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of historic buildings in urban areas]**

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0 Abstract

The Scientific Community has been reached through **publications on scientific journals** and also by means of presentations in **conferences** and workshops in which 3ENCULT scientific partners are involved.

The following themes are inserted:

- Energy efficiency in historic buildings;
- Conservation Criteria;
- Analysis and diagnosis;
- Monitoring of building performances;
- "Raumbuch" integrated with energy issues - a tool for the multidisciplinary design approach;
- Tools and concept;
- Internal insulation;
- Moisture damages;
- Efficient windows and shading systems;
- Airtightness;
- Low impact ventilation system;
- Daylight optimization;
- High quality – low impact lighting;
- Efficient active solutions. HVAC systems for historic buildings.
- RES integration;
- BMS and wireless sensors;
- Solutions for monitoring & control systems.

1 Peer Reviewed Publication

Journal: Energy and Buildings

Date: To be confirmed

Partner: CARTIF, USTUTT, UNIBO

Authors: Jose-Luis Hernandez-Garcia, Daniel Garcia-Gil, Harald Garrecht, Giacomo Paci, Simone Reeb

Title of the paper: A novel service-oriented Building Management System for heritage buildings

Abstract: Nowadays the role of a Building Management System (BMS) is increasing in any energy analysis of buildings. That fact is greater when a historical building is involved in the retrofitting owing to the conservation issues associated to this kind of buildings. Thus, during the 3EnCult project, a novel BMS working with a wireless sensor network based on ZigBee has been developed. The BMS solution presented in this paper covers the needs of cultural heritage, as well as the requirements of transparent control possibilities in order to monitor and control the energetic performance of a building. It becomes more important when the constraints for retrofitting are highly restrictive, being the BMS solution adequate, as happens in the historic buildings. Moreover, the integration of technologies such as Service Oriented Architectures, OSGi, Spring Dynamic Modules, Hibernate and persistent databases provide an added value in order to full quality of service issues. This BMS, in combination with the ZigBee based wireless sensor network, has been deployed in the Engineering School of Bejar so as to demonstrate the viability of the integration of this solution.

2 Papers in Conferences Proceedings

Conference: 15th International Passive House Conference

Place: Innsbruck (Austria)

Date: March 2011

Partner: UIBK

Authors: Rainer Pfluger, Mattias Rothbacher

Title of the paper: Active overflow ventilation for refurbishing of school buildings

Abstract: The AOP was developed and tested for the application in residential buildings by “Hochbaudepartement, Amt für Hochbauten, Stadt Zürich”. The occupied spaces take the air from the corridor via a fan installed in the door. The return flow of the air into the passage can be realized via the crack in the door or via an overflow valve (passive or active) back to the corridor, which works as distribution and mixing zone. It is vented by a heat recovery system. As the AOP works successfully in refurbishing of residential buildings, the author decided to investigate, if the principle is also applicable for school buildings. The major difference compared to residential buildings is the higher flow rate, which is more difficult to distribute without draft risk and low sound emission. Airborne sound transmission from the class room to the corridor and vice versa can be minimized as described in the next section.

Conference: Energy Management in Cultural Heritage Conference

Place: Dubrovnik (Croatia)

Date: April 2011

Partner: EURAC

Authors: Alexandra Troi, Roberto Lollini

Title of the paper: Interdisciplinary research: FP7 project “3ENCULT – Efficient Energy for EU Cultural Heritage”

Abstract: The FP7-project 3ENCULT bridges the gap between conservation and climate protection, which is not a contradiction at all: historic buildings will only survive if maintained as living space – and energy-efficient retrofit can improve structural protection and “comfort”, both for users and heritage collections. Reducing the energy demand by Factor 4 to 10 is feasible, if a multidisciplinary approach guarantees high-quality energy-efficiency-solutions, targeted and adapted to the specific case. Twenty-two partners, including conservation, technical and urban development experts, industry partners and stakeholder associations, work on (i) criteria for the assessment of energy-efficiency-measures regarding their conservation-compatibility, (ii) diagnosis, monitoring and control instruments, (iii) passive and active energy-retrofit-solutions, (iv) implementation in urban context and (v) regulation framework. Eight case studies will demonstrate and verify the solutions.

Conference: Energy Management in Cultural Heritage Conference

Place: Dubrovnik (Croatia)

Date: April 2011

Partner: KA

Authors: Anders Brüel

Title of the paper: Energy conservation in a historic building in practice

Abstract: Realdania Byg has studied the limits to energy preservation measures set by the historical settings of a specific, listed 18th C property in Copenhagen, Denmark. The findings of that study are currently being carried out in practice. In collaboration with the Danish Heritage Authorities Realdania Byg organized a series of workshops where all possible technical solutions were discussed. In the end

a combination of simple, low-tech solutions and some high-tech consumption control systems were chosen. Altogether, the measures taken will reduce the CO₂-emission of the property by about 20%. Most of these measures are economically realistic and can thus be replicated by others. The project has been selected as a case study in 3ENCULT, a EU 7th Framework Programme entitled “Efficient Energy for EU Cultural Heritage”.

Conference: Energy Management in Cultural Heritage

Place: Dubrovnik (Croatia)

Date: April 2011

Partner: EURAC

Author: Alexandra Troi

Title of the paper: Historic buildings and city centres – the potential impact of conservation compatible energy refurbishment on climate protection and living conditions

Abstract: Is it reasonable to invest - thoughts and money - in the energy refurbishment of historic buildings? This paper quantifies the potential impact in terms of climate protection and enhanced living conditions – looking not only at exemplary listed buildings, but more generally historic “cityscapes”. Statistics reveal that 14% of EU-27 building-stock dates before 1919, other 12% between 1919 and 1945 (with considerable national differences), corresponding to 30 resp. 55 million dwellings and 120 million Europeans living there. With information on climatic regions and building performance a heating-demand of 855 TWh corresponding to more than 240 Mt CO₂ can be estimated. Refurbishment can save 180 Mt CO₂ within 2050 (3.6 % of 1990’s EU-27-emissions), while bringing indoor comfort increases (higher surrounding temperatures, less draughts, ...) and energy-costs decrease. Finding conservation compatible solutions enhances therefore long-term-conservation and sustainable management of our towns.

