

**IEA International Energy Agency
ECBCS Energy Conservation in Buildings
and Community Systems**

Annex 45

**Energy Efficient Electric Lighting for
Buildings**

Annex Workplan / September 2006

www.lightinglab.fi/IEAAnnex45

Operating Agent

Liisa Halonen
Professor, D.Sc. (Tech.)
Helsinki University of Technology
Lighting Laboratory
P.O.Box 3000; 02015 HUT
Finland

Phone : +358 9 4512418
Fax : +358 9 4514982
E-mail: liisa.halonen@hut.fi



HELSINKI UNIVERSITY OF TECHNOLOGY
Lighting Laboratory

1 Background

Lighting-related electricity production for the year 1997 was 2016 TWh, of which 1066 TWh was attributable to IEA member countries. Of the global lighting electricity use approximately 28 % is distributed to residential sector, 48 % to service sector, 16 % to industrial sector, and 8 % to street and other lighting. In the industrialized countries national lighting electricity use ranges from 5 % to 15 %, while in developing countries the value can be as high as 86 % of the total electricity use. Of the lighting-related electricity production the corresponding carbon dioxide emissions were 1775 million tonnes, of which approximately 511 million tonnes were attributable to the IEA member countries. [1]

The more efficient use of lighting energy would limit the rate of increase of electric power consumption, reduce the economic and social costs resulting from constructing new generating capacity, and reduce the emissions of greenhouse gases and other pollutants. At the moment fluorescent lamps dominate in office lighting. In domestic lighting the dominant light source is still the more than a century old, inefficient incandescent lamp. Interesting aspects of desired lighting are energy savings, daylight use, individual control of light, quality of light, emissions during life cycle and total costs. The demands for the new light sources are: higher efficiency, ecological, lower costs, better light quality, longer lifetime, suitability for dimming, control and other value added features. LEDs (Light Emitting Diodes) are new alternative light sources, which are foreseen to revolutionise the lighting technology in the near future. According to Agilent Technologies the lm/package value of red LEDs is increasing 30 times per decade whereas the price is decreasing 10 times per decade [2]. According to one scenario, the LED's share of lighting market can be 20 % in 2010 and 50 % in 2020 [3]. The use of LED based lighting will decrease the lighting energy consumption by 50 % by the year 2025 [4]. The foreseeable future of LED luminaires targeted for general illumination will use arrays of LEDs and not a single LED [5].

At present, high pressure discharge lamps cannot replace other lamp types. Reasons are given in the start performance and in the fact that they cannot be dimmed well. On the other hand, their advantages are good colour rendering and high luminous efficacy. The high pressure discharge lamps are very energy-efficient lamp types. Their small discharge body allows a more efficient reflector design for luminaires so that the luminous flux leaving the luminaire can be distributed effectively in the room. Typically, it takes 3 minutes to emit 80% of the luminous flux of high pressure discharge lamp. For car lamps, this time has been reduced to 3 seconds already [6]. Research on the interaction of ballast electronics and high pressure discharge lamps may generally improve the performance of this lamp type.

The building sector in the EU consumes over 40 % of energy use in EU and is responsible for over 40 % of its carbon dioxide emissions. Lighting is a substantial energy consumer, and a major component of the service costs in many buildings. The percentage of the electricity used for lighting in European buildings is 50 % in offices, 20-30 % in hospitals, 15 % in factories, 10-15 % in schools and 10 % in residential buildings [7]. To promote the improvement of the energy performance of buildings within the community, the European Parliament has adopted the Directive 2002/91/EC on the energy performance of buildings. [8]

Electric light is obtained as a result of combination of equipment. Modern lighting system needs light sources, ballasts, luminaires and controls. Part of the power input to the lighting

unit is transformed into light, while the rest is considered as loss. Energy is lost in lamps, luminaires and ballasts in the form of heat. The saving of lighting energy requires the use of energy efficient components as well as the application of control, dimming, and the use of daylight. CEN TC 169 has working groups on illumination of indoor and outdoor applications, and on measurement and presentation of photometric data of lamps and luminaires. The Annex has to also acknowledge the work conducted by the various other international organisations including CEN (European Committee for Standardisation [9]), CIE (International Commission on Illumination) and IESNA (Illuminating Engineering Society of North America [10]). This Annex will have close contacts with IEA SHC Task 31 Daylighting Buildings in the 21st Century.

2 Objectives

The goal is to identify and to accelerate the widespread use of appropriate energy efficient high-quality lighting technologies and their integration with other building systems, making them the preferred choice of lighting designers, owners and users.

The aim is to assess and document the technical performance of the existing promising, but largely underutilized, innovative lighting technologies as well as future lighting technologies and their impact on other building equipment and systems (ie: daylighting, HVAC). These novel lighting system concepts have to meet functional, aesthetic, and comfort requirements of building occupants.

The aim is to assess and document the barriers preventing the adoption of these promising existing and future technologies (ie: technical, economic, risk factors, resistance to change, legislative, etc.) and propose means to resolve these barriers.

3 Scope

The potential for energy savings in lighting is very large and can be further increased by integrating electric lighting, daylighting and HVAC systems. The character of lighting used in buildings is changing dramatically in parallel with these efficiency-related changes. The implementation of new light sources, integrated and 'smart' controls and innovative luminaires provides the opportunity for much greater variation in the spatial distribution, spectral content and temporal control of various light sources. For instance with LEDs it is possible to control the correlated colour temperature, colour rendering, luminous intensity and luminous distribution. These flexible and responsive systems are seen as having critical value to the next generation of lighting solutions in buildings. As lighting moves into this more dynamic regime, it is critical that the impact on performance of the system components, the end user, and associated integrated building systems are well understood, documented and predicted. This knowledge will help to optimize the energy efficiency of the new and existing building-integrated systems, improve the implementation of the new technologies, and accelerate the introduction of more energy efficient and ergonomic products and procedures, thus providing better working environment and cost-effectively contributing to the global reduction of greenhouse emissions.

The components that affect the total lighting energy use are and, thus, the scope of the proposed new Annex is:

- The lighting equipment used (lamps, ballasts, luminaires, sensors, etc)
- The lighting performance targets and design of lighting
- The control and integration of lighting.

4 Structure

The structure of Annex 45 is shown in Figure 1.

