

MASONRY FACADES AND ENERGETIC REDEVELOPMENT

Facing the challenge

A lecture by Dipl.-Ing. Werner Kaul

Co₂lBricks

Partner Meeting
21.-22.02.2012 Velikij Novgorod

Institute for Applied Building Technology
Hamburg University of Technology
Prof. Dr.-Ing. habil. Hans-Jürgen Holle



TUHH

MASONRY FACADES AND ENERGETIC REDEVELOPMENT

What is the real challenge?

What is so special about masonry walls?

How can we take the right decisions?

What methods and tools should be used?

What parameters have to be investigated?

“Hans Rosling and the magic washing machine”

Hans Rosling, a brilliant statistician from Sweden, is working on international health care. In his lecture he was talking about the further development of living-standards all over the world...

Here is how he divided the world's population:

TALKS

Hans Rosling and the magic washing machine

TEDWomen, Filmed Dec 2010, Posted Mar 2011



696,968 Views

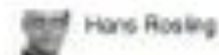
Get it on

What was the greatest invention of the Industrial revolution? Hans Rosling makes the case for the washing machine. With newly designed graphics from Gapminder, Rosling shows us the magic that pops up when economic growth and electricity turn a boring wash day into an intellectual day of reading.

In Hans Rosling's hands, data sings. Global trends in health and economics come to vivid life. And the big picture of global development—with some surprisingly good news—snaps into sharp focus. [Full bio >](#)

“There are two billion fellow human beings who live on less than \$2 a day.” (Hans Rosling)

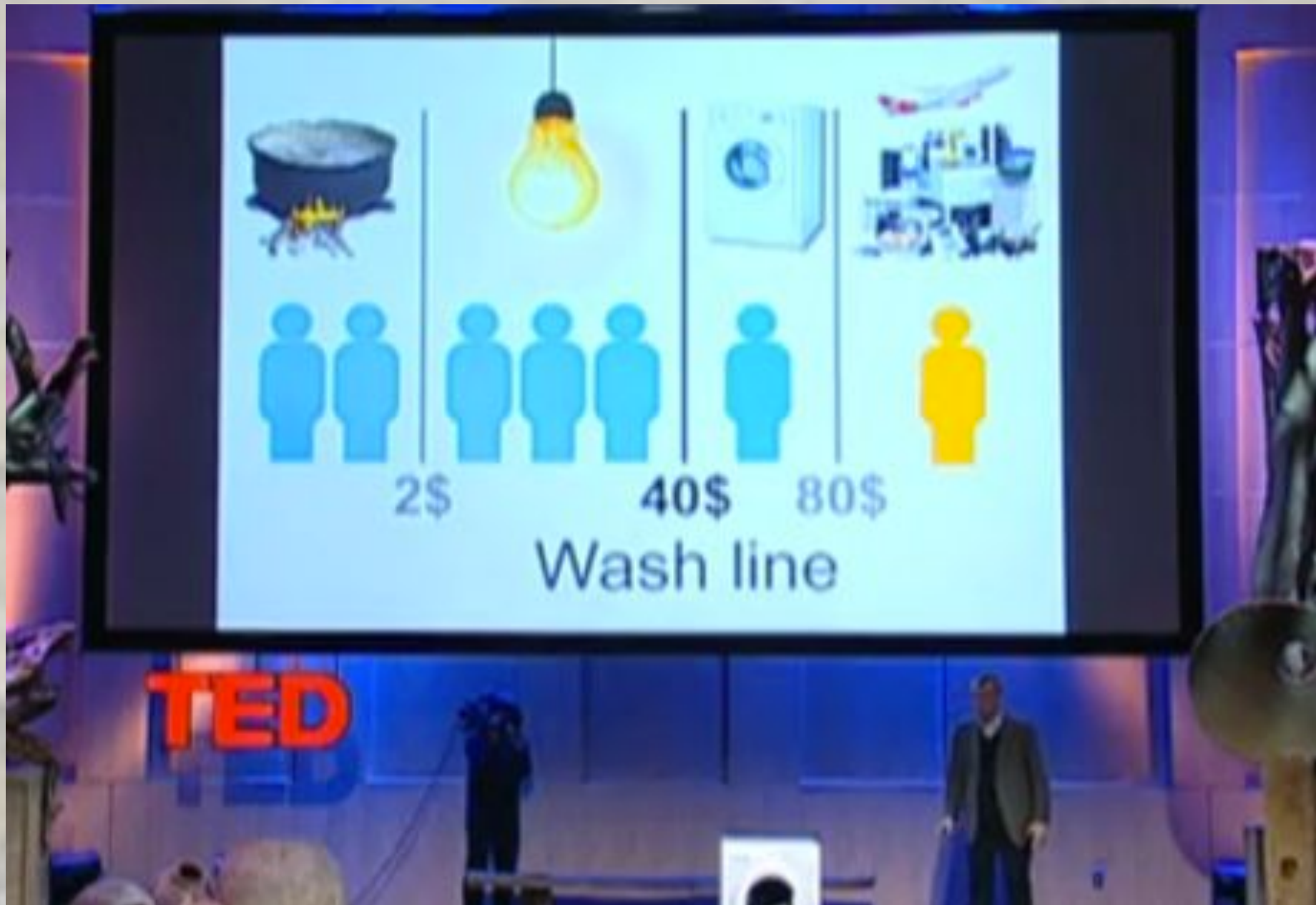
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WHAT TO WATCH NEXT



Hans Rosling: Let my dataset change your mindset
19:56 Posted: Aug 2009
Views: 620,648 | Comments: 94



By taking the use of washing machines as an indicator for emerging wealth, he is showing up, which consequences on the energy consumption will go along with it. But:

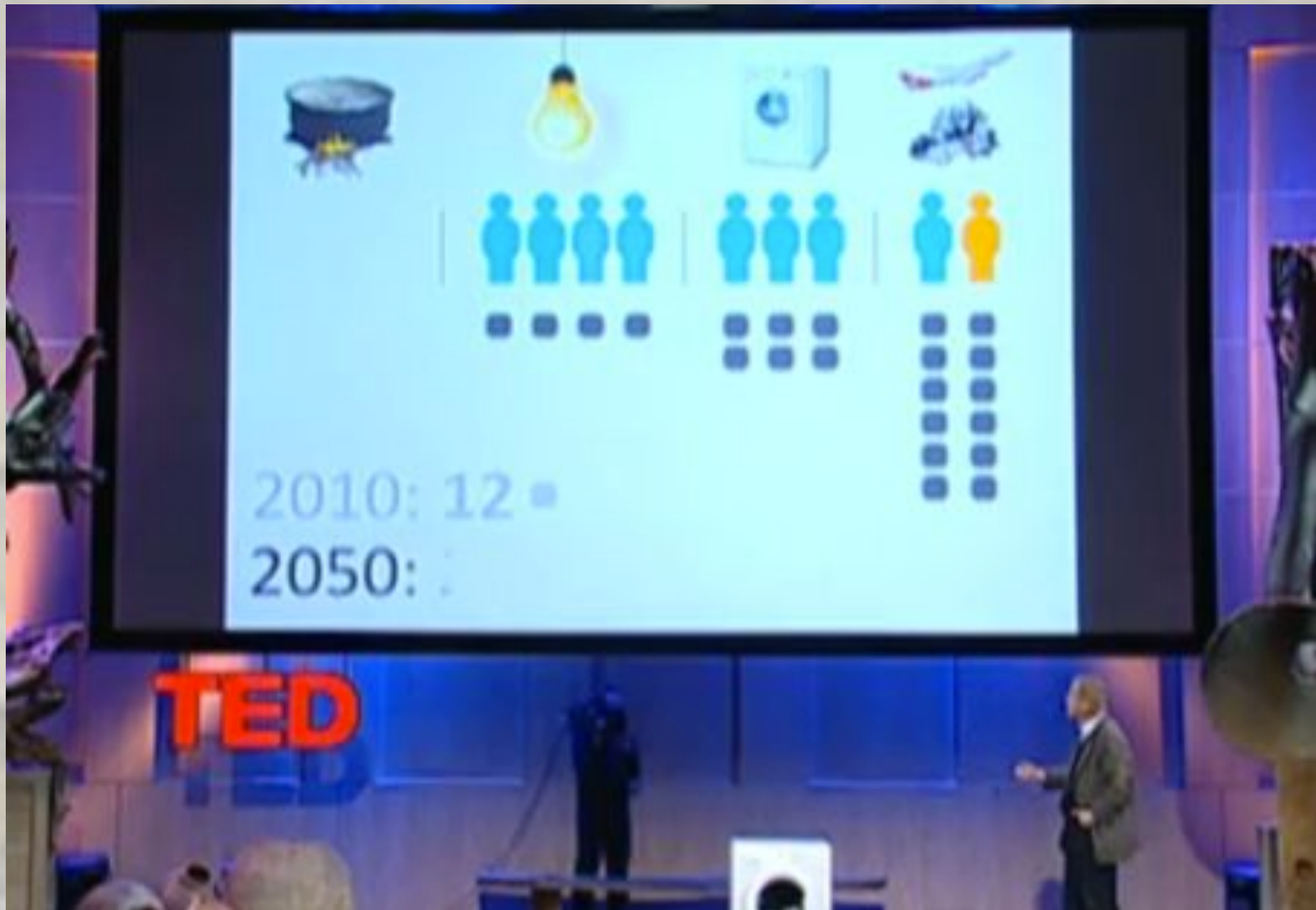
What is the relevance of washing machines for us?



Source: Werner Kaul 2004

Washing machines in operational condition usually do not stand around all alone. They are part of a domestic infrastructure, which obviously is including building services like electricity, water supply or heating systems.

Here is how according to Rosling's data the wealth of the people might change in the next 40 years.



As you can see, Rosling predicts an additional 3 Billion of people reaching the "washing" zone until 2050.

What does this mean for us?

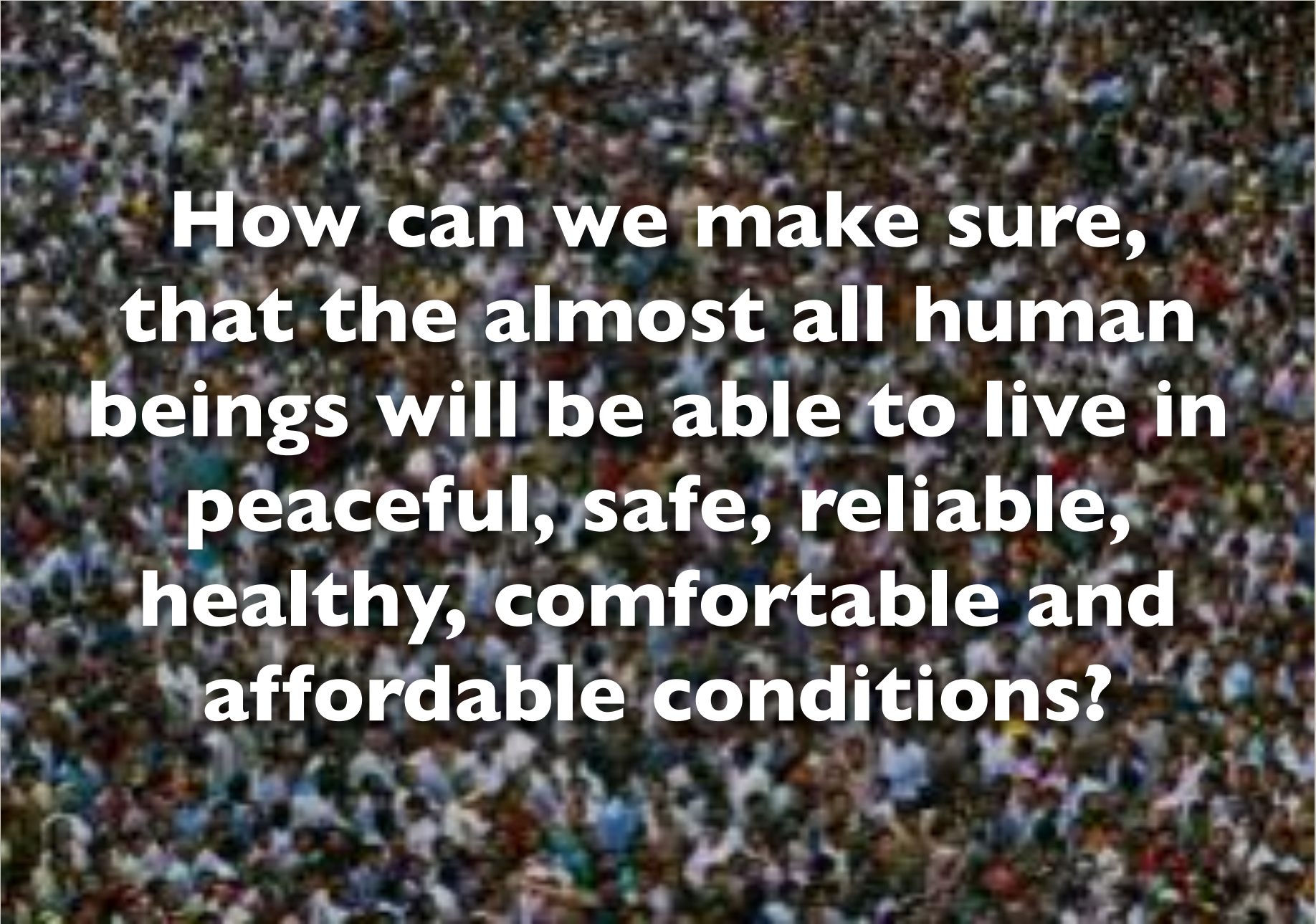
At a conservative estimate we can expect, that by minimum half of the additionnal 3 billion people will require energy for heating purposes.



