasonable**)

- Multiplied Glm at task level with Pjlx (W/task-lm) values from prEN-15193 (lighting in buildings) (assumptions on average room index, upward flux fraction, mix of lamp types, MF=0.8, reflections)
  -> 111 GW installed power
  MELISA: 106 GW installed power (surprisingly **close match**)

- From prEN-15193: Default Potential Operating Hours + estimate of daylight factors + occupancy dependent factors -> 2200 - 2500 hours (full-power equivalent)
  MELISA: 1467 hours (**are EN-15193 hours too high or MELISA hours too low ??**)

Main uncertainty: non-residential operating hours

MELISA, Conclusions

- MELISA input parameters have been verified against data from literature.
  In general the input parameters seem reasonable, even if adjustments could be made on some points.

- MELISA outcomes for the residential sector are compatible with data from literature.

- MELISA outcomes for the non-residential sector seem reasonable as regards installed power and installed lighting capacity (lumen).

- Largest uncertainty are operating hours for the non-residential sector (and consequently energy).

- The study team explicitly invites the stakeholders to comment on the MELISA model.

- Following the presented data and the comments from stakeholders the MELISA model will be adjusted before its use in the scenario analyses of MEErP Task 7.

Any questions or remarks on this part ?

Task 3 report (Users), survey 2nd part

Heat aspects of lighting

Health aspects

End-of-Life aspects

Dimming

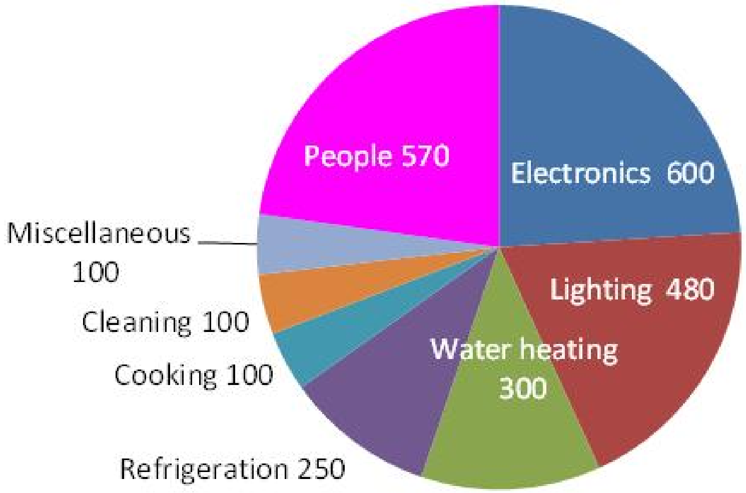
Heat aspects of Lighting products

- Light sources emit heat as a by-product → energy-related products for HVAC equipment
  (heat produced by lighting must be taken into account when dimensioning such equipment).

- Energy efficient light sources use less power → emit less heat → impact on HVAC dimensioning.

- *"Internal gain is the space heating contribution of people, pets and energy-using products in the household"*.

Internal gain in heating season EU 2010
In kWh per residential dwelling, total 2500 kWh



- Total internal heat gain → +2.3 °C on household temperature.

- Lighting contributes for ≈20% to the 'internal heat gain' (2010)

- If for example 50% decrease in lighting energy use
  → ≈10% on 'internal heat gain'
  → ≈ 0.23˚ C deficit in temperature, to compensate by heating

Source: Building Heat Demand report, VHK 2014

Health aspects

- Statements of Stage 6 review report (SCENHIR and SCHER reports) still valid.

- September 2014, IEA 4E report on health aspects of Solid State Lighting (i.e. LEDs):
  - Electrical safety appropriately addressed by existing safety standards.
  - Human exposure to electromagnetic fields emitted by SSL products is not a critical issue.
  - Glare can be a critical issue; recommended to report maximum luminance for finished SSL products.
  - Recommendation: perform a photobiological safety assessment for all SSL devices according to the existing standards.
    - Manufacturers to report the risk group for their product.
    - Use warning labels in certain cases (make general public iaware of potential risks).
    - IEC 62471 to take into account the sensitivity of certain specific population groups.
  - Particular attention asked for white LEDs based on violet and UV chips: potential for blue light/UV hazard.
  - Unacceptable that there are no clear requirements to limit light flickering.
  - SSL products do not have more negative non-visual effects than other light sources.
    However, LED technology → more lighting points → increase in exposure to artificial light.

End-of-Life aspects (1)

- Discharge lamps, LEDs, and non-household luminaires covered by **Waste Electrical and Electronic Equipment (WEEE) Directive 2012/19/EU** -> have to be collected separately.

- Excluded from the WEEE directive: GLS, HL, household luminaires -> general waste stream.

- Main concern at end-of-life: avoid mercury contained in FL- and HID-lamps is released to environment.

- Responsibility for handling of WEEE: producers.
  - Producers finance the collection and treatment of their WEEE.
  - Producers will shift payments to the consumers ('polluter pays'). No cost for tax payer.

