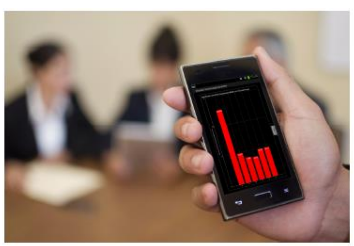
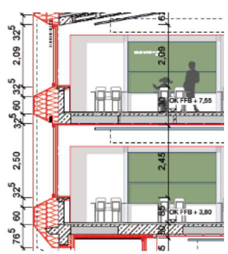
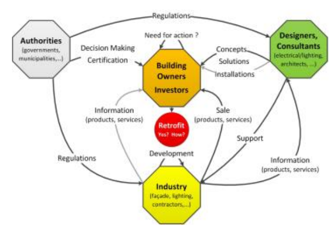
IEA SHC Task 50: *Advanced lighting solutions for retrofitting buildings*

An integrative approach to allocate potentials in lighting retrofits

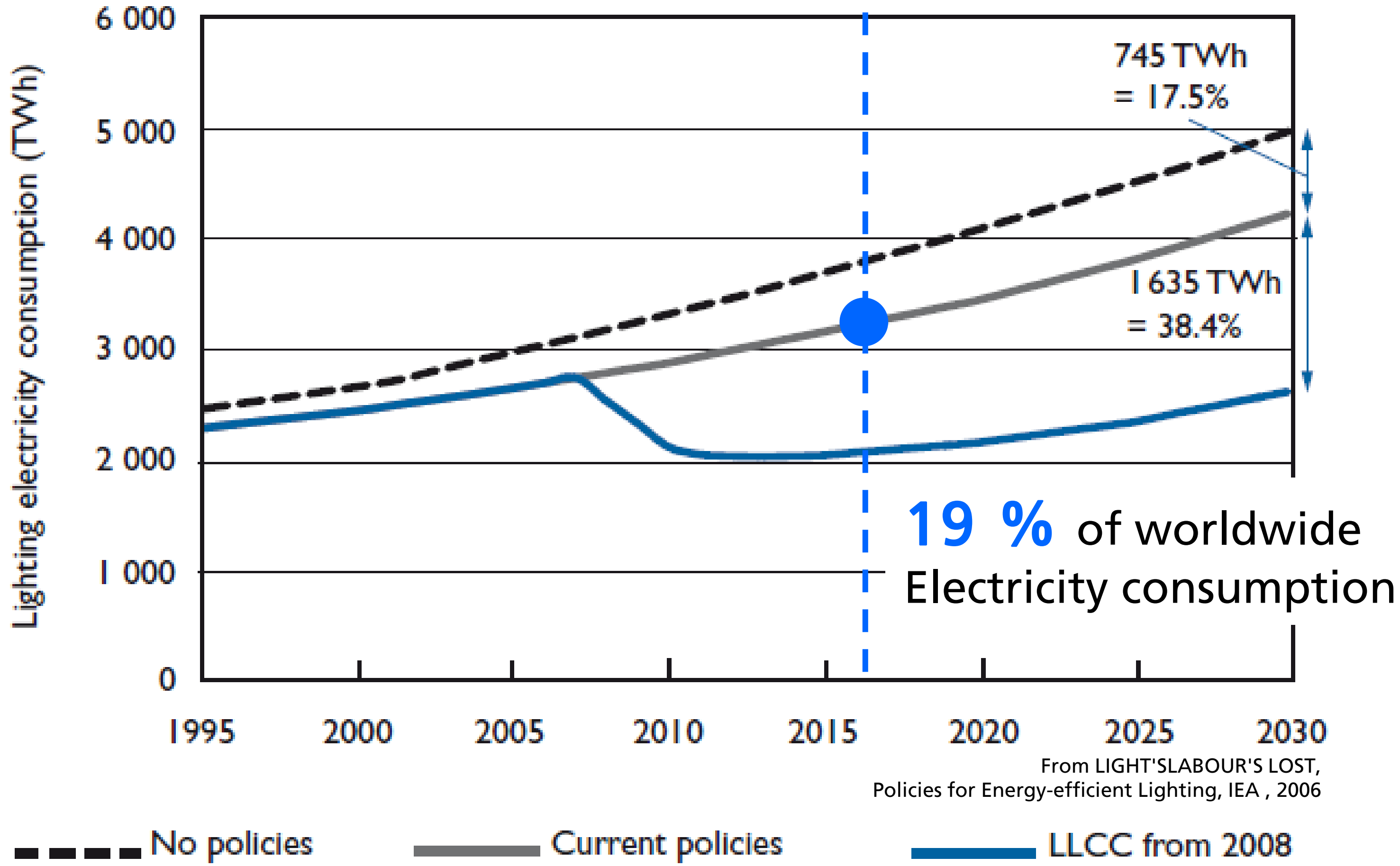
Jan de Boer, FHG-IBP, Stuttgart







Lighting and Energy: Status Quo and Prediction



From LIGHT'SLABOUR'S LOST,
Policies for Energy-efficient Lighting, IEA , 2006

(LLCC: Least Life Cycle Cost)

Lighting and Energy: Potentials in Retrofitting

Only small volume of new building constructions


Geo-reisecommunity

~3 % retrofit rate
(estimation facade and lighting industry)

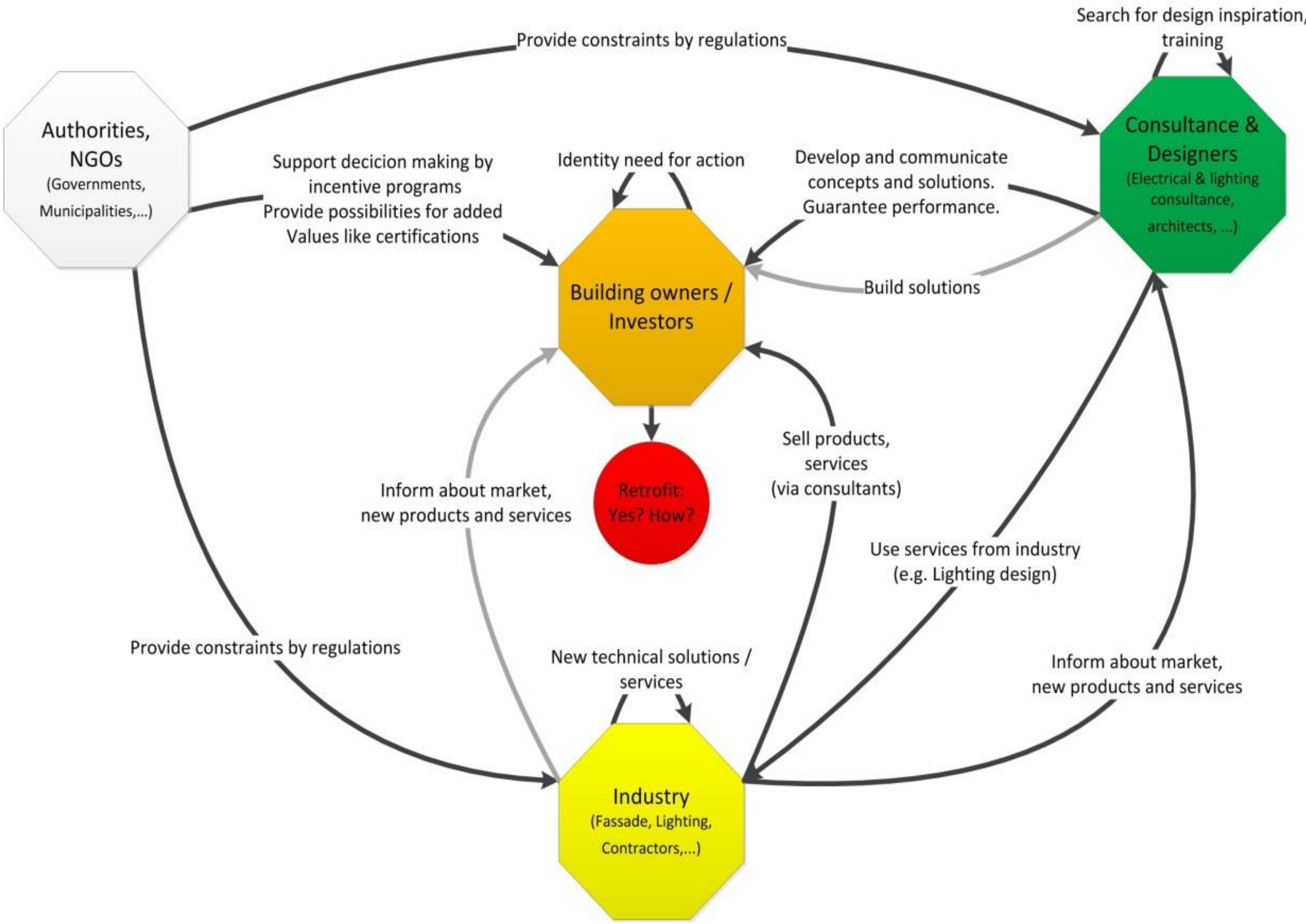

Wikipedia, Apfel3748


Marquardt

40-50% of turnover of facade and lighting industry in retrofitting

75 % of appliances outdated (older than **25 a**)

Target audiences



Task Structure

The objective is to accelerate retrofitting of daylighting and electric lighting solutions in the non-domestic sector using cost - effective, best practice – approaches, which can be used on a wide range of typical existing buildings.

IEA SHC Task 50

Advanced lighting solutions for retrofitting buildings

Operating Agent: J. de Boer, DE

Subtask A	Subtask B	Subtask C	Subtask D
M. Fontoynont, DK	*M. Knoop, DE*	*J. Kaempf & B. Paule, CH*	*M.-C. Dubois, SE*
Market and Policies	**Daylighting and Electric Lighting Solutions**	**Methods and Tools**	**Case Studies**

Joint Working Group: "Lighting Retrofit Adviser"

Task Structure

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IEA SHC Task 50

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Subtask A

M. Fontoynont, DK

Market and Policies

and Electric Lighting Solutions

Methods and Tools

Case Studie

Joint Working Group: "Lighting Retrofit Adviser"

18 universities/
institutes/companies
14 Countries

Subtask A: Market and Policies

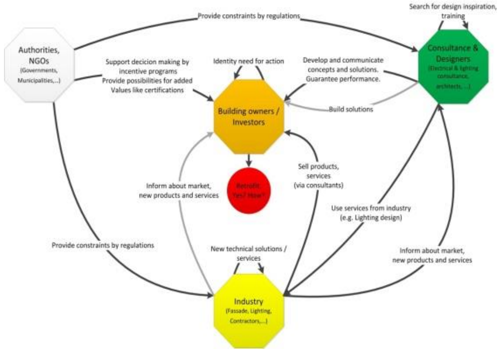
[Coordination: M. Fontoynont, SBI, DK]

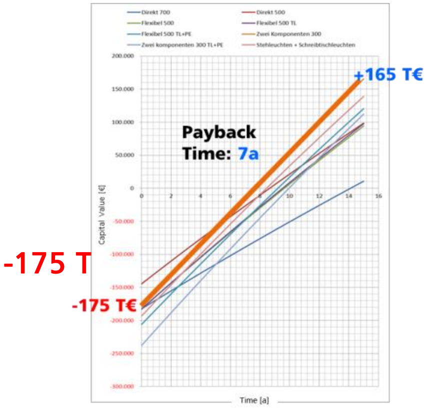
Objective: To understand, and model, the financial and energy impact associated to retrofitting daylighting and electric lighting of buildings.

