LIPID 2013

Interdisciplinary Laboratory of Performance-Integrated Design

Group Head: Prof. Marilyne Andersen

School of Architecture, Civil and Environmental Engineering (ENAC)
École Polytechnique Fédérale de Lausanne (EPFL)

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Interdisciplinary Laboratory of Performance-Integrated Design (LIPID) 2013

Bâtiment GC
Station 18
CH-1015 Lausanne

T +41 (0) 21 693 80 21 | F +41 (0) 21 693 08 85 |lipid.epfl.ch

CONTENT

LIPID TEAM

The Interdisciplinary Laboratory of Performance-Integrated Design (LIPID) has been growing since its inception in 2010. It comprised five PhD students and four research collaborators in 2013, in addition to the head Prof. Marilyne Andersen and administrative assistant Martine Tiercy. LIPID also regularly hosts visiting or exchange graduate students for a semester or year at a time.

Direction

Prof. Marilyne Andersen
Full Professor

Marilyne Andersen is a Full Professor of Sustainable Construction Technologies and Dean of the School of Architecture, Civil and Environmental Engineering of EPFL (ENAC). She heads the Interdisciplinary Laboratory of Performance-Integrated Design (LIPID) that she launched in the Fall of 2010. Before joining EPFL as a faculty, she was an Associate Professor in the Building Technology Group of MIT's School of Architecture and Planning and the Head of the MIT Daylighting Lab that she founded in 2004.

Marilyne Andersen holds a Master of Science in Physics and specialized in daylighting through her PhD in Building Physics at EPFL in the Solar Energy and Building Physics Laboratory (LESO) and as a Visiting Scholar in the Building Technologies Department of the Lawrence Berkeley National Laboratory in California.
Her research focuses on building performance in the architectural context in general, and the use and optimization of daylight in buildings in particular. Specific topics she has been working on include: visual and thermal comfort; design tools in the early stages of the design process; goal-driven approaches in design; performance visualization; design implications of the effects of light on circadian photoreception and health; advanced glazing and shading systems, daylight redirecting devices; and video-based approaches in photometry.

Marilyne Andersen has taught doctoral, graduate and undergraduate level classes on Daylighting and Building Technology and has been involved in workshops, studios or classes related to these fields. She also supervises research and thesis work for undergraduate and graduate students in architecture, building technology and mechanical, civil and environmental engineering.
As part of her non-institutional activities, she has been a daylighting consultant for design projects for housing, campus buildings and mid-rise office buildings and as an expert for a patent infringement case. She is an active member of several Illuminating Engineering Society (IES) and International Commission on Illumination (CIE) committees.

She is the author of more than 90 papers published in peer-reviewed journals and international conferences and the recipient of several grants and awards including: three best conference paper awards (in 2011 & 2012), the Taylor Technical Talent Award granted by the Illuminating Engineering Society (2009), the 3M Non-Tenured Faculty Grant (2009), the Mitsui Career Development Professorship at MIT (2008) and the EPFL prize of the Chorafas Foundation awarded to her PhD thesis in Sustainability (2005). Her research or teaching has been supported by professional, institutional and industrial organizations such as the U.S. National Science Foundation, the Boston Society of Architects, the MIT Energy Initiative, 3M, Velux and Saint Gobain.

Martine Tiercy
Secretary

Martine Tiercy takes care of LIPID's administrative duties and shares her time with the Laboratory of Architecture and Sustainable Technologies (LAST).

Post-docs & research staff

Dr. Boris Karamata
Research Scientist

Boris Karamata holds a Master of Science in Microengineering from EPFL (1994). He specialized in optics and photonics through his PhD in the Laboratory of Biomedical Optics at EPFL (2000-04) and as a senior engineer at Logitech (2005-10). Between 1995 and 1999 he was with the European Space Technology and Research Center in the Netherlands and with the Tyndall National Institute in Ireland, working mainly in the field of microfluidic systems for space and biology applications, respectively. His research activities are at the crossroads between science, engineering and architecture. He currently focuses on two main axes: (i) adaptive building skins with passive actuation to provide optimal indoor daylighting and minimize thermal gains, and (ii) novel solar thermal concentrators.

Dr. Antoine Guillemin
Research Scientist

Antoine Guillemin holds a Master of Science in Physics from EPFL (1998). He specialized in building automation (artificial intelligence control techniques) and lighting control, earning a PhD in the Laboratory of Solar Energy and Building Physics (LESO_PB) at EPFL (1999-2003). Antoine has co-founded two start-up companies (http://www.adhoco.com) and (http://www.neurobat.net) to provide new heating control systems that adapt to user needs and building characteristics. In 2011, he joined the Interdisciplinary Laboratory of Performance-Integrated Design (LIPID). At LIPID, Antoine coordinates the Lightsolve project (an innovative tool for daylight performance evaluation), by maintaining the bridge between the newest research achievements of the LIPID group and its corresponding implementation in the Lightsolve tool.
Antoine also became the scientific deputy to the Dean in September 2013. His main tasks there are to identify technology transfer opportunities and support ENAC research laboratories to establish new partnerships with industries.

Dr. Shady Attia
PostDoc

Shady Attia is an architectural engineer and LEED®AP who joined LIPID in 2012 and worked as scientist and lecturer at LIPID until end of 2013. His current research focuses on developing and describing methodologies that support architectural design decisions using building performance simulation tools. His areas of expertise include zero energy buildings and cradle to cradle design. During his PhD at UCL in Belgium, he developed a simulation tool called ZEBO that uses a graphical user interface for EnergyPlus in addition to a knowledge-base of guidelines, codes and case studies for sustainable architectural design. With 10 years of experience in energy efficiency for buildings, solar architecture, and sustainability, he has worked in government research and university level teaching, as well as building design and energy consulting companies. As an architect and researcher he is working currently on exploring the creation of synergies and accumulating know-how about informative design decision support.

Lorenzo Cantelli
Scientist

Lorenzo Cantelli is a software engineer developing a platform for daylighting performance simulation (Lightsolve) at the LIPID Lab. He holds a master's degree in Computer Science Engineering from EPFL (2004). He began his career in Computer Graphics programming at the Brain and Mind Institute at EPFL in 2005, developing a CAD application to reconstruct 3D shapes of neurons from microscopy images of brain tissue. As a software engineer and project leader for 6 years at ITSS and Hotela (2006-2012), he specialized in object-oriented programming and software usability, working with teams of 2-3 engineers (projects of up to 400 man-days long) and learning all the aspects of a software's lifecycle. His main activity is to provide the team with an intuitive and flexible software platform to develop performance modules based on their research, and useful as a support for teaching.

PhD students

Mandana Sarey Khanie
PhD student

Mandana Sarey Khanie joined LIPID in 2010 as a PhD student in the Doctoral Program in Civil and Environmental Engineering (EDCE). She graduated with an MSc degree from Chalmers University of Technology, Gothenburg, Sweden, in Design for Sustainable Development, in 2009. Her Master thesis "Visual Comfort in Office Environment" was conducted at the Lighting Technology group at Fraunhofer Institute for Solar Energy Systems (ISE), Freiburg, Germany, where she worked as a research assistant. She has one and a half year of professional work experience at K-KONSULT ELMILJÖ AB, Stockholm, where she co-initiated the lighting design section dealing with concept development, integration, and realization of lighting projects. Mandana's research explores the relationships between view-direction patterns and perceived visual comfort from light distribution in office spaces.

Émilie Nault
PhD student

Émilie Nault joined EPFL in 2011 as a PhD student in the Doctoral Program in Civil and Environmental Engineering (EDCE). Émilie holds a BSc in Physics from Sherbrooke University in Canada (2005-2009) and an MSc in Renewable Energy Engineering from Heriot-Watt University in Scotland (2009-2010). Émilie's current research focuses on solar potential evaluation and improvement at the early design stage of neighborhoods.

María Lovísa Ámundadóttir
PhD student

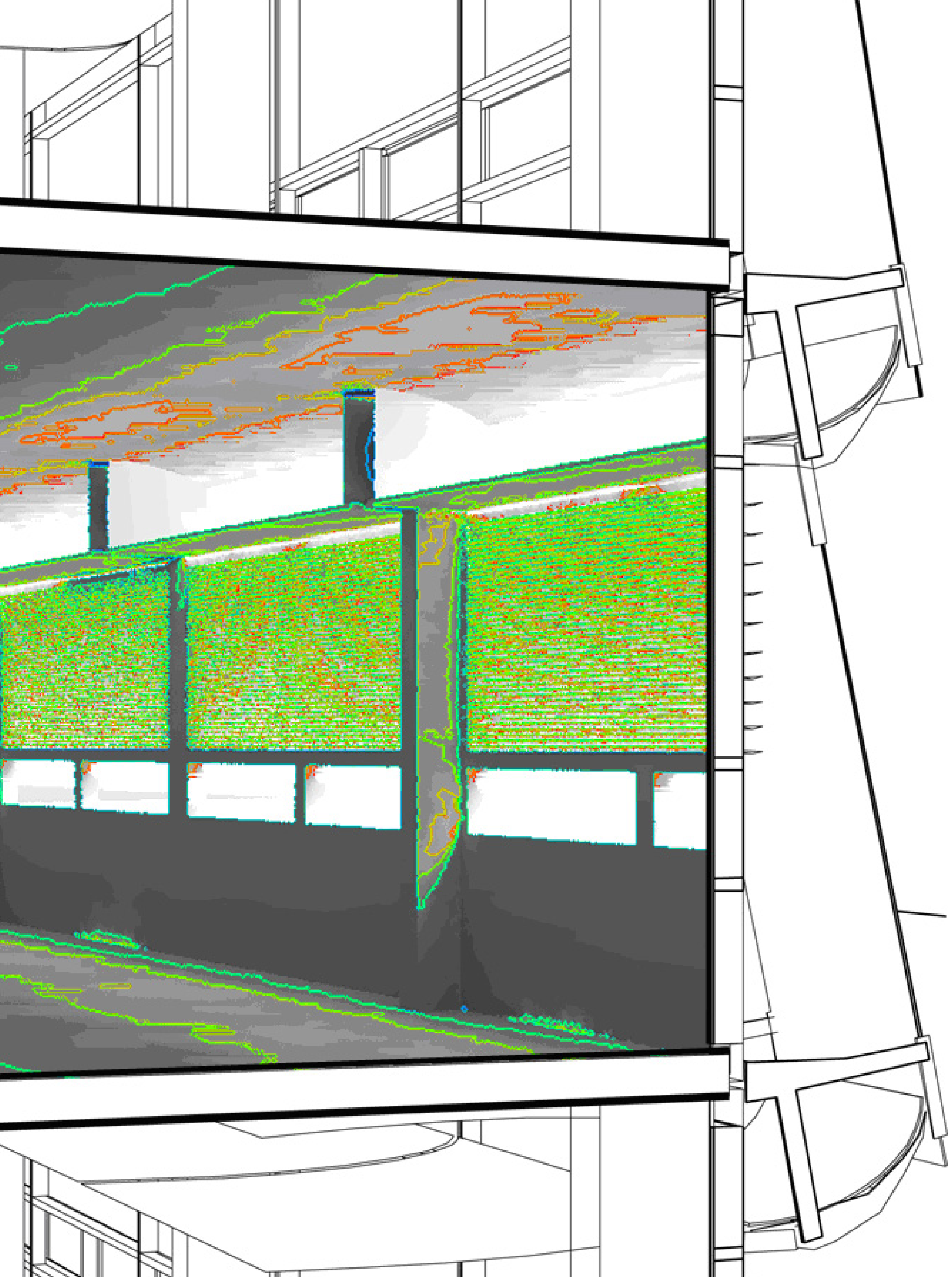
María Lovísa Ámundadóttir is a PhD candidate enrolled in the doctoral program in Civil and Environmental Engineering (EDCE) at EPFL since October 2011. María holds a MSc in Computational Science and Engineering from ETHZ (2008-2011) and a BSc in Industrial Engineering from the University of Iceland (2005-2008). In her masters program, she specialised in chemistry and biology and worked on projects related to molecular dynamics simulations, pedestrian dynamics, multi-agent simulations and robust optimization.
The aim of María's current research at LIPID is to understand how the nonvisual effects of light evolve over time with respect to changes in intensity, spectral composition and duration of light exposure using mathematical models.

Parag Rastogi
PhD student

Parag Rastogi is a PhD candidate enrolled in the Doctoral Program in Civil and Environmental Engineering (EDCE) since 2012. He holds a MSc (2011) and BSc (2010) from the School of Civil Engineering at Purdue University, USA. In his Masters program, he worked with the interdisciplinary Architectural Engineering department on developing algorithms for control of shading and lighting. Parag has worked as an intern for Parsons Brinckerhoff International Pvt. Ltd. (construction project management at the New Delhi International Airport) and Lutron Electronics Co., Inc. (research and development activities at their headquarters in Pennsylvania, USA). He holds a LEED Green Associate certification since January 2011 and is a registered Engineering Intern with the State of Indiana, USA.
Parag's current research activity revolves around the idea of climatically appropriate building design.

Siobhan Rockcastke
PhD student

Siobhan Rockcastke joined LIPID Lab in 2013 as a PhD candidate in the Doctoral Program in Architecture and Sciences of the City. Siobhan received her BArch from Cornell University in 2008, where she served as a team leader for the 2007 Solar Decathlon project and, upon graduating, was offered a Teaching Associate position in the first year undergraduate design studios. She received her SMArchS degree in Building Technology from MIT in 2011 and was awarded a top prize by faculty in the department of architecture for her thesis titled "Daylight Variability and Contrast-Driven Architectural Effect." Upon graduating, she was awarded a fellowship at Northeastern University where she taught comprehensive architectural design, environmental systems, and daylighting design. Siobhan has two years of professional work experience at KVA matX in Boston where she managed schematic design on the Minneapolis riverFIRST development initiative and the 3M Sunlight Delivery project.
Siobhan's current research studies the impacts of contrast and variability in daylit architecture.



LIPID RESEARCH

The Interdisciplinary Laboratory of Performance-Integrated Design (LIPID) focuses on the integration of building performance considerations in the architectural design process.

Designing energy-efficient spaces that provide a confortable environment is a challenge faced by architects and building designers everyday. Within the overall framework of promoting links between analysis and design, there is a real need for new approaches in research and education to better integrate building performance considerations in the architectural design process.

Research conducted at LIPID ranges from new façade technologies to interactive visualization methods and climate-based performance metrics, with a common overarching goal of promoting energy-efficiency, human comfort and health in buildings. Daylighting and passive solar strategies are a strategic focus for LIPID, since they are central to sustainable architectural design and substantially important for a building's technical performance and resulting human comfort and health.

Ongoing projects include new calculation methods, evaluation tools, instruments and metrics that aim to support this integration effort in the classroom as well as in applied contexts.