**Today approximately 2 billion people
live in fairly comfortable homes**


**Until 2050 we will need comfortable
homes for 5 billion people**

Source: Werner Kaul 2006



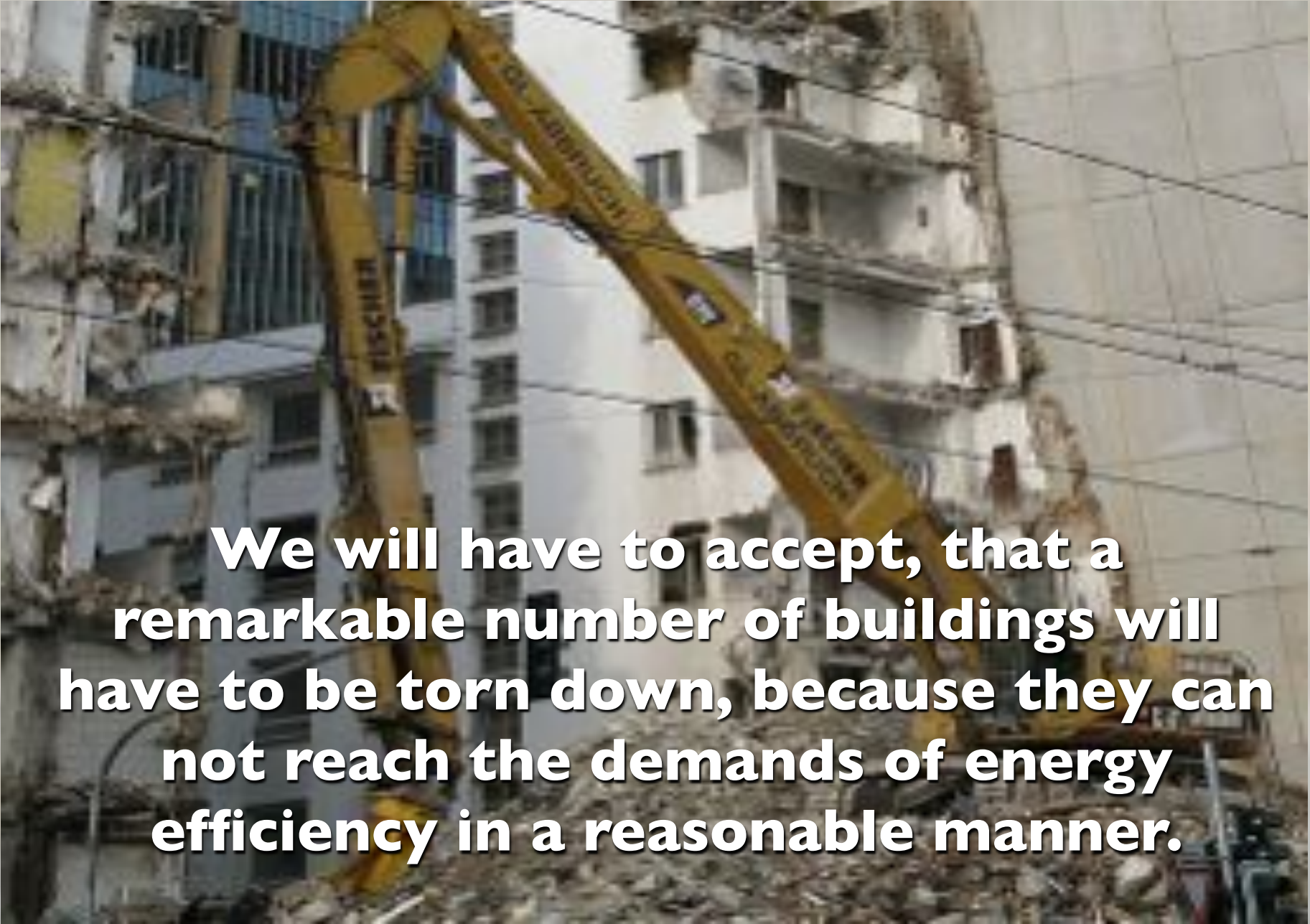
**How can we make sure,
that the almost all human
beings will be able to live in
peaceful, safe, reliable,
healthy, comfortable and
affordable conditions?**

Source: Werner Kaul/ABT TUHH 2009



In the next 40 years a tremendous number of buildings will have to be constructed throughout the world. They all will have to be energy efficient.

Source: Werner Kaul 2004

A photograph showing a yellow excavator with a long boom demolishing a multi-story building. The building is partially destroyed, with debris visible. The excavator's arm is extended towards the structure. The background shows other buildings and a clear sky.

We will have to accept, that a remarkable number of buildings will have to be torn down, because they can not reach the demands of energy efficiency in a reasonable manner.

Source: Werner Kaul 2008

CRITERIA FOR REASONABLE ENERGETIC RESTORATION

Absolute value

Cultural value

Achievable energy standards

Achievable comfort

Economic viability

Sustainability

WHAT IS SO SPECIAL ABOUT MASONRY WALLS?



WHAT IS SO SPECIAL ABOUT MASONRY WALLS?

One of the most common construction principles!

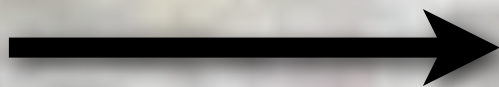
Masonry walls are never homogenous!

They are compounds of very different materials!

Aging changes their hygrothermal behaviour!

