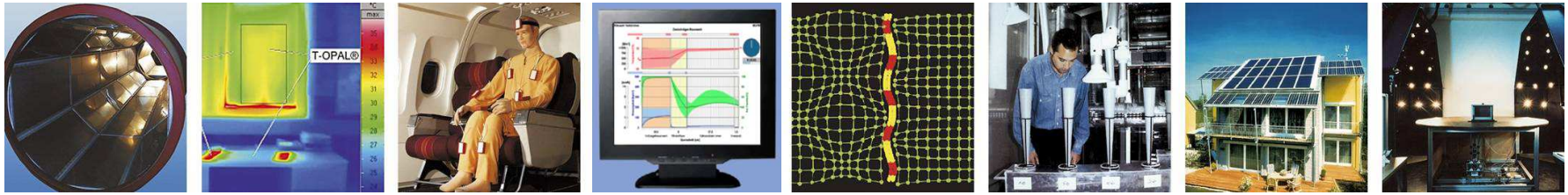

Multi Climate Global Passive House

Hartwig M. Künzel
(Fraunhofer Institute for Building Physics)

Fraunhofer
IBP

Multi Climate Global Passive House

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Static vs. dynamic

Moisture control

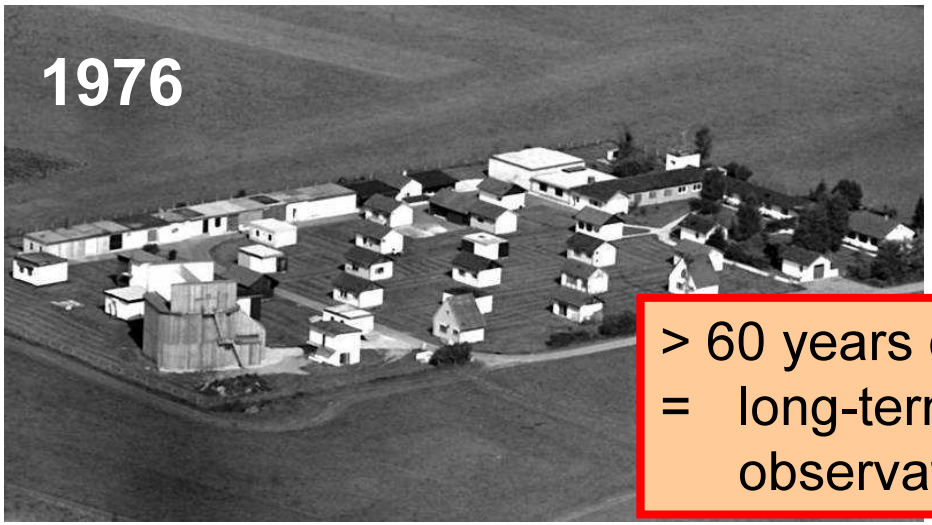
Hygrothermal whole building simulation

Renewable energy sources an alternative for passive design?

Conclusions

Introduction

IBP field test site in Holzkirchen



> 60 years of field tests
= long-term durability observation

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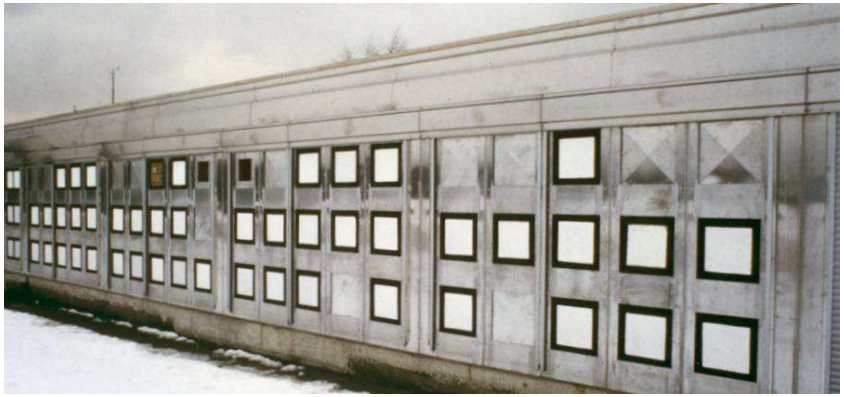
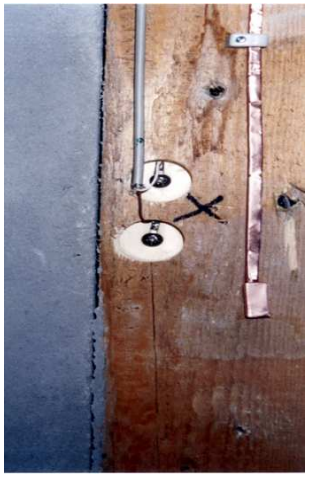
Introduction





Measure-ments help to validate calculations

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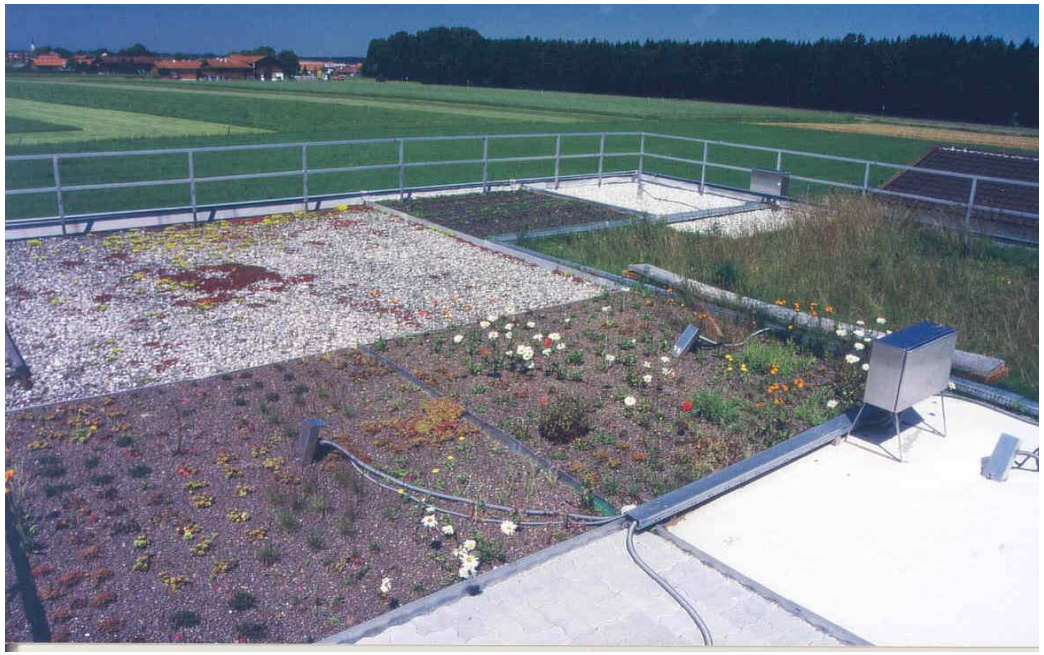
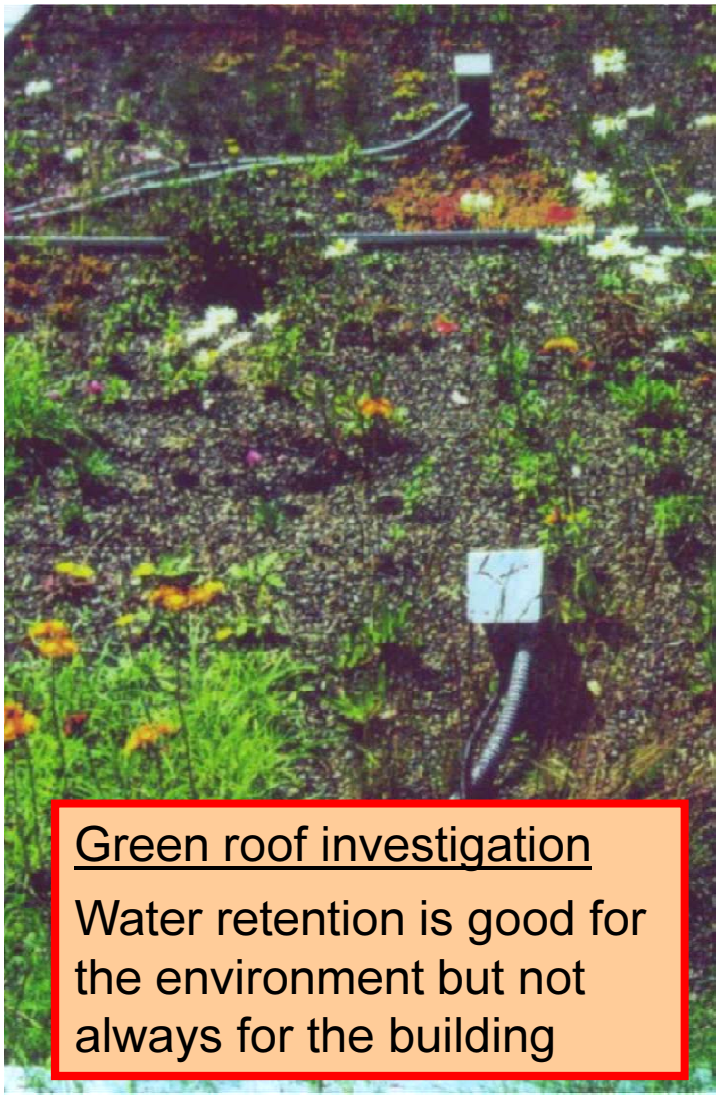
Introduction





Green roof investigation

Water retention is good for the environment but not always for the building

Introduction

Long-term obeservation of degradation processes

Moisture seems to be the main cause for degradation

Introduction

Investigating visible mold growth

Test of building material's susceptibility for different species of mold

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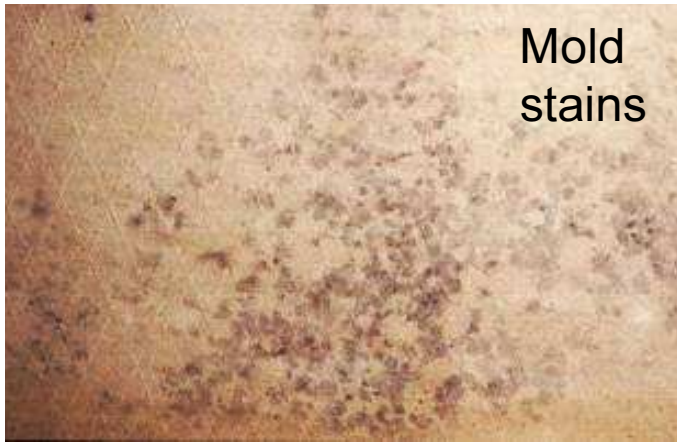
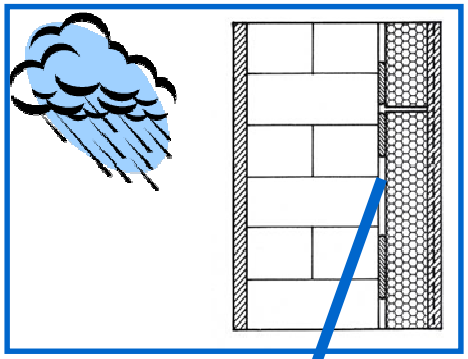
Introduction

Investigating invisible mold growth



Mold on kraft paper due to solar vapor drive

Mold behind interior insulation due to high RH



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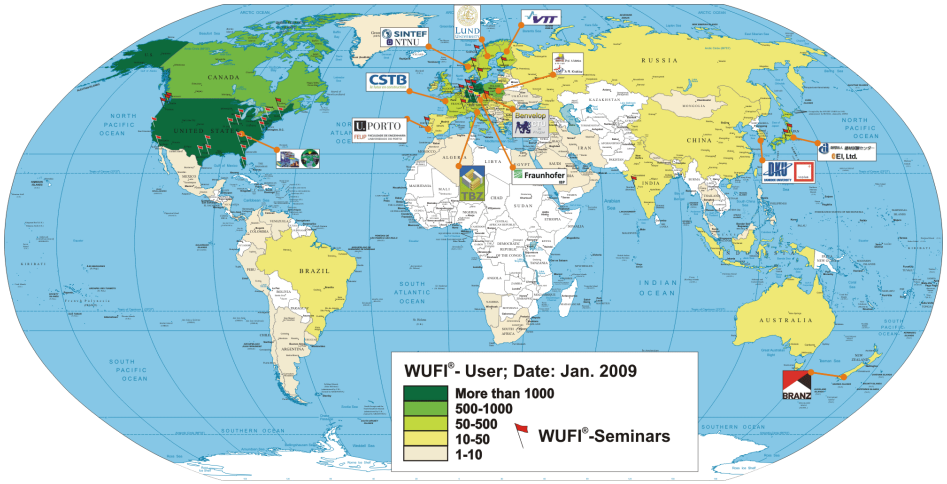
Introduction

▲ Twin houses for comparative energy efficiency tests of residential buildings

◄ Commercial test building to determine energy consumption and comfort conditions

Introduction



The hygrothermal simulation tool WUFI is used in more than 40 countries world-wide

PRESS RELEASE

PRESSE RELEASE
6. September 2012 || Page 1 | 3

A Design Tool for Passive Houses of the Future

Adoption of Passive House building principles is accelerating worldwide. The climate of the various countries where Passive Houses are being built has to be considered carefully for this unique type of design. Fraunhofer-Institute for Building Physics (IBP) has developed, in cooperation with the Passive House Institute US (PHIUS), the WUFI® Passive design software for Passive Houses in North America. The Fraunhofer IBP's hygrothermal analysis software WUFI® Plus was the basis for this new modeling tool.

3 years of successful cooperation with

PHIUS
Passive House Institute US

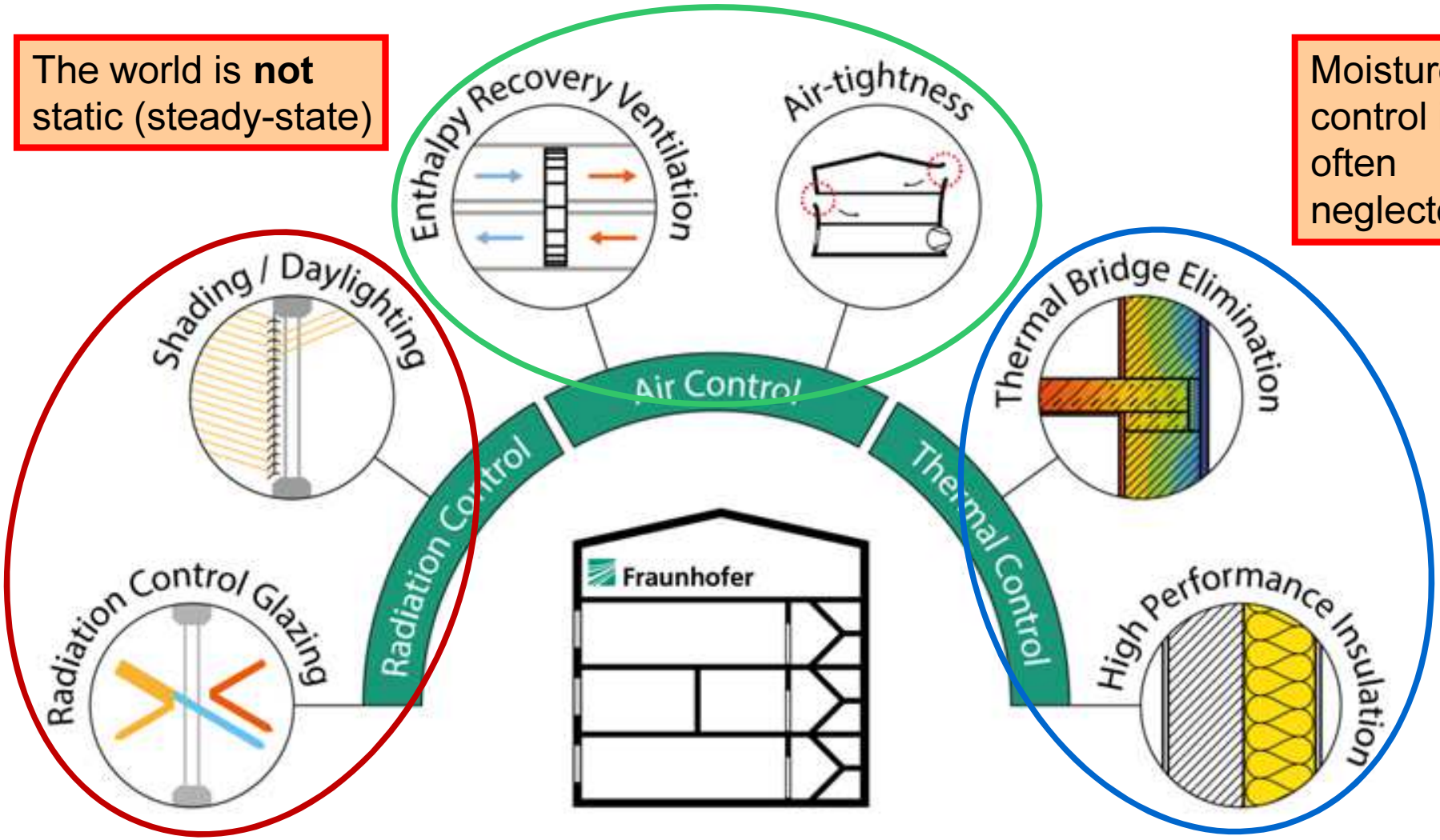
Fraunhofer IBP

Introduction

Passive design principles for energy efficient buildings

The world is **not** static (steady-state)