Areas of Focus

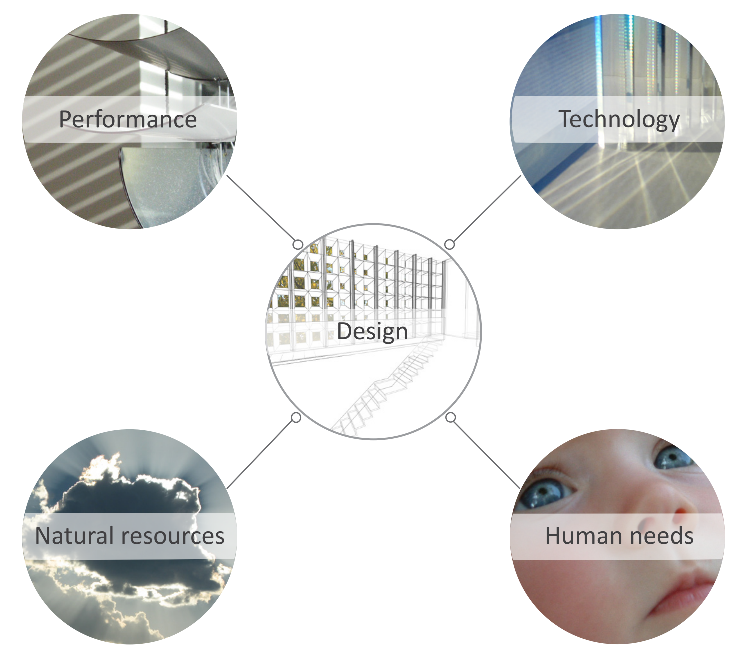
Overall, LIPID's research activities are built around the central theme of design, from four main perspectives:

Climate Appropriateness – how to benefit from the natural environment in creating robust envelopes;

Human Needs Fulfillment – how closely we are able to fulfill human needs in an interior environment;

Building Skin Technology – how we should design the interface between the variable outdoors and the stable indoors, with technology that can vary from the simplest to the most sophisticated;

Performance Optimization – how performance can be evaluated with the many variables that play a role in defining the quality of a built space.



Climate Appropriateness

A range of computer simulation, visualization and measurement techniques can be used in combination with space modeling and prototyping methods to investigate the interactions of interior environments with the outdoors.
We can experiment with the highly dynamic light and sun conditions, which will generate rich and complex indoors conditions. What we need to ensure is that they are conducive to human comfort, delight and health, a question that can be tackled from multiple perspectives. At the urban level, new simulation methods are needed to support the planning of sustainable neighborhoods especially during the earliest design stages, on the basis of potential solar input, e.g. the potential for access to daylight or passive solar gains. At the façade level, we can and sometimes should draw inspiration from vernacular architecture to enhance climate-appropriateness. Current work on the ubiquitous solar screens (Mushrabiya) of the Middle East e.g. already led to promising solutions for arid climates. Researchers in the group are also exploring ways of quantifying climatic volatility at the meso-scale using intuitive energy-based metrics. These metrics are meant to indicate and hierarchize priorities for environmental design for occupant comfort and well-being. Whether we choose to adopt mitigation measures or not, it seems risky to design a building without accounting for some changes in climate and deviations from the widely used Design Reference Year files. The complexity of climatic phenomena suggests the use of stochastic simulation to understand and quantify the impact of climate and volatility on passive and low-energy architecture, for which a better understanding of the sensitivity of different envelope types to climatic volatility and change seems essential.

Human Needs Fulfillment

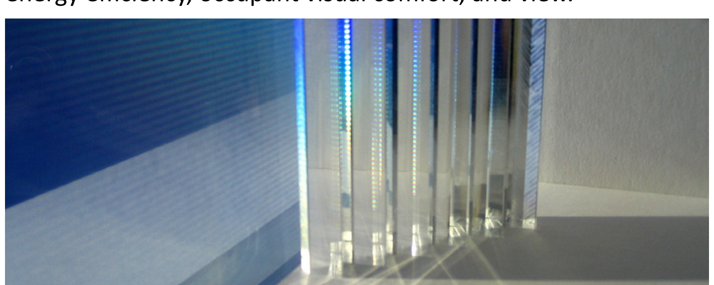
While energy-efficiency or environmental measures have benefited from numerous and powerful research efforts, further research is needed to better understand the complex interactions between the many parameters influencing human comfort.
Advancing our capabilities to assess and predict visual and thermal comfort in interior spaces can be approached from different ways. Studies concerning discomfort glare, for instance, have so far been based on conventional psycho-physical procedures. Given the importance of discomfort glare in building performance, a pioneering study has been conducted at LIPID to refine our understanding of this phenomenon. In this study, the view direction dependencies of glare are investigated by integrating eye-tracking methods in the experiments. The experiments, which account for view direction derived luminance values, seek to establish a basis for accurate glare evaluations and integration of dynamics of view direction in the glare calculations.
Another topic of particular interest at LIPID is to strengthen the connection between lighting conditions and human health, based on collaborations with the scientists working in photobiology and neuroscience. The link between daylight and human circadian organization (as a proxy for health) is explored here in terms of its architectural implications for an increased understanding of the health effects of daylighting in architecture. Critical parameters include lighting intensity, timing, and spectrum and the research aims at specific recommendations for architectural design and light source design. Now is also the right time to start developing calculation methods and simulation workflows that would allow us to extract circadian-relevant information from traditional, vision-based building simulation results, as well as from novel experimental methods currently being explored at LIPID.

Building Skin Technology

Part of LIPID's activities focus on the development and evaluation of advanced façade designs and high-performance envelopes with regards to energy loads, human comfort and overall occupant acceptance. With the ever growing variety of innovative façade technologies, finding ways to better connect the design and industry fields is becoming a necessity. A new approach has been developed as an interactive search and selection platform to address this need, focusing on the designer's perspective, under construction at www.d-lite.org.

It is very challenging to obtain a trade-off between solar protection, appropriate daylighting and occupant visual comfort. Different passive technologies are being investigated such as the Soralux Daylighting System, a passive louver unit that requires no shading adjustments and works well with deep-plan spaces. Others rely on passive actuators, adaptively reacting to direct solar radiation, combined with robust skin designs for arid climates with unique dayligthing, optical and aesthetic features. Along those lines, we currently investigate designs of solar thermal concentrator based on an innovative self-adaptive design that avoids complex tracking mechanisms.

LIPID has substantial expertise in the experimental assessment of the so-called Bidirectional Transmission Distribution Functions (BTDFs), including pioneering designs of parallel goniophotometers, i.e. instruments that allow dramatic reductions in measurement time compared to their step-by-step scanning counterparts. We are currently investigating limitations of these new instruments as well as design rules ensuring robustness. Because raw BTDF data lack comprehensiveness and intuitiveness, a new set of performance metrics is being developed in parallel for describing important key features of a complex window system, such as energy efficiency, occupant visual comfort, and view.



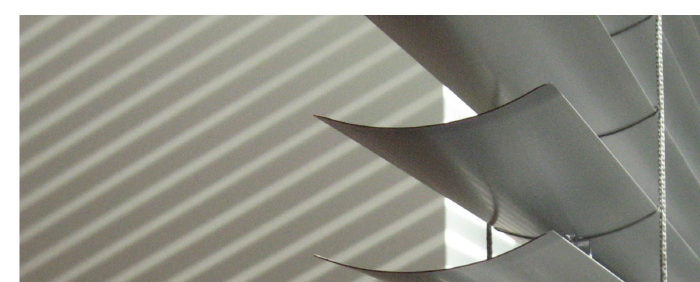
Performance Optimization

To assist designers in their search for the right balance between human comfort, energy-efficiency and well-being in a given climate, new calculation methods and design support approaches are being developed at LIPID.

A strong research effort is being put into the development of new methods to evaluate the annual daylighting potential of a schematic building project interactively. This research initiative started at MIT and was initially developed in collaboration with the Computer Science Department at the Rensselaer Polytechnic Institute for the rendering engine. It resulted in a full year, climate-based daylighting simulation tool named Lightsolve. In addition to comprehensive illumination, glare and solar gains analyses, this tool aims to offer an interactive, goal-based expert system that acts as a "virtual daylighting consultant," guiding the user towards improved performance while maintaining the integrity of the original design and of the design process itself.

On the other hand, visual interest in architectural daylighting refers to the aesthetic and perceptual aspects of a space's illumination. The subjective nature of design makes indicators such as visual interest difficult to define, but a closer look at contemporary architecture suggests that there are certain similarities in how architects choose to choreograph daylight for varied programmatic needs and experiential effects. This could potentially support the need for a new measure of light distribution, not only based on comfort and needs but also delight.

Performance thus encompasses an always growing range of aspects, from the urban to the components scale, and from climate and energy-efficiency considerations to health, comfort and pleasure.



PhD Projects

There are five PhD theses currently in-progress at LIPID. Following the list of ongoing and completed theses, a description of the current PhD projects is presented.

PhD theses in-progress at LIPID:

Mandana Sarey Khanie
“Human-responsive workplace design: A model for view direction patterns to objectify discomfort glare”
To be completed by 2014

Emilie Nault
“Energy Potential and Interactive Design in the Urban Context”
To be completed by 2015

María Lovísa Ámundadóttir
“Healthy lighting: a framework for predicting the non-visual effects of light”
To be completed by 2015

Parag Rastogi
“A framework for climate- conscious design: from climate characterisation to façade selection”
To be completed by 2016

Siobhan Rockcastle
“Dynamic Peceptual Effects of Daylight in Architectural Space”
To be completed by 2017

Completed PhD theses (co-advised):

Coralie Cauwerts
PhD in Architectural Engineering
University Catholique de Louvain (UCL), Belgium
“Évaluation de la qualité lumineuse et de l’intérêt visuel d’un espace éclairé naturelle- ment: potentiel de différents modes de visualisation”
Completed in November 2013
Advisors: Prof. André De Herde and Dr. Magali Bodart
Accompanying committee: Prof. Marie-Claude Dubois and Prof. Marilyne Andersen

Human responsive workplace design

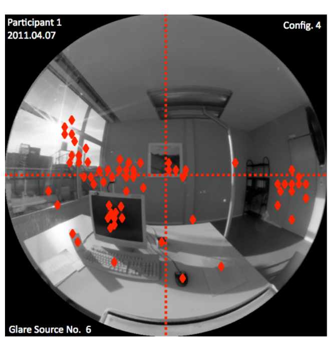
Mandana Sarey Khanie

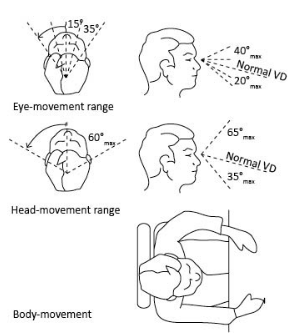
Prof Marilyne Andersen, advisor
Dr. Jan Wienold, co-advisor

PhD program: Civil and Environmental Engineering (EDCE)
2010-2014 (expected)
Candidacy exam in September 2011

Email: mandana.sareykhanie@epfl.ch

In this work the fields of architecture, building technology and psychophysics come together in search for objective relationships between perceived comfort, occupant response patterns and lighting conditions in office spaces. Depending on the occupants' seating position and view direction, light distribution in the field-of-view (FOV) can range from interesting highlights to visually discomforting situations, commonly known as discomfort glare. There are several discomfort glare metrics that can be used at the design phase to predict discomfort glare risks. A major limitation, shared by all known glare metrics, is that the dependencies of glare on view-direction are ignored. This study seeks to eliminate this limitation through a deeper understanding of the dynamics of view-direction as a result of light distribution across the FOV. The methodological novelty in this study relies on experiments in which the eye movements of human participants are measured in a parameterized office-like environment. Concretely this implies using an head-mount eye-tracker while the participants are exposed to different light conditions. The hypothesis is that there are clear view-direction distributions patterns under different lighting conditions. The ultimate goal is to foster a factor in visual comfort prediction models, which will enable the accounting for one's actual position and view direction in space in a work environment.





At left:
View direction weighted luminance distributions represent the actual luminous environment experienced by the participants

At right:
View direction is where we direct our gaze by mutually moving our body, head and eyes.

Solar potential and interactive design in the urban context

Emilie Nault

Prof Marilyne Andersen, advisor
Prof Emmanuel Rey, co-advisor

PhD program: Civil and Environmental Engineering (EDCE)
2011-2015 (expected)
Candidacy exam in August 2012

Email: emilie.nault@epfl.ch

This PhD thesis targets the issues of assessing and improving the energy performance of a neighborhood project in its early design phase. Architects and urban designers are increasingly dealing with projects which are either located in an existing built environment, or consisting in a multi-building design (e.g. urban renewal project). In such cases, the energy performance of buildings will be strongly conditioned by their configuration and morphology, which will dictate the level of solar exposure of each façade and roof (e.g. level of inter-building shading), in turn influencing heating, cooling and artificial lighting needs as well as energy production potential (e.g. via photovoltaic panels).

This research aims at developing a design decision support methodology as a framework for iteratively improving the energy potential of a neighborhood project, by playing on its geometrical features (e.g. height). As a first step, a climate-based evaluation method is to be conceived to assess the potential of a design for exploiting solar energy through active measures (photovoltaic and thermal collectors) and passive means (daylighting, passive heating and cooling). The second phase consists in a step-by-step improvement procedure, where geometrical modifications on flexible early design parameters, leading to an improved performance, are proposed to the practitioner. Performance results are translated into various intuitive graphical forms expressing the level of achievement of the goals over time and space.

Radiation maps of two student designs created in the architectural design studio BA 3-4 (LAST). Maps were generated (using DIVA-for-Rhino software) as part of the study conducted for the Green Density project.

A dynamic computational model to evaluate non-visual effects of light on human health in buildings

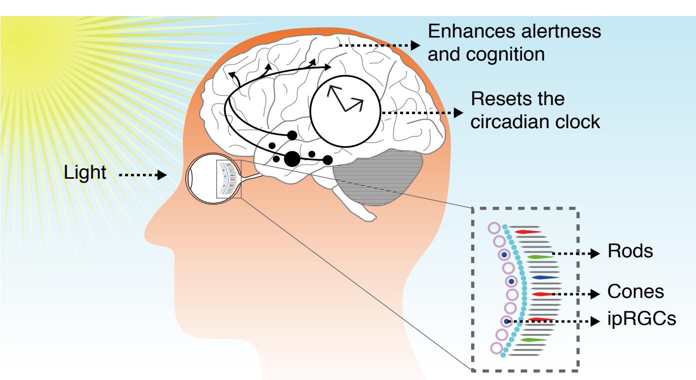
María Lovísa Ámundadóttir

Prof Marilyne Andersen, advisor

PhD program: Civil and Environmental Engineering (EDCE)
2011-2015 (expected)
Candidacy exam in September 2012

Email: maria.amundadottir@epfl.ch

The focus of María's current research at LIPID is on computational approaches to understand the impact of the nonvisual effects of light on health outcomes in occupants. Although light influences both visual and nonvisual responses in humans, lighting standards for building design and operation are mainly based on visual criteria. Human lighting needs include lighting that is appropriate to maintain good physiological health, as well as lighting for visual comfort, task performance and aesthetic appreciation. Conventional methods, used to assess visual function and comfort, are not sufficient to evaluate nonvisual responses to light. This means that illuminance measured on a horizontal working plane, where the most important visual tasks in the space are performed, does not predict the amount of light received at the eye in all lighting conditions (for example ceiling amounted electric light versus daylight from windows), therefore vertical or retinal irradiance at the eye level must be considered to evaluate nonvisual responses to light. The goal of María's thesis is to develop a dynamic model capable of predicting human non-visual responses to light and to validate novel guidelines that can inform building design and operation.