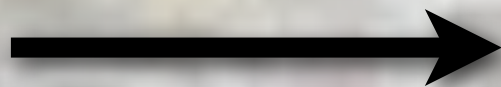
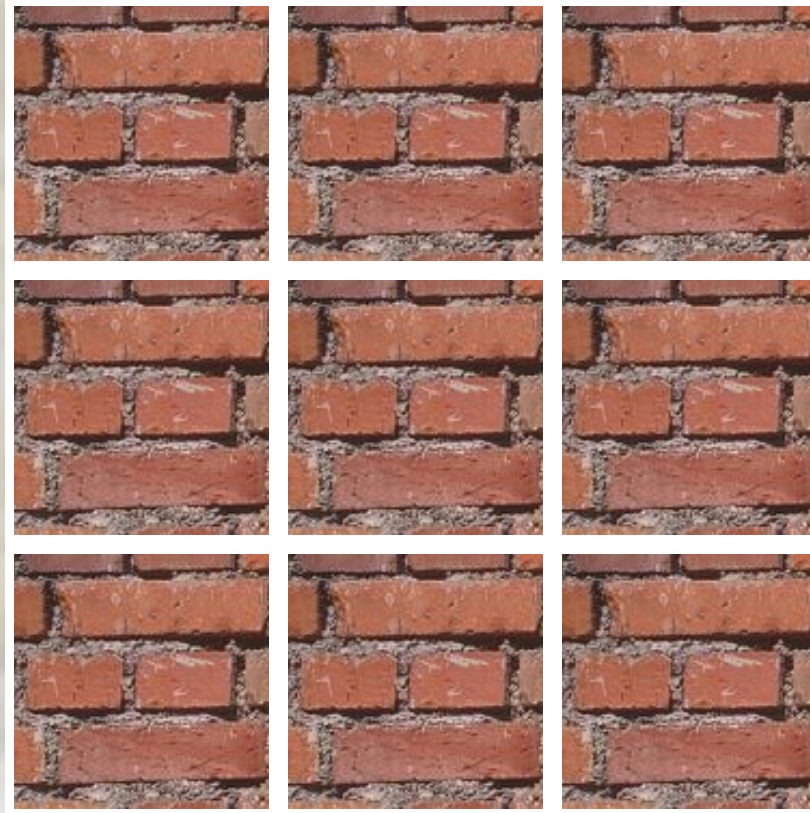
A THOUGHT EXPERIMENT:

3 classes of bricks of different
hygrothermal characteristics



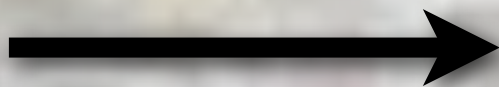
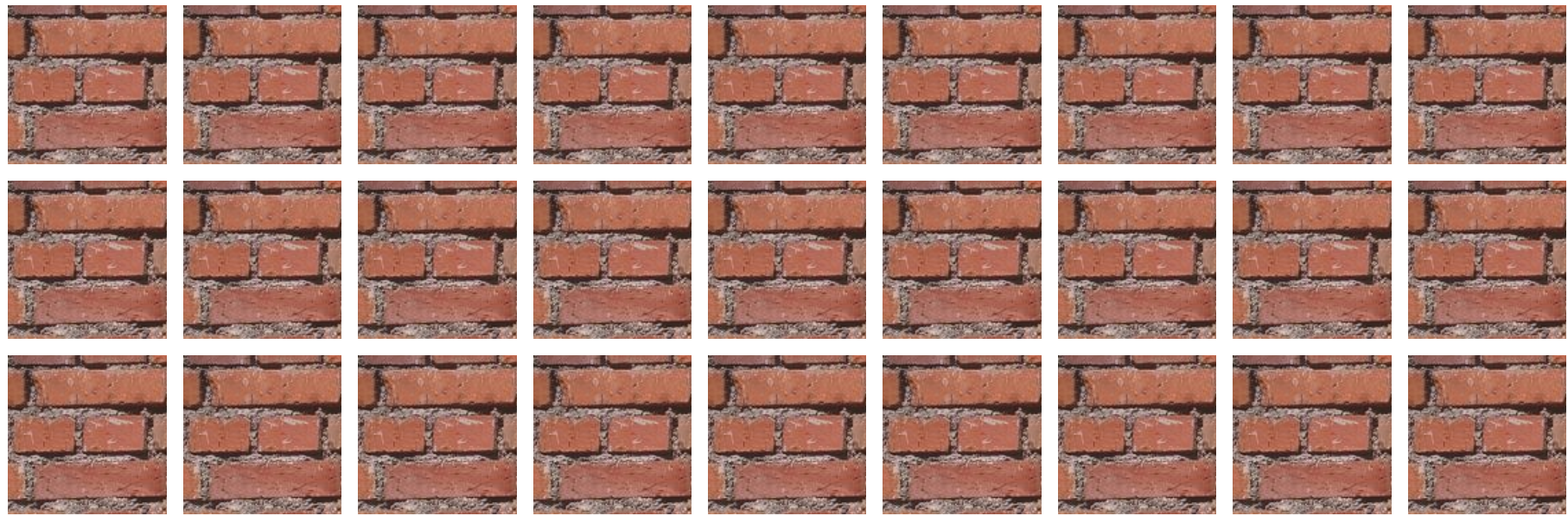
3 possible combinations

3 classes of mortar of different hygrothermal characteristics



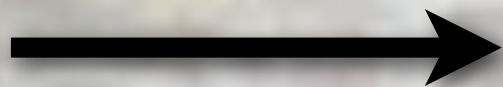
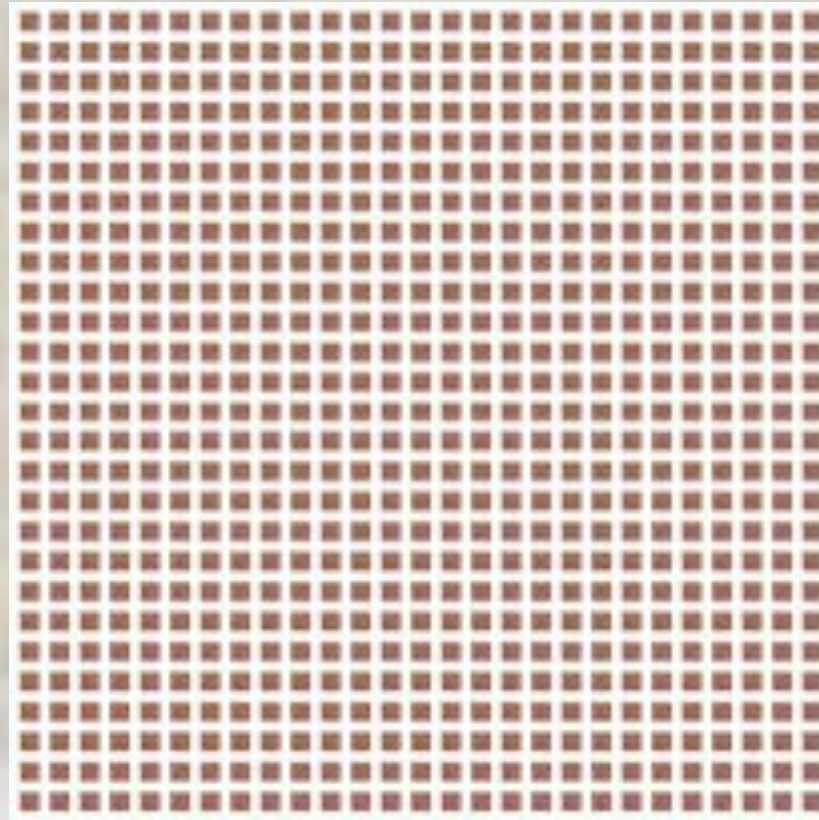
9 possible combinations