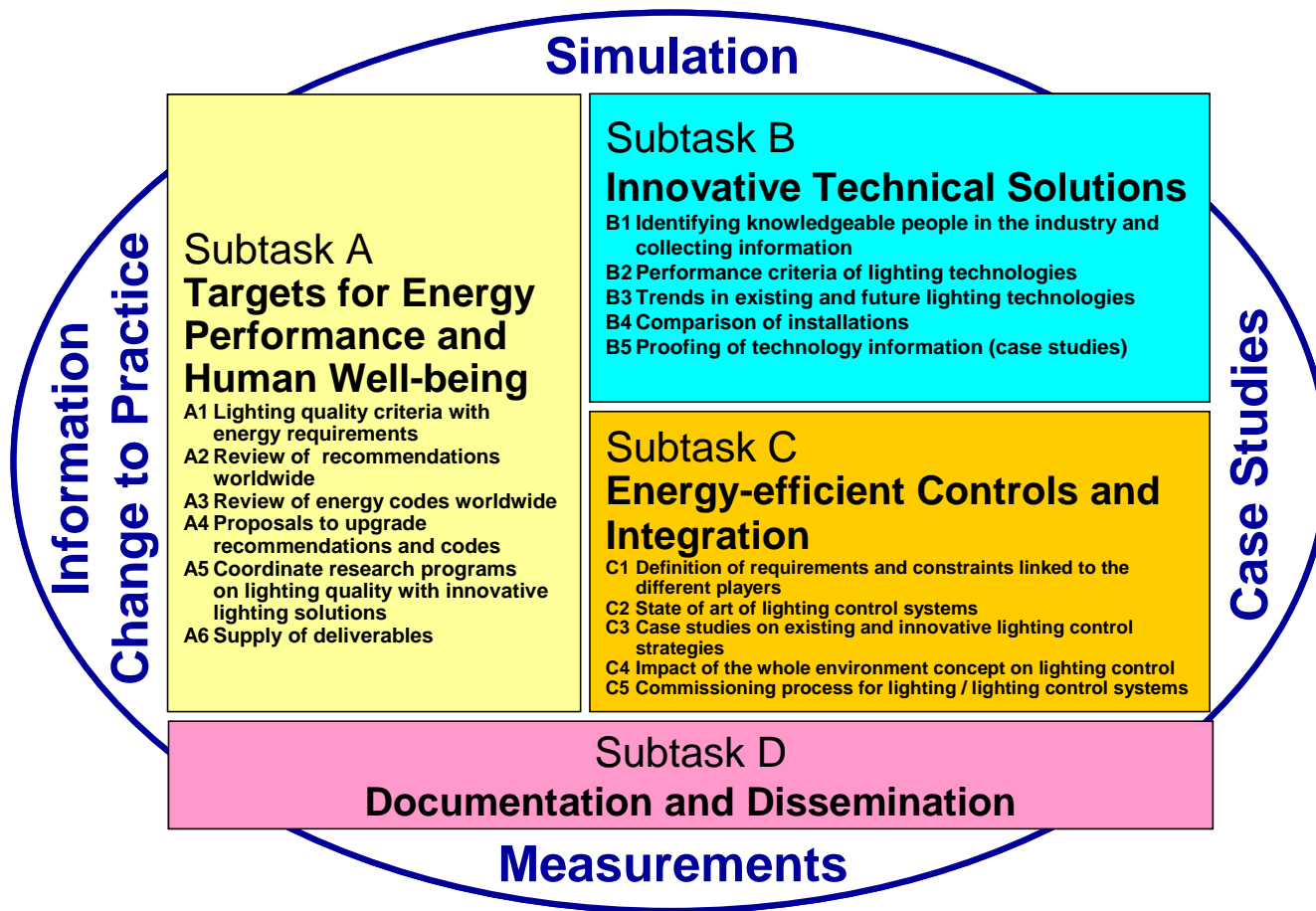


Figure 1. Structure of the Annex 45.

The following four Subtasks will be carried out in order to reach the objectives:

- Subtask A Targets for energy performance and human well-being
- Subtask B Innovative technical solutions
- Subtask C Energy-efficient controls and integration
- Subtask D Documentation and dissemination

The detailed working plans for the Subtasks are given at the end of this document.

5 Management of the Annex

The Annex is managed by the Operating Agent with the assistance of the Subtask Leaders.

Operating Agent and Subtask Leaders

Operating Agent:	Finland, Helsinki University of Technology, Professor Liisa Halonen
Subtask A Leader:	France, École Nationale des Travaux Publics de l'État (ENTPE), Professor Marc Fontoynt
Subtask B Leader:	Austria, Bartenbach LichtLabor, General Manager Wilfried Pohl
Subtask C Leader:	France, Centre Scientifique et Technique du Batiment, Mireille Jandon and Ahmad Husaunndee
Subtask D Leader:	Finland, Helsinki University of Technology, D.Sc. Eino Tetri.

Responsibilities of Operating Agent

The Operating Agent is responsible for the overall status and planning, time schedule, compilation of reports and information dissemination of the Annex.

The operating Agent shall:

- Prepare the detailed Workplan for the Annex in consultation with the Subtask Leaders and the Participants and submit the Workplan and time schedule for approval to the Executive Committee
- Be responsible for the overall management of the Annex, including overall co-ordination, liaisons between the Subtasks and communications with the Executive Committee
- Chair the Annex meetings and be responsible for setting the meeting Agendas. Assistance for each meeting will be provided by the Participant from the country hosting the meeting
- Prepare and distribute the results of the Annex
- At the request of the Executive Committee organize workshops, seminars, conferences and other meetings
- Provide semi-annually periodic reports to the Executive Committee on the progress and results of the work
- Provide an annual technical report to the Annex Participants
- Provide to the Executive Committee, within 12 months after completion of all work under the Annex, a final report for its approval
- Provide the Participants with the necessary guidelines for the work to be carried out under the Subtasks, for the reports to be made and information to be distributed.

Responsibilities of Subtask Leaders

The Subtask Leader shall be a Participant who provides expertise to the Subtask and undertakes substantial research and development in the field of the Subtask.

The Subtask Leaders are responsible for:

- Co-ordinating the work performed under that Subtask
- Assisting the Operating Agent in preparing the detailed workplan

- Assisting in the co-ordination of the Annex and advising the Operating Agent on the performance of the Annex
- Providing semi-annual status reports on progress and results to the Operating Agent and to the other Participants
- Directing technical workshops and provide the Operating Agent with written summaries of workshop results
- Editing technical reports resulting from the Subtask and organising their publication
- Assisting the Operating Agent in editing the final report of the Annex.

6 Deliverables and Annex beneficiaries

The design guidebook of energy efficient lighting will be the final product of the Annex. It will be published as a book, as a CD-ROM and on the web. The other deliverables are semi-annual newsletters, seminars and a web-site.

In addition to technical reports, scientific papers and conference papers will be published during the Annex. Each of the Subtasks A, B and C will deliver a written summary reporting the work carried out in the Subtask during the Annex. These reports will be compiled and completed in Subtask D. The editorial work will be carried out by the Operating Agent with the assistance of the Subtask Leaders.

The main target groups of the deliverables are lighting designers, electrical building services and system integrators in buildings and the end-users/owners. The designers are a good target group while it is well defined and serving both commercial and residential lighting applications. They require references, guidelines and analysis tools which are applicable also for researchers. The end-users/owners need promotional material that is simple in content. The results are also disseminated by delivering information to standardisation and recommendations and by providing educational material to educational institutions in order to positively affect the future lighting professionals. The integration of lighting to building services benefits the occupant, the building operator, the owner and the society at large. The objective is to positively impact the current lighting practices in a manner that accelerates the use of energy efficient products, thus benefiting lighting industry, improves the overall building performance and enhances the occupant's environmental satisfaction.