Light exposure activates rods, cones and melanopsin-containing intrinsically photosensitive retinal ganglion cells (ipRGCs). Melanopsin-containing ipRGCs project to a range of 'nonvisual' areas of the brain.

A framework for climate-conscious design: from climate characterisation to envelope performance

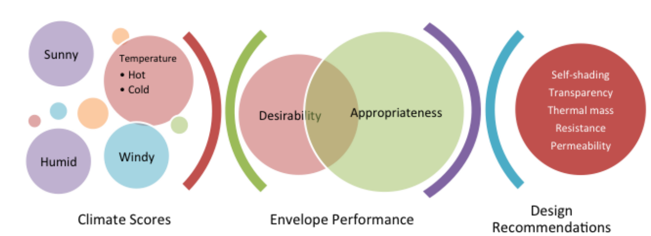
Parag Rastogi

Prof Marilyne Andersen, advisor

PhD program: Civil and Environmental Engineering (EDCE)
2012-2016 (expected)
Candidacy exam in January 2013

Email: parag.rastogi@epfl.ch

This thesis deals with the idea of climatically appropriate building design. Parag is developing a schema for supporting early-stage architectural design which is cognisant of the role a comfortable indoor environment plays in creating desirable buildings. The project also ties together the role that climate plays in both affecting conditions in the building and influencing the expected values of 'comfortable' temperatures, humidity, etc. at a given time. The goal is to use the most applicable statistical (stochastic) and numerical methods (equations governing heat transfer) to transform raw climate data into a simple, intuitive, 'map' of energy performance. This map is delineated by the performance characteristics of a building envelope (e.g. thermal resistance), which is treated as an abstraction of the interface between the people in a building and the outside environment. Using stochastic programming to create this map, with some crucial boundary conditions which are usually known at the early stages of design, the schema should be able to assist a designer in verifying their intuition about the energy performance of their designs. These are, essentially, performance- or outcome-based recommendations to guide the design of envelopes toward climate-appropriate alternatives. This project aims to distance itself from conventional approaches involving recommendations of materials or designs. It avoids a confrontation with energy modelling, since it uses the same physics. Rather, it focuses on the aspect of design that is currently not well-served by energy modelling – the early phase – with all its attendant lack of details and clarity about design objectives.



Overview of the keywords in this thesis, divided into three parts corresponding to different aspects of the thesis

Measuring the Perceptual Dynamics of Daylight in Architecture

Siobhan Rockcastle

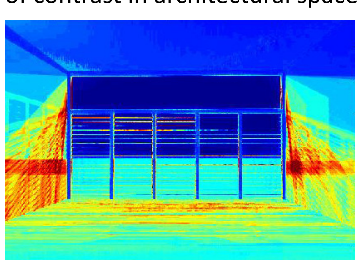
Prof Marilyne Andersen, advisor

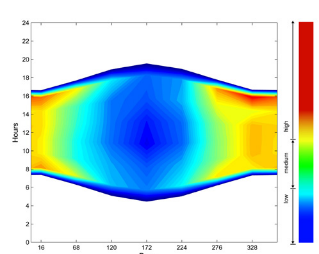
PhD program: Architecture and Sciences of the City (EDAR)
2013-2017 (expected)

Email: siobhan.rockcastle@epfl.ch

Daylight offers both functional and aesthetic value to architecture, providing natural and energy-efficient illumination for interior tasks and infusing interior space with light, shadow, and texture. Unlike artificial light sources, which can be adjusted to meet a desired luminous effect regardless of latitude, climate, or time of day; daylight is sensitive to a number of dynamic conditions. These variable conditions result in a highly dynamic source of illumination and perceptual phenomena. While many architects have expressed the importance of these phenomenological effects on our perception of space we are left with disproportionally few, if any, daylight design metrics that can evaluate the positive impacts of luminous variability within the visual field.

Daylighting research has gravitated toward the widespread development of task-based illumination metrics as a means of offsetting a building's reliance on electric light. Visual comfort metrics, especially those pertaining to glare, have also gained predominance within the last two decades, as the emphasis on daylight integration has led to an increase in glazed facades and complex shading systems that can trigger occupant discomfort during visual tasks. Perceptual performance indicators such as contrast and variability, on the other hand, are traditionally defined as qualitative design factors and quantitative methods to explore their impact or relevance have been limited. Although subjective in nature, the visual perception of space is central to architectural design and criteria for its performance must be considered alongside illumination and comfort metrics to develop a more holistic evaluation of daylight in architecture. This research will propose a new family of metrics for quantifying the dynamic performance of contrast in architectural space.





False Color image and annual temporal map showing the luminance variability in a side-lit space in Boston, MA.

Postdoctoral Projects

Measuring the Usability, Efficiency and Effectiveness of Simulation Tools and Applications
Shady Attia

Solar Thermal concentrator independent of sun's position
Boris Karamata

Adaptive solar shading system with passive actuation
Boris Karamata

Measuring the Usability, Efficiency and Effectiveness of Simulation Tools and Applications

Shady Attia

Prof Marilyne Andersen, advisor

Post-doctoral work

Email: shady.attia@epfl.ch

Computer Aided Architectural Design (CAAD) decisions and judgments have been at the heart of architectural design practice. Despite the increasing popularity of computer aided design applications, measuring the decision making of designers empirically remains elusive. Past research claiming usefulness of the CAD has relied largely on anecdotal or case studies that are vulnerable to bias. The study reviews results of prior investigations. The relatively few laboratory experiments report hardly any empirical results regarding the measurement of CAD decision making. Given the tremendous potential of CAAD applications substantial research efforts are justified with a focus on one major research challenge: Highly interactive, intuitive and attractive interfaces can facilitate the creative architectural design process required. CAAD applications are meant to facilitate creative design and educational processes through concept testing and experimentation. Promising concepts must be tested for their feasibility, performance and ability of realization. At this point decisions may have a substantial impact design. Therefore, it is crucial to base such decisions on validated and user friendly interfaces. With current interface technology, however, participants often spend a substantial part of their cognitive resources on understanding and controlling interfaces. Therefore, the effect of combing physiological, behavioral and subjective assessment support measures is significant (Figure 1&2). The ideas of possible research initiatives that can apply physiological measures in correlation to subjective measures for the usability, effectiveness and effectiveness of CAAD applications:

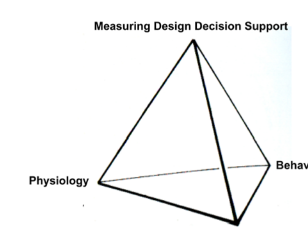
- Emotional influences on judgment and choice
- Performance of CAAD decision making
- Trust in CAAD decision making

In future work, we are looking to conduct experimental subjective and physiological tests for users using CAAD applications. It is expected that users' physiological responses correspond to their physiological responses. Studying the relationship between a physiological measure and subjective measure would be an empirical evidence to measure the quality of use an application or tool.

In conclusion, the field of human factors has been concerned with optimizing the relationship between humans and their technological systems. The quality of a system has been judged not only on how it affects user performance in terms of productivity and efficiency, but on what kind of effect it has it on decision making of the CAAD tool users. Although very little research has been conducted in the CAAD domain, results from the few studies in HCI and the more plentiful studies in the field of human factors are encouraging. The studies presented in this paper reveal how different physiological measures were successfully used in different work-related domains, however, the emerging nature of this technique means that there has been no standardization of task, domain, or measures in the CAAD domain. As such, comparison across studies is difficult. Building a corpus of knowledge surrounding the use of physiological measures for CAAD applications evaluation is occurring, albeit slowly. There is still a need for researchers from the AEC industry, who are interested in physiological techniques for CAAD applications evaluation, to create a research community in order to advance the fledgling field.

The three metrics for measuring the quality of use of CAAD applications.

The three combined approach for measuring the quality of use of CAAD applications.



Solar Thermal concentrator independent of the sun's position

Boris Karamata

Prof Marilyne Andersen, advisor

Post-doctoral work

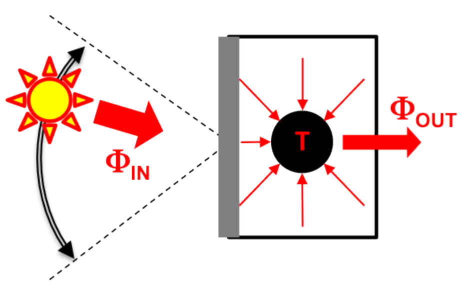
Email: boris.karamata@epfl.ch

We investigate novel designs of solar thermal concentrator for reaching high enough temperatures (> 250 °C) to allow efficient conversion of heat into other forms of energy or enable specific thermo-chemical reactions. Solar flux concentration requires focussing direct sunlight. Given the sun's motion, this requires a relatively complex tracking system incorporating mechanisms, detectors, actuators and control electronics.

In this research we investigate novel modalities that allow an efficient concentration of solar radiations collected over a large portion of the hemisphere independent of the position of the sun, without tracking system like in a conventional device.

Such an outstanding feature (static and passive solar concentrator, i.e. not relying on moving parts and control electronics), is obtained without violation of the fundamental law of étendue thanks to a transformation of the optical properties of the solar concentrator depending on the sun's position. To achieve this we propose a self-adaptive innovative design that combines custom optics and material phase change properties.

Such a design is not trivial and relies on a very sensitive opto-thermal design, as well as on the synthesis of a new material. Deeper investigation if carried on to validate the theoretical and practical feasibility of this unique solar thermal concentrator.



Schematics of operation of a novel static solar thermal concentrator. The power throughput Φout/Φin is independent of the sun's position without tracking.

Adaptive solar shading system with passive actuation

Boris Karamata

Prof Marilyne Andersen, advisor

Post-doctoral work

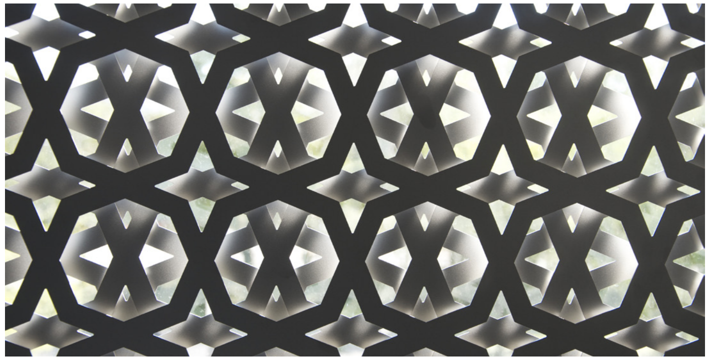
Email: boris.karamata@epfl.ch

In the framework of a broader research on adaptive building skin designs based on passive actuation, we investigate a novel solar and climate responsive building skin that allows preventing excessive solar gains (and the resulting energy consumption) and glare, while maximising daylight and external view depending on the sun's position and climate. The focus is on hot and sunny climates like in the Middle-East countries, with the design of an adaptive masharbiya solar protection system based on passive actuation relying on a phase change material.

The structure of this novel masharbiya, which is made of three layers, needs to be optimized to efficiently block and transform direct sunlight into diffuse light so as to ensure comparable indoor lighting than obtained with skylight, while fully blocking direct solar radiations. Theoretical predictions resulting from modelling and simulations will be compared to the corresponding experimental results obtained with a prototype.

The dynamics of the diffuse light pattern created within this three-dimensional solar protection will be accounted for by exploiting a tool developed at the LIPID laboratory. In addition, a particular emphasis is put on the preservation of the local architectural character and on the potential for architectural integration in the harsh climatic conditions encountered in the Middle-East countries (sand, wind, salted water corrosion, etc...).

Photography of a real-scale masharbiya prototype with three layers made of aluminium blocking direct sunlight.



Development Projects

Lightsolve: an interactive simulation framework for daylighting performance evaluation
Lorenzo Cantelli, Antoine Guillemin and Marilyne Andersen

D-LITE: Database of Light-Interacting Technologies for Envelopes
Marilyne Andersen, in collaboration with Dr. Rosa Urbano Gutierrez, University of Liverpool

Lightsolve: an interactive simulation framework for daylighting performance evaluation

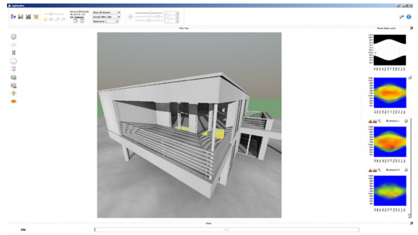
Development project

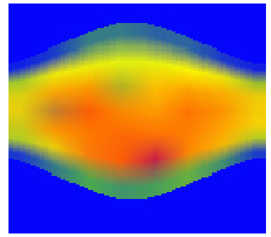
Website: lightsolve.epfl.ch
Email: lorenzo.cantelli@epfl.ch

Taking advantage of the same cutting edge computer graphics technologies that are commonly used by CAD designers, Lightsolve is an advanced visualization platform that simultaneously and interactively displays daylighting performance based on user defined goals.
In addition to other performance simulation platforms for daylighting, Lightsolve allows the assessment of new performances metrics beyond conventional ones, such as health, contrast and variability. The aim of taking into account the health aspect is to integrate non-visual responses to light (such as sleep and health, based on the latest findings in photobiology) into a dynamic light-response model. The contrast and variability aspects are meant to help deepen our understanding of how lighting changes over space and time affect the perception, through a dynamical analysis.
Although functional for evaluating performances, Lightsolve is still in development: the existing performance aspects are constantly being refined and more are being studied by researchers; the simulation engine is being improved availing of the daylighting and optics experts that are naturally part of the team.
Finally, an expert system suggesting modifications to improve performances is at its early development stage: an interactive knowledge base integrating interdisciplinary knowledge and capable of suggesting the best modification to apply to the building's envelope in order to improve the performances. The goal of this system is to make it possible to improve the quality of design even when consulting several specialists of different domains is not affordable or not possible.