A.1. Global economical models

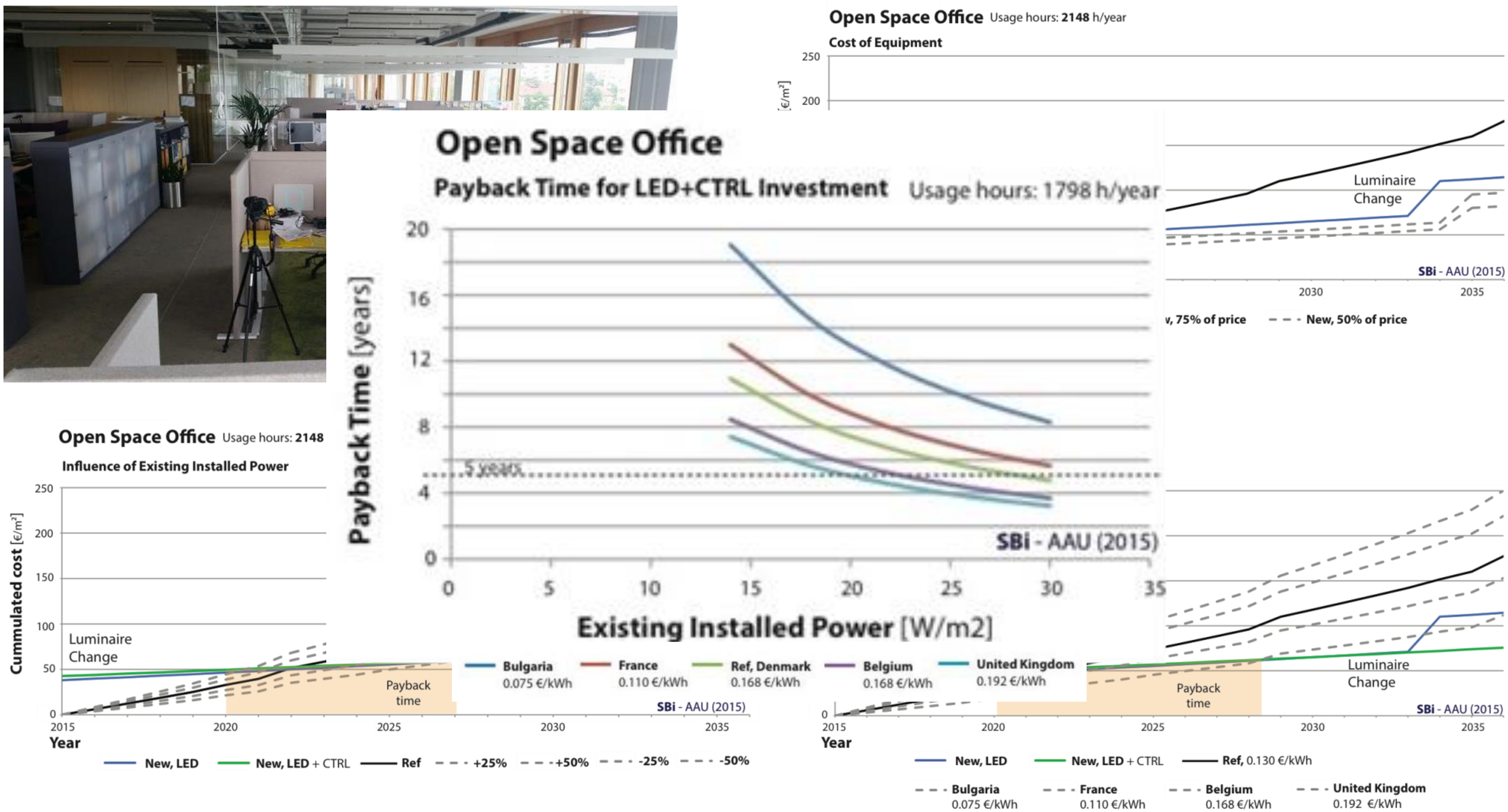
A.2. Barriers and benefits. Regulation and certification

A.3. Proposal of action concerning value chain





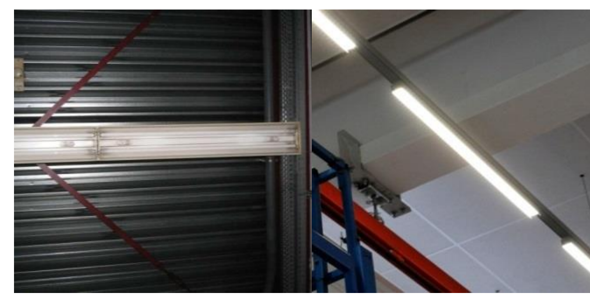
„Low hanging fruits“: Efficiency & Economics



[Data for Personal, open floor offices; education; manufacturing hall with and without rooflights; whole sale retail]

„Low hanging fruits"

Type	Solution	Invest [€/m²]	Annual Cost, new [€/m²]	Payback time
Single Office	Existing	-	2,57	-
	LED	36,7	0,81	17
	LED + LM	42,7	0,22	16
Open Plan office	Existing	-	6,12	-
	LED	36,7	1,41	7
	LED + LM	42,7	1,18	7
Classroom	Existing	-	1,33	-
	LED	36,7	0,42	>20
	LED + LM	42,7	0,28	>20
Wholesale / Retail	Existing	-	10,35	-
	LED	36,7	4,31	5
	LED + LM	42,7	3,65	5
Hall without Rooflights	Existing	-	7,19	-
	LED	10,0	2,05	2,5
Hall with rooflights	Existing	-	5,37	-
	LED	10,0	1,53	3,5
	LED + LM	16,0	1,17	4,5



Financing

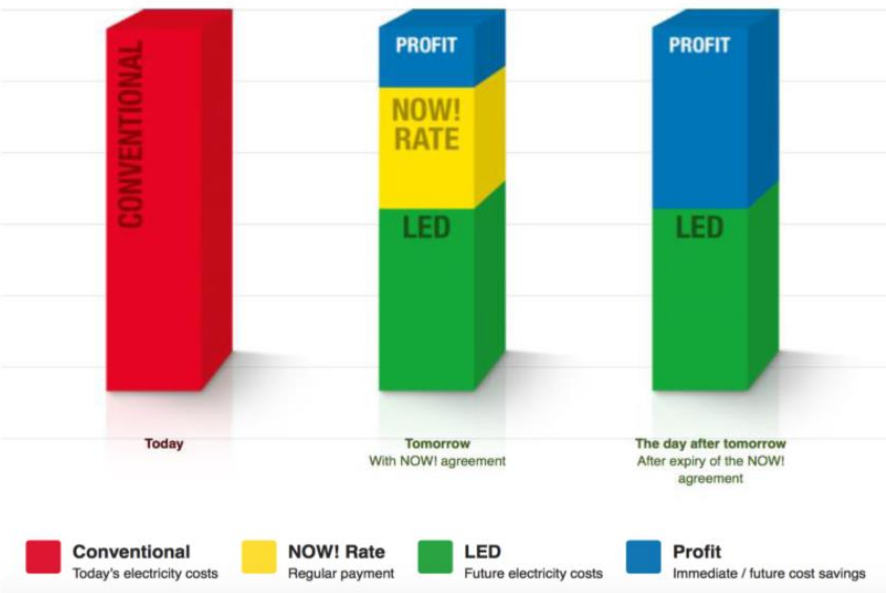
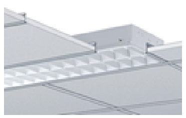


Figure 1 - Principle of NOW! Lighting, Source: Zumtobel

- ESPC (Energy Saving Performance Contracts) and Leasing
- Added simplicity for the building owner
- Integration a guarantee of service
- This new approach triggers a new kind of competition:
  - manufacturers, installers, utilities, facility managers are moving to this field,
  - creating a high financial pressure on costs of products,
  - but fortunately, on their reliability and quality as well.

Regulations

- Assessments of existing codes, comparisons, recommendations
- E.g. Taking old luminaires out of operation
- E.g. Requirements for the total luminous efficacy of new luminaires (for replacement)
- E.g. Requirements for system efficiency

Product class to be taken out of operation			Luminaire luminous efficacy: Existing installation lm/W	Luminaire luminous efficacy: Comparison new installation lm/W	Efficiency increase	Comment on replacement
Recessed luminaires	Halogen downlights in various designs		10 - 15	Up to 110 (LED)	approx. 8-11	For recessed LED luminaires, bezels are offered, which ensure that the new technologies are compatible with the existing ceiling plan.
	CFL-based downlights		30 - 40	Up to 110 (LED)	approx. 3	
	Luminaires with simple white glare protection louver with (T12-) T8-, CB lamp technology		40 - 60	Up to 110	approx. 2 - 3	
Surface-mounted luminaires	Prismatic diffusers with (T12-) T8-, CB lamp technology		approx. 40	Up to 110	approx. 2 - 3	
	Surface-mounted opal diffuser luminaires with T12 light source and LLB		approx. 50	Up to 110	approx. 2 - 3	
row luminaires	Continuous-row luminaires with T12 light source and CB		40 – 60	Up to 130	approx. 2 - 3	Many manufacturers offer conversion kits for retrofitting LEDs to existing continuous-row luminaire systems, which allow making further use of the - usually expensive - bearing structure.
High Bay	High-bay fitting, like mercury vapor lamp.		50 - 60	90 - 100 (HMI) to 140 (LED)	1.5 - 2.5	

