03.04_PH-SUMMER SCHOOL

PH-CALCULATION – Dynamic simulation with WUFI

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CONTENT OF THIS PRESENTATION:

03.03.01 Description of the software “WUFI – ORNL / IBP”
03.03.02 Working with “WUFI” – some examples

This presentation shows the possibilities of a dynamic simulation software to develope and optimize new components of the building shell.

It is based on a presentation of
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The WUFI hygrothermal model software

Description

WUFI – ORNL / IBP

Advanced hygrothermal model that solves the coupled heat, and moisture transport in building envelope systems such as walls and roofs. The model is a joint development between the US Oak Ridge National Laboratory and the Fraunhofer Institute in Building Physics (IBP) in Germany. WUFI-ORNL/IBP is an easy-to-use, menu-driven program for use on a personal computer which can provide customized solutions to moisture engineering and damage assessment problems for various building envelope systems. The model was specifically developed for architects, and engineers alike. It is an excellent education tool as the user can visually review the transient thermal and moisture distributions as the simulation is executed.

Keywords

Moisture modeling, hygrothermal model, combined heat and moisture transport, building envelope performance

Source: http://apps1.eere.energy.gov/buildings/tools_directory/software.cfm/ID=362/pagename=alpha_list

The WUFI hygrothermal model software

Description

Validation/Testing
N/A

Expertise Required
Low level of computer literacy required; Building science fundamental knowledge is suggested. Training is being provided at regular intervals by either ORNL or IBP.

Users
Over 680 licensed users since the release in Feb. 2001. Within the 8 months of the first release more than 6 universities have included this model in their Building Science Courses. The comprehensive on-line help and documentation amounts to ca. 200 A4 pages. WUFI-ORNL/IBP is available

Audience
Building Envelope Consultants, Architects, Designers, Architectural Engineers, Engineering Students, Code Inspectors and Universities.

Source: http://apps1.eere.energy.gov/buildings/tools_directory/software.cfm/ID=362/pagename=alpha_list

The WUFI hygrothermal model software

Description

Input

A flexible graphical user interface is included that helps the user enter the building construction geometry, interior and exterior surface characteristics, material properties already exist in an hygrothermal material property database, initial conditions and interior and exterior climatic conditions. The user may enter monitor positions to investigate the localized layer. The WUFI-ORNL/IBP model has been adapted to employ ASHRAE SPC 160P design inputs. The user may choose either SI or Imperial Units.

Output

Visual distributions of both space and time variables such as temperature, relative humidity, moisture content. Moisture content of each construction layer is plotted out as a function of time. The user can also select from a list of output data and plot these out as well. Each selected monitor position is also available in a graphic representation. Heat and moisture fluxes are also generated. Finally, the user may also create an animation that can be stored for presentations purposes. The user may choose either SI or Imperial Units.

Source: http://apps1.eere.energy.gov/buildings/tools_directory/software.cfm/ID=362/pagename=alpha_list

The WUFI hygrothermal model software

Description

Computer Platform
PC-compatible, 486 or higher; Windows 95/98/NT/2000 and a VGA or higher Resolution

Programming Language
Delphi

Strengths
Easy to use; fast to learn; employs state of the art hygrothermal physics; includes the influence of wind-driven rain. An excellent moisture design tool.

Weaknesses
One-dimensional; does not include the transfer of heat and moisture by air movement. Limited material property database for North American construction materials. ORNL is currently generating material properties to enhance the Database.

Source: http://apps1.eere.energy.gov/buildings/tools_directory/software.cfm/ID=362/pagename=alpha_list

The WUFI hygrothermal model software

Description

Languages
English and German versions

Contact
Company: Fraunhofer Institute for Building Physics
and Oak Ridge National Laboratory
E-mail: info@ibp.fraunhofer.de
ank_hammodel@ornl.gov
Website: http://web.ornl.gov/sci/btc/apps/moisture

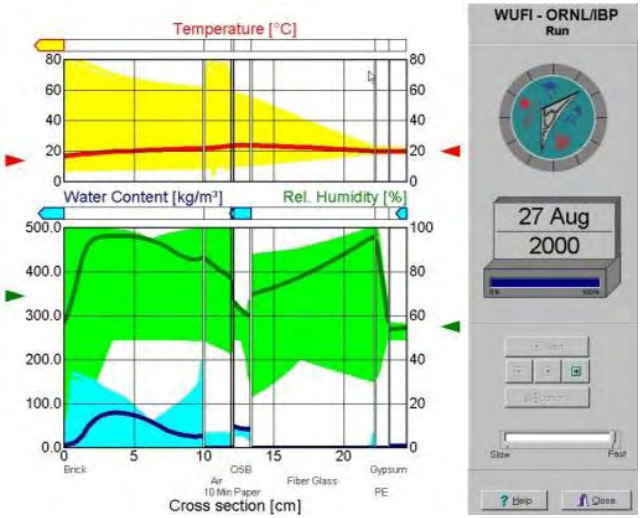
Availability
A free Research and Education version is available The user is required to maintain a valid license which is renewed each year. This allows all users to work with the latest software version.