Conference: Energy Management in Cultural Heritage. International Conference, UNDP

Place: Dubrovnik (Croatia)

Date: April 2011

Partner: UIBK

Authors: Rainer Pfluger, Matthias Werner, Wolfgang Feist

Title of the paper: Optimisation of daylight and artificial light in cultural heritage Hauptschule Hötting in Innsbruck, Austria (3ENCULT Case Study 5)

Abstract: Within the FP7 project “3ENCULT – Efficient Energy for EU Cultural Heritage”, the school building “Höttinger Hauptschule” in Innsbruck (Austria) is one of the 8 case studies for demonstration and verification of energy efficient solutions. Besides the reduction of thermal losses, a special focus will be on the optimization of daylighting and energy efficient artificial lighting with high priority of conservation-compatibility for all of the interventions. New software for visualization (VIVALDI by Zumtobel) is used. The principle behind it is to evaluate the luminance of interesting areas of calibrated HDR (High Dynamic Range Image) photos taken of rooms with prototypically installed systems. As the electric consumption of the artificial light is well known, the saving potentials of different lighting solutions can be evaluated.

Conference: AIMETA 2011 – XX Congresso dell’Associazione Italiana di Meccanica Teorica e Applicata”

Place: Bologna (Italy)

Date: September 2011

Partner: UNIBO

Authors: Marco Giuliani, Camilla Colla

Title of the paper: Analisi termografica: esempi di sviluppi applicativi della tecnica IR per la diagnostica strutturale degli edifici storici

Abstract:

In order to carry out a proper assessment of the structure is necessary to have an adequate level of information about composition and conformation of the structure. The analysis of the consistency becomes more essential for the historical walls. Objects of the IR-thermography are the quantification of the areas affected by the wall inhomogeneity and their relative position on the wall, the union of thermograms to analyze a masonry side by side with large surfaces without compromising the resolution and therefore the accuracy of the analysis. Although the analysis methods need to be improved, for example by considering the different behavior of materials during heating and cooling in order to retrieve information on the stratigraphy of the walls and floors. All this allows to identify and quantify the presence of inclusions in the stone, from the weak points caused by rear-end collisions, occlusions, cavities, chimneys and other things, assess the percentage inhomogeneity of a wall, the presence of frescoes beneath the surface finish. These are all necessary information for a proper evaluation of the building and structural modeling as accurate as possible in order to provide reliable predictive results. These methods of analysis were applied to the Palazzina della Viola, a XVI century building located in Bologna, chosen as a case study for the FP7 research project 3ENCULT. You will then be presented the work done in the particular case study highlighting the benefits of adopting this technique for non-destructive investigation as well as the critical issues encountered, and examples of the results obtained .

Conference: 1st European Workshop on Cultural Heritage Preservation - EWCHP-2011

Place: Berlin (Germany)

Date: September 2011

Partners: UNIBO, IDK, ARTEMIS, EURAC, IBK

Authors: Christoph Franzen, Paolo Baldracchi, Camilla Colla, Enrico Esposito, Gerald Gaigg, Rainer Pfluger, Alexandra Troi

Title of the paper: Assessment of historic structures by IRT, in: Markus Krüger, Cultural Heritage Preservation, European Workshop on Cultural Heritage Preservation

Abstract: Examination by Infrared-thermography (IRT) of historic buildings has become an indispensable tool for the investigation of historic masonry structures, their construction details as well as thermal bridges in facades. Four case study examples from different historic periods, climatic regions, and quite different by construction type are presented and discussed. These are the 1928 Hötting secondary school in Innsbruck, Austria, a listed early concrete modern architecture; the 13th Century "Waaghaus" in Bolzano, Italy, example of traditional architecture; the huge Palazzo D'Accursio, Bologna, Italy, originated in XIII century and now hosting the Municipality of the city, offices and museums; lastly, the 1497 Palazzina della Viola, Bologna, Italy, a little and light masonry building with 2-stores open gallery.

Conference: 26th European Photovoltaic Solar Energy Conference and Exhibition - EUPVSEC2011

Place: Hamburg (Germany)

Date: September 2011

Partner: CARTIF

Authors: Jacques Izard, Esteban Sánchez, José Torreblanca, Oscar Montero, Daniel Blanco

Title of the paper: On the Operation and Performance of Two a-Si Photovoltaic Façades in Spain

Abstract: Photovoltaic technology is quickly approaching grid parity, especially in southern Europe countries. In this situation, with smaller feed in tariffs (both in terms of final price and quotas) and a rising price for electricity at the consumer point, photovoltaic are emerging as an option for self-consumption. In the present work we explore the possibilities of two PV façades made with a-Si modules. Both façades are placed on the R+D buildings at Soliker's factory, facing southwest. For one

of then we have a full year of monitoring data. While southwest orientation is not optimal for yearly energy production, it could be a good option for self-consumption depending on the building use because of the different hourly and yearly electricity consumption profiles.

Conference: Comsol Users Conference 2011

Place: Ludwigsburg (Germany)

Date: October 2011

Partners: UIBK, PHI

Authors: Michele Bianchi Janetti, Fabian Ochs, Wolfgang Feist

Title of the paper: 3D Simulation of heat and moisture. Diffusion in the construction

Abstract: The simulation of heat and moisture transfer represents an essential resource in designing energy efficient buildings. In this paper a time-dependent wall model, consisting of several homogeneous domains, with third-type boundary conditions imposed on the surfaces, is implemented in the COMSOL Multiphysics environment. Temperature and moisture content is calculated inside the construction for different materials and the results are compared with those of commercial heat and moisture transfer programs showing good agreement. The use of COMSOL Multiphysics compared to other commercially available programs is profitable, as it allows also the solution of more complex three-dimensional time-dependent problems. In this paper a model describing the heat and moisture transfer inside a wooden beam-end is addressed.

Conference: AR&PA Biennial of Heritage Restoration and Management

Place: Valladolid (Spain)

Date: May 2012

Partner: EURAC

Authors: Alexandra Troi, Roberto Lollini, Dagmar Exner

Title of the paper: Application of a holistic approach for realizing energy efficiency in historic buildings respecting his heritage value

Abstract: The FP7-project 3ENCULT demonstrates that reducing the energy demand by Factor 4 to 10 is feasible also in historic buildings respecting their heritage value, if a multidisciplinary approach guarantees high-quality energy-efficiency-solutions, targeted and adapted to the specific case. Twenty-two partners, including conservation, technical and urban development experts, industry partners and stakeholder associations, collaborate on the development of both methods and tools to support the holistic approach and multidisciplinary exchange and the needed technical solutions, both adapting existing retrofit solutions to the specific issues of historic buildings and developing new solutions and products. The Public Weigh house of Bolzano as one of the eight case studies will demonstrate and verify the solutions.