Moisture control is often neglected



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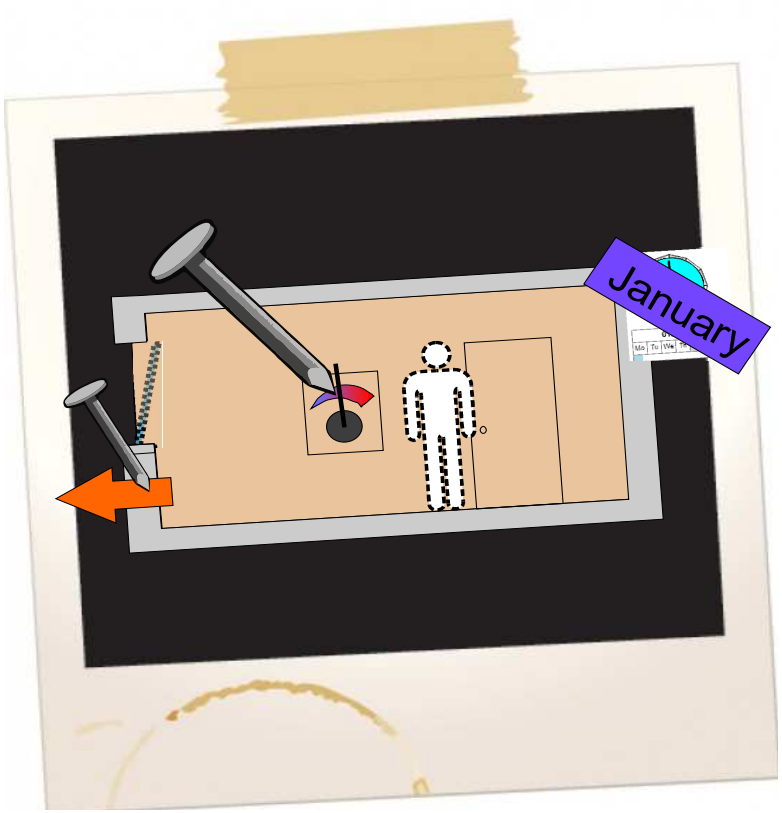
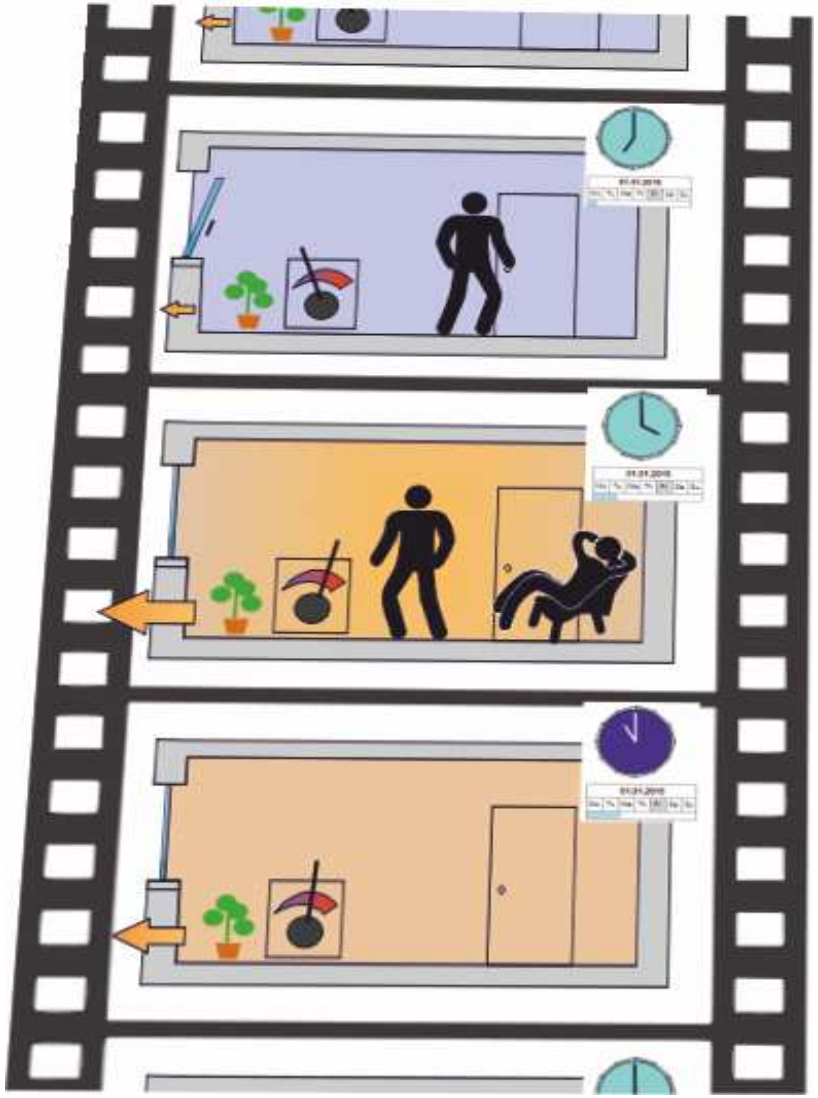
Static vs. dynamic

simple vs. complicated?
vague vs. accurate?





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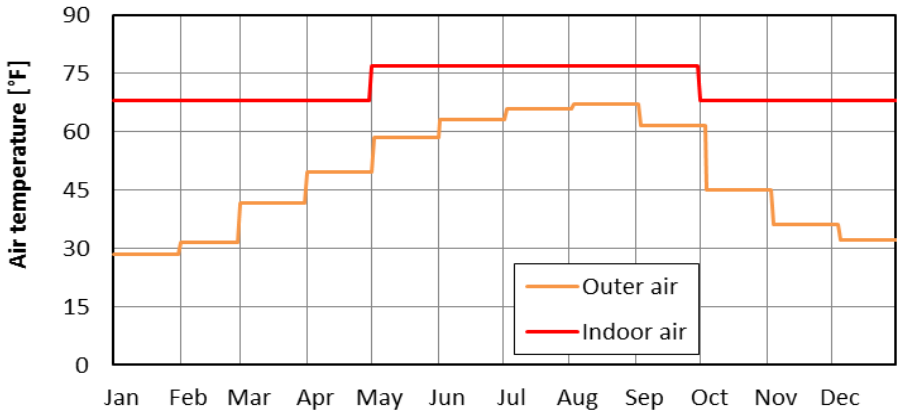
Static vs. dynamic

Monthly balance calculation



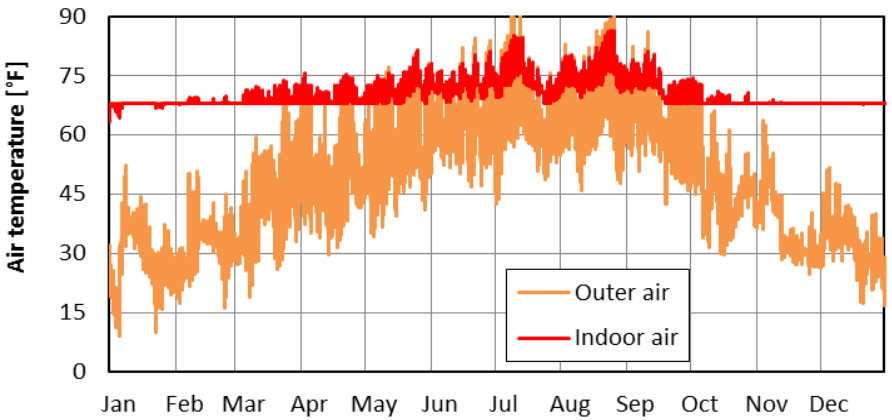
no thermal inertia

peak loads calculated separately

comfort conditions are estimated

time-averaged operation assumed

Dynamic simulation (hourly)



full heat and moisture storage

peak loads are part of results

dynamic comfort simulated

detailed operation profiles definable

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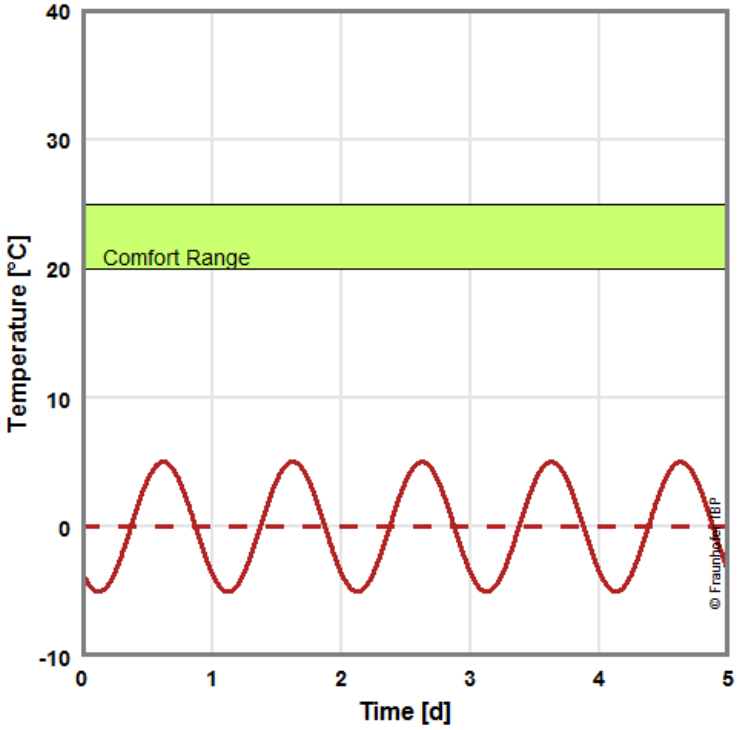
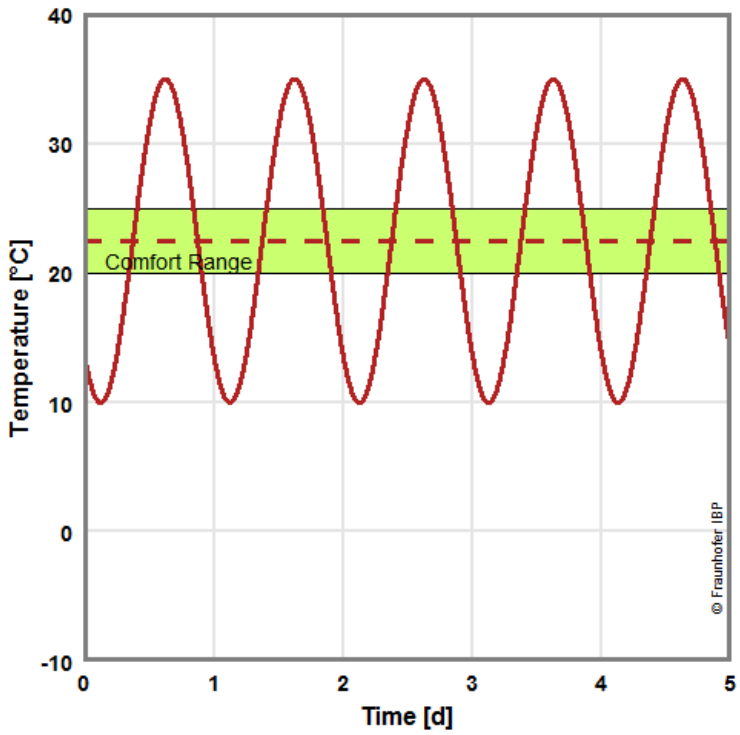
Static vs. dynamic

Heating climate



Monthly balance methods work well if heating is continuous

Cooling / mixed climate



Additional dynamic (hygrothermal) simulation recommended

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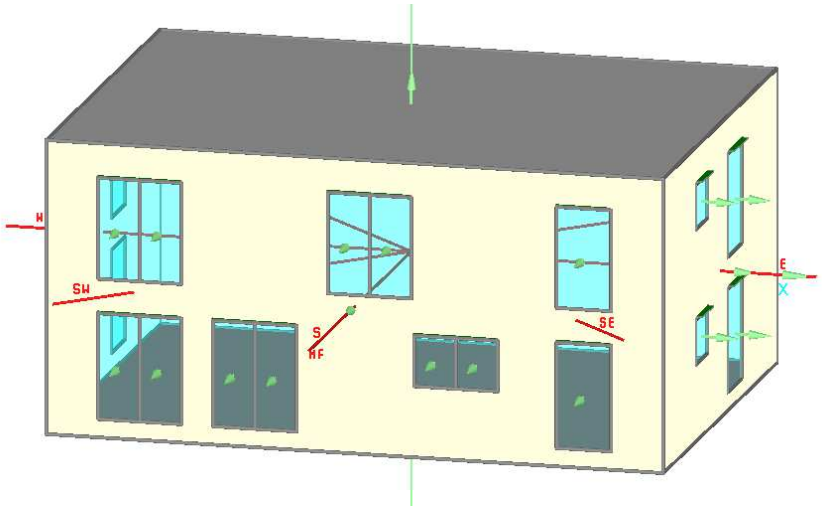
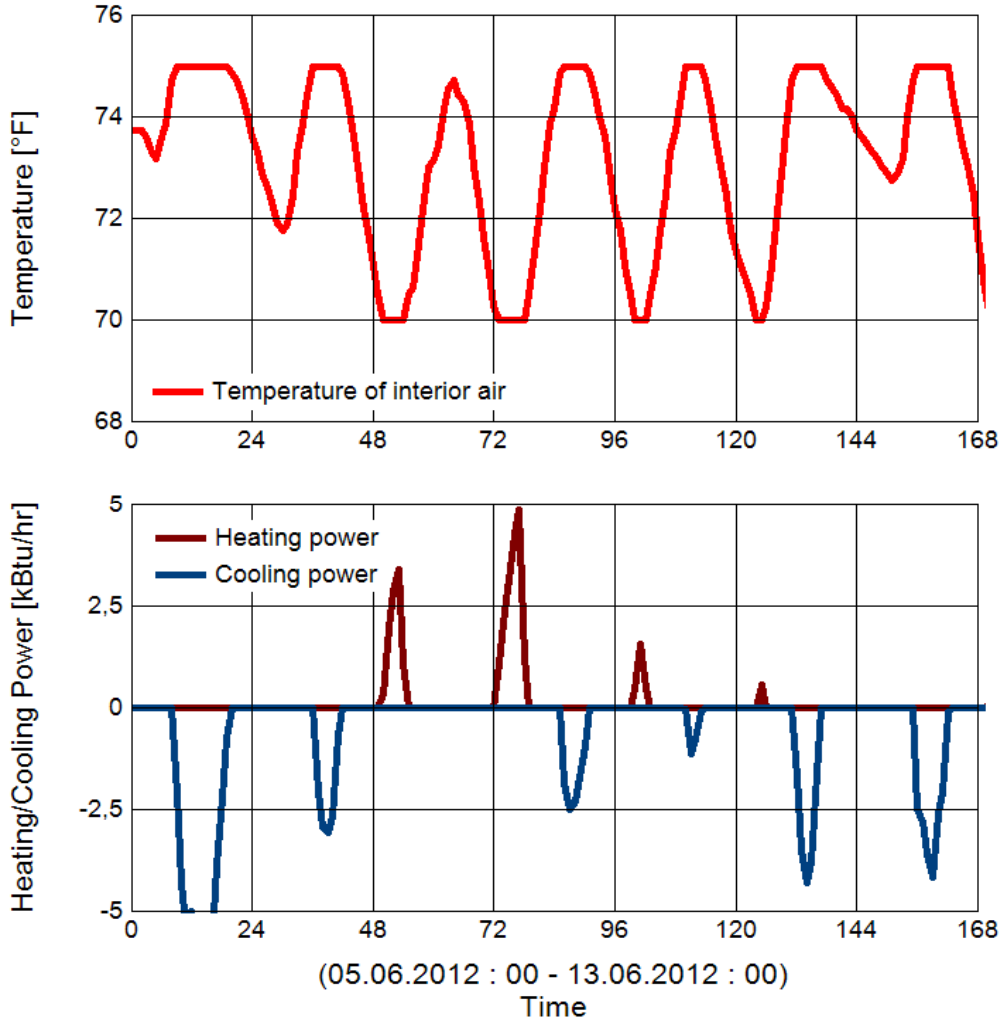
Static vs. dynamic

Heating and cooling in the same month



- **Passive House in Chicago**
- **Large window areas**
- **Mainly cellulose insulation**
- **R_{wall} and R_{slab} = 50 (h ft² F) / Btu**
- **R_{roof} = 60 (h ft² F) / Btu**

One week, beginning of June



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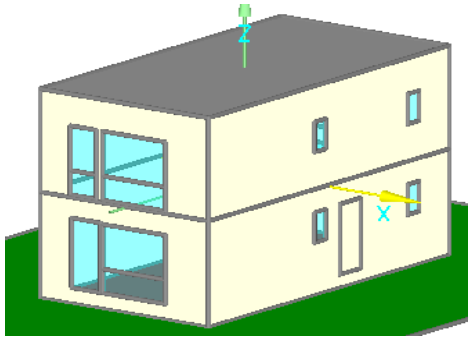
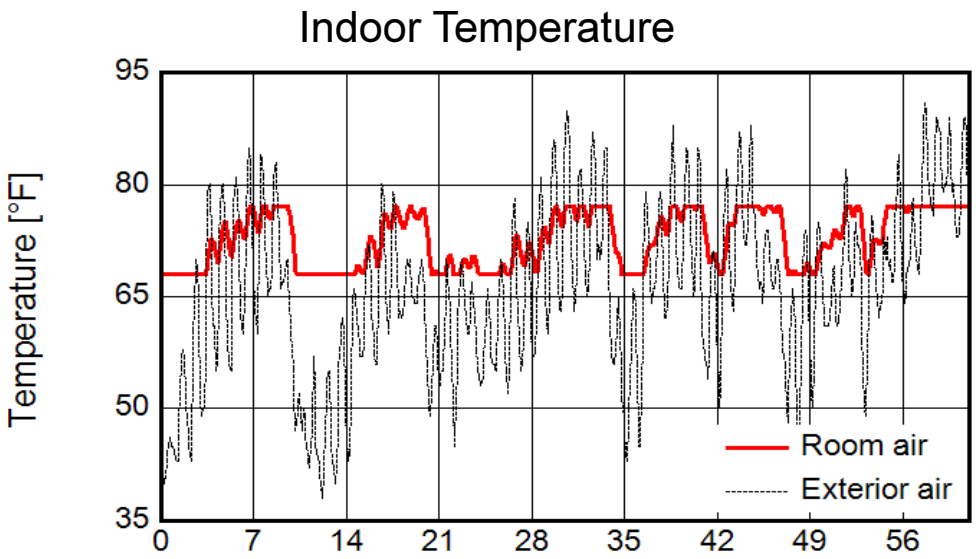
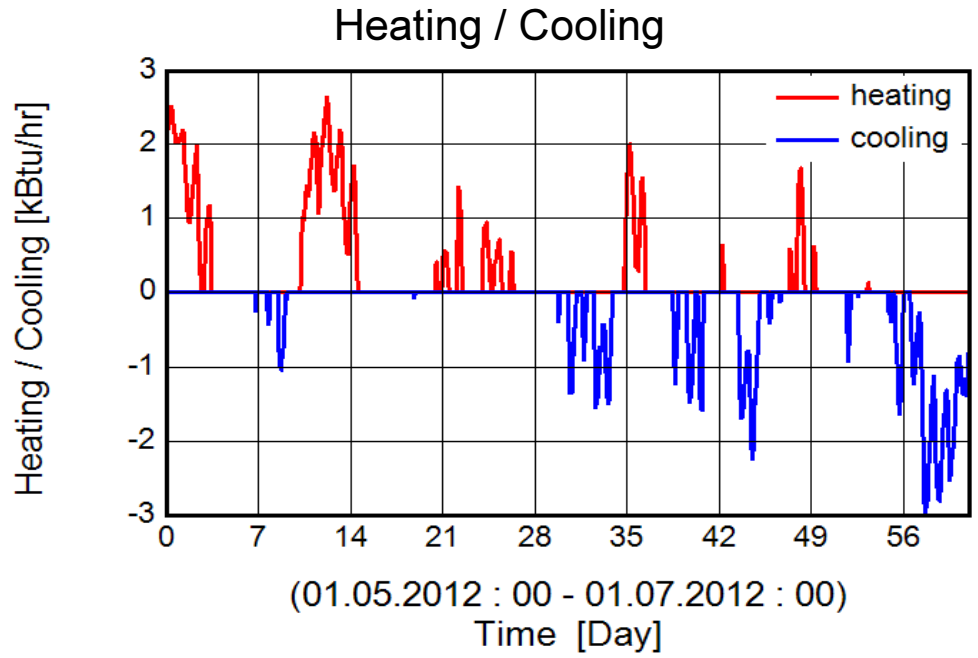
Static vs. dynamic



