



7<sup>th</sup> and 8<sup>th</sup> September 2017

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From Research to Application

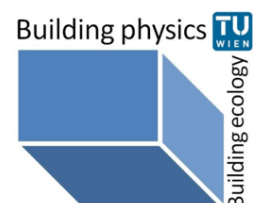
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## BOOK OF ABSTRACTS



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**F2.1. : Friday 8<sup>th</sup> of September 2017, 09:30 – 11:00, HS6**

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# Conference Opening

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**Session:**

T0.0. Conference Opening & Plenary Lecture

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**Title:**

Building Science from the Viewpoint of a city administration body

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**Authors:**

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**Abstract:**

This welcome note outlines the perspective from the city administration regarding specific research questions that can potentially be worked on by researchers in the field of environmental and energy assessment of the built environment. In other words, the demands and needs that attach the work within the administrative bodies of the city of Vienna in terms of a sustainable future development can be summarized as follows:

- General holistic approaches regarding a better integrative city planning that considers sustainability as a core topic.
- Information policies regarding the different offers that can be found in urban agglomerations regarding collaboration in the field of sustainability. Thereby, the existing programmes and incentives of the city of Vienna can be considered as a role model.
- Collaboration / Integration of the administrative bodies in terms of thesis topics suggestions. It can be stated that often specific problems and open questions could benefit from academic approaches. This is a bi-directional win-win situation, as perspective graduate students can work in real-life problems that will cross their road in similar fashion in their work-lives.
- The Big-Data aspect: The bringing together of different data pools, as for instance existing in the city administration or generated in the course of academic works could offer benefits for all involved sides. The better understanding of processes going on in urban agglomerations based on such data pools. might bring out fruitful new ideas for a better and more sustainable life in the cities.
- Generally speaking, a lot of research possibilities in terms of call for research proposals exist, partly funded by national, international, or continental budgets. The administrative bodies of the city of Vienna are highly interested to collaborate in terms of project proposals and research projects. Past experiences proved that such collaborations can lead to precious insights (as for instance experienced within the UHI-project).

# Conference Opening

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**Session:**

T0.0. Conference Opening & Plenary Lecture

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**Title:**

The Problem with the People

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**Authors:**

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**Abstract:**

In the last decades, there has been much progress in the building performance simulation domain in the last decades concerning methods and practices for specification of building geometry, material properties, and weather conditions. However, modelling of people's presence and behaviour in buildings are still in need of substantial improvement. This talk addresses the relevant challenges and promising paths toward developing reliable people-related models for building analysis applications.



# Sustainable Buildings and Environmental Assessment

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**Session:**

T1.1. Sustainable Buildings and Environmental Assessment I (Thursday 7th of September, 11:30 – 13:00, HS7)

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**Title:**

Waste prevention in the prefabricated building sector

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**Authors:**

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**Keywords:**

Waste preventions  
Prefabrication  
Construction  
Construction and Demolition Waste  
Design for Deconstruction  
Design for Reuse

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**Abstract:**

The present study investigates waste generation during the production and erection phase of a prefabricated single family house in Austria as a basis for identifying waste prevention potentials. Therefore, the material composition of a case study building (wood frame construction) is compared to waste generated during production and erection. In order to assess the whole life cycle of prefabricated buildings the use phase as well as the end-of-life phase are also considered. Examples are given to show how different measures can impact the generation of waste directly and indirectly. The results show that production and erection are already very efficient with regard to waste generation and prevention potentials mainly exist in further offcut reduction and optimization in packaging. The use phase and the end-of-life of the building are more complex to investigate and waste prevention potentials are less tangible. However, important measures for waste reduction are related to the easy exchangeability of building components as well as their reusability. The lifetime extension of the building and building components, which can be achieved through proper operation and maintenance, can be considered a key issue for preventing waste in the building sector.

**Session:**

T1.1. Sustainable Buildings and Environmental Assessment I (Thursday 7th of September, 11:30 – 13:00, HS7)

**Title:**

LCA-based design support for a senior citizens' residence

**Authors:**

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**Keywords:**

Buildings  
Life cycle  
LCA  
Integrated design  
Environmental impact

**Abstract:**

This paper reports on a project for a senior citizens' residence in the vicinity of Trento, Italy. The project constitutes the major part of a Master's thesis in Architectural Engineering, developed at the University of Trento in Italy and at TU Vienna in Austria. The work entails a full account of environmental impacts during the life cycle of the building through LCA (Life Cycle Assessment). Furthermore, as buildings' end of life scenarios are insufficiently considered in most conventional LCA studies, the present contribution attempts to pursue a "cradle to cradle" approach (exploring a closed-loop flow of materials, energy, and resources) and to emphasize that the consequences of the choices made at the early stage of the design phase are critical for the subsequent stages of construction, use, maintenance, and end of life.

The work consists of two parts. The first part relating to the architectural project involves careful consideration of the local characteristics of the site according to bioclimatic studies. In the second part, a comparative LCA study of different timber constructions and energy system options is presented, followed by a global LCA of the project. This aims at the estimation of the impacts of construction and end of life. Thereby, different possibilities are explored for reusing and recycling materials, such that disposal and incineration could be reduced as much as possible. Thus, the relative significance of different stages of the building construction, operation, and decommissioning can be explored.

In conclusion, the paper offers a number of theoretical reflections on uncertainty analysis in LCA, addressing input assumptions (availability and quality of data) as well those regarding normalization and weighting factors. Thereby, the aim is to contribute to efforts toward a more pervasive application of the LCA methodology in the building design and delivery process.

**Session:**

T1.1. Sustainable Buildings and Environmental Assessment I (Thursday 7th of September, 11:30 – 13:00, HS7)

**Title:**

Energy and Cost Performance of Existing Buildings under Step-by-step Retrofit in Turkey

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**Keywords:**

Energy Performance  
Cost-optimal  
Step-by-step Retrofit  
EPBD  
Building Retrofit

**Abstract:**

Recast version of Energy Performance of Building Directive (EPBD-Recast) obligate member states to keep the cost analysis in parallel with the energy analysis during the retrofit actions for the existing building by taking the cost-optimal level of minimum energy performance requirement to the account. Although this cost-optimal level is indicating the minimum cost level for a period, it can provide buildings' owners with an enormous initial cost. One of the most challenging barriers to energy efficient and cost-optimal retrofit of existing buildings is the reluctance of owners to involve in their project as an investor due to the high cost of application. Particularly in developing countries, such reluctance is more tangible as the governments are not capable of providing enough financial incentives for owners due to a large number of buildings that should be retrofitted and small available budget. A proper solution for the problem is to divide necessary actions for each building to certain sub-actions and apply them as a step-by-step retrofit project. On the other hand, progressive application of retrofit activities has some restrictions. It is necessary to define the due amount for households and keep the cost of each step in this interval.

Moreover, the low rate of building retrofit which affects the EU goals can be improved remarkably by application of step-by-step actions not only by increasing the number of owners' contributions but also by improving the time of implementation, proper distribution of skilled labours and directed economic resources.

This paper aims to assess the step-by-step application of the energy efficient retrofit actions through energy and cost analysis under Turkey's climatic, economic and sociological conditions. One of 26 reference residential buildings in Turkey is analysed in this paper. The due amount for each step is defined, and some retrofit actions and their combinations applied to the case building and the results compared with the base condition. Then a proper combination of measures established based on the cost-optimal analyses. These appropriately combined actions are then divided into some sub-actions; following this, cost and energy studies are conducted again to determine the appropriate arrangement of sub-actions.

**Session:**

T1.1. Sustainable Buildings and Environmental Assessment I (Thursday 7th of September, 11:30 – 13:00, HS7)

**Title:**

BIM-based material passport (MP) as an optimization tool for increasing the recyclability of buildings

**Authors:**

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**Keywords:**

Material Passport  
BIM  
Circular Economy  
Recyclability of Materials

**Abstract:**

Building stocks and infrastructures are representing the largest material stock of industrial economies, whereby the largest fraction of building materials is transformed into waste at the end of the life cycle. In order to optimize the recycling potential of buildings, new design-tools and methods are required, whereby it is of utmost importance to have a documentation of the material composition of buildings. In this paper, the methodology for creating a BIM-based Material Passport, enabling optimization of the design of buildings and serving as a documentation of materials existing in buildings, is described. Therefore, a specific building component - the flat roof - of a residential building is used in order to test the proposed tool-chain and show the recycling potential of the built-in materials. Thereby, the recycling potential of a version in timber construction and a version in concrete construction is assessed. The results show that the two versions have a similar recycling rate. However, concrete has a significantly higher mass in comparison to timber, by what the mass of the total waste materials is less in the timber version.

**Session:**

T1.1. Sustainable Buildings and Environmental Assessment I (Thursday 7th of September, 11:30 - 13:00,HS7)

**Title:**

A Visual Method for Detailed Analysis of Building Life Cycle Assessment Results

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**Keywords:**

LCA  
building life cycle assessment  
result visualization  
parameter analysis  
optimization

**Abstract:**

In the environmental analysis of buildings, Life Cycle Assessment (LCA) is gaining more and more interest. It is due to the fact, that LCA is very comprehensive in considering many impacts in all life-cycle phases of the examined building. Since buildings have a complicated geometry that is built up with numerous constructions that consist of many materials, and the life-cycle includes many phases, the results of an assessment are likely to be difficult to analyze in detail. In this paper we introduce a visual method to help architects and analysts to quickly understand the results of an environmental assessment. It includes the hierarchic visualization of the performance of the individual elements of the building. Both energy use and environmental impacts can be presented. Also the contribution of the different life-cycle phases in the overall impact is visualized. There are increasing efforts nowadays to find the most efficient way to improve the environmental performance of buildings [1]. This can be supported with a detailed analysis of the results. The method is presented through a case study of a realized energy efficient one-family house.

**Session:**

T1.1. Sustainable Buildings and Environmental Assessment I (Thursday 7th of September, 11:30 – 13:00, HS7)

**Title:**

Energy and Cost Performance of Existing Buildings under Step-by-step Retrofit in Turkey

**Authors:**

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**Keywords:**

sustainable development  
green construction  
hybrid building  
ecological building materials  
agriculture waste recycling  
energy flow balance  
rural area  
circular economy.

**Abstract:**

**Actuality.** Last years the central Ukraine territories have been faced the new challenge such as the need to provide energy efficient housing and jobs (employment) for displaced people from Donbas regions. In the same time in the state level, the economic development of rural areas, as the agrarian sector is leading today. In the context of circular economy the combination of building and agrarian sectors is logical as the building sector may propose the rational way of agriculture waste recycling and the rural infrastructure development together with new activities providing. **The purpose.** To develop a scientifically sound model of rural area planning development based in the integration of hybrid multi-functional building structures, taking into account the main principles of sustainable development and circular economy. **Methodology.** The model is based on a review of scientific work on the problem and the analysis of statistical data. It uses the methods of field research to study the features of sustainable development and energy-efficient structure systems in the rural areas. **Findings.** A new approach to design and structural solutions of the rural area is proposed, using the innovative hybrid system, which supports the balanced energy and information flows. The combination of environmental building technologies with modern bio-agricultural technologies can solve many of the socio-economic problems of the modern village - providing affordable quality housing, safe and useful work with green farming technologies, in tourism, and in scientific spheres. The proposed solution integrates rural area cultural and material heritage conservation as a socially important element. The research focuses on environmentally clean and renewable local materials: straw, flax, reed, hemp, earth-concrete, and others. Ideally, the proposal will achieve nearly 100% utilization, or recycling, of the construction and shell building materials in the end of building life cycle. It will also design solutions for nearly zero waste during exploitation. **Scientific novelty and practical value.** The spatial planning model of the region meets the basic criteria of sustainable development: economic and energy efficiency, social orientation, environmental friendliness, preservation of cultural heritage. The implementation of the proposed new planning model and building construction will facilitate balanced development and renaissance of the rural area.

**Session:**

T1.2. Sustainable Buildings and Environmental Assessment II (Thursday 7th of September, 14:00 – 15:30, HS7)

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**Title:**

Approaches to Urban Weather Modeling: A Vienna Case Study

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**Authors:**

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**Keywords:**

Urban Climate  
Modeling  
Dynamic Downscaling  
Morphing  
Data Analysis

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**Abstract:**

Given the adverse implications of both urbanization and global climate change for cities, specifically regarding issues such as human health and comfort, local air quality, and increased summertime energy use in buildings, it is becoming imperative to develop models that can accurately predict the complex and nonlinear interactions between the surrounding urban fabric and local climatic context. Over the past years, a number of comprehensive tools have been widely applied for the generation of near-surface urban climatic information. In this paper, we report on the potential of two alternative approaches to urban climate modeling. Specifically, we compare the climatic output generated with Urban Weather Generator (UWG) and the Weather Research and Forecasting (WRF) model. The WRF model has been widely applied due to its capability of downscaling global weather data to finer resolutions, thus representing the location-specific microclimatic information, while considering the interactions with the surrounding urban and regional context. However, this approach is computationally intensive. The UWG was recently introduced as a simpler alternative to such complex models. The tool morphs rural weather data to represent urban conditions given a set of location-specific morphological parameters. In the present paper, WRF and UWG methods were compared based on empirical data pertaining to air temperature, wind speed, and humidity, collected from 12 locations in the city of Vienna, Austria, over 5 distinct time periods. In general, our results suggest that, as compared to the WRF model, the UWG model results are closer to monitored data. However, during the extreme conditions in summer, the WRF model was found to perform better. It was further noted that the discrepancy between the two models increases with decreasing temperatures, thus revealing a higher offset between UWG and WRF output during the winter period.