Conference: 16th International Passive House Conference

Place: Hanover (Germany)

Date: May 2012

Partner: PHI

Authors: Armin Bangert, Søren Peper, Zeno Bastian

Title of the paper: Inserting the ends of wooden beams in the airtight layer

Abstract: In renovations with interior insulation that aim to fulfill strict energy targets, old wooden beams with cracks present planners and tradespeople with a difficult challenge. Standards aren't particularly helpful here; even experts can't come to a consensus about how to avoid having wooden beams penetrate the airtight layer. The danger here is insufficient integration of beam ends in the

building's airtight layer, which greatly increases the probability of structural damage from convective moisture entering the cold external wall area. The building envelope's airtightness plays an important role in energy-efficient buildings, and it is primarily details – such as the integration of beam ends with cracks – that affect the level of airtightness achieved in a renovated building. If that level is low, it could result in additional heating demand and structural damage. The studies conducted as part of this series of experiments provide tips on successfully sealing exposed beams in a renovation. Another result was a scale for the expected leakage flows at a differential pressure of 50 Pa.

Conference: EU-CHIC International Conference on Cultural Heritage Preservation

Place: Split (Croatia)

Date: May 2012

Partner: UNIBO

Authors: Camilla Colla, Veronica Corradetti

Title of the paper: Integration of structural and energetic nondestructive diagnostics: dynamics of air fluxes by IR thermography

Abstract: Historical buildings are often characterised by structural and energetic deficiency because of the poor or lack of maintenance. NDT can provide a great aid to the knowledge of the building. Particularly, by using paper stripes hanging from the ceilings, it was possible to survey the air temperature at different heights, in climatic conditions and to obtain horizontal and vertical temperature maps of high precision.

Conference: BauSIM 2012, IBPSA Germany

Place: Berlin (Germany)

Date: September 2012

Partners: UIBK, PHI

Authors: Michele Bianchi Janetti, Fabian Ochs, Rainer Pfluger, Wolfgang Feist

Title of the paper: Hygrothermische 3d Simulation Von Bauteilen Mit Comsol Multiphysics

Abstract: In this paper a model for the simulation of heat and moisture transfer in building elements including convective transport through air gaps is presented. The model is implemented with the program COMSOL Multiphysics for solving 3D problems. Such simulations give essential knowledge for planning the retrofit of existing buildings. Valuable recommendations for planners and decision makers with regard to the reduction of condensation risk can be derived. The simulation of a brick wall with internal insulation connected with wooden beam ceiling is presented as an applicative example.

Conference: 2nd European Workshop on Cultural Heritage Preservation - EWCHP 2012

Place: Kjeller (Norway)

Date: September 2012

Partners: UIBK, PHI

Authors: Michele Bianchi Janetti, Rainer Pfluger, Kai Längle, Fabian Ochs, Francesco Nesi, Wolfgang Feist

Title of the paper: Building physics problems in early modernism and how to solve - A school built by Baumann/Prachenzky (1929/31) as case study (CS5) in 3ENCULT

Abstract: A 3D model for the hygrothermal simulation of the ceiling-wall connection in a listed school building located in Innsbruck is presented. The model is implemented with the FE program COMSOL Multiphysics in order to estimate the risk of condensation and mould growth in case of application of internal insulation. The investigated construction is part of the case study CS5 within the EU-Project (seventh framework program) 3ENCULT, a detailed description of the problem and critical evaluation

of the simulation results is reported. Valuable recommendations for planners and decision makers in terms of minimal invasive measures will be derived.

Conference: 2nd European Workshop on Cultural Heritage Preservation - EWCHP 2012

Place: Kjeller (Norway)

Date: September 2012

Partners: UIBK, TUD, IDK

Authors: Dagmar Exner, Franziska Haas, Alexandra Troi, Christoph Franzen

Title of the paper: A tool for multidisciplinary development of energy efficiency solutions for historic buildings: the «Raumbuch» concept extended to energy aspects

Abstract: Through implementation of high quality energy efficiency solutions a remarkable reduction in the energy demand of historic buildings is achievable. Those solutions have to be very specifically targeted and adapted to the particular building case. Important basis for this approach is an experienced multidisciplinary team which guarantees a failure free implementation. This is the base postulate in FP7 project 3ENCULT. The paper outlines actual experiences with multidisciplinary in the planning process both in heritage objects and low energy buildings and illustrates how the – in conservation well established – “Raumbuch” (room book) can be integrated with energy issues to support the constructive discussion across disciplines. It describes, which specific issues the conservation and energy experts look at in the survey and documentation phase and how the joint an structured documentation, not only on an aggregated level, but down till the single room supports also the development of solutions, comparison of different options and finally selection of the best one for the specific building. The potentiality of the tool does however not end with the support during a single energy retrofit as: Well documented study cases, where the reasons for decision can be reproduced, allow applying solutions in „smaller“ projects where the application of the whole process would not be feasible. And finally the comprehensive documentation of as-it-is-state and all interventions together with supporting justification, given over to future generations – of restorers and users of the specific buildings – are the basis for the sustainable maintenance and long-term preservation of this piece of built heritage.

Conference: 2nd European Workshop on Cultural Heritage Preservation - EWCHP 2012

Place: Kjeller (Norway)

Date: September 2012

Partner: UNIBO

Authors: Giacomo Paci, Elena Gabrielli, Camilla Colla

Title of the paper: On-site dynamic wireless sensor monitoring in the historic building of Palazzina della Viola, Bologna, Italy

Abstract: A wireless sensor network was installed at Palazzina della Viola, Bologna, Italy, and equipped by sensors for monitoring indoor environmental parameters such as air temperature, relative humidity, light, semiconductor metal oxide gas sensors interface; in addition 3-axis accelerometers for monitoring structural vibration. The network is made of about 40 nodes, distributed on the different buildings levels and acquiring data from the whole building.