Source: http://apps1.eere.energy.gov/buildings/tools_directory/software.cfm/ID=362/pagename=alpha_list

The WUFI hygrothermal model software

Description

WUFI-ORNL/IBP can be used for assessing:



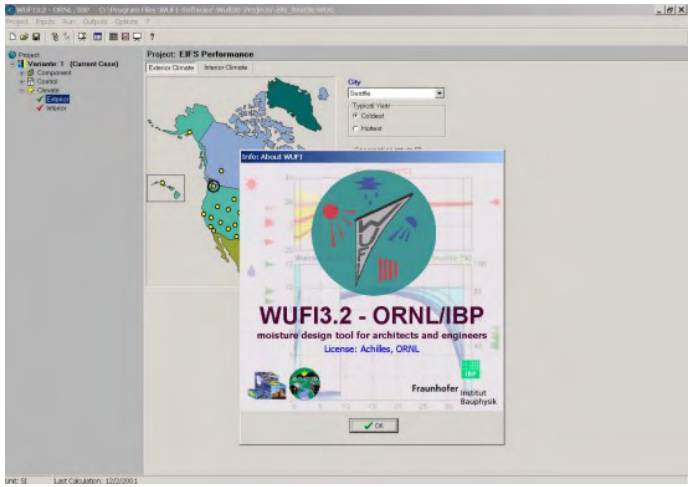
- the drying time of masonry with trapped construction moisture
- the danger of interstitial condensation
- the influence of driving rain on exterior building components
- the effect of repair and retrofit measures
- the hygrothermal performance of roof and wall assemblies under unanticipated use or in different climate zones.

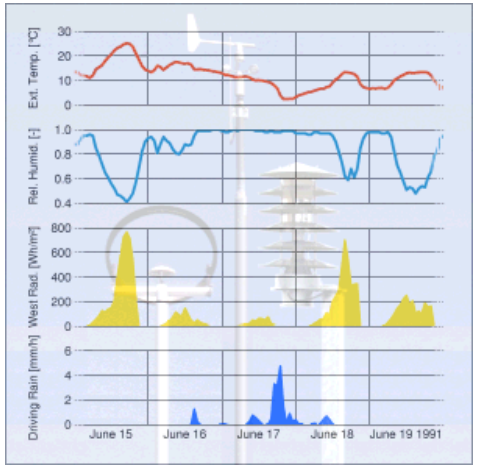
Source: http://apps1.eere.energy.gov/buildings/tools_directory/software.cfm/ID=362/pagename=alpha_list http://www.ornl.gov/sci/btc/apps/moisture/

The WUFI hygrothermal model software

Description

WUFI-ORNL/IBP is a tool for developing and optimizing building materials and components (for different places).





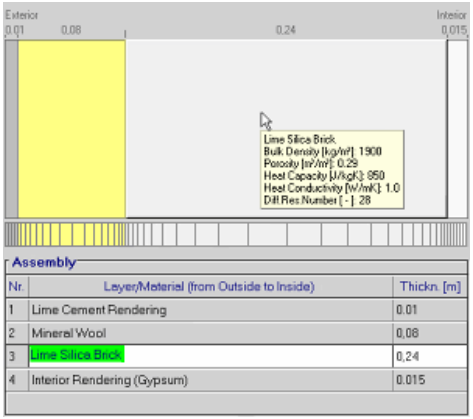
The boundary conditions acting on the building component are the temperature and relative humidity of the interior and exterior air and the rain and radiation loads, both depending on inclination and orientation of the building component. These data can be derived from a database. ASHRAE provided the raw data for the development of a moisture design year for 50 cities.

Source: http://apps1.eere.energy.gov/buildings/tools_directory/software.cfm/ID=362/pagename=alpha_list www.ornl.gov/sci/btc/apps/moisture/

The WUFI hygrothermal model software

Description

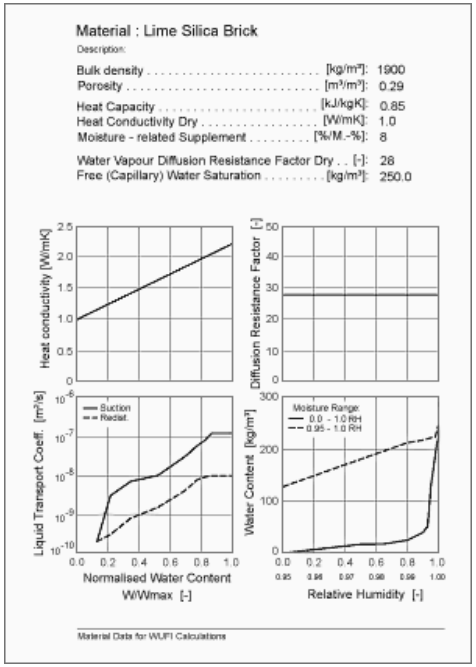
Component Assembly and Numerical Grid



Assembly

Nr.	Layer/Material (from Outside to Inside)	Thickn. [m]
1	Lime Cement Rendering	0.01
2	Mineral Wool	0,08
3	Lime Silica Brick	0,24
4	Interior Rendering (Gypsum)	0.015

The individual layers of the component and their respective thickness are entered into a table.
The component is then divided into numerical grid elements whose widths are chosen according to the temperature and moisture variation expected for the respective location.