Dynamic conditions indoor

- Design conditions
  set points: 68 – 77°F
- Climate: **Savoy, IL**
- Heating Demand
  3,45 kBtu/ft²yr
- Cooling Demand
  2,843 kBtu/ft²yr





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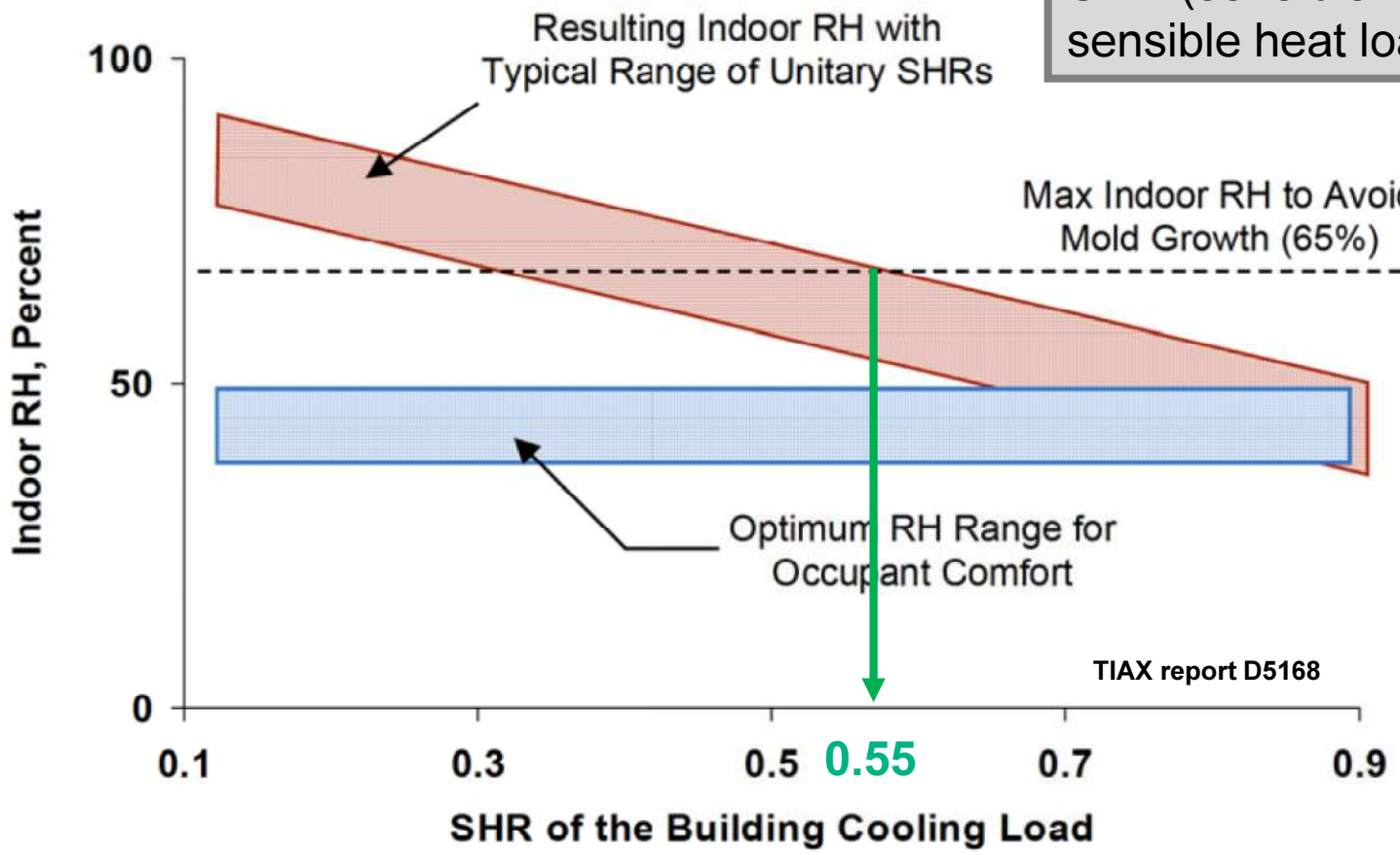
Static vs. dynamic

Moisture removal capacity of standard unitary AC systems

SHR (sensible heat ratio) = sensible heat load / total heat load)



High latent loads may cause high indoor RH

Further problem:

latent capacity degradation at part load

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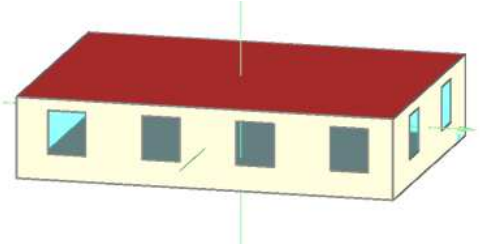
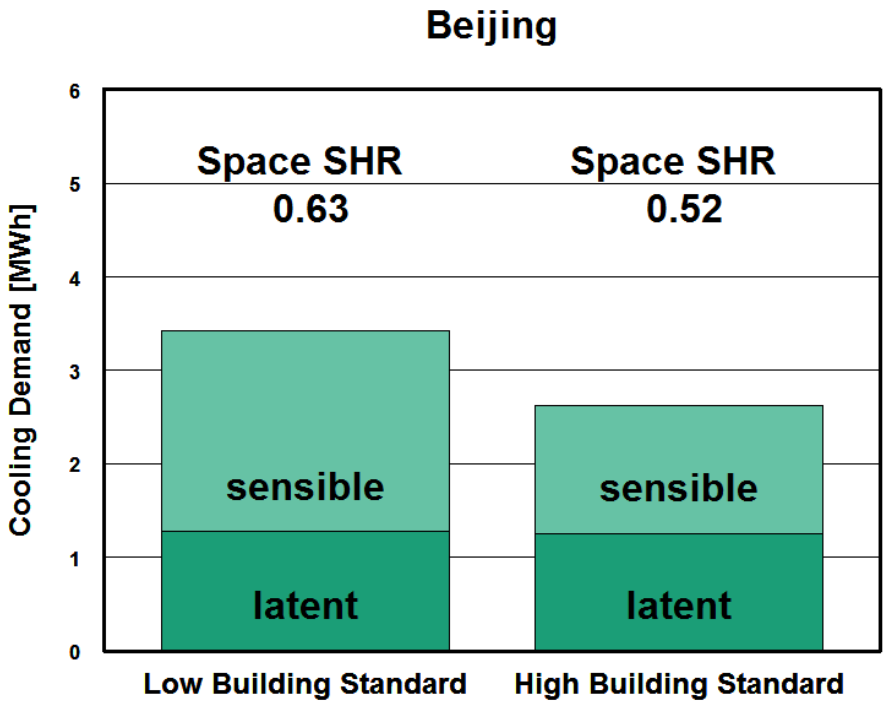
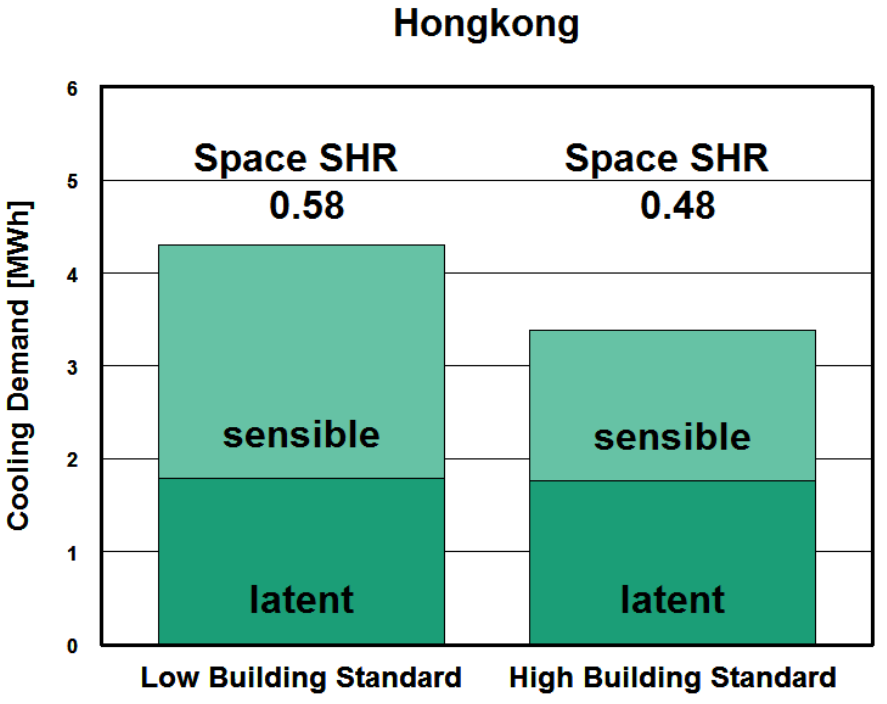
Static vs. dynamic



Sensible heat ratio (SHR) of cooling loads in apartment building July / August





- Low Building Standard: U-wall = 1.2 W/(m²K), U-window = 2.7 W/(m²K), g=0.45
- High Building Standard: U-wall = 0.26 W/m²K, U-window = 1.3 W/(m²K), g=0.3
- Ventilation: 0.6 ACH
- Set-Points: 25°C; 50 % RH

Improving the building standard reduces SHR of the cooling load

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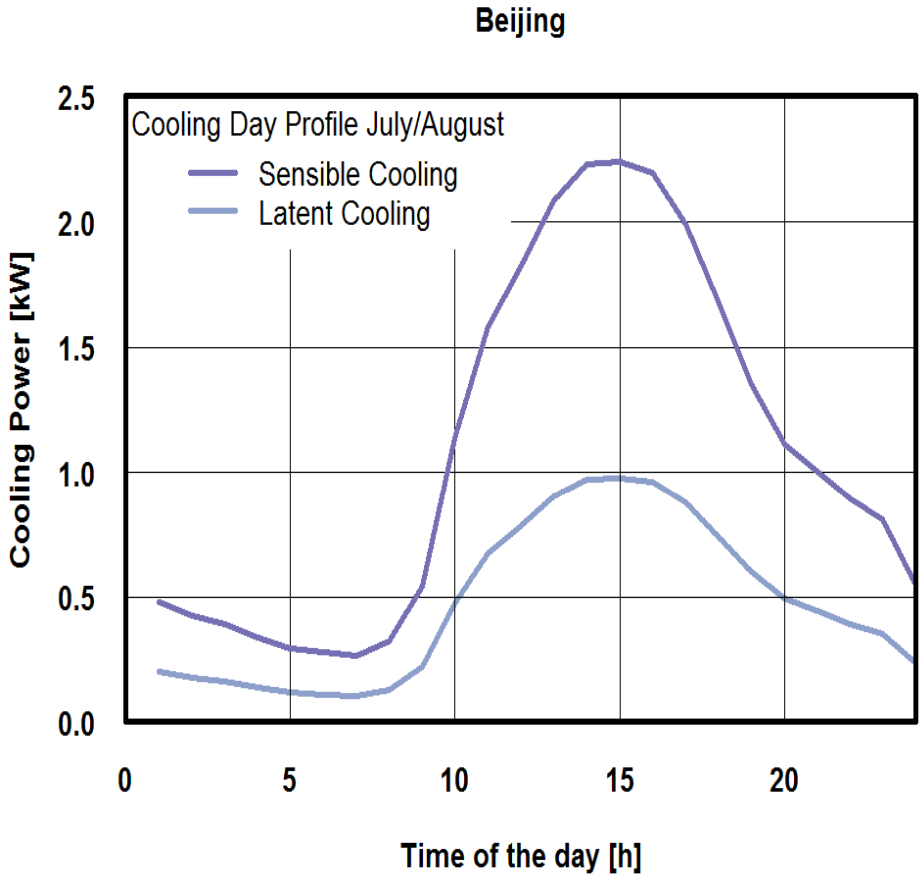
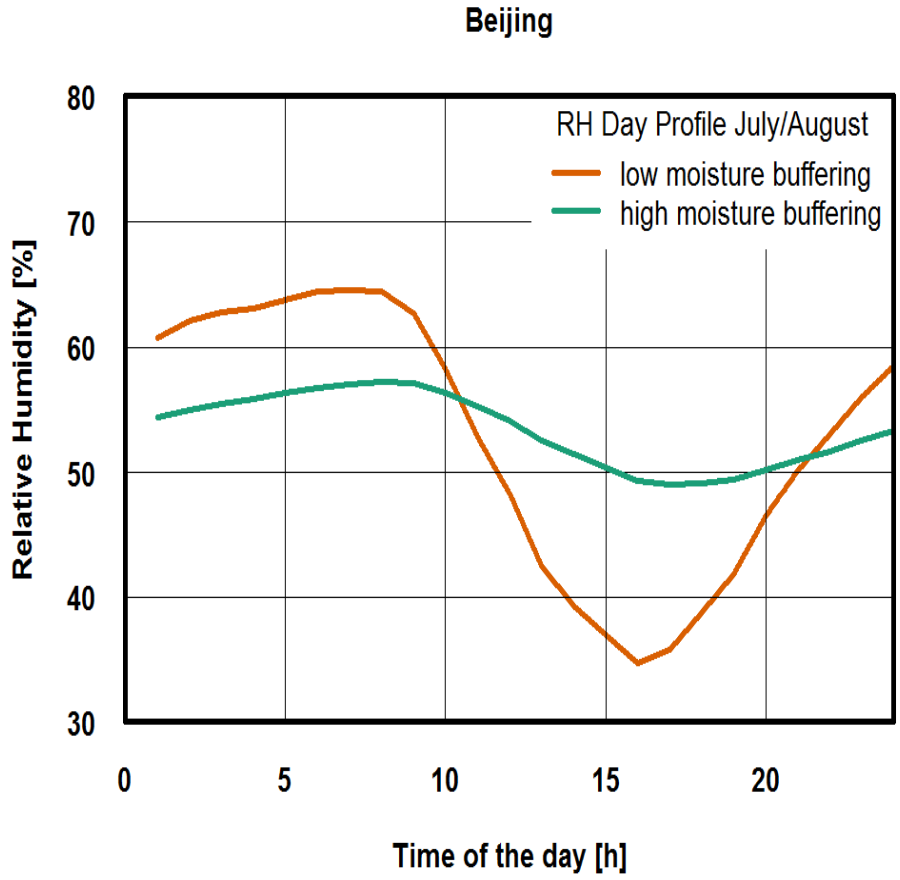
Static vs. dynamic

Cooling loads and indoor RH in apartment building July / August





Moisture buffering capacity of the envelope dampens daily indoor RH fluctuations

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Static vs. dynamic

Energy efficiency measures and moisture control

In 2003 ASHRAE created a new TC on **Moisture Management in Buildings**

They sponsored a Forum dealing with the topic: **Solving Moisture Problems Created By Energy Retrofits**

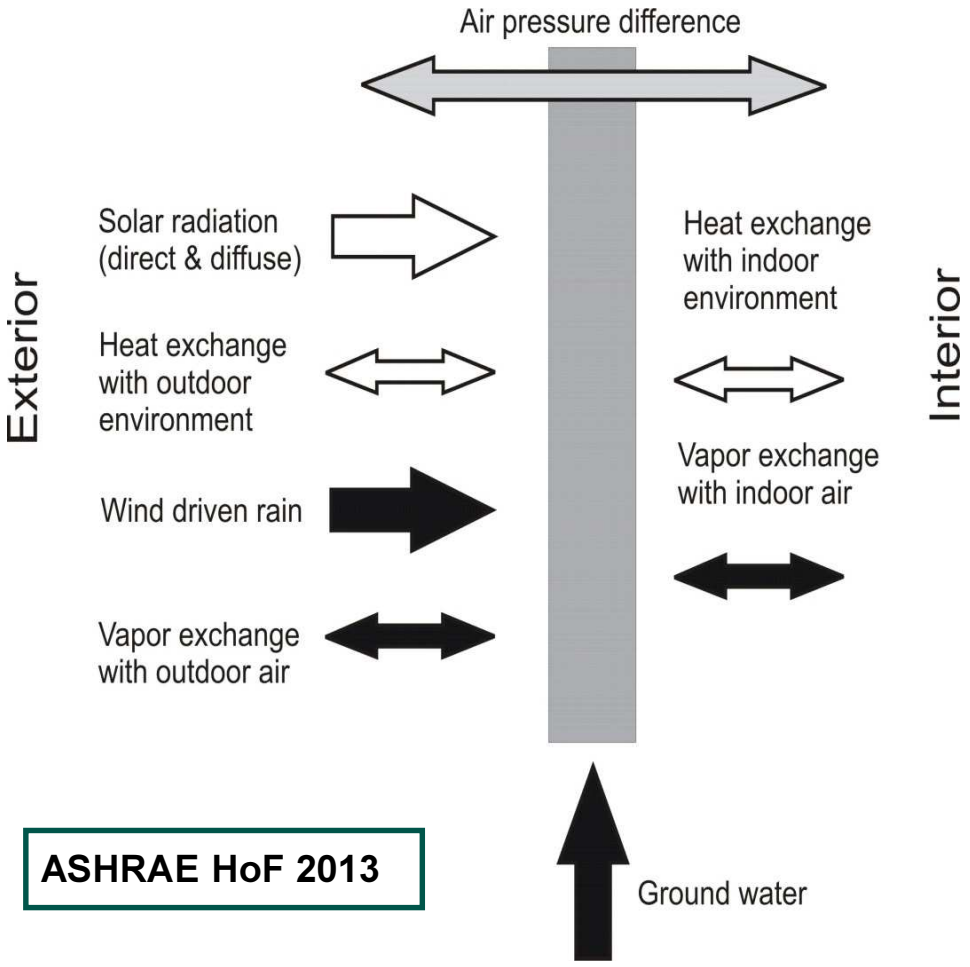
General problems / challenges associated with energy efficiency:

- better insulation >> colder exterior surfaces & less heat available to evaporate water in the assembly
- better air-tightness >> less air infiltration (cold climate problem)
- HVAC dehumidification capacity at part load conditions