Conference: 2nd European Workshop on Cultural Heritage Preservation - EWCHP 2012

Place: Kjeller, Norway

Date: September 2012

Partners: KA

Authors: Ola Wedebrunn, Torben Dahl, Christoffer Pilgaard

Title of the paper: Experiencing Energy and Culture - *application of environment assessment to heritage*

Abstract: EIA (Environmental Impact Assessment) and methodology normally addresses defined typologies as buildings, materials, and production. Thus impact tends to be defined as quantity and effect of matter and time, as standards assessed by parameters and over thresholds. While this methodology works well for industrial projects and infrastructure it is insufficient and comes to short for projects with certain concern for energy and culture. Through analyse of case studies of the 3encult project, and of methods and polices of EA it is the intention to develop the draft of this position paper to assessment methods and arguments to be used as applications on historic buildings' energy retrofit. Thus we search experiences to find and elaborate on existing methodologies recognizing the impact of energy and culture as historic buildings and heritage. Seen from this point of view, assessment opens to an environment of possibilities, in general as well as case by case. Though the assessment corresponds to system of scientific objectivity and legal context, directives and standards doesn't necessary serve the purpose when it comes to find feasible solutions for assessment of environment and culture. Concern for energy and culture is fairly subject to tabula rasa, it is care for environment, concern for subjective references to moral, ethics, and maybe even to the integrity of heritage. Thus cultural heritage is recognized as diversity and case by case inseparable from the case as a conscious relation to consume and produce energy. Thus environment is the balance of local and interdependent concerns, not the difference. Following this argumentation, the method of the EIA procedure must be performed with argument for culture and energy in a local context and as environment at large, involving public participation, experts, and decision makers to unfold possible impact and scenarios.

Conference: Comsol Users Conference 2012

Place: Milan (Italy)

Date: October 2012

Partner: UIBK

Authors: Michele Bianchi Janetti, Fabian Ochs, Rainer Pfluger

Title of the paper: Coupling Forced Convection in Air Gaps with Heat and Moisture Transfer inside Constructions

Abstract: In this paper a model for coupling heat and moisture transfer inside solid domains with convective transfer through thin air gaps between the solid domains is addressed. As applicative example, the time-dependent moisture and temperature distributions inside the external wall of a building with internal insulation crossed by a wooden ceiling is calculated. An air gap between the beam-end of the wooden ceiling and the wall has been modeled.

Conference: 2nd Darmstädter Ingenieurkongress - Bau und Umwelt

Place: Darmstadt (Germany)

Date: March 2013

Partner: EURAC

Authors: Alexandra Troi

Title of the paper: Innovative Konzepte der energetischen Modernisierung im Baudenkmal

Abstract: The reduction of energy consumptions is possible also in historic buildings if a multidisciplinary team finds the right solutions. The most important steps are: i) the analysis and diagnosis of conservatory and energetic aspects; ii) the consideration of the building as a whole; iii) the work in multidisciplinary team composed by architects, engineers and conservation experts. To support these aspects, the "Raumbuch" (originally used only by the conservation experts) was integrated with the energy information from the diagnosis. The aim is to have a useful tool to find the right solution both for conservation and energy efficiency. During the 3encult project, many solutions have been developed. Two of them are a new window (installed in the case study "Waaghaus" – (Weigh House in Bolzano/Bozen) and a new ventilation system (installed in the case study

“Höttingerschule” – Hötting school - Innsbruck). The new window was the results of many workshops with project partners and conservation authorities. It is a very energy efficient window, respecting the aesthetic of the façade. The new ventilation system has a low impact on the original architecture of the building and works exploiting the floors as fresh air reservoirs and using ventilator to supply the air in the classrooms.

Conference: 17th International Passive House Conference

Place: Frankfurt am Main (Germany)

Date: April 2013

Partner: EURAC

Authors: Alexandra Troi

Title of the paper: Solutions & tools for the conservation compatible energy retrofit of historic buildings

Abstract: Historic buildings are the trademark of many European cities, towns and villages and are a living symbol of Europe’s rich cultural heritage. However, they are also substantial contributors to CO₂ emissions and rising energy bills, and often do not offer the comfort needed – comfort for users and “comfort” for heritage collections. Can these buildings be made more energy efficient while conserving their heritage value – or rather: in order to guarantee their long term structural health and preservation?

Conference: 2nd Internationaler Innendämmkongress

Place: Dresden (Germany)

Date: April 2013

Partner: UIBK

Authors: Michele Bianchi Janetti, Kai Längle, Rainer Pfluger, Fabian Ochs

Title of the paper: Comparing solutions for retrofitting of a listed school building with internal insulation

Abstract: Two different solutions for internal insulation applied to listed buildings are compared and evaluated. The analysis includes considerations about the air tightness, the moisture protection and the heat protection of the different systems. In order to assess the performance of retrofitting solutions, numerical simulations have been performed; moreover capacitive sensors for temperature and relative humidity monitoring have been applied in test rooms. A critical analysis of the simulation results is presented in the paper. This study is performed within the European project 3ENCULT for the renovation of cultural heritages.

Conference: ASHRAE Annual Conference 2013

Place: Denver, Colorado (USA)

Date: June 2013

Partners: UIBK, PHI

Authors: Rainer Pfluger, Wolfgang Feist, Wolfgang Hasper, Gabriel Rojas-Kopeinig

Title of the paper: Energy and Cost Efficient Ventilation Systems with Heat Recovery—State of the Art and Enhancement

Abstract: How could residential ventilation look in 2020? What are the main design principles for both energy and cost efficient ventilation systems with heat recovery? This paper investigates the potential and seeks to advise manufacturers and designers on how to enhance their products in terms of thermal and electrical efficiency as well as investment and maintenance costs.

Conference: CLIMA 2013 Congress

Place: Prague (Czech Republic)

Date: June 2013

Partner: UIBK

Authors: Rainer Pfluger, Kai Längle

Title of the paper: Minimal Invasive Ventilations Systems with Heat Recovery for Historic Buildings

Abstract: This paper shows three solutions for integration of ventilation systems with heat recovery in historic buildings with special focus on school buildings. With respect to the cultural heritage, systems with minimal impact (maximum reversibility) for the architecture and structure of the building are needed. In case of decentralized systems, the ductwork can be minimized by wall integrated heat recovery units, whereas for central systems, a horizontal air distribution in the attic combined with vertical ducts was found to be the minimal invasive solution best suited for listed buildings. A new ventilation system was designed and tested for a listed school building in Innsbruck (Austria), which is one of 8 case study buildings within the EU-project 3ENCULT. In order to minimize the ductwork within the building, an active overflow system takes the air from the corridor to the class room and vents the extract air back to it. A central heat recovery system ventilates the staircase and the corridors with preheated fresh air. The prototype of the active overflow system as well as the control strategy and simulation results are presented.