Regulations

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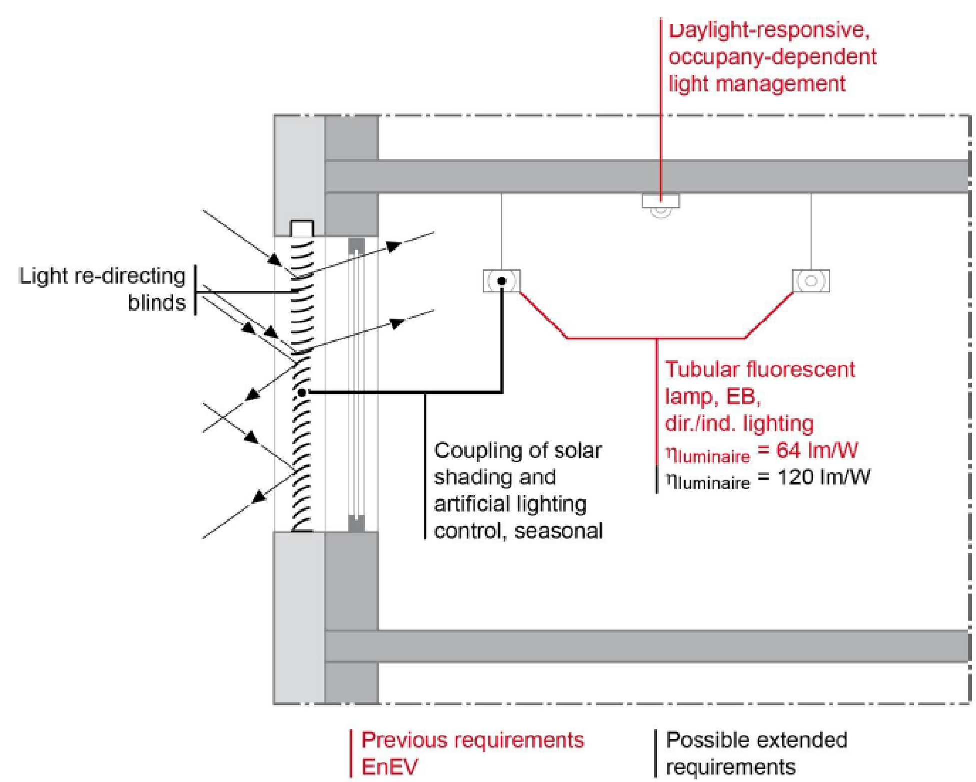

Figure 7: Previous reference technologies according to EnEV. Possible extended requirements.

Sustainability Labels

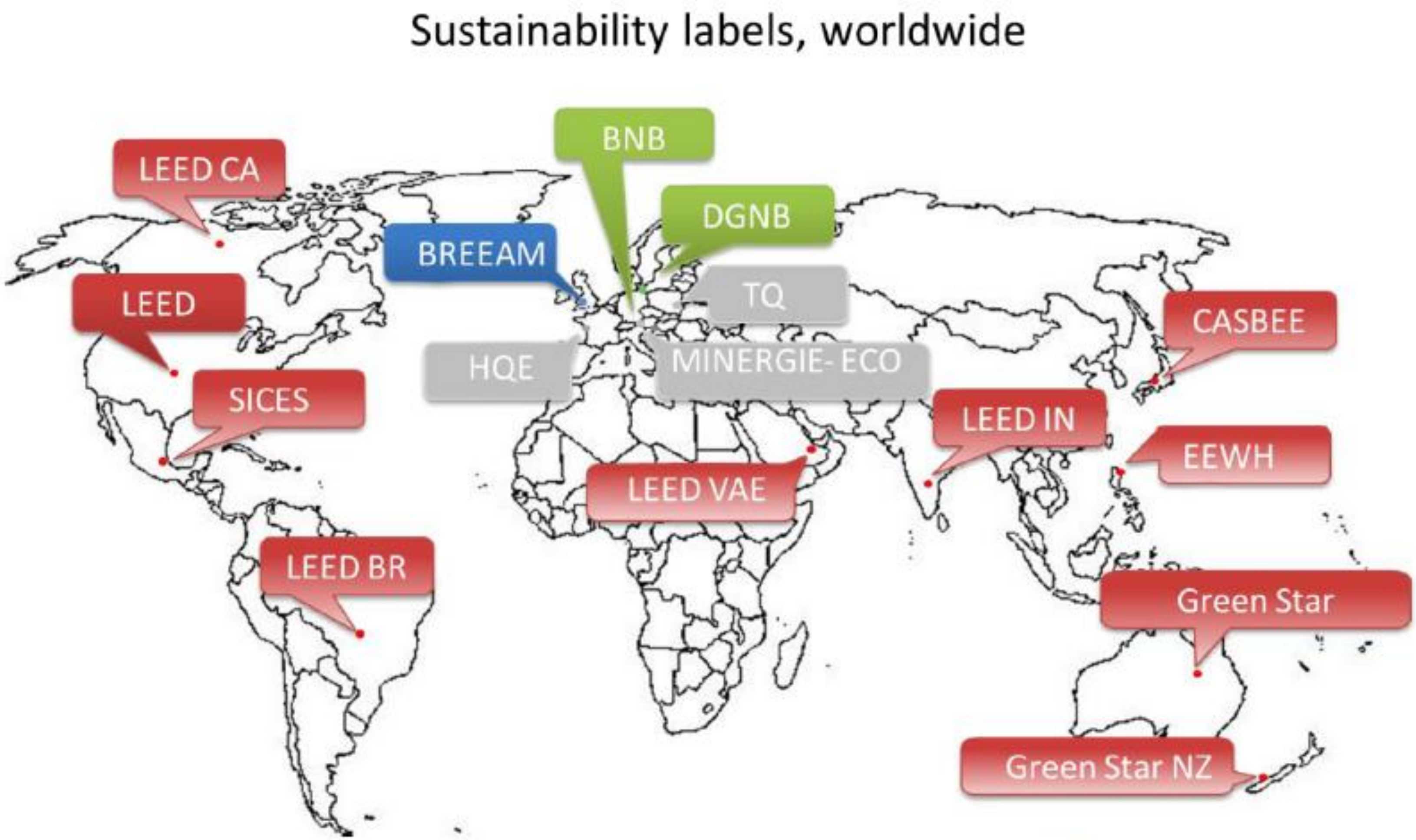

Figure 8 Overview on sustainability labels worldwide (based on data in [22]).

Sustainability Labels

- Electric lighting in general not the problem
- Sustainability labels in lighting offer new perspectives for daylight and visual comfort
- Comparison of different approaches according to a set of criteria

		System		
		DGNB / BNB	**LEED**	**BREEAM**
General	Version	DGNB: New construction office and administration buildings Version 2015 BNB: Version 2015	New Construction and Major Renovation Version 2009	BREEAM New Construction Nondomestic Buildings Version 2013
General	Main criterion	Sociocultural and functional quality	Indoor Environmental Quality	5.0 Health and Wellbeing
General	criterion	DGNB: SOC 1.4 BNB: 3.1.5 Visual Comfort + lighting in the overall energy context	Credit 8: Daylight and Views	Hea 01: Visual comfort
General	share of lighting in the overall rating	DGNB: 3,2% BNB: 2,4%	3,6% (max. 4 / 110)	4% (4/15 credits, weighting „Health and Wellbeing“ 15%
Daylight entire building	Requirement	Min. 50% of the usable floor area: DGNB: Min. 1,0% DF - 2% and higher DF BNB: Min. 1,0% DF - 2% and higher DF	-	-
Daylight entire building	Evidence	DGNB: Simulation / measurement BNB: Simulation / EnEV	-	-
Daylight workplaces / continual used spaces	Requirement	All Workplaces: DGNB: min. 45% - 75% relative luminous exposure BNB: Min. 45% - 80% relative luminous exposure	75% of continual used spaces: Min. 270lux (Sept)	80% of continual used spaces: e.g. Ø 2% DF + Uniformity 0,4 or other options
Daylight workplaces / continual used spaces	Evidence	Simulation / simplified in compliance with DIN 18599	Simulation / description Light transmission glazing + share of openings/ measurement	Simulation, measurement CIBSE Lighting Guide 10
line of sight	Requirement	DGNB: window area + solar-/ glare protection class 2 – highest BNB: window area + solar protection + view through activated solar protection with/without adjustment	90% of continual used spaces	Share of openings ≥ 20% - ≥ 35% of room surface and 95% of the area are within 7- ≥ 14 meters to a wall with windows or other openings
line of sight	Evidence	DGNB: area DIN 5034 solar protection. DIN 14501 data sheet / photo BNB: area DIN 5034 photo / plan of the office	Drawing line of sight	Plans / photos / confirmation

Sustainability Labels

- Electric lighting in general not the problem
- Sustainability labels in lighting offer new perspectives for daylight and visual comfort
- Comparison of different approaches according to a set of criteria

		System		
		DGNB / BNB	LEED	BREEAM
absence of glare trough daylight	requirement	Function of glare protection DGNB: class 1 – highest BNB: glare protection BschAVO / light directing with glare protection + shielding of direct light	-	glare control strategy with sufficient daylight for cloudy situations and situations without direct sunlight or
	evidence	DGNB: DIN 14501 classification, data sheet solar / glare protection BNB: photo	-	description inspection, photo
absence of glare artificial	requirement	artificial light DIN 12464 yes / no	-	illuminance, max. luminance (national best practice lighting guides)
	evidence	DGNB: artificial light simulation BNB: documentation luminaires	-	specification, inspection, photo
colour rendering	requirement	colour rendering for artificial light + daylight (whole system) ≥ 80 - ≥ 90	-	-
	evidence	DGNB: spectral calculation according to DIN EN 410 manufacturer specifications BNB: DIN EN 12464 data sheets/ measurement or spectral characteristic values	-	-
light distribution	requirement	BNB: artificial light: compliance norm – combined direct-indirect lighting with control of single workplaces	-	uniformity
	evidence	BNB: DIN EN 12464 description + list of luminaires	-	-
possible influence of the user	criterion (differing)	DGNB: SOC 1.5 BNB: 3.1.6 Possible influence of the user	Credit 6.1: Controllability of Systems - Lighting	5.0 Health and Wellbeing (as mentioned above)
	requirement	DGNB: influence on solar / glare protection for 80% of the rooms of the main use per room or per group (max. 3 persons) BNB: per window / per zone (max. 3 persons) / per room	controlling is possible for 90% of the users / group of users	Max 4 workplaces controlled together, window workplaces can be controlled separately
	evidence	DGNB: data sheet, description BNB: description, explanatory report, photo documentation	-	-

Subtask A: Market and Policies

[Coordination: M. Fontoynont, SBI, DK]

