SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

IEA SHC TASK 61 / EBC ANNEX 77

INTEGRATED SOLUTIONS FOR DAY-LIGHTING AND ELECTRIC LIGHTING

ANNEX

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Annex Outline

Integrated Solutions for daylighting and electric lighting
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1. Definitions

(a) Description of technical sector

Lighting accounts for approximately 19% of the global electric energy consumption. Research and development in the field of energy efficient lighting techniques encompassing daylighting, electric lighting and lighting controls potentially can contribute significantly to reduce this demand. Nonetheless, growing economies, higher user demands for quality lighting and rebound effects as a result of low priced and more versatile electric lighting – "more for less" – lead to an absolute increase of the worldwide lighting energy consumption. More light is used, less consciously. The lighting as well as the façade market have seen significant technological developments and strong growth in the past decade - where nevertheless both market sectors still act mainly completely independent of each other, leaving out big chances for better user centred and at the same time efficient systems.

Following the component performance improvement phase, the focus shifts towards digitalized - "smart and connected" - lighting. This shift offers the chance to overcome problems in the integration of daylight and electric lighting: (New) technologies / components equipped with sensors and "intelligent software" and wireless data communication introduce great possibilities to bring the separate market sectors of electric lighting and façade technology closer together. These smart and integrated solutions can unfold the saving potentials of (new) lighting technologies.

(b) Definitions

The scope of the Task is on general lighting systems for indoor environments. The focus is laid on lighting appliances in non-domestic buildings. Technically the Task deals with integrating

- daylight utilization by enhanced facade technologies and other architectural solutions,
- electric lighting schemes addressing technology and design strategies, and
- lighting control systems and strategies with special focus on visual and non-visual user needs special emphasis on the interface of day- and electric lighting.

The task targets building designers and consultants, industry (façade, electric lighting, software companies), owners (investors) and authorities by providing strategic, technical and economic information and with network activities helping these stakeholders overcome barriers in integrating lighting installations and implementing holistic lighting solutions.

2. Purpose and Objectives

The overall objective of the activity is to foster the integration of daylight and electric lighting solutions to the benefits of higher user satisfaction and at the same time energy savings. This can be subdivided into the following specific objectives.

- Review relation between user perspective (needs/acceptance) and energy in the emerging age of "smart and connected lighting" for a relevant repertory of buildings.
- Consolidate findings in use cases and "personas", reflecting the behaviour of typical users.
- Based on a review of specifications concerning lighting quality, non-visual effects as well as ease of design, installation and use provision of recommendations for energy regulations and building performance certificates.
- Assess and increase robustness of integrated daylight and electric lighting approaches technically, ecologically and economically.
- Demonstrate and verify or reject concepts in lab studies and real use cases based on performance validation protocols.
- Develop integral photometric, user comfort and energy rating models (spectral, hourly) as pre-normative work linked to relevant bodies: CIE, CEN, ISO. Initialize standardization.
- Provide decision and design guidelines incorporating virtual reality sessions. Integrate approaches into wide spread lighting design software.
- Combine competencies: Bring companies from electric lighting and façade together in workshops and specific projects. Hereby support allocation of added value of integrated solutions in the market.

3. Activities

(a) Main activities

To accomplish the objectives of the Task, the Participants will carry out research and developments in the framework of the following four subtasks and one joint working group:

- Subtask A: User perspective and requirements
- Subtask B: Integration and optimization of daylight and electric lighting
- Subtask C: Design support for practitioners (Tools, Standards, Guidelines)
- Subtask D: Lab and field study performance tracking
- Joint Working Group: Evaluation tool & VR Decision Guide

(b) Sub-activities

The activities performed in the subtasks and joint working group and their specific projects are:

<u>Subtask A: User perspective and requirements</u>

This Subtask will deal with the consolidation of available knowledge (demands, chances and challenges) on user-, activity- and time-depending visual and non-visual requirements, as well as acceptance of lighting controls and their control strategies, including cultural and climatic dependencies. This knowledge will be used to set up use cases in specific applications, reflecting typical temporal changes in the usage of these interior spaces. The usage and the corresponding lighting requirements will be aggregated in so called personas, representations of the behaviour of a hypothesized group of users in the defined applications. Personas can be used to define the potential and benefits, such as user comfort and energy efficiency, of user centred integrated solutions more accurately, which is beneficial in the development (target group: lighting and façade industry) and lighting design (target groups: architects, lighting designers, policy makers and facility managers) of integrated solutions.
The work of Subtask A will be structured into three project areas:

A.1 User requirements
A.2 Use cases
A.3 Representation of user behaviour - personas

Subtask B: Integration and optimization of daylight and electric lighting

The subtask aims at enlarging and communicating the potential and impact of integrated technical solutions with respect to user needs and system efficiency. Work will focus especially on advanced light management concepts (e.g. contrast and DGP based, spectral controls, lighting load prediction, meteo prediction) on the link between user perspectives and technologies (sensors, electric lighting, façade). This will be based on an appropriate modelling / performance metrics backbone. Workshops and projects with companies from different industrial sectors will be defined to combine knowledge and experience to allocate added value of integrated solutions. Technology roadmaps will be generated. The objective of this subtask is to identify the promising technical solutions to offer optimal control of lighting and daylighting components. The success of these solutions will deal with minimum use of lighting electricity, maximum satisfaction of users and with most attractive user interface (for users and facility managers).
In the following six projects the subtask will gather information on existing systems:

B.1. Interview of professionals: opportunities and barriers
B.2. Critical review of existing control systems and their functionalities
B.3. Critical review of new approaches under development
B.4. Review of other important aspects affecting performance of controls
B.5. Critical analysis of interfaces
B.6. Link with standardization activities

Subtask C: Design support for practitioners (Tools, Standards, Guidelines)

This subtask focuses on the application of technical innovations the field of integrated lighting solutions in practitioners' workflows. The intent is to bring the findings onto the desktops of designers by integration of approaches into widely used software tools, standards and codes, and design guidelines. Hereby the different design phases from conceptual up to the final design shall be addressed. An initial state of the art review of workflows applied in current practice will summarize well working examples and highlight open issues in the design of integrated lighting solutions. Due to missing standards for the characterization of daylight systems, including them in the planning process is still a major problem. Existing approaches for the characterization of façade systems will be collected and a compiled characterization scheme including specifications for measurements and simulations will be proposed as a draft standard. For the design of integrated solutions that support human well-being not only intensities, but also spectral effects are important. To enable statements also for the daylight part of the integrated solution, a spectral sky model will be elaborated. For the decision-making process, it is important to provide practitioners with a possibility to compare solutions. An hourly rating model for user-centered

integral performance assessment will be developed. This evaluation algorithm will allow to assess both the non-visual effect and the energy efficiency of integrated lighting solutions at once.
The work in Subtask C will be structured into four project areas:

C.1. Review of state of the art design workflows
C.2. Standardization of BSDF daylight system characterization
C.3. Spectral sky models for advanced daylight simulations
C.4. Hourly rating method for integrated solutions

Subtask D: Lab and field study performance tracking

This subtask will demonstrate and assess, and either verify or reject, currently available and typically applied concepts for daylighting and electric lighting design and their integration in order to better understand how various integrated lighting systems and their control mechanisms behave with respect to a number of important parameters (e.g. energy use, thermal and visual environment, maintenance, adaptability to new requirements, etc.) and how building user respond to them. This will be achieved through a comprehensive literature review of relevant research materials (in close collaboration with Subtask A.1), targeted medium-term experiments in a number of living laboratories, supplemented by short-term investigations of specific concepts or ideas in controlled research laboratory environments, as well as performance tracking through "real" field studies in recently completed or retrofitted buildings across selected building types in several of the participating countries. Case studies will be selected in close collaboration with other subtasks, especially with subtasks A and B.
The work of Subtask D will be structured into four project areas:

D.1 Literature Survey: Quantifying Potential Energy Savings
D.2 Monitoring Protocol
D.3 Case Studies: Living Laboratories and Real Buildings
D.4 Lessons Learned – Guidance to Decision Makers

Joint Working Group: Evaluation tool & VR Decision Guide

All subtasks will provide major parts of their results, as input to the joint working group comprising the development of an evaluation method for integrated lighting solutions as well as a virtual reality (VR) decision guide.
The work of the joint working group will be structured into two project areas:

JWG.1. Evaluation method for integrated lighting solutions
JWG.2. VR Decision Guide on integrated lighting solutions

(c) Workshops and Seminars

Industry workshops, during the Task duration, in conjunction with every Task meeting, will be organised in the host country of the meeting. All relevant target groups will be invited.

National industry workshops will be organised by Task participants using the information gathered during Task workshops and the material produced by the Task.

(d) Publications/Newsletters

The overall scope and objectives of the Task and the different Subtasks will be described on a public website, possibly the IEA-SHC-website. Apart from publications of scientific results at

conferences and in journals and magazines, a brochure will be produced and distributed to describe to scope of the Task.