Conference: Building Simulation Conference 2013

Place: Chambéry (France)

Date: August 2013

Partners: UIBK, PHI

Authors: Michele Bianchi Janetti, Fabian Ochs, Wolfgang Feist

Title of the paper: On the conservation of mass and energy in hygrothermal numerical simulation with COMSOL Multiphysics

Abstract: In this paper, two different forms of the non-linear PDE-system for heat and mass transfer in porous materials and their implementation with COMSOL Multiphysics are considered. The ϕ -based form presents the relative humidity as system variable and leads in general to non-conservative solutions. The u -based form uses the water content as variable and is conservative. This study aims to select the most appropriated form for the implementation of the heat and mass transfer problem in COMSOL Multiphysics, comparing the quality of the numerical solutions and the solver performances. As first test-example, the simulation of a one-dimensional porous layer with a moisture flux imposed on one of the boundaries is presented. As second example, the moisture redistribution inside a partially saturated layer is simulated.

Conference: Building Simulation Conference 2013

Place: Chambéry, France

Date: August 2013

Partners: UNIBO, EURAC

Authors: Marco Giuliani, Stefano Avesani, Ulrich Filippi Oberegger

Title of the paper: Quantitative Comparison of Massive Walls Thermal Response among Commercial Software

Abstract: Simulating heat conduction in massive walls with commercial software is reported to cause numerical instability or reduced accuracy. As contribution to the discussion, we have simulated one-dimensional heat conduction in massive walls and their dynamic thermal responses to a step, a sinusoid and time series in TRNSYS, EnergyPlus, Delphin and Matlab. As reference, we have used EN ISO 13786:2007 and a self-written Matlab response factor method implementation. We have compared transient and steady-state wall surface temperatures and heat fluxes for two different accuracy settings using suitable metrics. Errors up to 1 kWh/(m² month) have been observed.

Conference: 2nd Central European Symposium on Building Physics

Place: Wien (Austria)

Date: September 2013

Partner: CARTIF

Authors: José Hernández-García, Cristina de Torre, Daniel García-Gil

Title of the paper: Energy efficiency and comfort improvement in historic buildings: an approach of a methodology for diagnosis and interventions evaluation

Abstract: Nowadays, the energy performance improvement in historic buildings has become essential and sometimes difficult due to the cultural value conservation. In this context, this paper is focused on developing a methodology for the diagnosis through non-intrusive methods such as infrared thermography or blower door test, energy performance simulations by using tools as TRNSYS or PHPP and the implementation of a monitoring system in order to validate the models and set up the baseline for the evaluation of the possible interventions. Thus, the monitoring of comfort values and energy consumption allows evaluating the comfort improvement and energy savings in the test rooms where the interventions are deployed. For that purpose, it has been chosen a distinctive building as demo site, the Industrial Engineering School of Béjar where the interventions for improving the energy efficiency and the comfort conditions have been compliant with aesthetical and historical conservation issues.

Conference: 2nd Central European Symposium on Building Physics

Place: Vienna (Austria)

Date: September 2013

Partners: UIBK, PHI

Authors: Michele Bianchi Janetti, Fabian Ochs, Wolfgang Feist

Title of the paper: Numerical Quality of a Model for Coupled Heat and Moisture Transport in COMSOL Multiphysics

Abstract: Numerical modelling of heat and moisture transfer in construction material represents a challenging task, since the material properties are in general non-linear. Numerical difficulties may arise in case of problems involving phase transition and steep gradients of temperature and moisture. In this study, the quality of a numerical solution calculated with the FEM program COMSOL Multiphysics is investigated. The influence of the maximum time-step and of the mesh refinement on the results is considered and different shape functions are tested. The COMSOL solution is compared with that calculated with the FVM-based program Delphin.

Conference: 3rd European Workshop on Cultural Heritage Preservation - EWCHP 2013

Place: Bolzano (Italy)

Date: September 2013

Partner: TUD

Authors: Ayman Bishara, Rudolf Plagge

Title of the paper: Development of new systems and technologies for sustainable refurbishment of Europe's built heritage

Abstract: Historic buildings are a living symbol of Europe's rich cultural heritage and reflect society's identity. Yet, this is an area where the high level of energy inefficiency is contributing to a huge percentage of greenhouse gas emissions. Climate change poses a real and urgent threat to humanity and its surroundings. Hence it is necessary to guide an improved approach to all refurbishment actions in historic buildings. In this paper the sustainable refurbishment of Europe's built heritage is improved through the development and demonstration of new systems and technologies both for "hard

facts” energy efficient building concept and “soft systems”, such as the intelligent monitoring & control system. This approach is also reflected in the application of this system at eight practical case studies.

Conference: 3rd European Workshop on Cultural Heritage Preservation - EWCHP 2013

Place: Bolzano (Italy)

Date: September 2013

Partners: UNIBO, DA, IDK

Authors: Ola Wedebrunn, Camilla Colla, Torben Dahl, Christoph Franzen

Title of the paper: Analysis of built heritage. Energy and culture

Abstract: Built heritage is a balance of sources and assets of energy and culture, which have to be maintained and enhanced for a sustainable continuing fruition. This is emphasized and specified as insight of research throughout the 3ENCULT project in view of preserving the construction stock but coupled with measures for reducing inefficiencies and thus carbon emissions in Europe. Discussions of historic, architectural, functional aspects, measures, data, models, practical solutions have taken place to evaluate the sources of value and the expressions which identify the quality of preservation as balance of energy and culture.

Conference: 3rd European Workshop on Cultural Heritage Preservation - EWCHP 2013

Place: Bolzano (Italy)

Date: September 2013

Partner: USTUTT

Authors: Harald Garrecht, Simone Reeb

Title of the paper: Energetic retrofit of a historic log house on the example of a “Strickbau”

Abstract: In the project 3ENCULT “Efficient Energy for EU Cultural Heritage” both, the conservation of historic buildings and climate protection are the focus of the research presented here, which is not a contradiction in terms. Energy efficient retrofit is useful for structural protection as well as for comfort reasons. Therefore, the physical behaviour of a so called “Strickbau”-construction is analysed on site, to work out feasible technologies and strategies to improve the energy efficiency of this type of historic wooden building. Beside preservation aspects, the comfort and energy standard was improved, to bring this type of Alpine building up to the high demands of the 21st century. The main interest lies in the fields of application and analysis of new techniques for internal insulation.