7 Time Schedule and milestones

The Annex will run for four and a half year from July 2004. Preparation and planning will be carried out during the first half a year and the following four years will be full working years.

Table 1. Time schedule of the Annex and Subtasks.

Subtask A	2005	2006	2007	2008
A1 Lighting quality criteria with energy requirements	■	■	■	■
A2 Review of specifications worldwide	■	■	■	■
A3 Review of energy codes worldwide	■	■	■	■
A4 Proposals to upgrade specifications & codes	■	■	■	■
A5 Coordinated research programs on lighting quality	■	■	■	■
A6 Supply of deliverables	■	■	■	■
Subtask B	2005	2006	2007	2008
B1 Identifying knowledgeable people in the industry and collecting information	■	■	■	■
B2 Performance criteria of lighting technologies	■	■	■	■
B3 Trends in existing and future lighting technologies	■	■	■	■
B4 Comparison of installations	■	■	■	■
B5 Proofing of technology information (case studies)	■	■	■	■
Subtask C	2005	2006	2007	2008
C1 Requirements for control and constraints	■	■	■	■
C2 State of art of lighting control	■	■	■	■
C3 Case studies on existing and innovative control	■	■	■	■
C4 Impact of whole environment concept on lighting	■	■	■	■
C5 Commissioning process for lighting & lighting -> input to "guide book"	■	■	■	■
	2005	2006	2007	2008
Subtask D	■			
Expert Meetings	●	●	●	●

■ Extended

Table 2. Milestones of the Annex.

Milestones	2005	2006	2007	2008
Milestones A				
State-of-the-art quality criteria		● D1		D2 F
State-of-the-art specifications		● D1		D2 F
Comparisons of existing practice			D2	F
Performance assessment			●	
D1 Draft 1, D2 Draft 2, F Final				
Milestones B				
Identification (B1)	●	●	●	
Technology report (B2+B3)			●	●
Documentation of case studies (B4)		●	●	●
Matrix for end-users and owners (B5)			●	
Lighting Desing Matrix for designers (B5)			●	●
Milestones C				
Questionnaire		●		
State of art			●	
Conventional Best Practice on control			●	
Evaluation of new technologies for controls				●
Case studies				●
Commissioning plan				●
Milestones D				
Newsletter	●	●	●	●
Seminars			●	●
Web-site update	●	●	●	●
Guidebook			● D1	● D2 ● D3
Expert Meetings	●	●	●	●

● Milestone postponed

8 Funding and Commitment

The work has been divided into four Subtasks and each Participant shall work in at least one of the Subtasks. All Participants are also required to deliver information and written material to the final reports as agreed in the Annex. Each Participant shall individually bear its own costs incurred in the Annex activities. This funding is expected to cover labour costs (including eventual overhead costs) associated with the execution of activities defined in chapter 4 and in the detailed Subtasks working plans, and travelling costs for participating in at least two expert meetings per year during the four-year working phase of the Annex. The working meetings shall be hosted in turn by the various Participants. The costs of organising and hosting the meetings shall be borne by the host Participant.

Any participating country has access to the workshops and results of all Subtasks. The participating country must designate at least one individual (an active researcher, scientist or engineer, here called expert) for each Subtask they participate in. It is expected that the same expert attends all expert meetings and acts as technical contact person regarding the national Subtask contribution. A minimum commitment of 3 manmonths of labour for each year of the Annex term will be required for participation in the Annex. For the Subtask Leaders the funding shall allow for extra 2 manmonths per year for Annex activities. For the Operating Agent the funding shall allow for extra 4 manmonths per year for Annex activities including the attendance at two ExCo-meetings per year.

9 Meetings

The Operating Agent will organize semi-annual Expert Annex Meetings, which will be alternatively hosted by the participating countries. In connection with the Expert Annex Meetings the Subtask Leaders will organize and convene Subtask meetings. The Participants of each Subtask may also decide to organize separate Subtask meetings.

10 Co-operation with other Implementing Agreements

Information will be exchanged with the IEA Task 31 Daylighting Buildings in the 21st Century.

11 Participants

The working Participants of this Annex are presented in Table 3.

Table 3. Participants of the Annex.

Phillip Greenup	Sustainable Technologies Group	Australia
Steve Coyne	Queensland University of Technology	Australia
Peter Dehoff	Zumtobel Staff GmbH	Austria
Wilfried Pohl	Bartenbach LichtLabor GmbH	Austria
Arnaud Deneyer	Belgian Building Research Institute	Belgium
Magali Bodart	Université Catholique de Louvain	Belgium
Alexander Rosemann	University of British Columbia	Canada

Lorne Whitehead	University of British Columbia	Canada
Michele Mossman	University of British Columbia	Canada
Chen Dahua	Fudan University	China
Chen Yuming	Fudan University	China
Edward Yuan	Fudan University	China
Wang Aiqun	Shanghai Hongyuan Lighting & Electric Equipment Co	China
Eino Tetri	Helsinki University of Technology	Finland
Liisa Halonen	Helsinki University of Technology	Finland
Markku Virtanen	TAKE	Finland
Marc Fontoynt	École Nationale des Travaux Publics de l'État (ENTPE)	France
Ahmad Husaundee	CSTB	France
Michel Perraudeau	CSTB	France
Mireille Jandon	CSTB	France
Herve Lefebvre	ADEME	France
Susanne Harchaoui	Lumen Art	France
Heinrich Kaase	Technische Universität Berlin	Germany
Henri Kretschmer	Technische Universität Berlin	Germany
Felix Serick	Technische Universität Berlin	Germany
Mehmet Yeni	Technische Universität Berlin	Germany
Jan de Boer	Fraunhofer Institute	Germany
Fabio Bisegna	Università di Roma "La Sapienza"	Italy
Simonetta Fumagalli	ENEA Ispra	Italy
Anna Pellegrino	Politecnico di Torino	Italy
Valentina Serra	Politecnico di Torino	Italy
Yasuhiro Miki	National Institute for Land and Infrastructure Management	Japan
Toshie Iwata	Tokai University	Japan
M. van der Voorden	Delft Univ of Technology	Netherlands
Regina Bokel	Delft Univ of Technology	Netherlands
Barbara Matusiak	NTNU and SINTEF	Norway
Tore Kolås	NTNU	Norway
Zbigniew Mantorski	Silesian University ofTech.	Poland
Julian Aizenberg	Svetotehnika, Light House Moscow	Russia
Lee Siew Eang	National University of Singapore	Singapore
Nils Svendenius	Lund University	Sweden
Sven Huldt	Lund University	Sweden
Peter Pertola	WSP Elteknik	Sweden
Lars Bylund	BAS Bergen school of architecture	Sweden
Nicolas Morell	Solar Energy & Building Physics Laboratory	Switzerland
David Lindelöf	Solar Energy & Building Physics Laboratory	Switzerland
Gilles Courret	CeTT Ecole d'Ingénieurs du Canton de Vaud	Switzerland
Dilek Enarum	Istanbul Technical University	Turkey
Li Shao	University of Nottingham	UK
Trevor Forrest	Helvar	UK
Stephen Selkowitz	Lawrence Berkeley National Laboratory	USA

National Interest Groups

The intention is to build an interest group to each country. Following interest groups exists:

Finland

Helvar

<http://www.helvar.com/>

Helvar manufactures ballasts and lighting control electronics for the luminaire industry and other customers specialising in lighting. The product range includes magnetic ballasts, controllable and non-controllable electronic ballasts, and a wide variety of lighting control systems.

