ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

ACTIVITY REPORT
2008

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PROJECTS LIST

2008.6	CISBAT 2009 International Conference – Renewables in a changing climate – From Nano to Urban Scale
2008.5	Coloured Thermal Collectors – Scientific Equipment
2008.4	Coloured Solar Thermal Collectors
2008.3	Daylighting and Perception
2008.2	Heat and corrosion resistant nanocomposite selective solar absorber coatings by Sol-gel processing
2008.1	Master of Advanced Studies in Architecture and Sustainable Development
2007.5	HOLISTIC - Optimisation Leading to Integration of Sustainable Technologies in Communities
2007.4	Evaluation of the Potential of Optical Switching Materials for Overheating Protection of Thermal Solar Collectors
2007.3	Evaluation of the Potential of Quantum Dots concentrators for Photovoltaic electricity production
2007.2	CCEM - House 2000
2007.1	CCEM - Retrofit
2005.7	EEDACS - Explosion of Energy Demand for Air Cooling in Summer: Perspectives and Solutions
2005.5	Green Lighting: IEA Task 45 – Energy Efficient Electric Lighting of Buildings
2005.3	Multiscale Modelling of Building-urban Interactions
2005.2	Eco-systemic Modelling of Urban Metabolism based on Modern Thermodynamics
2005.1	Guidelines for Daylighting Performance Assessment of Buildings
2004.1	Coloured Thermal Collectors (Phase II)
2003.4	Solar Impulse

Title:	**CISBAT 2009 International Conference** **Renewables in a changing climate – From Nano to Urban Scale**
Project Nr:	2008.6
Mandator:	EPFL / OFEN
Keywords:	Research and development, solar energy, built environment
Project leader:	Prof. J.-L. Scartezzini
Collaborator:	B. Smith
External collaboration:	Prof. L. Glicksman (MIT/USA) Prof. K. Steemers (Cambridge University/UK)

Description:

The latest achievements of research into human induced climate change have led international experts to the conclusion that the World needs a fundamental reboot, as stated in particular by the IPCC and the WEF Global Agenda Councils for instance. Although much has been done already to reduce the environmental impact of the built environment in the last thirty years, there is still huge scope for and a great need of further improvement in the field.

The biannual international conference CISBAT 2009 – to be held at EPFL on September the 2nd and the 3rd, 2009 – invites researchers from academic and public institutions, as well as industry representatives, to present and discuss the latest R&D results on advanced sustainable building technologies for the built environment. Backed by the positive achievements of the former editions, the conference organizers decided to again join forces with prestigious academic institutions – Cambridge University (UK) and the Massachussetts Institute of Technology (USA) – for the upcoming event.

Results obtained in 2008:

Centred on research and development in solar energy applications to the built environment, the 2007 issue of the CISBAT international conference once more highlighted a good number of relevant innovations. The scientific discoveries and technological developments presented by researchers from five continents are due to play a role in reducing the human contribution to climate change.

Some important events linked to these environmental concerns of planetary dimension have marked this year and confirmed the pertinence of the CISBAT Conference cycle: among other, the European Commission has set-up new binding targets regarding renewable energies, which will cover 20% of energy demand in Europe by the year 2020.

Publications:

Scartezzini J.-L. (Editor), CISBAT 2007 Special Issue, *Solar Energy Journal (2009).*

Title: **Coloured Thermal Collectors – Scientific Equipment**

Project Nr : 2008.5

Mandator: OFEN

Keywords: Vacum chamber, nanocomposite coatings, solar energy

Project leaders : Dr A. Schueler
C. Roecker

Description:

- Construction of an advanced vacuum chamber for the plasma-deposition of novel nanocomposite coatings, for solar energy applications such as colored and thermochromic thermal solar collectors and improved switchable glazing. The installation will allow magnetron-cosputtering and deposition of multilayers with up to five magnetrons under high vacuum and ultra-high vacuum conditions.

- Developing new processes and products for thermal collectors with the latest technologies implies using up to date equipment, both for production of samples and measurements of characteristics.

  This set of new equipment comprises also:

  - 1 Thermo camera, Model FLIR B400, with IR and normal modes and video capability to capture transient evolutions
  - 1 spectroradiometer JETI Specbos 120

Titre	**Coloured Thermal Collectors (Phase III)**
Project No:	2008.4
Mandant:	OFEN
Mots-clé:	Thermal collector, architectural integration, prototyping, cost
Chef de projet :	C. Roecker
Collaboratrice:	M.C. Munari Probst

Description:

L'installation des capteurs thermiques en façade présente plusieurs avantages, notamment une production de chaleur plus constante sur l'année et une diminution des risques de surchauffe. Mais cette intégration en façade est difficile avec les collecteurs actuels du fait de leur couleur très sombre (noir ou bleu très foncé) et des irrégularités ou défauts sur la surface des absorbeurs, visibles à travers le verre d'isolation. Le but de ce projet est de permettre une meilleure intégration des capteurs en façade en proposant un verre qui cache l'absorbeur derrière une couche colorée tout en laissant l'énergie solaire traverser. La phase précédente du projet a montré la faisabilité du concept et la qualité que l'on peut en attendre, mais il faut encore diversifier les résultats (couleurs, traitements), améliorer les performances et rendre la production industrielle économiquement viable.

Au niveau architectural, le premier concerné, les caractéristiques particulières de ces nouveaux verres ouvrent également des possibilités très intéressantes en permettant des façades actives uniformes, utilisant le même produit devant les capteurs solaires et l'isolation de la façade. Ces applications architecturales nouvellement rendues possibles doivent être étudiées en détail et développées jusqu'au concept de façades actives.

Résultats obtenus en 2008:

Plusieurs échantillons de verres extra-blancs diffusants ont été (difficilement) obtenus pour être évalués en termes de possibilités techniques (transmission solaire acceptable) et architecturales (usages possibles, acceptabilité formelle). L'évaluation est en cours et sera combinée avec les résultats des nouvelles couches. Un nouvel équipement de déposition par évaporation sous vide a été installé pour permettre de réaliser des multicouches dans des conditions proches de celles du magnetron sputtering industriel (simple face par opposition au double face du dip-coating). La mise en service se fera début 2009 et les résultats attendus pour mi-2009.

Au niveau architectural, plusieurs simulations ont été réalisées pour démontrer les possibilités d'utilisation des nouveaux verres devant des capteurs thermiques, permettant une intégration plus aisée des capteurs.

Publication :

Munari Probst M.C.
Architectural integration and design of solar thermal systems
PhD Thesis EPFL, *Nr 4258* (2008).