**Session:**

T1.2. Sustainable Buildings and Environmental Assessment II (Thursday 7th of September, 14:00 – 15:30, HS7)

**Title:**

Living wall systems' effect on the U-value of the façade

**Authors:**

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**Keywords:**

Façade greening  
heat transfer  
U-value  
Heat transmission coefficient  
heat demand

**Abstract:**

This paper shows how façade greening affects the heat resistance value of an old building. Two greened façades with different living wall systems have been researched and measured for one heating season. At the same time two not greened parts of the façade were measured. The heat flux, the surface temperatures of the facades and the air temperatures on both sides of the facades were documented for one heating season. So far there does not exist a general method, how to calculate the u-value of greened facades. The method which is developed within this research-paper makes the comparison between the greened part of the façade and the not greened part possible. It turned out that there is a difference of the thermal resistance between greened and not greened parts of the façades in winter. Depending on the greening system the increases of the thermal resistances are between  $0.31 \text{ m}^2 \cdot \text{K} \cdot \text{W}^{-1}$  and  $0.67 \text{ m}^2 \cdot \text{K} \cdot \text{W}^{-1}$ .



**Session:**

T1.2. Sustainable Buildings and Environmental Assessment II (Thursday 7th of September, 14:00 – 15:30, HS7)

**Title:**

A Review of the Impact of Vegetation in Solar Control towards Enhanced Thermal Comfort and Energy Performance in Buildings

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**Keywords:**

Air quality  
Energy performance  
Microclimate  
Thermal Comfort  
Vegetation

**Abstract:**

Man requires a thermal environment that is within the range of his adaptive capacity and if this fluctuates outside the normal, a reaction is required beyond its adaptive capacity which results to health challenges. Therefore, the aim of building design in the tropical region is to minimize the heat gain indoors and enhance evaporative cooling of the occupants of the space so as to achieve thermal comfort. In most cases, the passive technologies are not adequate in moderating indoor climate for human comfort thereby relying on active energy technique to provide the needed comfort for the building users. The need for the use of vegetation as a panacea for achieving comfortable indoor thermal conditions in housing is recognised by architects globally. However, the practice by architects in Nigeria is still at the lower ebb. The thrust of this paper therefore is to examine the impact of vegetation in solar control reducing thermal discomfort in housing thereby enhancing the energy performance of the buildings. Using secondary data, the paper identifies the benefits of vegetation in and around buildings to include improvement of indoor air quality through the aesthetics quality of the environment and concludes that vegetation in and around building will in no small measure contributes to saving energy consumption.

**Session:**

T1.2. Sustainable Buildings and Environmental Assessment II (Thursday 7th of September, 14:00 – 15:30, HS7)

**Title:**

Simulation-Supported Early Stage Design Optimisation for a Case Study of Life Cycle Oriented Buildings

**Authors:**

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**Keywords:**

Heating demand  
dynamic simulation  
energy-efficiency  
sustainable building  
energy certificate

**Abstract:**

To reduce the energy and resource consumption in the building sector this study is focusing on a design optimisation of life cycle oriented buildings. In order to optimise the performance of the buildings and in consequence also to achieve improved results for the mandatory Austrian energy certificate a simulation-based rapid design approach is used for the early stage design phase of the buildings, in particular for the architectural design of the buildings.

Methods like the Window to Wall Ratio, at the very beginning of the design process, a parametric simulation with EnergyPlus or a more detailed optimisation approach with GenOpt are integrated in this study applied to example buildings. The results are showing that the method can be used in a circular approach for improving the heating demand of the Austrian energy certificate for this case study by more than 25 % compared to the preliminary design.

**Session:**

T1.2. Sustainable Buildings and Environmental Assessment II (Thursday 7th of September, 14:00 – 15:30, HS7)

**Title:**

Assessment of the Life Cycle Energy Efficiency of a Primary School Building in Turkey

**Authors:**

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**Keywords:**

Life Cycle Energy Assessment  
School Building  
Energy Efficiency  
Energy Consumption  
Life Cycle CO2 Emissions

**Abstract:**

Energy efficiency has become a crucial part of human life, which has an adverse impact on the social and economic development of any country. In Turkey, it is a critical issue especially in the construction sector due to increase in the dependency on the fuel demands. The energy consumption, which is used during the life cycle of a building, is a huge amount affected by the energy demand for material and building construction, HVAC and lighting systems, maintenance, equipment, and demolition. In general, the Life Cycle Energy (LCE) needs of the building can be summarised as the operational and embodied energy together with the energy use for demolition and recycling processes.

Besides, schools alone are responsible for about 15% of the total energy consumption of the commercial building sector. To reduce the energy use and CO2 emission, the operational and embodied energy of the buildings must be minimised. Overall, it seems that choosing proper architectural measures for the envelope and using low emitting material can be a logical step for reducing operational and embodied energy consumptions.

This paper is concentrated on the operating and embodied energy consumptions resulting from the application of different architectural measures through the building envelope. It proposes an educational building with low CO2 emission and proper energy performance in Turkey. To illustrate the method of the approach, this contribution illustrates a case study, which was performed on a representative school building in Istanbul, Turkey. Energy used for HVAC and lighting in the operating phase and the energy used for the manufacture of the materials are the most significant parts of embodied energy in the LCE analyses. This case study building's primary energy consumption was calculated with the help of dynamic simulation tools, EnergyPlus and DesignBuilder. Then, different architectural energy efficiency measures were applied to the envelope of the case study building. Then, the influence of proposed actions on LCE consumption and Life Cycle CO2 (LCCO2) emissions were assessed according to the Life Cycle Assessment (LCA) method.

**Session:**

T2.1. Building Materials and Structures I (Thursday 7th of September, 11:30 – 13:00, HS6)

**Title:**

Sustainable materials with potential application as core materials in vacuum insulations

**Authors:**

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**Keywords:**

Core materials  
vacuum insulation panels  
organic fibers  
thermal conductivity  
thermal insulation  
heat transfer.

**Abstract:**

The paper focuses on the various uses of several types of textile fibers (mainly by-products) in the development of modern insulation materials with a high value added. These materials bear several specific advantages over conventional insulations, which enable, among others, easier installation. Some of the newly developed insulations can also be used as core insulations in the manufacture of vacuum insulation panels (VIP). In the context of the research, the study of behavior of thermal insulating materials based on organic polymeric and natural fibers (including fibers from recycled textiles) was conducted. The experimental materials were used to study their physical and mechanical properties and their behavior under reduced pressure (up to vacuum) to evaluate their possible use in the field of VIP as core insulations. Researches have shown that developed insulation based on alternative base can have very good potential in the VIP area and compete with the standard core insulations based on glass fibers of SiO<sub>2</sub>.

**Session:**

T2.1. Building Materials and Structures I (Thursday 7th of September, 11:30 – 13:00, HS6)

**Title:**

Thermal Performance Testing for Window with Vacuum Glazing

**Authors:**

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**Keywords:**

vacuum glazing  
U-value, pillars  
Edge  
window

**Abstract:**

This document deals with the determination of thermal transmission properties of wood-aluminium window with vacuum glazing. Test measurements are performed with guarded hot-box method at defined temperature difference. They describe how the support pillars influence temperature distribution on the surface and how the edge vacuum glazing influence the heat flow through window. The deformation of the temperature field due to support pillars is surprisingly small and its range is from 0.20 K to 0.46 K with temperature difference on both sides of approximately 20 K. Decrease of internal surface temperature from the middle of glass to the edge is about  $20.04 - 16.15 = 3.89$  K.

**Session:**

T2.1. Building Materials and Structures I (Thursday 7th of September, 11:30 – 13:00, HS6)

**Title:**

The application potential of vacuum glazing in building's thermal retrofit: A Case Study

**Authors:**

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**Keywords:**

vacuum glazing  
thermal building retrofit  
building construction  
numeric thermal bridge simulation  
efficiency evaluation

**Abstract:**

Vacuum glazing is considered as a viable alternative for improvement of transparent components of the building envelope in the course of thermal building retrofit. Research and development efforts in the past decades focused on the vacuum glazing itself. Thereby, research targeted the development of durable edge sealing and selecting suitable materials for spacers in the vacuum between the two glass panes. However, the availability of durable vacuum glass is only the first step toward energy-saving transparent building components. The next step is to think about window constructions that consider the specific requirements of vacuum glazing. While new windows can be constructed from scratch to meet these requirements, this does not apply to the windows of existing buildings. Thus, the impact of vacuum glazing in existing window constructions has to be thoroughly evaluated. This contribution describes the method and results of a case study that focused on the implementation of vacuum glass in a number of window frames typical to the building stock in Central Europe. To assess the thermal performance of such assemblies, numeric thermal bridge simulation was deployed. Based on the results of a number of implementation scenarios, key performance indicators for building details as well as for overall building energy performance were derived. Subsequently, the results were utilized in simple economic calculations to explore the overall sustainability of such window retrofit measures.

**Session:**

T2.1. Building Materials and Structures I (Thursday 7th of September, 11:30 – 13:00, HS6)

**Title:**

Transparent facade constructions: A comparison between conventional insulation glass and vacuum glazing

**Authors:**

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**Keywords:**

vacuum glazing  
numeric thermal bridge simulation  
transparent façade constructions  
performance comparison  
key performance indicators

**Abstract:**

In recent years, contemporary architectural design has been influenced by new technical opportunities offered by the glass industry. Large glass panels and even structurally active glass elements can be found in many recent building designs. Moreover, building envelopes in many cases include large glass panels. Needless to say, the use of glass as an envelope material comes with advantages and disadvantages, and a good architectural design has to consider these aspects. Advantages, amongst others, encompass the increased solar penetration and solar gains in the cold season, the increased daylight availability, and the “clean” appearance of buildings; Disadvantages include, amongst others, the overheating risk in summer, thermal discomfort as a result of radiant temperature asymmetries, and increased heat loss. The last two aspects are directly linked to the rather high heat flow through conventional glazing systems compared to well-insulated opaque building components. There are numerous examples of buildings, where prevailing performance problems can – in one way or the other – be linked to inadequate planning of the transparent building envelope. Generally speaking, the transparent parts of building envelopes can be distinguished in elements that are operable (windows, doors), and elements, which are fixed. The former are characterized by highly complex opening mechanisms and seals and thus rather high cost. The latter regularly are less complex, but their design needs to consider other aspects (durability, structural stability, etc.). This contribution illustrates the results of a number of numeric thermal bridge simulations focusing on transparent façade constructions with fixed glazing. Thereby, the key performance indicators of different construction scenarios are derived and compared. These indicators include thermal coupling coefficient, surface temperature, and condensation risk. The scenarios are based on typically applied transparent façade constructions, which are simulated with insulation glass and, alternatively, with vacuum glazing. As transparent constructions with fixed glazing regularly have higher life-time expectancies than openable windows (given the reduced complexity), such constructions might be promising in terms of vacuum glass application and a thus improved thermal building performance. Moreover, the reduced weight of vacuum glazing panels in comparison to highly-insulating double and triple glazing might allow for more efficient building construction (structural elements, etc). The present contribution illustrates the construction principle of different elements, the simulated scenarios, and the results of the simulation runs.

**Session:**

T2.1. Building Materials and Structures I (Thursday 7th of September, 11:30 – 13:00, HS6)

**Title:**

Grip fixing instead of adhesive - Exterior Insulation Finishing Systems (EIFS) as a sorted recyclable façade system with reclosable fastener fixation

**Authors:**

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**Keywords:**

Exterior Insulation Finishing Systems (EIFS)

grip fixing system

Grip fixing instead of adhesive

carrier board made of recycled glass

dust- and noise-reduced dismantling

reuse and recycling

**Abstract:**

The paper describes the project facade4zeroWaste which includes the development, architectural design relevance, grants of patents, results of pre-certification testing's and the product publication in the time frame from 2009 till 2017. Aim of the research project facade4zeroWaste was the idea of a recyclable facade insulation system that can easily be dismantled after its lifetime and reused thanks to an innovative grip fixing system consisting of mushroom-shaped heads and loops - Grip fixing instead of adhesive.



**Session:**

T2.2. Building Materials and Structure II (Thursday 7<sup>th</sup> of September, 14:00 – 15:30, HS6)

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**Title:**

Development of Prefabricated Timber-Steel-Concrete Ribbed Decks

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**Authors:**

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**Keywords:**

Multistory buildings  
ribbed deck  
timber-steel-concrete  
hybrid structures

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**Abstract:**

In the last years several projects of medium and high-rise timber-based multi-story buildings have been proposed and developed. In most of the cases timber-concrete composite (TCC) floors play a significant role for the design of the structural slabs due to acoustic performance, fire protection and structural issues. Within several research projects and with the aim to optimize the structural and ecological characteristics of building components the Department of Structural Design and Timber Engineering (ITI) at the Vienna University of Technology (TU Wien) developed timber-steel hybrid beams that can be used independently or combined with concrete floors, proposing for this last case prefabricated and semi-prefabricated timber-steel-concrete ribbed elements that make the most of all this potential.

In order to recognize the potential for future market implementation and to demonstrate the competitiveness of the developed hybrid ribbed floor slabs, the economic feasibility and the ecological impact, structural elements were analyzed in several case studies. The environmental assessment shows the ecological advantages of the developed concepts and underlines the potential for further developments.

This paper contains an introduction on the state-of-the-art floor solutions for timber-based multistory buildings, the fundamental ideas and design concepts behind the timber-steel and timber-steel-concrete proposals as well as a short review of the tests carried until now and results obtained.

**Session:**

T2.2. Building Materials and Structure II (Thursday 7<sup>th</sup> of September, 14:00 – 15:30, HS6)

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**Title:**

Development of Timber-Wood Lightweight Concrete-Glass Composite for Multi-Story Façades

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**Authors:**

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**Keywords:**

Timber  
Glass  
Composite  
Façades  
wood-based construction  
sustainable building

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**Abstract:**

Within several research projects and with the aim to optimize structural performance, energy efficiency and ecological characteristics of structural building components the Department of Structural Design and Timber Engineering (ITI) at the Vienna University of Technology (TU Wien) developed several wood-based composite systems, which combine timber products with other conventional building materials and components. As a representative example for these developments, this paper illustrates the results of the joint research project “Wood-based concrete: building construction with composite elements of wood-concrete compounds and timber (WooCon)”. The objective of the research project “WooCon” is to develop a multi-layer wall system composed of wood lightweight concrete (WLC), connected timber sections, textile reinforcement as well as glass layers on the exterior to gain and use advantages of each used material - lightweight, structural, thermal storage and insulation, ecological and economic benefits - to name the most important ones.