Idman Oy

<http://www.idman.fi/>

Idman Oy develops, manufactures and markets luminaires and lighting systems for private and public use and is the market leader in special purpose luminaires in Finland. Idman is part of the international Philips consortium and is Philips Lighting's centre for lighting expertise in the Nordic countries.

Senate Properties

<http://www.senaatti.com/>

Senate Properties is a government-owned enterprise responsible for managing, developing and letting the property assets of Finnish state.

China

Shanghai Hongyuan Lighting & Electric Equipment Co

www.LVD.cc

www.shhongyuan.com

Contact person: Amy Wang

Shanghai Hongyuan Lighting & Electric Equipment Co, Ltd. owns electromagnetic induction lamp R&D center with Fudan University, forms the largest manufacture base for induction lamps in China, produce industrial and commercial light fixtures to accomade induction lamp with CE, UL approval.

Poland

ENTE Sp.z o.o. (Ltd.)

<http://www.ente.com.pl>

ENTE Sp. z o.o. manufactures IT and electronic components and systems for different systems of economy, among others offers equipment for intelligent control and visualization and broadband platform for the long range networks.

WASKO S.A. (joint stock comp.)

<http://www.wasko.com.pl>

WASKO S.A. implements IT solutions to companies and institutions, builds data communication networks and base stations for telephony, offers comprehensive ICT services for emergency communication centers.

13 References

- [1] Mills E. Why we're here: The \$320-billion global lighting energy bill. Right Light 5, May 2002, Nice, France. pp. 369-385.
- [2] Haitz, R. Another Semiconductor Revolution: This Time it's Lighting; Proceedings of 9th International Symposium on the Science and technology of Light Sources; Ithaca, NY, USA, 2001
- [3] Kendall M. & Scholand M. 2001. Energy Savings Potential of Solid State Lighting in General Lighting Applications, Final Report. Prepared by Arthur D. Little, Inc. for U.S. Department of Energy. April 2001.
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- [5] Narendran, N. & Bullough, J. D. Light Emitting Diodes as Light Sources; Proceedings of 9th International Symposium on the Science and technology of Light Sources; Ithaca, NY, USA, 2001
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- [7] http://www.europa.eu.int/comm/energy_transport/atlas/html/lightdintro.html, accessed on 24th of April 2004.
- [8] Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings, 6 p.
- [9] EN 12464-1 Light and lighting – lighting of work places – Part 1: Indoor work places November 2002.
- [10] The IESNA Lighting Handbook. Reference and Application. Illuminating Engineering Society of North America. 9th Edition. 2000.

Detailed Working Plan of Subtask A Targets for energy performance and human well-being

Subtask A Leader

Professor Marc Fontoynt
Ecole Nationale des Travaux Publics de l'Etat (ENTPE)
Rue Maurice Audin F 69120 Vaulx en Velin
France
Phone: +33(0)4 72 04 70 35
Fax: +33 (0) 4 72 04 70 41

1 Objectives

Subtask A aims at providing the grounds for future high efficiency lighting schemes which should meet various specifications of the human being, with the lowest possible requirement in energy. The major outputs will be performance targets, both regarding the quality of the luminous environment and the lighting installation. New methods will be developed to assess the performance of lighting installation, at the design stage, or during analysis of given scenes, either in buildings or in laboratory test rooms. The Subtask A will also coordinate research activities in the field of solid state lighting to define high performance criteria for lighting fittings which should replace progressively the most non-efficient solutions today. An important objective is also the identification and description of technical and psychology barriers preventing energy efficient technical solutions and methods.

Targets for energy performance as well as targets for human well-being which describe the lighting quality are defined in subtask A. Different demands on levels of lighting quality have a strong impact on the technical solution how energy efficiency will be reached. The performance criteria include the spectral (colour rendering, colour temperature), electrical (harmonics and power factor, power supply aspects) and user related issues (acceptability, glare considerations etc.) The energy criteria include energy efficiency as well as suitability for other energy savings systems, life cycle energy considerations, maintenance and operation. The economical criteria include cost of devices and of application (also into existing systems).

The members of Subtask A have to acknowledge the work conducted by the various international organisations:

- Commission Internationale de l'Eclairage in general, particularly:
 - CIE (2004) Ocular lighting effects on human physiology and behaviour (Technical Report 158), Vienna Austria
 - Commission Internationale de l'Eclairage, (2004) Test cases to assess the accuracy of lighting computer programmes, Technical report 3.33
 - Division 6 and Division 3 activities
- International Energy Agency, SHC Programme, Task 31 "Daylighting Buildings in the 21st Century"
- International Energy Agency, Task 43 (Modelling)
- All activities conducted by the IES (North America) and National organisations in the OECD Countries.

2 Structure and tasks

The work of Subtask A will be conducted through six tasks. Two tasks will deal with review of specifications: on one hand human needs, on the other hand, lighting installation standards. This will allow us, in subtask 3 to define short term and long term performance targets. In parallel, the research teams will collaborate to develop assessment methods and will launch prospective research aimed at defining new solid state lighting options.