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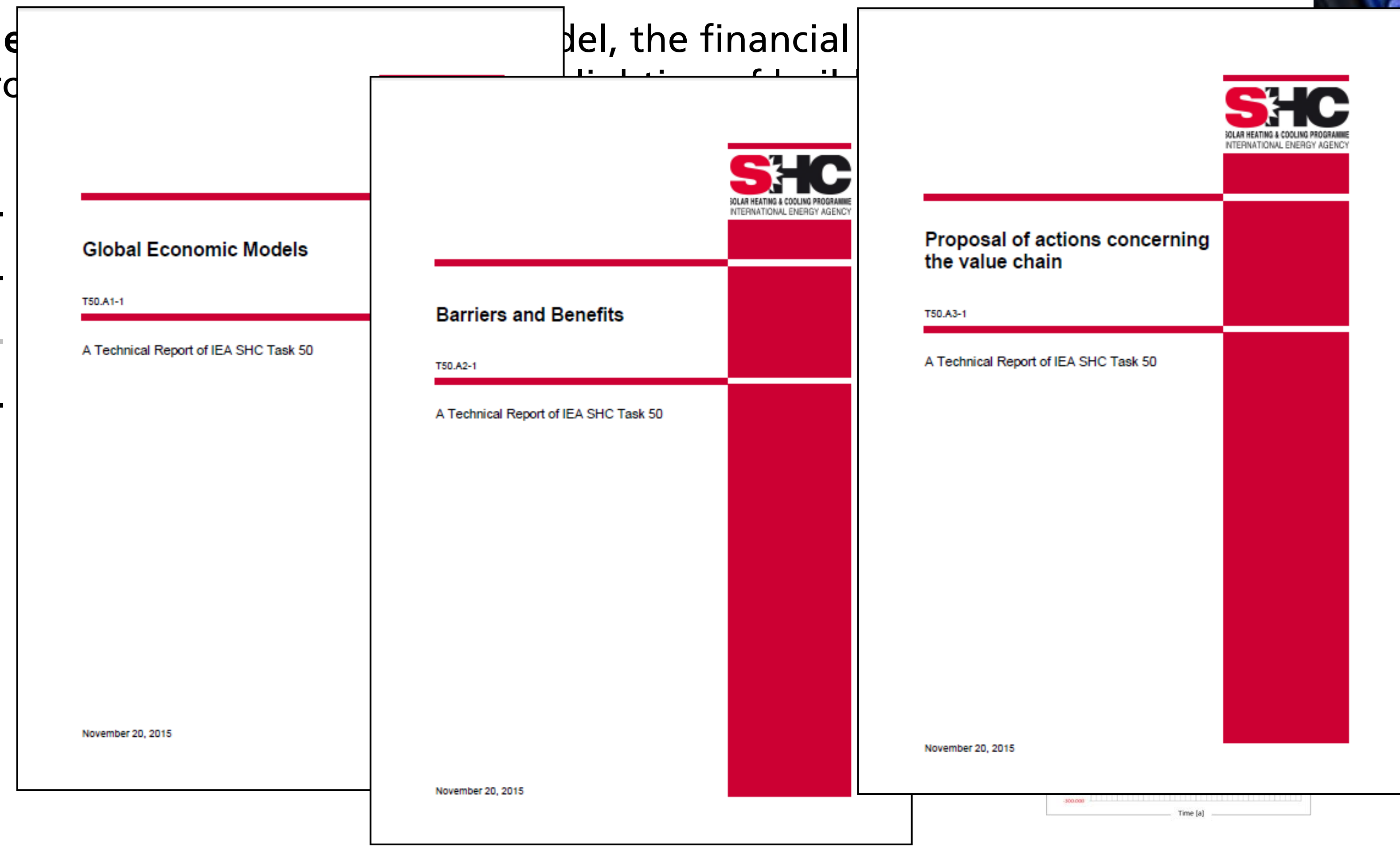
A.1.

A.2.

A.3.

A.4.



Global Economic Models

T50.A1-1

A Technical Report of IEA SHC Task 50

November 20, 2015

Barriers and Benefits

T50.A2-1

A Technical Report of IEA SHC Task 50

November 20, 2015

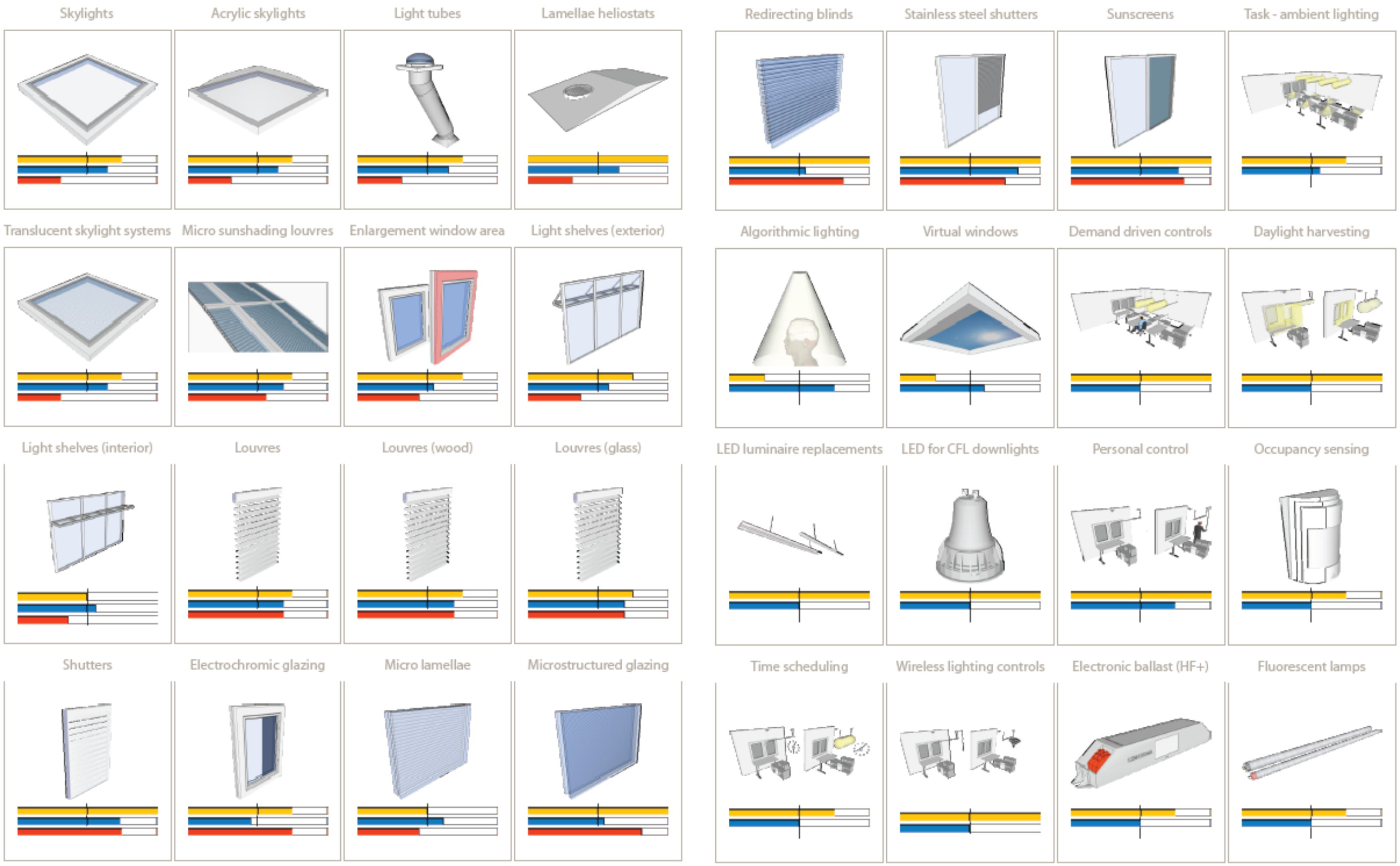
Proposal of actions concerning the value chain

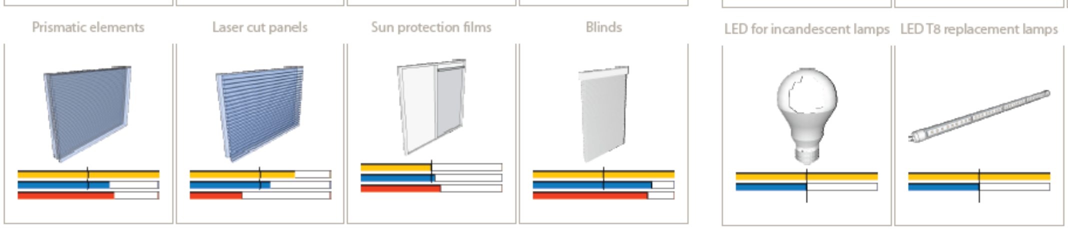
T50.A3-1

A Technical Report of IEA SHC Task 50

November 20, 2015

Subtask B: Daylighting and Electric Lighting Solutions

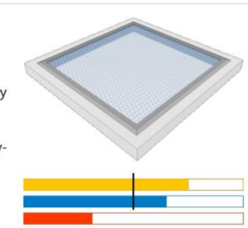




38 Technologies

- Electric lighting
- Daylighting / Facade
- Lightmanagement

» Upper bar - Yellow - Energy efficiency
Reflects savings potential of retrofits
» Middle bar - Blue - Lighting quality
Reflects the retrofit's impact on lighting quality aspects
» Lower bar - Red - Thermal benefits
Reflects the thermal benefit of façade and daylight technology retrofit
» Baseline performance
positioned in the middle (marked by black line)



IEA SHC Task 50 *Advanced lighting solutions for retrofitting buildings*

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Subtask C: Methods and Tools

[Coordination: Jérôme Kaempf, EPFL, Bernard Paule, Estia Switzerland]

Objective: Provide methods and tools to make energy efficiency and economics of lighting retrofits transparent to stakeholders.

C.1. Analysis of workflow and needs

C.2. State of the art review

C.3. Development of a simple integrated rating model

C.4. Energy audit and inspection Procedures

C.5. Advanced and future simulation Tools

Subtask C: Methods and Tools

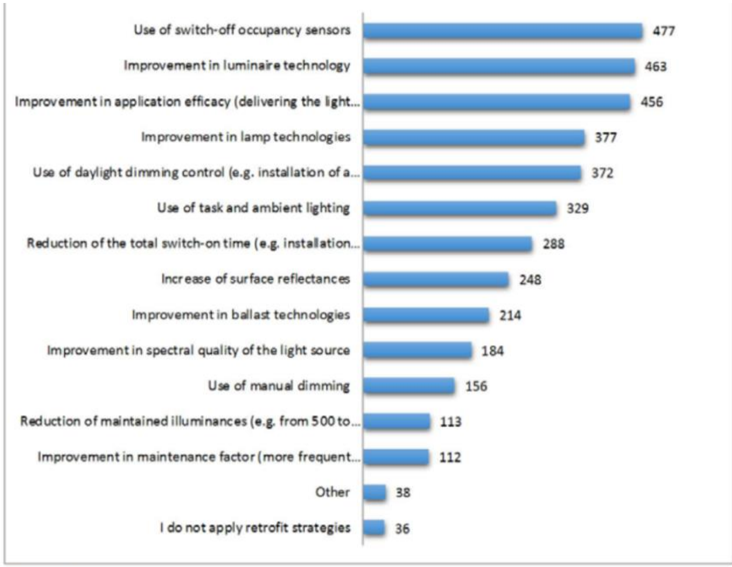


Figure 7: Evaluations of the questions on main retrofit strategies used in current practice.