In order to assess the structural physical properties of wood-based composite wall elements, in a first step measurements of the thermal properties with respect to thermal-insulating properties and thermal storage capacity are carried out. In following step, the results obtained are used further to simulate the thermodynamic and hygrothermal building behavior. The aim of the simulations is to investigate the effect of the wood-based composite wall elements to the annual heating demand as well as to the operative room temperature of a typical south-orientated living space.

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**Session:**

T2.2. Building Materials and Structure II (Thursday 7<sup>th</sup> of September, 14:00 – 15:30, HS6)

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**Title:**

Case Study on Comparison of Joint Sealant Adhesive Properties Tested in Laboratory and In-situ

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**Authors:**

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**Keywords:**

Adhesion  
Cohesion  
Durability  
Façade  
Field – moulded  
In-situ performance  
Sealant joint  
Surface temperature;

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**Abstract:**

The main objective of this case study is to compare whether standardised test methods are able to reliably prognosticate the performance of joint sealants and adhesives after installation in a construction. The authors of the presented study believe that the existing testing procedures intended for the testing of bonded and sealed joints do not fully reflect the weather changes exterior surfaces have to withstand. Based on previous experiences, a unique geometry for testing samples was used for this purpose, allowing the testing of a so-called real joint. A group of test samples was subjected to two normalised test procedures that may influence the resulting behavior of the joint in the exterior. The second group of test samples was exposed to the external environment for a particular period. The results obtained from the tests show that the standardised methods are able to simulate an outdoor environment, however, only to a certain level. Unfortunately, these methods do not consider the possibility that the sealed or bonded joint might have already been damaged during the application itself. While the laboratory environment is clean and often dust-free, it is not possible to ensure the same conditions in-situ. Moreover, in some cases it was monitored that some of the selected sealants tested in an external environment aged rapidly compared to the ones cured and stored in the laboratory. In some cases, the difference between monitored failure modes for indoor and outdoor environment was substantial. The predominant type of sealant failure observed in-situ was adhesive, while mainly cohesive failure was monitored in the laboratory.

**Session:**

T2.2. Building Materials and Structures II (Thursday 7th of September, 14:00 – 15:30, HS6)

**Title:**

Evaluative Case Study in Lightweight Wooden Wall Research

**Authors:**

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**Keywords:**

lightweight timber frame wall  
temperature measurement  
test laboratory room  
controlled environment  
monitoring of boundary conditions

**Abstract:**

This presented article deals with two newly designed experimental walls with different measuring sections (5 for each lightweight wooden wall). All fragments meet the standards required for zero and energy-plus buildings, which would be mandatory in Slovakia from the year 2020. The experimental walls are located in central Europe (town Zilina, Slovakia). Description of individual test sections, the measuring technology, data collection, interior technical equipment and outdoor boundary conditions monitoring are introduced. In the future, the experimental research should progressively combine theoretical calculations with real measurement and computer HAM simulation. In this paper, the focus is aimed to the temperature profiles in wall fragments during seven days chosen from the spring period in the year 2017. The results were graphically presented and evaluated from a point of view of continuous temperature measurement in the structure, exterior boundary conditions, wall orientation and surface character (material, color). Also further intensions of research are drawn.

**Session:**

T2.2. Building Materials and Structures II (Thursday 7th of September, 14:00 – 15:30, HS6)

**Title:**

Assessment of the dynamic temperature profile in fire loaded sandwich structures based on wood in comparison with conventional structural systems

**Authors:**

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**Keywords:**

Fire resistance rating  
time temperature curves  
light buildings  
sandwich panels  
apartment building

**Abstract:**

Fire safety is an important feature of healthy internal environment. If a fire breaks out, the interior of fire compartments within the building is exposed to very high temperatures and further phenomena accompanying the burning process. All of them impact the boundaries of the compartment structures, including the structures that are located inside them. Some structures serve the load bearing function hand in hand with fire barriers, some are only fire barriers. As to the dramatic increase of temperature, its impact upon the opposite surface of the fire separating structure should be considered, in particular regarding the behaviour of the load bearing elements and their stability. This is topical at the present day, since the conventional construction materials are seen to give way to wooden sandwich structures that are preferred especially for their thermal insulation properties, low weight, small thickness and speediness of construction. The article uses dynamic simulation to illustrate how these modern structures react to high temperatures within specific time intervals, offering comparisons with traditional brick structures.

**Session:**

T2.2. Building Materials and Structure II (Thursday 7<sup>th</sup> of September, 14:00 – 15:30, HS6)

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**Title:**

Utilization of Waste Packaging Glass as Progressive Filler in Polymer Anchor Material Based on Epoxy Resin

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**Keywords:**

Polymer anchor material  
epoxy resin  
waste packaging glass  
shrinkage  
chemical resistance  
pull-out strength.

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**Abstract:**

The work deals with the use of waste glass to the polymer anchor material based on epoxy resin, primarily for anchoring to a high strength concrete (HSC). The main aim was to use the largest possible amount of the waste packaging glass by reducing the amount of epoxy resin, which is an expensive material and its production has a negative impact on the environment. Within the experimental verification, the influence of waste packaging glass fraction 0–0.63 mm on the final properties of the polymer anchoring material was observed. To determine the optimal formulation compressive strength, flexural strength, chemical resistance, shrinkage and pull-out test were performed. Based on the evaluation of the results the optimal percentage of filling was determined, when the polymer anchor material showed high strengths, minimal shrinkage, good chemical resistance, optimal consistency for anchoring into the HSC and high anchor bolt pull-out strength.

**Session:**

F2.1. Building Materials and Structures III (Friday 8<sup>th</sup> of September 2017, 09:30 – 11:00, HS6)

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**Title:**

Performance Evaluation of a Building Integrated Photovoltaic / Thermal System Combined with Air-to-Water Heat Pump

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**Keywords:**

building integrated photovoltaics, heat pump, simulation, office building, coefficient of performance, space heating.

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**Abstract:**

This study presents a research of envelope systems entailing elements that use and control incident solar energy to deliver renewable thermal or electric energy to the systems providing heating, ventilation and air conditioning to buildings. A simulation model of an office building was developed in the simulation program TRNSYS. A photovoltaic / thermal system was integrated into the building's southern facade to generate electricity and to increase the temperature of the air flowing through the channel behind the photovoltaic modules. Subsequently, the electricity generated was used to power the heat pump and the warm air was used as the primary fluid for the heat pump to generate thermal energy for space heating in the winter. The useful energy gain and power production increased with increasing length of the photovoltaic modules and the air flow rate through the channel in the periods, when there was enough solar radiation impinging on the facade. In January to April, the benefits of the photovoltaic / thermal system were minor because of the low levels of low solar radiation and insufficient efficiency of the system components.

**Session:**

F2.1. Building Materials and Structures III (Friday 8<sup>th</sup> of September 2017, 09:30 – 11:00, HS6)

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**Title:**

Simulation study of dry floor heating systems

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**Keywords:**

floor heating  
software CalA  
numerical simulation  
spreader plate; heat losses

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**Abstract:**

This case study is aimed at simulation of dry floor heating system. Heating pipes are inserted in system boards made of thermal insulation. These boards should be supplemented with spreader plates which are installed under the heating pipes. Impact of different thermal conductivity of spreader plates on useful heat flux and uniformity of temperature field is examined. Heat losses are also investigated. These simulations are performed using software CalA with time steady-state boundary conditions. The results show that the dry floor heating system without spreader plates has very low useful heat flux caused by positioning of heating pipes in the insulation material. On the other hand, use of spreader plates causes significant increase of useful heat flux of this system. The higher heat conductivity of spreader plates is, the higher useful heat flux is. The floor surface temperature is also more uniform and the thermal comfort is better. The minimal thickness of additional heat insulation is determined in order that heat losses are lower than ten percent of total heat flux.



**Session:**

F2.1. Building Materials and Structures III (Friday 8<sup>th</sup> of September 2017, 09:30 – 11:00, HS6)

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**Title:**

Numeric thermal bridge simulation and Building Information Modelling: A structured coupling approach

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**Keywords:**

numeric thermal bridge simulation  
Building Information Modelling  
Ifc  
seamless linking  
integrated planning and building delivery process  
building informatics

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**Abstract:**

This contribution illustrates recent development efforts for a better data interlinking between Building Information Modelling tools and numeric thermal bridge simulation applications. As widely recognized within the professional and research communities working in the fields of building informatics and building physics, the desired seamless data interchange between modelling and assessment tools with regard to relevant data on buildings, building components, and details. Moreover, this attractive possibility is hampered from a multitude of obstacles, which are related to different modelling techniques, missing input data, uncertainties regarding the full understanding of data interchange formats by all involved tools, etc. Progress regarding such data interchange has to be made in small and well-documented steps, so that potential end-users (architects, engineers, consultants) can benefit from the developments. Toward this end, we present recent implementation work within a state-of-the-art commercially available numeric thermal bridge simulation tool. Building information models based on the IFC-format can now be read within this tool. The present contribution illustrates the workflow, the benefit, and the limitations of the recent implementation, and delivers a proof of concept for this approach.

**Session:**

F2.1. - Building Materials and Structures III (Friday 8<sup>th</sup> of September 2017, 09:30 – 11:00, HS6)

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**Title:**

Analyzing the relation between input data and key performance indicators for building energy certificates: An approach using algorithmic modeling.

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**Authors:**

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**Keywords:**

algorithmic modeling  
building energy certificates  
input data  
key performance indicators  
sensitivity analysis

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**Abstract:**

This contribution concerns the reproducibility of energy certificates. To examine the impact of different input data assumptions on the results of energy certificates, sensitivity analysis was performed. Conducting such sensitivity analysis manually is not only time consuming and error-prone, but is also typically limited in view of input-data/result combinations. This can be a problem, as a number of input data combinations can have contradictory influences on corresponding KPI (key performance indicator) results. For instance, transparent building components increase not only solar gains, but also transmittance losses. As an alternative to manual modification of input data, the parametric algorithm-editor, Grasshopper (an Add-on to the CAD/CAM-environment Rhino) was utilized. The calculation standards of the Austrian energy certificate procedure were implemented in this environment. Input data values can be modified via a graphical user interface (rulers), and the impact of the change is instantly generated by the environment. Past research regarding planners' usage of energy certificate tools identified usability and overall user acceptance of such calculation tools as a weak spot. Thus, the implementation of calculation routines within a widely used drafting/parametrization tool could result in increased acceptance by planners. In a first methodological approach, the impact of input assumptions regarding building typology and window properties on solar gains, transmittance losses, and heating demand were considered.

The contribution illustrates the method and the results of a number of case studies, which show that the concept can be usefully deployed in energy evaluation of buildings. Thereby, the approach can accommodate two requirements: On the one hand, it can result in a tool to evaluate building concepts in early design stages. On the other hand, it can serve as a conceptual vehicle to explore and evaluate calculation methods, such as the standardized energy certification procedure.

**Session:**

F2.1. Building Materials and Structures III (Friday 8<sup>th</sup> of September 2017, 09:30 – 11:00, HS6)

**Title:**

Recent progress in the EVA project: Evaluation of visionary architectural concepts

**Authors:**

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**Keywords:**

visionary architectural concepts  
energy performance  
unconventional solutions  
alternative approaches  
monitoring  
realization

**Abstract:**

This contribution reports on the progress in the EVA project. This project was started in 2017 based on past experiences made in the framework of workshops and design seminars at the University of Applied Arts in Vienna. Within these workshops different concepts toward energy-active and reactive architectural concepts were conceived and realized into scale models. The major design goal is to provide a built structure that is able to adapt to different climate and usage patterns and can display dynamic behavior in response to stimuli from the surroundings and the occupants. To construct the designs into scale models, different supportive tools and techniques were deployed, such as numeric thermal building simulation, parametric design programming, micro-controllers and mechatronic systems among others. Moreover, the different designs and concepts were inspired by a wide range of resources, such as biology, bionics, natural phenomena, and traditional architectural concepts. Partly, these concepts (e.g. the photosynthesis of algae plants) were integrated in the scale models and mockups. As such, the workshops and design seminars could be considered a success as challenging, and exciting designs were developed and engineered. However, the proof of concept in terms of real life implementation is missing. This gap will be bridged by the EVA project, which targets the evaluation of different concepts and the realization of the most promising project as a fully functional full scale mock-up. Needless to say, the level of complexity increases by the scale: Aspects of structural and dynamic stability have to be considered, mechatronic elements have to be constructed, and intelligent and reliable building control methods have to be implemented.

This paper describes the first phase of this project, which is the collection, description, and structured evaluation of a number of design studies from the past years. Thereby, it was decided not only to assess projects that were designed in the framework of the University of Applied Arts, but to investigate similar design studies from professional and academic backgrounds worldwide. The contribution concludes with an outlook of the project's next steps.

**Session:**

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**Title:**

Calibration of thermal analysis models and thermal sensors in a homogeneous building enclosure

**Authors:**

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**Keywords:**

Building materials  
Calibration  
thermal sensors  
façade

**Abstract:**

A low-cost data acquisition system that records information with K-type temperature probes and Dallas thermometers has been designed to carry out this research. For this, both the software and the hardware have been designed. A specimen was conducted for the thermal analysis of a homogeneous prism of a building wall. Environmental conditions have been controlled in laboratory. Four of the prism faces are thermally insulated with nearly adiabatic conditions. A source of heat is placed on one of the two uninsulated faces of the prism. This induces a temperature gradient in the wall. A sufficient set of thermometers is introduced into the prism to control the temperature gradient. The data acquisition system consists of Arduino-based controllers. The temperature at each moment can be accurately controlled with them. The data generated are saved in a file for later analysis, and to publish them on a web page is possible for real-time queries. These data allow to validate the finite element simulation model which has been carried out for this specimen. Thus, the results of the specimen have been compared with the data obtained from the model, and this allows to extrapolate the model for the thermal analysis of other façades.