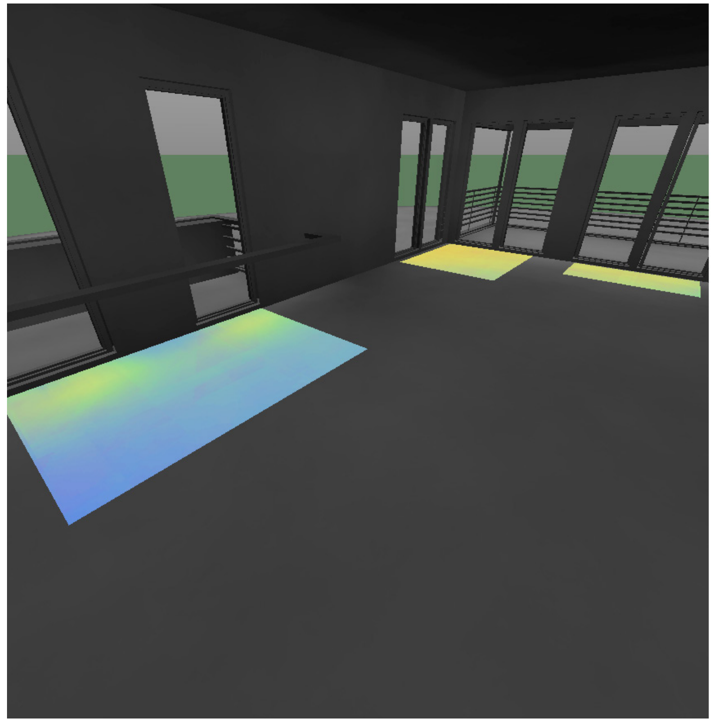
At left: User interface of the Lightsolve tool

At right: Lightsolve simulation output - Rendering for yearly illuminance





Lightsolve simulation output - Temporal map for illuminance on sensor points.

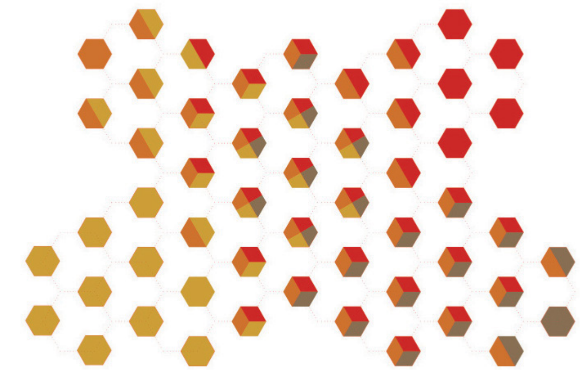


D-LITE: Database of Light-Interacting Technologies for Envelopes

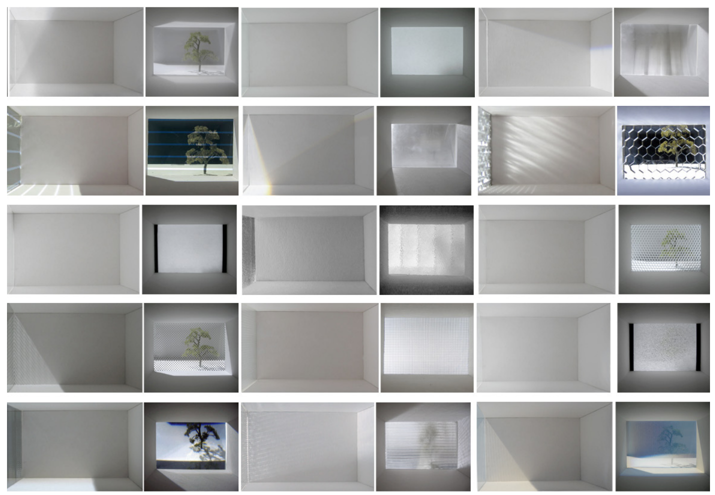
Development project

Website: d-lite.org
Email: info@d-lite.org

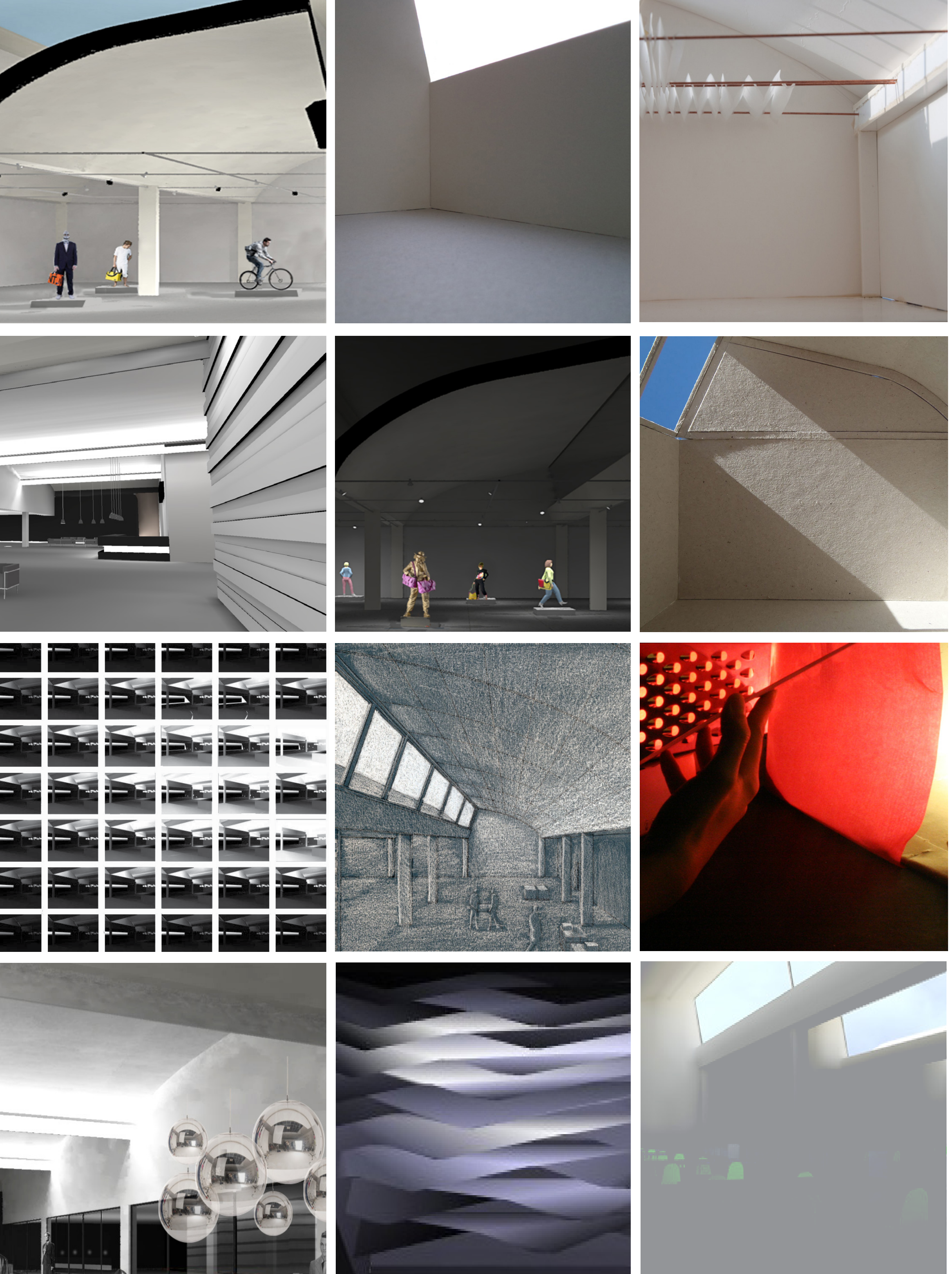
The Database of Light Interacting Technologies for Envelopes (D-LITE) is an online database presenting light and sun control products, prototypes, research projects and case studies in an interactive database format. The aim of D-LITE is to facilitate the exploration and selection of such systems for those in the design and research fields so as to engage them early on to think about daylight and solar radiation for a better integration of sustainability and energy concerns in the built environment., Light interacting technologies are classified into system categories according to their functional and performance characteristics. Based on the user's requirements a number of filters can be activated to identify suitable systems for a given project and get access to intuitive information about them in terms of performance (also on a comparative basis), characteristics and architectural implementation. D-LITE's content can alternatively be accessed through a comprehensive directory providing information on systems, categories, technology developers and envelope designers.



Interactive d-lite categorization matrix based on performance filters



Diversity of d-lite systems and visualization of their light-interacting and view-through properties



LIPID TEACHING

The Interdisciplinary Laboratory of Performance-Integrated Design (LIPID) participates in teaching activities at both undergraduate and graduate levels in architecture, and more broadly within the School of Architecture, Civil and Environmental Engineering (ENAC) at the EPFL, while also collaborating in international educational events such as the EuroTech PhD Summer School.

Recently initiated by LIPID along with the Laboratory of Architecture and Sustainable Technologies (LAST), the axis Integrated Design Architecture and Sustainability (IDEAS) responds to a need to further reinforce the integration of sustainable architecture questions within the framework of the Doctoral program Architecture & Science of the city (EDAR), as well as to strenghten exchanges and synergies between the ENAC institutes. Two modules, described further below, are offered within the IDEAS framework; Architecture and Sustainability - Critical approaches (Module 1) and - Performance studies (Module 2).

LIPID also participates in the Master in Energy Management and Sustainability (MES), an innovative program built to educate engineers with a multidisciplinary profile, capable of mastering real-world thinking and complex problem solving.

Main Teaching Activities

2010-13 *EDAR course (AR-616) – Architecture and sustainability: critical approaches [IDEAS Module 1]*
LIPID: Prof. Marilyne Andersen, Dr. Shady Attia
LAST: Prof. Emmanuel Rey, Dr. Sophie Lufkin
EDAR Doctoral school
Student numbers: 11 in Fall 2012, 12 in Fall 2103

2012-13 *Teaching Unit UE K (AR-440) – Architecture and sustainability: performance studies [IDEAS Module 2]*
LIPID: Prof. Marilyne Andersen, Dr. Shady Attia
LAST: Prof. Emmanuel Rey, Dr. Sophie Lufkin & Dan Bolomey
EDAR Doctoral school
Student numbers: 13 in Spring 2011, 14 in Spring 2012, 10 in Spring 2013

2011-13 *Teaching Unit UE M (AR-441) – Espace & Lumière: Le Projet d'Eclairage*
LIPID: Prof. Marilyne Andersen
Ext: Dr. Bernard Paule
Elective, 4 credits (6 credits until 2013), MA 1 & 3, Architecture
Student numbers: 30 in Fall 2010, 28 in Fall 2011, 24 in Fall 2012, 10 in Fall 2013

2013 *Theory course (AR-437) – Architecture et Qualité de l'Environnement Intérieur: Stratégies durables*
LIPID: Dr. Boris Karamata, Prof. Marilyne Andersen
LESO: Dr. Maria Cristina Munari Probst
Ext: Dr. Peter Zurbrügg
Elective, 4 credits, MA 1 & 3, Architecture
Student number: 14 in Fall 2013

Integrated Design, Architecture and Sustainability (IDEAS)

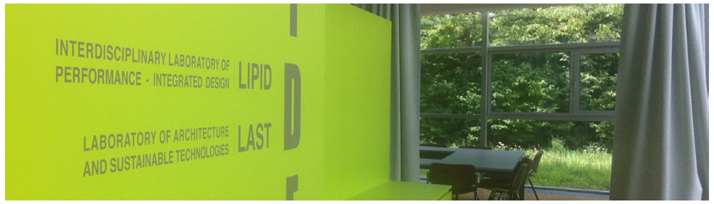
The orientation “Integrated Design Architecture and Sustainability” (IDEAS) is a joint initiative of the Interdisciplinary Laboratory of Performance-Integrated Design (LIPID) and Laboratory of Architecture and Sustainable Technologies (LAST) of the School of Architecture, Civil and Environmental Engineering (ENAC) at EPFL. The IDEAS axis offers an innovative and attractive answer adapted to the following assessment and vision:
- Essential issues: Due to changes in awareness of environmental issues and research for improved performance in buildings, sustainability plays an increasingly important role in research and practice related to architecture and building engineering.
- Global offer: The teaching of architecture is characterized by a quest for greater integration of sustainability, both at the bachelor and master levels. The IDEAS project aims to provide specialized teaching also at the doctoral level.
- Increased visibility: The teaching program also aims to enhance skills already present at EPFL in this field and to promote the visibility of expertise in sustainable architecture.

Two courses are offered within the IDEAS framework: IDEAS 1 (2 credits) and IDEAS 2 (6 credits).

Head:
M. Andersen, E. Rey

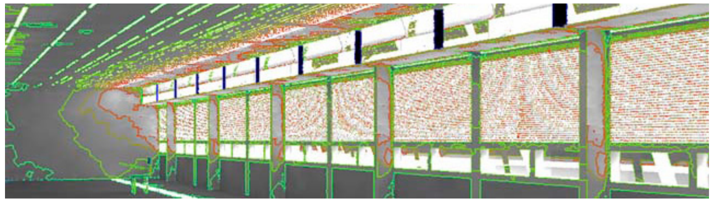
Laboratories:
LIPID | LAST

2012-2013
EDAR Doctoral School
modules 1 & 2
Minor - Master’s in ENAC
(from 2013)



PhD Orientation
IDEAS is one of the four PhD orientations proposed within the Architecture & Science of the City doctoral program (EDAR). The IDEAS 1 course module is targeted specifically at IDEAS PhD students, but is also open to PhD students from other doctoral schools. The second module (IDEAS 2, master’s level) can be taken as an optional course for credits. In parallel, informal meetings are organized to encourage networking of doctoral students, collaborators and researchers of the laboratories involved in IDEAS (“IDEAS Lunches”).

Minor for the Master’s Degree
The IDEAS axis offers an interdisciplinary Minor within the Master’s program in Architecture, Civil and Environmental Engineering. It responds to a need to further reinforce the integration of skills related to sustainable architecture within the curriculum. The objective is also to strengthen exchange and synergy between the three institutes of ENAC. Moreover, this Minor creates a new orientation to prepare second year students more explicitly for doctoral work in this field.
The IDEAS 2 course module is one of the basic courses listed for this Minor.



IDEAS Module 1: Architecture and Sustainability, Critical approaches - EDAR

The objective of this course is to raise the awareness of PhD students to the issues of sustainability in architecture and to interdisciplinary methods (multi-criteria approach). In parallel, this module provides PhD students with an opportunity to apply rigorous analysis methods, which play an essential role in the structuring of a thesis work, whether in terms of the addressed topics, the chosen approach for building/neighbourhood analysis, literature search, etc. The major outcome of this class is the writing, by the PhD students, of a critical report regarding the concept of sustainability for a chosen case study. The aim is to discuss pros and cons of each solution, based on criteria ranging from the careful use of non-renewable resources or a more optimum consideration of the specific climate, to occupant comfort issues, or, more broadly, the optimization of environmental, sociocultural and economic criteria.