Title:	**Post-Doctoral Fellowship in Daylighting and Perception**
Project Nr :	2008.3
Mandator:	Velux Foundation
Keywords:	Daylighting technology, photobiology, circadian rhythms
Project leader :	Prof. J.-L. Scartezzini
Collaborator:	Dr M. Münch
External collaboration:	Prof. M. Herzog (BMI/EPFL)

Description:

This project is aiming to strengthen the education and research activities in the fields of building science and chronobiology. It is expected moreover to initiate innovating activities in relation to psycho-physiological aspects of daylight with an emphasis on human response factors, such as the perception of three-dimensional spaces and luminous environment. New fundamental and applied research projects in relation with the impact of daylight on the circadian regulation system of human beings will be developed for that purpose.

This will be addressed through the creation of a Post-Doctoral Fellowship in "Daylighting and Perception", supported by the VELUX Foundation and attached to the Solar Energy and Building Physics Laboratory of ENAC School. Interdisciplinary research projects aiming toward a better understanding of the neuro-physiological mechanisms of light perception will be set-up in collaboration with units of the EPFL School of Life Sciences (e.g. the Psycho-physics Laboratory of Brain and Mind Institute for instance).

Results obtained in 2008:

The priority was set during the year 2008 on the deployment of the VELUX Post-Doctoral Fellowship in "Daylighting and Perception". A position was formally open and publicized at the highest academic and international level. A Search Committee, made-up of field experts, was set-up for that purpose, more than 15 candidates having been considered for the position.

After interview of the short list's candidates, the Search Committee decided unanimously to offer the post to Dr Mirjam Münch (MSc Anthropology & Anatomy/Zürich University; BSc Biology/ETHZ), who just initiated a Post-Doctoral sojourn at Harvard Medical School in Boston (USA).

Title:	**Heat and Corrosion resistant Nanocomposite selective Solar Absorber Coatings by Sol-gel Processing**
Project Nr :	2008.2
Mandator:	CTI
Keywords:	Selective solar absorber, nanocomposite, coatings
Project leader:	Dr A. Schueler
Collaborator:	M. Joly
External collaboration:	J.-P. Rossy (Energie Solaire S.A./Sierre)

Description:

This project aims at the development of novel nanocomposite selective absorber coatings for solar thermal collectors. By the new production process, highly toxic Cr(VI) shall be completely avoided. The novel coatings shall be absolutely chrome-free, more corrosion-resistant, and more durable at elevated temperatures than existing products. Our approach is based on low-cost sol-gel techniques, and will be suitable for up-scaling to industrial production.

Results obtained in 2008 :

We succeeded in the preparation of novel nanocomposite coatings exhibiting a solar absorptance of 95% and a thermal emittance of 11%. These values are competitive with respect to the optical performance of commercial coatings on the market. Preliminary tests indicate that the stability of our coatings at elevated temperatures is highly superior to the stability of the most durable coatings available on the market.

Publications:

N/A

Title:	**Master of Advanced Studies (MAS) in Architecture and Sustainable Development**
Project Nr :	2008.1
Mandator:	EPFL
Keywords:	Post-graduate studies sustainable design
Project leader:	Dr D. Robinson
Collaborators:	P. Tosolini
	S. Renfer
External collaboration:	Prof. A. De Herde (UCL/Belgique)
	Prof. A. Chatelet (Université de Toulouse/France)

Description:

This course, which has duration of 12 to 18 months, is intended to enable Architects in particular but also Engineers to deepen their theoretical and practical understanding of how to design, deliver and manage sustainable building and urban design projects.

The course consists of a taught component and a personal research component. The taught component involves two two-month sessions. The first, which is based at EPFL, concentrates on the physical principles of sustainable design; whereas the second focuses on architectural and urban application / integration. This latter rotates between the partner institutions at Louvain-La-Neuve (Belgium) and Toulouse (France).

For the personal research phase students investigate their proposed subjects in detail – posing and testing hypothesis with a view to arriving at new and innovative research results. A research prize is awarded to the strongest dissertation.

Results obtained in 2008:

The first taught session of this seventh edition of the MAS took place at EPFL in June and July 2008; whereas the second session took place at Toulouse in October and November 2008. All 29 students, which represent some 9 countries in Europe, North America, South America and Africa, successfully completed their examinations.

These students are now heavily involved with their personal research topics, many of which are extremely promising and seem likely to merit publication and presentation at international conferences relating to sustainable design.

Title:	**HOLISTIC - Optimisation Leading to Integration of Sustainable Technologies in Communities**
Project Nr:	2007.5
Mandator:	EU
Keywords:	Urban district energy modelling optimisation
Project leader:	Dr D. Robinson
Collaborators:	Dr F. He C. Giller F. Haldi A. Rasheed

Description:

The HOLISTIC project aims to stimulate a paradigm shift in the use of energy within communities to more sustainable patterns. It will demonstrate how this transformation can be initiated in three typical communities, in Dundalk (Ireland), Mödling (Austria) and Neuchâtel (Switzerland), by acting on every aspect of community life. The role of the LESO-PB within this 32MEuro European RTD project, which started in June 2007, is to develop new software for optimising the energy performance of urban districts.

This new open source district energy modelling environment is expected to be developed, tested and released within the next four years. Called CitySim this new software tool will include an easy-to-use user interface to describe the geometry of buildings and their attributes as well as local energy supply systems. This will be coupled with an integrated energy modelling tool which will simulate energy demand in a way that is sensitive to the urban climate as well as to human behaviour in buildings, as well as energy supply from a suite of energy conversion models. This modelling environment will also be coupled with evolutionary algorithms to identify optimal solutions for minimising urban energy consumption. Results will then be parsed back to the user interface for analysis.

The new modelling environment will be deployed within a case study site in the City of Neuchâtel in Switzerland. Experience from this exercise (particularly model calibration) will then serve as a guide for those wishing to use the tool in other towns and cities.

Results obtained in 2008:

A first very basic prototype of CitySim was developed for the purposes of demonstrating its underlying modelling principles to project partners.

Publications:

Page J., Robinson D., Morel N., Scartezzini J.-L.
A generalised stochastic model for the prediction of occupant presence
In *Energy and Buildings*, 40(2) p83-98 (2007).

Robinson D., Campbell N., Gaiser W., Kabel K., Le-Mouele A., Morel N., Page J., Stankovic S., Stone, A.
SUNtool – a new modelling paradigm for simulating and optimising urban sustainability,
In *Solar Energy*, 81(9), p1196-1211 (2007).

Kämpf J., Robinson D.
A simplified thermal model to support analysis of urban resource flows
In *Energy and Buildings* 39(4), p445-453 (2007).