A Newsletter will be produced at the end of Year 2 and 3. The Newsletter will be distributed through national channels (for instance, included in a solar industry or lighting association or lighting journal).

4. Expected Results/Deliverables

All Subtasks will provide material for the common Task products, the evaluation method and the VR decision guide for integrated lighting solutions, developed within the joint working group. The main results of this Task shall be:

4.1 Subtask A: User perspective and requirements

- Collection of user requirements for user centred integrated lighting solutions
- Collection of time sequences of activities and occupancy in specific applications (use cases)
- Development of personas for each defined application with user centred integrated lighting solutions - summarized in a report
- Report on personas for user centred integrated lighting solutions
- Implementation of use cases and personas in Decision Guide (JWG)

4.2 Subtask B: Integration and optimization of daylight and electric lighting

- Identification and understanding of opportunities and barriers
- Report: The control technology seen by users and installers
- Report on existing control systems and their functionality
- Identification of promising innovative solutions and criteria of success
- Critical analysis and mapping (with performance attributes) of new approaches
- Documentation of selected solutions with respect to energy saving potential
- Report on other important aspects affecting performance of controls
- Review of interfaces and identification of successful solutions
- Identification of existing and planned standards relevant to control products and development of recommendations

4.3 Subtask C: Design support for practitioners (Tools, Standards, Guidelines)

- Documentation of established workflows and methods as guidelines for practitioners including open issues to be addressed in simulation tools
- Pre-normative work (draft standard) for BSDF daylight system characterization, including BSDF data format, specifications of BSDF generation routines (measurement, simulation), requirements for BSDF data based on intended application as well as a labelling scheme
- Development of a spectral sky model (ready for implementation in software) and of algorithms to derive spectral evaluations from reduced spectral data

- Development of a generic hourly rating model for performance evaluation of integral lighting solutions and implementation into wide spread lighting design software
- Reports about developed models and implementation in software products

4.4 Subtask D: Lab and field study performance tracking

- Collection of documented experience with state-of-the-art, integrated daylighting and electric lighting systems and the operation of their control systems , including a presentation of solutions which are likely to achieve high user satisfaction and energy savings if implemented appropriately
- Development of a purpose- and resource-based monitoring protocol with different levels of complexity
- Documentation of research and case studies of exemplary integrated lighting systems across a range of spaces and building types from around the world
- Report of key results and concept from the conducted research activity with respect to understanding the user-driven energy use and performance of integrated lighting systems
- Development of a "Lessons learned" guidance document

4.5 Joint Working Group: Evaluation tool & VR Decision Guide

- Development of a web and app based software tool for hourly energy rating for integrated lighting solutions encompassing the most significant design parameters and technical solutions.
- Proposal of a method for international standardization
- Development of a VR (virtual reality) Decision Guide with sessions available in various communication formats, to visualize various electric and daylighting strategies in selected environments

5. Rights and Obligations of Participants

In addition to the obligations enumerated in Article 4 of the Agreement

(a) Reporting

Each participating institution/company shall provide the Operating Agent with detailed reports on the results of the work carried out for each Subtask.

(b) Data collection

Each participating institution/company shall collect, assess and report to the Operating Agent data on lighting retrofits for non-domestic buildings [such as market, benchmarks, technologies, case studies, etc.] in his country.

(c) Editing and reviewing

Each participating institution/company shall participate in the editing and reviewing of draft reports of the Task and Subtasks.

(d) *Operating Agent Meetings*

Each country will bear the costs of its own participation in the Task, including necessary travel costs. The cost of organising meetings will be borne by the host country.

(e) Individual Financial Obligations

Aside from providing the resources required for performing the work of the Subtasks in which they are participating, all Participants are required to commit the resources necessary for activities that are specifically collaborative in nature and would not be part of activities funded by national or international sources. Examples include the preparation for and participation in Task meetings, co-ordination with Subtask Participants, contribution to the documentation and dissemination work, and Task related R&D work which exceeds the R&D work carried out in the framework of the national (or international) activity.