- Cost of collection and recycling of lamps is 25-100% of the cost price of a lamp.
  Other WEEE product categories: only a few per cent of the cost price or even a positive value
  The average collection and recycling fee is 0.14 euros/lamp
  (source: Philips).

- In 2003, European lamp manufacturers decided to found not-for-profit Collection & Recycling Service Organizations (CRSO's). Now present in 22 EU member-states. Market share of 75-95%.

End-of-Life aspects (2)

- Eurostat publishes data on WEEE collection and recycling. Data present gaps: use with caution.
  As regards lighting:
  - lighting equipment (all except discharge lamps)
  - discharge lamps.

- Discharge lamps:
  - Fraction recycled or re-used is close to the target of 80% (of the collected items)
  - Fraction collected is around 30%
  - No significant change from 2008 to 2012.
  - Main problem in waste management of discharge lamps seems to be the collection phase.

Heating, Health, End-of-Life

Any questions or remarks ?

Next topic (last): Dimming

Dimming, survey

Relevance in this study: compatibility between light sources and dimmers (other controls)
Important to understand some of the backgrounds of the problems (Task 3 report).

Importance of dimming and current problems
Dimming between Control Gear and LED (PWM, CCR)
Dimming between Dimmer and Control Gear (phase-cut, 0-10V, wireless)
Power supply for dimmers (2-wire, 3-wire case)
How many dimmers in EU-28 will have problems?
Dimming curves: what is 'dimmable' ?
Ongoing standardization work

Dimming (1)

- Future lighting energy savings expected from: 1- Use of energy efficient light sources: LEDs
  2- Daylight dependent and occupancy dependent dimming

- However, **there are still problems related to dimming of LEDs**.
  → potential to disturb market introduction of LEDs
  → potential to slow down the use of LEDs in controlled lighting systems
  → potential to disturb the further introduction of dimming

- Now: main problem is the compatibility of LED lighting products with existing control components (dimmers).
  - already installed
  - designed to operate on other types of lamps (incandescent, halogen, fluorescent, HID)
  - those lamps have completely different electrical characteristics than LEDs.

  → characteristics of existing dimmers are a given fact (even if often not well known…..)
  → design dimmable LED control gears accordingly to guarantee compatibility (as far as possible…..).

- Future issue: guarantee that any new LED and any new control will operate satisfactorily together.
  Development of standards ongoing.
  Requirements prescribed both for LED control gears and for the dimmers (or other control components).

Dimming (2)

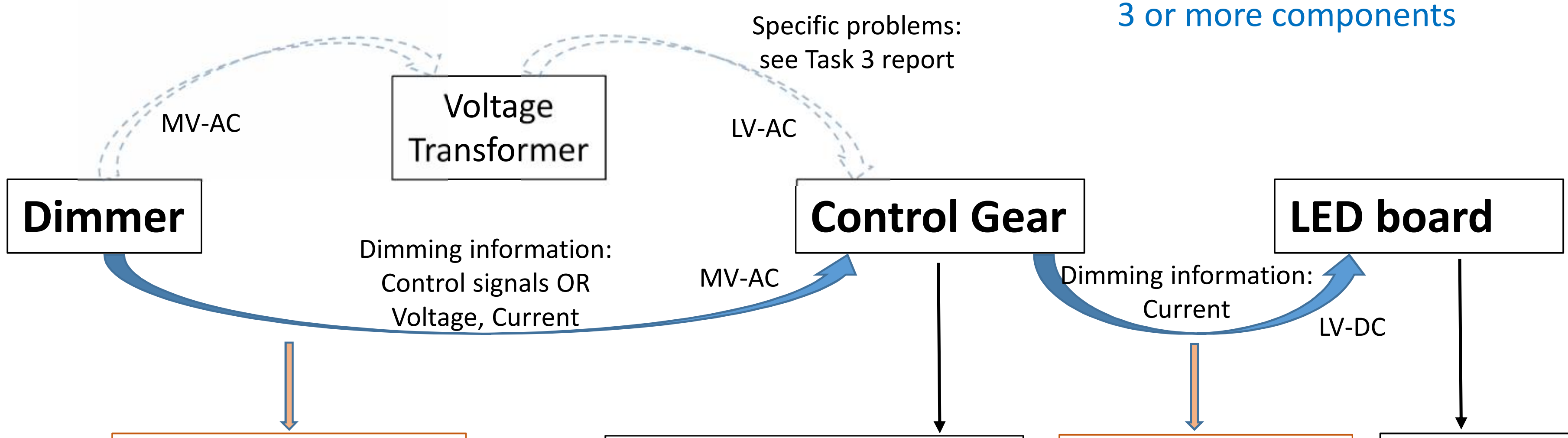
Problems encountered with dimming:

- Flicker (on/off of lamps, at a frequency that is perceived by the consumer).
- Shimmer (variations in light intensity, at a frequency that is perceived by the consumer).
- Stroboscopic effects (when objects are moving fast with respect to the light source).
- Dead travel (changes in dimmer position do not lead to perceived changes in light intensity).
- Pop-on (raising the dimmer from the off-position, the light suddenly pops on at an unexpected high intensity).
- Popcorn (different lamps on same dimmer will pop-on at different dimming levels)
- Drop-out (lowering the dimmer, light suddenly shuts off while consumer expected further intensity decrease, impossible to reach low dimming levels).
- Colour change when dimming (this may be desirable or undesirable).
- Non-linear dimming curve (the (perceived) light intensity does not vary linearly with the dimmer position; this may be desirable or undesirable).
- Reduced light intensity at maximum dimmer setting (the consumer does not want to dim, but the emitted light is (far) less than the rated maximum output of the light source).
- Noise, buzzing (from the dimmer, the control gear or the lamp itself)
- Ghosting (the lamp continues to glow in the off-position)
- Reduced lifetime or abrupt failure of one of the system components (dimmer, control gear or LED-module).
- Higher energy consumption than expected (low efficiency when lights are on, and/or high standby consumption).

Dimming (3)

Components involved in dimming:

Dimming results from the cooperation of 3 or more components



Acting on power supply:
Phase-cut dimming
(2-wire, 3-wire)

Emitting control signals:
0-10 V dimming
4 wire digital control
wireless control

The Control gear determines if a LED lamp is dimmable at all, and down to which level (specifically designed).

Constant voltage gears
(10 V, 12 V, 24 V)
OR
Constant current gears
(350 mA, 700 mA, 1050 mA)

Pulse Width Modulation (PWM)

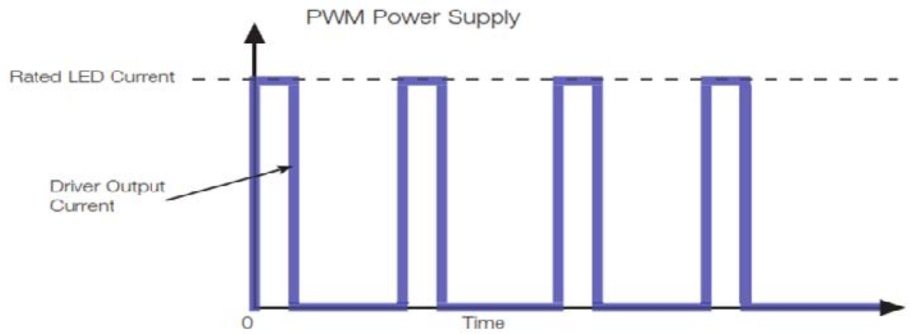
Constant Current Reduction (CCR)

Unlike filament lamps that have some thermal inertia, LEDs react very quickly to presence / absence of current
-> prone to flicker

Light up only when current in correct direction -> DC

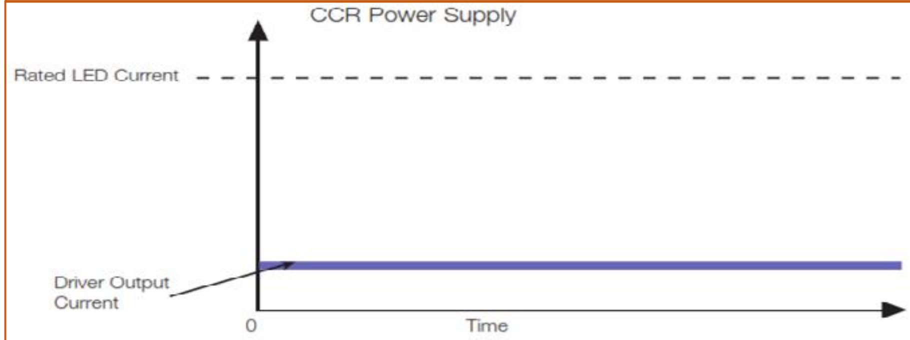
Dimming (4)

Pulse Width Modulation (PWM)	Constant Current Reduction (CCR)



Maintains current level, switches on/off
Ratio on/off -> % dimming

- High frequency required (otherwise flicker)
  -> high cost when need for low dimming levels
- Risk stroboscopic effect when fast moving objects
- More precise, down to 1% (importance for colour mix)
- Higher EMI risk due to up/down currents
- May have difficulties in presence of long wires
- No change in current level -> constant light colour
- Both for constant voltage or constant current drivers
- More widely used (at least in USA; in Europe ?)



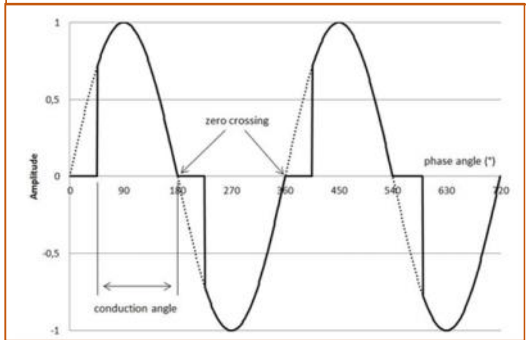
Reduces current level, constant in time
Current level -> % dimming

- Less risk of flicker
- Potentially cheaper
- Suitable in fast moving environments
- Less precise, dimming level down to 10%
- Suitable for EMI-sensitive environments
- Suitable also when long wires gear-to-board
- Changes current level -> change in CCT (desired ?)
- Only for constant current drivers
- More efficient (?) (contrasting information)