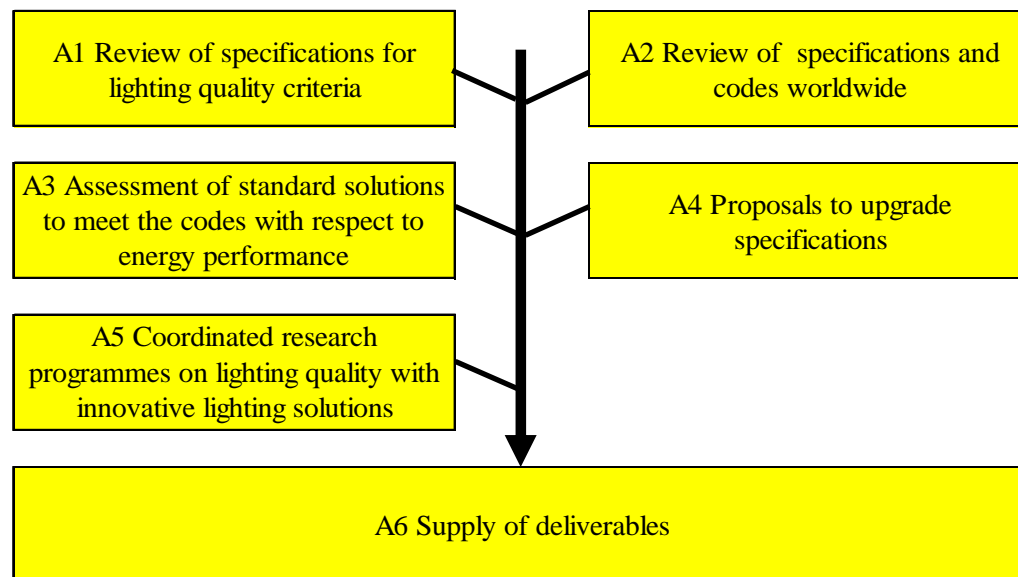


Figure 1. The structure of the Subtask A.

The tasks are listed below:

- A1 Review of specifications for lighting quality criteria
- A2 Review of specifications and codes worldwide
- A3 Assessment of standard solutions to meet the codes with respect to energy performance
- A4 Proposals to upgrade specifications
- A5 Coordinated research programmes on lighting quality with innovative lighting solutions
- A6 Supply of deliverables

A1 Review of specifications for lighting quality criteria

Before identifying the way to establish a sound compromise between lighting quality and energy performance of lighting systems, it is essential to summarize what are the specifications regarding lighting quality on various aspects: psychological, physiological, ergonomics, productivity, aging population, visually impaired population, cultural differences, social role of lighting quality.

For each of the above categories, it will be defined what are the relevant parameters and quantities relevant to the field and the range of values corresponding to the rating of qualitative indices, from low quality to high quality.

Teams in charge: ENTPE (France), University Lund (Sweden), HUT (Finland), NRCC (Canada)?

A2 Review of specifications and codes worldwide

For four major categories of buildings, such as offices, educational buildings, industrial buildings, and homes, the specifications of the electric lighting installation as is expressed in codes in various countries. The aspects considered will be illuminances and uniformities, luminance distribution, glare control, spectral distribution, and also energy management strategies.

Teams in charge: ENTPE (France), University of Lund (Sweden), HUT (Finland).

A3 Assessment of standard solutions to meet the codes with respect to energy performance

The objective of this task is to supply various scenarios of evolutions of indoor lighting, from existing state of the art in OECD countries, to common practice following new energy codes, and then according to various future scenarios in 10 or 20 years. Again, major building categories will be covered in the field of offices, educational buildings, industrial buildings, and homes. The calculations of the annual consumption in lighting for all schemes will require the development of model integrating hypothesis on daylight availability and the type of electrical supply (ballasts / voltage). This task will also help to identify energy saving potential, priorities of actions, and barriers for dissemination of lighting technologies.

Teams in charge: ENTPE (France), CSTB (France), University of Lund (Sweden), HUT (Finland).

Additional input from: LBNL (USA), TUB (Germany), Fraunhofer Stuttgart (Germany), Zumtobel (Austria), SUT (Poland), LESO (Switzerland), BBRI (Belgium).

A4 Proposals to upgrade specifications

The task will develop methods to assess lighting quality and lighting performance. These methods will be fully documented. They will cover for instance: Lighting simulation, characterization of luminous environment, experimental protocol, simulation, etc.

Teams in charge: ENTPE (France), CSTB (France), Lund (Sweden), HUT (Finland), Fraunhofer Institute (Germany).

A5 Coordinated research programmes on lighting quality with innovative lighting solutions

This task will collect spectral data and perform calculations of colour temperature and colour rendering of mixtures of various LEDs. Colour chart tests will be organised and presented to panels of observers. Tests in real physical environments will be performed, dealing with LEDs and fluorescent and discharge lamps. Define light fittings with LEDs (configuration, type of LEDs, optics, etc.), and compare them with existing luminaires.

Teams in charge: ENTPE (France), HUT (Finland) and TUB (Germany). Part of the work will be done in two parallel PhD Programmes (2005-2008).

A6 Supply of deliverables

The Subtask A will produce five reports:

- RA1 Review of specifications for lighting quality criteria
- RA2 Review of specifications concerning the electric lighting installation
- RA3 Comparison of existing practice, potential for energy savings in lighting
- RA4 Development of performance assessment methods and presentation of tools
- RA5 Research on lighting quality specification with LEDs (publications and PhD Thesis)

3 Deliverables and beneficiaries

The targets and the solutions will be published to update lighting and energy codes in the OECD countries, through the various international and national bodies (CIE, CEN, IES, etc.). They will be also used by the professionals, decision makers and the scientific and technical community. The Subtask A will produce five reports mentioned above.

4 Time Schedule and milestones

Table 1. Time schedule and milestones of Subtask A.

Subtask A	2005	2006	2007	2008
A1 Lighting quality criteria with energy requirements				
A2 Review of specifications worldwide				
A3 Review of energy codes worldwide				
A4 Proposals to upgrade specifications & codes				
A5 Coordinated research programs on lighting quality				
A6 Supply of deliverables				
Milestones	2005	2006	2007	2008
Milestones A				
State-of-the-art quality criteria	●	D1	D2	F
State-of-the-art specifications	●	D1	D2	F
Comparisons of existing practice		D1	D2	F
Performance assessment			●	

D1 Draft 1, D2 Draft 2, F Final

5 Participants

Coordinator

Marc Fontoyront	marc.fontoyront@entpe.fr	École Nationale des Travaux Publics de l'État (ENTPE)	France
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Participants

Reto Miloni	miloni@swissonline.ch	Miloni Lichtplanung	Switzerland
Regina Bokel	r.m.j.bokel@bk.tudelft.nl	Delft Univ of Technology	Netherlands
M. van der Voorden	m.vandervoorden@bk.tudelft.nl	Delft Univ of Technology	Netherlands
Jan de Boer	jdb@ibp.fhg.de	Fraunhofer Institute	Germany
Nils Svendenius	nils.svendenius@astro.lu.se	Lund University	Sweden
Peter Pertola	peter.pertola@wspgroup.se	WSP Elteknik	Sweden
Toshi Iwata	iwata@keyaki.cc.u-tokai.ac.jp	Tokai University	Japan
Patrice Drapier		EDF R&D	France
Hervé Lefebvre	herve.lefebvre@ademe.fr	ADEME	France
Arnaud Deneyer	arnaud.deneyer@bbri.be	BBRI	Belgium
Zbigniew Mantorski	mantors@polsl.gliwice.pl	Silesian Univ. of Technology	Poland

Detailed Working Plan of Subtask B Innovative Technical Solutions

Subtask B Leader

General Manager Wilfried Pohl
Bartenbach LichtLabor GmbH
Rinner Straße 14
6071 Aldrans/Insbruck
Austria
wilfried.pohl@bartenbach.com
www.bartenbach.com

1 Objectives

The objective of the Subtask B is to identify, assess and document the performance, energy and economical criteria of the existing promising and innovative future lighting technologies and their impact on other building equipment and systems. The purpose is to reduce the energy use of buildings by investigating the saving potential by comparing the existing and future technologies and by applying information on concepts, products and lighting solutions.