(f) Task-Sharing Requirements

The Participants agree on the following funding commitment:

1) Participation in this Task requires a minimum effort of 12 person-month per country. Each Participant's country is required to participate in at least two subtasks and in the Joint Working group "Lighting Retrofit Adviser" with a total minimum effort of 4 person month per year to the result of the Task.
2) The Operating Agent will contribute with a minimum of 0.33-person year per year to the Task (i.e., a total of 1 person years for his/her work as Operating Agent).
3) The Subtask leader shall commit a minimum of 3 person-month per year for the work.
4) Participation may partly involve funding already allocated to a national (or international) activity that is substantially in agreement with the scope of work outlined in this Annex. Aside from providing the resources required for performing the work of the Subtasks in which they are participating, all Participants are required to commit the resources necessary for activities that are specifically collaborative in nature and that would not be part of activities funded by national or international sources. Examples include the preparation for and participation in Task meetings, co-ordination with Subtask Participants, contribution to the documentation and dissemination work and Task related R&D work which exceeds the R&D work carried out in the framework of the national (or international) activity.

6. Management

(a) The Federal Republic of Germany, represented by Jan de Boer, Fraunhofer Institute of Building Physics for the Project Management Center Jülich (PTJ) for the Federal Ministry of Economics and Technology, is designated as Operating Agent.

The Subtask leaders shall be from the following countries:

Subtask A: Norway
Subtask B: Denmark
Subtask C: Austria
Subtask D: Sweden / Denmark

(b) The Operating Agent's rights, obligations and responsibilities in addition to those indicated in the main body of the Implementing Agreement and the organisation of the work under this Annex enumerated in Article 5 of this Agreement, the Operating Agent shall:

1) Prepare and distribute the results mentioned in paragraph 4 above;

2) Prepare joint assessments of research, development and demonstration priorities for advanced lighting solutions for retrofitting buildings;

3) At the request of the Executive Committee, organise workshops, seminars, conferences and other meetings;

4) Prepare the detailed Program of Work for the Task in consultation with the Subtask Leaders and the Participants and submit the Program of Work for approval to the Executive Committee of the Solar Heating and Cooling Programme;

5) Propose and maintain a methodology and a format for the submission of information on advanced lighting solutions for retrofitting buildings, which is collected by the Participants as described in paragraphs 3 and 4 above;

6) Provide reports semi-annually to the Executive Committees on the progress and the results of the work performed under the Programme of Work;

7) Provide to the Executive Committees, within six months after completion of all work under the Task, a final report for its approval;

8) In co-ordination with the Participants, use its best efforts to avoid duplication with activities of other related programmes and projects implemented by or under the auspices of the IEA or by other competent bodies;

9) Provide the Participants with the necessary guidelines for the work they carry out with minimum duplication;

10) Perform such additional services and actions as may be decided by the Executive Committees, acting by unanimity; and

11) Gather documents from Subtask Leaders, organize the output of the Task either as a printed handbook, electronically or on a website.

12) A Subtask Leader for each of the foregoing Subtasks will:

    a. Co-ordinate the work performed under that Subtask.
    b. Assist the Operating Agent in preparing the detailed Programme of Work;
    c. Direct technical workshops and provide the Operating Agent with written summaries of workshops results.
    d. Edit technical reports resulting from the Subtask and organise their publication.
    e. Subtask leaders may arrange meetings in between or in association with Experts meetings of the Task.

13) The Subtask Leader shall be a Participant that provides to the Subtask a high level of expertise and undertakes substantial research and development in the field of the Subtask. The Subtask Leaders shall be proposed by the Operating Agent and designated by the Executive Committee, acting by unanimity of the Participants. Changes in the Subtask Leaders may be agreed to by the Executive Committee, acting by unanimity of the Participants.

(c) *Experts Meetings:* There will be Experts meetings of the Task at intervals of approximately 6 months. Subtask Leaders may arrange meetings in between or in association with Experts meetings of the Task. Attendance at the Experts Meetings of the Task will be mandatory.

(d) It is intended to organize expert / industry workshops directly linked to the Task meetings. The overall scope and objectives of the Task and the different Subtasks will be described on a public website, possibly the IEA-SHC-website. The server should be able to process an automatically distributed electronic newsletter.

7. Admission, Participation and Withdrawal of Participants

In addition to the specific obligations, the Operating Agent will produce, promote and distribute the results of the Task. The Participants will support these activities by contributing respective papers and by dissemination activities financed by the individual Participants.

8. Information and Intellectual Property

(a) Executive Committee's Powers

The publication, distribution, handling, protection and ownership of information and intellectual property arising from this Task shall be determined by the Executive Committee, acting by unanimity, in conformity with the Agreement.

(b) Right to Publish

Subject only to copyright restrictions, the Participants shall have the right to publish all information provided to or arising from this Annex, except proprietary information.