Material Data

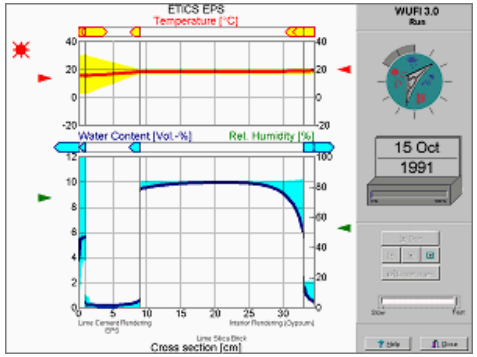
The hygrothermal material data for each layer can be read from WUFI-ORNL/IBP's database. As a minimum, WUFI-ORNL/IBP requires the bulk density, the porosity, the specific heat capacity, the heat conductivity (dry) and the diffusion resistance factor (dry).
Depending on the object and the purpose of the calculation, additional data can be entered: the moisture storage function, the liquid transport coefficients for suction and redistribution, the moisture-dependent heat conductivity and the moisture-dependent diffusion resistance factor.

Source: www.ornl.gov/sci/btc/apps/moisture/

The WUFI hygrothermal model software

Description

Calculation

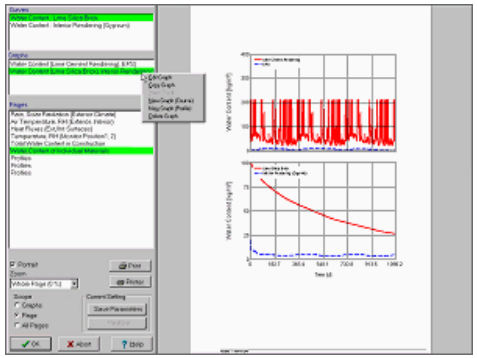


After entry of a few remaining data like surface transfer coefficients, initial conditions etc., the calculation can be started. It then computes the temporal evolution of the temperature and the moisture field in the component.

Displaying the Results

After the calculation, the results - stored in a binary result file - are available for display and analysis.

WUFI-ORNL/IBP lets you display the curves of courses in time and cross-sectional profiles as graphics, compare them with measured data, edit and print them. You can also view graphics of the climate data.



Source: www.ornl.gov/sci/btc/apps/moisture/

The WUFI hygrothermal model software

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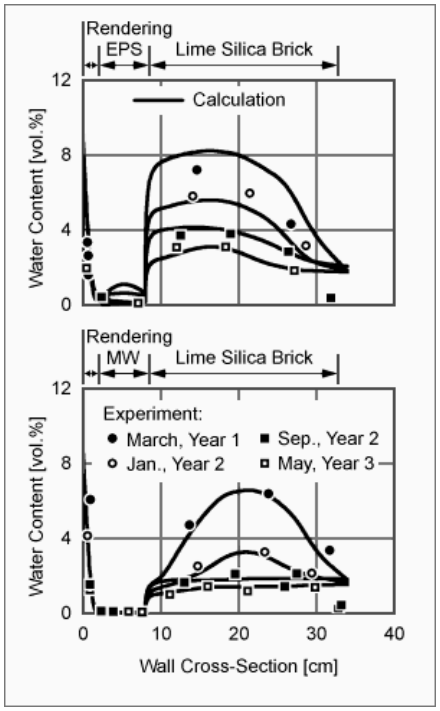
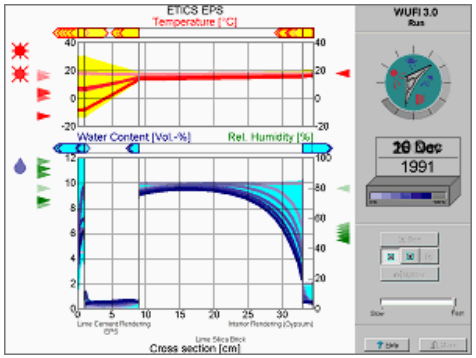
Finally it can show the temperature and moisture behaviour in the building components during the whole year (or some years).

Profiles

For points in time selected by the user WUFI-ORNL/IBP provides profiles which show the distribution of the following quantities across the component:
- the temperature,
- the relative humidity,
- the moisture content.



Film



The time steps for the climate data and the calculation may be selected at the user's discretion; for most cases hourly values are appropriate. It also writes a film file during the calculation which contains all the computed profiles and which - displayed as a 'film' - conveys a dynamical impression of the thermal and hygric processes in the component.