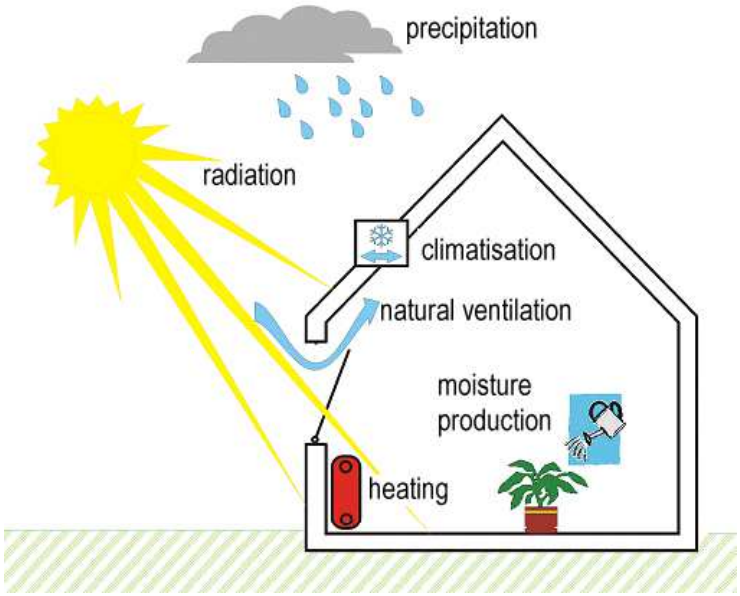
Most problems can be solved by appropriate moisture control design

Moisture control

Hygrothermal envelope loads



ASHRAE HoF 2013



Moisture control:

Protecting buildings and building systems from exterior and interior moisture loads

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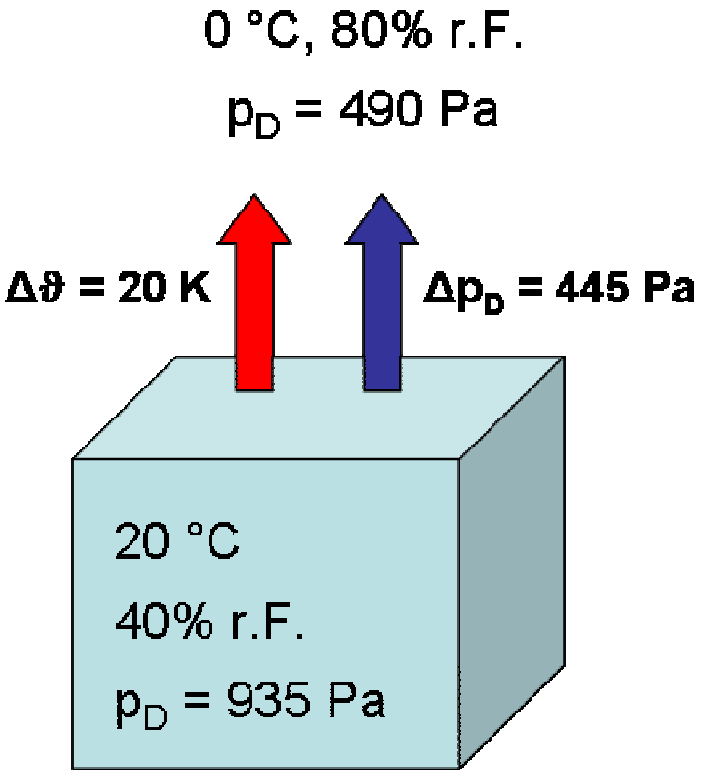
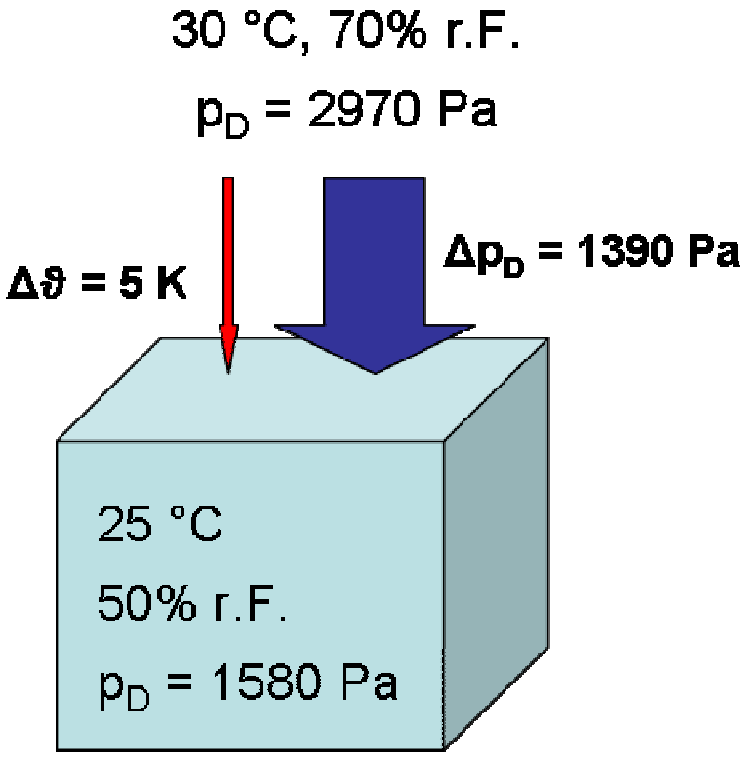
Moisture control

Temperature and vapor pressure gradients

Heating period: outdoor temp. 0 °C



Cooling period: outdoor temp. 30 °C



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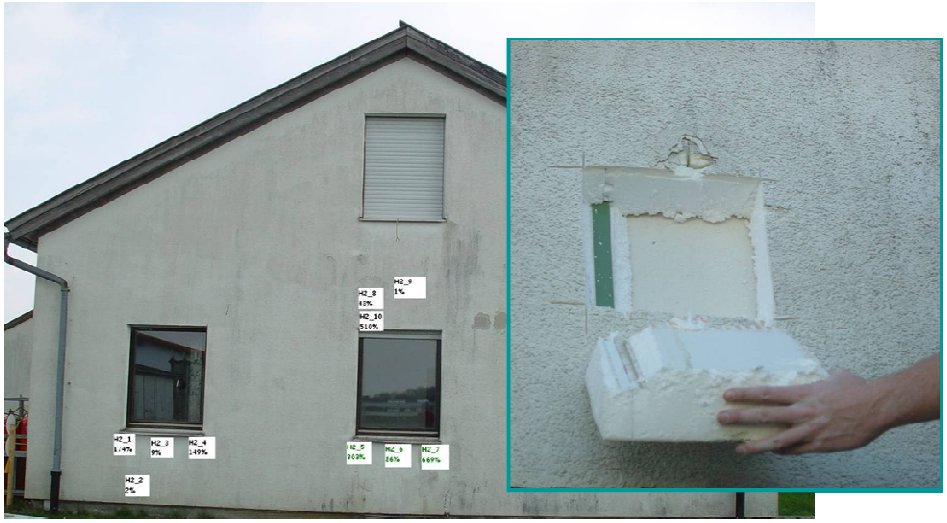
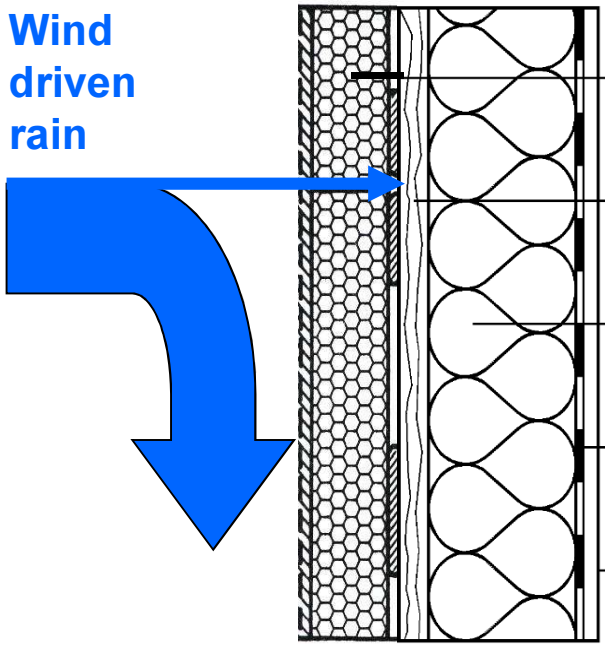
Moisture control

Driving rain





Driving rain is a major cause for building envelope failure

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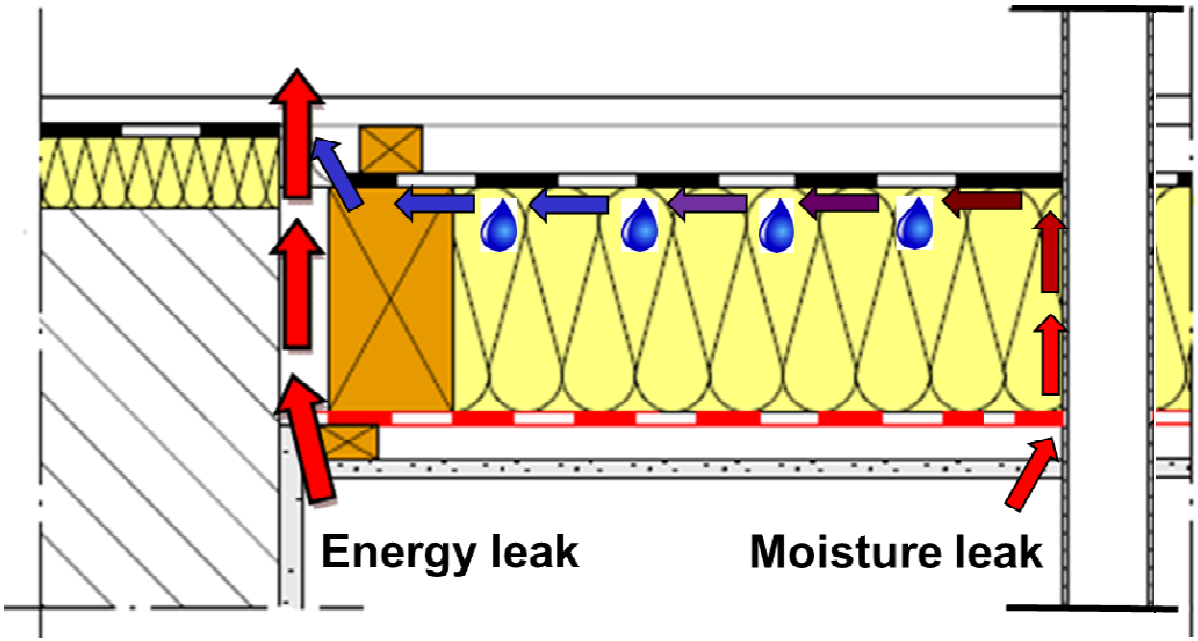
Moisture control

Air flow through the envelope



There is no perfect seal against airflow. Even best practice installations cannot exclude some limited vapor convection.

Therefore: sufficient drying potential is essential!

Condensing moisture may be trapped

>> Double barrier assemblies often fail

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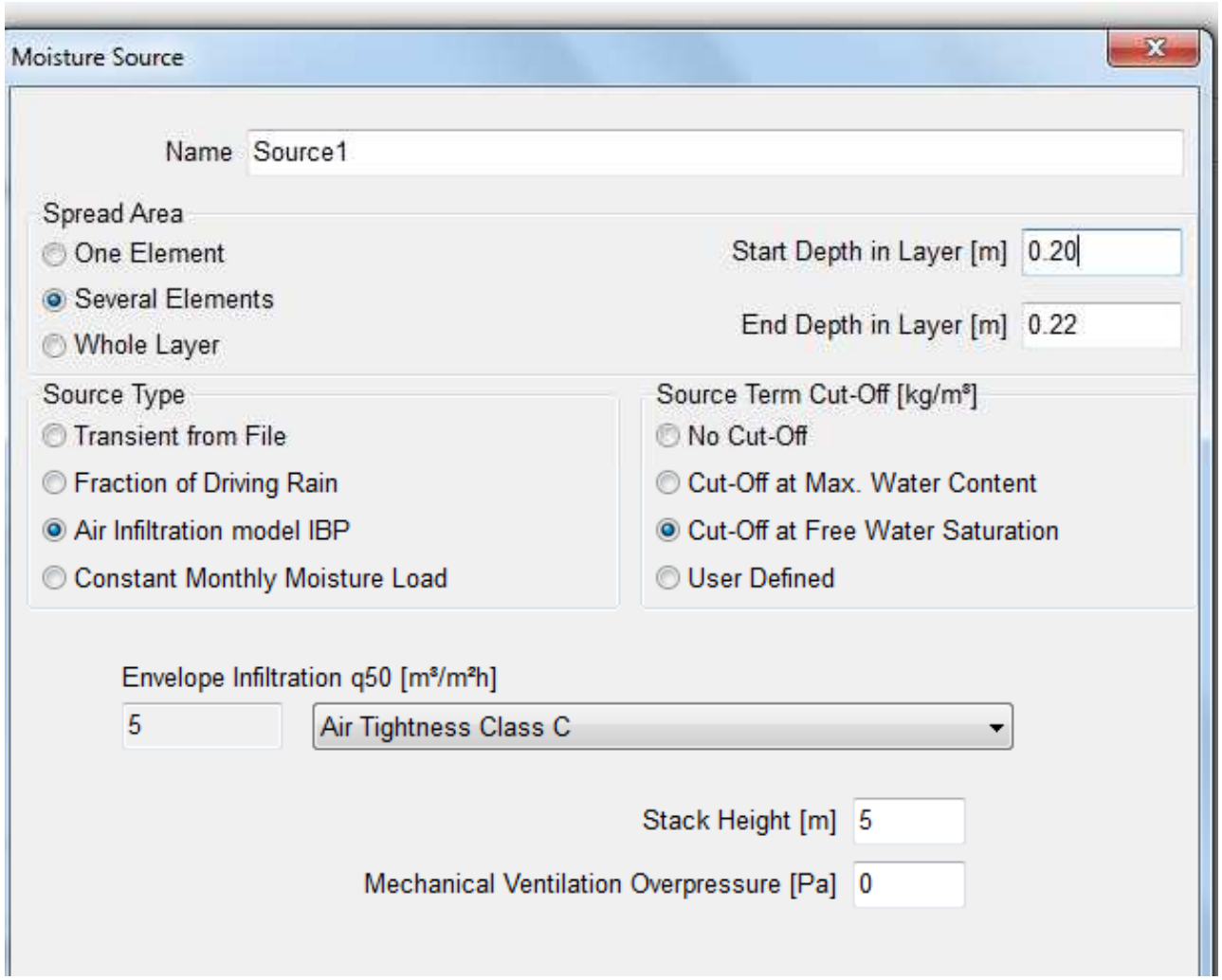
Moisture control

Air flow through the envelope



Options to consider moisture sources in WUFI®

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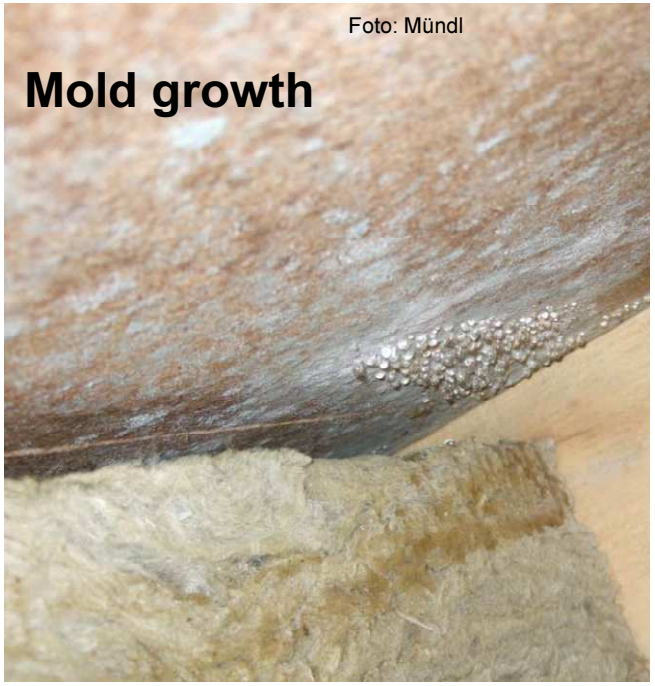
Moisture control

Construction moisture



Masonry moisture may move upwards into the roof

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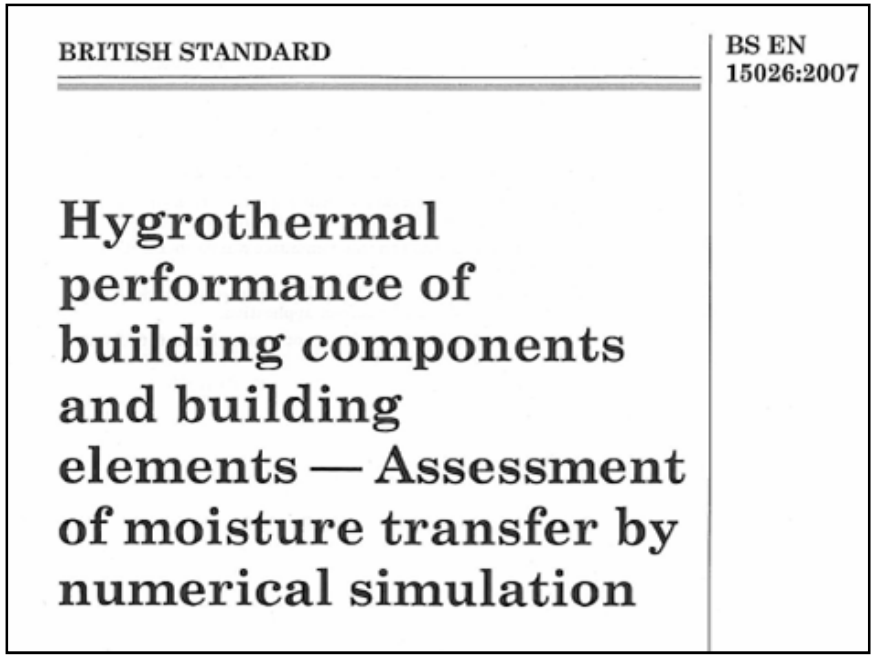
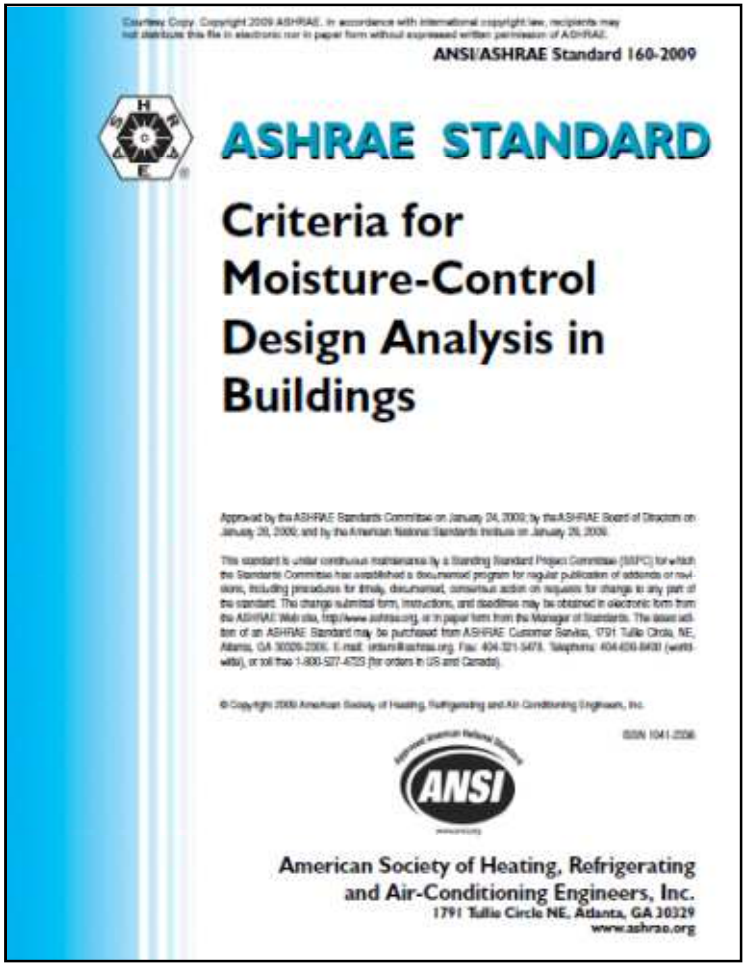
Moisture control