3 different brick-joint-ratios



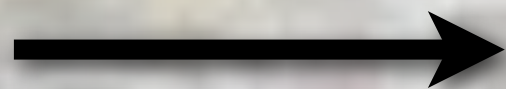
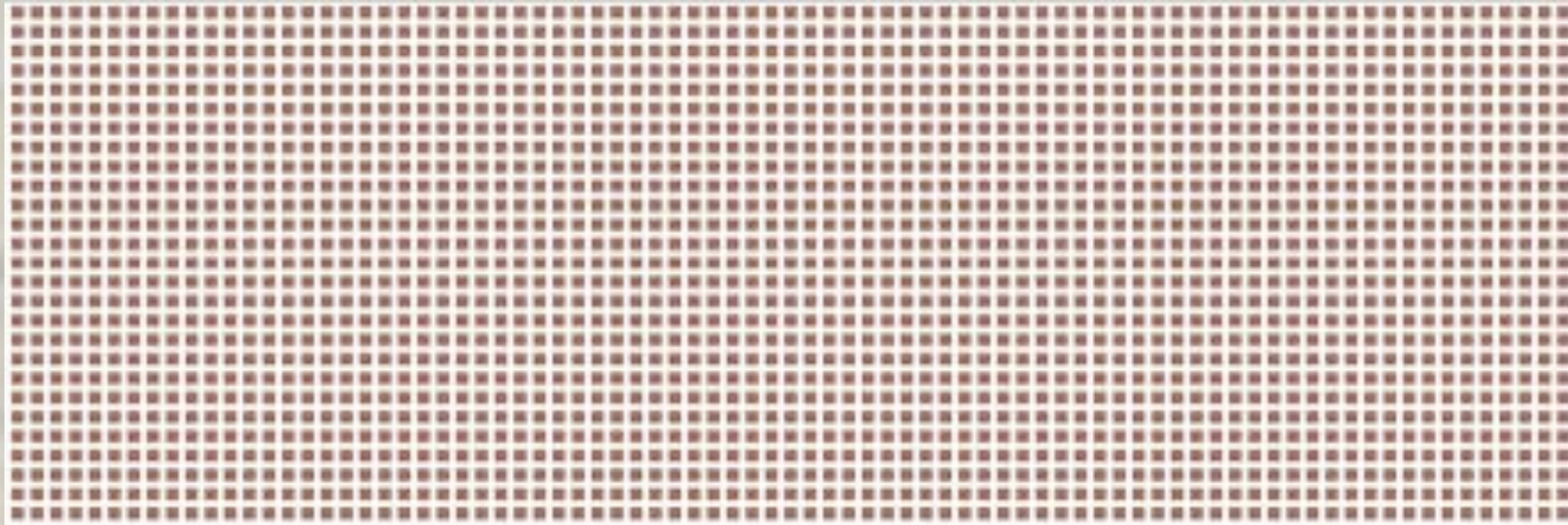
27 possible combinations