Instructors:
E. Rey, S. Lufkin, M. Andersen, S. Attia

Laboratories:
LIPID | LAST

2012-2013
EDAR

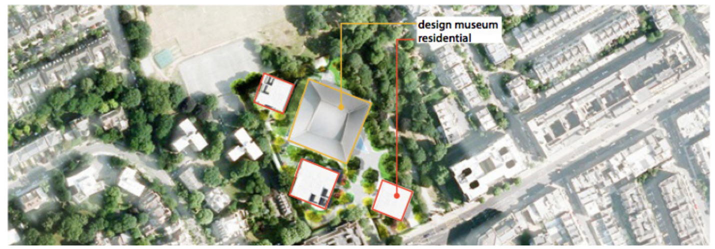
Example projects by:
M. Tursic, F. Bahrami (group A)
S. Rockcastle, M. Skjonsberg (group B)

Project on the Savonnerie Heymans, Brussels (group A)

At left:
The building

At right:
The façade

Project on the Commonwealth Institute & Hollandgreen Residential Development, London (group B)



Top:
Site plan

Bottom:
Design museum: existing space and new renderings

IDEAS Module 2: Architecture and Sustainability, Performance studies
Teaching unit: UE K

This course articulates itself around a detailed design and analysis exercise of the climate-responsiveness and energy-efficiency of a building's envelope. This exercise resorts to several assessment methods, of which the students will have to master the principles and use, with a particular emphasis on a range of simulation tools of variable complexity. The students are asked to integrate several environmental criteria together with performance objectives and the theories behind a resource-efficient and sustainable structure in the design process of a building's façade. They will thus explore different ways of modeling and assessing performance within this integration context. Emphasis will notably be placed on energy and response to climate, on occupant visual and thermal comfort and on the adequate use of materials and sustainable construction technologies.

Instructors:
M. Andersen, S. Attia, E. Rey,
D.-A. Bolomey, S. Lufkin

Laboratories:
LIPID | LAST

2012-2013
Master semester 2

Example projects by:
M. Laprise, L. Fumeaux (group A)
A. Lancelot, F. Couto, G. Wasner (group B)

Project: Double-skin façades with solar chimneys (group A)

View of the tower

Project: Massive façades (group B)

View of the tower

Teaching Unit UE M
Space and light: the lighting project

This course aims to improve the students' ability to see, plan and design light in architecture. The approach is to enable students to consider light as a resource that structures a project, and to master its effects so as to better serve architecture. The students are thus asked to understand the basic principles of natural and artificial lighting, and use them to generate a luminous atmosphere as well as specific performance objectives, that must then be tested through the use of appropriate evaluation tools.
This course adopts a technical approach, focused on performance in terms of illumination potential, visual and thermal comfort but within the framework of a global design intent, which also comprises luminous ambiance. It embraces a sustainable perspective, with an integrated approach combining comfort and energy concerns.
The course is organized in three successive phases: Problem statement (visual and luminous requirements based on space use), Preliminary design (design intent), Dimensioning and verification (project development and validation with adequate simulation tools). Several themes are addressed such as luminous quantities, visual comfort and solar gains, luminaires and light play, as well as an important emphasis on evaluation tools and computer simulation.

Instructors:
M. Andersen, B. Paule

Laboratory:
LIPID

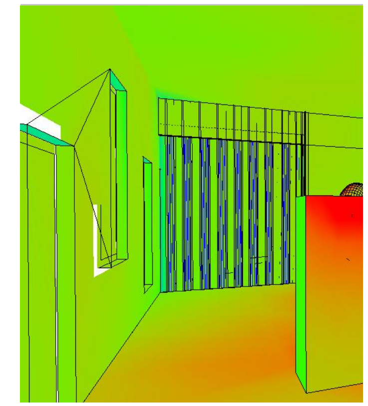
2012-2013
Master semesters 1 & 3

Example projects by:
S. Droux, N. Fernandes, I. Santis (group A)
D. Dubey, S. Harri, A. Zurbuchen (group B)
T. Bloesch, C. Ndayizeye, F. Tornberg, B. Woringer (group C)

Group A's project

At left:
3d-exhibition space, false-color image

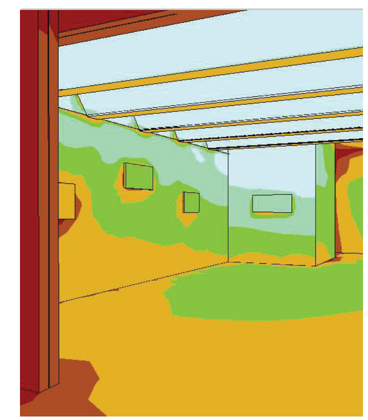
At right:
3d-exhibition space, rendered image

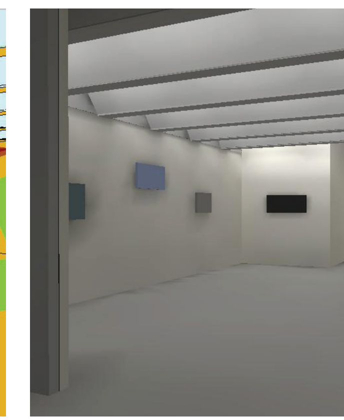


Group B's project

At left:
2d-exhibition space, false-color image

At right:
2d-exhibition space, rendered image





Group C's project

At left:
Entrance and café, day

At right:
Entrance and café, night

Architecture et Qualité de l'Environnement Intérieur: Stratégies Durables

This class focuses on the architectural strategies suited to ensure the highest possible indoor environment quality for buildings from the perspective of the occupants' comfort and using predominantly passive means, possibly complemented with available sustainable technologies.
The course articulates itself around comfort needs for occupants to generate a reflexion on evaluation methods as well as architectural strategies best adapted to ensure these needs.
The contents are organized as follows:
- Introduction to various requirements in terms of indoor comfort to be guaranteed within buildings, and their assessment: thermal comfort, air quality and ventilation, visual comfort, etc. Relevant norms and regulations are discussed as well as the state of the art in defining these different comfort aspects to support and contextualize the proposed reflexion.
- For each type of comfort, the architectural measures (in terms of geometry and materials, typically) capable to fully or partially ensure comfort are introduced as priority measures for architects to work with. Their description and analysis is performed through specific case studies.
- The sustainable systems or technologies available today to complement comfort where passive means are insufficient are presented in detail. The constraints regarding their integration to the architectual design process are analyzed and the available integration solutions are discussed (e.g. solar systems).
-The theoretical contents are complemented by an introduction to several simulation tools appropriate for the quantitative assessment of the energy and comfort performance of a project.

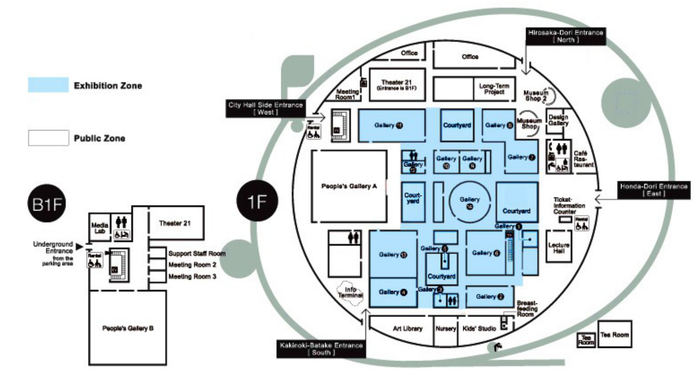
Instructors:
B. Karamata, M. Andersen, M.C. Munari Probst, P. Zurbrügg

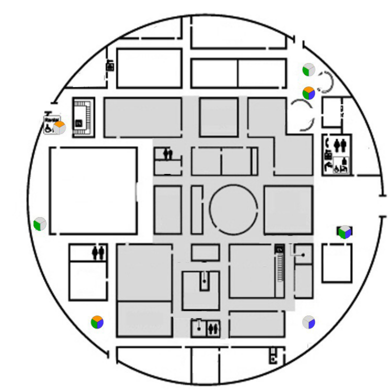
Laboratories:
LIPID | LESO

2012-2013
EDAR

Example projects by: S. Gochenour (group A)
Claire Duclos, Elena Grigore, Hermine Bertrand (group B)

Project on the 21st Century Museum of Contemporary Art, Kanazawa, Japan (group A)

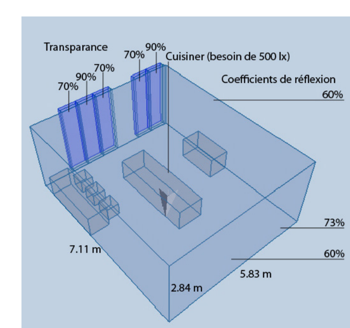


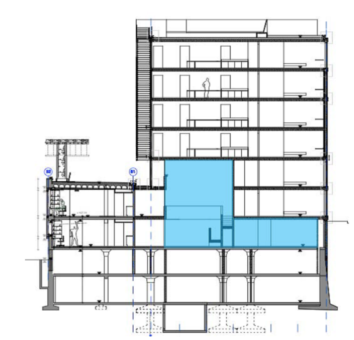


Top:
Floor plan of the museum showing the public and private portions

Bottom:
Simulated viewpoints for glare analysis

Project on the Résidence Stud'Home (group B)





At left:
3D representation of the common room

At right:
Cross-section of the building

Collaborative Teaching Activities

2012-13 *ENAC Week - Sustainable Development of city and landscape of DAVOS*
Lead faculty / coordinator: Prof. Michael Lehning (CRYOS/ENAC)
Spring 2012, 2013
Renewable energy supply and architecture
Instructors:
CRYOS: Prof. Michael Lehning (Lead instructor), Dr. Hendrik Wolf Huwald
LIPID: Prof. Marilyne Andersen, Parag Rastogi
REME: Philippe Bélanger
Ext: Josep Bunyesc Palacín
Student numbers: 20 in Spring 2012, 30 in Spring 2013

2011-13 *Master in Energy Management and Sustainability (MES)*
Program coordinator: Prof. Maher Kayal (eLAB/STI)
Mandatory (for MES degree), 10 credits, MA 1 & 2

2013 *Eurotech Summer School-Integrated Approach to Energy Systems*
Chairman / coordinator: Prof. Mario Paolone
Summer 2013
Theme: *Energy-efficient Design of Building and Urban Systems*
Instructors for theme: Prof. M. Andersen, Dr. S. Attia, E. Nault, P. Rastogi
Student number for theme: 6

LIPID also participates in studio teaching such as in *Atelier Weinand (AR-401)* and *Atelier Rey (AR-201)* as part of the jury and guest lecturer/module supervisor on energy topics.

EuroTech Summer School 2013
Integrated Approach to Energy Systems

The EuroTech Universities Alliance brings together four leading European universities (DTU, EPFL, TU/e and TUM) in a strategic relationship to advance collaboration on leading research and educational programs. LIPID is involved in the “Energy Efficient Buildings and Communities” group of the EuroTech GreenTech Initiative.
Within the general framework of the Alliance, a EuroTech summer school, titled “Integrated Approach to Energy Systems”, was held for the first time in May-June 2013, at EPFL. 40 students participated in 2 weeks of intensive lectures, ending the course with mini-projects in groups.
The LIPID laboratory participated in teaching this class and also proposed a project, focused on the rapid comparison and ranking of sustainable building technologies for residential construction in two contrasting climates in Switzerland – Lausanne and Davos. LIPID’s lectures briefly introduced the students to the concept of a building’s energy balance, thermal comfort, and the position and importance of buildings to the wider energy grid. The lectures treated the building as a holistic system situated in, and intimately connected to, its environment. The students were motivated to approach the building as an essential but malleable component of the human environment.
Six students chose to do the project proposed by LIPID. The goal set for the students was to use sustainable (i.e. renewable, low-impact, etc.) technologies to create a comfortable indoor environment in a home. The project was based on simple equations of heat transfer and balance. The idea was not to deliberately shun complex transient heat balance calculations (i.e. numerical building simulation), but to enable realistic back-of-the-envelope comparisons of designs and strategies for buildings in a short time. The students were asked to compare and contrast the differing priorities and requirements for homes in Lausanne and Davos, Switzerland. The former is a moderate temperate climate, while the latter is an alpine climate. They had two days to analyse, contrast, order, select, and finally present the different strategies and systems for achieving a comfortable indoor environment.

Instructors: M. Paolone (lead), D. Favrat, F. Avellan, S. Haussener, F. Porté-Agel, A. Pautz, C. Ballif, A. Hessler-Wyser, J. Van Herle, A. Rufer, F. Maréchal, C. Nicolet, J.-Y. Le Boudec, C. Jones, N. Morel, M. Finger, R. Cherkaoui, E. Gnansounou, M. Andersen, E. Rey, M.C. Munari Probst, J.H. Kämpf

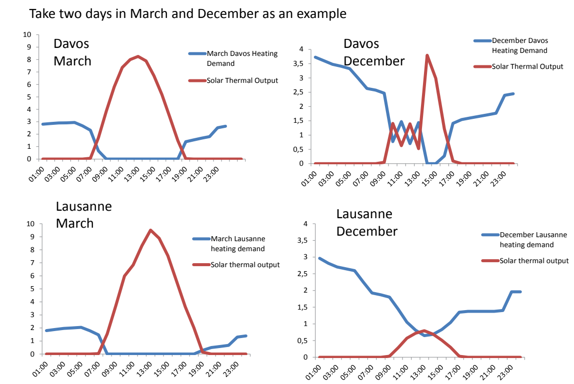
Instructors for LIPID theme:
M. Andersen, S. Attia, E. Nault, P. Rastogi

Laboratories:
BPE | CEN | DESL | LA3 | LAST
LCA2 | LEI | LESO | LIPID
LMH | LRS | MTE | SEL | SGM
SMX | STI | WIRE

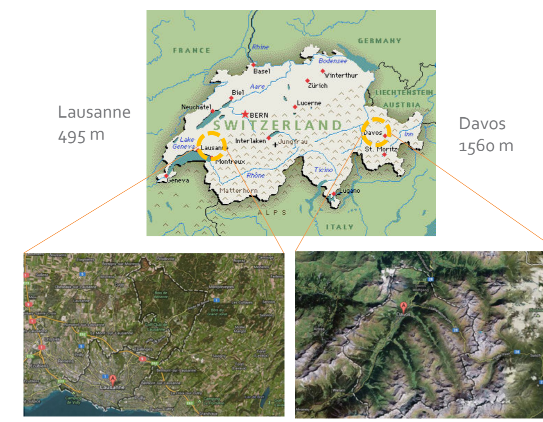
2013

Example project by:
Silvia Coccolo (LESO, EPFL)
Govinda Upadhyay (LESO, EPFL)
Yunming Shao (ENPB, TUM)
(group A)

The mismatch probleme of solar thermal - daily cycle



The studied sites



Results of group A’s project

Ranking of the solutions analysed

Energy converter	Market availability	Sustainability	Storage capacity	Cost
Heat pump (A-W) with inverter	+	+	++	-
PV	++	++	++	-
PVT	-	++	++	-
Boiler	+	-	++	++
Deep water cooling system	++	++	++	++
CHP(Stirling engine)	-	+	++	-
CHP (Reciprocating Engine)	++	-	++	+

ENAC Week
Sustainable development of the city and landscape of Davos

The Semaine ENAC is part of comprehensive efforts in ENAC to increase interdisciplinary teaching and project work. It is intended to bring together second-year students from the three sections that constitute ENAC (Architecture, Civil and Environmental Engineering) for a weeklong project. One of these projects is hosted by the SLF (WSL Institute for Snow and Avalanche Research) in Davos, where researchers from LIPID teach alongside scientists specializing in Environmental Engineering, Snow Physics, Economics, and Alpine Architecture. In this project, students learn about the complexities of designing and constructing sustainable buildings and renewable energy installations in an alpine environment. Particular attention is paid to environmental concerns like the effect and hazards of snow, cold temperature, availability of sunlight, and the appropriateness of materials. The students also learn about integration into an existing landscape and infrastructure as they are exposed to the needs and resources of the town of Davos and the wider region of Graubünden (Grisons). The students are expected to propose and design a comprehensive project that reconciles economic and environmental concerns to ensure its long-term viability. The project emphasizes interdisciplinary teamwork and a holistic view of projects.