The innovative technical solutions of subtask B cover power supply, light sources, luminaries and concepts of controls. These result in principal lighting solutions (planning methods, lighting design layouts and installations). The Subtask B covers solutions to existing and new buildings.

2 Structure and tasks

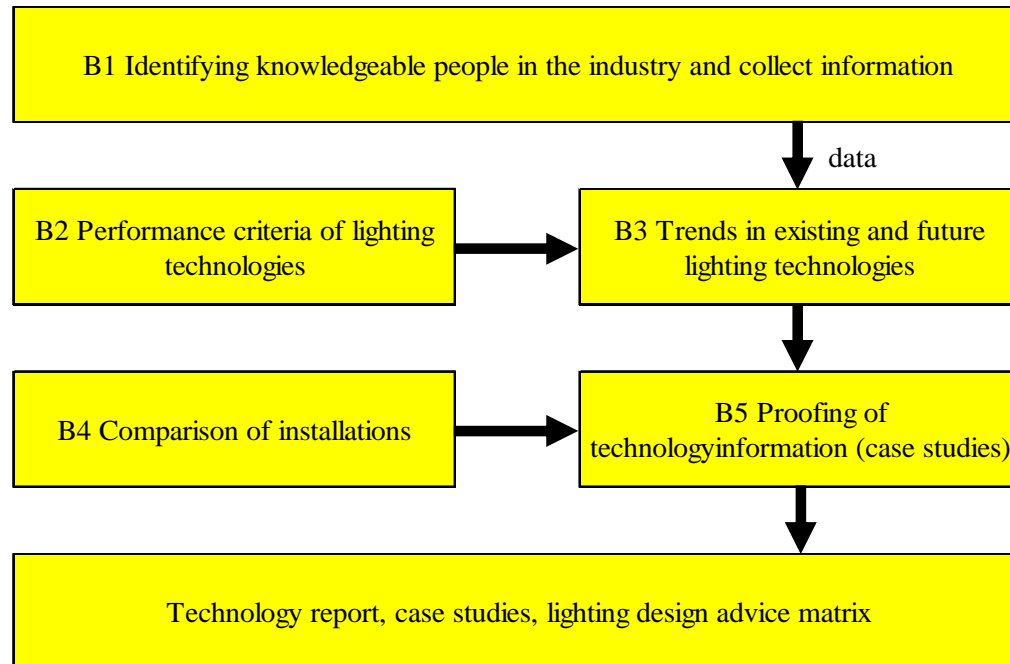


Figure 1. Structure of the Subtask B.

The tasks of Subtask B are listed below:

- B1 Identifying knowledgeable people in the industry and collect information
- B2 Performance criteria of lighting technologies
- B3 Trends in existing and future lighting technologies
- B4 Comparison of installations
- B5 Proofing of technology information (case studies).

B1 Identifying knowledgeable people in the industry and collect information

The target is to collect information on innovative technical solutions and possibilities for case studies. The contacts should be from the research, manufacturing or application sides. Each participant is invited to note his contacts in the following categories or even to open additional category if necessary.

- Research institutes
- Manufacturers (lamps, luminaries, daylight systems, control gears etc.)
- Innovative key projects in the following project categories: offices (high and middle standard), production, shopping malls, hospitals, schools, homes....
- Federal energy consultancies, energy agencies and consultants.

B2 Performance criteria of lighting technologies

The criteria with impact on energy efficiency will be investigated. The impact on the environment by the materials for the production of lamps and luminaries are also covered. Criteria are from:

- Architecture: Form, composition, type of materials, style, codes & standards, possibility of integration, influence on architecture, light as a design tool for the ambiance of a room, possibility for an integration of a daylight system or a special combination of artificial light with daylight.
- Economics: installation, maintenance, operation, compatibility with other systems, easy to obtain, possibility of integration in existing buildings.
- Energy related topics: efficacy of lamps including ballasts, light output ratio of luminaries, presence control, controls depending on daylight availability, life cycle, synergy with other building systems.

These cover cost aspects as well.

B3 Trends in existing and future lighting technologies

B 3.1 Trends in lamps and their power supply:

Two principal tendencies: Either the lamps become smaller/thinner with higher luminous flux and/or more efficient, or they are getting larger surfaces.

Concerning the energy saving and the combination of daylight and artificial light as well as the variation of colour of artificial light, the following technologies are of interest:

- Higher wattage for high discharge lamps with ceramic envelope. Dimming for using them in combination with daylight in the same light systems (pipe)
- LEDs
- OLEDs: can be used on flexible materials: surfaces with variable luminance will be possible
- Lamps for the suppression of melatonin
- Lamps which can change colour temperature or which are small enough to be integrated in RGB-mixing luminaries.

B 3.2 Trends in luminaries:

Trends are on technical side and on aesthetical/ architectural side

- Improvements in light output ratio
- Increase the luminous output (higher light density) of luminaires
- Improvements in energy consumption
- Architectural design of luminaries
- Materials for recycling
- Changing of lighting parameters (colour, light distribution and light intensity).

B 3.3 Trends in controls:

→ covered by subtask C

B 3.4 Trends in lighting solutions

Demands from architecture

- Flexibility of the layout

Demands from work organisation and kind of work

- Influence of display screen work
- Flexibility in workplace layout

Demands from user well-being

- Outcome of subtask A.

Lighting solutions cover the layout of the room design (position and combination of luminaries), description of different principals (stand-alone luminaries, ceiling luminaries, pendant luminaries, wallwashers, ...). Special attention is given to the influence of lighting control like daylight dependent control, occupancy control, individual controls according to the needs of the user, controls supporting health and well-being of the user.

B4 Comparison of installations

For a correct comparison of one installation with another, all the main quality factors should be taken into account. Therefore a point system (spider web for groups of criteria) is proposed.