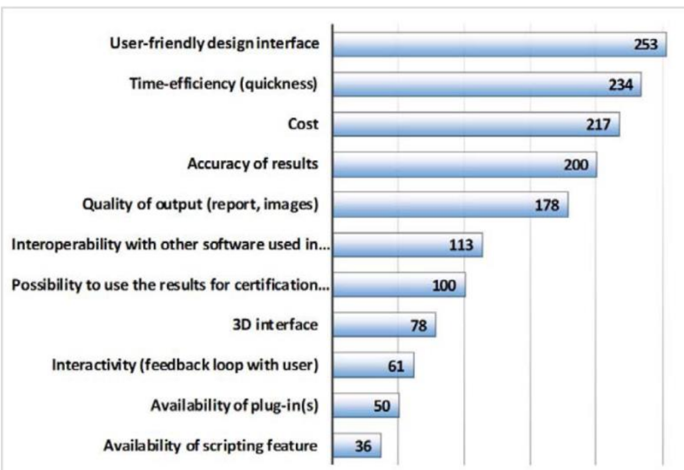


Figure 8: Evaluation of main factors influencing the choice of software.

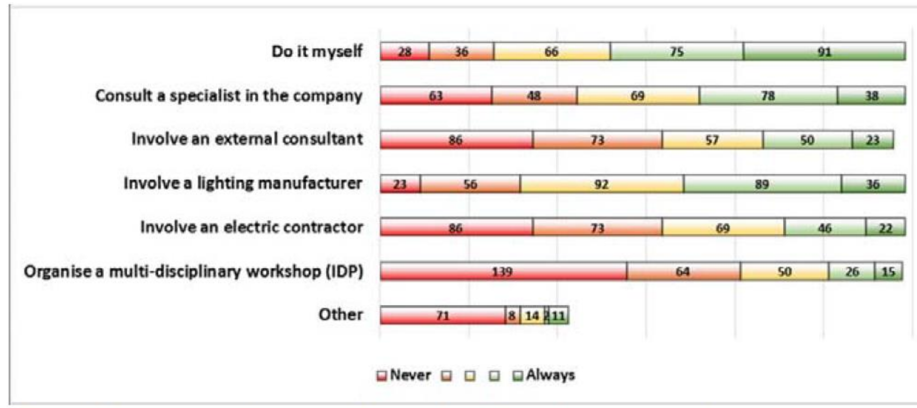


Figure 9: Evaluation of the question on handling of design and decision processes concerning the integration of lighting technologies in retrofit projects.

Subtask C: Methods and Tools

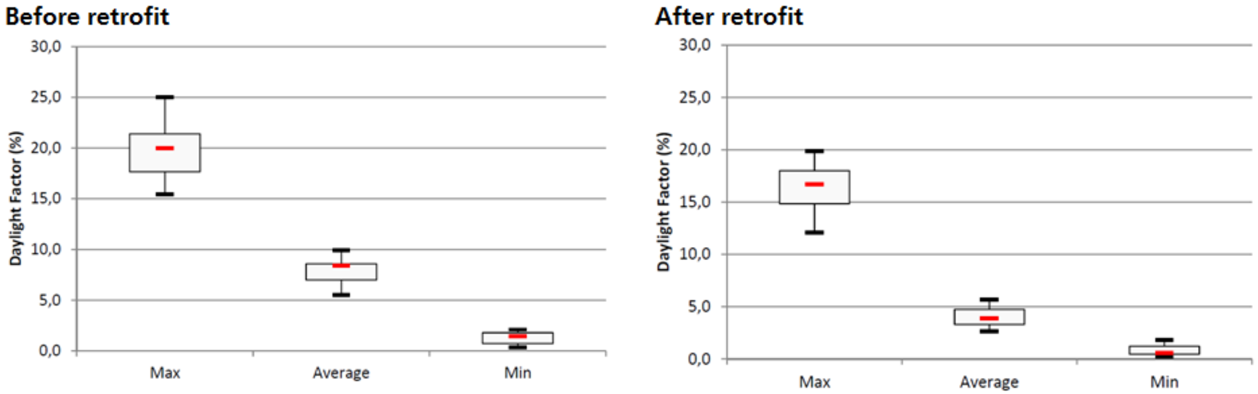
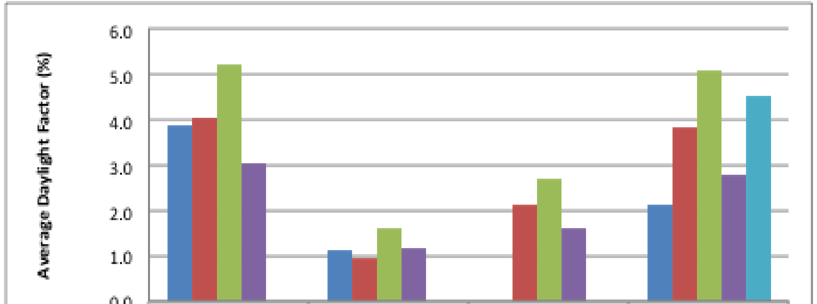


Figure 6: Exemplary results from the state of the art review of 13 simulation tools. The figures show the calculated daylight factors for a test scenario before and after retrofit. The general drop of the daylight factor due to lower light transmittance of new glazing systems (due to low ε coating) is shown. Additional the review showed a quite significant spread of calculation results.

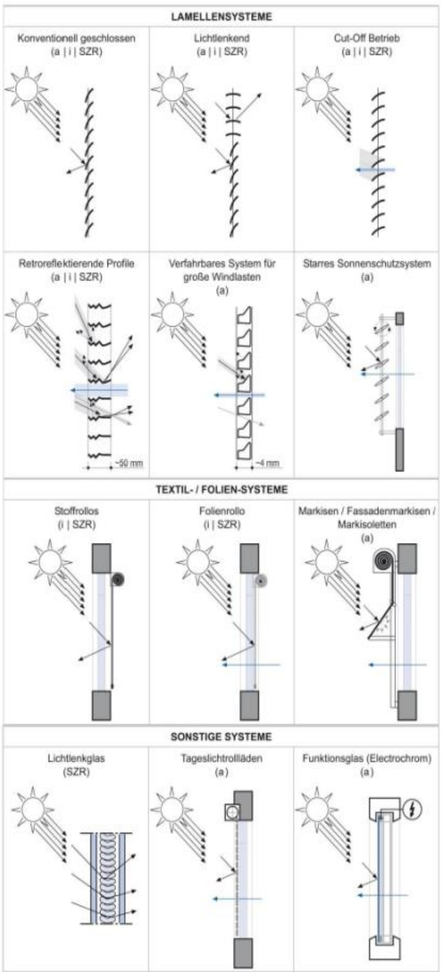


	Double clear glass	Double clear glass with diffuse blinds	Double clear glass with vertical blinds	Laser Cut Panel
DIALux evo	3.9	1.1		2.1
FENER	4.1	1.0	2.1	3.8
Geronimo	5.2	1.6	2.7	5.1
Radiance	3.0	1.2	1.6	2.8
ReluxPro				4.5

Figure 7: Daylight Factor obtained with different advanced simulation tools for 4 different complex fenestration systems.