Instructors:
M. Lehning, H. Huwald Wolf, M. Andersen, P. Rastogi, P. Bélanger, J. Bunyesc

Laboratories:
CRYOS | EFLUM | LIPID | REME

2012-2013
Bachelor semester 4

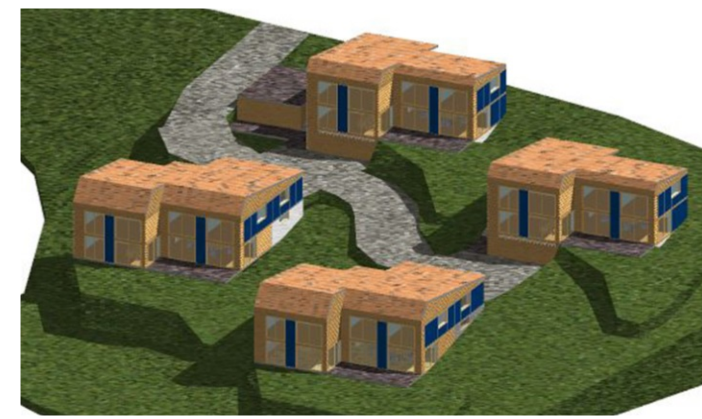
Example projects by:
G. Aguettant, S. Fahrni, P. Meyer, M. Minnig, A. Plagué (group A)
M. Realini, J. Gehring, S. Thomas, C. Studer, S. Roux (group B)
M. Balmer, S. Bonjour, Y. Claessens, M. Gantet, T. McMullin (group C)

Project: An urban landscape in the Alps with sustainable energy production (group A)

Rendering of proposed placement of solar power system

Project: A home in the Alps (group B)

Rendering of the proposed residential buildings



Project: A dam in Davos (group C)

Rendering of the proposed dam above the Davos valley

Master in Energy Management and Sustainability (MES)

The Energy Management and Sustainability (MES) degree is a unique interdisciplinary opportunity fully geared towards achieving lasting advances in a world where the issue of sustainability has become paramount. Students receive theoretical and practical training, using state-of–the-art environmental and sustainable research & development framework.

The program uses a broad-based educational platform - which includes courses across all of EPFL's programs in Lausanne - to train the new generation of professionals who will tackle critical issues in energy management and sustainability. A new project-focused curriculum has been created, built on scientific rigor and professional practice, to provide a unique, interdisciplinary training within this domain. The new generation of problem solvers will be able to understand complex systems such as: smart grids for electricity distribution; water dissemination systems; environmental services and electronic networks that control energy consumption. And ultimately, to be able to both maximize their efficient use and minimize their negative impact on society.

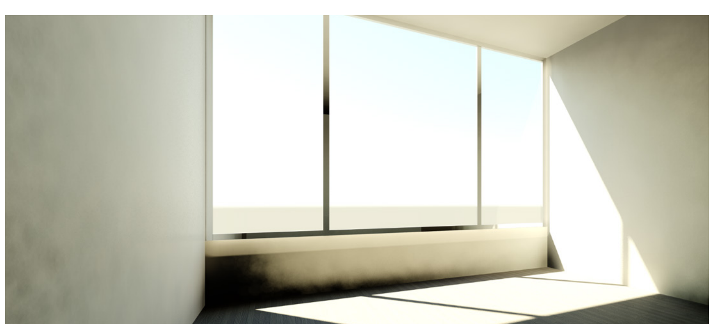
Strong emphasis will be placed on dealing with engineering tasks, taking into consideration important technical, economical, environmental, safety and social constraints. Students will also gain skills in project management and implementation that will help them find solutions for a wide range of energy engineering issues.

Instructors:
M. Kayal, M. Andersen,
F. Porté-Agel, M. Finger

Laboratories:
ELab | LIPID | WIRE | MTEI

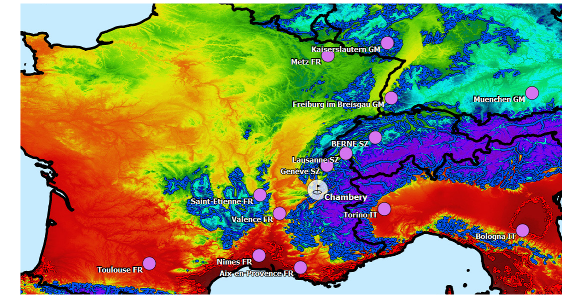
2011-2013
Master semesters 1 & 2
(fall and spring)

Example projects conducted at LIPID by:
S.F. Horn, S. Gochenour, E. Walter, H.E. Bütün, J.F. Beney



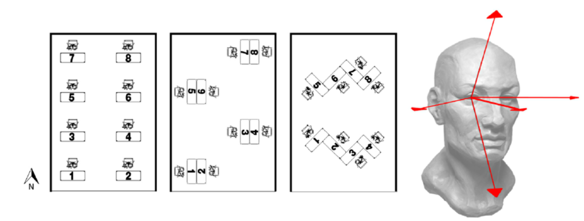
Project: Towards assessing the sensitivity of buildings to changes in climate (S.F. Horn, supervisor: P. Rastogi)

"Temperature contour lines" around a test location for simulating a changing climate



Project: Significance of view direction in simulating circadian potential of architectural spaces (S. Gochenour, supervisor: M.L. Ámundadóttir)

Three different desk arrangements and five view directions investigated

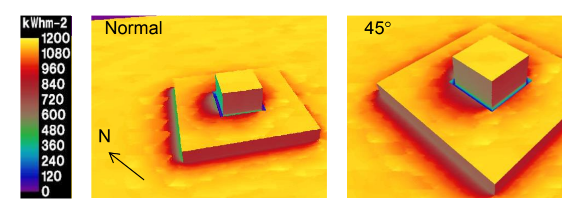


Project: Identifying and modeling the integrated design process of high performance buildings (E. Walter, supervisor: S. Attia)

Chosen case study: Lutz Architects, Green Offices

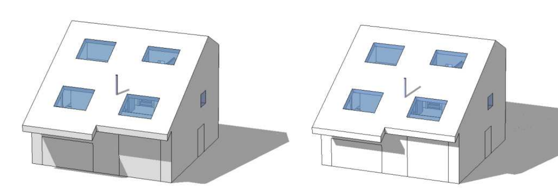
Project: The influence of early design decisions on solar potential at the urban scale (H.E. Bütün, supervisor: E. Nault)

Radiation maps for different orientations



Project: Parametric analysis for material selection of a cradle to cradle house in Switzerland (J.F. Beney, supervisor: S. Attia)

At left: shadow on 21.06, at 15:00
At right: shadow on 21.03 at 15:00



Master's and Diploma Project Advising

Completed master's theses:

Adeline Hainoz & Lucia Keller, MArch Thesis, EPFL, completed in June 2013
Advisor: Prof. Y. Weinand
Co-advisor: Prof. M. Andersen

Awarded the 2013 Prix Durabilis UNIL-EPFL

David-Pascal Mueller, MArch Thesis, EPFL, Habitat bioclimatique alpin, completed in June 2013
Advisor: Prof. E. Rey
Co-advisor: Prof. M. Andersen

Lorraine Kehrli, MArch Thesis, EPFL, completed in June 2013
Advisor: Prof. F. Graf
Co-advisor: Prof. M. Andersen

Master's theses in-progress:

Giuseppe Peronato, MArch Thesis, University IUAV of Venezia, Italy, Solar potential and urban form - densification strategies for sustainable urban planning and design, expected completion in March 2014
Advisors: Prof. F. Peron, Dr. F. Cappelletti
Co-advisor: Prof. M. Andersen

Madeleine Deshaires, MArch Thesis, EPFL, expected completion in June 2014
Advisor: Prof. M. Ruzicka
Co-advisor: Prof. M. Andersen

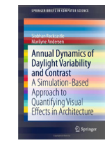
Gian-Luca Ponzetta & Baptiste Wenger, MArch Thesis, EPFL, expected completion in June 2014
Advisor: Prof. E. Rey
Co-advisor: Prof. M. Andersen

Giorgia Chinazzo, MSc in Building Engineering, Department of Energy, Politecnico di Torino, expected completion in July 2014
Advisor: Prof. M. Perino
Co-advisor:Prof. M. Andersen

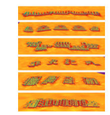
LIPID PUBLICATIONS

In 2013 , LIPID has published 3 books and book chapter contributions, 6 peer-reviewed journal articles, 33 conference papers, 2 technical reports, 6 invited posters and 4 completed theses and diploma projects.

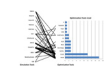
Books and book chapter contributions



S. Rockcastle and M. Andersen, Annual Dynamics of Daylight Variability and Contrast: A Simulation- Based Approach to Quantifying Visual Effects in Architecture, Springer Brief, Springer-Verlag London, UK, in press (expected publication in Jul/Aug 2013)



M. Andersen and E. Nault, Influence de la forme urbaine sur le potentiel solaire, in E. Rey et al., Green Density, Presses polytechniques et universitaires romandes, Lausanne, Switzerland, in press (expected publication in August 2013)



Attia, S. et al. (2013) Building Performance Optimization of Net Zero Energy Buildings Design, Wiley Press, in Press

Annual Dynamics of Daylight Variability and Contrast: A Simulation-Based Approach to Quantifying Visual Effects in Architecture

S. Rockcastle, M. Andersen

Interdisciplinary Laboratory of Performance-Integrated Design (LIPID), École Polytechnique Fédérale de Lausanne, Lausanne, SWITZERLAND

Springer Briefs in Computer Science, London, 2013

Email: siobhan.rockcastle@epfl.ch

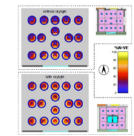
Sample book publication

Daylight is a dynamic source of illumination in architectural space, creating diverse and ephemeral configurations of light and shadow within the built environment. It can generate contrasting levels of brightness between distinct geometries or it can highlight smooth gradients of texture and colour within the visual field. Perceptual qualities of daylight, such as contrast and temporal variability, are essential to our understanding of both material and visual effects in architecture. But what aspects of light qualify the performance of a space? How does an architect determine how best to integrate changing light into a set of design intentions? Under the rapidly growing context of energy conscious research, we need to re-balance our definition of "performance" to include those perceptual and aesthetic aspects of light that are often disregarded by the world of simulation. Contrast is important to the definition of space and it is essential in understanding how architecture is enhanced and transformed over time by the dynamic and variable characteristics of daylight. Although there are a growing number of studies that seek to define the relationship between brightness, contrast, and lighting quality, the dynamic role of daylight within the visual field is underrepresented by existing metrics. A method that addresses this challenge could help designers in contextualizing the relative strength as well as the temporal stability of contrast within a given architectural space, which would open up a new dimension in architectural performance.

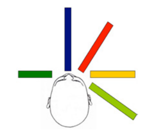
At left: Chapel of St. Ignatius by Steven Holl

At right: Kogod Courtyard by Norman Foster

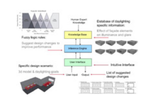
Peer-reviewed journal articles



J. Mardaljevic, M. Andersen, N. Roy, J. Christoffersen, A framework for predicting the non-visual effects of daylight - Part II: the simulation model, Automation in Construction, vol. 35, p. 338-352, 2013.

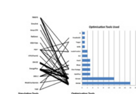


M. Andersen, S. Gochenour, S.W. Lockley, Modeling 'Non-Visual' Effects of Daylighting in a Residential Environment, Building and Environment, vol. 70, p. 138-149, 2013.

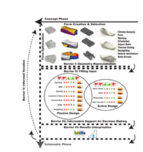


M. Andersen, J.M.L. Gagne, S. Kleindienst, Interactive expert support for early stage full-year daylighting design: a user's perspective on Lightsolve, Automation in Construction vol. 35, p. 338-352, 2013.

P. Correia da Silva, V. Leal, M. Andersen, Occupants interaction with electric lighting and shading systems in real single-occupied offices, Building and Environment, vol. 64, pp. 152-168, 2013.



S. Attia, M. Hamdy, W. O'Brien and S. Carlucci, Assessing Gaps and Needs for Integrating Building Performance Optimization Tools in Net Zero Energy Buildings Design, Energy and Buildings, vol. 60, p. 110-124, 2013.



S. Attia, A. Herde, E. Gratia and J. L. M. Hensen, Achieving informed decision-making for net zero energy buildings design using building performance simulation tools, Building Simulation, vol. 6, num. 1, p. 3-21, 2013.

Interactive expert support for early stage full-year daylighting design: A user's perspective on Lightsolve

M. Andersen[1], J.M.L. Gagne[2], S. Kleindiest[2]

[1]Interdisciplinary Laboratory of Performance-Integrated Design (LIPID), École Polytechnique Fédérale de Lausanne, Lausanne, SWITZERLAND
[2]Building Technology Program, Department of Architecture, Massachusets Institute of Technology, Cambridge, MA, US

«Automation in Construction», vol. 35, p. 338-352, 2013.

Email: marilyne.andersen@epfl.ch

Sample journal article

Designing spaces that are able to balance illumination, glare and solar gains over a year is a real challenge, yet a problem faced every day by building designers. To assist them, a full year, climate-based daylighting simulation method, called Lightsolve, was developed, providing guided search based on the variation of daylight performance over the year by combining temporal performance visualization with spatial renderings.
This paper focuses on the user's perspective for Lightsolve. After a summary of its foundational concepts, it discusses the results of several pilot and more formal user studies conducted in educational contexts. As a core element of the paper, the method and results of an original, design-oriented user study on Lightsolve's expert system are discussed. It was conducted to determine how well its decision-making algorithm would work when independent human interactions were included. It demonstrated that the expert system is generally successful as a performance-driven design tool respectful of the non-deterministic nature of the design process itself, and as a method for educating designers to improve daylighting performance.

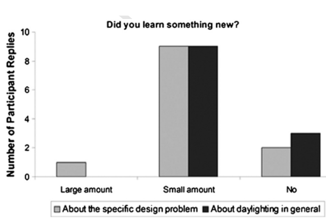


Fig. 15. Participants' responses on educational value.