Moisture control design by hygrothermal simulation


BRITISH STANDARD

BS EN 15026:2007

Hygrothermal performance of building components and building elements — Assessment of moisture transfer by numerical simulation


ANSI/ASHRAE Standard 160-2009

ASHRAE STANDARD

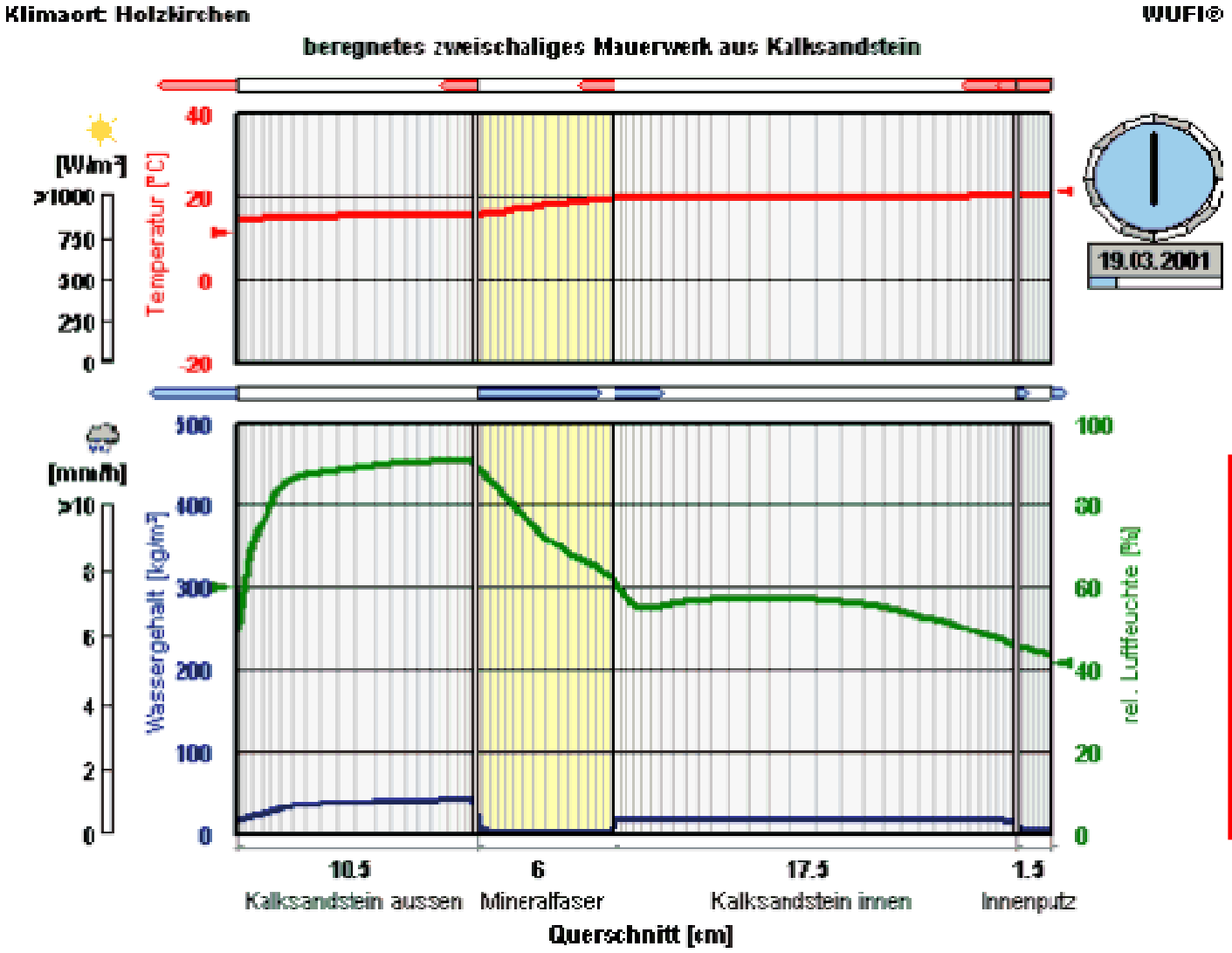
Criteria for Moisture-Control Design Analysis in Buildings

ANSI

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
1791 Tullie Circle NE, Atlanta, GA 30329
www.ashrae.org

Hygrothermal behavior may be determined by validated simulation models ref. to EN 15026 or ASHRAE Std 160

Moisture control



Hygrothermal simulation of dynamic temperature and moisture conditions in a cavity wall

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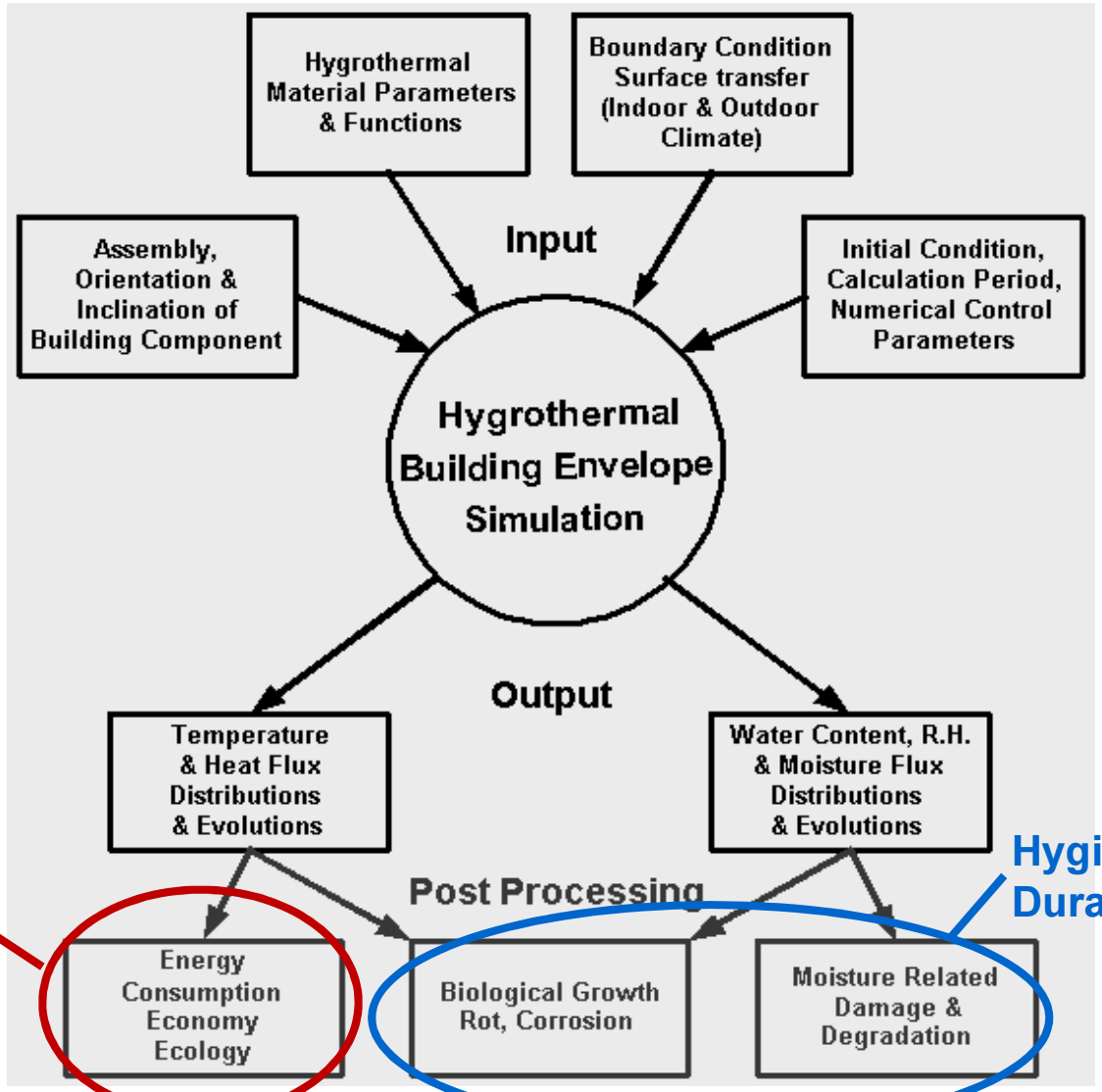
Moisture control

Evaluation of transient hygrothermal simulation results by post process models

Flow chart in prEn 15026 showing how to perform hygrothermal simulation and how to evaluate the results



Energy related consequences

Hygiene Durability

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Moisture control

Assessing durability

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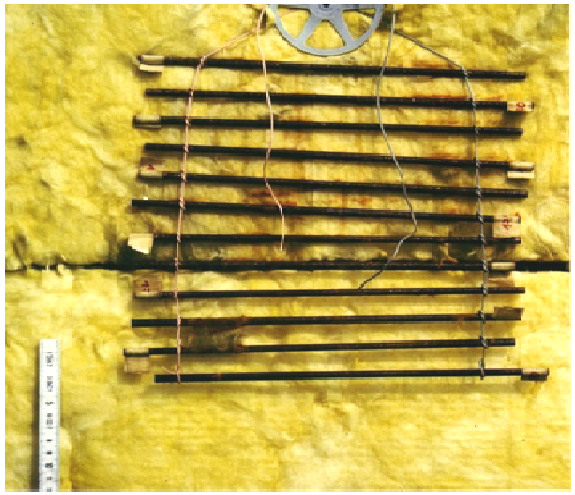
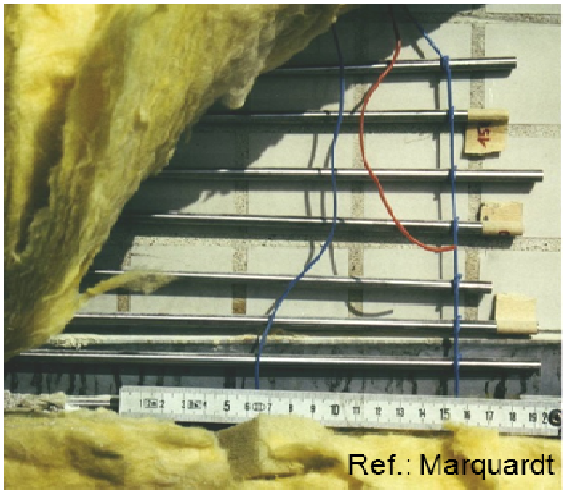
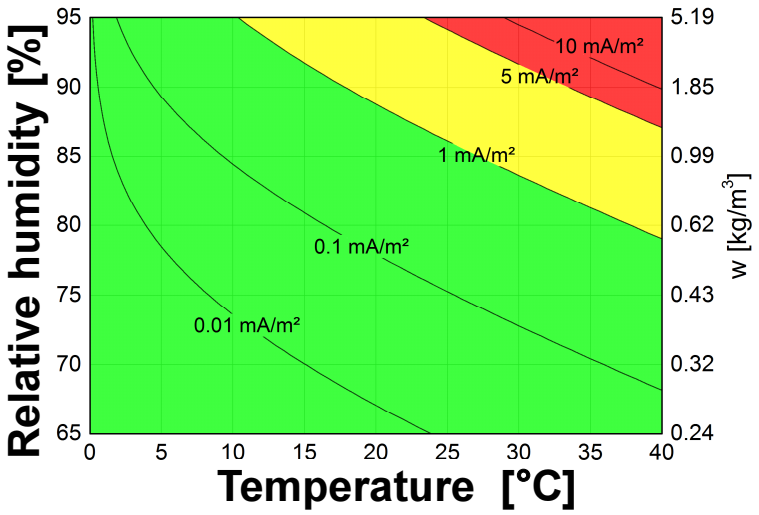
Moisture control

Predicting corrosion (WUFI® Corr)





Steel bars behind cladding & behind insulation



Corrosion rate = f (temp., RH)

Corrosion rates of steal in mortar determined as function of temp. and RH

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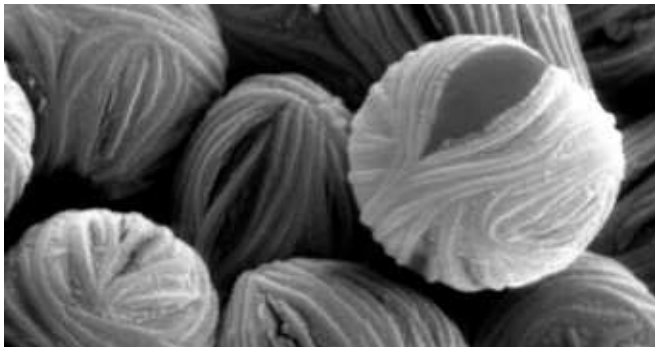
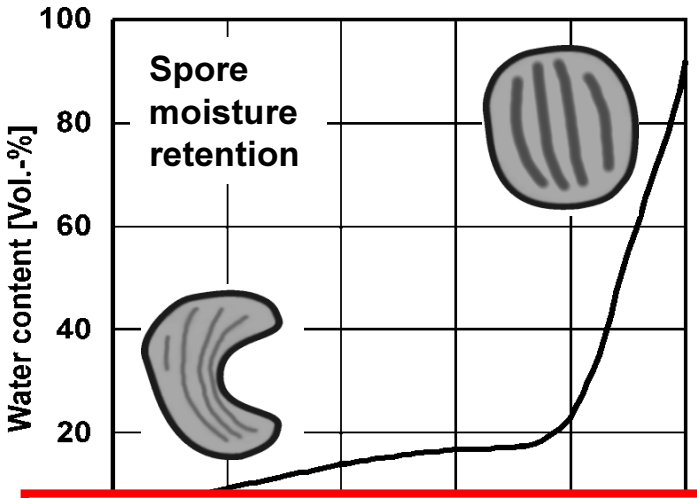
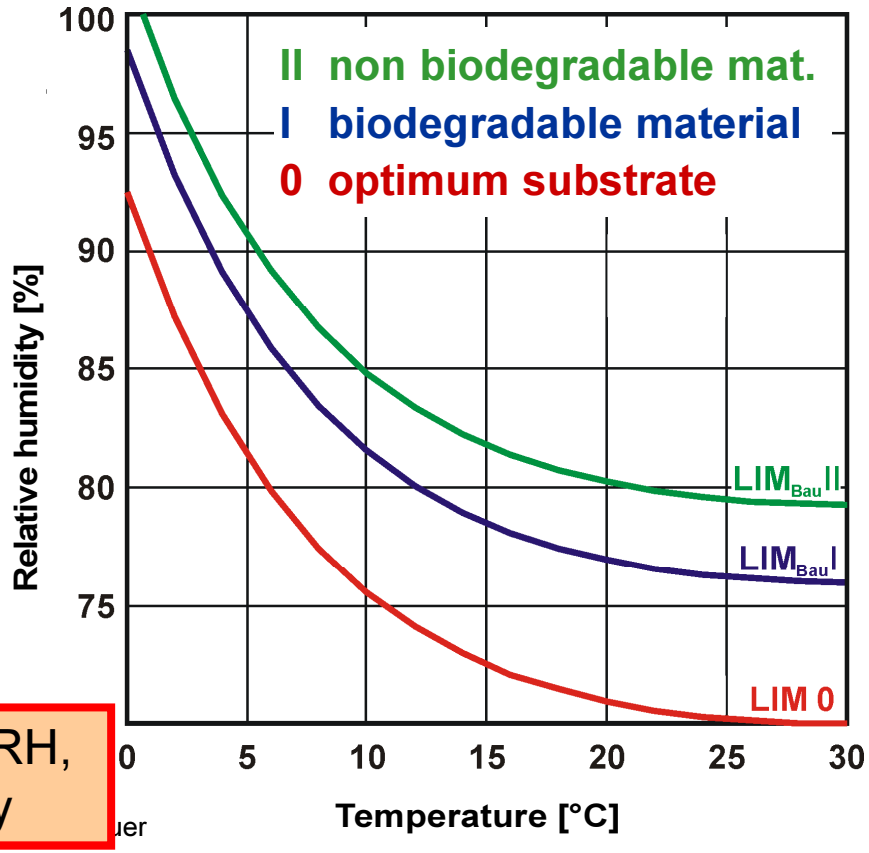
Moisture control