Source: www.ornl.gov/sci/btc/apps/moisture/

Working with THERM

Some examples

Assessment of Building Envelope Performance with theoretical simulation tools

“DYNAMIC SIMULATION”

Source:

Working with THERM
Some examples

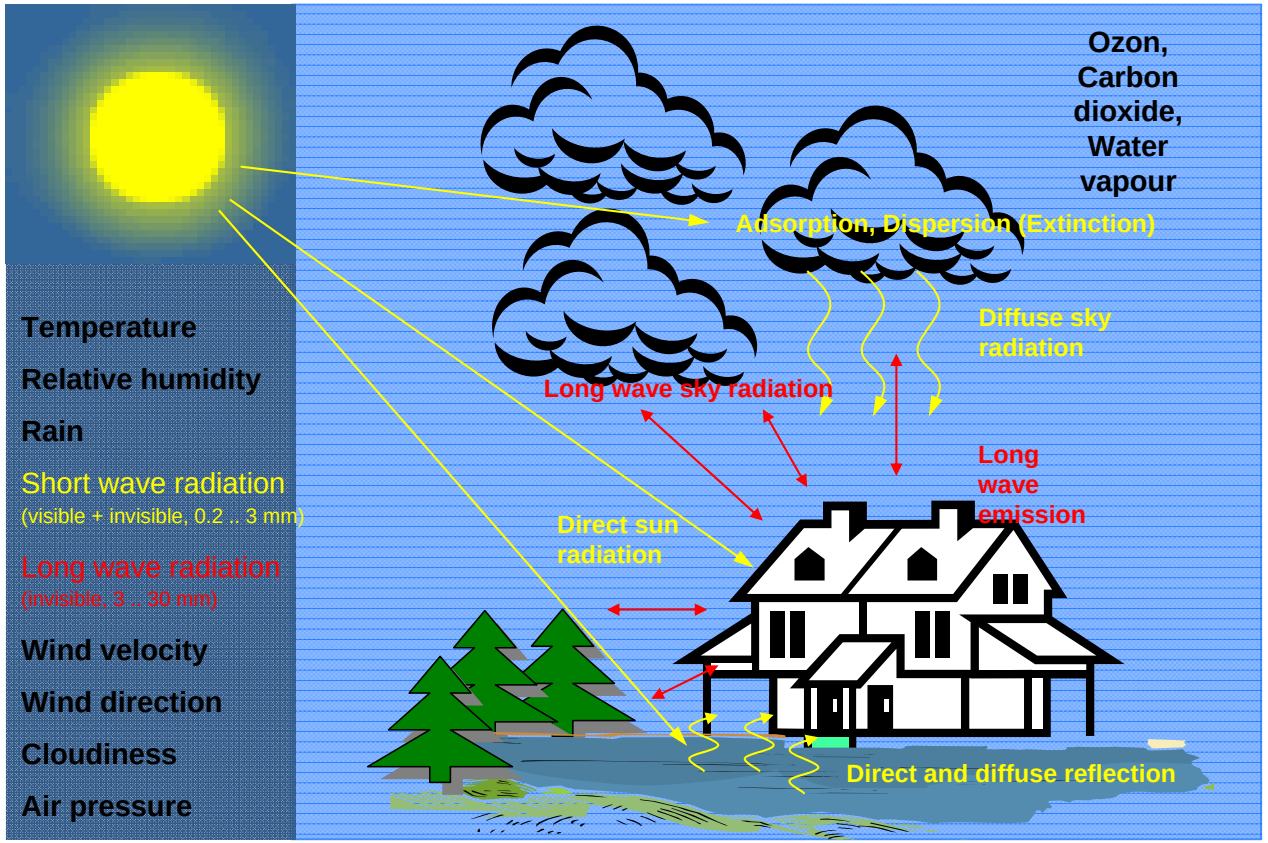
Purpose of our Research Work at the Carinthia University of Applied Sciences :

- Analyzing the hydrothermal performance and probable durability of different building assemblies.
- Predicting the potential transferability of the developed envelope systems?
- (Exposure to different exterior climates, altitudes, etc.)

Source: Christoph Buxbaum

Working with THERM
Some examples

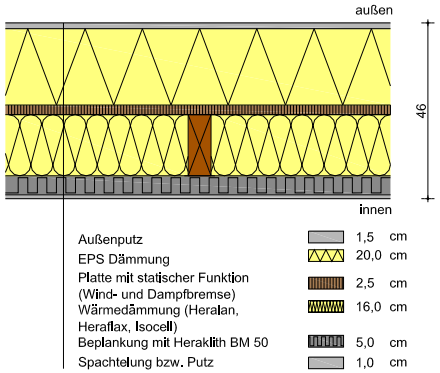
Climatic Impact???

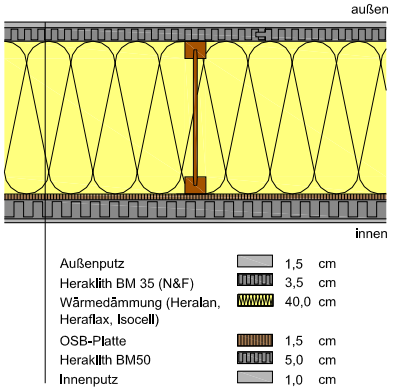


Source:

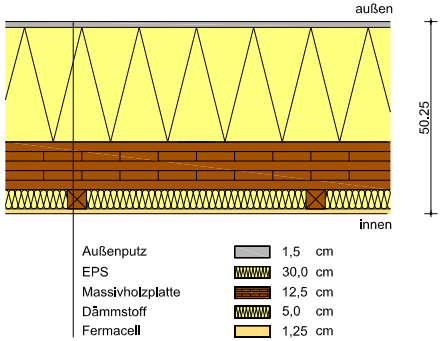
Working with THERM
Some examples

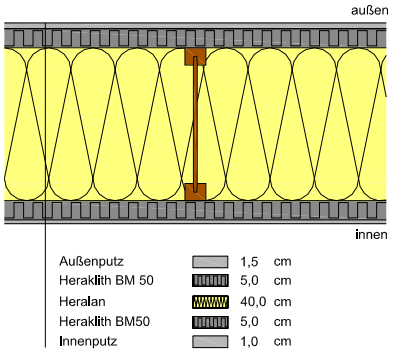
e.g. Developing & Analyzing different Timber - Systems:





- Different assemblies
- Different insulations
- Different coverings





Source: Christoph Buxbaum

Working with THERM
Some examples

- Moisture management?
- Drying potential?
- Moisture accumulation?
- Mould growth & wood decay?
- Effective U- value?

Durability???

Risk Assessment of unscheduled Moisture Entry due to:
incorrect storage, wetting during transport and erection process, etc.

Source: Christoph Buxbaum

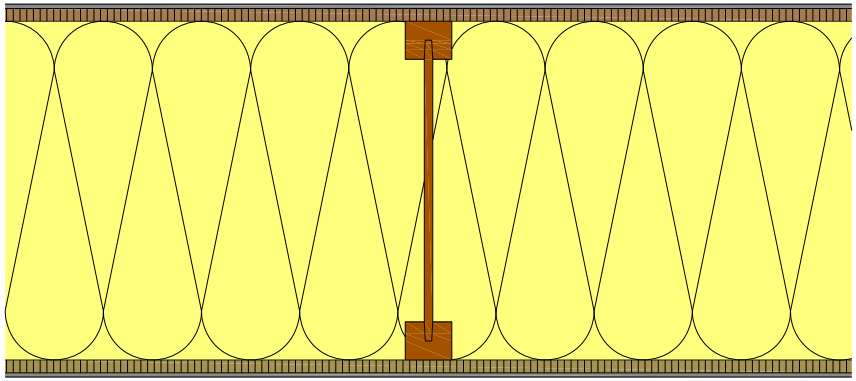
Working with THERM
Some examples

Examples…..

Exterior Covering

Insulation

Interior Covering



Case 1	Case 3 (Germany) = Case 11 (Calgary)
External Plaster 5mm (1/4“)	External Plaster, 15mm (5/8“)
Medium-Density-Fibreboard (MDF) 40mm (1 ½“)	Mineral-bound (Magnesite) Wood-Wool Panel, 50mm (2“)
Mineral Wool Insulation, 400mm (16“) between wooden I- Joists	
Oriented Strand Board (OSB) 15mm (5/8“) also acting as Air barrier and vapour retarder	Mineral-bound (Magnesite) Wood-Wool Panel, 50mm (2“) without vapour retarder
Gypsum Board, 12.5mm (½“)	Internal Plaster, 15mm (5/8“)