switch to double-shell masonry walls



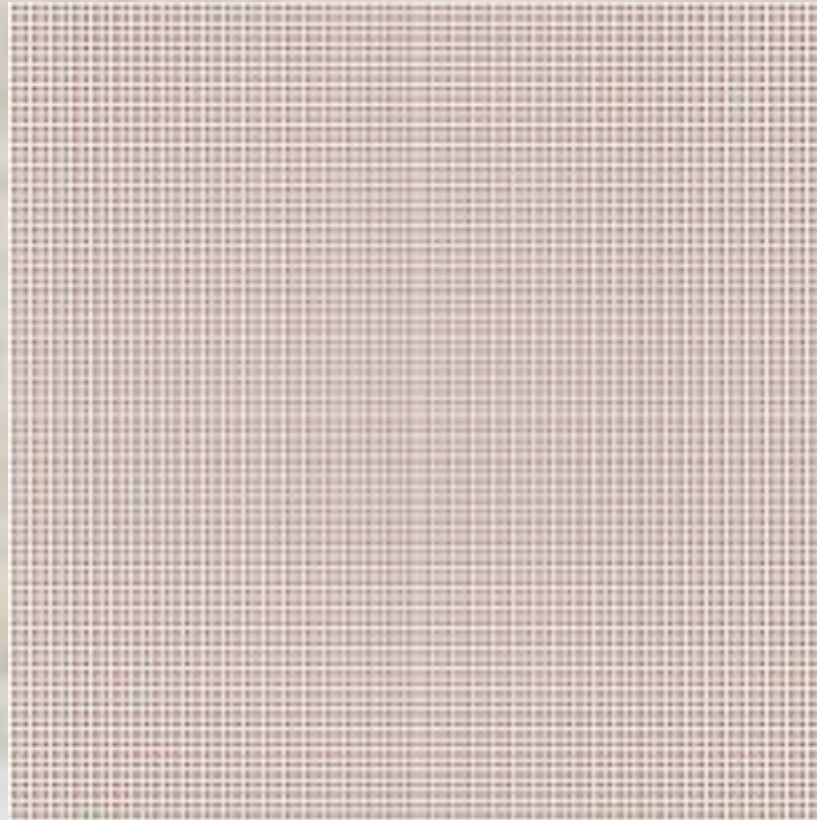
729 possible combinations

3 different kinds of gap characteristics



2187 possible combinations

3 inside claddings of different
hygrothermal characteristics

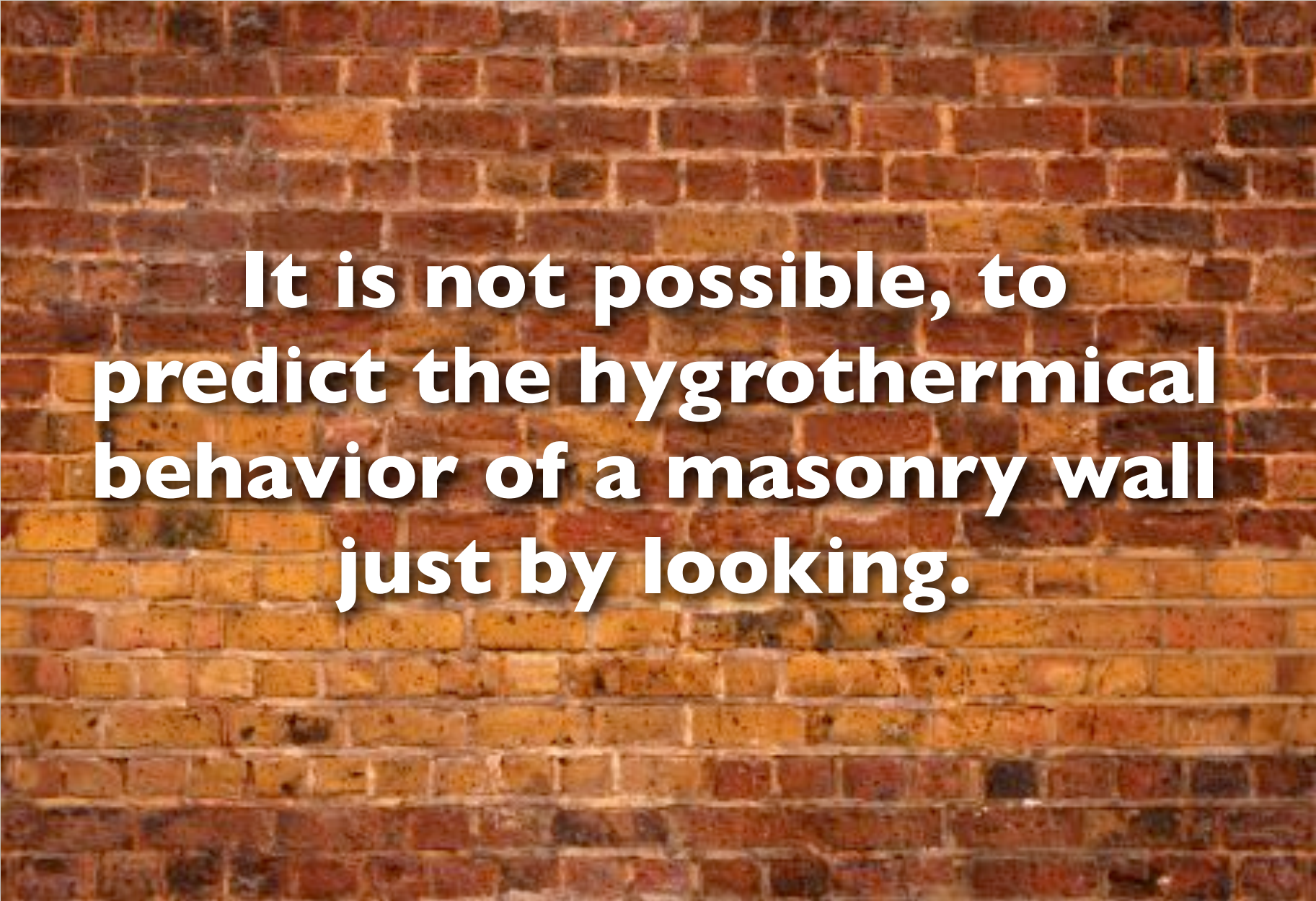


→ **6561 (81) possible combinations**

9 relevant locations of weather exposure

N - base
N - middle
N - eaves
S - base
S - middle
S - eaves
E/W - base
E/W - middle
E/W - eaves

→ 59.049 (729) possible combinations



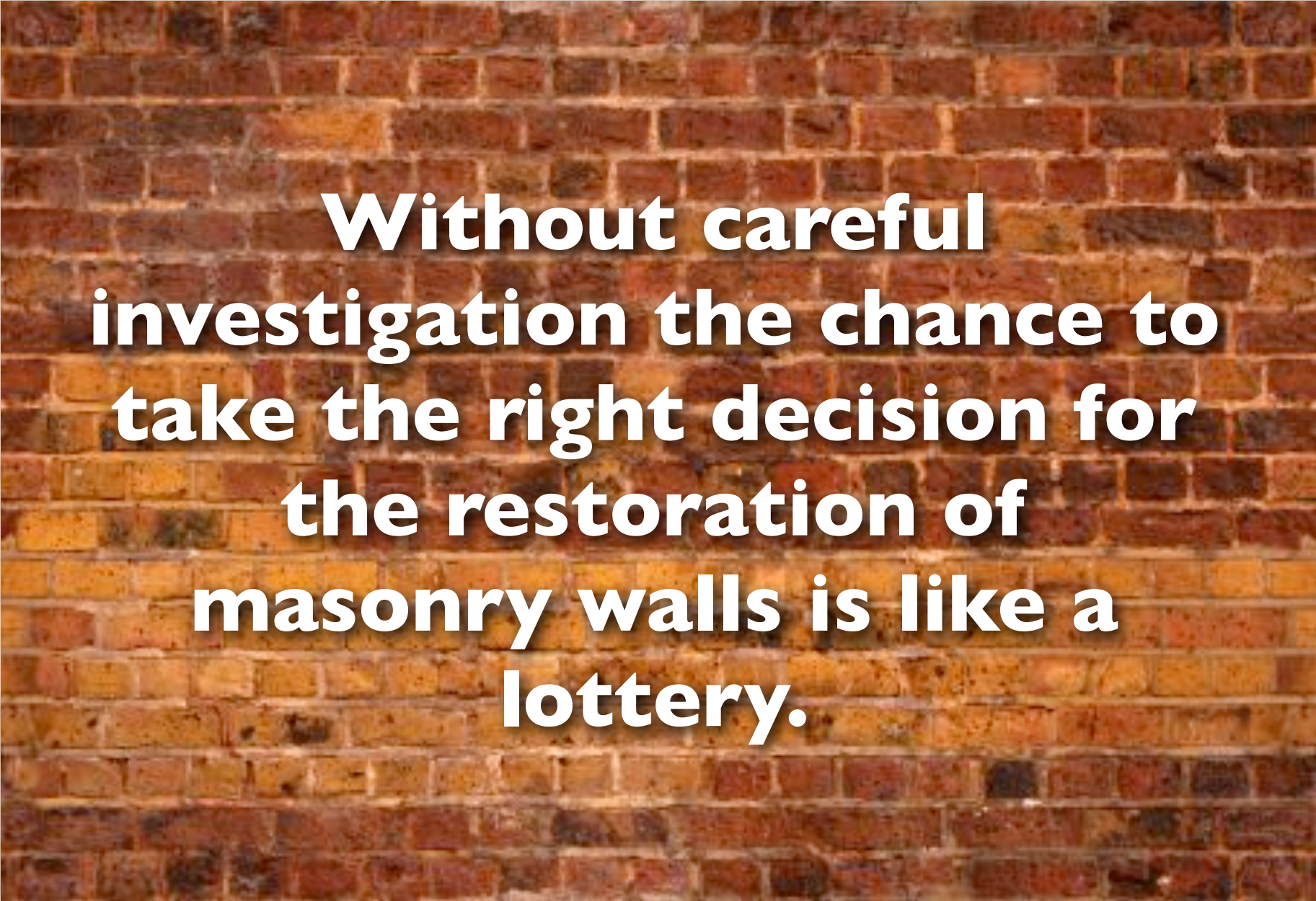
**It is not possible, to
predict the hygrothermal
behavior of a masonry wall
just by looking.**

Source: Mayang's Free Textures - <http://www.mayang.com/textures/>



**There is a variety of
options to improve the
energetic efficiency of
buildings apart from wall
insulation.**

Source: Mayang's Free Textures - <http://www.mayang.com/textures/>



**Without careful
investigation the chance to
take the right decision for
the restoration of
masonry walls is like a
lottery.**

Source: Mayang's Free Textures - <http://www.mayang.com/textures/>

HOW CAN WE CLOSE THE KNOWLEDGE GAP?