Conference: 3rd European Workshop on Cultural Heritage Preservation - EWCHP 2013

Place: Bolzano (Italy)

Date: September 2013

Partner: CARTIF

Authors: José Hernández-García, Simone Reeb, Giacomo Paci, Harald Garrecht, Daniel García-Gil

Title of the paper: Novel Monitoring and Control System for Historical Buildings

Abstract: Monitoring and control concepts are the basis of energy savings and comfort improvement because they occur in the analysis and diagnosis phases. However, in historical buildings it is more complex to determine the best system for the monitoring concepts because of conservation issues such as aesthetic aspects. For this reason, wired sensors are not adequate for such kind of buildings and a new concept of wireless sensors has to be adopted. A major problem is providing a power supply without the need to change batteries frequently. The ZigBee is an appropriate solution due to its low energy consumption. On the other hand, the sensor network has to be complemented by software, that is to say, a Building Management System adapted to the requirements of monitoring and control for these buildings. Sculptures, frescos and drawings have to be maintained in a specific

condition in order to avoid degradation, therefore, a management system helps to keep the best conditions for historical buildings. For the implementation, a service-oriented architecture is developed which favors the inclusion of further services. Moreover, the usage of new technologies gives an added value to the system in order to facilitate advanced implementations.

Conference: 5th Passivehaus Spanish Conference

Place: Gijón (Spain)

Date: October 2013

Partner: CARTIF

Authors: Miguel Á. García-Fuentes, Alberto Meiss, José Hernández-García, Cristina de Torre, Daniel García-Gil

Title of the paper: Aplicación del estándar Passivhaus a la rehabilitación energética de edificios: estudio de caso en la E.T.S.I.I. de Béjar (Salamanca)

Abstract: The intervention over existing buildings with energy efficiency criteria becomes in an essential issue in the construction topic. In that sense, it arises research projects where it is proposed the study of new solutions from the diagnosis to the intervention assessment. The European project 3EnCult, funded by the 7th framework programme of the European Commission, has the objective of establishing an intervention methodology so as to increase the energy efficiency and the comfort conditions on existing heritage buildings. Within the methodology, the use of simulation tools, such as PHPP, developed by Passivhaus Institut, has an important role, where the experiences obtained in the project are helping the analysis of application of this tool and the Passivhaus standard into non-residential and historic buildings. One of the case studies, which is placed on the village of Béjar (Salamanca), is implementing the diagnosis methodology and the essays allow the validation of the energy performance simulations, as well as the analysis of the interventions.

Conference: Comsol Users Conference 2013

Place: Rotterdam, The Netherlands

Date: October 2013

Partner: UIBK

Authors: L. Nespoli, Michele Bianchi Janetti, Fabian Ochs

Title of the paper: Comparing Different Approaches for Moisture Transfer inside Constructions with Air Gaps

Abstract: A model for the conjugate simulation of heat and moisture transfer inside porous materials and fluid domains is implemented in Comsol. The results of this model are compared with those obtained through a simplified approach: the line-source approach. The models are both validated with experimental data and with numerical results from other authors. On the one hand the conjugate approach is able to predict better results from a physical point of view, since it calculates the velocity field inside the air cavities through computational fluid dynamics (CFD); on the other hand, including fluid dynamics in long period hygrothermal simulation increases numerical effort and computational time. Thus the simplified approach can be advantageous e.g. in building physics applications presenting complex geometry and long simulation time.

Conference: Digital Heritage International Congress

Place: Marseille (France)

Date: November 2013

Partners: TUD, IDK, EURAC

Authors: Franziska Haas, Dagmar Exner, Christoph Franzen, Alexandra Troi, Wolfgang Frey

Title of the paper: 3ENCULT Monument Information System: The “Raumbuch” principle extended to energy issues

Abstract: The implementation of high quality solutions enables a significant reduction in the energy demand of historic buildings. But for monuments it has to be established, that all refurbishments are specifically targeted and adapted to the particular case. That's why the ongoing FP7 EU project “3ENCULT Efficient Energy for EU Cultural Heritage” recommends the collaboration within an experienced multidisciplinary team. The “3ENCULT Monument Information System” is based on the “Raumbuch” (room book), an inventory documentation tool, which is well established in heritage preservation praxis. It enables the structured documentation on urban and building level down to the single room. Thus users can “move” through the building on different levels of detail. The stocktaking with a “room book” not competes with other methods of acquisition, like a restoration survey, but it gives the possibility to involve the different information at one common platform. To support a constructive discussion across disciplines the heritage related information of the objects is cross-linked to energy issues. The user can compare the different options and finally select the best one for the specific building. The implementation of catalogues, e.g. for materials, construction elements or windows greatly facilitate and speed up the working process. The database was implemented as a web-based system. The technical demands for the 3ENCULT architecture were kept to a minimum. This innovative digital tool can be used for all energy retrofit cases of historic buildings. The comprehensive documentation of the as-it-is-state and all interventions is extended with a post-evaluation. The archiving of this information gives the possibility to reuse it in the future – for monitoring the building itself but also as a guideline for comparable constructions.

Conference: Energy Forum 2013

Place: Bressanone, Italy

Date: November 2013

Partners: TUD

Author: Franziska Haas

Title of the paper: Solar Energy and Conservation of Monuments - A Contradiction?

Abstract: Cultural heritage is an integral part of our environment, the conservation of and care for monuments is therefore an important social concern. But what is actually a monument and what are the principles of heritage preservation? These two questions should be answered shortly as an introduction to continue with aspects of energy retrofit of historic buildings with special emphasis on solar energy. First of all, it must be clarified which requirements must be fulfilled to guarantee the effectiveness of local solar systems in the context of historic buildings and city centres. Certain urban instruments can avoid problematic interventions without compromising the use of renewable energy. Smaller systems for the own-requirement are possible also for historic buildings, provided that they do not contradict to existing laws and regulations. For the installation must be paid full attention to the design quality as well as to the preservation of historical values.

Conference: Energy Forum 2013

Place: Bressanone, Italy

Date: November 2013

Partner: BLL

Authors: Robert Weitlaner

Title of the paper: Solar lighting solutions in historic buildings

Abstract: Any historic building will be kept for future generations only if adequate and comfortable utilization is provided. Otherwise they will turn abandoned and will wait their break down. The starting point of any daylight intervention is the measurement of the current situation. The diversity in daylight exploitation potential is vast in historic buildings. On the one hand, buildings with mediaeval walls and small windows represent the lowest potential of exploitation. On the other hand, glass & metal architecture in some regions of Europe is representing the contrary extreme of the exploitable

potential. Concluding, there are listed buildings with a severe lack of daylight while others suffer from overheating in summer and accelerated surface deterioration caused by the immense daylight/solar energy input. The foreseen usage of the building defines requirements for daylighting solutions. Assessed daylighting devices help to define the needed improvements in new developments. Finally, an intelligent daylighting solution solves the inconsistent requirements: providing a scenery of maximum - task related – visual comfort, reducing the demand of artificial lighting, slowing down deterioration and controlling solar gains in winter and summer times.