Robinson D., Giller C., Haldi F., He F., Kämpf J., Kostro A.
Towards comprehensive simulation and optimisation for more sustainable urban design,
Presented at *15. Schweizerisches Status Seminar*, p. 155-162, ETHZ, September (2008).

Title:	**Evaluation of the Potential of Optical Switching Materials for Overheating Protection of Thermal Solar Collectors**
Project Nr:	2007.4
Mandator:	OFEN
Keywords:	Thermochromic coatings, overheating protection, stagnation of thermal solar collectors
Project leaders:	Dr A. Schueler, Christian Roecker
Collaborators:	G. Huot A. Paone
External colllaboration:	SPF Rapperswil

Description:

Thermal solar collectors, which are an ecological solution for water heating, are more and more widespread; their market is increasing consequently. Durability of materials is a critical point as the collector lifetime should be at least 25 years. Overheating and the resulting stagnation of the collector is a common problem with solar thermal systems. During stagnation high temperatures lead to water evaporation (and glycol degradation above 160°C) and stresses in the collector with increasing pressure. Special precautions are necessary to release this pressure; only mechanical solutions exist nowadays. High temperatures also lead to degradation of the materials that compose collectors: seals, insulation materials, and also the selective coating which is the most important part of the collector. A promising way to achieve overheating protection of collectors without any mechanical device for pressure release or collector emptying is to produce a selective coating which is able to switch its optical properties at a critical temperature Tc. Such "smart" solar collectors will allow increasing the collector surface on facades and roofs in order to get high efficiency and hot water production during winter without inconvenient overheating during summer. Optical switching of materials can be obtained by many ways. Inorganic and organic thermochromic compounds and organic thermotropic coatings are the main types of switching coatings that are studied at LESO-PB. A concept for absorptance switching of collectors with inorganic materials is also studied.

Results obtained in 2008:

Successful production of durable inorganic thermochromic coatings at LESO-PB.

Titre :	**CCEM - House 2000 - Innovative Building Technologies for a 2000 Watts Society**
No projet :	**2007.2**
Mandant:	CCEM – CH
Mots clés :	Société à 2000W, intégration architecturale, solaire thermique, photovoltaïque, démonstration
Chef de projet :	C. Roecker
Collaboratrice :	M.C. Munari Probst
En collaboration avec:	Dr T. Franck (EMPA/Dübendorf)
	Prof. M. Morari (ETHZ)

Description :

Ce projet vise à promouvoir une nouvelle génération de technologies pour le bâtiment permettant de réduire sa consommation d'un facteur quatre et ainsi d'atteindre le but d'une société à 2000 Watts. Cela nécessite la mise en place d'une plateforme interdisciplinaire regroupant des chercheurs actifs tant dans le domaine de la physique du bâtiment que dans celui des systèmes énergétiques. Une haute priorité sera évidemment donnée à l'utilisation d'énergies renouvelables en remplacement d'énergie fossile. Le travail est organisé selon 4 axes :

- **A. Advanced Building Materials and Components** (isolation hautes performances, vitrages, façades solaires)
- **B. Soft Heating and Cooling Technologies** (chauffage et froid solaire, pompes à chaleur)
- **C. Smart Control and User Interfaces** (contrôles adaptatifs/prédictifs utilisant prédictions météorologiques et nouveaux algorithmes pour interactions avec l'usager)
- **D. Demonstration, Dissemination, Market and Education** (application des précédentes technologies à un ou plusieurs démonstrateurs taille réelle situées à l'EPFZ, l'EMPA ou l'EPFL).

Résultats majeurs obtenus durant l'année 2008 :

Le groupe Intégration Architecturale du Solaire Actif a participé aux diverses réunions de lancement et présenté les résultats de ses recherches dans le domaine des façades thermiques. Une description complète des caractéristiques des développements au LESO-PB a été présentée. La principale contribution sera apportée lors de la conception et réalisation des démonstrateurs en adaptant les verres colorés et collecteurs, actuellement en cours de développement, au cas spécifique de ce projet. La participation à la conception architecturale de démonstrateurs est également prévue.

Publication :

Munari Probst M.C.
Architectural integration and design of solar thermal systems
PhD Thesis EPFL, Nr 4258 (2008).

Title:	**CCEM - Retrofit Advanced Energy – Efficient Renovation of Buildings**
Project Nr:	2007.1
Mandator:	CCEM - CH
Keywords:	Building retrofit, Advanced building technologies, Smart control systems
Project leaders:	Dr N. Morel
Collaborators:	D. Daum
External collaboration:	M. Zimmermann (EMPA/Dübendorf) Prof. E. Jochem (ETHZ) Prof. A. Binz (UAS Northwestern, Switzerland) Adhoco AG (Winterthur)

Description:

The CCEM-Retrofit and CCEM-House 2000 projects have been grouped as one single project for the LESO-PB advanced building control participation. They are based on the research and development project BEL Control, carried out by LESO-PB/EPFL (Lausanne) and Adhoco (Winterthur), and completed on November 2007.

The BEL Control project is documented in the present activity report. It includes 3 tasks: (1) Control algorithm development, (2) Experimental tests preparation, (3) Field tests.

Additional CCEM-CH specific tasks have been added; they address two issues: the specificity of control system issues for a building retrofit, and the experimentation on a demonstration building unit, in the framework of the CCEM-House 2000 project. The additional tasks are:

- Task 4: Elaboration of a simulation and design tool for control systems
- Task 5: Guidelines and catalog of existing solutions for retrofit
- Task 6: Retrofit field tests
- Task 7: Field tests on the demonstration building units

Results obtained in 2008:

We have started the simulation of a simple building (specifications are close to the LESO building), with an advanced controller based on the use of Fuzzy Logic. A novel approach has been defined, where we consider a multi-objective minimization and mutually contradictory objective functions. As an illustration of this method, we can show the case of a blind controller trying to minimize simultaneously the heating/cooling demand and the lighting discomfort, by finding the optimal value of the Fuzzy Logic rule base parameters. Genetic algorithms are used for the minimization, and the IDA/ICE tool is used for the simulation.

Title:	**EEDACS - Explosion of Energy Demand for Air Cooling in Summer: Perspectives and Solutions**
Project Nr :	2005.7
Mandator :	SNSF
Keywords :	Thermal comfort, Overheating risk, Modelling, Surveys
Project leaders :	Dr D. Robinson
Collaborator :	F. Haldi
External collaboration:	L. Azzi
Senior Advisor:	Prof. Claude-Alain Roulet

Description:

Our role within this project was to develop a new model for predicting the risk of summertime overheating in indoor spaces, defined in terms of the probability that occupants will be thermally dissatisfied with the summertime thermal history of an occupied space. When used in conjunction with results from thermal simulations of rooms, this should enable users to determine the acceptability of design proposals with a view to avoiding the use of applied energy for space conditioning.