**Session:**

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**Title:**

Assessment of Color Degradation of Wood Plastic Composites in Outdoor Applications

**Authors:**

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**Keywords:**

wood Plastic Composite (WPC)  
artificial weathering  
outdoor decking  
biocomposite  
ultraviolet degradatio  
natural-organic filler  
green building material

**Abstract:**

Construction sector has consumed an important percentage of natural resources and generated much of the waste discharged into the environment in the last decades. This is the reason why the social consciousness has strongly grown towards sustainable development. Concepts such as recycle, reuse, reduce and energy saving are gaining importance in obtaining products under a clearly defined objective of a sustainable development. The revaluation of agroforestry waste has established itself as a solution to the problems associated with these wastes and, increasingly, is being incorporated into the manufacture of new materials.

The Wood Plastic Composites (WPC's) are an important group within these new sustainable building materials. WPC's are obtained from recycled plastics and natural fibres waste. This kind of materials reduces the consumption of resources and the amount of waste. These materials have emerged to replace natural wood in some exterior applications, where the durability of natural wood is most damaged. Natural wood, in addition to the loss of color that suffers in exterior, has other disadvantages such as anisotropy and hygroscopicity. WPC's do not have these drawbacks. In this way, the WPC's try to imitate the appearance of natural wood, with a good durability outdoors. Because of this, there are numerous companies that develop WPC products with different plastics and natural waste, with the aim of obtaining the best appearance and durability.

In this paper, the color degradation of various WPC materials when exposed to ultraviolet (UV) radiation is evaluated. An artificial aging chamber with a fluorescent UV lamp and a colorimeter have been used to quantify the color parameters. Thus, conclusions are drawn on which plastics and residues achieve a minor alteration of color, an aspect highly appreciated in outdoor applications.

# Hygrothermal Performance of Buildings

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**Session:**

T1.3. Hygrothermal Performance of Buildings (Thursday 7<sup>th</sup> of September 2017, 16:00 – 17:30, HS7)

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**Title:**

Simulation Study of a Novel Solar Thermal Seasonal Heat Storage System based on Stable Supercooled PCM for Space Heating and Domestic Hot Water Supply of Single Family Houses

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**Keywords:**

PCM  
stable supercooling  
sodium acetate trihydrate  
long term thermal energy storage  
system simulation

**Abstract:**

A TRNSYS model of a novel PCM heat storage, utilizing stable supercooling of Sodium Acetate Trihydrate (SAT), is presented. To achieve high solar fractions in heat supply of single family houses, the necessary integration of big water volumes is challenging. To evaluate its functionality, a system model of a solar thermal combisystem for space heating and domestic hot water supply for dynamic system simulation was built. The key component is a PCM volume for long term heat storage. While conventional heat storage concepts with SAT release the latent heat a few degrees below the melting temperature, with the concept of stable supercooling latent heat can be stored for long periods of time at ambient temperature. This allows the design of a partly loss-free storage. Solar fractions were evaluated for simulation runs with two building variations. Annual specific space heating demands of 15 and 30 kWh.m<sup>-2</sup>.a<sup>-1</sup>) and a domestic hot water demand of a typical single family house were considered. A sensitivity analysis on solar fractions of domestic heat supply was performed by variation of the collector field and the PCM volume. While the increase of the PCM volume from 4.5 m<sup>3</sup> to 9 m<sup>3</sup> shows moderate effects in all simulation runs, an increase of the collector area has substantial effects on the share of solar heat on the total energy demand of the building.

# Hygrothermal Performance of Buildings

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**Session:**

T1.3. Hygrothermal Performance of Buildings (Thursday 7<sup>th</sup> of September 2017, 16:00 – 17:30, HS7)

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**Title:**

Efficiency increase of solar heated buildings by thermal activation of construction elements

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**Keywords:**

Thermally activated building systems  
construction elements  
solar heated buildings

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**Abstract:**

The Austrian project “solSPONGEhigh” examines the use of thermal activation of building components in order to increase the solar fraction of the heat demand of buildings. The aim of the project is to evaluate, under which conditions a high solar fraction of a single family house (low energy building) can be achieved with solar technologies (PV and solar thermal, in this paper the focus is on solar thermal). Different heat supply systems based on solar thermal energy (basic or complex supply systems) have been defined. The systems were modeled in the simulation environment TRNSYS, analyzed concerning their system behavior and further developed. The investigated systems range from classical monovalent heat supply systems, systems combined with solar thermal up to complex integrated hydraulic solutions. The heating of the building via concrete core activation was compared with a conventional underfloor heating system. A detailed analysis of the dynamic system and building simulation results shows that the system efficiency can be significantly increased, if solar heat is used to charge the storage capacity of the building structure directly. A further advantage when activating the building structure (primarily concrete) is the less rapidly changing room air temperature with strongly fluctuating environmental conditions.

# Hygrothermal Performance of Buildings

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**Session:**

T1.3.Hygrothermal Performance of Buildings (Thursday 7<sup>th</sup> of September, 16:00 - 17:30, HS7)

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**Title:**

Comparison between Glaser method and Heat, Air and Moisture transient model for moisture migration in building envelopes

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**Authors:**

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**Keywords:**

Humidity  
Moisture  
Vapour  
Building envelopes  
Heat, Air and Moisture transfer  
Glaser Method  
Heat and Mass Transfer

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**Abstract:**

The Glaser method is an assessment procedure for the risk of moisture accumulation in building mono-dimensional structures that could be used to evaluate mould risk and interstitial condensation risk. It is based on a simplified model that does not represent the real phenomenon and its limitations are well-known qualitatively. This work provides a comparison in terms of moisture content between the Glaser method and WUFI Pro, an advanced heat, air and moisture transfer prediction tool. First the influence of material properties is evaluated on four fictitious materials walls, then six different building envelope typologies for six weather files from Central and Southern Europe are modelled to evaluate the Glaser method results. The effects of the Glaser method simplifications are quantified in terms of moisture content percentage difference.



# Hygrothermal Performance of Buildings

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**Session:**

T1.3. Hygrothermal Performance of Buildings (Thursday 7<sup>th</sup> of September 2017, 16:00 – 17:30, HS7)

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**Title:**

Predictive Performance of Hygro-Thermal Simulation Models: A Case Study

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**Authors:**

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**Keywords:**

Hygro-thermal simulation  
building retrofit  
building monitoring  
Aerogel

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**Abstract:**

In recent years, many researchers have focused on the energy efficiency and performance of existing buildings. In order to predict the hygrothermal performance and minimize the risk of moisture damage in retrofit cases, user-friendly moisture calculation tools have been developed. However, concerns have been raised as to how to increase the reliability of such tools. In this context, the present study uses simulation to investigate the retrofit potential of the historical building façades via application of silica aerogels on the external walls. Monitored data provided the basis for generation of a more accurate initial simulation model, as well as the evaluation of the predictive performance of the model.

# Hygrothermal Performance of Buildings

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**Session:**

T1.3. Hygrothermal Performance of Buildings (Thursday 7<sup>th</sup> of September 2017, 16:00 – 17:30, HS7)

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**Title:**

Thermo-hygral and environmental evaluation of chosen parts of an ultra-low-energy family houses

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**Keywords:**

surface temperature  
foundation detail  
embodied energy  
CO<sub>2</sub> emissions  
SO<sub>2</sub> emissions  
LCA

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**Abstract:**

The goal of this paper is to assess two ultra-low-energy family houses from thermo-hygral and environmental perspectives. Thermo-hygral evaluation, done in two-dimensional PC software Area, has shown results that consent with the newest standards for designing critical details in ultra-low-energy family houses. Both cases show correctness in design with regards to thermo-hygral properties. Both critical spots – corners are well insulated with surface temperatures over 17°C, which indicates low risk of mold occurring. Most of the embodied energy is in the roof structure with value of 3084 MJ in house A and 1943 MJ in house B. In terms of global warming potential indicator, the most emissions were calculated in the exterior walls of house B (593 kgCO<sub>2eq</sub>/m<sup>2</sup>). From the acidification potential, the most emissions were determined in the roof structure of house B (1.02283 kgSO<sub>2eq</sub>/m<sup>2</sup>).

**Session:**

T2.3. Smart Buildings, Smart Cities (Thursday 7<sup>th</sup> of September 2017, 16:00 – 17:30, HS6)

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**Title:**

Assessing Energy profiles of urban neighborhoods: A streamlined GIS-based approach

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**Keywords:**

heating demand  
building-related energy demand  
neighborhoods  
decision support systems  
GIS

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**Abstract:**

The present contribution illustrates recent developments within the research project E\_Profil. This project targets the development of a toolbox for the exploration of neighborhood profiles in terms of socio-cultural, urban development and energy-related aspects. Thereby, the major goal is to facilitate an energy and resource efficient and environmentally responsible mid- and long-term development of Austrian cities. The specific contribution described in this paper illustrates a simple methodology for the efficient use of GIS-data toward the derivation of urban development strategies in view of energy usage. In a first step, the geometry data of one (or multiple) specific urban neighborhoods is semantically enriched by additional information (building period, energy status of the buildings, etc.). Such data can be usually found in different archives of the corresponding city or can be collected in-situ. Subsequently, this enriched database must be further processed to form input data bundles, which can be used to derive key performance indicators of individual buildings, selected subsets of the total building stock of the neighborhood or the overall building stock. Based on these procedures, impact analysis of different mid- and long-term transformation policies regarding the energy performance of the neighborhood(s) can be performed in a convenient fashion. This contribution illustrates the approach and delivers a proof of concept based on two urban districts of the city of Linz, Austria.

**Session:**

T2.3. Smart Buildings, Smart Cities (Thursday 7<sup>th</sup> of September 2017, 16:00 – 17:30, HS6)

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**Title:**

Performance enquiries regarding traditional and contemporary Indonesian architecture: A holistic approach

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**Keywords:**

Indonesia  
Building Performance  
Monitoring  
Holistic Approach  
Monitoring  
Indoor environmental conditions

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**Abstract:**

This contribution sheds light on recent research efforts that pertain to the built environment in Indonesia. Within the rich diversity of cultures in the Nusantara archipelago interesting examples can be found that illustrate the adaptation to the challenging environmental conditions. Through this research the possibilities for sophisticated solutions for future are investigated, focusing on the building performance. Architecture and planning tasks in Indonesia have to consider the following preconditions: (i) The prevailing hot and humid climate, which will be strongly influenced by the climate change in the future; (ii) the country's geography, which consists of a number of wide-spread islands; (iii) the rich and diverse historical development, including a very diverse architectural heritage; (iv) the location within the "Pacific Ring of Fire", causing recurring natural disasters (e.g. volcano eruptions, earthquakes); (v) a currently ongoing rapid change in socioeconomic key data (economic growth rate, population growth, digitalization); (vi) a strong tendency to urbanization. Whereas these facts are known, as well as the need for energy efficient buildings, the level of knowledge about the performance of buildings in different regions of Indonesia is rather limited. Specifically, regional building traditions are often treated only in historical discourse. Thus, an interdisciplinary research effort that aims to examine Indonesian architecture in a comprehensive and holistic way has been undertaken in the past years, based on works dating back to 2005. In this paper we present parts of these efforts, namely (i) the assessment of a contemporary art museum in the city of Yogyakarta using monitored indoor conditions, and conception of potential future improvement; (ii) Further data collection efforts currently performed on a number of traditional residential buildings, (iii) a review of current, exemplary re-development efforts including the utilization and adaptation of traditional architectural concepts in Indonesia, and (iv) the details of the recently started incentive on interdisciplinary research on Indonesian architecture.

**Session:**

T2.3. Smart Buildings, Smart Cities (Thursday 7<sup>th</sup> of September 2017, 16:00 – 17:30, HS6)

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**Title:**

Thermal Performance of Konrad Frey's Prefabricated Low-cost Loft House – A Case Study of a pioneering instance of sustainable architecture

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**Keywords:**

Thermal building performance  
passive cooling  
nighttime ventilation  
low-cost loft house

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**Abstract:**

This contribution presents an ongoing research effort addressing the performance assessment of a number of buildings planned by the Austrian architect Konrad Frey, who is considered to be one of the pioneers of sustainable architecture in Austria. A number of his buildings, planned in the 1970s, consequently integrated principles of modern solar houses. Relevant key projects are subject of an on-going research project. Thereby numeric building simulation was deployed to assess the energy performance of the buildings. In this contribution, we present the intermediate results of a study that focused on one of his latest buildings, namely the prefabricated low-cost loft house. As opposed to architect's rather complex early designs the loft house concept targeted inexpensive solutions and used simple and commonly available building components and systems. As part of the overall project, the thermal performance of this building was evaluated in terms of the effectiveness of passive cooling via various ventilation schemes (including night time ventilation).

**Session:**

T2.3. Smart Buildings, Smart Cities (Thursday 7<sup>th</sup> of September 2017, 16:00 – 17:30, HS6)

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**Title:**

Generation Tool for Automated Thermal City Modelling

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**Authors:**

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**Keywords:**

urban energy modelling  
automation  
dynamic simulation  
IDA ICE

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**Abstract:**

Constructing dynamic building models of entire urban districts or cities is a time consuming effort. An automation process is required to shorten the considerable time needed for manual input and to parameterize simulation tools. This paper presents a generation tool for fully automated thermal city modelling that generates dynamic building models with detailed heating systems. The tool is an interface between a PostgreSQL database and the dynamic building energy simulation environment IDA ICE. Tests show that up to 300 automated generated buildings with a simple geometry and 70 buildings each with a heating system can be simulated per CPU.