Dimming (5)

Dimmer → **Control Gear** ⇢ LED board

Phase-cut, Leading-edge (LE)
Forward phase-, TRIAC- , SCR- , Incandescent dimming

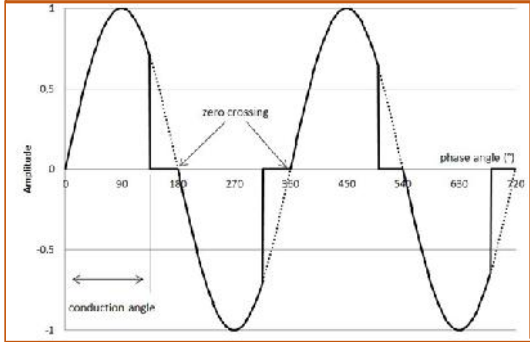


Does NOT transmit part of sine-wave **AFTER** zero crossing.
Average voltage transmitted varied by conduction angle
-> dimming level

Originally developed for filament lamps (resistive load).
Later for lamps with magnetic low voltage transformer (resistive/inductive loads).
Now some specifically designed to operate LED lamps.

- Cheapest type of phase-cut dimmer
- Installed base in Europe 60% (of phase-cut dimmers)
- Even more widespread in USA

Phase-cut, Trailing-edge (TE)
Reverse phase dimming, ELV dimming



Does NOT transmit part of sine-wave **BEFORE** zero crossing.
Average voltage transmitted varied by conduction angle
-> dimming level

Originally developed for lamps with electronic low voltage (ELV) transformer (capacitive loads).

Most LED control gears use ELV-type transformer.

- More expensive than LE-dimmers
- Installed base in Europe 30% (Germany, Scandinavia)
- Better control to lower dimming levels than LE
- Longer lifetime, less noisy than LE

Dimming (6)

Other types of dimmers:

- Universal dimmers: capable both of LE phase cut dimming and TE phase cut dimming. Manual or automatic choice between LE and TE operation. Installed base in Europe ≈ 10% of phase-cut dimmers. More expensive.

- Sine-wave dimmers: instead of cutting away part of the sine, reduce the amplitude of the sine.

- 0-10 V analogue control dimming: Power supply is switched (on/off) by the dimmer, but not 'dimmed'. Instead, the dimmer sends low-voltage signals to the control gear, varying from 0 V (off), 1 V (minimum light) to 10 V (maximum light) that have to be translated by the control gear in an associated dimming level. This implies a total of 4 wires arriving at the control gear (2 MV power, 2 LV control). Widespread especially in non-residential applications. 0-10 V systems should work with LED retrofit lamps that have drivers able to interpret these signals. This type of dimming control is defined in IEC standard 60929 Annex E. May have problems if wires are long.

- 4-wire digital control dimming: Dimmer and Control Gear (and other control components) exchange digital signals over the low voltage wires. Increased functionality (also colour control, moveable fixtures, individual addressing). Bi-directional signals: feedback from control gear to dimmer. Communication protocols: DMX, DALI (IEC 62386). Expensive and specific installer and operator knowledge required -> mainly in non-residential applications.

Dimming (7)

Other types of dimmers (continued):

- <u>Wireless control dimming</u>:

  - Wireless Radio Frequency (RF) technology is increasingly used for the control of LED lighting products.

  - The LED lamps themselves can have built-in RF receivers/transmitters (**smart lamps**).
  - Alternatively: implement RF transceivers in separate interface devices, using one of the other technologies (phase-cut dimming, analogue 0-10 V signals, digital signals) to control the dimming of LED lamps.

  - Several RF communication protocols, not compatible with each other → requiring special interfaces, bridges or gateways to function together.