Conference: AICARR, 49th International Conference, Historical and existing buildings: design the retrofit

Place: Roma (Italy)

Date: February 2014

Partner: EURAC

Authors: Francesca Roberti, Dagmar Exner, Ulrich Filippi Oberegger, Andrea Gasparella

Title of the paper: Energy diagnosis of a historic building and building simulation

Abstract: The energy diagnosis and the energy refurbishment of a historic building are in most of the cases difficult. Not only there are seldom drawings with any constructive indications, but often there are also limited possibilities to investigate the properties of the building envelope because invasive measurements are not allowed. Dynamic simulation models may be used not only to investigate the possible retrofit interventions and to optimize them, but also to improve the energy diagnosis by simulation model calibration and validation from the measured performance. In this work, we have analyzed the “Waaghaus” (weigh house), a historic building located in Bolzano/Bozen (Northern Italy), one of the eight case-studies within the FP7 project 3encult. It is a four storeys XIII century building with thick stone walls and a wooden roof located in the center of the city. The former use during the middle age was to weigh the products before they could go to the market. Today it is unused and without any heating and cooling system, waiting for a complete architectural and energy refurbishment to become a photography museum. This work focuses on the diagnosis of the building’s thermal behavior and on the sensitivity analysis of the simulation model’s parameters. We have investigated the properties of the thermal envelope, measured the infiltration rates and equipped the building with a monitoring system measuring the air temperature and relative humidity of some rooms and of some outdoor and indoor surfaces. Then, with all the collected information, we have built the energy simulation model of the building with the software EnergyPlus 7.2. After some tuning of the model parameters by graphically comparing the monitored and simulated data, we have done a sensitivity analysis in order to explore the impact of the model parameters on the errors between monitored and simulated data. The sensitivity analysis has shown that on a building level the thickness of the exterior wall, the constant term coefficient in the infiltration model and the solar transmittance of the windows are the most influencing factors. Other important factors are the material properties of the external wall, the infiltration rates, the window dirt correction factor and the temperature term coefficient in the infiltration model.

Conference: AICARR, 49th International Conference, Historical and existing buildings: design the retrofit

Place: Roma (Italy)

Date: February 2014

Partner: EURAC

Authors: Dagmar Exner, Elena Lucchi

Title of the paper: Learning from the past: the recovery and the optimization of the original energy behaviour of “Portici” Houses in Bolzano

Abstract: The paper presents the studies realised on the “Portici” Houses, a part of the historic Centre of Bolzano, built at the end of the 12th century. This characteristic architectural typology is composed by a system of houses with narrow facades and a continuous arcade on the front. The serial repetition of this type of building forms a constant structure, interrupted only by a system of atria that provide

daylight and fresh air to the dwellings. The surface-to-volume ratio, the dimensions of the courtyards, the presence of internal shadowing, the thermal inertia of walls and cellars, and the colour of the surface finishing have a positive influence on heating and cooling demand of the buildings. Unfortunately, more recently, the users have altered the historic energy system with roofs and canopies to improve comfort and to protect from sun and water. This situation has completely changed the original energy and environmental behaviour. The study aims to restore the original concept and to adapt it to the modern requirements, both optimizing energy efficiency and preserving the heritage values. This means to recognize historical transformations, users' needs, present uses, critical points, and opportunities for the retrofit. The deeper knowledge is the starting point for defining the more appropriate retrofit actions, which include suitable technologies and systems, which are cost-effective, technically and aesthetically compatible with the value of buildings and urban settlement.

Conference: 18th International Passive House Conference

Place: Aachen (Germany)

Date: April 2014

Partner: EURAC

Authors: Dagmar Exner, Elena Lucchi, Alexandra Troi, Franz Freundorfer, Mathilde André, Waltraud Kofler Engl

Title of the paper: Energy efficiency of windows in historic buildings

Abstract: Windows are inseparable components of the building envelope. They shape the building from architecture point of view – and in a historic building, this aesthetical value is complemented by the value of perhaps still preserved original material. They provide daylight, fresh air and view to the outside, but are energetically speaking also the weak part of the thermal envelope: The thermal transmittance of windows was in the past and remains till today lower than for walls. But windows also let in solar radiation which lightens and heats up the room. Therefore, by optimizing gains and minimizing losses, windows have a huge potential to save energy. Building efficiency legislation actually has triggered replacement of traditional windows recently, but inappropriate window replacements or upgrades can ruin the historical value of the building and, in addition, cause problems of building physics nature, like condensation, and thermal bridges. In the recent history two main mistakes occurred: the raising of airtightness without raising the air exchange/ventilation at the same time and exchanging of windows without enhance the thermal insulation of the opaque part of the envelope at the same time. This led to a high risk of mould growth because of higher condensation risk (water activity) in combination with less ventilation. The paper presents a method for improving the energy efficiency of the windows in a historic building, through a progressive approach and targeted intervention that respects the documentary value. After explaining the heritage value of historic windows, glasses and frame and the development of a holistic façade concept, the replacing of an existing window with a high efficient system is discussed. Basis are the experiences from one case study: the Public Weigh House of Bolzano/Italy.

Conference: 18th International Passive House Conference

Place: Aachen (Germany)

Date: April 2014

Partner: PHI

Authors: Zeno Bastian

Title of the paper: Variant calculations and economic assessment with PHPP 9

Abstract: The Passive House Planning Package (PHPP) has a long track record as an accurate and easy-to-use tool for planning Passive House buildings and EnerPHit retrofits. It is also accepted as proof of compliance for certification purposes and subsidy programs. The Passive House Institute regularly refines, improves, and adds more functions to this tool. PHPP 8, the latest version when this presentation was drawn up, allows users to input a single building with its geometry and the heat insulation properties of its building components etc. and calculates an energy balance for them. But a frequent PHPP user may be asked repeatedly to calculate various design options for the same

building. This may arise with modernization projects if users need to calculate an unrenovated and renovated version, and possibly any intermediate steps, too. Comparing different designs may also help to come up with the most cost-effective combination of measures to achieve Passive House Standard for new builds as well. Up until now, users had to overwrite each cell entry with different values, for instance for insulation thickness. Looking at different designs in parallel was only possible by copying the PHPP project file once it had been filled out, unless users had advanced Excel programming skills. This process quickly became impractical, confusing, and prone to errors where several variants existed. PHPP version 9, which is slated for release towards the middle or end of 2014, will feature two additional worksheets entitled Variants and Comparison along with other innovations. The Variants sheet gives users the option of inputting different designs and displaying the results in parallel. The Compare sheet allows two of these variants to be selected to compare their energy demand and affordability in depth. Another tool, the PHeco external calculation tool (not integrated into the PHPP) has been developed by the working group for cost-efficient Passive Houses [AKKP42, 2012]. This worksheet uses the PHPP's findings to calculate affordability. It does so by comparing different building designs' heating energy demand and the costs of their respective energy-saving measures. The PHI can provide this tool on request.