Results obtained in 2008:

Historical thermal comfort field survey data in conjunction with the state of the art in thermal comfort prediction was initially reviewed to develop ideas regarding a possible prototype model. This process was used to design a new field survey methodology which was then applied to a range of office buildings. The data from these surveys has been used to support the development and testing of the final model.

Publications:

Robinson D., Haldi F.
An integrated adaptive model for overheating risk prediction,
In *Journal of Building Performance Simulation*, vol. 1, num. 1, p. 43-55 (2008)

Haldi F., Robinson D.
On the behaviour and adaptation of office occupants,
In *Building and Environment*, vol. 43, num. 12, p. 2163-2177 (2008)

Robinson D., Haldi F
Model to predict overheating risk based on an electrical capacitor analogy,
In *Energy & Buildings*, vol. 40, num. 7, p. 1240-1245 (2008)

Title:	**Eco-systemic Modelling of Urban Metabolism based on Modern Thermodynamics**
Project Nr:	2005.2
Mandator:	SNSF
Keywords:	Urban, metabolism, simulation, optimisation, thermodynamics
Project leaders:	Prof. J.-L. Scartezzini
	Dr D. Robinson
Collaborators:	J. Kämpf
	N. Filchakova
External collaboration:	Dr H.-P. Bader, Dr R. Scheidegger (EAWAG)
	Dr D. Keller (AEU, Basel)
	Prof M. Batty (UCL, UK)
	Prof. P. Allen (Cranfield University, UK)

Description:

In analogy to the physiological processes involved in natural ecosystems, the uptake, transport and storage of chemical substances in urban sites, as well as their transformation, can be considered as equivalent to Urban Metabolism. In common with living organisms, urban sites may be regarded as open thermodynamic systems, situated in a far from equilibrium state and dissipating energy and matter due to irreversible internal processes (entropy growth). To counterbalance their internal entropy growth, entropy must be exchanged with the biosphere at the boundary of the system. The most important of these exchanges relates to the combustion of non-renewable fossil fuels with a subsequent export of greenhouse gases and low grade heat in the biosphere. The evidence in now undisputable that current entropy exchanges with the biosphere are leading to climatic disorders. Furthermore, there is an alarming risk that, owing to large scale urban migration, such disorders will intensify considerably in the coming years. This risk can be addressed on two fronts in urban sites: energy can be better conserved [moderated entropy growth] and fossil fuels can be displaced by renewable energy [negentropy generation].
But in order to quantify the potential for these two strategies some form of mathematical model is necessary, likewise some means of characterising the system entropy or a corollary of it. To this end we have developed three techniques to model and optimise urban metabolism.

Results obtained in 2008:

These new modelling and optimisation techniques are the principle outcome from this project. However, an important secondary outcome relates to applications of these new models to generate new knowledge of use to urban designers. From these early applications we conclude that:

- Based on simulations of Basel and with no special improvements to building regulations or the rates of buildings' renovation, the energy consumption of the residential stock is expected to halve by 2050; by virtue of expected demolition, construction and renovation trends. However, this assumes that protected and preserved buildings are available for such renovation.
- Assuming that these heritage buildings are unavailable the energy consumption of the residential building stock is expected to fall to just 57% of its current value.
- Irrespective of the treatment of heritage buildings, the target to achieve a 2kW society by 2050 will not be realised without further improving upon rates of renovation and the energy performance of these measures whilst also being mindful of the energy consequences of the materials used. Further work is required here.
- Compared with subjectively chosen interventions to optimise buildings' energy performance (best guesses) the new evolutionary algorithm consistently brings added performance improvements of up to 20%, whilst also yielding highly interesting and non-intuitive solutions. This should be of interest to architects and urban designers.

Publications:

Kämpf J., Robinson D.
A hybrid CMA-ES and DE optimisation algorithm with application to solar energy potential, *Applied Soft Computing* 2(9) p.738-745, March (2009)

Filchakova N., Robinson D., Scartezzini J.-L.
Quo vadis thermodynamics and the city: a critical review of applications of thermodynamic methods to urban systems,
Int. J. Ecodynamics, 2(4), p.222-230 (2007)

Page J., Robinson D., Morel N., Scartezzini J.-L.
A generalised stochastic model for the prediction of occupant presence,
Energy and Buildings, 40(2) p. 83-98, (2007)

Robinson D., Campbell N., Gaiser W., Kabel K., Le-Mouele A., Morel N., Page J., Stankovic S., Stone A.
SUNtool – a new modelling paradigm for simulating and optimising urban sustainability, Solar Energy, 81(9) p. 1196-1211 (2007)

Kämpf J., Robinson D.,
A simplified thermal model to support analysis of urban resource flows
Energy and Buildings 39(4), p.445-453 (2007)

Title: **Multiscale Modelling of Building-urban Interactions**

Project Nr: 2005.3

Mandator: SNSF

Keywords: Fluid, dynamics, urban, heat, island

Project leader: Dr D. Robinson
Collaborators: A. Rasheed
External collaboration: Dr A. Clappier (LPAS/EPFL)
A. Krpo (LPAS/EPFL)

Description:

Compared with rural settings, in the urban context more shortwave radiation is absorbed, less longwave radiation is emitted and the mean wind speed is lower, so that the mean air temperature is higher. This urban heat island is exacerbated by anthropogenic heat sources and the relative lack of evapotranspiration due to vegetated surfaces. Although the mechanisms are reasonably well understood predicting the urban climate and its implications for the wider regional climate as well as for urban energy use is high complex. This is in large part due to the scales involved: from the buildings within the urban canopy (the size of a few meters) to large topographical features such as nearby water bodies or mountains (the size of a few kilometres). These scales cannot be satisfactorily resolved in a computationally tractable way using a single model. Our solution to this problem has been to couple different models which each address different spatial scales.

Results obtained in 2008:

Results from a meso-scale model may have been used to define boundary conditions for micro-scale simulations. We used a new approach based on immersed boundaries in which the flow around any complex geometry can be computed using a simple Cartesian grid, so that users benefit from both improved productivity and accuracy. Finally this model has also been coupled with a simplified radiosity algorithm which solves for shortwave and longwave radiation exchange in an Thus, a completely coupled macro, meso and micro model can be used to predict the temperature, wind and pressure field in a city taking into account not only the complex geometries of its built fabric but also the scales which are bigger than the city itself. This is the major achievement of this project!