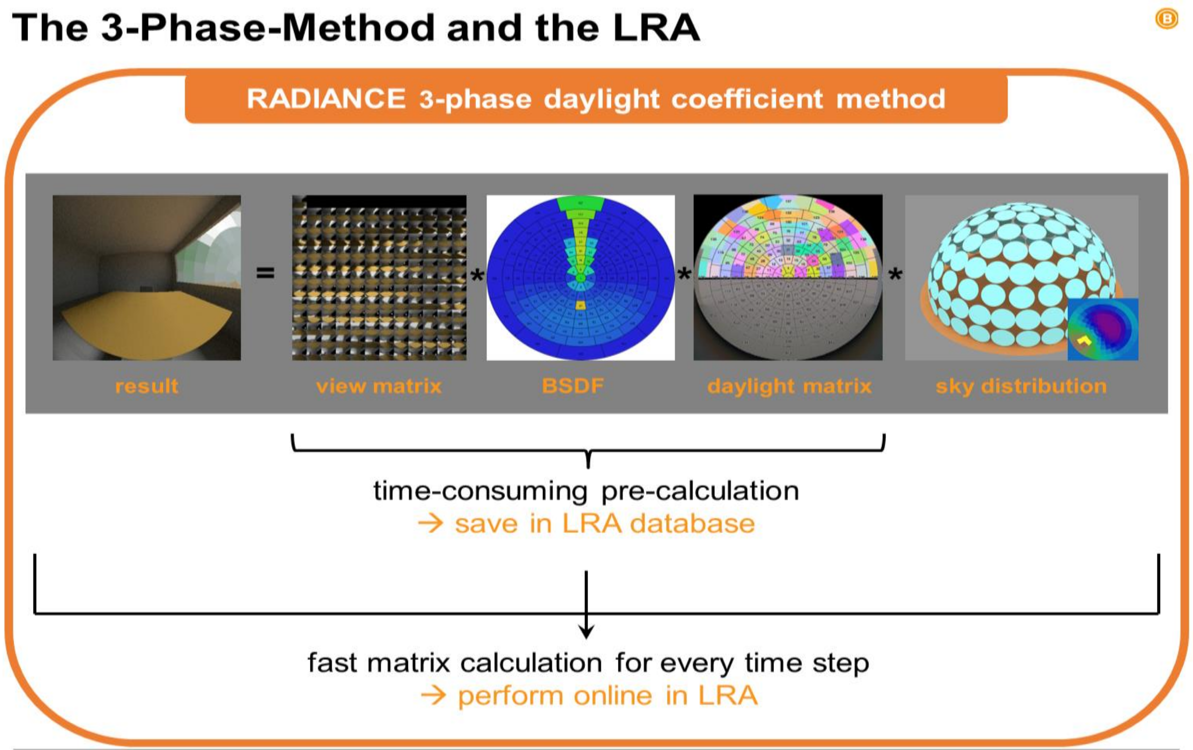
20 Tools, Methods

Subtask C: Methods and Tools



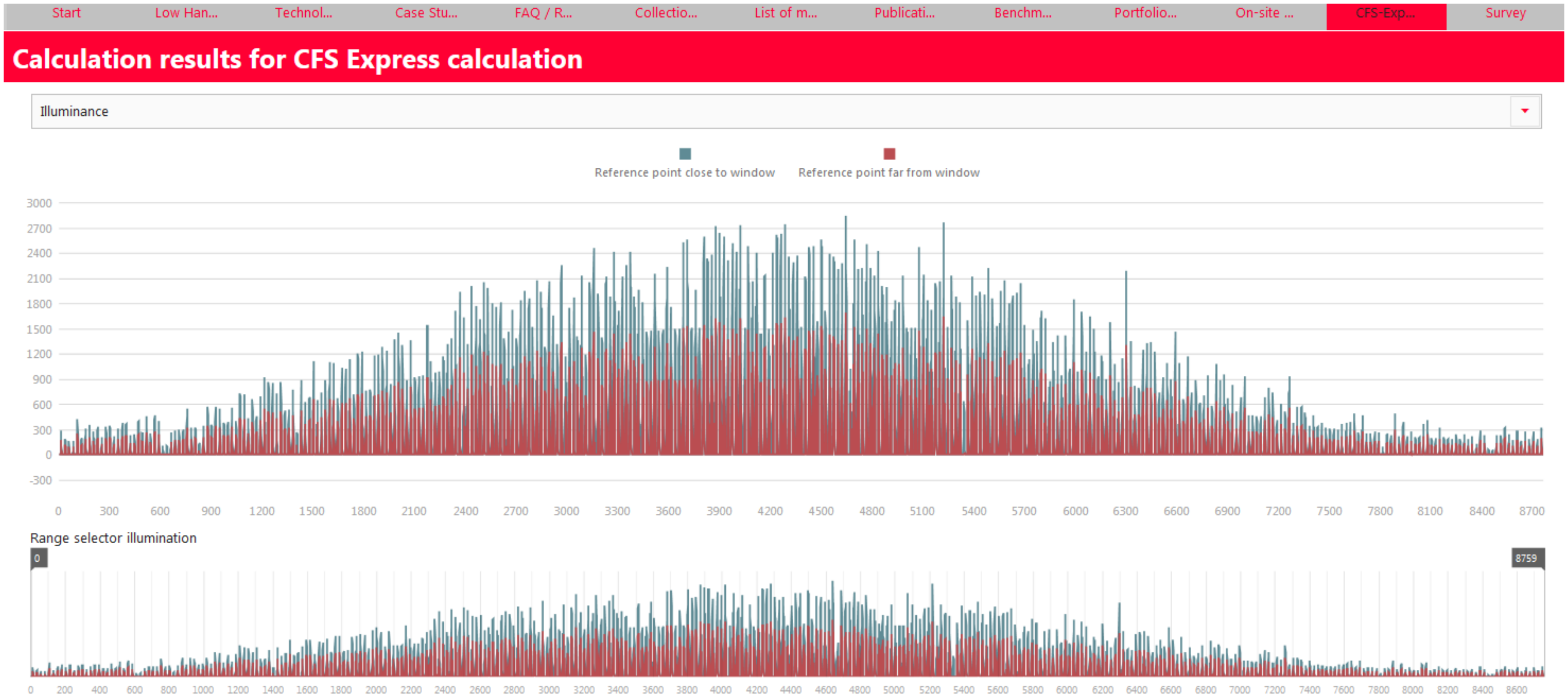
a: außenliegend; i: innenliegend; SZR: Scheibenzwischenraum

CFS (Complex Fenestration System) in Fener and LRA



IEA SHC Task 31: hours to evaluate annual performance
Now: < 5 s on a mobile device

Fast daylight analysis over a year: Illuminances



Subtask C: Methods and Tools

[Coordination: Jérôme Kaempf, EPFL, Bernard Paule, Estia Switzerland]

ciency and economics of

Lighting retrofit in current practice
Evaluation of the international survey

T50.C1

A Technical Report of IEA SHC

Draft, November 11, 2015

Methods and tools for lighting retrofits
State of the art review

T50.C2

A Technical Report of IEA SHC Task 50

Draft, November 11, 2015

Energy audit and inspection procedures

T50.C4

A Technical Report of IEA SHC Task 50

Draft, November 11, 2015

Advanced and future simulation tools

T50.C5

A Technical Report of IEA SHC Task 50

Draft, November 11, 2015

Subtask D: Case Studies
[Coordination: Marie-Claude Dubois, LTH, Sweden]

Objective: Perform building stock analysis including generation of a building typology for lighting retrofits. Based on this deliver proven and robust evidence on achievable savings and show integrated retrofit strategies for representative Case studies

D.1. Building stock / typology (selection, classification)

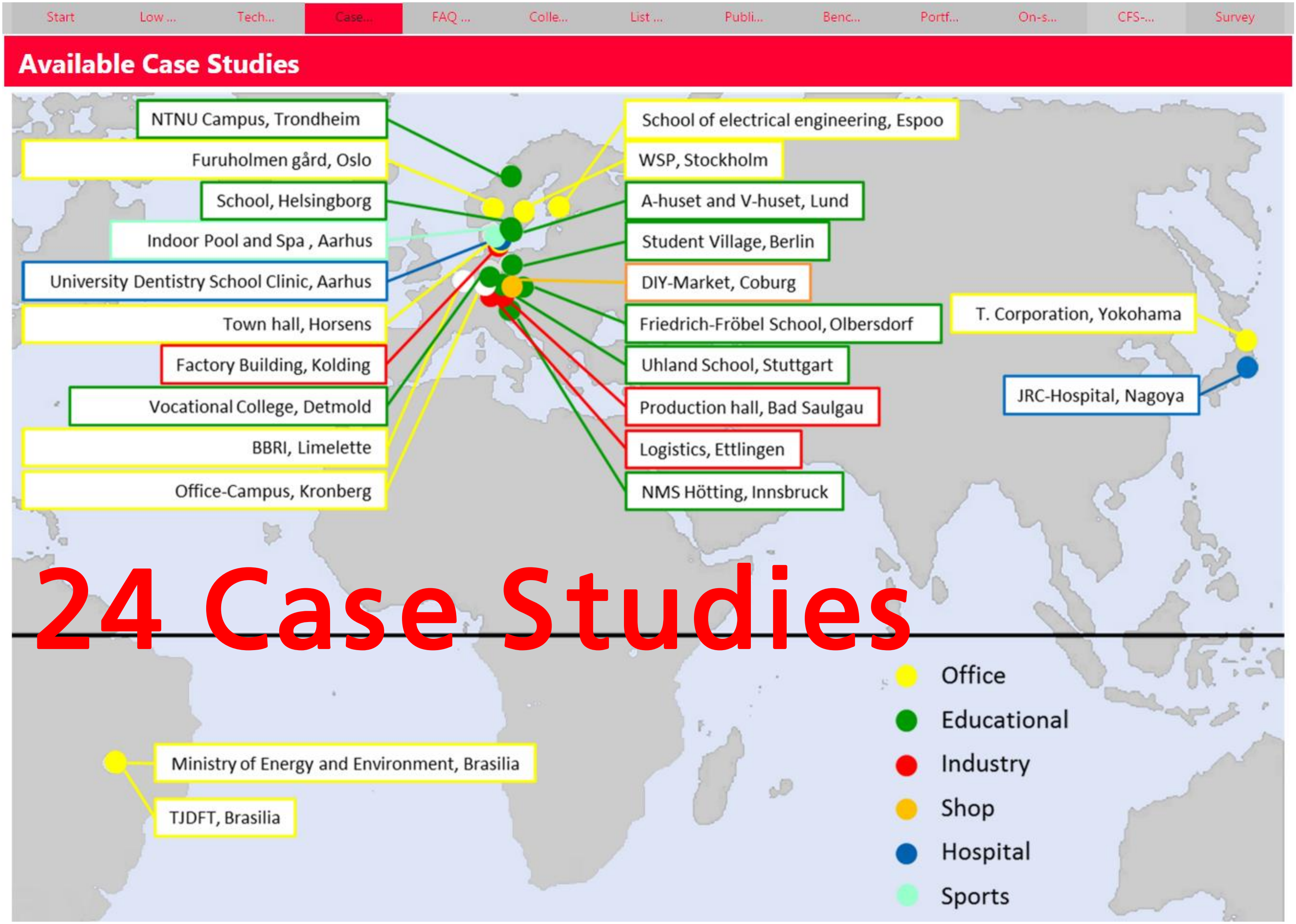
D.2. State-of-the-art (literature, e-info)

D.3. Assessment and Monitoring Procedure

D.4. Case Study assessment

D.5. Overall conclusions, lessons learned

D.6. Case Study book / e-documentation


Start
Low ...
Tech...
Case...
FAQ ...
Colle...
List ...
Publi...
Benc...
Portf...
On-s...
CFS-...
Survey
Available Case Studies
NTNU Campus, Trondheim
Furuholmen gård, Oslo
School, Helsingborg
Indoor Pool and Spa , Aarhus
University Dentistry School Clinic, Aarhus
Town hall, Horsens
Factory Building, Kolding
Vocational College, Detmold
BBRI, Limelette
Office-Campus, Kronberg
School of electrical engineering, Espoo
WSP, Stockholm
A-huset and V-huset, Lund
Student Village, Berlin
DIY-Market, Coburg
Friedrich-Fröbel School, Olbersdorf
Uhland School, Stuttgart
Production hall, Bad Saulgau
Logistics, Ettlingen
NMS Hötting, Innsbruck
T. Corporation, Yokohama
JRC-Hospital, Nagoya
24 Case Studies
Ministry of Energy and Environment, Brasilia
TJDFT, Brasilia
Office
Educational
Industry
Shop
Hospital
Sports

AUSTRIA Bartenbach R&D office, Aldrans electric/daylight-ing retrofit	BELGIUM BBRI, Limelette, Wavre Daylighting and T8 to LED	BELGIUM BBRI, Sint-Stevens-Woluwe, Lorenzberg Halogen to LED	BRAZIL Tribunal of Justice (TJDF-T), Brasília Shading devices	BRAZIL Ministry of Environ-ment (MMA), Brasília Shading devices and T12 to T8
BRAZIL Ministry of Energy (MME), Brasília Shading, T12 to T5, daylight controls	CHINA The National Library of China, Bejing Shading, T12 to T5, daylight controls	DENMARK Horsens Town Hall, Horsens Fluorescent 2700K to LED 6000K + controls	DENMARK Aarhus University Dental School Clinic T8 3000K to T5 4000K and daylight controls	DENMARK Swimming pool and bath 'Spain', Aarhus Historical building, LED and fluorescent
FINLAND Aalto University office, Espoo T8 to LED with daylight controls	GERMANY Friedrich-Fröbel School, Olbersdorf Daylighting systems and controls	GERMANY DIY Market, Coburg HMI to LED lighting	GERMANY Dietrich Bonhoeffer College, Detmold Facade renovation and T5 to LED	GERMANY Flat, Berlin Incandescent to LED bulbs
GERMANY Student Village Schlachtensee, Berlin Glazing, shadings and incandescent to LED	GERMANY Production hall Baden-Württemberg Rooflight, T8 to LED and controls	GERMANY Logistic hall T8 to LED and day-light-linked controls	GERMANY Uhlandschule School, Stuttgart-Rot T8 to T5 and combined controls	JAPAN Taisei Technical Center Fluorescent to LED
NORWAY Powerhouse Kjørbo, Oslo Building retrofit to zero emission building	SWEDEN Architectural School A-hus, Lund Renovation of interior to higher reflectances	SWEDEN WSP Headquarter, Stockholm Enhanced reflectances, T8 to T5 and controls	SWEDEN High school, Helsingborg T5 pendants to indirect LED	