**Session:**

T2.3. Smart Buildings, Smart Cities (Thursday 7<sup>th</sup> of September 2017, 16:00 – 17:30, HS6)

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**Title:**

The return of spatial dimension into architecture

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**Keywords:**

Housing  
Flexibility  
Responsiveness  
Adaptability  
Replaceability  
Affordability  
sustainability certification tools  
quantification  
spatial quality  
envelope  
inhabited wall  
energy

**Abstract:**

The aim of the paper is to explore and establish a base for a possible development of a more holistic and spatially-inclusive method for evaluating energy performance of buildings. This is to be achieved by envisioning building envelopes as arrangements of spatial zones, which could improve the overall energy balance of buildings but at the same time reduce the usage of construction materials and thus consumption of production energy and built-up space. The wall deconstructed in spatial zones, as shown e.g. in Antivilla by Brandlhuber+, opens a series of questions about the future of existing building codes and certification tools. The potentials are discussed based on the aspects of flexibility, responsiveness, adaptability, replaceability and affordability. The analysis outlines the benefits of the inclusion of those paradigms in the definition of sustainable architecture, and at the same time exposes the lack of possibility to reflect their potential by the established certification criteria. The paper aims at opening the discussion about the limits and traps of quantifying architecture and calls for rethinking of established schemes of sustainability in building sector.

# Energy Performance of Buildings

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**Session:**

F1.1. Energy Performance of Buildings I (Friday 8 of September 2017, 09:30 – 11:00, HS7)

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**Title:**

Building Physics and Building Simulation: an Integrated Approach to Educational Programs

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**Authors:**

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**Keywords:**

Building Physics  
Building Simulation  
Educational Programs

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**Abstract:**

To fill the gap between the students' knowledge of building physics, their comprehension of the different phenomena, and their capability of deploying building simulation with simulation tools, an integrated teaching approach for a course in a MS program in Energy Engineering has been adopted and tested for five years. In approximately 90 hours, the fundamentals of building physics are presented, starting from the thermodynamic balance of the indoor air volume, moving to the analysis of unsteady state thermal conduction in the envelope components, and to the convection and long wave radiation interactions at the external and internal surfaces, to conclude with the internal gains and the solar radiation. For each of the listed items, the students are first introduced to the topic with an exhaustive overview, then the main controlling equations are derived, their numerical or analytical solution analyzed, to conclude with a step-by-step implementation of a detailed solution, in a general productivity spreadsheet. At the end of the course, the spreadsheet has become a comprehensive simulation tool that, despite the limitations in computational efficiency, can favorably compare to the most diffuse tools available on the market, in terms of both detail and results, while allowing the students an insight into the physics and simulation of buildings thermal performance.



**Session:**

F1.1. Energy Performance of Buildings I (Friday 8 of September 2017, 09:30 – 11:00, HS7)

**Title:**

A Guideline for the Implementation of an Energy Management System in Facility Management Organisations

**Authors:**

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**Keywords:**

Energy Management System  
ISO 50001  
Information Requirements  
Facility Management

**Abstract:**

Organisations are becoming more intensively conscious about energy related-topics. The overall societal recognition, changing legal requirements and cost reduction pressure results in increasing interests in holistic energy management activities well embedded into the overall facilities and asset management context.

This paper aims to specify the information requirements for setting-up energy management systems. Such systems aim to ensure that owners, tenants and operators of buildings can deliver facility and energy management services in compliance to the relevant legislative, technical and environmental standards. Initial information requirements for such systems are presented in this paper.

The paper summarises the achievements of the first year of research of the first author. The presented information requirements are the results of literature studies complemented by field studies in different FM-organisations in Germany and Ireland. During the field studies it was found that a diverse, inhomogeneous spectrum of energy data exists in FM-organisations. In the majority of the cases the authors identified a need for a structured, strategic approach to the implementation of energy management systems compared to the currently practised “ad-hoc” activities. This finding delivered the primary motivation for our paper.

**Session:**

F1.1. Energy Performance of Buildings I (Friday 8 of September 2017, 09:30 – 11:00, HS7)

**Title:**

Assessing Facility Maintenance Models for Data Centres: Status and Deficits of Current Facility Management and Maintenance Concepts

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**Keywords:**

Data Centre  
Energy Performance  
Building Automation  
Facility Management  
Maintenance

**Abstract:**

According to studies conducted by Information Technology (IT) analysts, the average cost per minute of IT equipment downtime is about \$7,900, depending on the sector the company is active in. The average reported incident length is 86 minutes, resulting in average costs per incident of approximately \$690,200 [1]. This illustrates that failure in the operation and maintenance of Data Centre (DC) infrastructure has enormous impacts and consequences.

Facility Management (FM) in data centres requires a broad and clear understanding of procedures and processes to avoid human errors and to ensure an economic and reliable operation of the clients' primary activities. For DC availability is the most important factor followed by economical aspects. Therefore, both research and implementation of stable processes with an optimal number of interfaces between IT related functions and FM are necessary to increase the effectiveness and efficiency.

This paper explains the settings of current FM and maintenance concepts used for the operation of data centres. Furthermore, the need for a more innovative approach to ensure an economic and reliable operation of DC in the future is introduced. A special emphasis is on a review of the current status and deficits of facility maintenance and management concepts for DC providing direction for future research. It is argued that maintenance has developed from an operational, technically-based activity to a strategically important management function.

**Session:**

F1.1. Energy Performance of Buildings I (Friday 8 of September 2017, 09:30 – 11:00, HS7)

**Title:**

Development Of Extreme Reference Years For Building Energy Simulation Scenarios

**Authors:**

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**Keywords:**

Extreme Reference Year  
Test Reference Year  
EN ISO 15927-4:2005  
Finkelstein-Schafer statistic  
Building Energy Simulation.

**Abstract:**

Typical years are developed from the analysis of multi-year series, selecting actual months to assembly in a single reference year, representative of the long-term typical weather. Some statistical techniques are generally involved in the development process to ensure true frequencies, sequences and cross-correlations of the weather quantities: as regard the reference year built according to the European technical standard EN ISO 15927-4:2005, TRYEN, the method is based on the Finkelstein-Schafer statistics. In this work, we exploit the same statistic with a different target: to develop an extreme reference year, ERY, by identifying those candidate months far from being representative of the long-term weather data distribution. These new artificial extreme years are composed of statistically “non-representative” months warmer in the summer and colder in the winter - which means with daily dry bulb temperature and global solar irradiation higher in summer or lower in winter than the long-term averages respectively. The analysis is performed for five Italian localities belonging to the Alpine Regions and to Sicily. Aiming to assess the efficacy of the proposed procedure, TRYEN and ERY are compared and both used to simulate the energy performance of 48 simplified buildings, parametrically built by varying insulation level, windows’ size, orientation and SHGC and kind of opaque elements.

# Energy Performance of Buildings

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**Session:**

F1.1. Energy Performance of Buildings I (Friday 8 of September 2017, 09:30 – 11:00, H57)

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**Title:**

Energy Loss through the Ventilated Air Channel for Historical Building

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**Authors:**

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**Keywords:**

historical buildings  
ventilated air channel  
rising damp in historical buildings.

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**Abstract:**

The purpose of the research is to find adequate solution against rising damp in historical buildings with minimal energy loss. The improvement in this case is the use of ventilated air channels. A special group of historical buildings are churches because they do not use routines as for example museums, galleries. The amount of possible causes of moisture problems in historic masonry underlines the complexity of this phenomenon. Evaporation is an important factor in rising damp. The surface of an affected wall contains moisture that has risen from the ground and this moisture is then subject to evaporation. The factors controlling evaporation include: temperature, humidity, air movement and surface. We de-signed 4 differently constructed ventilated air channels. These are: open or closed, with overpressure and underpressure. As a verification we use a relevance to these constructions which we simulated in software Ansys CFX the air flow of channels. We modelled the equal segments of the channels. This research should offer the solution for architects against problems of rising damp in historical buildings. To find the right solution is necessary to research every case.

# Energy Performance of Buildings

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**Session:**

F1.1. Energy Performance of Buildings I (Friday 8 of September 2017, 09:30 – 11:00, HS7)

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**Title:**

Dynamic simulation of the energy performance of a ground source heat pump serving a block of flats

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**Authors:**

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**Keywords:**

Horizontal ground heat exchanger  
heat pump  
dynamic simulation  
TRNSYS software

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**Abstract:**

In this study, a dynamic simulation of the annual performance of two different systems is reported: 1) a traditional one composed by a gas boiler for winter and a water chiller for summer and 2) one consisting of a ground coupled heat pump (GCHP) having horizontal pipes as ground heat exchanger for winter and summer seasons. Both systems are connected to two thermal storage tanks, a warm water tank for winter and a cold water tank for summer, serving a block of flats located in the city of Bologna, Italy. The air handling unit (AHU) coupled with the GCHP exhibits an excellent control of temperature, and has high performance parameters (COP and EER), making conduction costs about 30% lower than those estimated for a traditional plant.

**Session:**

F.1.2. Energy Performance of Buildings II (Friday 8<sup>th</sup> of September 2017, 11:30 - 13:00, HS7)

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**Title:**

A Comparison of Three Evolutionary Algorithms for the Optimization of Building Design

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**Keywords:**

Multi-Objective Optimization  
Genetic Algorithm  
Building Refurbishment  
Cost Optimal  
Building Energy Simulation

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**Abstract:**

In building design, the need of optimization algorithms is considerably increasing due to the requirements of enhancing the overall performances, cost and sustainability objectives. An evolutionary algorithm coupled with building simulation code is often used. However, this approach is not widespread in actual application due to the high number of expensive simulation runs required by evolutionary algorithms. For this reason, the selection of an efficient and effective optimization algorithm becomes a key aspect in building design. In the literature there are several works analyzing the performance of different optimization algorithms, most of them by comparing the results obtained for the optimization of analytical test functions. However, there are no evidence-based studies deepening the efficiency and efficacy of these methods by comparing against the true solution of the discrete optimization problems on building design. This study compares the number of cost function evaluations and the percentage of the actual Pareto solutions of three evolutionary algorithms used for the evaluation of the optimal refurbishment of three reference buildings for which the actual Pareto front is known through a brute-force approach.

**Session:**

F1.2. Energy Performance of Buildings II (Friday 8<sup>th</sup> of September 2017, 11:30 – 13:00, HS7)

---

**Title:**

Uncertainties in Building Energy certification: Two case studies pertaining to zoning

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**Keywords:**

building energy certification  
zoning  
key performance indicators  
usage profiles

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**Abstract:**

Building energy certification is stipulated by law in the majority of the European countries. The intention of these regulations is to offer key performance indicators (KPIs) to relevant and interested stakeholders. Another motivation for implementing these calculation schemes was to compare the energy performance of different buildings. However, existing guidelines for building energy evaluation do not comprehensively outline the input data collection process and the derivation of substantial KPIs. Furthermore, practitioners do not share a common understanding of the approach to energy certificates, resulting in different practical methods and different interpretations of the calculation guidelines. As a result, the envisioned comparability between buildings is not ensured, as a number of studies illustrated in the past.

This contribution focuses on a specific uncertainty in building energy evaluation input data, pertaining to zoning and usage assumptions. Toward this end, two case studies are presented. A number of existing buildings (typical Viennese building stock) were subjected to the Austrian normative energy certification calculation. Thereby, different scenarios regarding the zoning and usage profiles of the buildings were developed. On the one hand, the calculated performance of individual (residential) units was compared with the calculated performance of the whole building. On the other hand, calculations considering different usage assumptions in different zones within the building (detailed calculation) were compared to results based on generalized assumptions for the whole building. The evaluation of the case study buildings showed significant differences in KPIs, given different input data (depending on the case study, heating demand showed deviations up to 50%). The results emphasize the importance of a clear documentation of input data assumptions for building-related energy assessment.

# Energy Performance of Buildings

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**Session:**

F.1.2. Energy Performance of Buildings II (Friday 8<sup>th</sup> of September 2017, 11:30 - 13:00, HS7)

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**Title:**

The Impact of Various Factors on the Energy Performance of Selected Types of Family Houses

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**Keywords:**

energy for heating  
demand of heat for heating  
building shape factor  
primary energy  
renewable energy resources

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**Abstract:**

The tightening of requirements for “Energy Performance of Buildings” (EPB) during the period of 2013 to 2021 gradually results in designing buildings with requirements four times lower than we were accustomed to design and construct for many years (U-values, demand of heat for heating). It is necessary to pay increased attention to this topic due to the aforementioned reasons and gradually preparing the laic public, but mainly the professional public for designing, assessment and construction in accordance with the development of EPB requirements. The objective of this paper is to point out the actual requirements for the construction of single storey family houses. Theoretical assumptions, legislative and normative environment are stated for assessment of their thermal-insulation properties. The paper contains comparison and analysis of calculated EPB values of the selected representatives of single-storey family houses representing a large portion of their construction in the practice at the present time.



# Energy Performance of Buildings

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**Session:**

F1.2.Energy Performance of Buildings II (Friday 8 of September 2017, 11:30 – 13:00, HS7)

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**Title:**

Villa Castelli - Transformation of historical building into Nearly Zero Energy Building

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**Keywords:**

Retrofit historical building  
nZEB  
hygroscopic material  
dynamic simulation  
interior insulation

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**Abstract:**

What Americas Cup and a heritage building have in common? They both aim at innovative technologies and cutting-edge solutions. The owner of the project, an ex-crew member of the most famous sailing match race in the world, pushed the planning team to develop extraordinary solutions for his house. The house, Villa Castelli, is an historical listed building located on the Como lake. During its history, it has been transformed many times, giving as results a non-uniform structure composed by different construction technologies. The aims of the owner were: an overall refurbishment particularly focused on energy efficiency, the exploitation of renewable energy sources based on-site production and a fixed budget. To reach these goals, the energy needs have been reduced improving the performance of the thermal envelope. Then, the building's technical systems have been re-developed in order to exploit as much as possible available renewable energy sources. From the very beginning, it was clear that, for finding optimal solutions, a multidisciplinary approach was necessary. The design approach should be the result of a shared approach integrating different fields, such as creative design, technology, knowledge of material properties, building physics. The great synergy among building envelope retrofitting, innovative technological solutions and the deployment of renewable energy sources allows the transformation of this historical listed building into an outstanding example of a nearly zero energy building (nZEB).

