**Institute/organisation:**

University of Innsbruck
Unit: Energy Efficient Buildings

**Contact person:**

Assoz. Prof. Dr.-Ing Rainer Pfluger
Technikerstr. 13
A-6020 Innsbruck
tel: +43/512-507-6564
e-mail : rainer.pfluger@uibk.ac.at

**Exact location:**

Innsbruck, Austria
47° 15’ N, 11°20’ E

# GENERAL DESCRIPTION

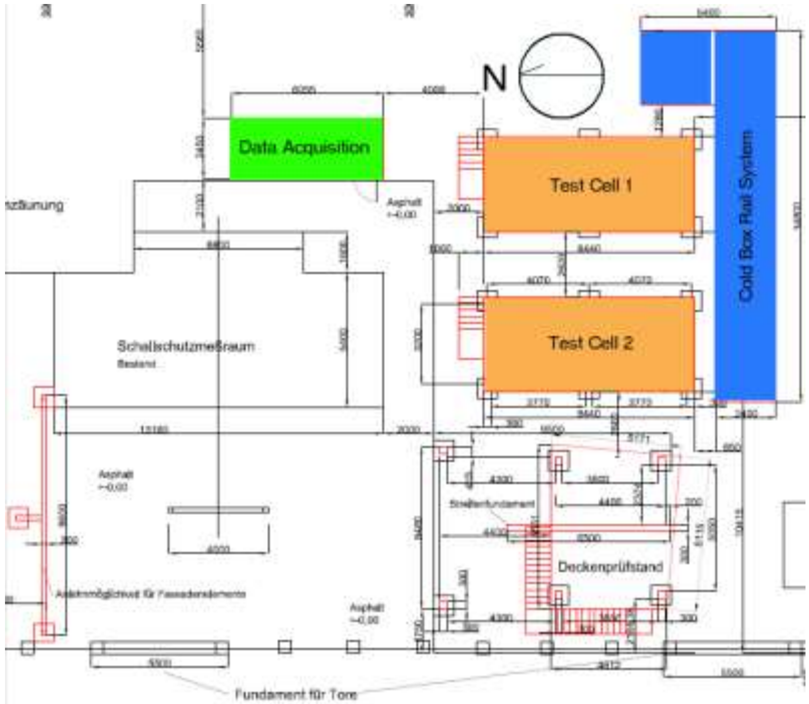
## Major aim of the test facility

The major aim of the UIBK test facility at the outdoor test site is thermal and visual (daylight and artificial light) test of passive and active building components, lighting products and control devices. It is used within several research projects with the aim of research and tests on prototypes for energy efficient buildings. Besides the two PAS/PASSYS – test cells, there is a test facility for measurement of sound protection of building elements (air and solid borne sound).

Besides the research on the thermo-physical behaviour of building components, research on thermal and visual comfort as well physiological impacts is performed in close collaboration with medical departments.

*Placing the test cell at the UIBK test site*

## Overall lay-out




*Test cell and Cold-Box in parking position*

The test site consists of one PAS test cell and one PASSYS test cell, both for test elements with the size of 2,75 x 2,75 m.

In front of both cells, a rail system was constructed for positioning of a so-called "Cold-Box", which is used to create a constant low temperature in front of the test component. This way, tests under steady state ambient conditions can be performed.

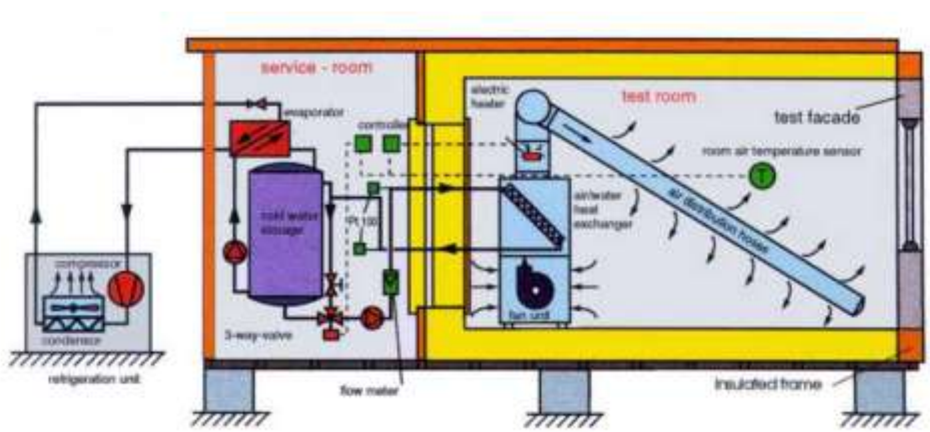
*View of both test cells and replacement of one test facade*

North of the test cells, a double chamber sound tests facility is located. At the east side of the test cells, the foundation for a future test device for ceilings is located.