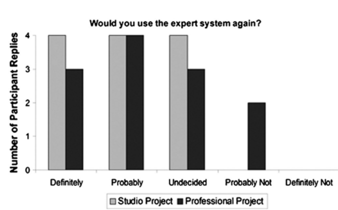
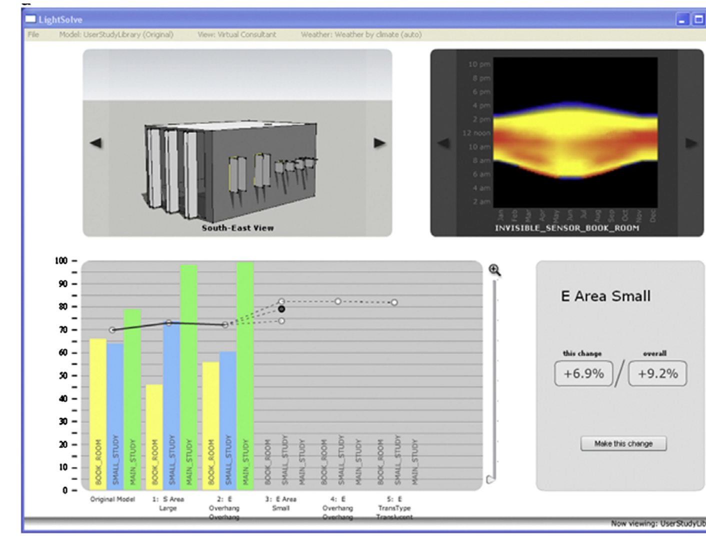


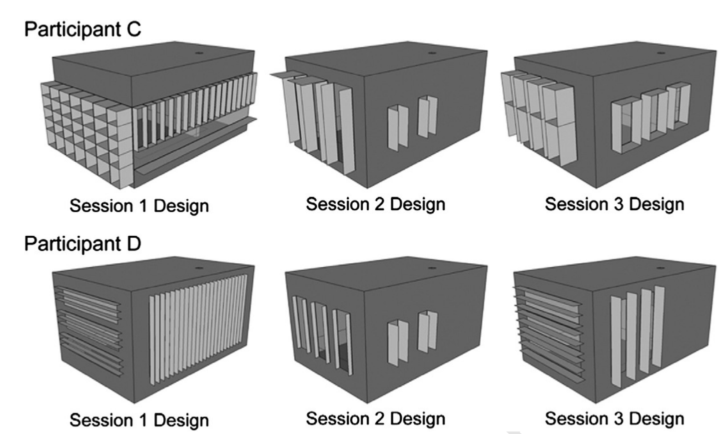
Fig. 16. Participants' responses on using the system.

Participants' responses on educational value and on using the system

Lightsolve expert system interface (virtual consultant)



Two sets of designs from all three sessions



Conference papers

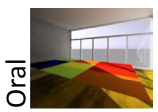
Peer-reviewed conference papers

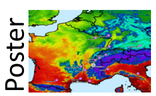
Oral

S. Attia, M. Andersen, Measuring the Usability and Effectiveness of CAAD Tools and Applications, eCAADe 2013, Delft, The Netherlands, Sept 18-20, 2013.

Poster

S. Attia, J.-F. Beney, M. Andersen, Application of the Cradle to Cradle paradigm to a housing unit in Switzerland: Findings from a prototype design, PLEA 2013, Munich, Germany, Sept 10-12, 2013.

Oral

M. Andersen, A. Guillemin, Daylight dynamics to guide early stage design: a user-driven goal-based approach to “good” lighting, PLEA 2013, Munich, Germany, Sept 10-12, 2013.

Poster

P. Rastogi, S.F. Horn, M. Andersen, Toward assessing the sensitivity of buildings to changes in climate using a novel performance metric, PLEA 2013, Munich, Germany, Sept 10-12, 2013.

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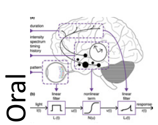
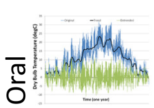

M. Andersen, A. Guillemin, M.L. Amundadottir, S. Rockcastle, Beyond illumination: An interactive simulation framework for non-visual and perceptual aspects of daylighting performance, In Proceedings IBPSA 2013, Chambéry, France, Aug 26-30, 2013.

Oral

P. Rastogi, M. Andersen, Generation of weather files using resampling techniques: an exploratory study, In Proceedings IBPSA 2013, Chambéry, France, Aug 26-30, 2013.

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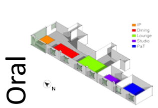
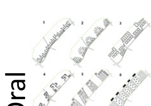
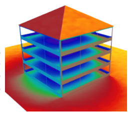

M.L. Amundadottir, S.W. Lockley, M. Andersen, Simulation-based evaluation of non-visual responses to daylight: proof-of-concept study healthcare re-design, In Proceedings IBPSA 2013, Chambéry, France, Aug 26-30, 2013.

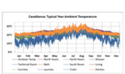
Oral

E. Nault, E. Rey, M. Andersen, Early design phase evaluation of urban solar potential: insights from the analysis of six projects, In Proceedings IBPSA 2013, Chambéry, France, Aug 26-30, 2013.

Poster 

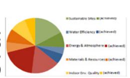
E. Nault, E. Rey, M. Andersen, Towards climate-based irradiation recommendations for optimal solar design: insights from a parametric study, In Proceedings SB13 Munich: Implementing Sustainability - Barriers and Chances, Munich, Germany, Apr 24-26, 2013.

Oral 

S. Attia, E. Walter and M. Andersen, Identifying and modeling the integrated design process of net Zero Energy buildings, High Performance Buildings, Design and Evaluation Methodologies, Brussels, Belgium, June, 24-26, 2013.

Oral 

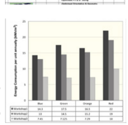
Attia, S., Van Moeseke, G. (2013) Bioclimatic Design in Casablanca: Decision Support through Building Performance Simulation, Proceeding of: The 4th Biennial subtropical cities conference, Braving a new world: Design interventions for changing climates, Fort Lauderdale, FL, USA.

Oral 

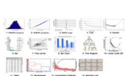
Attia, S., Dabaieh, M. (2013) The usability of green building rating systems in hot arid climates: A case study in Siwa, Egypt, Proceeding of: The 4th Biennial subtropical cities conference, Braving a new world: Design interventions for changing climates, Fort Lauderdale, FL, USA.

Oral 

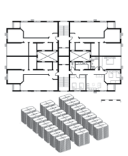
Attia, S., (2013) Achieving Informed Decision Making Using Building Performance Simulation, eCAADe, TU-Delft, The Netherlands.

Oral 

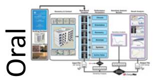
Attia, S., Gratia, E., De Herde, A, Hensen, J. (2013) Early decision support for net zero energy buildings design using building performance simulation, CISBAT, September, Lausanne, Switzerland.

Oral 

Attia, S., Hamdy et al., (2013) Computational Optimisation for Zero Energy Buildings Design Interviews results with twenty eight International expert, International Building Performance Simulation Association, August, Chambery, France.

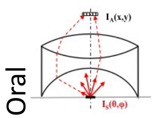
Oral 

Attia, S., Evrard A., (2013) Benchmark Models for Air Conditioned Residential Buildings in Hot Humid Climate, International Building Performance Simulation Association, August, Chambery, France.

Oral 

Attia, S., Gratia, E., De Herde, A, Hensen, J. (2013) A Tool for Design Decision Making Zero Energy Residential Buildings in Hot Humid Climate, International Building Performance Simulation Association, August, Chambery, France.

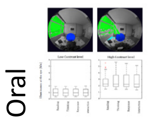
Conference paper with peer-reviewed abstracts

Oral 

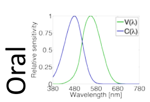
B. Karamata, M. Andersen, A review and analysis of parallel goniophotometry, In Proceedings LuxEuropa 2013, Krakow, Poland, Sept 17-19, 2013.

Oral 

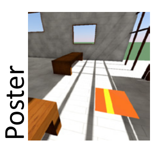
S. Rockcastle, M. Andersen, Celebrating contrast and daylight variability in contemporary architectural design : A typological approach, In Proceedings LuxEuropa 2013, Krakow, Poland, Sept 17-19, 2013.

Oral 

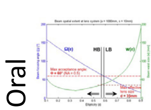
M. Sarey Khanie, M. Andersen, Uncovering relationships between view direction patterns and glare percep-tion in a daylit work environment, In Proceedings LuxEuropa 2013, Krakow, Poland, Sept 17-19, 2013.

Oral 

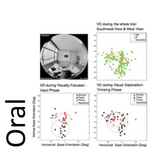
M. Amundadottir, M. Andersen, Integrating non-visual effects of light into building simulation: challenges ahead, In Proceedings LuxEuropa 2013, Krakow, Poland, Sept 17-19, 2013.

Poster 

M. Andersen, A. Guillemin, L. Cantelli, Lightsolve - a full-year goal-based tool for daylighting performance evaluation, In Proceedings CISBAT 2013 - CleanTech for smartcities and buildings, Lausanne, Switzerland, Sept 4-6, 2013 (software presentation paper).

Oral 

B. Karamata, M. Andersen, Revisiting parallel catadioptric goniophometers, Proceedings of the Optical Measurement Systems for Industrial Inspection VIII conference, SPIE Optical Metrology 2013, Munich, Germany, May 13-16, 2013

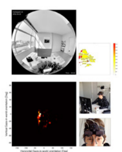
Oral 

M. Sarey Khanie, S. Mende, J. Stoll, W. Einhäuser, M. Andersen, Investigation of gaze patterns in daylit workplaces: using eye-tracking methods to objectify vewi direction as a function of lighting conditions, In Proceedings CIE Midterm conference - Towards a new century of Light, Paris, France, Apr 15-16, 2013.

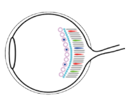
Oral


M.L. Amundadottir, M.A. St Hilaire, S.W. Lockley, M. Andersen, Modeling non-visual responses to light: unifying spectral sensitivity and temporal characteristics in a single model structure, In Proceedings CIE Midterm conference - Towards a new century of Light, Paris, France, Apr 15-16, 2013.

Peer-reviewed extended conference abstracts

Oral


J. Stoll, M. Sarey Khanie, S. Mende, J. Wienold, M. Andersen, W. Einhäuser, Real-world tasks with full control over the visual scene: combining mobile gaze tracking and 4pi light-field measurements, ECEM Symposium, 17th European Conference on Eye Movements, Lund, Sweden, August 11-16, 2013

Oral


M.L. Amundadottir, M. St Hilaire, S.W. Lockley, M. Andersen, Modeling dynamic aspects of human non- visual responses to light, Society for Light Treatment and Biological Rhythms conference SLTBR 2013 - Translational Chronobiology, Geneva, Switzerland, June 21-23, 2013.

Sample conference paper (1/5)

Investigation of gaze patterns in daylit workplaces: using eye-tracking methods to observe view direction as a function of lighting conditions.

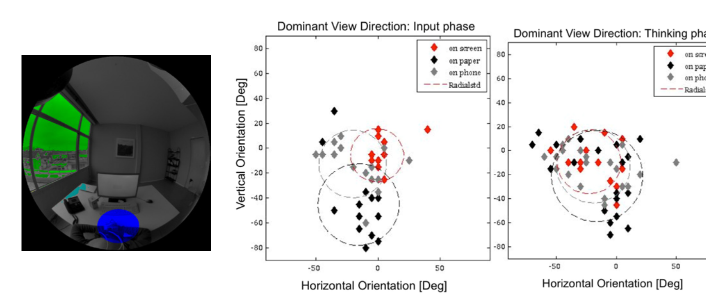
M. Sarey Khanie[1], J. Stoll[2], S. Mende[3], J. Wienold[3], W. Einhäuser[2,4], M. Andersen[1]

[1]Interdisciplinary Laboratory of Performance-Integrated Design (LIPID), École Polytechnique Fédérale de Lausanne, Lausanne, SWITZERLAND
[2]Neurophysics Department, Philipps-Universität Marburg, GERMANY
[3]Fraunhofer Institute for Solar Energy Systems (ISE), Freiburg, GERMANY
[4]Center for Interdisciplinary Research (ZiF), Bielefeld, GERMANY

Presented at CIE Centenary Conference, Apr 15-16, 2013, Paris, FRANCE

Email: mandana.sareykhanie@epfl.ch

Despite numerous efforts in developing glare indices through human assessment studies, predicting visual comfort in indoor environments still poses important challenges in design. A major limitation in discomfort glare indices is that they all ignore its dependencies on view direction. In this study we adopted eye-tracking methods in order to record actual visual response when experiencing discomfort glare. We set up an experiment where the view directions distributions were monitored as the participants were working in a daylit office with three different task-supports - monitor, paper and phone - on a standardized office task sequence. The participants were allocated randomly to two groups where they were exposed to two different views outside the window. The results show that the "view outside the window" is the main determinant of view direction bias whenever the participant is not focused on any cognitive or visual office task procedure.



At left: Photometric parameters relevant to visual comfort are gathered and evaluared using Evalglare

At right: The dominant view directions during two differnt phase under low contrast lighting conditions

Sample conference paper (2/5)

Early design phase evaluation of urban solar potential: insights from the analysis of six projects

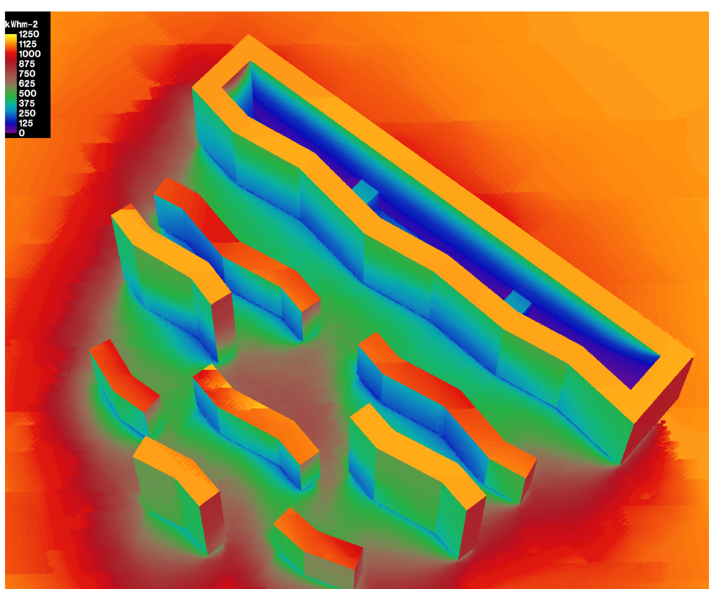
E. Nault[1], E. Rey[2], M. Andersen[1]

[1]Interdisciplinary Laboratory of Performance-Integrated Design (LIPID), École Polytechnique Fédérale de Lausanne, Lausanne, SWITZERLAND
[2]Laboratory of Architecture and Sustainable Technologies (LAST), École Polytechnique Fédérale de Lausanne, Lausanne, SWITZERLAND

Presented at IBPSA, Aug 26-30, 2013, Chambéry, FRANCE

Email: emilie.nault@epfl.ch

This paper presents the outcome of a study based on the early-stage analysis of six virtual urban-scale designs located in Bern, Switzerland. A preliminary solar potential evaluation methodology is devised, inspired by previous studies, to allow the comparison of the projects' potential for exploiting solar energy through passive (e.g. daylight) and active (e.g. photovoltaic) measures. The workflow employed distinguishes itself by integrating and confronting conflicting performance indicators and geometrical parameters. Findings show diversity in the performance among the different designs, while also highlighting the need to review the definition of urban solar potential and refine its assessment.