Colour Key for building types

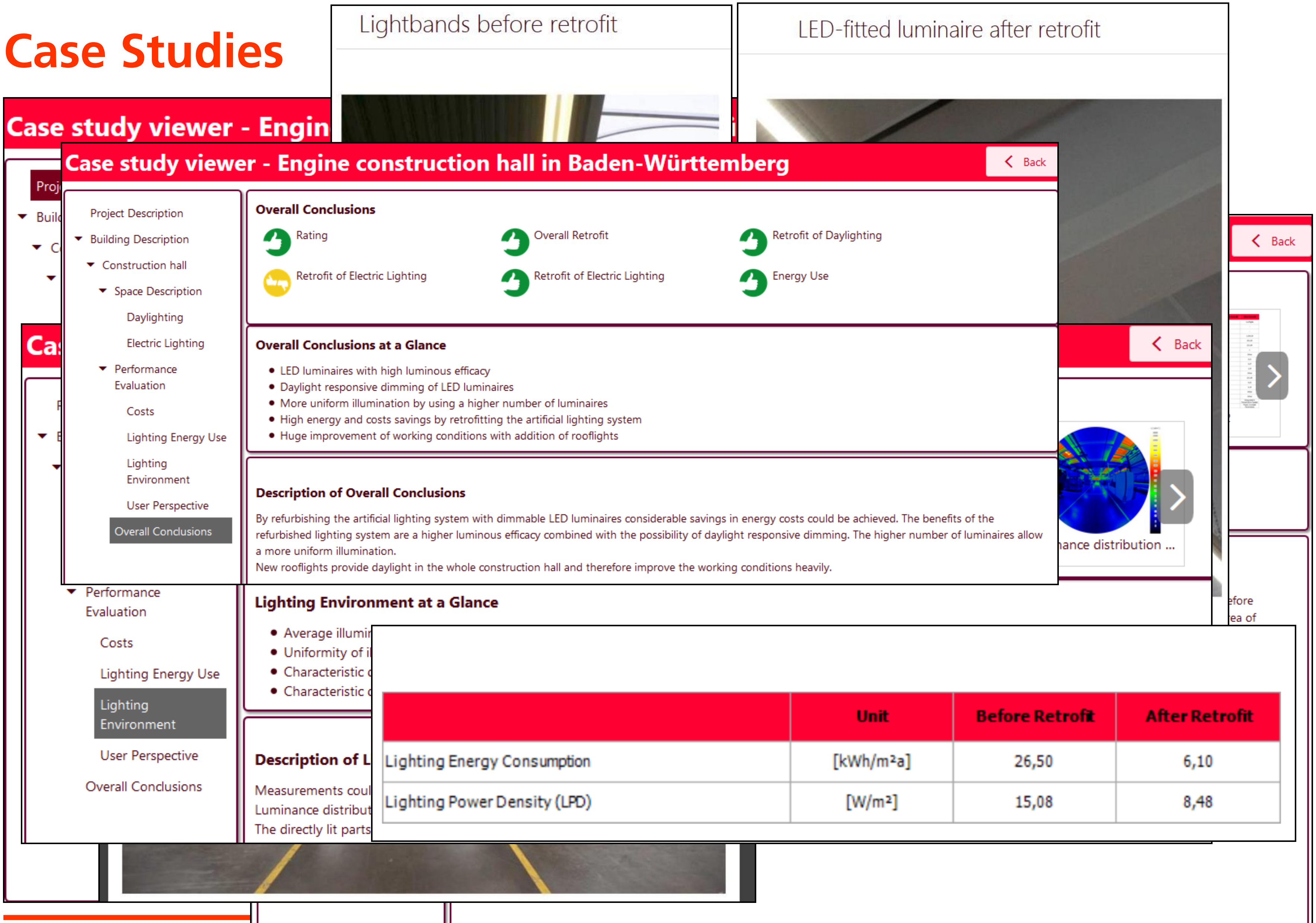
Industry	Retail	Office	Housing	Sport	Education

Assessment and Monitoring Protocol

Energy use	Retrofit costs	Photometric assessment	User assessment
assessment of the energy use	estimation of installation and running costs	objective evaluation of the luminous environment	subjective evaluation of the luminous environment

reflector		sensors	
▪ Reference grey surface		▪ many extension cables	
▪ 1 reference colour chart		▪ 1 exterior global illuminance sensor on horizontal plate	
▪ 1 hand-held lux meter (interior)		▪ 1 vertical illuminance sensor with horizontal shield	
▪ 1 hand-held lux meter (exterior)		▪ 1 amplifier	
▪ 1 hand-held luminance meter		▪ 1 cylindrical illuminance sensor mounted on tripod	
▪ 1 good quality digital camera (preferably Nikon or Canon) for HDR photography		▪ 1 spectrophotometer	

Case Studies



Case Studies Cross Evaluation

- Average improvement in energy efficiency:
  - Before retrofit: **27,1 kWh/m²a** to
  - After retrofit: **14,3 kWh/m²a.**

- All retrofits monitored achieved improvements in either energy efficiency or lighting quality or both.

Hardware Store Coeburg Germany
60 kWh/m²a
16 kWh/m²a

Lobby Lozenburg Belgium
86 kWh/m²a
16 kWh/m²a

Clinic Aarhus Denmark
73 kWh/m²a
41 kWh/m²a

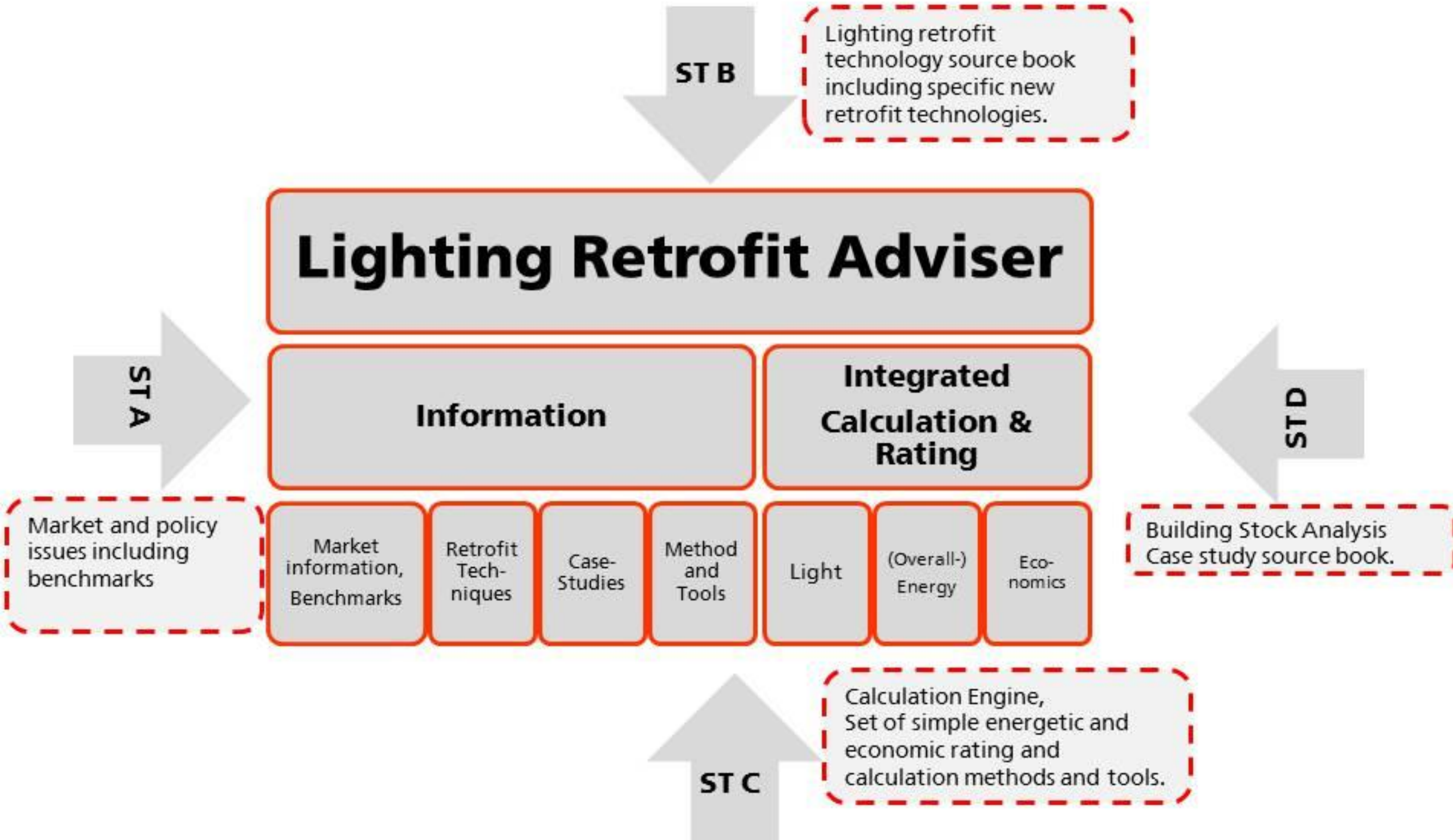
Subtask D: Case Studies

[Coordination: Marie... Dubois, LTH, Sweden]

n of a building
robust evidence on
...tative Case

Joint Working Group: Lighting Retrofit Adviser

[Coordination: Simon Wössner, Jan de Boer, Fraunhofer-IBP, Germany]