We have also applied this new urban climate modelling platform to study the climate of Basel. From this we conclude that:

- The physical phenomena responsible for the urban heat island (UHI) of Basel have a combined intensity of some 5-6°C.
- This UHI intensity can be adjusted by:

  0.5°C to 2°C with plausible changes to the thermophysical properties of building materials.

0.5°C by modifying the reflectance of building envelopes.

- These adjustments (if positive) together with anthropogenic gains resulting from widespread use of air-conditioning systems could increase energy use due to mechanical cooling by around 25%.

However, further work is required to produce comprehensive guidance for urban climate planning.

Publications:

Rasheed A., Robinson D., Clappier A.
On the sensitivity of building performance to the urban heat island effect
Proc. CISBAT 2007, 4–5 September, Lausanne (2007)

Rasheed A., Robinson D., Clappier A., Chidambran N., Lakehal D.
Characterization of dispersive fluxes in Mesoscale models using LES of flow over an array of cubes, *Journal of Wind Engineering and Industrial Aerodynamics* (submitted).

Rasheed A., Robinson D., Clappier A.
Development of a new urban canopy model
Journal of Wind Engineering and Industrial Aerodynamics (in prearation).

Rasheed A. Robinson D.
Multiscale modelling of the urban climate
Proc. Eleventh Int. IBPSA Conf: Building Simulation 2009, Glasgow, UK (paper accepted).

Title:	**Guidelines for Daylighting Performance Assessment of Buildings: Comparing Physical and Digital Models**
Project Nr:	2005.1
Mandator:	VELUX Foundation
Keywords:	Physical and digital models, complex fenestration systems, sources of errors
Project leader:	Prof. J.-L. Scartezzini
Collaborators:	A. Thanachareonkit F. Linhart

Description:

Despite the fact that the capability of computer simulation programmes for daylighting design was significantly enhanced, scale models still represent a standard method for most architects and lighting designers.

The goal of this project, following this statement, is to achieve the upcoming objectives:

- Identifying the main factors responsible for errors within scale and digital models of buildings during the course of daylighting performance assessment of complex fenestration systems;
- Comparing physical and digital models regarding their accuracy and reliability for performance assessment of advanced daylighting technologies;
- Setting-up practical guidelines for building design processes, involving the use of either physical and/or digital models.

Results obtained in 2008:

The activities of this project came to an end last year. This completed the achievements, according to the initial proposal, the following items having been achieved:

- Identification of the main errors sources within scale and digital models of buildings;
- Comparison of physical and digital models buildings with full scale test modules;
- Setting-up of design rules for assessment of daylighting performance using buildings models.

The project was completed by the way of the writing of a PhD Thesis, which was successfully defended at the ENAC School.

Publication:

Thanachareonkit A.
Comparing Physical and Virtual Methods for Daylight Performance Modelling including Complex Fenestration Systems
PhD Thesis EPFL, Nr 4130 (2008)

Titre :	**Projet d'avion solaire "Solar Impulse" - Vol autour du monde sans escale**
No projet :	2003.4
Mandant:	EPFL
Mots clés :	Sustainable flight, solar cells, airplane, composite materials
Chef de projet :	C. Roecker
Participation :	Prof. J.-L. Scartezzini
En collaboration avec :	A. Borschberg (Leader construction team) Yannick Louvrier (LEI)

Description :

Ce projet vise à concevoir et réaliser un aéronef, muni d'un moteur électrique et alimenté à l'énergie solaire, en vue d'effectuer le premier vol autour du monde sans escale au moyen d'énergies renouvelables.

L'étude de faisabilité d'un tel prototype a été menée à bien dans le courant de l'année 2003, au travers de la collaboration d'une dizaine de laboratoires de l'EPFL et de la participation d'experts en aéronautique (B. Piccard, B. Jones, A. Noble). Elle est suivie d'une phase d'étude et de construction d'une durée de 3 ans, en vue de la réalisation d'un premier vol d'essai en 2009. Une société s'est constituée pour ce projet (Solar Impulse SA); l'EPFL est conseillère scientifique du projet.

Résultats majeurs obtenus durant l'année 2008 :

La majeure partie de l'activité s'est concentrée de plus en plus du côté du Design Team, dont les effectifs ont fortement augmenté.

Du côté de l'EPFL, les activités majeures ont été effectuées dans les domaines suivants:

- Etude des convertisseurs statiques avec MPP tracker, de haut rendement et adaptés aux caractéristiques PV et DC de l'avion
- Etude extensive de l'interface homme-machine (diagnostic sommeil, veste sensorielle...)
- Etude des nouveaux moteurs en collaboration avec ETEL
- Etude des structures sandwich, optimisation des peaux et de la colle

L'activité de conseil en photovoltaïque étant actuellement réalisée par le Prof. Ballif (Université de Neuchâtel), spécialiste en technologie des cellules amorphes phtotovoltaïques, les activités du LESO-PB se sont concentrées sur l'encadrement général des activités « énergie » et un suivi du projet comme consultant pour certains éléments particuliers.

Des essais de résistance grandeur réelle ont été effectués et la construction de l'avion-test d'une envergure réduite (60 m.) a débuté.

RESEARCH PROJECTS

Solar Impulse
Ce projet a été initié par Bertrand Piccard. Le LESO-PB fait partie du groupe de "conseillers scientifiques" du projet, plus spécialement pour les domaines du photovoltaïque, du rayonnement solaire et de l'optimisation globale de l'avion.
Mandators: SolarImpulse Ltd, EPFL 2004-2009 (Resp. C. Roecker) CHF 60'000.-

Multiscale Modelling of Building-urban Interactions
This project has two related aims. The first is to develop a generic methodology for parameterising the effects of the built environment on the predictions from mesoscale atmospheric models, to simulate the urban meso-climate. This will help to understand the urban heat island effect and ways in which it may be influenced through urban design interventions. The second aim is to couple to this a local microclimate model, to simulate local temperature, pressure and velocity in an accurate way, with due regard for the larger urban meso-climate. This will help with simulating the pedestrian environment as well as the performance of buildings.
Mandator: SNSF 2005-2008 (Resp. MER Dr D. Robinson) CHF 135'000.-

Ecosystemic modelling of building-urban interactions
Informed by the application of ecological and thermodynamic principles, this project aims to better understand the metabolic activities taking place within urban systems and ways in which these may be optimised. Two alternative techniques are being employed: aggregate city-scale modelling based on system dynamics and spatially explicit physical modelling of resource flows at the scale of the urban district. Computational optimisation algorithms are employed to search for optimally sustainable solutions based on new ways of evaluating sustainability.
Mandator: SNSF 2005-2008 (Resp.: Prof. J.-L. Scartezzini, MER Dr D.Robinson) CHF 330'000.-