Modeling mold growth







Mold growth depends mainly on RH, temperature and substrate quality

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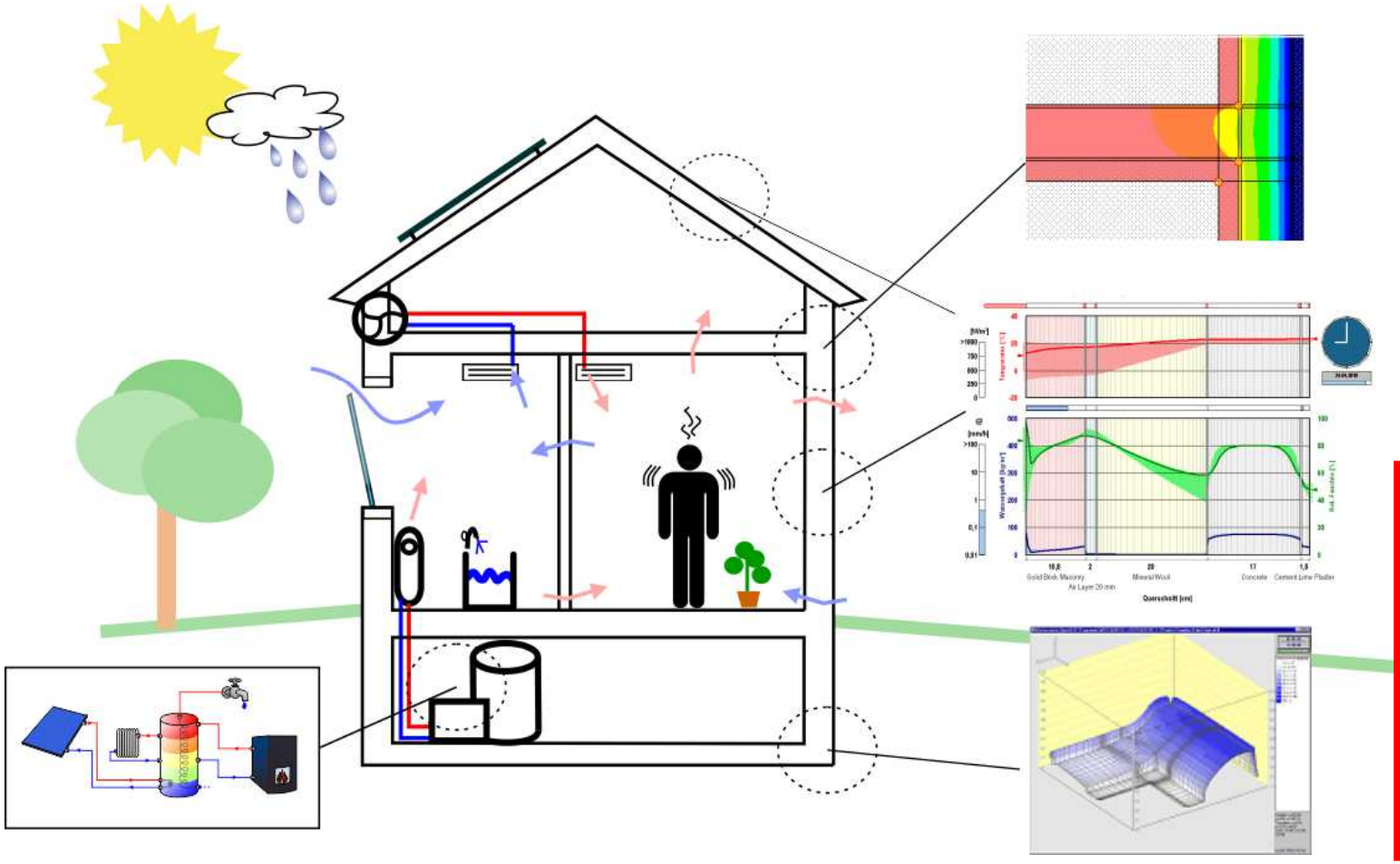
Hygrothermal whole building simulation

WUFI® Passive includes all heat and moisture exchange processes between the interior spaces and the building envelope



Thermal bridges bear the highest mold growth risk

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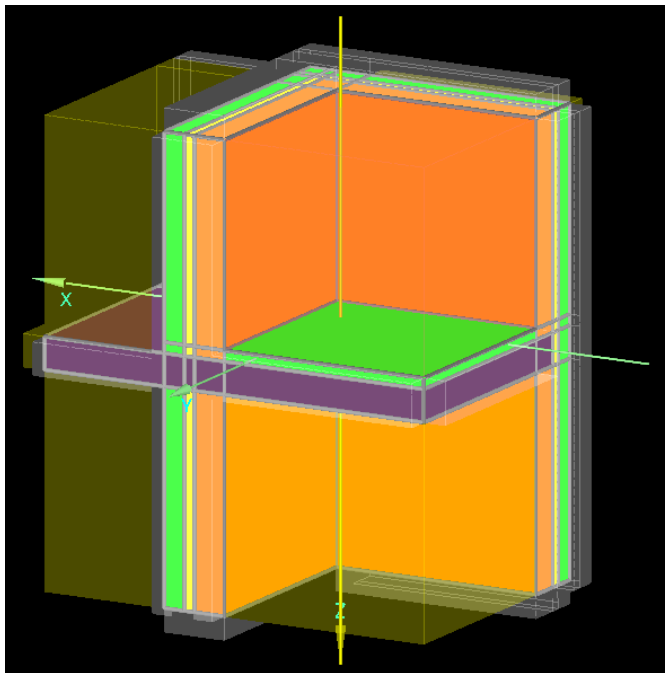
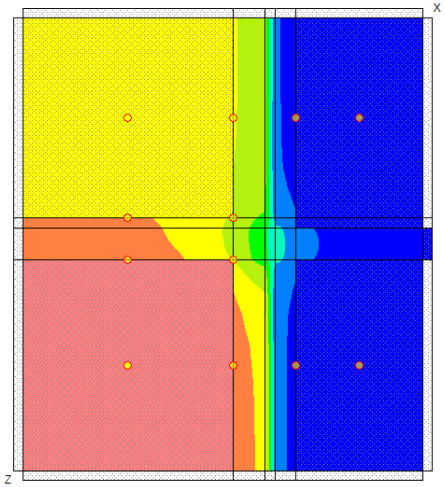
Hygrothermal whole building analysis

Dynamic thermal bridge calculation

- 2- and 3-dimensinal thermal bridges
- With temperature and solar radiation as boundary conditions
- Dew point assessment on monitor positions
- Additional heat flux due to thermal bridge





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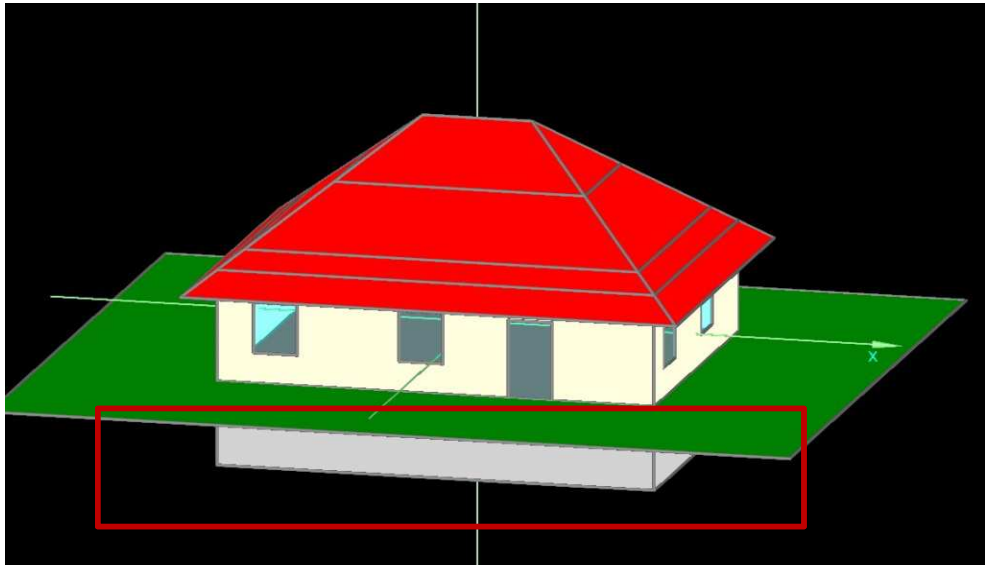
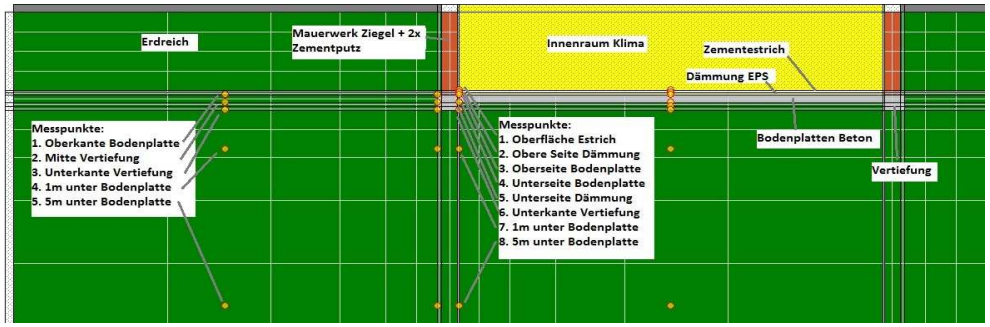
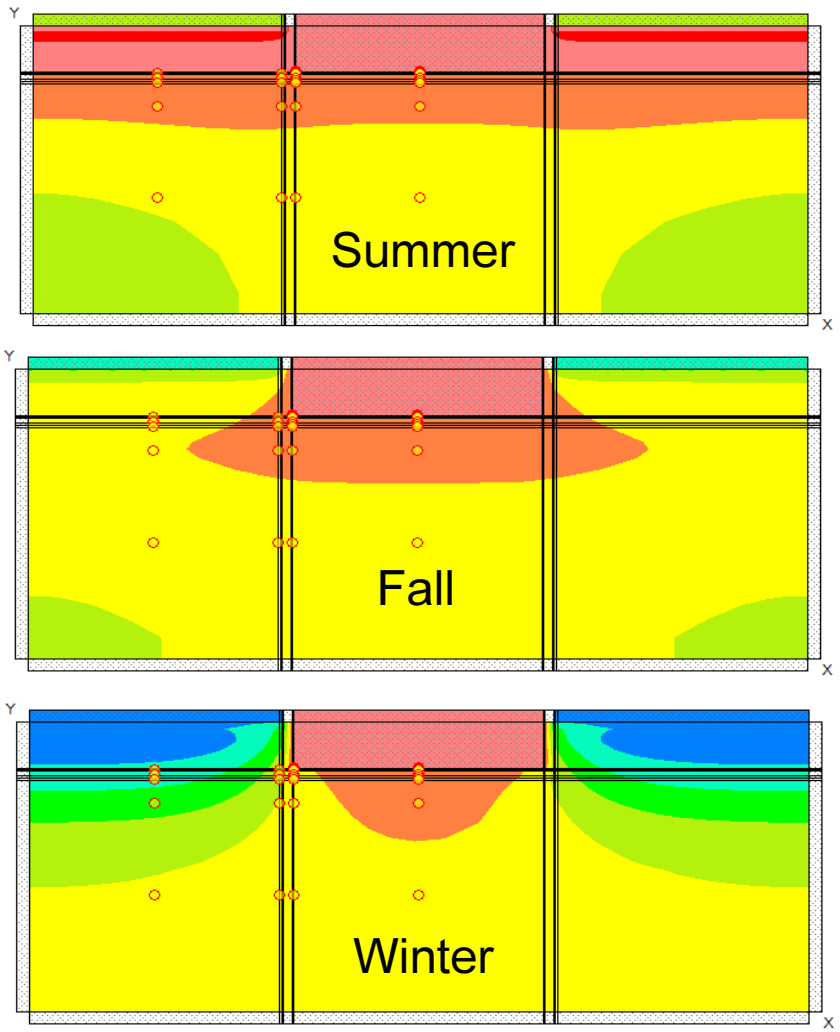
Hygrothermal whole building analysis

Ground heat transfer (3D simulation)





Temperature and solar radiation on the ground as boundary conditions



Results for heating dominated climate

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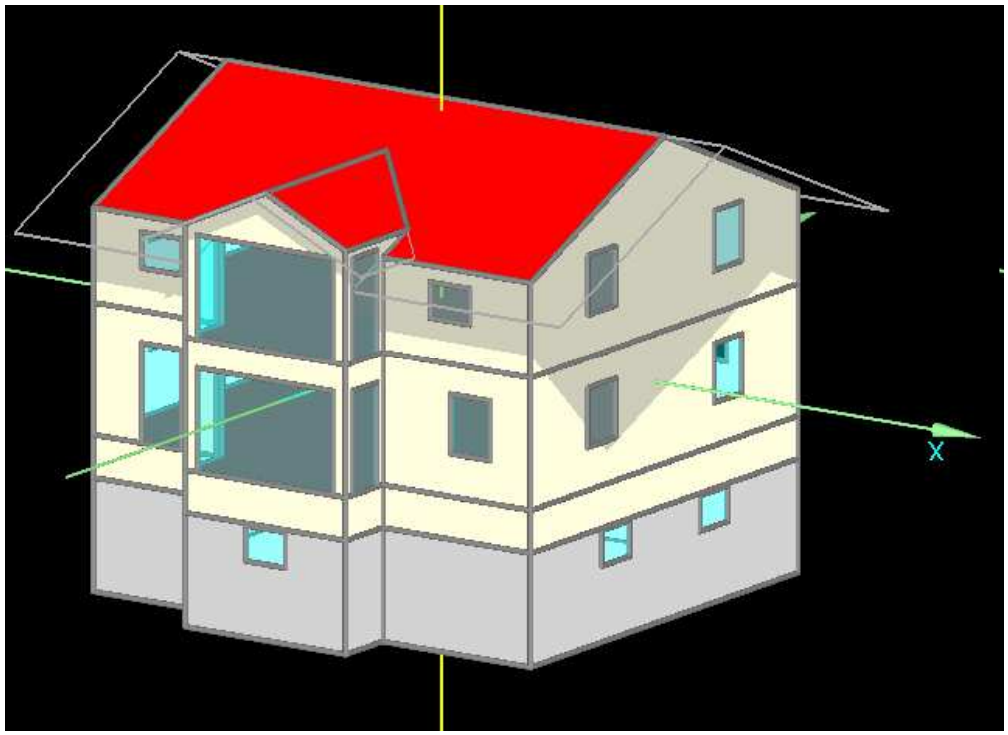
Hygrothermal whole building analysis

Shading (never static or constant)



- Specification of elements to be shaded
- Self shading and exterior elements
- Calculated shading factors for each hour of the simulation period

Hygrothermal whole building analysis

Shading or art – complex thermal bridges

J. Gang

Entering the details of the structure for thermal bridge calculations may be time-consuming

Hygrothermal whole building analysis

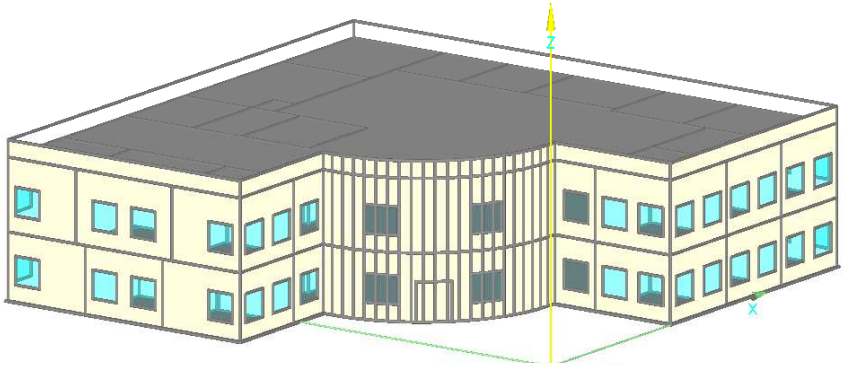
Data import for easy use of WUFI® Passive

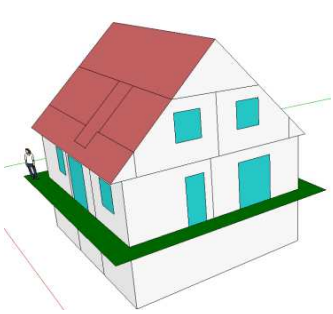
Revit import

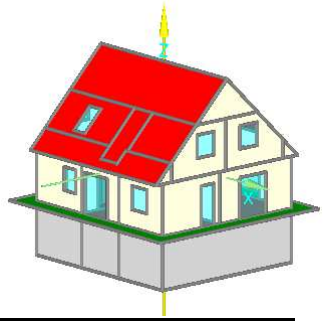
- Export Revit Model as gbXML
- Import any gbXML in WUFI Plus
- Predefined Zone definition

Sketch-Up import

- Additional Sketch-Up Plug-in
- One- and multi-zone Buildings
- With and without shading elements







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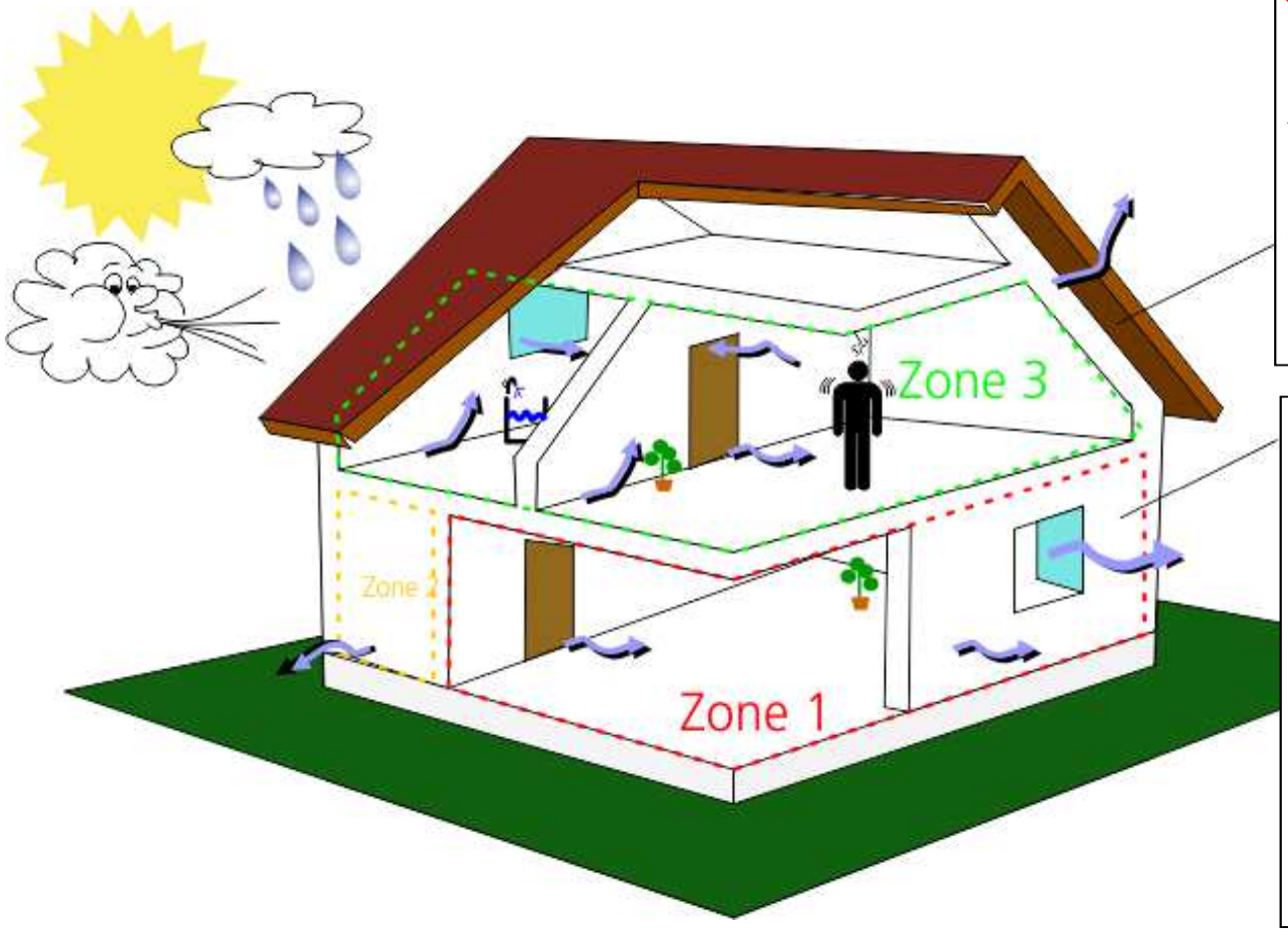
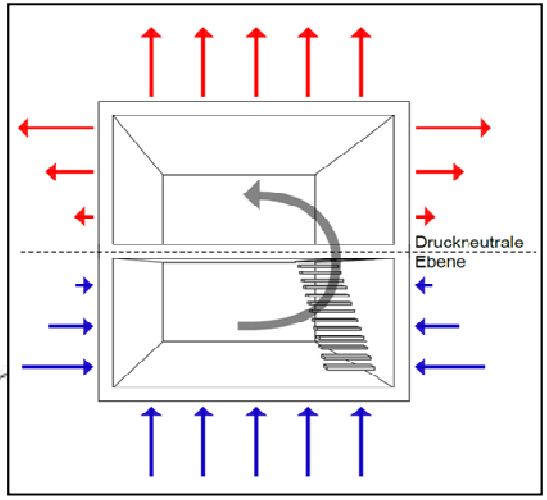
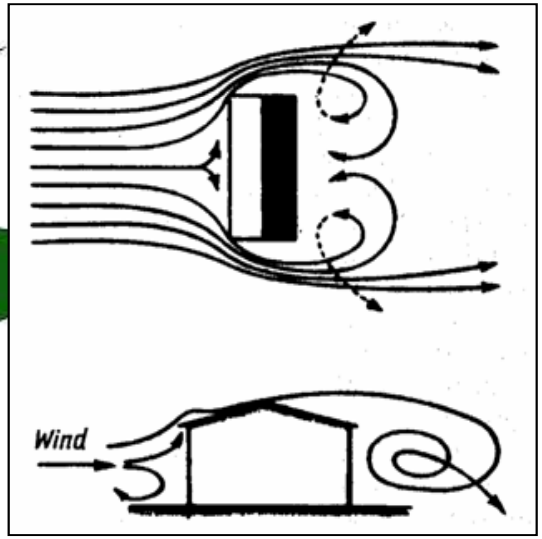
Hygrothermal whole building simulation