Conference: 18th International Passive House Conference

Place: Aachen (Germany)

Date: April 2014

Partner: PHI

Authors: Zeno Bastian

Title of the paper: International EnerPHit Certification Criteria for Energy Retrofit with Passive House Components

Abstract: When old buildings are renovated, it is often difficult to achieve Passive House standard. Typical reasons for this are unavoidable thermal bridges as well as a general building design, which was originally not optimized for compactness and solar gains. For such buildings, Passive House Institute (PHI) has introduced the EnerPHit standard. The basic principle is to modernize all relevant parts of the building with Passive House components. This way almost all advantages of the Passive House standard can be realized in retrofits, even if the heating demand is not reduced all the way down to 15 kWh/(m²a). In the past the requirements for Passive House components such as windows and ventilations systems were only defined for cool temperate climates as prevails in Germany and Central Europe. As the EnerPHit criteria are based on the requirements for Certified Passive House Components, the first version of the EnerPHit criteria published in 2010 was also applicable to buildings located in cool temperate climates only. However, this also already included locations outside of Central Europe with similar climatic conditions, such as New York. Additionally EnerPHit renovations in other climate zones have been certified as pilot projects, such as a family home in the colder climate of Minneapolis, USA. In the recent past PHI has carried out intensive research with the aim of defining truly international component requirements. An international certification scheme for Passive House windows is running with 6 windows for colder climate zones already certified. International requirements for other components have been defined, with corresponding certification schemes to be set up in the near future.

Conference: 18th International Passive House Conference

Place: Aachen (Germany)

Date: April 2014

Partner: UIBK

Authors: Pavel Sevela, Rainer Pfluger

Title of the paper: Energy refurbishment of heritage buildings with PHPP's and real measurements' feedback

Abstract: Historic buildings are the origin of uniqueness of European cities; they are a living symbol of Europe's rich cultural heritage and reflect society's identity. In the same time the heritage buildings are

area of the high level of energy inefficiency. The European project 3ENCULT bridges the gap between conservation of historic buildings and climate protection “[1]. Structural solutions and even non-invasive interventions were applied to a various groups of Case Studies located around Europe. This paper intends to demonstrate the application of PHPP (Passive House Planning Package) calculation tool and real data measurements and their combination in a way of approaching individual adapted energy efficient refurbishment interventions on listed buildings.

Conference: 18th International Passive House Conference

Place: Aachen (Germany)

Date: April 2014

Partner: UIBK

Authors: Michele Bianchi Janetti, Fabian Ochs, Wolfgang Feist

Title of the paper: Assessment of the moisture risk in constructions including convection inside air cavities

Abstract: Mould growth and structural damages can affect timber building components in case critical moisture content is exceeded. Numerical simulation is useful for predicting such a risk, however, in case of constructions including air cavities, realistic modelling becomes very complex. On the one hand, the convective transfer mechanisms which occur in air cavities can significantly influence the moisture distribution; on the other hand, including fluid dynamics in long period hygrothermal simulation leads to high numerical effort and computation time. In this study the moisture content at the timber beam heads is predicted taking as an example a real building where internal insulation is applied. The effect of streaming air through the gap between timber beams and masonry is taken in to account by means of a simplified approach (line source approach). The employed numerical model has been implemented in Comsol and validated within previous published studies. In this work different scenarios have been analysed varying the pressure drop over the air gap. It results that, within the realistic range of pressure drop, increasing air flux leads to higher water content inside the construction. The maximal value of the volumetric air flux compatible with a save construction is determined.

Conference: 18th International Passive House Conference

Place: Aachen (Germany)

Date: April 2014

Partner: UIBK

Authors: Michele Bianchi Janetti, Rainer Pfluger, Fabian Ochs

Title of the paper: Internal Insulation Applied to a Listed School Building: in Situ Measurements and Numerical Analysis

Abstract: The European Project 3ENCULT aims to develop energy efficient solutions for EU cultural heritage. In this framework a school building in Innsbruck is going to be retrofitted. The type of insulation is still under discussion; most probable is the application of internal insulation, since the façade has to be preserved. In November 2012 two classrooms have been provided with different internal insulation systems for testing. The employed insulation materials are PU-foam in combination with capillary active channels and clay glue for the first system (IQ-Therm system) and blow-in cellulose for the second one. Capacitive sensors have been installed for monitoring of temperature and relative humidity at different positions (between insulation and masonry, at the internal and external surfaces and in the surrounding ambient). The analysis of the measured data aims to select the most appropriate solution to be employed for the retrofitting of the whole building, with respect to the moisture damage risk.

Conference: 18th International Passive House Conference 2014

Place: Aachen, Germany

Date: April 2014

Partner: UIBK

Authors: Rainer Pfluger

Title of the paper: Application of Heat Pipe Technology on Frost Protection of Heat Exchangers for Passive House Ventilation Systems

Abstracts: In Passive Houses, high efficient ventilation units with recuperative counter-flow heat exchangers are commonly used. If they do not have humidity recovery, the condensate freezes at low outdoor temperatures. To avoid this, several strategies are possible, [Pfluger 2013] gives an overview. The preheating of the outdoor air is one of the most popular methods. For a typical counterflow heat exchanger with a heat recovery rate of around 80 %, a temperature of around -3°C is necessary in order to prevent frost at the exhaust air side of the heat exchanger. Frost protection by direct electric heating is one of the cheapest ways in terms of investment costs, but the consumption of primary energy, depending on the winter climate at the site, can be high. Other heat sources with lower primary energy coefficient can be used, however, a hydraulic brine circuit is necessary. To avoid high invest and maintenance costs, the heat pipe (or thermosiphon) principle can be applied.