Guidelines for daylighting performance assessment of buildings: comparing physical and digital models
Le projet vies à comparer les modèles physiques et numériques de bâtiments destinés à l'évaluation des performances de systèmes complexes d'éclairage naturel. Il s'agit en particulier d'identifier les principaux facteurs responsables d'erreur d'évaluation dans le cadre de modélisation physique et numérique et de prendre en compte ces derniers en vue de l'élaboration de règles pratiques de modélisation.
Mandator: Fondation Velux 2005-2008 (Resp. Prof. J.-L. Scartezzini) CHF 285'000.-

Greenlighting - IEA Task 45 – Energy Efficient Electric Lighting of Buildings
Le projet vise à tirer profit de l'expérience et des connaissances acquises à l'EPFL dans le domaine de l'intégration de dispositifs d'éclairage naturel et artificiel. Il s'agit en particulier de concevoir et réaliser un dispositif intégré d'éclairage naturel et artificiel, d'optimiser ses performances énergétiques et de comparer cers dernières avec une installation conventionnelle d'éclairage artificiel par le biais d'un suivi expérimental.
Mandator: OFEN 2005-2009 (Resp. Prof. J.-L. Scartezzini) CHF 180'000.-

HOLISTIC -Optimisation Leading to Integration of Sustainable Technologies in Communities
This project aims to stimulate a paradigm shift in the use of energy within communities to more sustainable patterns. It will demonstrate how this transformation can be achieved in three typical communities, in Dundalk (Ireland), Mödling (Austria) and Neuchâtel (Switzerland), by acting on every aspect of community life. The role of the LESO-PB within this project is to develop new software for optimising the energy performance of urban districts.
Mandator: EC 2007-2010 (Resp. MER Dr D. Robinson) CHF 950'000.-

Retrofit - Advanced Energy-Efficient Renovation of Buildings
Wireless home automation and advanced control algorithms offers new possibilities for demand controlled heating, cooling and ventilation for smart solar shading control, and for intelligent electricity management. A standard set for demand controlled operation of HVAC and lighting components will be developed and tested. Special efforts will be made to optimize self learning control algorithms. A control algorithm comparison will be the main component of a PhD study, along with experimental tests that will be carried out on a test building unit.
Mandator: CCEM 2007-2009 (Resp. Dr N. Morel) CHF 200'000.-

House 2000 - Innovative Building Technologies for the 2000 Watt Society
Coloured solar thermal collectors are expected to play an important role for building heating and cooling purposes thanks to their façade integration capabilities. It implies however to account for the appropriate thin film technology, the architectural integration of combined collector-glazing modules and the elaboration of demonstration elements. All together they will contribute to the setting-up of innovative building technologies in favour of the 2000 Watts Society launched by the Swiss Federal Council.
Mandator: CCEM 2007-2009 (Resp. C. Roecker) CHF 96'000.-

CISBAT 2009 – Renewables in a changing climate – From Nano to Urban Scale
The international Conference CISBAT 2009 invites researchers from academic and public institutions, as well as industry representatives, at EPFL to present and discuss the latest R&D results on advanced sustainable building technologies for the built environment.
Mandators: EPFL/OFEN 2008-2009 (Resp. Prof. J.-L. Scartezzini) CHF 75'000.-

Coloured Solar Thermal Collectors (Phase III)
Finalisation du développement des capteurs colorés, traitant des trois paramètres suivants: Sélection d'un verre industriel extra-blanc traité diffusant sur une face avec bonne transmission énergétique – Amélioration des couches sélectives colorées pour optimiser la transmission et la réflexion colorées – Traitement thermique du verre final et test sur capteur existant.
Mandator: OFEN 2008-2010 (Resp. C. Roecker) CHF 241'000.-

Post-Doctoral Fellowship on Daylighting and Perception
This project is aiming to strengthen the education and research activities in the fields of building science and chronobiology. It is expected moreover to initiate innovating activities in relation to psycho-physiological aspects of daylight with an emphasis on human response factors, such as the perception of three-dimensional spaces and luminous environment.
Mandator: VELUX Foundation 2008-2012
(Resp. Prof. J.-L. Scartezzini, Dr M. Münch) CHF 800'000.-

Heat and Corrosion resistant nanocomposite selective Solar Absorber Coatings by Sol-gel Processing
This project aims at the development of novel nanocomposite selective absorber coatings for solar thermal collectors. By the new production process, highly toxic (CR(VI) shall be completely avoided. The novel coatings shall be absolutely chrome-free, more corrosion-resistant and more durable at elevated temperatures than existing products. Our approach is based on low-cost sol-gel techniques, and will be suitable for up-scaling to industrial production.
Mandator: CTI 2008-2010 (Resp. Dr A. Schueler) CHF 322'000.-

Coloured Thermal Collectors – Scientific Equipment
Construction of an advanced vacuum chamber for the plasma-deposition of novel nano-composite coatings, for solar energy applications such as coloured and thermochromic thermal solar collectors and improved switchable glazing. The installation will allow magnetron-cosputtering and deposition of multilayers with up to five magnetrons under high vacuum and ultra-high vacuum conditions.
Mandator: OFEN (Resp. C. Roecker, Dr A. Schueler) CHF 210'000.-

MANDATES AND SURVEY

Spectrophotometric characterization of UV sources for industrial hardening processes
Mandate for AC-Technologies (D. Alessi).

EDUCATION AND TEACHING

PhD

A. Thanachareonkit
Comparing Physical and Virtual Methods for Daylighting Performance Modelling
Adivser: Prof. J.-L. Scartezzini — End : 2008
EPFL Thesis Nr: 4130

M.C. Munari Probst
Architectural Integration and Design of Solar Thermal Systems
Adviser: Prof. J.-L. Scartezzini — End : 2008
EPFL Thesis Nr: 4258

J.-H. Kämpf
On the Optimization of Urban Energy Fluxes
Advisers: Prof. J.-L. Scartezzini, MER Dr D. Robinson — End : 2009

A. Rasheed
Development of a Simplified Urban Heat Island Model
Adviser: MER Dr D. Robinson — End : 2009

E. De Chambrier
Nanostructured Dielectric Materials for Coloured Glazed Solar Thermal Collectors
Advisers: Prof. J.-L. Scartezzini, Dr A. Schueler — End : 2009

M. Montavon
Optimisation of Urban Form by the Evaluation of Solar Potential
Adviser: Prof. J.-L. Scartezzini — End: 2009

F. Haldi
On the behavioural Modelling of Human Comfort and Energy Simulation
Adviser: MER Dr D. Robinson — End: 2010

F. Linhart
High Performance Integrated Daylighting and Electric Lighting Systems
Adviser: Prof. J.-L. Scartezzini — End: 2010