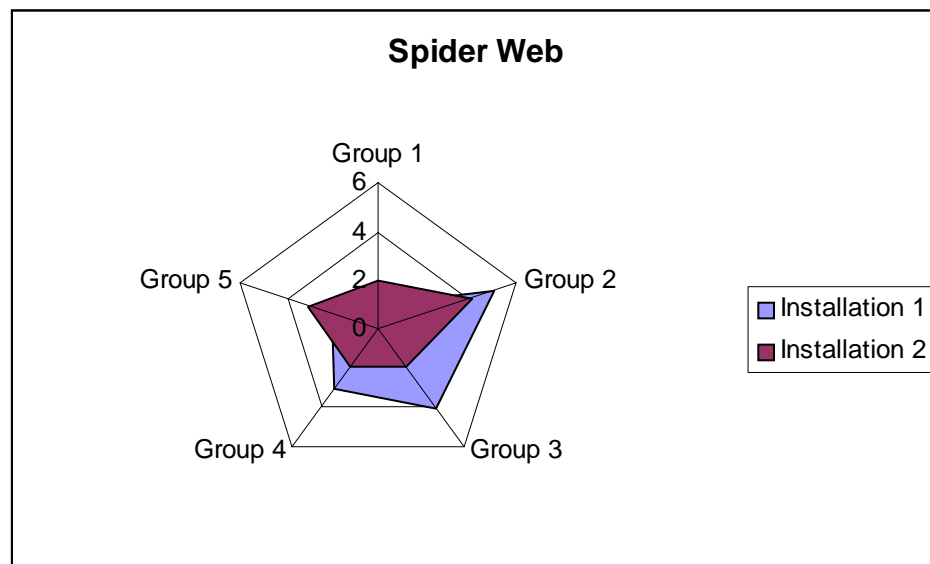


Figure 2. Example of a spider web.

By the use of a spider web unjust comparisons regarding only kWh/m² (W/m²) will be avoided, as the use of these values underestimates systems that are more focused on human needs and architecture.

The possible criteria are:

Group 1: Technical aspects of lighting:

- The standard quality features
- Luminaries: light output ratio (efficiency)
- Innovative technology

Group 2: physiological and psychological aspects: room atmosphere, acceptance, mood + health, etc.

- Luminance ratio of the task and the surrounding area
- Variation of illuminance level
- Colour temperature and colour appearance
- Luminance ratios between luminaries and surfaces in the field of vision, protection against direct view into the lamps
- Illumination of faces: cylindrical illuminance level in the task area

Group 3: Flexibility:

- Different lighting situations provided with one system
- Free positioning of work places
- Lighting design in accordance with building axes
- Number of different lighting components

Group 4: design

- Impact on architecture
- High/middle/low specific requirements of the system on the building vs. easily used for renovation
- Type of design (materials, form)

Group 5: Costs, maintenance

- Maintenance
- Installation costs
- Material costs per m².

The criteria should be modified according to the type of system to be evaluated.

B5 Proofing of technology information (case studies)

In order to collect information and define the necessary proofs the research topics shall cover the following areas.

- Energy savings by innovative systems in comparison to standard solutions
- Studies of synergies
- Case studies of existing prototype-buildings concerning savings and user acceptance, other experiences
- Research on user acceptance for each system group.

3 Deliverables and Subtask beneficiaries

The deliverables of Subtask B are:

- Technology Report: existing and future technology
- Documentation of case studies of lighting solutions linked with the Technology Report
- Lighting Design Matrix for end user and owners
- Detailed Lighting Design Advise Matrix for designers, architects and consultants

The Subtask B beneficiaries are:

- End users and owners
- Architects, consultants, ergonomists and lighting designers

- Lighting industry
- Associations like national energy agencies
- Standardisation committees.

4 Time schedule and milestones

The timetable and milestones of Subtask B are given in Table 1.

Table 1. Timetable and milestones.

Subtask B	2005	2006	2007	2008
B1 Identifying knowledgeable people in the industry and collecting information				
B2 Performance criteria of lighting technologies				
B3 Trends in existing and future lighting technologies				
B4 Comparison of installations				
B5 Proofing of technology information (case studies)				
Milestones B				
Identification (B1)	●	●	●	
Technology report (B2+B3)			●	●
Documentation of case studies (B4)		●	●	●
Matrix for end-users and owners (B5)			●	
Lighting Desing Matrix for designers (B5)			●	●

● Milestone postponed

5 Participants

Short Name	Organisation	Name(s)
Zumtobel	Zumtobel AG, Austria	Dehoff
Helvar	Helvar Merca Group, United Kingdom	Forrest
HUT	Helsinki University of Technology, Finland	Halonen, Tetri
LU	Lund University, Sweden	Huldt
TUB	Technical University of Berlin, Germany	Kaase, Kretschmer
Sil. Uni	Silesian University, Poland	Mantorski

Detailed Working Plan of Subtask C Energy-efficient Controls and Integration

Subtask C Leader

Mireille Jandon and Ahmad Husaunndee
Centre Scientifique et Technique du Batiment France

jandon@cstb.fr
husaunndee@cstb.fr
www.cstb.fr

1 Scope of Subtask C

The Subtask C focuses

- ❖ an optimal use of controls that enables energy savings whilst the user (occupant, facility manager, operation and maintenance team...) has the possibility to modify the electric lighting according to personal needs and preferences, within acceptable building operative requirements,
- ❖ on giving guidelines to designer, installers, manufacturers to achieve the above- mentioned aim

Particular attention is paid to:

- ❖ The communication and data exchange between the control components (sensors, actuators, electronic ballasts...)
- ❖ Better use of existing control (available off the shelf)
- ❖ Development of adapted control for new technologies
- ❖ The integration of these controls with other building systems (daylighting, HVAC, and demand energy management...)
- ❖ Commissioning of systems

Subtask C will focus on office and commercial (retail, supermarket...) buildings both new and existing (but also consider residential buildings.) Subtask C will also use lighting level (ST A) and scenarii (subtask B) for evaluation of strategies.

2 Structure of the Subtask

C1 Definition of requirements and constraints linked to the different players:

- ❖ **Task members:** BBRI (leader), All present + philips + helvar+ Zumtobel
- ❖ **Goals**
 - ❖ Who are the key persons who influence the use of the lighting control systems?
 - ❖ Building Owner Designer (architects, engineering team...), installers
 - ❖ Occupant / user Operation and maintenance team Facility manager
 - ❖ What criteria are of importance to each player?
 - ❖ What are the causes of the claims and the user non satisfaction?

Deliverables

- ❖ Synthesis of survey for guide book

C2 State of art of lighting control systems

❖ Participants

CSTB (leader), Zumtobel, TUB (?), LESO, Philips, Helvar, UBC, BBRI

❖ Goals

- ❖ Review of sensors, actuators, control strategies, networks
- ❖ How do we define the zoning of the building?
- ❖ Control functions: intermittency (presence, on/off, scheduler...), illuminance control (daylighting...), load shedding, fault detection, energy management and metering
- ❖ Developement of scenarii and "scene"
- ❖ Standardisation and regulations
 - ❖ What are the influence of the policies and regulations on lighting control?
 - ❖ How do we standardise lighting control?

❖ Deliverables

- ❖ Information for guide book
 - ❖ Short comings of existing control systems and strategies
 - ❖ Identification of the improvement areas on lighting control

C3 Case studies on existing and innovative lighting control strategies

Task members: LESO (leader), BBRI, UBC, BC-Hydro ITU, Philips, TUB (?.)