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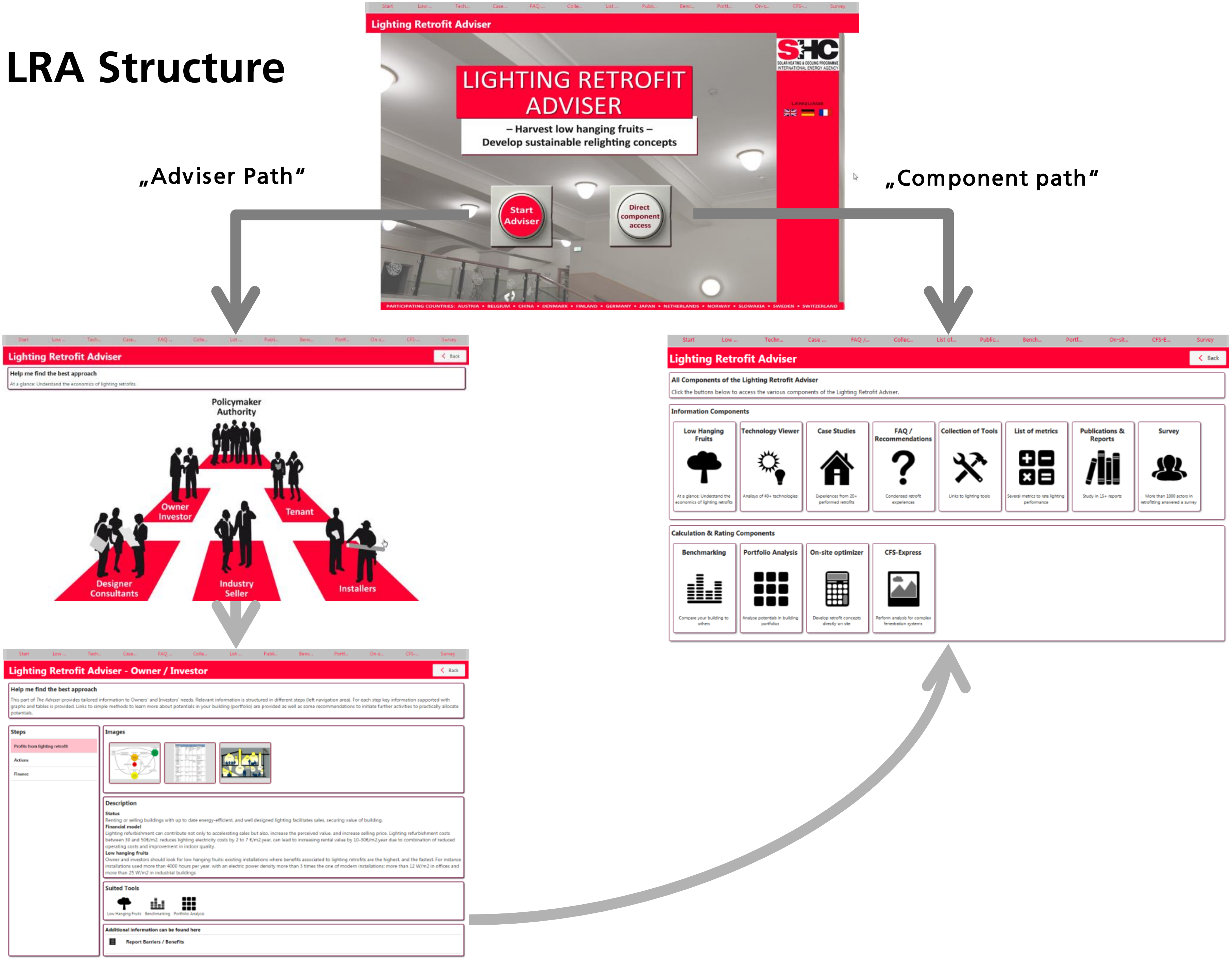
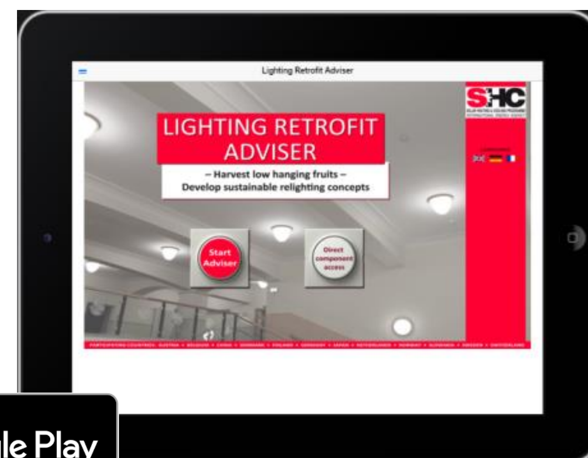
LRA Structure



Reports & Publication & Software

- 12 Technical reports
- 1 Source book
- 5 Fact Sheets
- 1 Software (LRA: Electronic Source Book), 190 MB
  www.lightingretrofitadviser.com



- 2 Newsletters
- 11 Journal articles
- 49 conference contributions

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Advanced Lighting Solutions for Retrofitting Buildings

Overview

Lighting accounts for approximately 19%, i.e. 2900 TWH, of the global electric energy consumption. Projections by the IEA show that if governments only rely on current policies, global electricity use for lighting will grow to around 4250 TWh by 2030, an increase of more than 40%. Due to the world's growing population and the increasing demand for electrically driven services in emerging economies the increase will occur despite constant improvements in energy efficiency of lighting systems. One recent study indicated that investments in energy - efficient lighting is one of the most cost-effective ways to reduce CO2 emissions.

Research and developments in the field of energy efficient lighting techniques encompassing daylighting, electric lighting and lighting controls combined with activities employing and bringing these techniques to the market can contribute significantly to reduce worldwide electricity consumptions and C02 emissions. These activities will therefore be in line with several different governmental energy efficiency and sustainability targets.

Task Information

DURATION
January 2013 — December 2015

OPERATING AGENT
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Inhalt

2 Lampenwechsel; 1:1 Leuchtentausch; »Deep Retrofit«. Wie an eine Sanierung herangehen?

Konkrete Gründe für den (Teil-) Austausch der Beleuchtungstechnik sind einerseits eine nicht mehr zeitgemäße Beleuchtungstechnik selbst oder die Miterneuerung der Beleuchtung als »Sowieso-Maßnahme« im Rahmen größerer Umbauten (Innenausbau und / oder auch Maßnahmen an der Fassade), vgl. Bild 2.

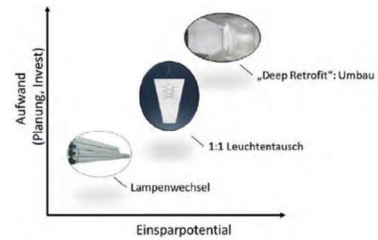


Bild 2: Einordnung von Sanierungsmaßnahmen im Bereich …trische Beleuchtung [Quelle: Fraunhofer IBP].

…ierung ausschließlich der Beleuchtung

… alleinige Sanierung alter Beleuchtungstechnik kann da- …ch motiviert sein, dass Nutzer unzufrieden sind und / …r die Kombination von ineffizienten Leuchten mit gro- … Betriebszeiten (+ höherer Wartungsanfälligkeit) hohe …irtschaftliche Betriebskosten verursacht.

4 Sind LEDs mittlerweile die zu bevorzugende Lösung?

Generell steht der Markt im Zeichen des Wandels hin zu LED-basierten Beleuchtungssystemen. Neue Leuchten werden heute bei fast allen Herstellern nur noch auf Basis der LED-Technologie entwickelt. Der Umsatz der Leuchtenindustrie mit LED-Technik in Deutschland liegt mittlerweile bei über 50 %.

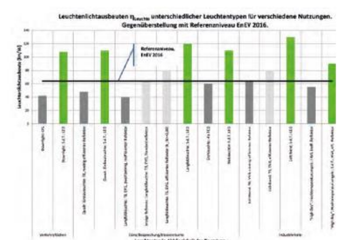
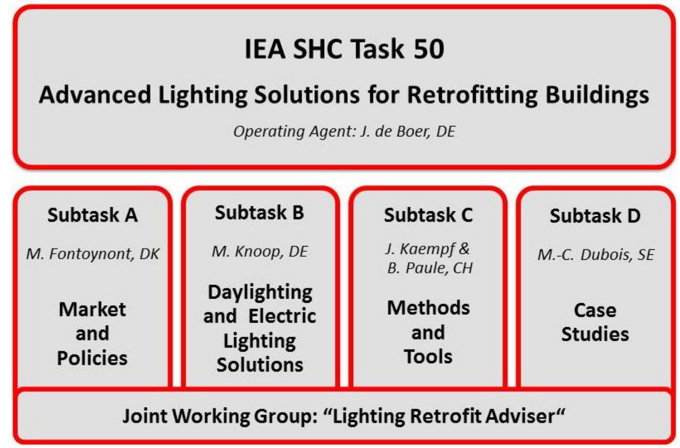
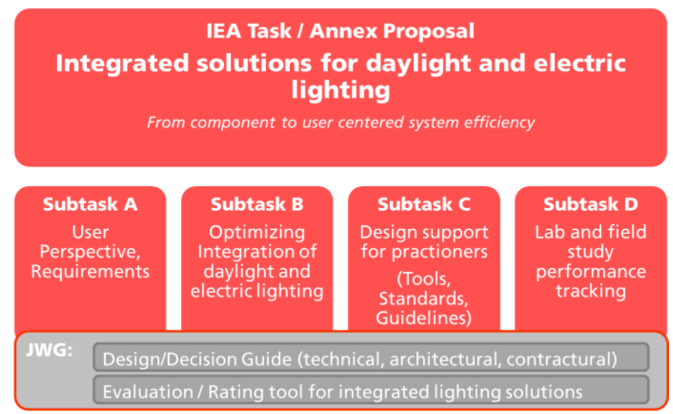


Bild 3: Leuchtenlichtausbeuten typischer elektrischer Beleuchtungslösungen (repräsentative niedrigeffiziente Leuchten: dunkelgrau. Stand der Technik Leuchten (S.d.T.): grün), Angabe verschiedener Niveaus der Leuchtenlichtausbeute (Stand: Anfang 2016) [Quelle: Fraunhofer IBP].

Lighting in the scope of IEA – SHC

- IEA-SHC Task 21/ECBCS Annex 29 *„Daylighting in Buildings", 1995-1999*
- IEA-SHC Task 31 *„Daylighting Buildings in the 21st Century", 2001-2005*
- **IEA SHC Task 50 *„Advanced lighting solutions for retrofitting buildings", 2013-2015 (2016)***
- IEA Task 56 *„Building Integrated Solar Envelope Systems for HVAC and Lighting", 2016-2020*
- **New Task proposal: "Integrated solutions for daylight and electric lighting"**





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Outlook

IEA Task / Annex Proposal

Integrated solutions for daylight and electric lighting

From component to user centered system efficiency

Task organizer: J. de Boer, Germany

Subtask A

M. Knoop, Germany

User Perspective, Requirements

Subtask B

M. Fontoynont, Denmark

Optimizing Integration of daylight and electric lighting

Subtask C

D. Geisler-Moroder, Austria

Design support for practioners

(Tools, Standards, Guidelines)

Subtask D

N. Gentile, Sweden

W.Osterhaus, Denmark

Lab and field study performance tracking

Joint Working Group

- Design/Decision Guide (technical, architectural, contractual)
- Evaluation / Rating tool for integrated lighting solutions