Investigation of boundary conditions
and material characteristics,

Hygrothermal assessment of the
existing wall structure,

Restoration drafts,

Hygrothermal assessment of the
wall structure after renovation.

WHY THE GLASER METHOD IS OUT OF DATE?

Steady-state model,

Simplified boundary conditions,

Does not consider capillary effects,

Does not consider gravity effects,

Does not cover singular impacts,

Does not cover hygrothermal resonance.

What are the appropriate tools?

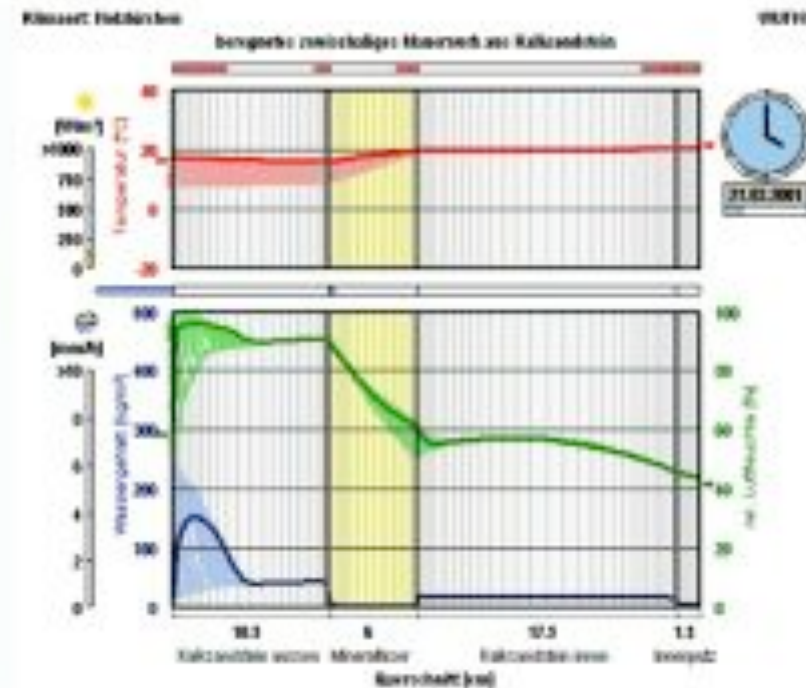
It is obvious that a contemporary method for hygrothermal assessment has to consider the dynamic processes inside the components.

This is exactly what modern transient simulation tools go for. There are is great variety of HAM solvers. They are mostly based on the same fundamental principles, but differ in their solution algorithms. For example:



WUFI® PRO, 2D, Plus

Software zur Berechnung des gekoppelten Wärme- und Feuchtetransports in Bauteilen



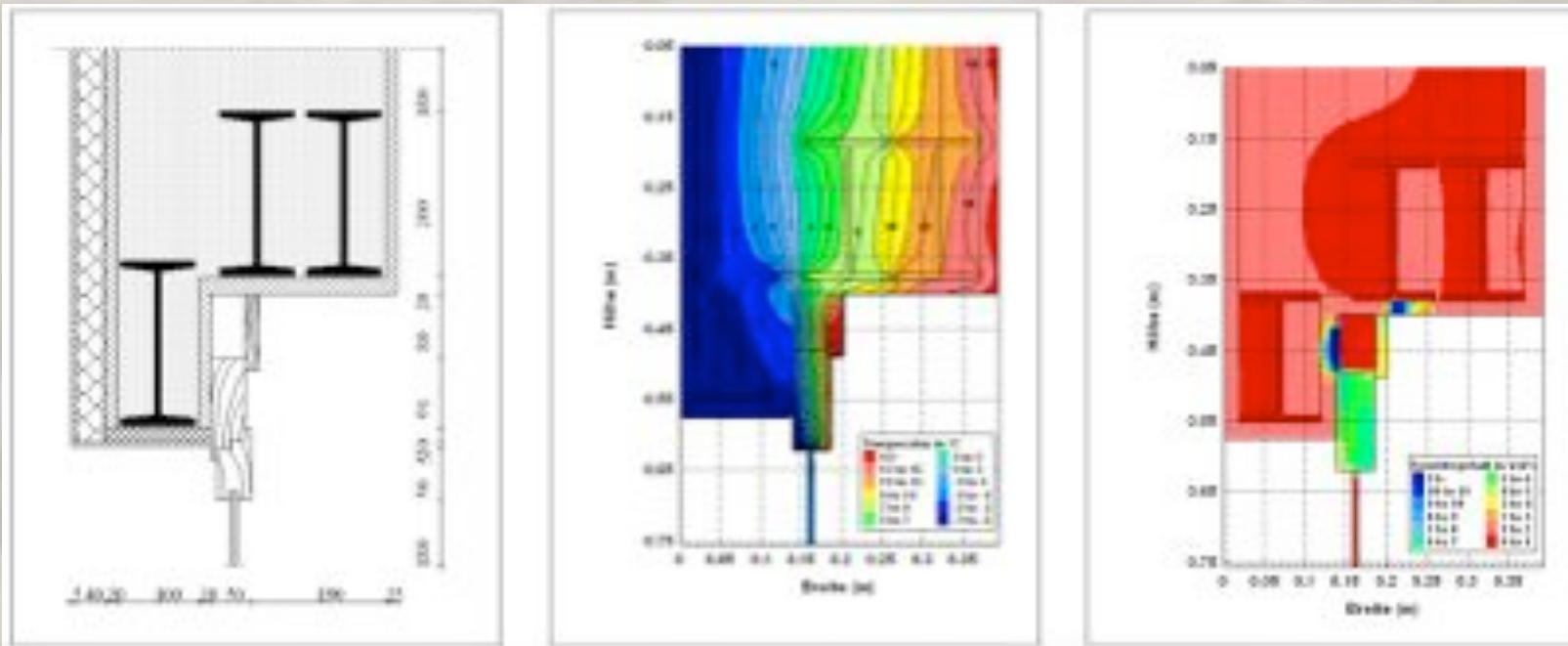
Source: Fraunhofer Institute <http://www.wufi.de>

The Fraunhofer Institute established WUFI, It is a relatively easy to use application. It is completely menu driven and has a variety of predefined graphic output layouts. Thus it delivers fast and reliable results for most standard layer structures.