# Energy Performance of Buildings

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**Session:**

F.1.2. Energy Performance of Buildings II (Friday 8<sup>th</sup> of September 2017, 11:30 - 13:00, HS7)

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**Title:**

Investigation of historical Villa architecture under combined consideration of cultural and performance-based aspects

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**Keywords:**

Villa architecture  
Building Performance  
Indoor Comfort  
Building Traditions  
architectural history

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**Abstract:**

Recent discussions about building's energy performance of the building stock often emphasize the poor thermal quality of existing buildings. At the same time, it is often forgotten that different historic building traditions since Roman Antiquity did address building performance based on low-energy design features. While such design features, which regularly were based on evolutionary climatic adaptation pressure, are frequently promoted for building traditions of hot-and-dry and hot-and-humid climates, relatively little attention is being paid to such design features in moderate climates, e.g. in central Europe. Moreover, the architectural discourse on historic objects that are considered as lighthouse projects does regularly neglect performance aspects. In this context, the present contribution focuses on a number of rural and sub-urban Villa projects of the past 2000 years. These projects were widely examined concerning their architectural meaningfulness in terms of the "Villa" concept. To further investigate their architectural quality, the projects are empirically evaluated regarding their utilization of different, "low-energy" measures for improving thermal performance and indoor climate, such as cross-ventilation and shading. Moreover, the designs are investigated with specific reference to their (micro-)climatic context, and a methodology for a future detailed examination is delineated.

# Energy Performance of Buildings

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**Session:**

F.1.2. Energy Performance of Buildings II (Friday 8<sup>th</sup> of September 2017, 11:30 - 13:00, HS7)

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**Title:**

The potential of descriptive building specifications as an alternative to detailed normative calculations

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**Keywords:**

descriptive building specification, energy performance of buildings, key performance indicators, heating demand, normative calculation procedures

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**Abstract:**

Energy performance calculations are stipulated by law in most European countries. Thereby, different calculation schemes have been developed in the past years in different countries. The physical processes in buildings were simplified in terms of normative calculation routines in most of these schemes. A major idea behind these simplifications was to enable different stakeholders (practitioners, engineers, and architects) to issue energy certificates without being simulation experts. Moreover, the simplifications needed to be described thoroughly in corresponding guidelines to ensure and facilitate the comparability of the energy performance of different buildings. However, neither of these objectives can be considered to be fully met. Regarding the former, the normative calculation procedures increased in complexity in the past years, so that the issuing of energy certificates requires not only the stakeholder's expertise but also a comprehensive knowledge of the standards that form the calculation method. Regarding the latter, recent research efforts revealed that many guidelines do not fully cover every aspect of the calculation procedures and the assumptions regarding required input data. Thus, the comparability of energy certificates has to be strongly questioned, as a number of relevant calculation parameters are dependent on the interpretation of the corresponding issuer.

Given this background, alternative approaches to building performance evaluation would be of interest. Previous approaches by different researchers suggested so called prescriptive indicators, which can be derived by basic building data (for instance, geometry and thermal quality of the building envelope components). This contribution is based on this concept. In the framework of a master thesis, a number of prescriptive indicators were considered. These indicators were derived for a set of sample buildings. In a parallel effort, energy certificates (encompassing Key Performance Indicators KPIs) were calculated for the sample buildings. It is clear that the prescriptive indicators cannot act as a 1:1 replacement for KPIs in terms of a numeric value. However, their usefulness can be expressed by the relation of the prescriptive indicator and the corresponding KPIs of a building. Thus, the results of the described calculation efforts were ranked. Subsequently, the lists of buildings ranked by the different indicators were compared in order to identify prescriptive indicators, which result in the same or at least similar ranking as the normative key performance indicators. Within this contribution, the suggested prescriptive indicators, the sample buildings, and the results of the analysis are presented and discussed.

**Session:**

F2.2. Building Monitoring and Automation I (Friday 8<sup>th</sup> of September 2017. 11:30 – 13:00, HS6)

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**Title:**

Hygrothermal analysis of mineral wool insulated building constructions based on in-situ measurements

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**Keywords:**

heat and moisture transfer  
mineral wool  
building insulation  
construction technology

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**Abstract:**

The paper discusses an experimental hygrothermal analysis of differently constructed additional mineral wool wall and attic insulation of a family house in Hajdúnánás, Hungary. The walls of the building were insulated in two different ways: half of the façade was insulated with Knauf stone mineral wool insulation boards glued to the walls in a continuous mortar bed as recommended, and on the other side of the same façade, the boards were glued only with patches of mortar. In the attic of the same building, one part of the attic was insulated by using Knauf glass mineral wool insulation batts along with vapour permeable underlay membrane as recommended, while the other part was constructed without underlay. Temperature and relative humidity sensors were placed between the layers and heat flux sensors were installed on the internal surfaces of the two differently constructed wall and attic insulations. An external meteorological station was installed on an unused chimney of the building. Besides the structural sensors, temperature and relative humidity sensors were installed in each room, and the energy consumption of the building was also monitored during the measurements. For control values, we monitored the internal hygrothermal conditions and the energy consumption of an identical but uninsulated family house only 8 km away in Hajdúdorog, Hungary. In the article, we analyse the heat and moisture transport through the building constructions and the energy consumption of the family house according to the recorded data of a full heating season.

**Session:**

F2.2. Building Monitoring and Automation I (Friday 8<sup>th</sup> of September 2017. 11:30 – 13:00, HS6)

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**Title:**

Monitoring of the airflow around the façade of an office building

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**Keywords:**

Wind  
wind flow  
façade  
office building  
in-situ measurement  
CFD simulation

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**Abstract:**

This paper describes measurement units on the building façade, which enable the possibility to conduct a full-scale measurement with a very high resolution of the outdoor climate parameters around the building. The façade of the Research center building, which is a part of University of Zilina campus, is equipped with 36 weather stations to measure the outdoor climate conditions and impact of the building on the approaching wind flow and air temperature distribution, solar radiance impact on the façade, etc. In this article, the wind flow around the building in different heights is monitored, analyzed and compared to the free wind flow.

**Session:**

F2.2. Building Monitoring and Automation I (Friday 8<sup>th</sup> of September 2017. 11:30 – 13:00, HS6)

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**Title:**

Initial Results of Monitoring the Temperature on the Façade of Office Building

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**Authors:**

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**Keywords:**

Temperature  
outdoor climate  
office building  
in-situ measurement

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**Abstract:**

This paper deals with creating of the unique measurement units on the building façade, which enable the possibility to conduct a full-scale measurement of the outdoor climate parameters around the building. The façade of the Research center building, which is a part of University of Zilina campus, is equipped with 36 weather stations to measure the outdoor climate conditions and impact of the building on the approaching wind flow, air temperature distribution, solar radiance impact on the façade etc.

In this article, the change of temperatures within the time and place on the facade (sides, position, time), is monitored. This takes into account the surroundings of the building and the temperature on the façade and comparison to the measured “basic” air temperature.

**Session:**

F2.2. Building Monitoring and Automation I (Friday 8<sup>th</sup> of September 2017. 11:30 – 13:00, HS6)

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**Title:**

On the Impact of Building Façades' Color on Thermal Building Performance and Outdoor Thermal Comfort

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**Authors:**

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**Keywords:**

Buildings' Façade  
Visual Reflectance  
Model Calibration  
Surface Temperature  
Thermal Performance  
Outdoor Thermal Comfort

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**Abstract:**

A surface property of building façades, which has implications for thermal performance of buildings as well as outdoor thermal comfort, is visual reflectance. In this paper, the effects of façades' visual reflectance on buildings' thermal performance and outdoor thermal comfort were investigated. A simulation tool was calibrated via empirical data and deployed to explore the impact of the visual reflectance of typical building façades in Vienna on indoor temperature and heating and cooling loads. The results show that the magnitude of visual reflectance has little impact on indoor temperature and energy demand of insulated buildings, while its effect on cooling load of non-insulated buildings is considerable. Finally, the effect of façades' visual reflectance on outdoor thermal comfort was investigated.

**Session:**

F2.2. Building Monitoring and Automation I (Friday 8<sup>th</sup> of September 2017. 11:30 – 13:00, HS6)

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**Title:**

A web based data processing concept for Building Diagnostics and Building Performance Evaluation

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**Authors:**

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**Keywords:**

Building monitoring  
building performance  
building diagnostic  
data analysis  
embedded systems

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**Abstract:**

Buildings are responsible for a major amount of the annual energy consumption. A detailed recording and evaluation of building data could provide a deeper understanding of the building operation and the related performance. This could help the building owner or operator to evaluate the actual situation. Based on this information a optimized operation in the near future seems to be possible. Additionally a more detailed understanding of the impact of previous interactions with the building systems will be possible. The building automation industry and the related service provider sector are actually providing proprietary solutions for data logging, visualization and energy optimization integrated into their own building management solutions. An Internet of Things (IoT) and web services inspired concept for the implementation of a generic web service for building diagnostics and a holistic performance evaluation, that considers both the energy consumptions and delivered building service seems to be a potential alternative solution. A general design of a web service is presented and the future possibilities for data access from various sources are discussed. Furthermore, details of actually developed and demonstratively implemented software components for data preprocessing are illustrated. Different data processing examples from real case studies are included and highlight the potential of the such web based approach.



**Session:**

F2.3. Building Monitoring and Automation II (Friday 8 of September 2017, 14:00 – 15:30, HS6)

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**Title:**

Communication analysis of hardware-in-the-loop test method for heat pumps and chillers

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**Authors:**

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**Keywords:**

hardware-in-the-loop  
building simulation  
heat pumps and chillers  
LabVIEW and TRNSYS coupling

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**Abstract:**

There are many modelling and simulation methods and techniques, which may be used for prediction or reproduction of heat pumps and chillers behaviour. The hardware-in-the-loop method (HIL) is a technique developed to test a system and its elements working real-time to validate simulated values and to determine the actual performance of heating and cooling capability and performance of the whole system under specific conditions. The HIL can also serve as an intermediate step before testing a system in its actual environment providing opportunity to change boundary conditions or use different control mechanisms. This paper deals with the analysis complexity and possible inaccuracies due to communication difficulties between the test rig and simulation software and due to the test rig hydraulic character. We test and compare several simulation and communication variants such as different time step or different steady-state detection methods in order to achieve the most realistic behaviour of the heat pump and the whole system. The main result of this research is enhancement of communication and simulation accuracy and speedup of the whole process.

**Session:**

F2.3. Building Monitoring and Automation II (Friday 8 of September 2017, 14:00 – 15:30, HS6)

**Title:**

Comparison of the energy performance of a heat pump under various conditions by using a hardware-in-the-loop (HIL) test method

**Authors:**

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**Keywords:**

Heat Pump  
HIL  
Hardware-in-the-Loop  
Heating & Cooling

**Abstract:**

For nearly Zero Energy Buildings, it is a challenge to optimize the heat supply of the building based on technologies like heat pumps. Within the project “energy4buildings” a test bench has been realized to create an interface between hardware, located in a laboratory, and a building simulation software. This integrated test bench with a focus on electrical driven heat pumps and chillers can be used to simulate realistic conditions like part load behavior, stand-by-losses, on/off behavior or user-/weather conditions by using different kind of building models. The requirements of the test rig have been realized by using a hardware-in-the loop (HIL) method, which allows real-time tests of embedded devices within a virtual environment under reproducible laboratory conditions. By using the HIL-method, early statements according performance with a reduction of costs under realistic conditions can be made for various devices. This paper describes the implementation of the HIL-interface consisting of hardware, simulation software and data acquisition including an optimization of the behaviour of the control system as well as HIL experiments at varying steady state conditions like temperature tolerance or holding time. Based on the tests both, a comparison of the performance and analyses of deviations between real and simulated value have been made, to make an accurate statement of the behaviour of the system. The knowledge gained in this paper indicates a potential for optimization of the control strategy of some components as well as the improvement of the communication process to make an early estimation regarding performance of the installed device.

**Session:**

F2.3. Building Monitoring and Automation II (Friday 8 of September 2017, 14:00 – 15:30, HS6)

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**Title:**

Experimental quantification of air permeability of building envelope with installed controlled ventilation system – case study

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**Authors:**

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**Keywords:**

Façade ventilation unit  
air permeability of building envelope  
Blower-door test.

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**Abstract:**

To meet the increasingly stringent requirements of standard energy consumption and thus reducing operating costs of buildings, it is necessary to use energy-saving elements of technical equipment and eliminate heat loss through the building envelope. The biggest losses are caused by heat transmission and ventilation in the form of uncontrolled air infiltration through the building envelope. Their elimination can be achieved by improving the thermal-technical quantification of building envelope and as well as its airtightness. Determination of air permeability as a measure of quality of building envelope is possible using the method of Blower-Door test. Any defects can be detected by detection tools, then a suitable method for their removal can be proposed and thus prevent unwanted unregulated air infiltration into the interior. On the other hand, there are opposing hygienic requirements that require certain air exchange in the room, which is a significant reason for transformation of uncontrolled ventilation from air infiltration to a controlled ventilation system. The subject of the paper is in-situ measurement of air permeability of a specific apartment envelope by Blower-Door test method and comparison of the efficiency of the installed controlled ventilation system with hygienic requirements for ventilation of residential buildings. Laboratory verification of parameters of façade ventilation unit in big pressure chamber – measurements of airflows in the inlet ventilation flap at variable pressure differences. Methodology of measurement employed Blower-Door test to determine the air permeability of building envelope structures and functionality of controlled ventilation system, it was based on a series of 10 measurements in 5 regimes. The overall air permeability of the building envelope or its integrated elements can be verified using the total air exchange rate  $n_{50}$  at 50 Pa pressure difference, determined experimentally according to STN EN 13829. Comparison of measured values with standard values recommended by some European countries with similar climate with sealed and unsealed ventilation flaps, which can determine the impact on the overall airtightness of the building envelope. Calculation of the total required air exchange rate of the apartment according to the hygienic requirements and its comparison with actual measured values by Blower-Door test method.