(c) Proprietary Information

The Participants and the Operating Agent shall take all necessary measures in accordance with this paragraph, the laws of their respective countries and international law to protect proprietary information provided to or arising from this Annex. For the purposes of this Annex, proprietary information shall mean information of a confidential nature such as trade secrets and know-how (for example computer programs, design procedures and techniques, chemical composition of materials, or manufacturing methods, processes, or treatments) which is appropriately marked, provided such information:

(a) Is not generally known or publicly available from other sources;
(b) Has not previously been made available by the owner to others without obligation concerning its confidentiality;

(c) Is not already in the possession of the recipient Participant without obligation concerning its confidentiality.

It shall be the responsibility of each Participant supplying proprietary information and of the Operating Agent for appraising proprietary information, to identify the information as such and to ensure that it is appropriately marked.

Arising Information

All information developed in connection with and during activities carried out under this Task (arising information) shall be provided to each Participant by the Operating Agent, subject only to the need to retain information concerning patentable inventions in confidence until appropriate action can be taken to protect such inventions.

For arising information regarding inventions the following rules shall apply:

(1) Arising information regarding inventions shall be owned in all countries by the inventing Participant. The inventing Participant shall promptly identify and report to the Executive Committee any such information along with an indication whether and in which countries the inventing Participant intends to file patent applications.

(2) Information regarding inventions on which the inventing Participant intends to obtain a patent protection shall not be published or publicly disclosed by the Operating Agent or the other Participants until a patent has been filed, provided, however, that this restriction on publication or disclosure shall not extend beyond twelve months from the date of reporting of the invention. It shall be the responsibility of the inventing Participants to appropriately mark Task reports that disclose inventions that have not been appropriately protected by filing a patent application.

(3) The inventing Participant shall license proprietary information arising from the Task for non-exclusive use to participants in the Task:

(a) On the most favorable terms and conditions for use by the Participants in their own country.

(b) On favorable terms and conditions for the purpose of sub-licensing others for use in their own country.

(c) Subject to sub-paragraph (1) above, to each Participant in the Task for use in all countries, on reasonable terms and conditions.

(d) To the government of any Agency Member country and nationals designated by it, for use in such country in order to meet its energy needs.

Royalties, if any, under licenses pursuant to this paragraph shall be the property of the inventing Participant.

(d) Production of Relevant Information by Governments

The Operating Agent should encourage the governments of all Participating Countries to make available or to identify for the Operating Agent all published or otherwise freely available information known to them that is relevant to the Annex.

(e) Production of Available Information by Participants

Each Participant agrees to provide to a Subtask Leader or to the Operating Agent all previously existing information, and information developed independently of the Annex, which is needed by a Subtask Leader or by the Operating Agent to carry out its functions under this Annex and which is freely at the disposal of the Participant and the transmission of which is not subject to any contractual and/or legal limitations:

(1)If no substantial cost is incurred by the Participant in making such information available, at no charge to the Annex therefore;

(2) If substantial costs must be incurred by the Participant to make such information available, at such charges to the Annex as shall be agreed between the Operating Agent and the Participant with the approval of the Executive Committee.

(f) Use of Confidential Information

If a Participant has access to confidential information which would be useful to a Subtask Leader or to the Operating Agent in conducting studies, assessments, analyses, or evaluations, such information may be communicated to a Subtask Leader or to the Operating Agent but shall not become part of the reports, handbooks, or other documentation, nor be communicated to the other Participants, except as may be agreed, between the Subtask Leader or the Operating Agent and the Participant which supplies such information.

(g) Reports on Work Performed under the Annex

The Operating Agent shall, in accordance with paragraph 7 above, provide reports of all work performed under the Annex and the results thereof, including studies, assessments, analyses, evaluations and other documentation, but excluding proprietary information.

(h) Copyright

The Operating Agent may take appropriate measures to protect copyrightable material generated under this Annex. Copyrights obtained shall be the property of the Operating Agent for the benefit of the Participants provided, however, that the Participants may reproduce and distribute such material, but if it shall be published with a view to profit, permission should be obtained from the Executive Committee.

(i) Authors

Each Participant will, without prejudice to any rights of authors under its national laws, take necessary steps to provide the co-operation from its authors required to carry out the provisions of this paragraph. Each Participant will assume the responsibility to pay awards or compensation required to be paid to its employees according to the laws of its country.

9. Entry into Force, Term and Extension

This Annex shall enter into force on 1st January 2018 and shall remain in force for a period of 3,5 years/until 30th of June 2021. At the conclusion of that period, this Annex can be extended by at least two participants, acting in the Executive Committee, for a period to be determined at that time, provided that in no event shall the Annex continue beyond the current term, or actual termination, of the Implementing Agreement.