## Inside boundary conditions

The inside temperature can controlled within the range from 5 up to 45 °C by means of a heating (electric) and cooling (hydraulic) system via air (recirculation air handler).

*View of sound tests facility*



## Outside boundary conditions

The outside boundary conditions are either ambient conditions or they can be kept constant by the Cold-Box (as described above) within the temperature range of -15°C up to 45 °C.

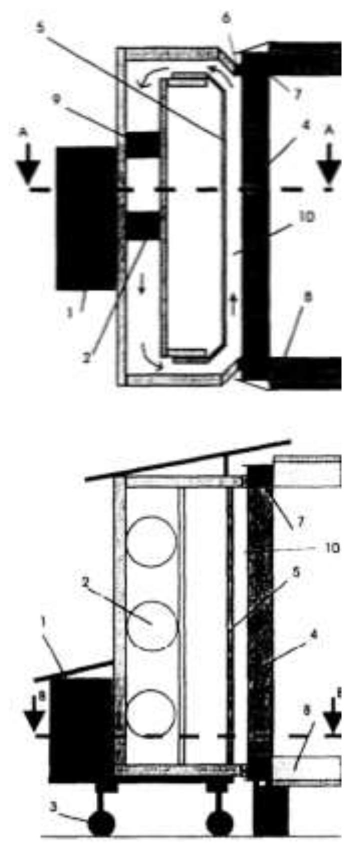
The weather station measures dry- and wet-bulb temperature, wind speed, relative humidity (capacitive sensor) and solar radiation (global horizontal, global vertical and diffuse vertical). A pyrgeometer measures the atmospheric long-wave radiation.

*Rail system for placement of the movable Cold-Box*

## Special limitations / possibilities

The standard heating and cooling system as developed during the EU-projects PASSYS and PASLINK is supplemented by an air dryer and ambient air ventilation system, which makes it possible to perform tests under different hygro-thermal conditions. This special feature is used for component tests as well as for medical tests under controlled adverse conditions.

# DATA ANALYSIS



*Schematic drawing of Cold-Box in top and side view*

## Typical equipment within test wall

The test component is equipped usually with additional temperature (Ni-CrNi thermoelements, Pt100), humidity sensors and heat flux sensors. In actual projects more than 50 sensors are used in one test component.

## Accuracy and logging resolution

Calibrated thermocouples (Ni-CrNi) and Pt100 temperature sensors for air and surface temperatures are in place. Calibration baths and a high precision reference sensor (10 mK) are used. Calibrated heat flux sensors (TUC) and air velocity (Omnisensor) are available. The logging resolution is 10 minute interval for standard measurements (higher resolution on demand for special measurements).

## Analysis of the data

The dynamic data is analysed with MATLAB scripts based on the Optimization Toolbox as well as with the Software LORD for determination of U and g-value of the components. Moreover stationary tests with Cold-Box in front of the component are applied for accurate and fast determination of the U-value under steady state conditions.

# EXAMPLES OF PREVIOUS STUDIES

*Mounting of test component (Project INTENSYS)*

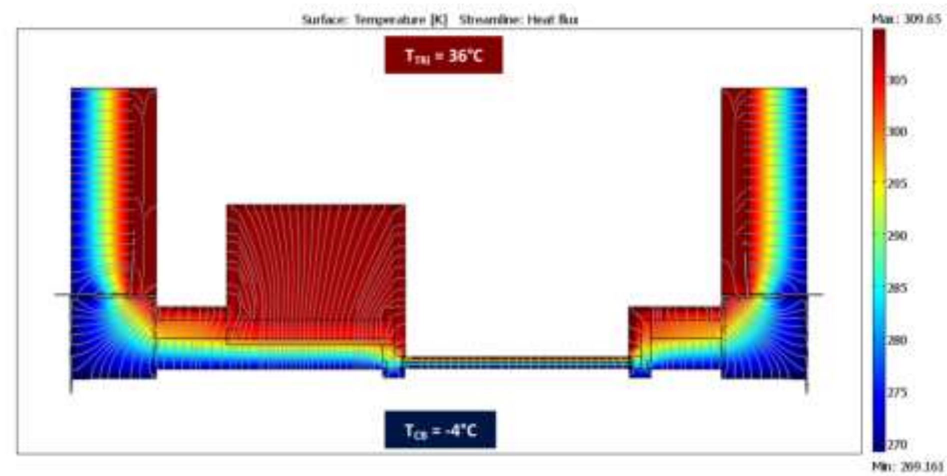
The test site in Innsbruck is used for research and development in the field of **façade components**, **innovative daylight and artificial light systems** as well as on **wall-integrated building services**, **active solar systems** and research on **indoor air distribution**. The following description will give some examples of previous studies within this wide range of applications.