❖ Goals

- ❖ Description of case studies to address the following:
 - ❖ How to answer to the requirements of the different players?
 - ❖ What type of information transfer is required (w.r.t local control, zone control, central control...)
 - ❖ Integration of new control functions (contrast management, colour temperature, adaptative...)
 - ❖ Application to new lighting technologies
 - ❖ Evaluation of impact (energy, economics...)

❖ Actions

- ❖ Identification & development of control strategies within case studies
 - ❖ New buildings
 - ❖ Existing buildings
 - ❖ (Replacement of for example metal halides lamps with T5 in gymnasiums \ possibility to use controls on 3 levels etc.. Check issue of wiring..)

- ❖ Use of wireless
- ❖ Assessment of control strategies
 - ❖ Identification of criteria: stability of control loops (Frequency of On/off,...), use of dimming and changes on illumination level, energy consumption, comfort, cost, installation issues (tuning, ...), maintenance of associated system
 - ❖ Use of simulation on a few examples (?)

Deliverables

- ❖ Technical analysis of strategies
- ❖ Economical analysis (?) → check with Helvar & Philips
- ❖ Case studies

C4 Impact of the whole environment concept on lighting control

Task members: LESO, CSTB (Leader), Philips, Helvar, LBL (??), NRC

❖ Goals / actions

- ❖ Analysis of integrated control strategies of applications (lighting/air conditioning/blinds/safety...)
 - ❖ What are the aims: comfort, energy savings...?
 - ❖ How to deal with conflicting aims? (master/slave solutions...?)
 - ❖ How to determine data exchange (amount, frequency) among applications?
 - ❖ What type of media are suitable for such exchange?

C5 Commissioning process for lighting/ lighting control systems

Task members: CSTB, (link to annex 47), HUT, Helvar

❖ Goals / actions

- ❖ How to verify that the systems designed meet the requirements of all players at each stage of the construction and operation of the building
 - ❖ Link to subtask A for indicators and targets

❖ Deliverables

- ❖ Definition of a commissioning plan for lighting systems

3 Deliverables

The deliverables of Subtask C are:

- Synthesis of survey for guide book
- Information for guide book
 - Shortcomings of existing control systems and strategies
 - Identification of the improvement areas on lighting control
- Technical analysis of strategies

- Economical analysis (?) → check with Helvar & Philips
- Case studies
- Definition of a commissioning plan for lighting systems

4 Timetable and milestones

Subtask C	2005	2006	2007	2008
C1 Requirements for control and constraints				
C2 State of art of lighting control				
C3 Case studies on existing and innovative control				
C4 Impact of whole environment concept on lighting				
C5 Commissioning process for lighting & lighting -> input to "guide book"				
Milestones C				
Questionnaire			●	
State of art			●	
Conventional Best Practice on control			●	
Evaluation of new technologies for controls				●
Case studies				●
Commissioning plan				●

● Milestone postponed

5 Participants

The following companies and institutions have agreed to become partners in the Subtask C:

Short Name	Organisation	Name(s)
BBRI	Belgian Building Research Institute	Deneyer
CSTB	Centre Scientifique et Technique du Bâtiment, France	Hussaunndee
Helvar	Helvar Merca Group, United Kingdom	Forrest
HUT	Helsinki University of Technology, Finland	Halonen, Tetri
LESO	École Polytechnique Fédérale de Lausanne, Switzerland	Lindelöf
LU	Lund University, Sweden	Sven Huldts
TUB	Technical University of Berlin, Germany	Kaase, Kretschmer
Zumtobel	Zumtobel AG, Austria	

Detailed Working Plan of Subtask D Documentation and Dissemination

Subtask D Leader

Research Scientist, D.Sc. (Tech.) Eino Tetri
Helsinki University of Technology
Lighting Laboratory
P.O.Box 3000; 02015 HUT
Finland
phone +358 9 4512420
fax + 358 9 4514982
<http://lightinglab.fi/>

1 Objective

The objective of Subtask D is to positively affect the current lighting practices in a manner that accelerates the use of energy efficient products, improves overall building performance and enhances occupants' environmental satisfaction. The objective of Subtask D is to compile and widely disseminate the Annex research results and to identify the means to influence the energy policies and regulations in order to promote the use of energy efficient lighting.

The design guidebook of energy efficient lighting will be the final product of the Annex. It will be published as a book, as a CD-ROM and in the web. The other deliverables are semi-annual newsletters, seminars and a web-site.

2 Structure and tasks

The subtasks A, B and C and the Participants of the Annex will contribute to the work of the Subtask D. The data to the deliverables of Subtask D is produced in other Subtasks. The work of Subtask D is structured in specific task areas in which the participants will:

- Evaluate the effect of energy policies and regulations on the adoption of energy efficient lighting and identify needs to influence them in order to promote the use of energy efficient lighting systems
- Develop strategy to strengthen the demand of energy efficient lighting
- Create and maintain a web-site
- Provide newsletters every 6 months
- Compile information packages (leaflets) for various interest groups
- Write publications and articles
- Organise international seminars
- Organise national seminars
- Compile design guidebook (book, CD-ROM and web versions).

3 Deliverables and Subtask beneficiaries

The main target groups of deliverables are designers of lighting, electrical building services and system integrators in buildings and end-users/owners. Designers are a good target group while it is well defined and serving both commercial and residential lighting applications. They require references, guidelines, analysis tool which are applicable for researchers, too. End-users/owners need promotional material that is simple in content. The results are disseminated also by delivering information to standards and recommendations and by providing educational material to educational institutions in order to positively affect future lighting professionals. Integration of lighting to building services benefits the occupant, the building operator, the owner and society at large. The objective is to positively impact current lighting practices in a manner that accelerates the use of energy efficient products, thus benefiting lighting industry, improves overall building performance and enhances occupant's environmental satisfaction.

The main deliverables of Subtask D are:

- Guidebook
- Semi-annual newsletters
- Seminars
- Web-site.

4 Time schedule and milestones

The time schedule and milestones of Subtask D are given in Table 1.

Table 1. Time schedule and milestones.

	2005		2006		2007		2008	
Subtask D								
Expert Meetings	•	•	•	•	•	•	•	•
Milestones D								
Newsletter	●	●	●	●	●	●	●	●
Seminars					●			●
Web-site update	●	●	●	●	●	●	●	●
Guidebook						D1	D2	D3
Expert Meetings	•	•	•	•	•	•	•	•

● Milestone postponed
D1, D2, D3 Draft 1, etc.

5 Participants

Subtasks A, B and C and the participants of the Annex will contribute to the work of the Subtask D. The data to the deliverables of Subtask D is produced in other Subtasks.

6 Country Contributions

Finland has 32 manmonths directly on Subtask D, the other participants will contribute to the Subtask D indirectly through other Subtasks and also directly, for instance organising national and international seminars.