**Session:**

F2.3. Building Monitoring and Automation II (Friday 8 of September 2017, 14:00 – 15:30, HS6)

**Title:**

Exploring the predictive performance of shade use models

**Authors:**

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**Keywords:**

Shade modeling  
Prediction  
occupancy modelling  
occupant control actions  
energy performance of buildings

**Abstract:**

Given the impact of occupants' control actions on indoor environment and the complex nature of such interactions, sophisticated occupant behavior models are increasingly deployed to enhance the reliability of building performance simulations. However, use of these models in building simulation efforts and their predictive performance in different contexts involves potentially detrimental uncertainties. While a number of recent studies have dealt with the validity of existing occupant behavior models, there is still a need for development of procedures and metrics for identification of fitting models for different building performance simulation scenarios. In this context, occupant behavior models pose a specific challenge for evaluative procedures: These models conventionally use indoor environmental parameters as independent variables, which themselves can be influenced by predicted states of building control devices. Thus, this is unlikely that for any sequence of predicted user actions matching monitored data can be obtained. Empirically calibrated building performance models could be of course used to obtain the indoor environmental parameters resulting from the predicted occupants' actions. But in this case, the uncertainties associated with the accuracy of such calibrated simulation models could represent a problem. In this context, the current study explores a variety of possibilities to analyze the predictive performance of shade operation models – as one example of occupant behavior models – without relying on building performance models. Specifically, empirical occupant behavior data obtained from an office area is used to evaluate the performance of shading use models in terms of the following parameters: i) Predicted states of the shades in discontinuous and continuous model runs, ii) Predicted action probabilities, and iii) Frequency and seasonal variations of predicted actions. Thus, the study provides a basis to address the challenges in evaluation of occupant behavior models.

**Session:**

F2.3. Building Monitoring and Automation II (Friday 8 of September 2017, 14:00 – 15:30, HS6)

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**Title:**

Monitoring the Effective Ambient and Sky Temperature Based on Infrared Sensor for Advanced Thermal Calculations

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**Authors:**

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**Keywords:**

IR sensor  
Infrared Thermometer  
Pyrgeometer  
Longwave radiation

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**Abstract:**

Building performance simulations and advanced thermal analysis are becoming the basis of a well-established practice of a building sector. This approach requires many input data which are typically not available on site. Apart from already well-practiced climate variable quantities, such as ambient temperature, solar radiation and parameters of wind, more complex data are needed for advanced building thermal analysis; one of those is based on longwave radiation level. A pyrgeometer is a device that measures longwave radiation as part of the whole thermal radiation phenomena. This can be determined based on sky or effective ambient temperature monitoring. Secondly, both variables might be approximated by infrared sensors as an applicable option in the calculation of longwave radiation heat exchange between the external surface and the ambient building environment. The paper presents data obtained both by pyrgeometer and infrared sensor, corresponding to their mutual comparison to demonstrate its application when longwave radiation exchange needs to be calculated or analyzed in advanced. Integrating the infrared sensor with the aim to monitor the effective ambient and/or sky temperature enables its applicability as an alternative, integrated and less cost consuming method towards the monitoring by commercial pyrgeometer.

**Session:**

-

**Title:**

Application of a low-cost strain monitoring system based on Internet of Things to the structural analysis of physical models

**Authors:**

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**Keywords:**

structural analysis  
experimental test  
internet of Things  
microcontroller  
strain gauges  
physical models

**Abstract:**

A low-cost system for the monitoring of strains in simple physical models within the field of Structural Engineering is presented, calibrated and discussed. It is based on Internet of Things and has reasonable accuracy. This system only requires normally, economic devices as Arduino microcontroller and strain gauges. Several tests on a case study of a scaled-cantilevered aluminium beam with different loading are conducted. Governing parameters are calibrated and optimized when benchmarked against theoretical and experimental results obtained with a reference device. Results show great accuracy, however, the need of setting of the parameters campaign-by-campaign, especially aimed at dealing with thermal drift, becomes a shortcoming. Still, its minimum cost and user-friendly management makes it a suitable solution for different applications.

# Indoor Climate, Thermal Comfort, and Ventilation

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**Session:**

F1.3. Indoor Climate, Thermal Comfort, and Ventilation I (Friday 8 of September 2017, 14:00 – 15:30, HS7)

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**Title:**

Analysis of night-time pre-cooling in a school building

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**Authors:**

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**Keywords:**

school building  
night ventilation  
operative temperature  
DesignBuilder  
thermal mass

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**Abstract:**

The content of this paper is a theoretical case study of a school building where the impact of night pre-cooling on operative temperature during summer period is analyzed. The classroom under pitched roof was selected for case study purposes. There are glass surfaces on roof and in external wall. We compare two types of building constructions. On the one hand side there is the wooden lightweight construction. On the other hand side there is the heavyweight construction made of reinforced concrete. The mechanical ventilation system provides for the required air change rate in classroom during whole day. The results from energy simulation show positive impact of night pre-cooling in combination with heavyweight building construction on maximum operative temperature in classroom during summer period. The results are output from dynamic energy simulation tool DesignBuilder.

**Session:**

F1.3. Indoor Climate, Thermal Comfort, and Ventilation I (Friday 8 of September 2017, 14:00 – 15:30, HS7)

**Title:**

Investigating Night Flushing Potential in a Multi-storey, Open-plan Office in Germany Using TRNLizard with TRNSYS 18

**Authors:**

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**Keywords:**

Natural ventilation  
passive cooling  
multi-zone simulation  
daylight  
thermal  
airflow modelling  
office building  
TRNSYS

**Abstract:**

Despite growing interest in sustainable office buildings and technological advancements, often either comfort or energy is sacrificed at the expense of the other in the conventional approach. This paper argues that wellness and energy savings are not contradictory aspects of design. An integrated design concept needs special considerations at the early stages using an accurate and fast simulation tool that considers dynamic thermal, daylight and airflow models. However, some passive measures such as natural ventilation are more difficult to simulate and validate due to the complex, non-linear relationship between wind forces and thermal buoyancy. The aim of this paper is to demonstrate the use of TRNLizard, an integrated thermal, daylight and airflow simulation tool based on Rhinoceros 5, Grasshopper, TRNSYS18, DaySIM and TRNFlow to develop and validate the concept for an energy efficient office building with a healthy, comfortable environment. The office building is located in Germany with a highly glazed façade and night ventilation for passive cooling. It is shown that night flushing reduces annual end-use cooling energy and peak cooling load of mechanical air conditioning systems by 55% and 15%, respectively.



**Session:**

F1.3. Indoor Climate, Thermal Comfort, and Ventilation I (Friday 8 of September 2017, 14:00 – 15:30, HS7)

**Title:**

Evaluation of Indoor Climate in Big Lecture Hall

**Authors:**

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**Keywords:**

parameters of thermal comfort

CO<sub>2</sub> concentration

design of mechanical ventilation and air conditioning system in big lecture hall

distribution air system in hall

**Abstract:**

The paper is oriented on the evaluation of the indoor climate in the big lecture hall. Providing the optimal parameters of the thermal comfort and the CO<sub>2</sub> concentration is immensely important for the students in the interiors of a university. Meeting these parameters is inevitable not only from physiological point of view but also for achieving the desirable students' performance. The high CO<sub>2</sub> concentration is related to incorrect and insufficient ventilation in the lecture hall and causes distractibility and feeling of tiredness of students. Experimental measurements were carried out in the winter season in 2016 in the big lecture hall in order to evaluate the thermal comfort and the CO<sub>2</sub> concentration. The device Testo 480 was used for the measurements. Obtained values of air temperature, air relative humidity, air velocity, CO<sub>2</sub> concentration are presented in the charts. Mechanical ventilation system and operation system of the big university lecture hall were evaluated on the basis of the parameters of the thermal comfort and on the basis of the CO<sub>2</sub> concentration. Based on the findings, design recommendations for new big university lecture halls are derived. Furthermore, there are presented recommendations how to operate the existing big university lecture halls.

# Indoor Climate, Thermal Comfort, and Ventilation

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**Session:**

F1.3. Indoor Climate, Thermal Comfort, and Ventilation I (Friday 8 of September 2017, 14:00 – 15:30, HS7)

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**Title:**

Thermal Performance of School Buildings: A Case Study from Albania

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**Authors:**

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**Keywords:**

Indoor thermal comfort  
School buildings  
heating demand  
thermal retrofit  
monitoring  
Albania

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**Abstract:**

Educational facilities are expected not only to provide good thermal performance regarding energy efficiency, but also healthy and comfortable indoor conditions. The latter is specifically relevant to the well-being and learning performance of the children or students in such buildings. While the performance of school buildings in central Europe has been subjected to several scientific investigations, the same does not apply to the same extent to educational facilities from CEE (Central and Eastern European) countries. Although general economic circumstances in these countries are arguably improving, the state of the public educational facilities remains less than ideal. In this contribution, which is based on a research effort conducted in the framework of a master thesis [1], we illustrate a related case study from Albania. This study focuses on the thermal performance of three school buildings (in different cities and climate zones in Albania) in view of energy demand and indoor thermal comfort. Thereby, both on-site data monitoring and numeric thermal simulation were deployed to assess the performance of these school buildings.

**Session:**

F1.3. Indoor Climate, Thermal Comfort, and Ventilation I (Friday 8<sup>th</sup> of September 2017, 14:00 – 15:30, HS7)

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**Title:**

Comparison of measured and calculated air changes for natural ventilation through single sided window openings – a case study

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**Authors:**

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**Keywords:**

natural ventilation  
air change rate  
calculation methods  
tracer gas measurements

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**Abstract:**

The main focus of this contribution is the evaluation of different calculation methods for the calculation of air change rates based on natural ventilation through opened windows. Those values are very important inputs for cases where the influence of window interaction on thermal comfort, air quality and building performance should be estimated. Especially, for the right setup of dynamic building simulation scenarios it is crucial to estimate proper values. Different standards and recent scientific contributions are already presenting various models for the calculation. Based on the physical model assumptions, different sets of input parameters related to room and outside conditions are needed. The quality of the calculated air change rates and the deviation to real measured ones is presented for a case study room. A precise tracer gas measurement campaign was executed for set of window openings. Resulting real air change rates were calculated based on the measured concentration decay of the tracer gas and compared with the calculated values from the different mathematical models.

**Session:**

F1.4. Indoor Climate, Thermal Comfort, and Ventilation II (Friday 8 of September 2017, 16:00 – 17:3, HS7)

**Title:**

A Simulation and Monitoring Based Case Study Regarding the Dynamic Thermal Conditions in Non-used Attic Space

**Authors:**

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**Keywords:**

Attic space  
Energy  
Temperatur  
Roof  
Simulation

**Abstract:**

This study solves a problem of the dynamic thermal performance of the residential attic space in moderate climatic zone. Heat loss into the attic space is difficult to be accurately determined by the quasi-stationary method. It depends on the thermal resistance of the ceiling, thermal resistance of the roof, ventilation characteristics and other details, such as the solar absorption of the roofing material or roof orientation. The paper presents results of some parametric simulative calculations, which were calibrated with measurements of air temperature in the attic space during the summer, winter and transitional season. It compares the mean air temperature in the ventilated and non-ventilated attics. The difference between the use of bright and dark color of the roof cover is also compared. An alternative with half thickness of thermal insulation was also simulated. Based on measurements and then the simulation the adjustment factor adjustment factor for heat transfer coefficient was quantified.

**Session:**

F1.4. Indoor Climate, Thermal Comfort, and Ventilation II (Friday 8 of September 2017, 16:00 – 17:3, HS7)

**Title:**

Modeling of Radiators with Mass-Flow-Control

**Authors:**

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**Keywords:**

Building simulation  
Heating system  
Thermostatic radiator valves  
Transport delay  
Energy savings  
TRNSYS

**Abstract:**

The topic of the contribution can be included in computer modeling of the thermal behavior of radiators for heating of buildings. Control of heaters leads to dynamic phenomena affecting the final thermal state of the heated room and heating energy consumption. The paper focuses on modeling of radiator quantitative control method using thermostatic valve. The objective of the paper is to show a quality of controlling and to compare an energy consumption when various thermostatic radiator valves time delay are set. The models of control, radiator, and a room are implemented in software TRNSYS. The results show significant differences in energy consumption.

**Session:**

F1.4. Indoor Climate, Thermal Comfort, and Ventilation II (Friday 8 of September 2017, 16:00 – 17:3, HS7)

**Title:**

Design of Fire Ventilation System for an Underground Car Park by CFD Simulations

**Authors:**

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**Keywords:**

fire ventilation  
CFD simulation  
Smoke  
underground car park

**Abstract:**

The aim of this study is to design a fire ventilation system with impulse jet fans for an underground car park. With respect to the number of parameters that can affect the flow of smoke that need to be considered, there is a good chance of miscalculations when computing the overall fluid flow using conventional plain calculations. To avoid mistakes, visualize the fluid flow and also to directly compare the different design variants it can be practical to use CFD (Computational Fluid Dynamics) simulations. By CFD it is possible to better analyse and keep control of the fluid flow, heat transfer and other related phenomena. In this study, CFD simulations were used to design, test and compare two alternatives of a fire ventilation system. The two alternatives differed from each other in the location of the impulse jet fans and exhaust ventilation shafts, and in the ventilation intensity (10-times per hour versus 15-times per hour). The results have shown that the first alternative is not suitable as the car park was not sufficiently ventilated after 1500 seconds after the simulation had begun, whereas in the second alternative the smoke was almost completely exhausted and the visibility was substantially improved. The simulation results emphasize the important effect of design and location of the different elements on the functionality and efficiency of a fire protection system.