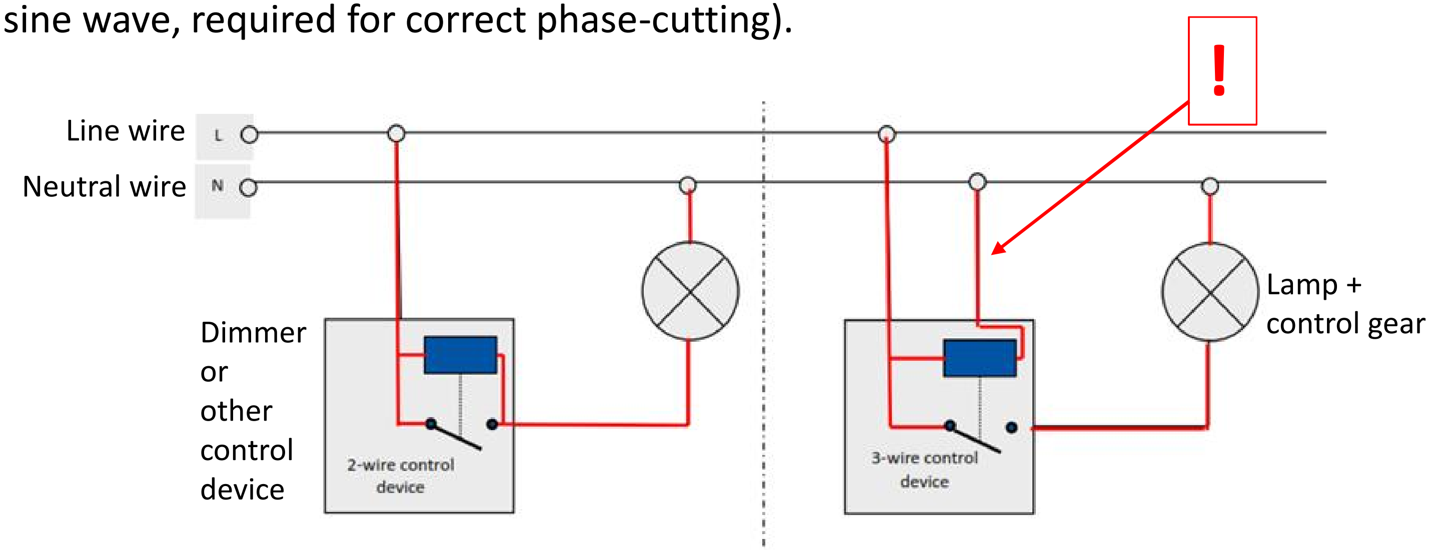
  - RF used for lighting control may interfere with RF for other applications (e.g. WiFi, Bluetooth). While this is 'just' annoying for some applications as mobile phones, the reliability of lighting control can be essential, considering that light can be a life safety system.

Dimming (8), Power supply for phase-cut dimmers

- Control devices such as dimmers, switches, time-clocks and sensors, can be connected to the mains power supply in a 2-wire configuration or in a 3-wire configuration (figure below).
- Essentially the difference is if the neutral wire is present at dimmer level.

- **In most European houses the neutral wire is not normally distributed to the controls.**

- The absence of the neutral wire implies that **the dimmer has to receive its power supply through the load** (lamp/control gear) and also that it has **to sense the phase through this load** (i.e. to detect the zero crossings in the sine wave, required for correct phase-cutting).



Dimming (9), Power supply for phase-cut dimmers

- **Some trailing-edge phase-cut dimmers require neutral wire** (3-wire) for acceptable dimming performance → means **pulling an additional wire** in most houses.

- **Dimmers that work in the 2-wire configuration, without neutral, have to receive their power supply through the load**, also during the short periods where the phase is cut and the control gear (or lamp alone) is not powered, and also when the control gear/lamp is switched off for longer periods, but the dimmer has to remain in standby.

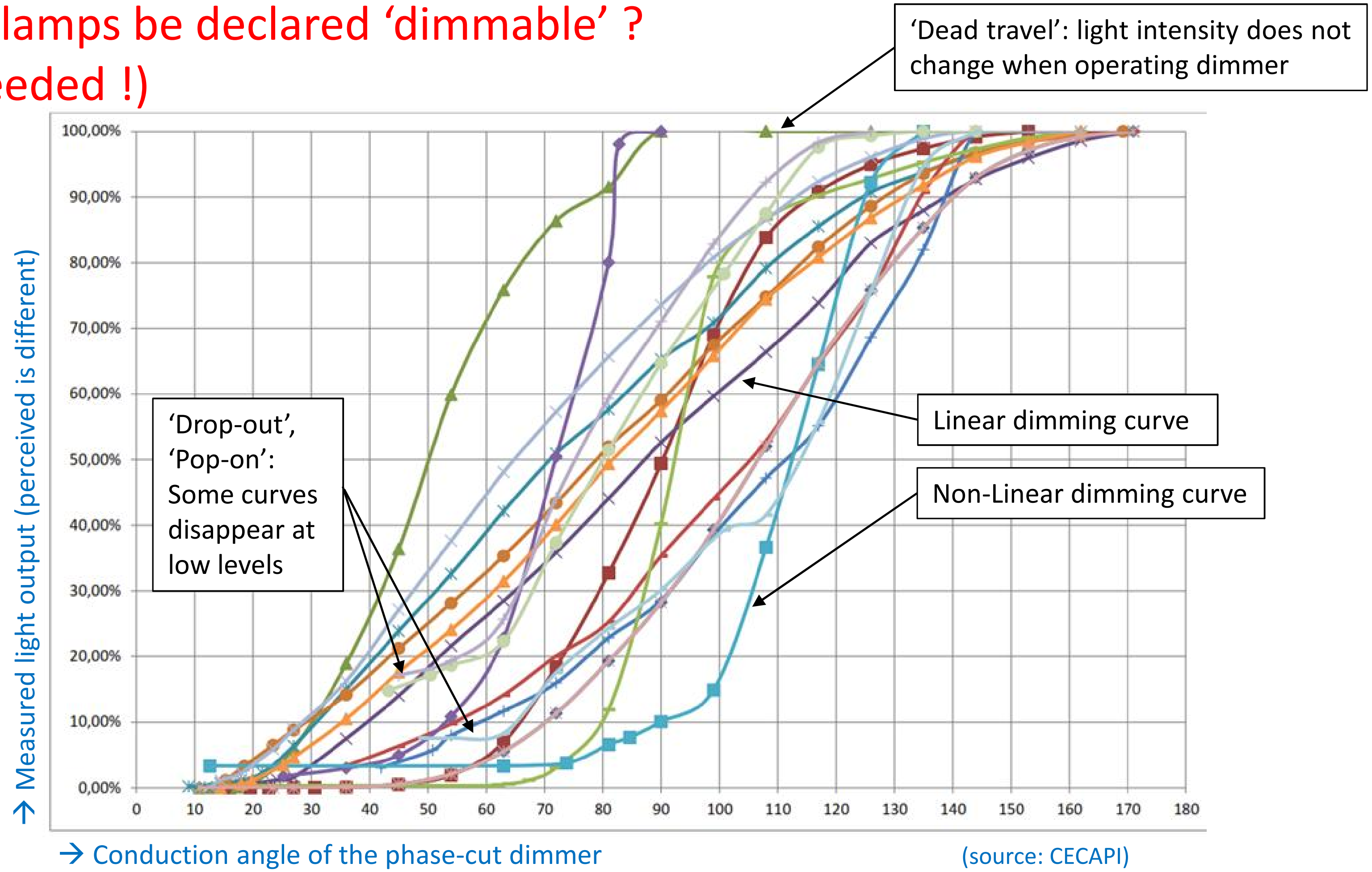
- For resistive loads as incandescent and halogen lamps, this does not present particular problems, because at the current levels needed for the dimmer (less than 50 mA) these lamps will not emit any light.
- LED lamps however operate at much lower currents, and the **current drawn by the dimmer might make the LED lamp light up** even when it is supposed to be switched off. This is called '**ghosting**'.