Example radiation map

Sample conference paper (3/5)

Simulation-based evaluation of non-visual responses to daylight: proof-of-concept study of healthcare re-design

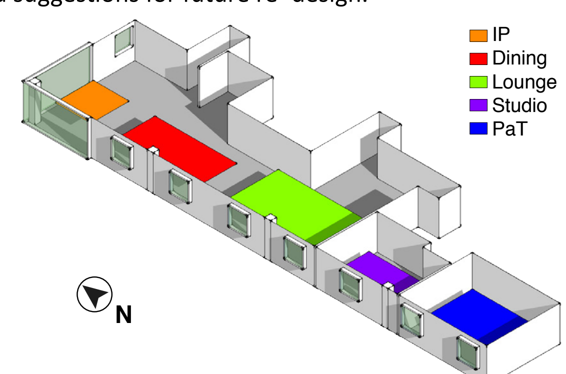
M.L. Ámundadóttir[1], S.W. Lockley[2], M. Andersen[1]

[1]Interdisciplinary Laboratory of Performance-Integrated Design (LIPID), École Polytechnique Fédérale de Lausanne, Lausanne, SWITZERLAND
[2]Division of Sleep Medicine, Department of Medicine, Brighman & Women's Hospital and Harvard Medical School, Boston, MA, USA

Presented at IBPSA, Aug 26-30, 2013, Chambéry, FRANCE

Email: maria.amundadottir@epfl.ch

The discovery of a novel non-rod, non-cone photo receptor in the human eye that mediates a number of effects on the brain has sparked a growing interest in incorporating these non-visual effects of light into the design process of buildings. Appropriately timed light exposure has the potential to stabilize and im- prove circadian rhythms, including sleep, and has di- rect stimulating effects on alertness and performance. The novel photoreceptors are more sensitive to blue light than the rods and cones used for vision, and respond differently to light intensity, duration, history and timing of a light exposure. The dynamic behavior of the non–visual system provides new challenges in evaluating lighting performance of buildings. In this proof–of–concept study, a novel model that predicts the non–visual responses to light is introduced. The model is used as a part of simulation–based framework for the evaluation of daylighting performance. The evaluation includes four different light pattern gener- ation methods used to investigate the influence of occupants' movements and activities on simulation results. The framework is applied to the re–design of a healthcare facility. The results lead to new ideas and suggestions for future re–design.



The case study building and locations of the 5 daylighting zones

Generation of weather files using resampling techniques: an exploratory study

P. Rastogi, M. Andersen

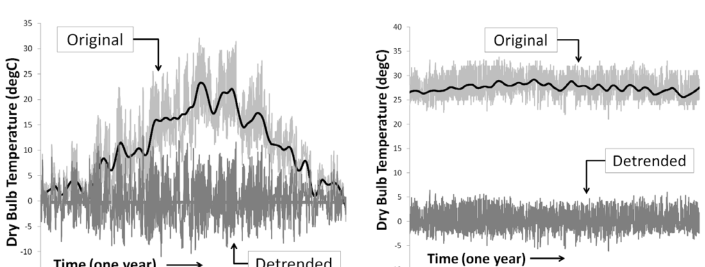
Interdisciplinary Laboratory of Performance-Integrated Design (LIPID), École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland

Presented at IBPSA, Aug 26-30, 2013, Chambéry, FRANCE

Email: parag.rastogi@epfl.ch

Sample conference paper (4/5)

Simulating a building to predict its performance over the course of a full year requires an accurate representation of the stable and representative weather patterns of a location, i.e. a weather file. While weather file providers give due consideration to the stochastic nature of weather data, simulation is currently deterministic in the sense that using one weather file always generates one performance outcome (for a given set of building parameters). Using a single time series or aggregated number makes further analysis and decision-making simpler, but this overstates the certainty of the result of a simulation. In this paper, we investigate the advantages and disadvantages of incorporating resampling in the overall simulation workflow by comparing commonly used weather files with synthetic files created by resampling the temperature time series from the same weather files. While previous studies have quantified uncertainty in building simulation by looking at the calculation itself, this paper proposes a way of generating multiple synthetic weather files to obtain better estimates of expected performance. As case studies, we examined the performance of the 'original' and synthetic files for each of a sample of world climates.



Temperature time series from the Geneva (left) and Singapore (right) time series. An aspect of climate data explored in this paper is the stark contrast in the trends between climates, which is clear from this comparison.

A review and analysis of parallel goniophotometry

B. Karamata, M. Andersen

Interdisciplinary Laboratory of Performance-Integrated Design (LIPID), École Polytechnique Fédérale de Lausanne, Lausanne, SWITZERLAND

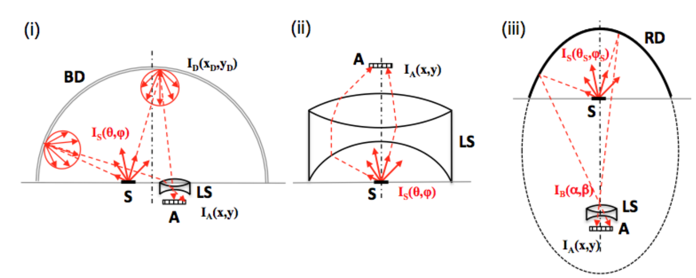
Presented at LuxEuropa, Sept 17-19, 2013, Krakow, POLAND

Email: boris.karamata@epfl.ch

Sample conference paper (5/5)

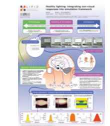
A reliable computer simulation of natural and artificial lighting of an indoor environment requires the thorough knowledge of the angular intensity distribution of light scattered or emitted by the various objects involved such as the illuminated surfaces, the trans- illuminated windows or fenestration systems, as well as the luminaires. The angular intensity distribution of light flux reflected, transmitted or emitted as a function of the illumination angle can be measured with an instrument called goniophotometer. Fast measurement, essential in most practical applications, requires the simultaneous detection of all scattering directions with a so-called parallel goniophotometer.
In this paper we define and explain the three working principles on which a parallel goniophotometer can rest, namely (i) screen imaging, (ii) dioptric angular mapping, and (iii) catadioptric angular mapping. We provide a state-of-the-art of these instruments and compare their performance and limitations based on a few key parameters.

Three working principles of a parallel goniophotometer: (i) screen imaging, (ii) dioptric angular mapping, (iii) catadioptric angular mapping.

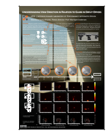


Invited posters

presented at external events

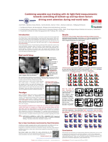


M.L. Amundadottir, M. Andersen, Healthy lighting: integrating non-visual effects into simulation framework, VELUX Academic Forum, Copenhagen, Denmark, May 14, 2013



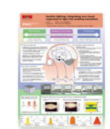
M. Sarey Khanie, M. Andersen, Understanding view-direction in relation to glare in daylit offices, VELUX Academic Forum, Copenhagen, Denmark, May 14, 2013

E. Nault, M. Andersen, E. Rey, Solar Potential and Interactive Design in the Urban Context, Young Researcher's Day SB13, Munich, Germany, April 24, 2013



J. Stoll, M. Sarey Khanie, S. Mende, M. 't Hart, M. Andersen and W. Einhäuser; W. Einhuäser (Dir.), Combining wearable eye-tracking with 4π light-field measurements: towards controlling all bottom-up and top-down factors driving overt attention during real-world tasks, 10th Göttingen Meeting of the German Neuroscience Society, Göttingen, Germany, March 13-16, 2013.

presented at home institution events



M.L. Amundadottir, M. Andersen, Healthy lighting: integrating non-visual responses to light into building simulation, ENAC Research Day, EPFL, Lausanne, Switzerland, April 23, 2013.

Standards

Contributions to IES Publications (Illuminating Engineering Society)

RP-5 (Recommended Practice): Recommended Practice for Daylighting (2013) – Chair of Daylighting committee: K. Papamichael

LM-83 (Approved Method): IES Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE), 14 p., ISBN: 978-0-87995-272-3, 2013 – Chair of Daylight Metrics committee: L. Heschong

Patents

K. Thuot, M. Andersen, A Passive Louver-Based Daylighting System, United States Patent and Trademark Office (USPTO), Patent No US20130321923A1, Application No: 13/888'045, Application type: Utility under 35 USC 111(a), Filed on May 6, 2013, Published on December 5, 2013.

LIPID INTERNATIONAL OUTREACH

The Interdisciplinary Laboratory of Performance-Integrated Design (LIPID) actively participates in international events, collaborations, and scientific committees in the fields of building performance and lighting.

IBPSA

IES

SIM AUD

SHC

CIE

iea

EF ENERGY FORUM

EuroTech Universities Excellence in Science and Technology

Research collaborations

International Energy Agency (IEA), Solar Heating & Cooling Programme (SHC)

Ongoing participation in Task 50: “Advanced Lighting Solutions for Retrofitting Buildings”

Ongoing participation in Task 51: “Solar Energy & Urban Planning”

EuroTech Universities - GreenTech Initiative

Energy-Efficient Buildings and Communities project – representative for EPFL in collaboration with partners at Danmarks Tekniske Universitet (DTU) (Prof. Bjarne Olesen), Technische Universiteit Eindhoven (TU/e) (Prof. Jan Hensen) and Technische Universität München (TUM) (Prof. Gerd Hauser)

Ongoing academic collaborations

National collaborations

Prof. Emmanuel Rey, EPFL (Laboratory of Architecture and Sustainable Technologies - LAST): IDEAS orientation, Smart Living Lab project, joint teaching, student co-advising, joint research initiatives (2010-pres)

Prof. Thomas Keller, EPFL (Composite Construction Laboratory – CCLAB): City Lifting Research Unit: part of the NEST project coordinated by Peter Richner, EMPA (2012-pres)

Jacques Bersier (Adjunct Vice-Director) & Jean-Philippe Bacher (Tech Transfer), EIA Fribourg : Smart Living Lab project for Blue Factory campus (2012-pres)

International collaborations

Prof. Steven Lockley, Brigham & Women Hospital, Harvard Medical School (Division of Sleep Medicine), USA: Integration of recent findings from photobiology to refine design guidelines for building design based on their ‘circadian potential’ (Sept 2006-pres), joint journal papers (2008, 2012) and conference papers

Dr. Magali Bodart, Université Catholique de Louvain (UCL), Belgium: Validation of Lightsolve sky models and outputs with Radiance calculations, joint journal papers (2008) and conference papers

Davidson Norris, Principal and Founding Partner of Carpenter Norris Consulting (CNC), James Carpenter Design Associates (JCDA), USA: Project on redefining light and health at the interface between academic research and design practice (also in collaboration with Prof. S.W. Lockley, Harvard Medical School and Aki Ishida Architect PLLC)

Prof. John Mardaljevic, Loughborough University, UK: Collaboration on HDR imaging project (2006), non-visual aspects of climate-based daylight analysis for residential buildings (2010-2012), and on climate-based comfort metrics, joint journal papers (LRT) in 2008 and 2012, joint conference papers

Prof. Wolfgang Einhäuser, Philipps-Universität Marburg (Dept of Neurophysics), Germany: Integration of eye-tracking methods in visual comfort studies (2011-pres), joint conference papers

Dr. Jan Wienold, Fraunhofer Institute for Solar Energy Systems (Fhg-ISE, Lighting Technology): Experimental Infrastructure for user studies on gaze and visual comfort (2011-pres), joint conference papers

Prof. Barbara Cutler, Rensselaer Polytechnic Institute (Computer Science Department), USA: Lightsolve project on simulation-based architectural design support for daylighting performance (2005-pres), joint journal papers in 2008

Dr. Rosa Urbano-Gutierrez, University of Liverpool (School of Architecture), UK: D-LITE project (Database of Light-Interacting Technologies for Envelopes): web-based interactive tool for façade technologies (www.d-lite.org) (2007-pres), joint conference papers

Prof. Vitor Leal, University of Porto (Faculty of Engineering): Co-supervision of PhD Candidate Pedro Correia da Silva (2008-2012), joint journal papers

International committees

International Building Performance Simulation conferences

2013	IBPSA International / IBPSA-France (BS)
2011-13	SimAUD Symposium on Simulation for Architecture and Urban Design
2009-13	Energy Forum for Solar Building Skins
2008, 2011-13	PLEA Passive Low-Energy Architecture

Chairing and organization of international symposia/workshops

2013	Half-day session organization for 8th ENERGY FORUM on Solar Building Skins: “Human- driven daylighting” – Bressanone, Italy, Nov 5-6, 2013
2013	2013 Two-day EuroTech GreenTech: Energy-Efficient Building and Communities (EEBC) workshop organization – EPFL, Lausanne, Switzerland, Jun 10-11, 2013

International lighting committees
Illuminating Engineering Society of North America (IES)

2008-13	IES Daylighting Committee - contribution to IES publication “RP-5 Recommended Practice for Daylighting” (pending)
2006-13	IES Daylighting Metrics committee - contribution to IES publication “LM-83 Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE)” (published)

International Commission on Illumination (CIE)

2013-present	CIE Joint Technical Committee, JTC Divisions 3 and 6: “Visual, Health, and Environmental Benefits of Windows in Buildings during Daylight Hours”, chaired by Dr. Martine Knoop
2012-present	CIE Technical Committee, TC 3.55: “Metrics for sunlighting and daylight passing through sunshading devices”, chaired by Prof. Marc Fontoynont
2009-present	CIE Technical Committee, TC 3-47: “Climate-Based Daylight Modelling”, chaired by Prof. John Mardaljevic, Loughborough University

Invited lectures

Nov 13	M. Andersen, L’enveloppe du bâtiment comme interface entre l’environnement et notre bien-être: approches passives et éclairage naturel, 0-carbonne dans l’environnement construit, Fribourg, Switzerland, November 20, 2013.
Nov 13	M. Andersen, Human-driven daylighting: research perspectives and outlook, Energy Forum on Advanced Building Skins, Bressanone, Italy, November 5-6, 2013.
Sept 13	M. Andersen, Human needs as a driver for lighting design, Photon Project conference, London, UK, September 16, 2013.
Sept 13	M. Andersen, Sun, Light and Space, WISH Pecha Kucha, Lausanne, Switzerland, September 2, 2013.
May 13	M. Andersen, New Eyes on Existing Buildings, 5th Velux Daylight Symposium, Copenhagen, Denmark, May 15-16, 2013.

EPFL|ENAC|IA|LIPID