## Wall integrated HVAC-systems

***Example 1: Project INTENSYS [1]***

First tests on window-components with integrated shading and ventilation system where performed within a research project called INTENSYS (FFG project 818867). The concept and performance of a wall integrated ventilation system combined with a window system with glazing integrated shading was measured and calculated. The ventilation losses of the heat recovery system in operation was identified as an additional conductance in parallel to the wall/window- component. The test was performed twice (with and without the fans in operation) in order to clearly separate the effect of ventilation losses from the transmission heat losses of the test component (see isothermal and heat flux lines derived from 2D-finite element calculations).

*Outside view of wall with integrated micro heat pump (Project iNSPiRe)*

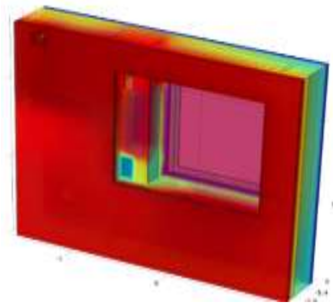



*2D-finite element thermal bridge calculation of the test component with ventilation system and window component (horizontal cross section of component, thermal insulated frame and test cell walls)*

*Inside view of wall with integrated micro heat pump (Project iNSPiRe)*

***Example 2: Project iNSPiRe (EU, FP7) [3,4,5,6]***

A micro-heat pump in combination with a mechanical ventilation with heat recovery (MVHR) unit is developed and integrated in the façade in the framework of the EU-FP7 project iNSPiRe. The heat pump uses the exhaust air of the MVHR unit as source and provides heat to the supply air of the ventilation system. Thus, one compact unit can be used for combined ventilation and heating (and/or cooling). Fresh outdoor air flows into the MVHR unit, where it is heated with a heat recovery efficiency of up to 90 %. It is then further heated by the micro-heat pump up to maximum 52°C in order to supply space heating (reverse operation for cooling would be possible in future versions). A simulation study has been performed to investigate the energy performance of the micro-heat pump. A detailed physical model of the µHP is developed within the Matlab simulation environment and validated against measurements of two functional models in the PAS test cells. The system including control will be optimized. Besides the measurements and tests in the test cell, the system will be monitored in a demo building in Ludwigsburg, Germany. The performance of the system is investigated for different renovation standards (EnerPHit with 25 kWh/(m$^2$·a) and Passive House with 15 kWh/(m$^2$·a)) at different climatic conditions (7 locations).



*Visualisation of 3D heat flow calculation of wall with integrated micro heat pump*

*MVHR-unit with micro-heat pump (Project iNSPiRe)*

## Day- and artificial light

***Example 3: K-Licht (P01)***

The second test cell is especially equipped for daylight and artificial light experiments. This type of measurements were performed for the first time within a national research project (K-Licht, P01) within which a specially integrated system for daylight and artificial light and it´s control was tested.

A new complex fenestration system developed from Bartenbach is installed which combines the different requirements (control of solar heat gain, glare protection, link to the outside, etc.) of a façade. In the course of the new complex façade system a new control strategy is developed. This control strategy defines the best blind position and artificial light settings in terms of energy and comfort aspects in each time step. With the help of the PASSYS cell this new development can be tested in real outdoor scenario. For that a new LED electric light system (Zumtobel) is installed, which allows different colour temperature und direct & diffuse settings.