- In addition, differently from filament lamps, the small **current required by the dimmer will normally not pass through the LED lamps and control gears**, unless special '**bleeder circuits**' are implemented.

- **110 - 120 million phase-cut dimmers installed in Europe**
- 75% installed in the residential sector
- 3% are 3-wire installations; bulk are 2-wire installations → face problem of power supply through load.
- **80% of the installed base of dimmers will face issues when loaded with new energy saving lamps.** (source: CECAPI)

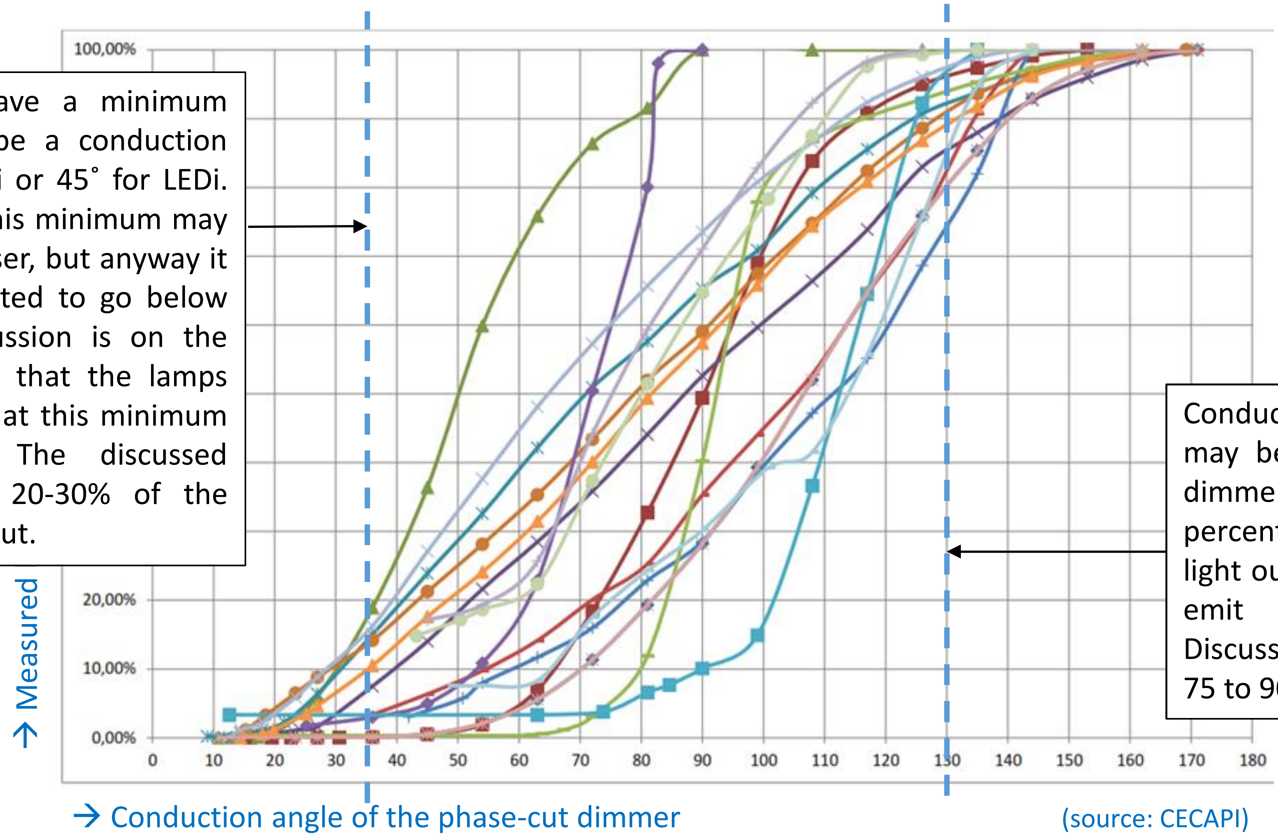
Dimming (10), Dimming curves

Can all these lamps be declared 'dimmable' ?
(definition needed !)