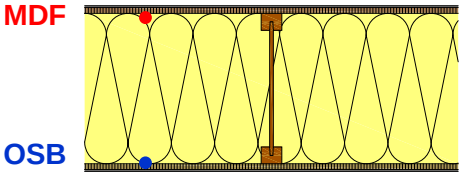
Source: Christoph Buxbaum

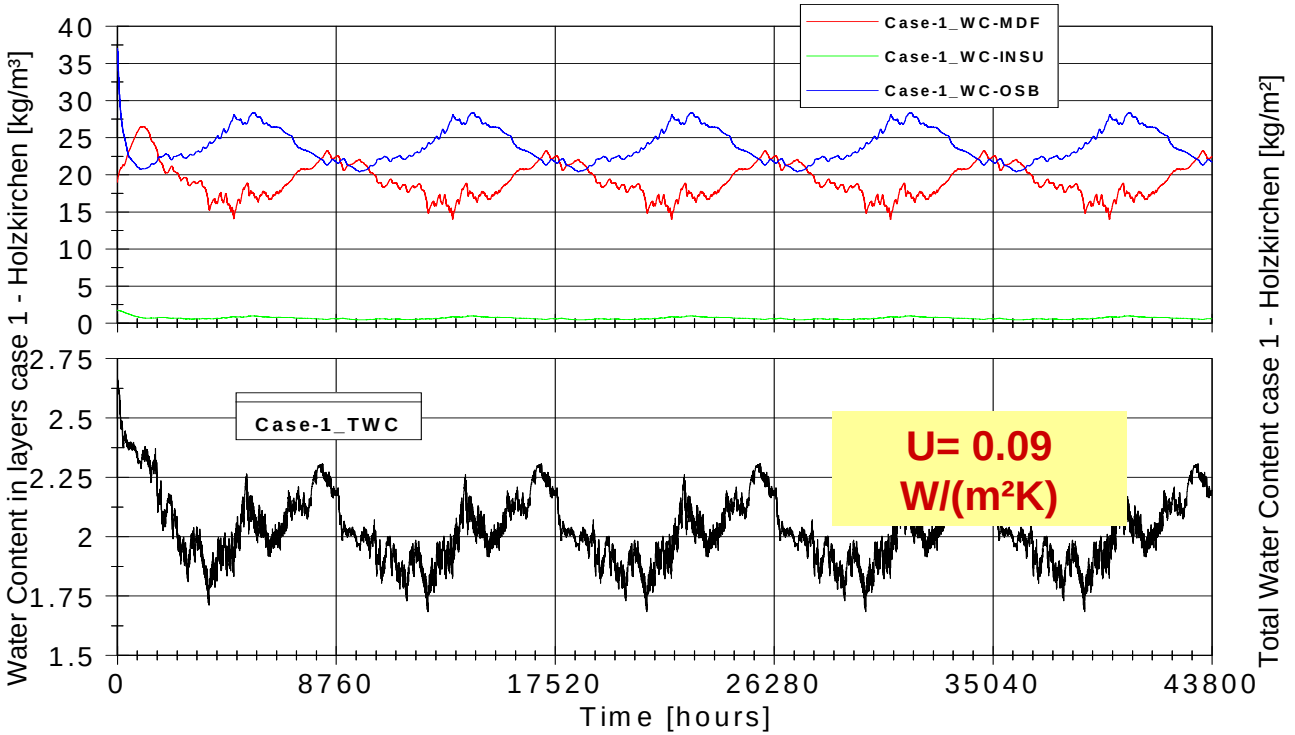
Working with THERM

Some examples

Case 1 – Holzkirchen Climate

Total Water Content & Water Content in layers





Source: Christoph Buxbaum

Working with THERM
Some examples

In-Situ Measurements and Comparing Simulations

Source:

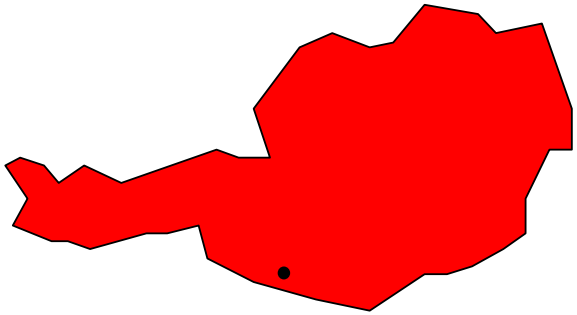
Working with THERM
Some examples

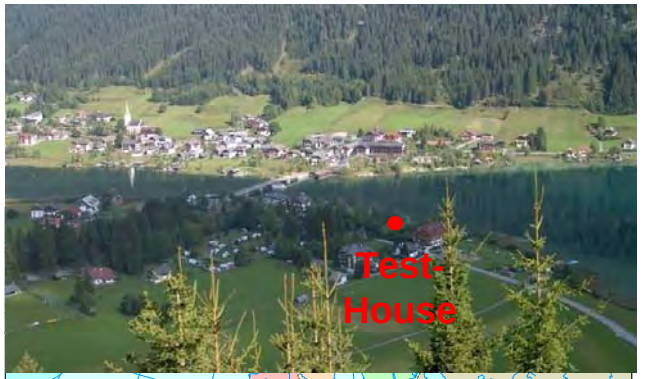
Prefabrication of wall assemblies &
Built-in measurement equipment