M. Joly
Nanocomposite Thin Films for Solar Thermal Collectors
Advisers: Prof. J.-L. Scartezzini, Dr A. Schueler — End: 2012

D. Daum
Evolutionary Optimization Algorithms for Biomimetic Building Control
Advisers: Prof. J.-L. Scartezzini, Dr N. Morel — End: 2012

MASTERS

F. Alotto, Politecnico di Torino
CIE Standard Skies in Switzerland
MSc Environmental Engineering
Supervisors : Prof. J.-L. Scartezzini, F. Linhart

M. Hadzikadunic, EPFL
Implantation d'un nouveau quartier à Maglaj (Bosnie)
MSc Architecture
Supervisors : Prof. J.-L. Scartezzini, Prof. I. Lamunière

N. Chollet, EPFL
A public Powerplant for urban Tokyo
MSc Architecture
Supervisors : Prof. J.-L. Scartezzini, Prof. H. Gugger

Y. Gramegna, EPFL
A public Powerplant for urban Tokyo
MSc Architecture
Supervisors : Prof. J.-L. Scartezzini, Prof. H. Gugger

E. Crawels, Université Catholique de Louvain-la-Neuve
Optimisating the sustainability of low income housing
MSc Architecture
Supervisor : MER Dr D. Robinson

A. Paone, Politecnico di Torino
Thermochromic films of vanadium dioxide for solar applications
MSc Physics
Supervisor : Dr A. Schueler

FOREIGN SCHOLARS AND TRAINEES

A. Borisuit, Chulalongkorn University, Thailand
High Dynamic Range Imaging Techniques
Swiss Confederation Scholarship
Supervisor : Prof. J.-L. Scartezzini

J. Rhishab Kumar, IIT Bombay, India
Stochastic Modelling of Human Interactions with Electrical Appliances
BTech Engineering
Supervisor : MER Dr D. Robinson

Y. Antonetti, HEIG
Nanostructured Inorganic Thin Films in Solar Energy Conversion
Master TIN
Supervisior : Dr A. Schueler

TRAINEES

F. Bourqui, ETML
Informatics Technical Supports
Trainee
Supervision : L. Deschamps

T. Moegli, ETML
Informatics Technical Supports
Trainee
Supervision : L. Deschamps

INVITED KEYNOTES & PRESENTATIONS

Scartezzini J.-L., R&D Activities in the Heat and Building Cluster
Invited Presentation, *Advisory Board of the Competence Centre Energy and Mobility (CCEM-CH)*, Zürich, 28 February 2008

Scartezzini J.-L., R&D Activities at the Solar Energy and Building Physics Laboratory
Invited Presentation, *Advisory Board of the EPFL Energy Centre*, Lausanne, 31 March 2008

Scartezzini J.-L., Innovation and Daylight in Buildings
Invited Keynote, *VELUX Foundation – DARCH/ETHZ Conferences*, Zürich, 3 April 2008

Scartezzini J.-L., Sustainable Buildings: Key Instruments in the Mitigation of Climate Changes
Invited Keynote, *EPFL Symposium: Counteracting Global Warming* (Visit of former US Vice-President Al Gore), Lausanne, 15 April 2008

Scartezzini J.-L., Ecosystemic Modeling of Urban Metabolism
Invited Presentation, *SNSF-NRP 54 Workshop: District/Village/City*, Bern, 23 October 2008

Schueler A., Part I –Vacuum Deposited selective absorber coatings
Invited Lecturer, *University of Malaga*, April 2008

Schueler A., Part II – Sol-gel coatings for solar thermal and photovoltaic applications
Invited Lecturer, *University of Malaga*, April 2008

Schueler A., Nanostructured thin films for solar energy conversion
Invited Keynote, *International Conference "From Solid State to BioPhysics IV"*, Cavtat, Dubrovnik, June 6-13, 2008

Robinson, D., Sustainable urban design,
Invited Lecturer, *University of Geneva*, December 2008

Robinson, D., Complexity, Sustainability and the City- Computable?, Webcast: Alliance for Global Sustainability
Invited Speaker, *ETH Zurich*, November 2008

Robinson, D., Simulation for sustainable urban design: a vision, Building Performance Simulation for Design and Operation
Invited Speaker, *UFSC*, Rio de Janeiro (Brazil), 3rd to 4th November 2008

Robinson, D., The modelling and optimisation of urban sustainability,
Invited Keynote, *BauSim*, Kassel (Germany), September 2008

Robinson, D., Towards integrated decision support for sustainable urban planning,
Invited Speaker, *World Renewable Energy Congress*, Glasgow (UK), July 2008

INVITED KEYNOTES & PRESENTATIONS (CONT'D)

Robinson, D., Design and Urban Planning: New Forms of Urban Life - New Forms of Development?, Global Humanitarian Forum – The Human Face of Climate Change, Invited Key Roundtable Discussant, *UNO*, Geneva, July 2008

Robinson, D., EuroAcademy on Ventilation and Indoor Climate (for European PhD students) Invited Lecturer, *University of Sofia*, Pomporovo, Bulgaria, May 2008

Robinson, D., Modelling and Optimising Urban Sustainability
Invited Keynote, *e-sim 2008*, Quebec (Canada), May 2008

Robinson, D., Meeting the future urban resource management challenge: A metabolic approach,
Invited Speaker, *Cooperation 2008, EPF Lausanne*, March 2008

Roecker Ch., Architectural issues and projects in building intergration of solar thermal collectors
Invited Presentation, *Taipei National University*, Taiwan, December 5, 2008

Munari Probst Maria Cristina, From façade integration of thermal collectors to active façade systems
Invited Presentation, *IEA SHCP new Task preparation workshop*, Copenhagen, May 12-14 2008

Munari Probst Maria Cristina, From façade integration of thermal collectors to active façade systems
Invited Presentation, *IEA SHCP ExCo meeting,* Graz, June 13-14 2008

Munari Probst Maria Cristina, Architectural integration of solar thermal
Invited Presentation, *SwissSolar Architecture Group*, Lausanne, October 31st 2008

AWARDS

Prof. J.-L. Scartezzini
Valued Associate Editor for Exceptional Contribution to the Quality of Solar Energy
Solar Energy International Journal, Elsevier Sciences Publisher (UK)

MER Dr D. Robinson
Ken Dale Travel Bursary, Chartered Institution of Building Services Engineers CIBSE (UK)

M.C. Munari Probst
Best Poster – Grand Prize Sustainable Development, EPFL Research Day 2008