Dimming (11), Dimming curves

Dimmers usually have a minimum setting that could be a conduction angle of 60˚ for CFLi or 45˚ for LEDi. On some dimmers this minimum may be settable by the user, but anyway it would not be expected to go below 35˚. Here the discussion is on the highest light output that the lamps are allowed to have at this minimum conduction angle. The discussed values are around 20-30% of the maximum rated output.



Conduction angles higher than 130˚ may be difficult to reach by future dimmers. The question is which percentage of the maximum rated light output the lamps should at least emit at this conduction angle. Discussed values currently vary from 75 to 90%.

Dimming (12)

LightingEurope and CECAPI:
It is impossible to develop (LED) lamps that are compatible with all types of dimmers now installed in Europe. The installed base of dimmers is to disparate and often characteristics are not well known.

LED lamp manufacturers:

- list of dimmers that have been tested to be compatible.

Valuable information, but:

- disclaimers and warnings: laboratory tests might not correspond to real situation
- not available for many older dimmer types

In many literature sources it is recommended to test each specific combination dimmer – control gear – LED board; **currently it is often a matter of 'hit and miss' if dimming will work properly**.

Dimming (13), Standardisation work

- Commission mandate 519 → IEC standardization Joint Adhoc Group (JAHG) (experts on light sources/control gears (TC34) + experts on dimmers (SC23B)).

- Purpose: prepare technical reports on:
  - "requirements and tests for dimmable LEDs to be used with phase-cut dimmers"
  - "requirements and tests for phase-cut dimmers to be used with dimmable LEDs".

- Now: work on Power Supply and Synchronization; other issues still to be handled.

- Timeline:

Timeline:	June 2015	Technical reports ready
	2017/2018	Implementation in standards
	2020	First effects on market

- These efforts should **ensure compatibility between new dimmers and new LED lamps** that are conform to the standard.
- This does NOT imply that these new conform LED lamps will work with all old existing dimmers: there will still be the **risk that consumers have to buy new dimmers**.

Dimming (14), Standardisation work

- **USA**, April 2013, NEMA SSL 7A-2013 "Phase Cut Dimming for Solid State Lighting: Basic Compatibility".
  - deals only with compatibility issues, not with performance issues for dimming.
  - limited to leading-edge phase-cut dimming (by far the most widespread technology in the USA).
  - defines dimming range only from 50% to 80% of maximum light output.
  - CECAPI: American standard would be insufficient for the European situation.

- IEC SC 77a, WG 1, TF8: new document (77A_847e_DC):
  - **manufacturers shall not produce leading-edge dimmers > 100 W for LEDs** due to high electromagnetic disturbances induced by integrated electronic control gear when dimmed in phase cut
  - **if dimming is operated in trailing-edge up to 200 W are allowed,** due to lesser perturbations.