WUFI® Passive includes interzonal air exchange







Warm & humid air entering a cold zone may cause mold problems

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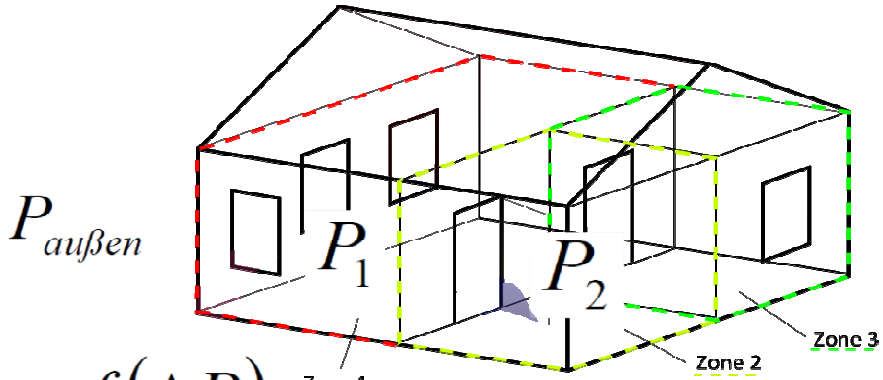
Hygrothermal whole building analysis

Multi-zone airflow model

Specification of airflow paths responding to pressure difference due to

- density difference (stack effect)
- wind pressure
- mechanical ventilation systems



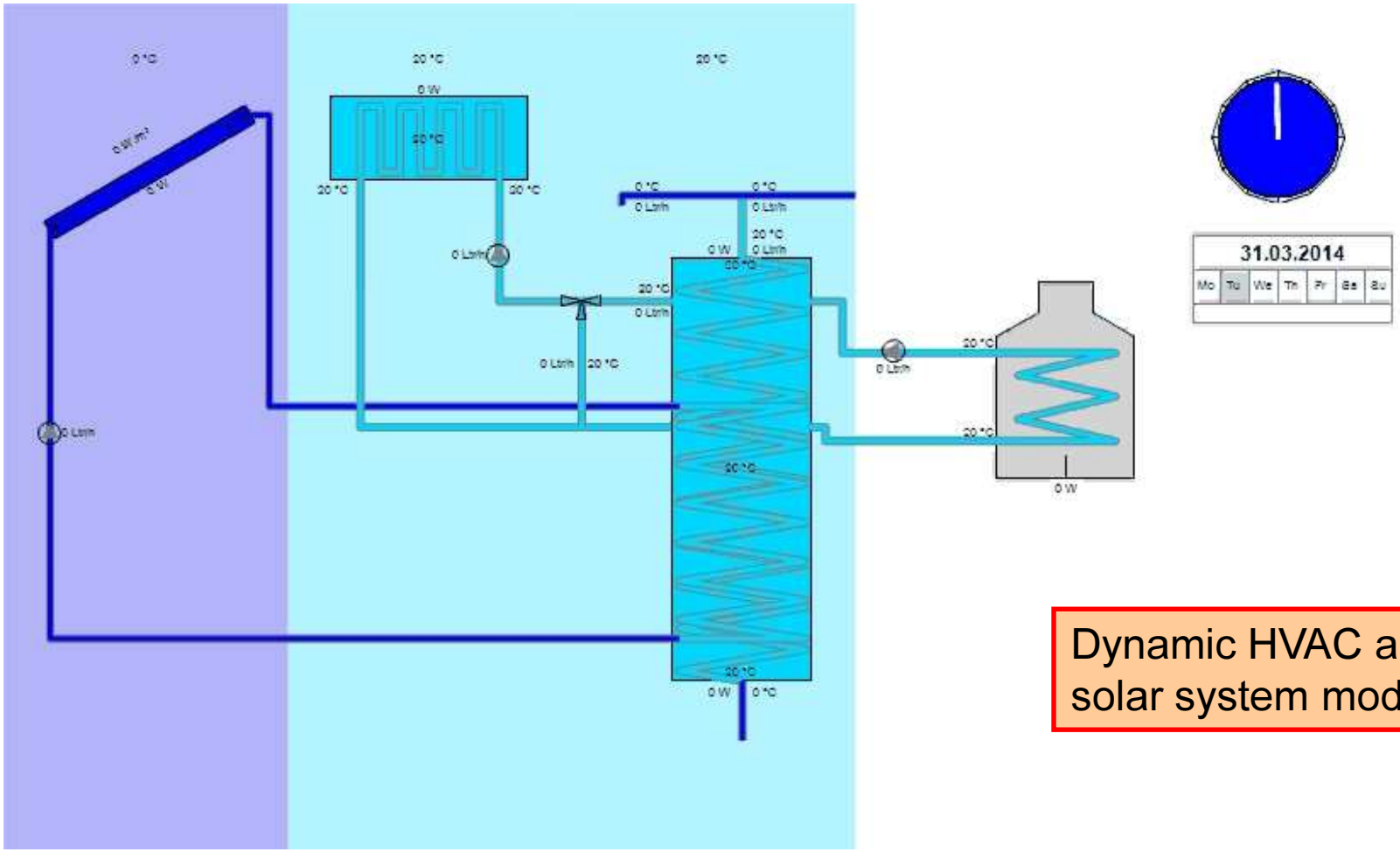
$$\dot{m} = f(\Delta P)$$

Implemented so far:

- small openings, cracks
- large openings / doors, windows (two way flow)
- fans (constant massflow-, volumeflowrate, fan-graphs)
- ducts
- effective leakage area

Hygrothermal whole building analysis

Solar Thermal Tabs Storage and DWH Gas Condensing Boiler



Dynamic HVAC and solar system modeling

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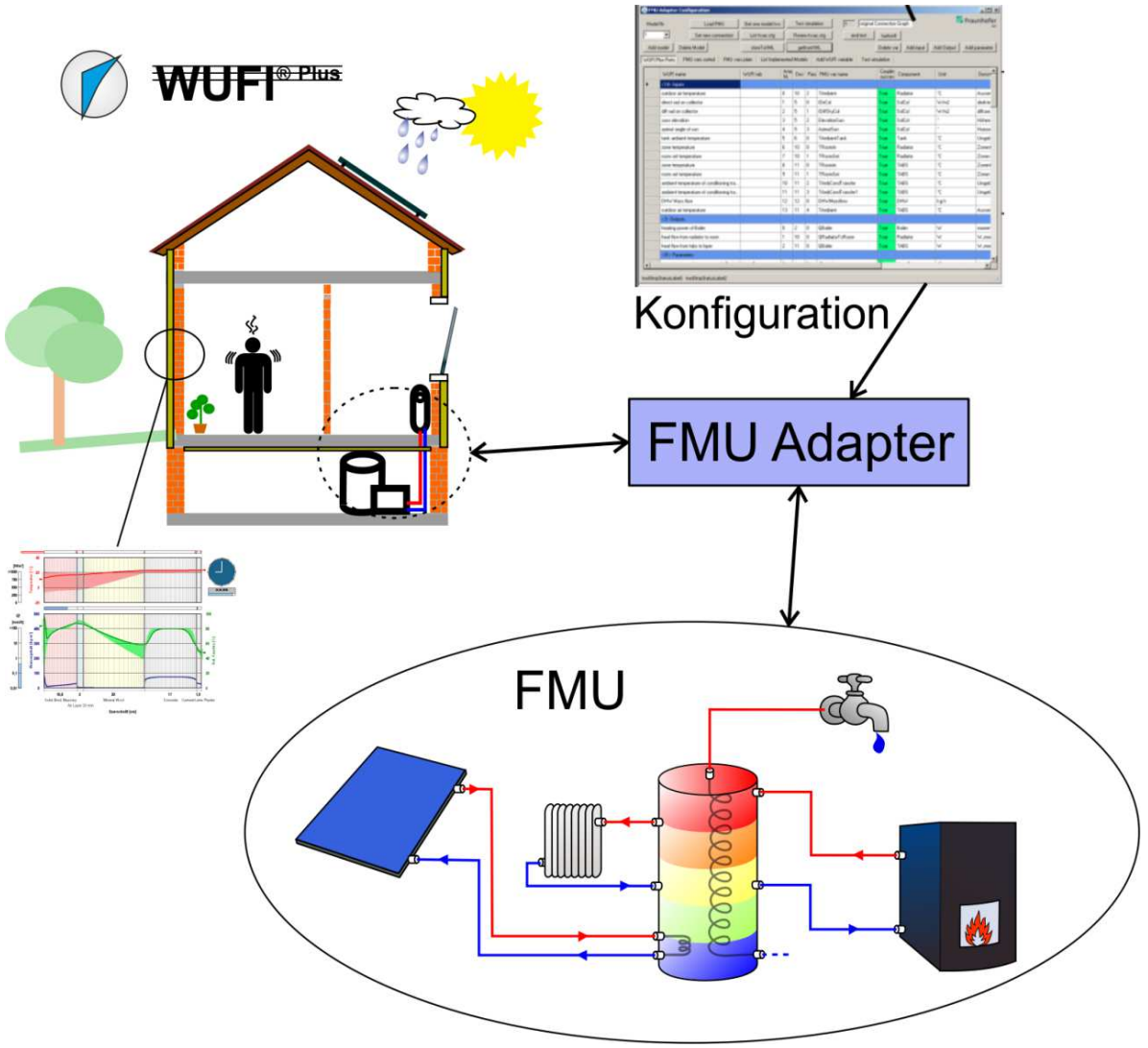
Hygrothermal whole building analysis

HVAC system integration

- Implementation via FMI (Funktional Mock-up Interface)
- Heating and Cooling
  - production
  - storage
  - distribution
- Currently only systems for residential buildings



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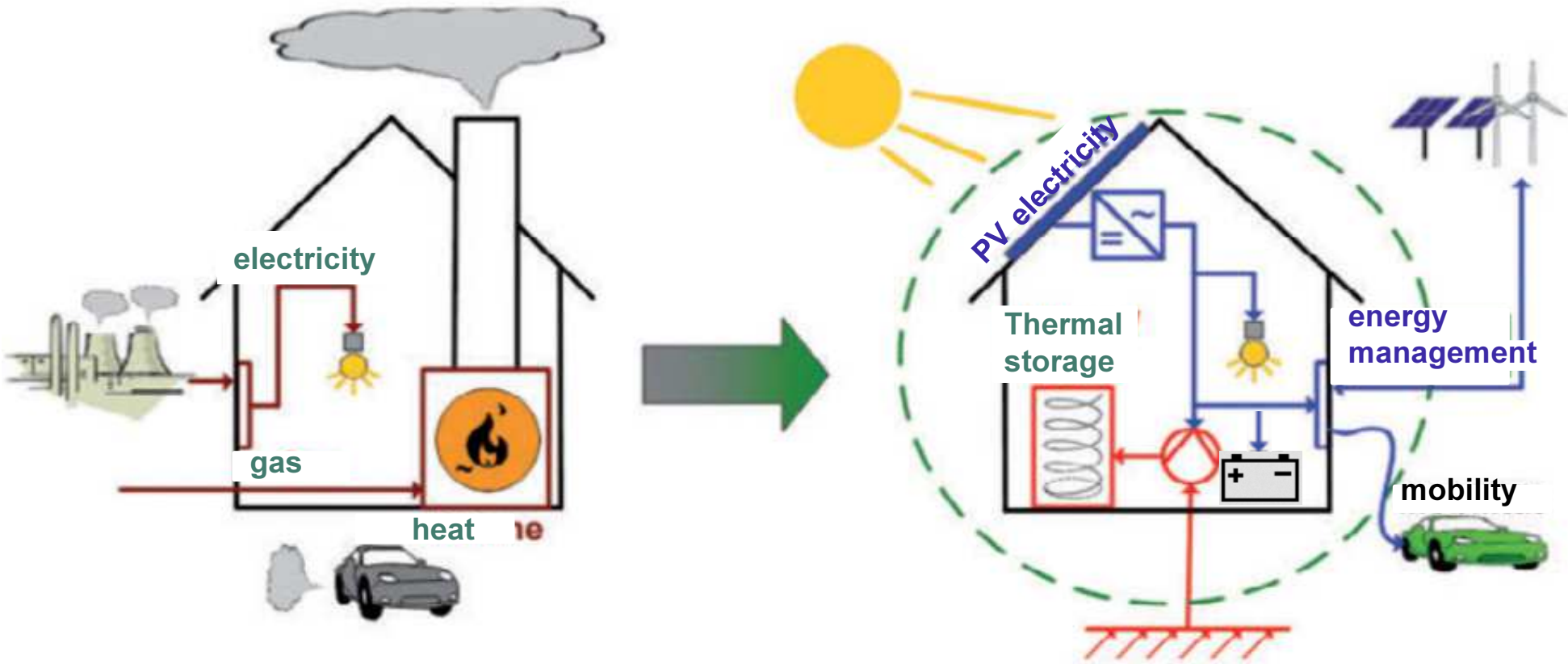
Renewable energy sources an alternative for passive design?

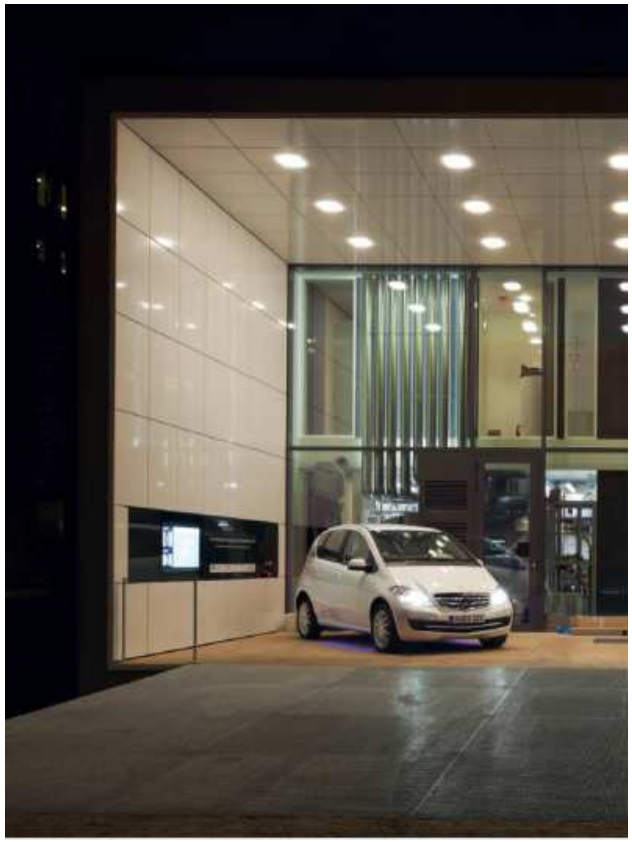
Do we need sophisticated energy savings measures if the building uses only renewable energy sources (RES)?

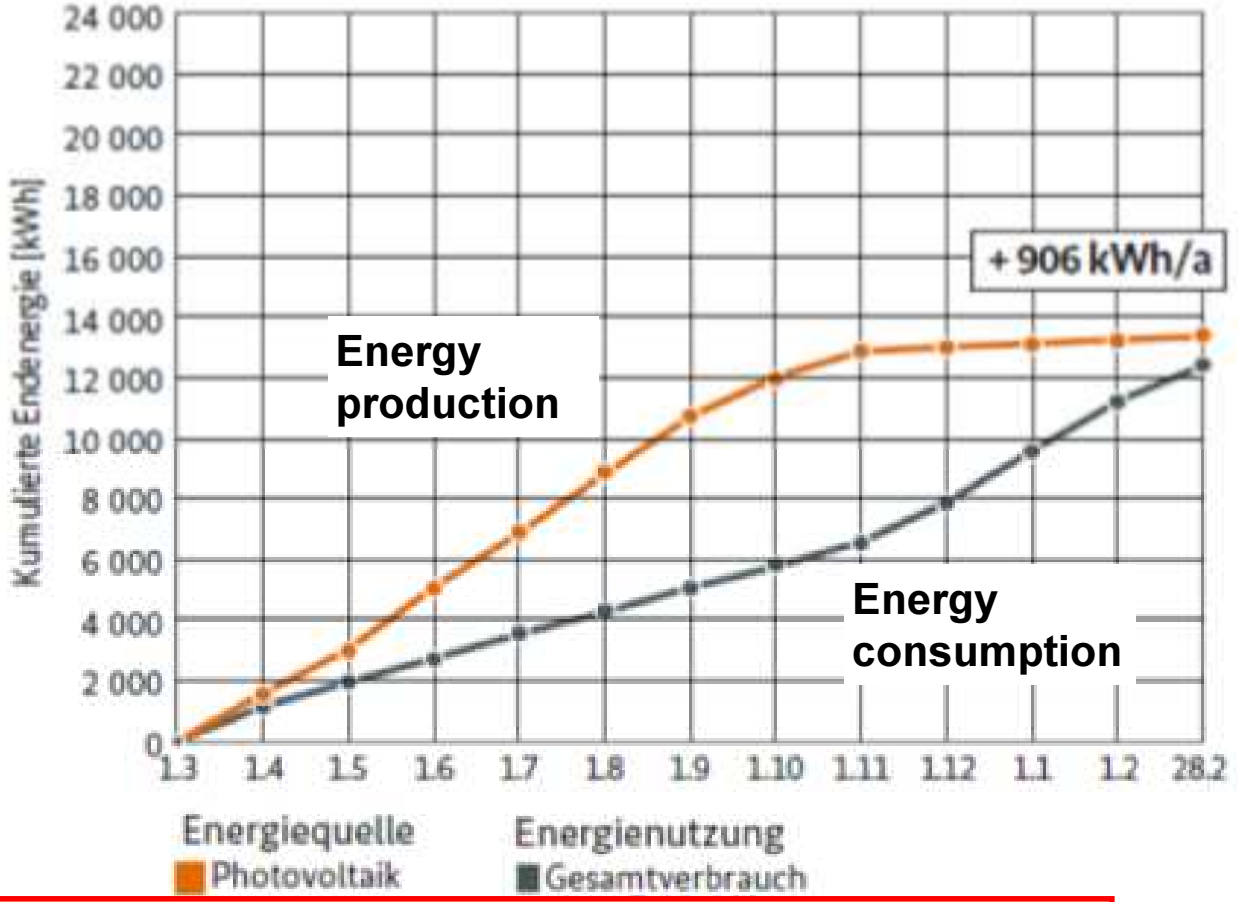


From energy consumer to energy producer

Renewable energy sources an alternative for passive design?