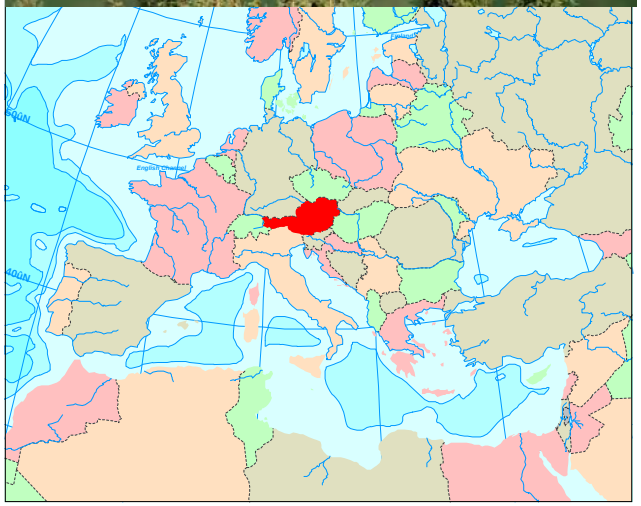
Source: Christoph Buxbaum

Working with THERM
Some examples

Test-House at Lake „Weissensee“







Lake „Weissensee“

930m above sea-level

Source: Christoph Buxbaum

Working with THERM
Some examples

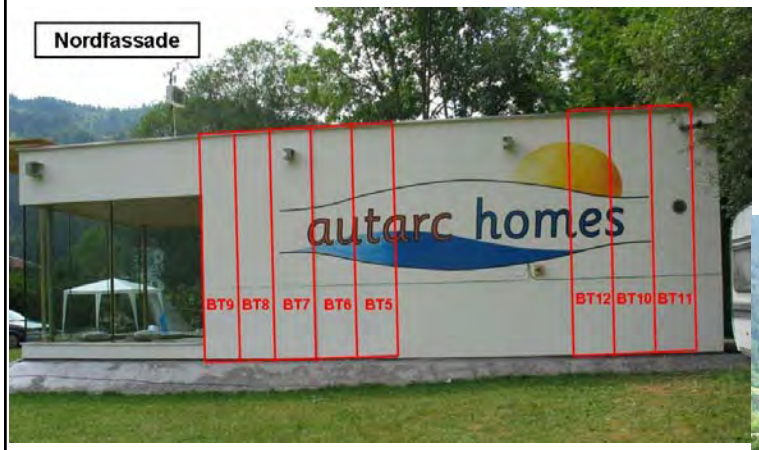
Images of Test-House

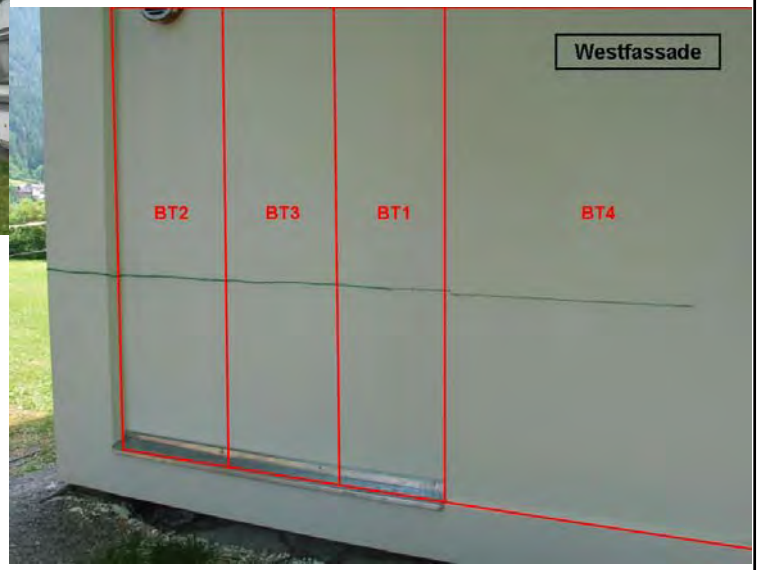
Source: Christoph Buxbaum

Working with THERM

Some examples

Wall Exposure north- & westward





Source: Christoph Buxbaum

Working with THERM
Some examples

Controlled Interior Conditions

Source: Christoph Buxbaum

Working with THERM
Some examples

Comparison between

In-Situ Measurements and Preliminary Simulations

Examples……..

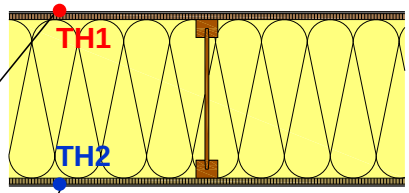
Source:

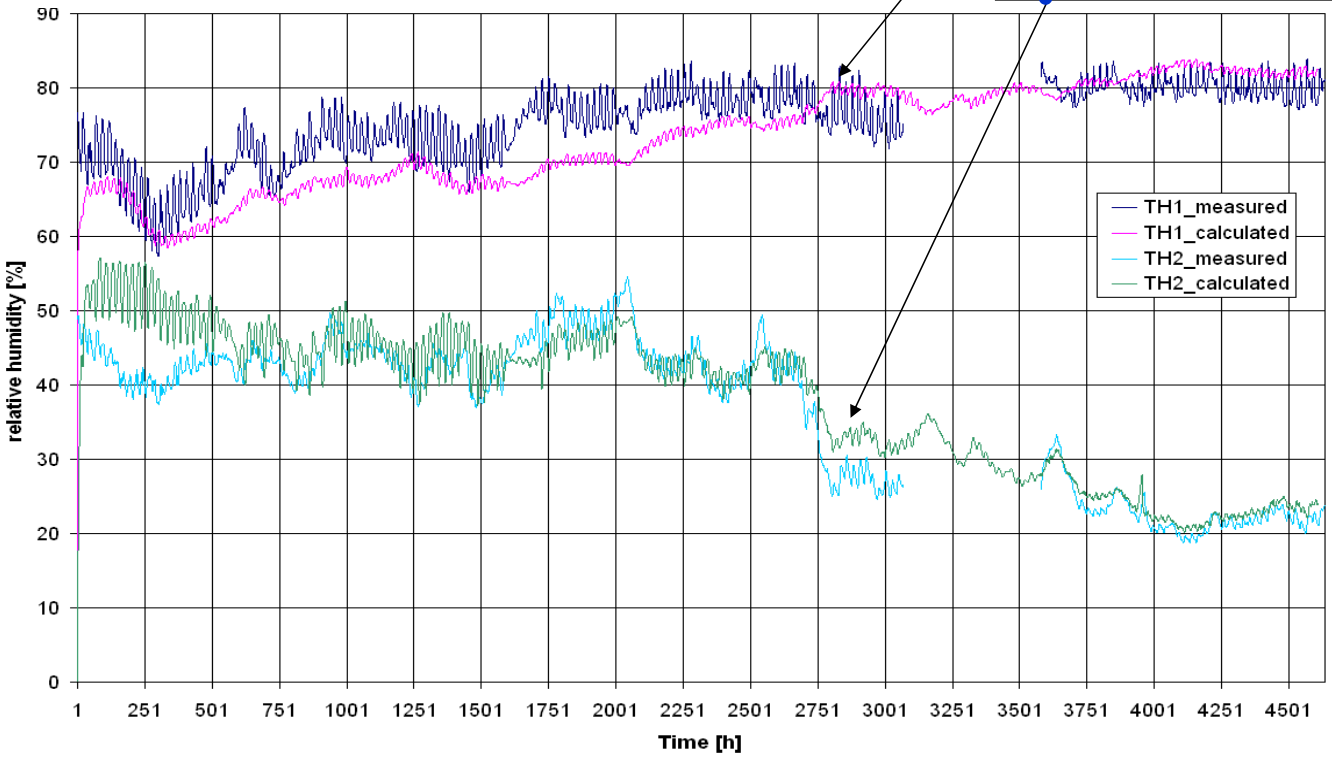
Working with THERM

Some examples

Case 1 – Weissensee Climate

Temperatures on interface MDF & OSB to insulation





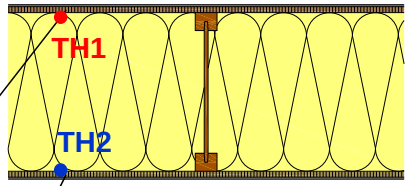
Source: Christoph Buxbaum

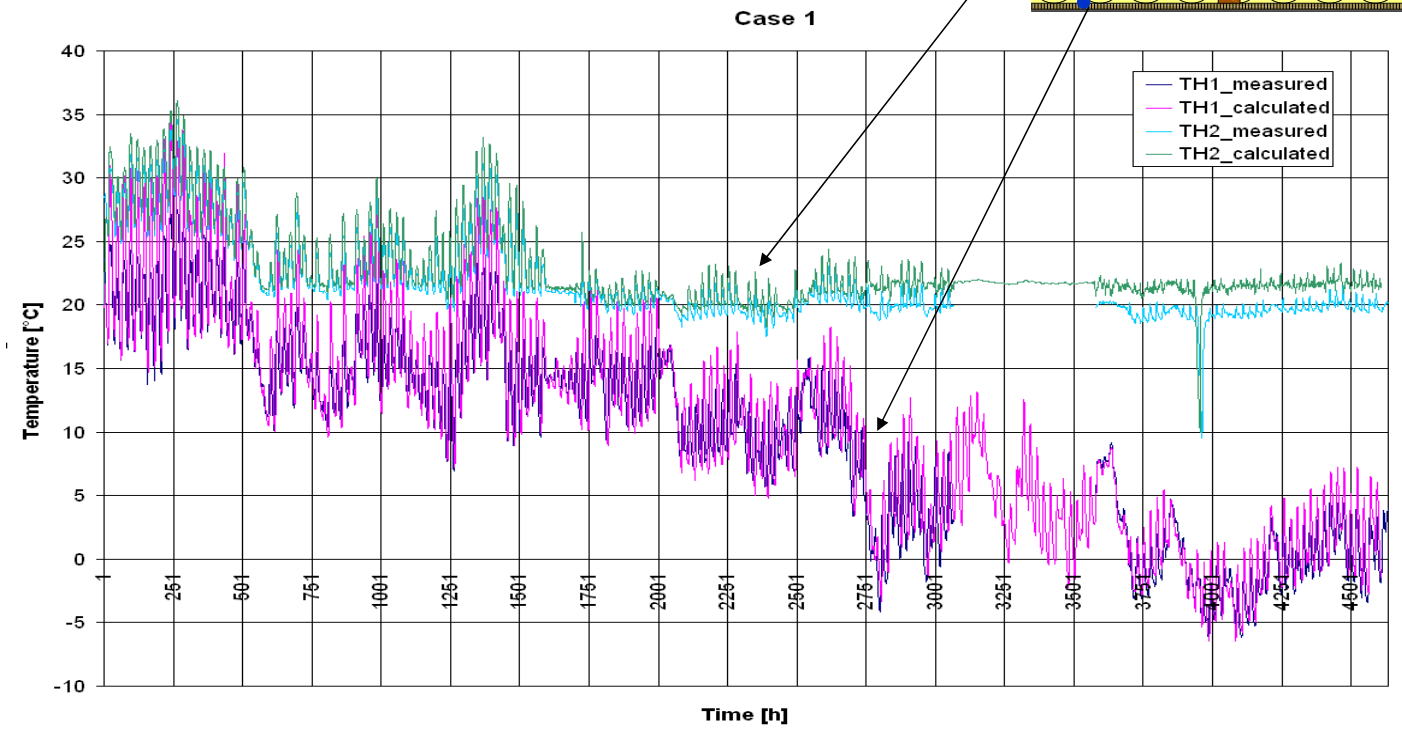
Working with THERM

Some examples

Case 1 – Weissensee Climate

Relative Humidity on interface MDF & OSB to insulation





Source: Christoph Buxbaum