Ecodesign Preparatory Study

Lot 8/9/19 Light Sources

1st Stakeholder Meeting

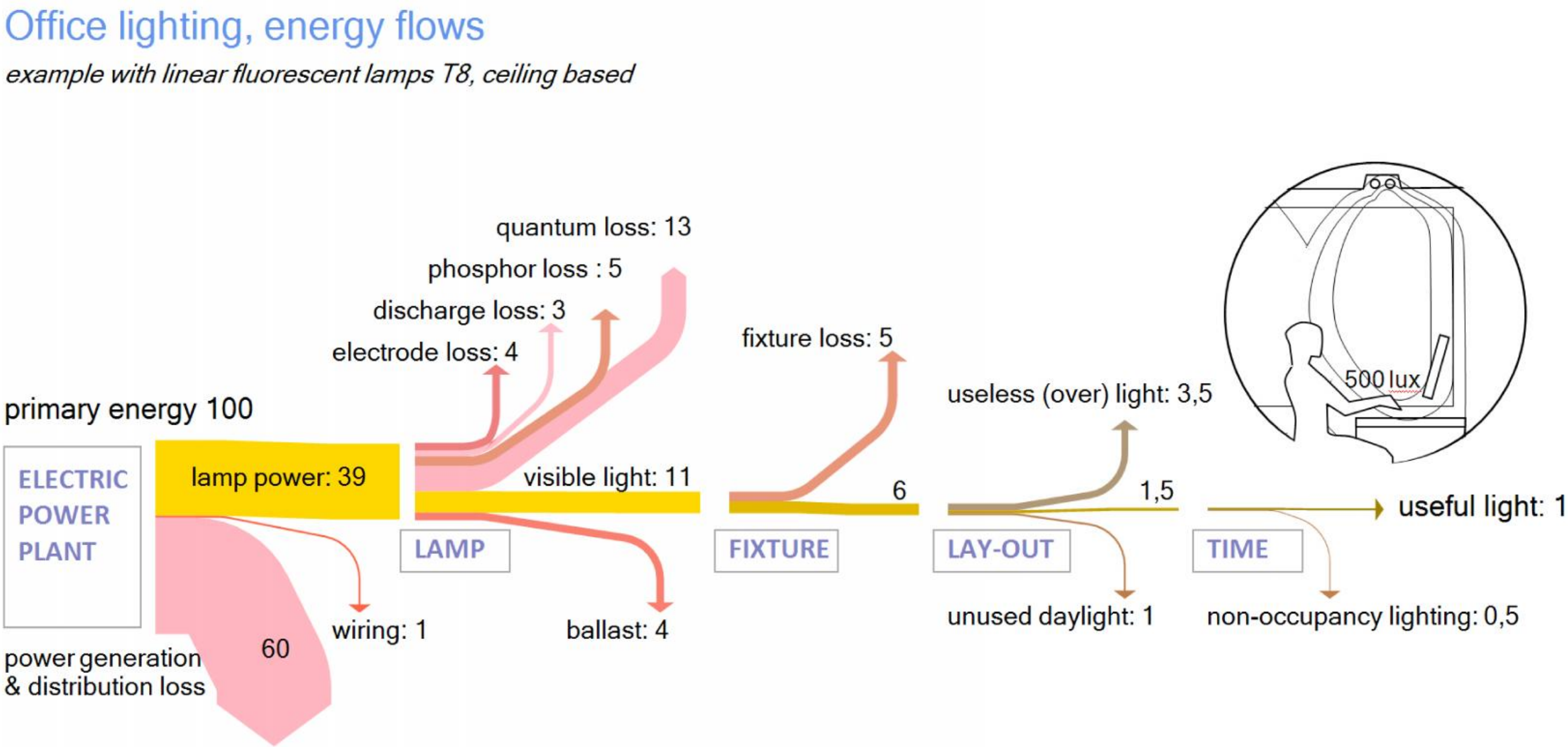
5 February 2015

Thanks for your Attention !

Any questions or remarks ?

Van Holsteijn en Kemna

Vlaamse Instelling voor Technologisch Onderzoek



Source: VHK 2011-2015 (own calculation)

Office lighting, illustrative energy flows. (source VHK)

Based on existing traditional single office with 4 ceiling-based fixtures each containing two 2x36W T8 tri-phosphate linear fluorescent lamps (h=2,7m). Reflectance of ceiling, walls and floor are 0.7, 0.5, 0.3 respectively. Manual on/off light switches are used. Office hours are from 7.00 to 18.00h (250 days/yr.). Figures in the diagram are **illustrative**, i.e. not necessarily representative of the existing average EU situation.

Efficiency electricity generation (including acquisition of energy resources) and electricity distribution to the building are in accordance with the MEErP 2011 indicator (η=40%). 'Wiring' indicates the resistive losses in the building wiring plus (negligible, CosPhi=0,96) extra resistive losses caused by the power factor, calculated throughout the whole electricity distribution chain.

Lamp losses are taken from [Kane, H., Sell, H., Revolution in lamps, The Fairmont Press, 2001]: ballast (η=90%), electrode losses (η=92%), discharge of non-visible radiation (η=85%), phosphor UV protons lost (η=86%), quantum efficiency at ratio 5.5 eV UV to 2.5 eV visible (η=45%). **Lamp output is 80-90 lm/W**.

Low-cost fixtures with Light Output Ratio (LOR) η=55% are assumed (compare www.olino.org measurements).

For 'over-lighting', i.e. lighting levels beyond requirement in parts of the office space, the existing lay-out is compared to a single-lamp suspended direct/indirect luminaire (downward flux 70-75%/upward flux 25-30%), one above the workspace (h=ca. 1,4-1,6m) one above meeting area (L-shaped desk h=0,75 m) and a switchable task light in or near the archive-cupboard, resulting in ca. 60% saving.

As regards unused opportunities for daylight-contribution, daylight supply factors for Lyon (F) in EN 15193:2007 were taken into account, corrected for ambient (window transmission values, dirt, overhangs, etc.). It is estimated, in line with industry claims for daylight sensor controls, that ca. 30-35% could be saved in an office space with large windows on one wall (common situation). For the occupancy of a single office, it is assumed that the 'building code' lighting can be reduced by 30-35%.

Controls (daylight sensors, occupancy sensors, dimmers) are not part of the example. If they were included they would reduce unused daylight and non-occupancy lighting, but they also use energy; EN 15193 gives a default electricity use for automatic controls of 5 $kWh/m^2.yr$ (if no data are available). Dimmers influence lamp light efficacy (e.g. ca. 70 lm/W at 50% dimmed instead of 80 lm/W undimmed).