Example: German Plus Energy House Project in Berlin





How do you transfer excess power from summer to winter ???

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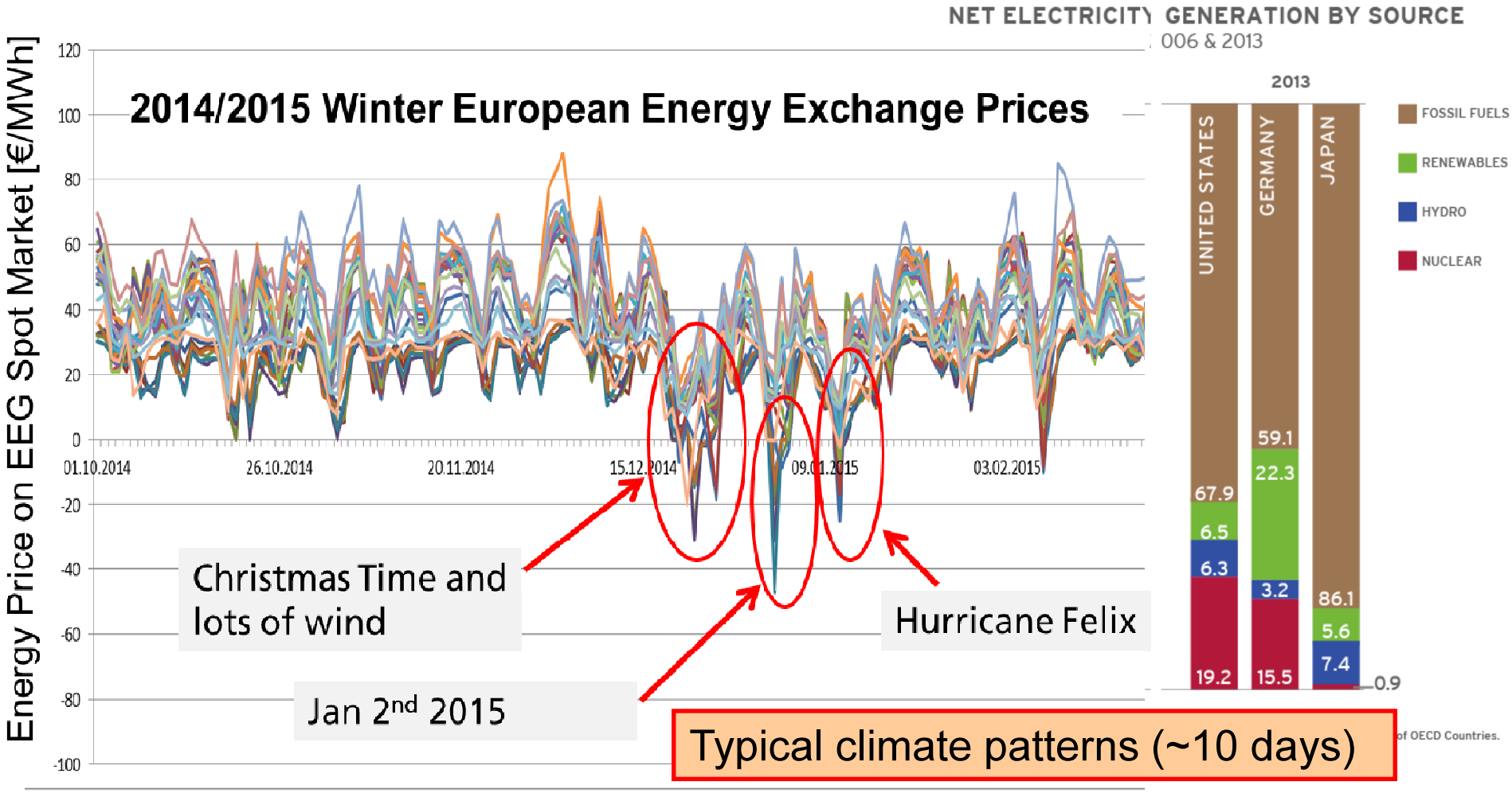
Renewable energy sources an alternative for passive design?

Fluctuating power supply by RES becomes a problem for the grid



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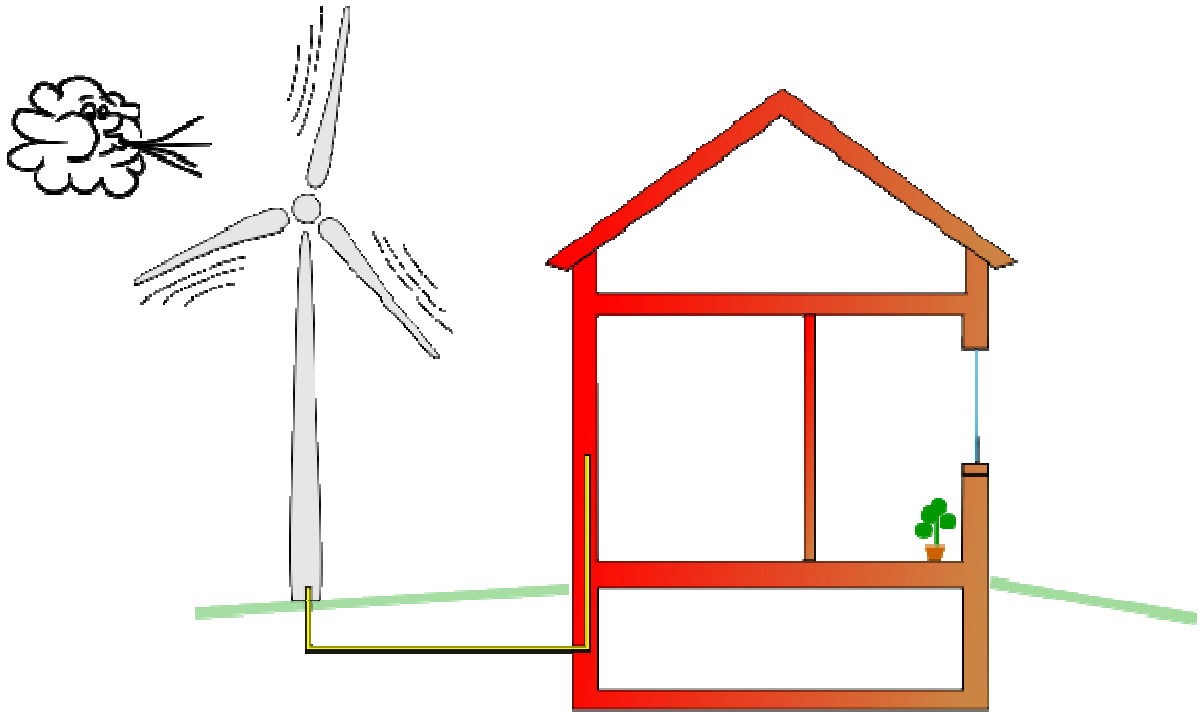
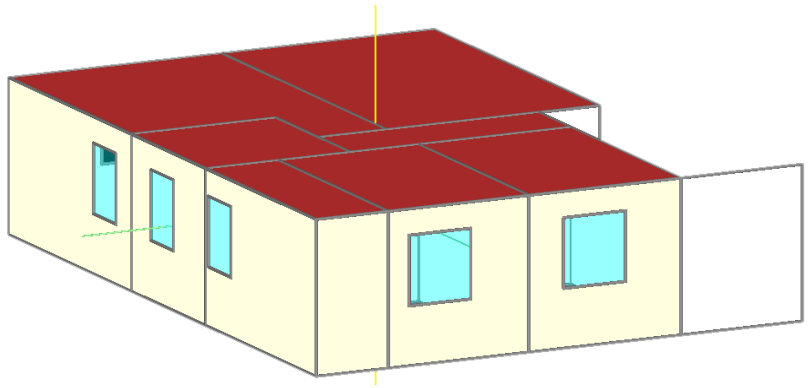
Renewable energy sources an alternative for passive design?

Power to heat: power peaks serve as sole heating supply

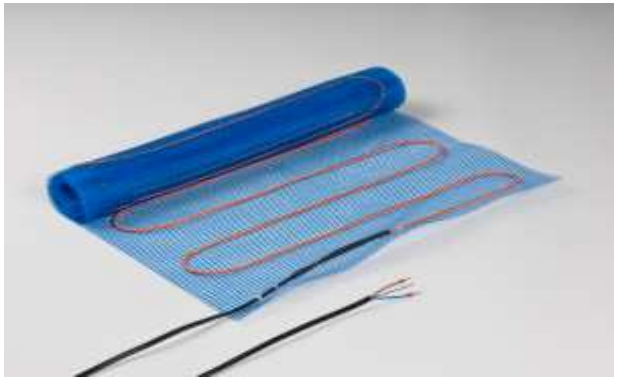




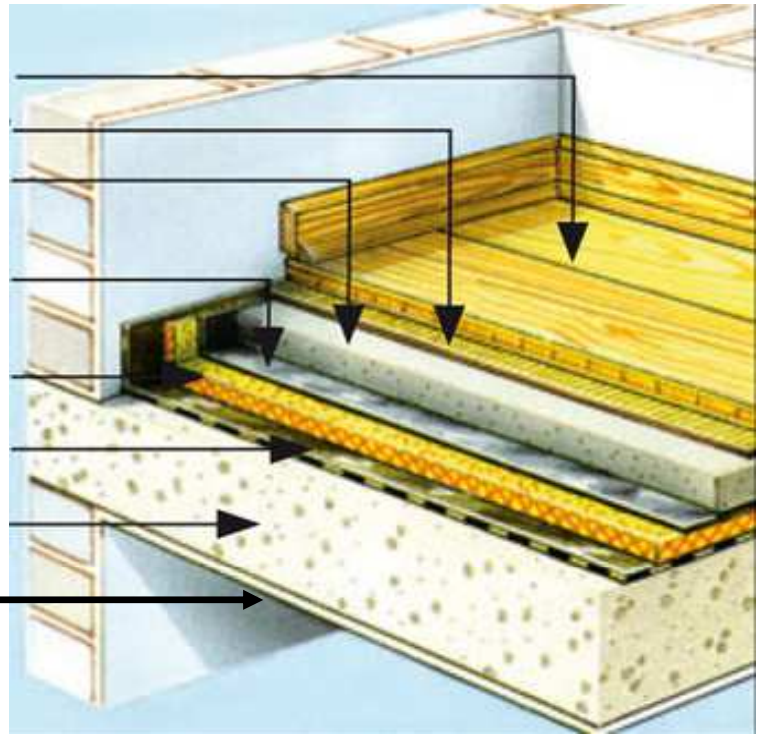
- Apartment in a multi-family building (7 Zones)
- Same conditions in apartment above and below
- Seperate interior load profiles per zone
- Climate conditions: Germany

Renewable energy sources an alternative for passive design?

Modeling of heat storing component



Electrical Panel Heating

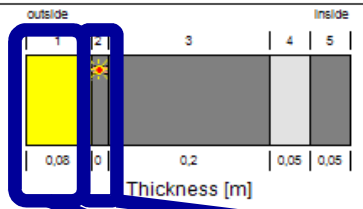


Homogenous layers

Thermal resistance: 3,332 m²K/W

Heat transfer coefficient(U-value): 0,28 W/m²K

Thickness: 0,4 m



Nr.	Material/Layer (from outside to inside)	ρ [kg/m³]	c [J/kgK]	λ [W/mK]	Thickness [m]	Color
1	EPS (heat cond.: 0.04 W/mK - density: 15 kg/m³)	15	1500	0,04	0,08	
2	Concrete, C12/15	2200	850	1,6	0,02	
3	Concrete, C12/15	2200	850	1,6	0,2	
4	Mineral Insulation Board	115	850	0,043	0,05	
5	Concrete Screed, mid layer	1970	850	1,6	0,05	

Panel Heating as Source in Component

Additional Insulation below

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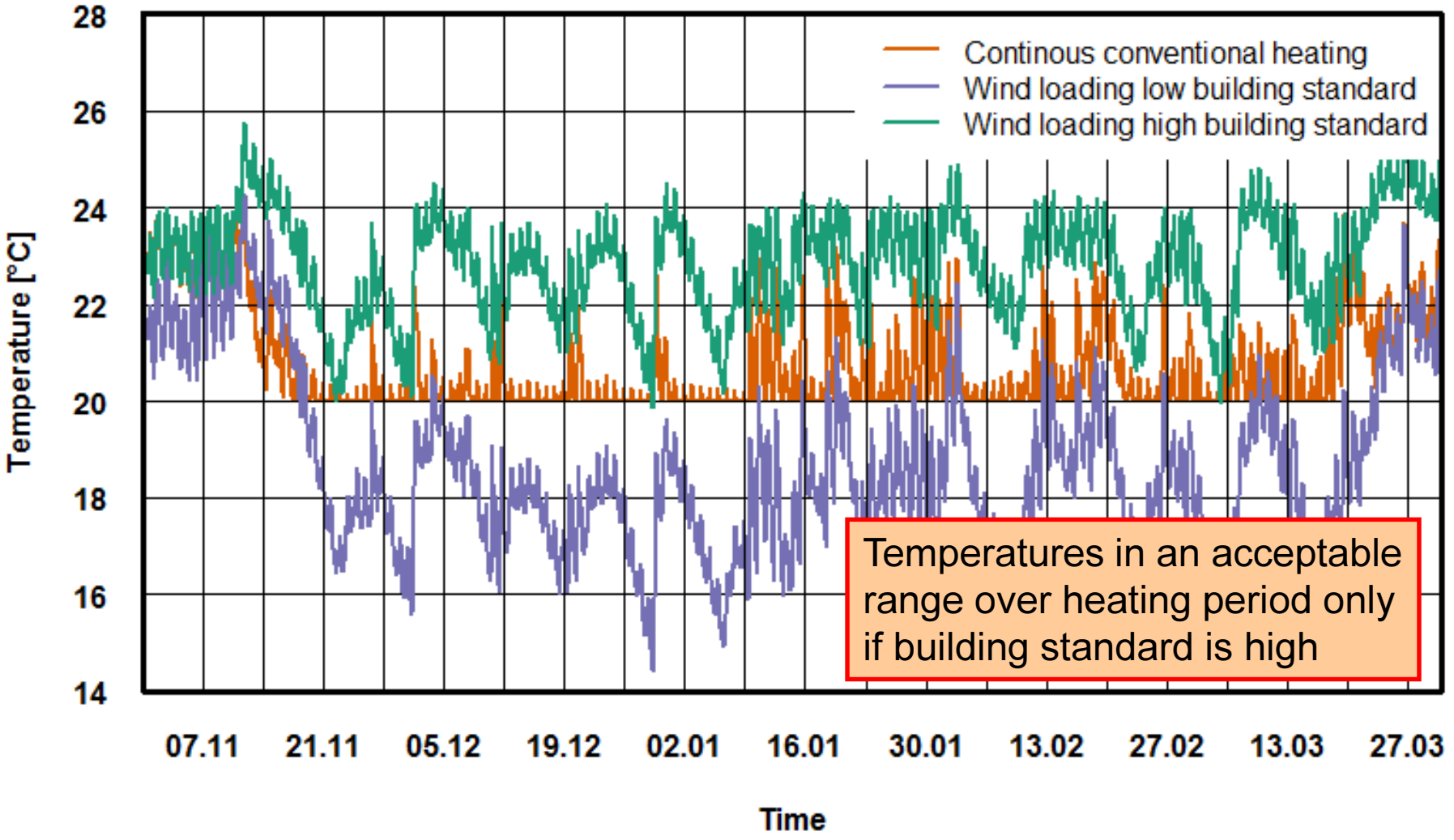
Renewable energy sources an alternative for passive design?

Resulting living room temperature



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Conclusions

Monthly balance methods work well for heating climates and should be complemented by dynamic building simulation if:

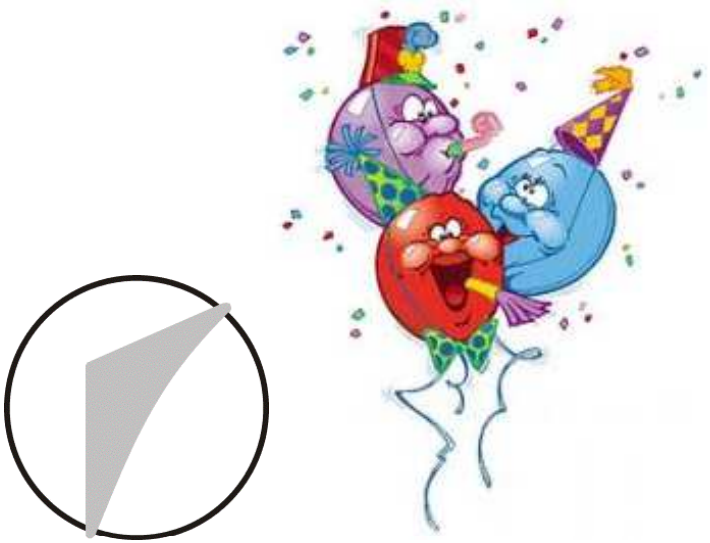
- cooling and/or moisture loads are high
- heating is discontinuous (during the heating period)
- occupancy and indoor conditions vary considerably
- comfort and overheating have to be assessed

WUFI® Passive calculates the monthly balances and simulates the dynamic heat and moisture transfer in the building, building envelope & HVAC systems

Renewable energy sources are no alternative for passive design – however, the importance of **hygrothermal storage** may increase

Challenge: designing passive buildings for all climates that are comfortable, durable (moisture tolerant) & economical

Multi Climate Global Passive House



20th anniversary rebate on all WUFI® tools from Oct. until the end of the year

Thank you for your attention !

More information:

www.phius.org

www.wufi.com

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