# Indoor Climate, Thermal Comfort, and Ventilation

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**Session:**

F1.4. Indoor Climate, Thermal Comfort, and Ventilation II (Friday 8 of September 2017, 16:00 – 17:3, HS7)

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**Title:**

Atmospheric Boundary Layer Wind Tunnel of Slovak University of Technology in Bratislava

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**Keywords:**

wind tunnel  
boundary layer  
experiment  
measurement

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**Abstract:**

Aerodynamics is a relatively young scientific discipline, which started developing in the 50's of the last century. There are known several methods for calculating and measuring of the aerodynamic variables – In-situ measurements, wind tunnel measurements, CFD simulations and calculations by national standards. Each method has its advantages and disadvantages. Nowadays a large focus is on the verification of the numerical methods with experimental approach. One of the validation possibilities are measurements in wind tunnels. The paper deals with construction and using of the wind tunnel by the Slovak University of Technology in Bratislava. This device was put into operation after experimental validation in 2012, so this wind tunnel is one of the newest of its kind in Europe. The concept of the construction of individual structural elements and the wind tunnel parts has been designed in collaboration with the Aeronautical Research and Test Institute (Czech Republic) and was based on previous made analysis of aerodynamic tunnels. Structure was designed and realized by Konštrukta Industry (Slovak Republic). We could it characterized as atmospheric boundary layer wind tunnel with open test section. It is unique with two test sections – front and back measuring space, where the front measuring space is used for uniform flow and the back measuring space is used for turbulent flow. That is why it is not only usable in the civil engineering sector (buildings, bridges, chimneys etc.), but also in city urbanism (pedestrian wind comfort and wind safety, dispersion of air pollutants), aircraft and automotive industries.

**Session:**

F1.4. Indoor Climate, Thermal Comfort, and Ventilation II (Friday 8 of September 2017, 16:00 – 17:3, HS7)

**Title:**

Analysis of thermal comfort and air quality in the Kindergarten Hart – A case study of a unique sustainable building design

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**Keywords:**

Indoor air quality  
Thermal comfort  
Kindergarten  
Building Monitoring  
Sustainable Building Design

**Abstract:**

In this contribution, we report on a study within ongoing research efforts involving the performance assessment of a number of buildings by the Austrian architect Konrad Frey, a pioneer of energy-efficient architecture. A number of his buildings, planned in the 1970s, adapted the principles of modern solar houses. The current study focuses on the Kindergarten Hart, which is especially designed to allow cross ventilation. Specifically, we conducted a long-term monitoring in summer and winter conditions to analyse thermal comfort, indoor air quality and the occupants' adaptive actions with respect to natural ventilation. The monitoring effort covered indoor and outdoor environmental conditions as well as the state of windows. Thereby, the analysis of the monitored dataset provides a deep understanding of the building performance. It also makes it possible to examine if the building fulfils the architect's expectations in terms of thermal comfort and indoor air quality. In addition, analysis of occupants' interactions with windows together with the associated indoor and outdoor environmental conditions allows for the understanding and potential optimization of their control-oriented actions.



**Session:**

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**Title:**

Principal Solutions for Sustainable Adaptive Facades Providing Suitable Indoor Environment for Inhabitants

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**Keywords:**

Façade  
energy efficiency  
climate adaptive building shells  
photovoltaic  
wind

**Abstract:**

Façade as a part of building envelope represents its dominant portion. The initial function of façade was to ensure safety for inhabitants against weather and animals. Growing interest in increasing the energy efficiency of buildings, caused mainly by oil crisis in the 70s, led to the development of scientific area, actually known as building physics. The goal established in the start was to design architectural, structural and material solutions that would lead to the reduction of building's energy consumption coming from heating. The principle was to properly insulate the whole envelope avoiding thermal bridges and utilization of selected thermal insulating windows and doors. The trend of material development for thermal insulation composite systems is soaring, same as demands of society. What was in the past the main desire, reducing the energy consumption for heating, is now reflected in even higher needs such as reducing energy consumption for cooling. Minimizing thermal bridges and tightness of fenestration on the one side lead to the savings on heating, but the excessive heat gains coming mainly from sunlight, electric equipment, people and other resources is necessary to cover with enough cooling. Applying of reflexive glazing represents frequently used passive solution but also causes lack of natural daylight leads to higher energy consumption for artificial light despite large transparent walls. Energy savings made from reduction of air changes requires mechanical ventilation systems with the necessary of air treatment also consuming energy and in addition also requires regular maintenance. Modern solutions are based on adaptive façade which is capable to react on random meteorological changes to ensure reduction of energy flows through the façade. The paper discusses various conceptual solutions providing architectural intelligent and energy-friendly designs. Particular ideas offers protection against overheating, but same time allows penetrating natural daylight enough during all seasons. Elements of dynamic photovoltaic panels, aesthetically and effectively built-in façade, provide in addition to significant architectural look and also represent available source of pure energy supporting sustainable architecture.

**Session:**

F.2.4. Acoustics and Lighting (Friday, 8<sup>th</sup> of September, 16:00 – 17:30), HS6)

**Title:**

A Cell-based Method to Support Hospital Refurbishment

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**Keywords:**

Cellular Automata  
Particle Simulation  
Computational Fluid Dynamics  
Noise  
Dust  
Vibration

**Abstract:**

Hospital refurbishments often take place in parallel to regular operation, resulting in a scheduling problem: Construction activities must be located such as they do not clash with daily work activities and vice versa. To be able to see this mutual influence, we have devised a tool in which we are able to visualize the adverse effects of construction on daily operation. The approach uses a cellular automaton to represent the three-dimensional hospital environment and uses a particle simulation for computing the distribution of dust, noise and vibrations. By interactively relocating work activities and construction activities, our tool can be used to solve the mentioned scheduling problem. It also enables us to show the sequence of construction and relocation activities in 3D, which might be easier to interpret than a classical project plan in tabular form.

**Session:**

F2.4. Acoustics and Lighting (Friday 8 of September 2017, 16:00 – 17:30, HS6)

**Title:**

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Characterization of Noise in Eating Establishments Based on Psychoacoustic Parameters

**Authors:**

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**Keywords:**

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Architectural Acoustics  
Psychoacoustics  
Soundscape  
Eating Establishments

**Abstract:**

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Noise in eating establishments has been studied in architectural acoustics literature. For evaluating acoustics in these spaces, researchers predominantly investigate sound pressure levels and reverberation times. Yet, noise in eating spaces originate from a wide variety of sources and is hard to describe and evaluate with only sound pressure levels and reverberation times. Better metrics for acoustics in closed public spaces are needed. Psychoacoustic parameters of loudness, sharpness, fluctuation strength and roughness are promising metrics that have been used by many recent studies evaluating noise annoyance. However, unlike the established metrics such as reverberation time, no set of recommended values exist for these parameters, yet. The aim of this study is to investigate noise in eating establishments through psychoacoustic parameters and understand both the noise characteristics and the metrics themselves. This paper presents a set of sound recordings during lunch hours in two eating spaces in İzmir Institute of Technology. The entry and egress of occupants have been tracked manually, while sound levels have been measured and the noise has been recorded for psychoacoustics analysis. The relationship between the number of occupants and psychoacoustic parameters has been investigated through these objective measurements. The relationship between the number of occupants and sound levels is discussed in the light of the Lombard effect.

**Session:**

F.2.4. Acoustics and Lighting (Friday, 8<sup>th</sup> of September, 16:00 – 17:30), HS6)

**Title:**

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Low Frequency Noise Level Assessment In Vienna

**Authors:**

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**Keywords:**

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noise pollution  
annoyance  
Environmental Noise Directive  
acoustical measurements

**Abstract:**

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The present contribution reports on the results of sound level measurements in a number of locations in the city of Vienna, Austria. Thereby, a primary objective was to determine the degree to which the measurement results agree with corresponding information in the E.N.D. (Environmental Noise Directive 2002/49/EC) maps. Moreover, the relationship between the low-frequency segment of the acoustical exposure to the broad-band data was investigated. The results point to traffic as the main source of urban noise exposure. E.N.D. maps appear to provide a reasonable general overview of the urban noise circumstances. However, measurement results at individual locations can considerably deviate from E.N.D. data. Numeric values of low-frequency sound level range were found to be generally higher than those of the broad-frequency levels. The results revealed also a strong correlation between measurement-based L50R and NR (Noise Rating) values.

**Session:**

F.2.4. Acoustics and Lighting (Friday, 8<sup>th</sup> of September, 16:00 – 17:30), HS6)

**Title:**

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Exploring the potential of simulation model calibration: An acoustical retrofit case study

**Authors:**

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**Keywords:**

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Room acoustics  
Gastronomy  
reverberation time  
ODEON  
calibration.

**Abstract:**

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The success of gastronomic facilities is due, not in a small part, to perceived indoor atmosphere. This includes not just the interior design but also lighting and acoustics. Especially acoustics is a crucial parameter concerning the perception of the environment, but it is often neglected. The present case study investigates the usability and accuracy of acoustics simulation as applied to the retrofit project of a restaurant. The restaurant space was modelled in CAD-based modelling environment. Subsequently, acoustical simulations based on ray tracing were conducted and the simulation model was calibrated based on on-site measurements of the reverberation time. The initial simulation showed large deviations from the measured values, mainly because of uncertainties in the input data concerning the absorption properties of the used materials. Within three calibration steps, the model was revised, such that better results could be achieved. Subsequently both the initial and the calibrated models were used to develop strategies for the improvement of the acoustical performance of the space. After the implementation of the new design options in the restaurant, measurements were repeated. Again the results were compared with both the initial and the calibrated model. The results suggest that the calibrated model displayed a better performance regarding the prediction of post-retrofit circumstances when compared to the non-calibrated one.

**Session:**

F.2.4. Acoustics and Lighting (Friday, 8<sup>th</sup> of September, 16:00 – 17:30), HS6

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**Title:**

Suitability evaluation of visual indicators on glass walls and doors for visually impaired people

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**Keywords:**

Universal Design  
Design for All  
Visual Impairment  
Visual Indicators on Glass  
Luminance Contrast

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**Abstract:**

This contribution focuses on the marking of glass with high contrasting indicators in view of the special requirements of people with visual impairment. Such people may have difficulties in identification of glass surfaces as obstacles. This can lead to accidents and injuries. This circumstance can be alleviated by applying appropriate visual indicators on glass surfaces that would be otherwise difficult to detect. Toward this end, guidelines and regulations exist in respective standards for barrier-free construction. However, designers appear to be reluctant in implementing such measures. Moreover, the range of preferences and options with regard to the design and positioning of such markers are not fully understood. This circumstance motivated the research presented in this paper. In an original experimental set-up, people with impaired vision evaluated various design solutions for such visual indicators, regarding their visibility and perceptibility. Thereby, the following aspects of the indicators were investigated: design of signs (uninterrupted versus interrupted, arrangement, color), vertical placement, and opening signage. The results (both objective measurements of visibility and subjective feedback from the participants) facilitate the identification of preferable design solutions for visual indicators. As such, they are not only valuable toward accommodation of the special requirements of sight impaired persons, but can also support fully sighted people in inauspicious situations (e.g. under sub-optimal lighting situations, stress or distraction).

**Session:**

F2.4.Acoustics and Lighting (Friday 8 of September 2017, 16:00 – 17:30, HS6)

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**Title:**

Visual impairment, adaptation luminance, and glare: an empirical investigation

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**Keywords:**

Visual Impairment  
Adaptation luminance  
Glare  
Experimental approach  
Eye tests

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**Abstract:**

Visually impaired people primarily rely on their remaining vision. Unfavorable lighting conditions can further hamper this remaining vision. In this context, the present contribution mainly focuses on the evaluation of the visual performance of visually impaired and normally sighted individuals under different lighting conditions. To investigate the visual performance empirically, we developed a test involving different adaptation luminance values. A monitor with adjustable brightness facilitated various tests to determine the visual performance as a function of the adaptation luminance and glare. In addition, the subjective impressions of the visually impaired participants were captured via interviews. The study included 98 visually impaired people and 38 people without eye-related ailments. The interview results suggest that most people with visual disabilities require special lighting conditions. An increased lighting requirement is observed amongst 50% of this group. Moreover, 75% of this group display increased glare sensitivity. Likewise, adaptation problems and critical issues related to non-uniform lighting are manifest. Visually impaired individuals display significant in the visual performance variance at different brightness levels. Individuals with eye disease display a greatly reduced contrast threshold and a higher subjective level of discomfort compared to individuals with normal vision. Most visually impaired individuals require a higher degree of brightness to achieve their maximum personal visual performance. About a quarter of these individuals achieves the optimal visual performance at lower brightness, while displaying an increased sensitivity to glare. In general, glare has a decisive influence on the visual performance of visually impaired people. For general lighting purposes, a predominantly indirect lighting source better accommodates these individuals' requirements.

**Session:**

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**Title:**

Evaluation of indoor daylight focused on the human circadian system

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**Keywords:**

daylight spectral characteristics  
spectral reflectance  
circadian system

**Abstract:**

The circadian phototransduction issue caused strong interest at the beginning of the new millennium, while the research of non-visual influence of light is predominantly developing in medicine field of science. The outputs confirmed hypothesis that human habits are strongly related with ambient light conditions and disruption of natural light conditions may result in complex of health diseases with negative consequences.

Actual effort for minimizing energy demands of buildings is very important for sustainable architecture, but the aspect of “circadian-friendly” design should not be neglected, even though it is not entirely investigated yet.

The paper presents an overview of evaluation methods of circadian effect of light on human including available actual calculation equations and standards, providing certain principles to design indoor spaces intended for long term occupation. The aim is to extend the knowledge focused on suggestion of internal surfaces, glazing and active shading systems into building physics and architectural design with a possibility to achieve a control by system of intelligent building



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