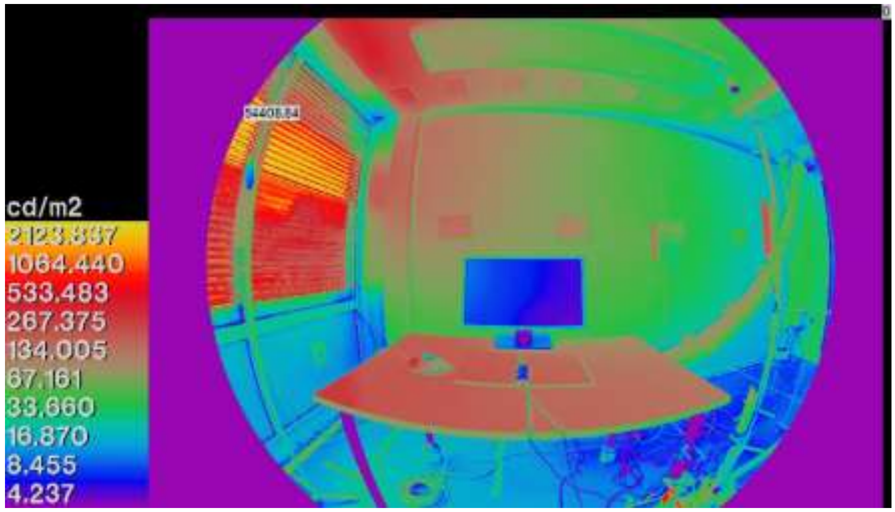
*LED Electric Light System*

*Interior view – Illuminance Sensor*

With two illuminance sensors on the working surface (one next to the fenestration and one far from the fenestration) the illuminance level could be measured. Furthermore Bartenbach installed a luminance camera detecting glare situations.

*Outside view test component with complex façade system (Project K-Licht)*

*External spectrometer*




*Luminance Picture (Source: Bartenbach)*

*Internal spectrometer*

Additionally an internal and external spectrometer measures the spectrum from the sky and the transmitted spectrum into the test facility. Furthermore an external daylight sensor “TLM” saves the horizontal and vertical illuminance of each facade orientation. These values can be used as input for the facade control strategies.

A fisheye webcam installed on the roof of the PASSYS test cell takes a picture of the sky every minute. This allows an evaluation of the sky conditions compared to the measurements results of the PASSYS cell.

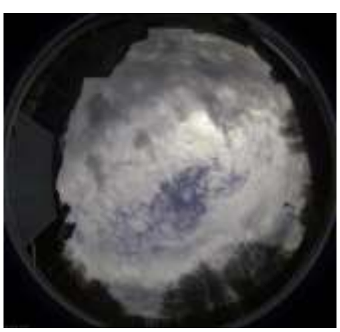
This measurement equipment allows a holistic light analysis of the façade, artificial light and control strategies.

*TLM – Daylight measurement sensor*

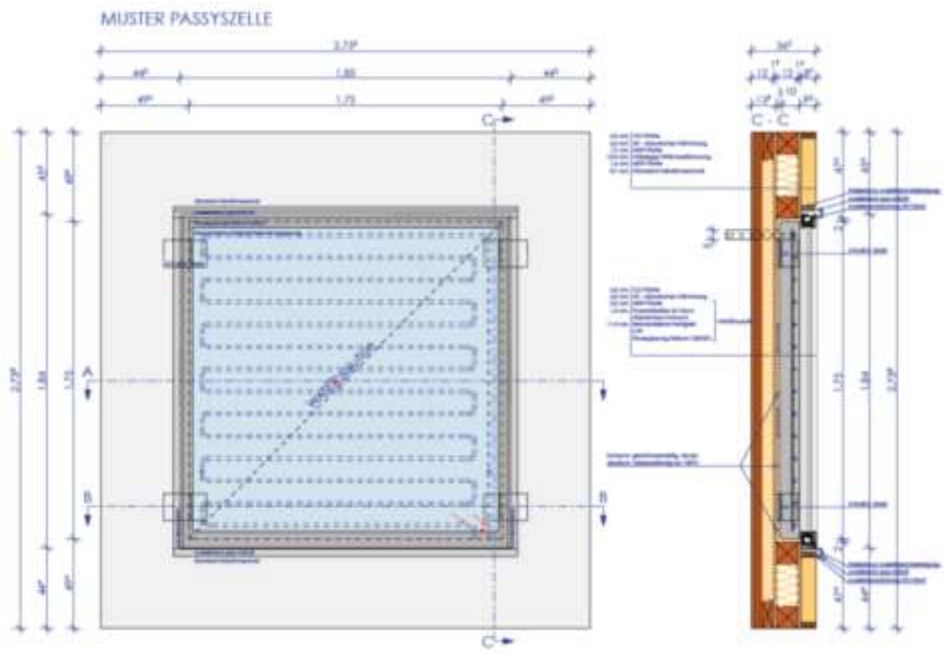
## Active solar systems (wall integration)

***Example 4: GAP water:solution (GAP solution GmbH, Leonding, A) [2]***

The component under investigation is a solar absorber made of concrete mounted in an insulated timber construction. Within the concrete absorber, a stainless steel tube is integrated for solar preheating of domestic hot water. To be able to test this system, additional hydraulic and monitoring equipment had to be installed for testing of active components. Besides the passive and active performance of the system, tested in the PAS test cell, the acoustic behaviour was measured in the acoustic testing facility at the UIBK test site as well.