EPFL EXTERNAL

Prof. J.-L. Scartezzini

- Swiss Academy of Engineering Sciences (SATW), Energy Committee Member
- Solar Energy International Journal, Associate Editor, Daylighting
- International Council for Research and Innovation in Building and Construction(CIB), EPFL Representative
- European Renewable Energy Research Centres Agency (EUREC), College of Members, EPFL Representative
- Swiss Competence Centre for Energy and Mobility (CCEM-CH), Research Committee Chair
- IPCC Working Group III – Mitigation, Scoping Meeting for Renewable Energy, Member of Experts Panel
- World Economic Forum (WEF), Global Agenda Council on Sustainable Energy, Member of Experts Panel
- Qatar National Research Fund (QNRF), National Priorities Research Program (NRRP), Peer Reviewer
- Canadian Foundation for Innovation (CFI), Civil Engineering Program, Member of Experts Panel
- Ministère de la Région Wallonne, Direction générale des Technologies, de la Recherche et de l'Energie (DGTRE), Membre du Comité d'Experts

MER Dr D. Robinson

- French National Research Agency (ANR), Member of Experts Panel
- International Building Performance Simulation Association, Switzerland, Board Member

Dr A. Schueler

- E-MRS Strasbourg 2008 Symposium on Protective Coatings and Thin Films, Scientific Committee Member
- Solid State Sciences International Journal, Guest Editor

C. Roecker

- IEA SHCP Task 41 "Solar Energy and Architecture", Member of Initiation Phase

EPFL INTERNAL

Prof. J.-L. Scartezzini

- Head of Institute (ICARE)
- Head of Doctoral Programme (EDEN)
- Member of EPFL Doctoral Committee (EDOC)
- Member of Working Group on Excellence in Doctoral Education (EiDE)
- Member of Search Committee (TTAP Sustainable Energy)
- Member of Academic Promotion Committee (TTAP C. Ancey)
- Member of Academic Promotion Committee (Adj. Prof. L. Laloui)
- Member of Academic Promotion Committee (Adj. Prof. C. Ludwig)

MER Dr D. Robinson

- Co-director of Master of Advanced Studies Architecture and Sustainable Development (co-organized with University of Toulouse and Catholic University of Leuven)
- Member of ENAC Faculty Council

Dr A. Schueler

- Administrator of Doctoral Programme (EDEN)

Dr N. Morel

- Member of ENAC Faculty Council

P. Loesch

- Member of ENAC Faculty Council

PUBLICATIONS 2008

REFEREED SCIENTIFIC JOURNALS

Haldi F., Robinson D.
On the behaviour and adaptation of office occupants,
In *Building and Environment*, vol. 43, num. 12, p. 2163-2177 (2008)

Robinson D., Haldi F
Model to predict overheating risk based on an electrical capacitor analogy,
In *Energy & Buildings*, vol. 40, num. 7, p. 1240-1245 (2008)

Robinson D., Haldi F.
An integrated adaptive model for overheating risk prediction,
In *Journal of Building Performance Simulation*, vol. 1, num. 1, p. 43-55 (2008)

Page J., Robinson D., Morel N., Scartezzini J.-L.
A generalised stochastic model for the simulation of occupant presence
In *Energy & Buildings*, vol. 40, num. 2, p. 83-98 (2008)

Theilemans K., Morel C., Jacobson M.W., Kämpf J.-H., Mustafovic S.
Normalisation of Histogrammed List Mode Data
In *Nuclear Science, IEEE Transaction*, vol. 55, num. 1, part. 2, p. 543-551 (2008)

Tosolini P.
Other Itineraries: Modern Architects on Countryside Roads
In *The Journal of Architecture*, vol. 13, num. 4, p. 427-451 (2008)

REFEREED SCIENTIFIC CONFERENCES

Haldi F., Robinson D.
A preliminary general stochastic model for window opening and closing
Presented at *e-Sim 2008*, Quebec City, Canada, May 20-23, 2008 (2008)

Haldi F., Robinson D.
A preliminary general stochastic model for window opening and closing,
In *Proc. Air-conditioning & the low carbon cooling challenge*, Windsor, UK, July 26-28 (2008)

Haldi F., Robinson D.
Stochastic / probabilistic modelling of multiple adaptive processes: some subtle complexities
Presented at *BauSIM*, Kassel, September 8-10 (2008)

Kämpf J.-H., Robinson D.
Optimisation de la forme urbaine pour une meilleure utilisation de l'énergie solaire
Presented at *IBPSA France Conference*, Lyon, November 6-7 (2008)

REFEREED SCIENTIFIC CONFERENCES

Linhart F., Scartezzini J.-L.
Energieeffiziente Bürobeleuchtung – Das Projekt "Green Lighting"
Presented at *15. Schweizerisches Status Seminar*, p. 155-162, Zurich, September 11-12 (2008)

Linhart F., Scartezzini J.-L.
Occupant satisfaction in office rooms equipped with Anidolic Daylighting Systems
Presented at *EUROSUN 2008*, Lisbon, October 7-10 (2008)

Robinson D.
Towards integrated decision support for sustainable urban planning
In *World Renewable Energy Congress – WREC*, Glasgow, July 19-25 (2008)

Robinson D.
Towards integrated decision support for sustainable urban planning
Presented at *BauSIM 2008*, Kassel, September 8-10 (2008)

Robinson D., Giller C., Haldi F., He F.
Towards comprehensive simulation and optimisation for more sustainable urban design,
Presented at *15. Schweizerisches Status Seminar*, p. 155-162, Zurich, September 11-12 (2008)

Robinson D., Haldi F.
An adaptive model of overheating risk
Presented at *15. Schweizerisches Status Seminar*, p. 497-504, Zurich, September 11-12 (2008)

Robinson D., Giller C., Haldi F., He F., Kämpf J.-H., Kostro A.
LESO-SUNtool: Comprehensive simulation and optimisation for more sustainable urban design
Presented *at PLEA 2008,* Dublin, Ireland, October 22-25 (2008)

Schüler A., Kostro A., Huriet B., Galande C., Scartezzini J.-L.
Monte Carlo simulations of quantum dot solar concentrators: ray tracing based on fluorescence mapping,
Presented at *SPIE Conference Optics and Photonics*, vol. 7046, San Diego, August 10-14 (2008)

PHD THESES

Thanachareonkit A.
Comparing Physical and Virtual Methods for Daylight Performance Modelling Including Complex Fenestration Systems
PhD Thesis EPFL, Nr 4130 (2008)

Munari Probst M.C.
Architectural Integration and Design of Solar Thermal Systems
PhD Thesis EPFL, Nr 4258 (2008)