*View of sky with Fish-Eye Sky Cam*



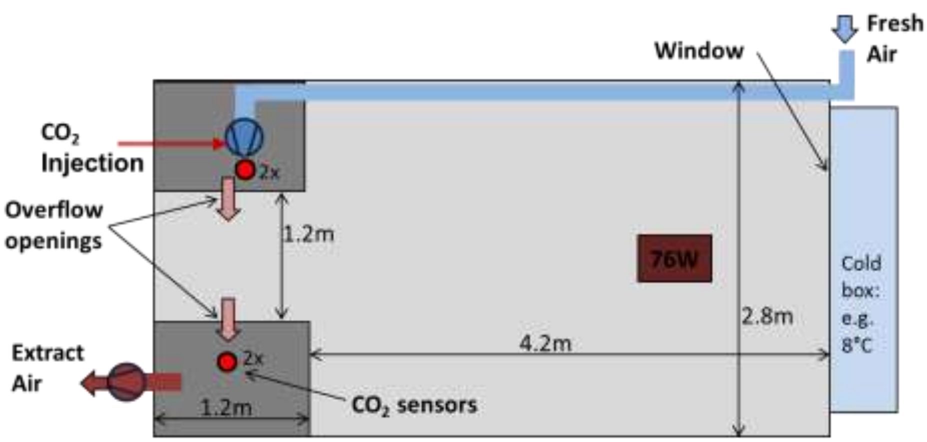

*Section C-C (left) and vertical section (right) of the water:solution component*

*Mounting of test component (Project water:solution)*

## Indoor air flow distribution measurements

***Example 5: FFG-project low_vent.com [7]***

In this project a test cell was used to measure the air exchange efficiency for a certain floor plan configuration. The study investigated the so called extended cascade ventilation (no supply air in the living room). The PAS test cell provided quasi-adiabatic conditions to measure a potential short circuit flow between opposing overflow elements for various temperatures.




*Schematics showing the experimental set-up measuring the air exchange efficiency Reprinted from [7], with permission from Elsevier*

*Interior of test cell for measurement of the air exchange efficiency*

# MAINTENANCE/ COLLABORATION

## Personal involved

The test facility is maintained by employees of TVFA and research persons of University Innsbruck. They are also responsible for data analysis and take care of smaller adaptations. The maintenance of the heating and cooling system is done by Sparer Klima&Kältetech.

## International collaboration

The test facility is used for national and international research projects.

## Link with other devices

The outdoor test facility as well as the indoor climate chambers and sound measurement test devices are part of the TVFA (Technische Versuchs und Forschungsanstalt) working as an accredited laboratory of the University Innsbruck. The test cells work as a stand-alone test facility, the data acquisition is located in an office container nearby, a fast data transfer by fibre optic cable is established.

# RELEVANT LITERATURE

## Literature on previous measuring campaigns:

[1] Pfluger, Rainer; Malzer, Harald; Feist, Wolfgang: Testing of a Window Device with Integrated Shading and Ventilation System with PAS-test cell and Coldbox, in: Bloem, Hans et al. (2010) DYNASTEE workshop on Dynamic Methods for Building Energy Assessment Centre Borchette Brussels, 11-12. October, 2010

[2] Hauer, Norbert; Neyer, Daniel; Richtfeld, Richtfeld; Streicher, Wolfgang: WATER-Solution, Evaluierung der Freifeldversuche, Ableitung eines Excel-Tools für die Ertragsprognose, Universität Innsbruck, AB Energieeffizientes Bauen, 12. Nov. 2014

[3] Ochs, Fabian; Dermentzis, Georgios; Siegele, Dietmar; Konz, Alexandra; Feist, Wolfgang: Façade integrated active components in timber-constructions for renovation - a case study. NSB 2014, Lund, SE

[4] Ochs, Fabian: Facade-integrated MVHR with Speed-controlled Micro-heat Pump; Fabian Ochs, Dietmar Siegele, Georgios Dermentzis, Wolfgang Feist, ICR 2015, Japan (accepted)

[5] Ochs, Fabian; Dermentzis, Georgios; Siegele, Dietmar; Feist, Wolfgang: Modelling, testing and optimization of a MVHR combined with a small-scale speed controlled exhaust air heat pump, Building Simulation Applications, BSA 2015, 2. IBPSA Italy Conference, Bolzano, Italy, 2015.

[6] Siegele, Dietmar: Measurement and Simulation of the Performance of a Façade-integrated MVHR with Micro Heat Pump, Master Thesis, University of Innsbruck, 2015.

[7] Rojas, Gabriel; Pfluger, Rainer; Feist, Wolfgang: Cascade ventilation – Air exchange efficiency in living rooms without separate supply air, Energy and Buildings. (2015). DOI: 10.1016/j.enbuild.2015.02.014