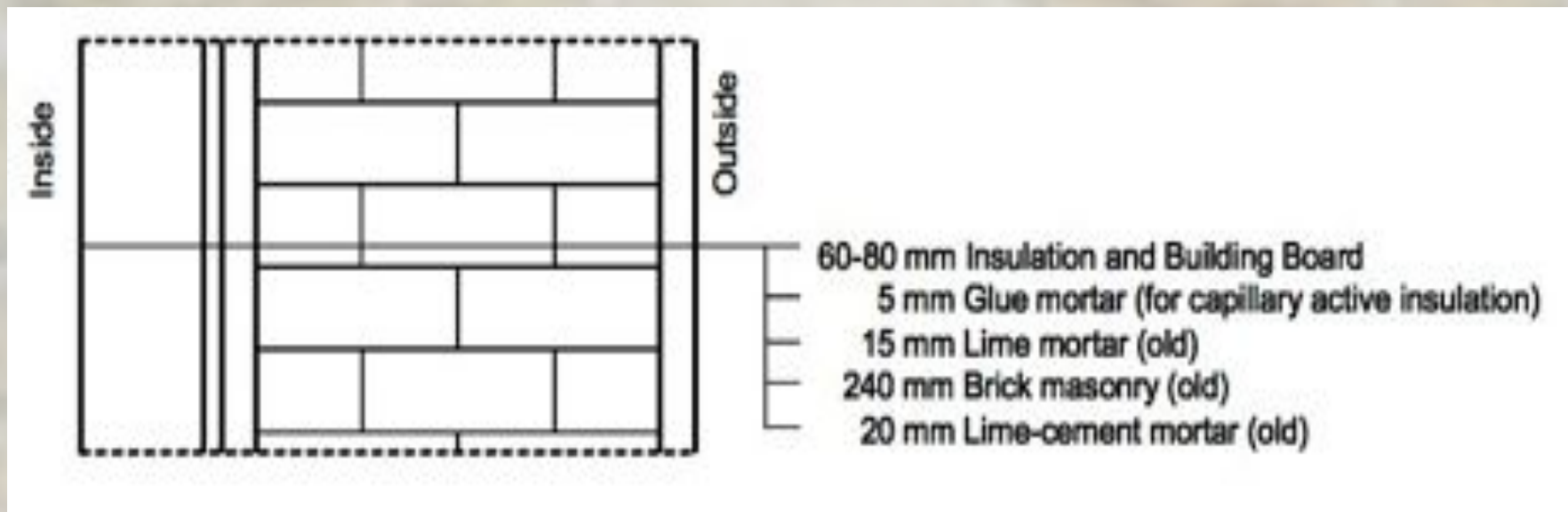
Simulationsprogramm für den gekoppelten Wärme-,
Luft-, Feuchte-, Schadstoff- und Salztransport

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More experimental, but not less reliable, is DELPHIN by the Institute of Building Climatology of the Dresden University of Technology. Additionally DELPHIN supports pollutant and salt transport mechanisms. While WUFI is some kind of a black box in many aspects, DELPHIN is completely open.

HOW DO SIMULATION TOOLS WORK?



Source: Institute for Building Climatology at Dresden University of Technology

Example: Brick masonry with inside insulation

HOW DO SIMULATION TOOLS WORK?



Source: Institute for Building Climatology at Dresden University of Technology

Modeling the structure,

Dividing the structure,

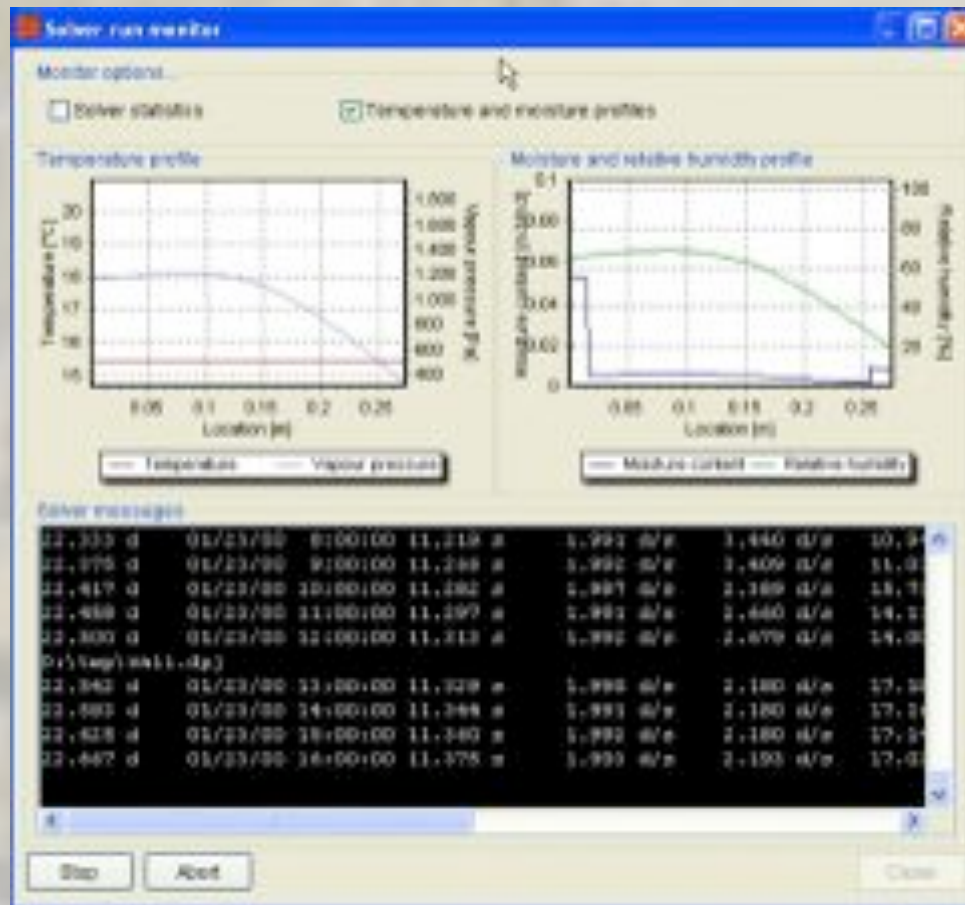
HOW DO SIMULATION TOOLS WORK?

Assign material characteristics,

Assign boundary conditions,

Assign output definitions,

HOW DO SIMULATION TOOLS WORK?



Source: Institute for Building Climatology at Dresden University of Technology

Calculations
(DELPHIN
solver run
monitor),

HOW DO SIMULATION TOOLS WORK?

Post processing,
Graphical representation,
Interpretation,
Final report.

WHICH PARAMETERS CAN BE CALCULATED?

Temperature,

Moisture mass,

Relative humidity,

Liquid water content,

Overhygroscopic water content,

and more...

WHAT WEATHER DATA HAVE TO BE AVAILABLE?

Temperature,

Relative humidity,

Driving rain,

Wind speed and direction,

Short and long wave radiation.

Duration: One year!

WHAT MATERIAL DATA HAVE TO BE ACQUIRED?

Bulk density

Bulk Porosity

Specific Heat capacity

Heat conductivity

...

WHAT MATERIAL DATA HAVE TO BE ACQUIRED?

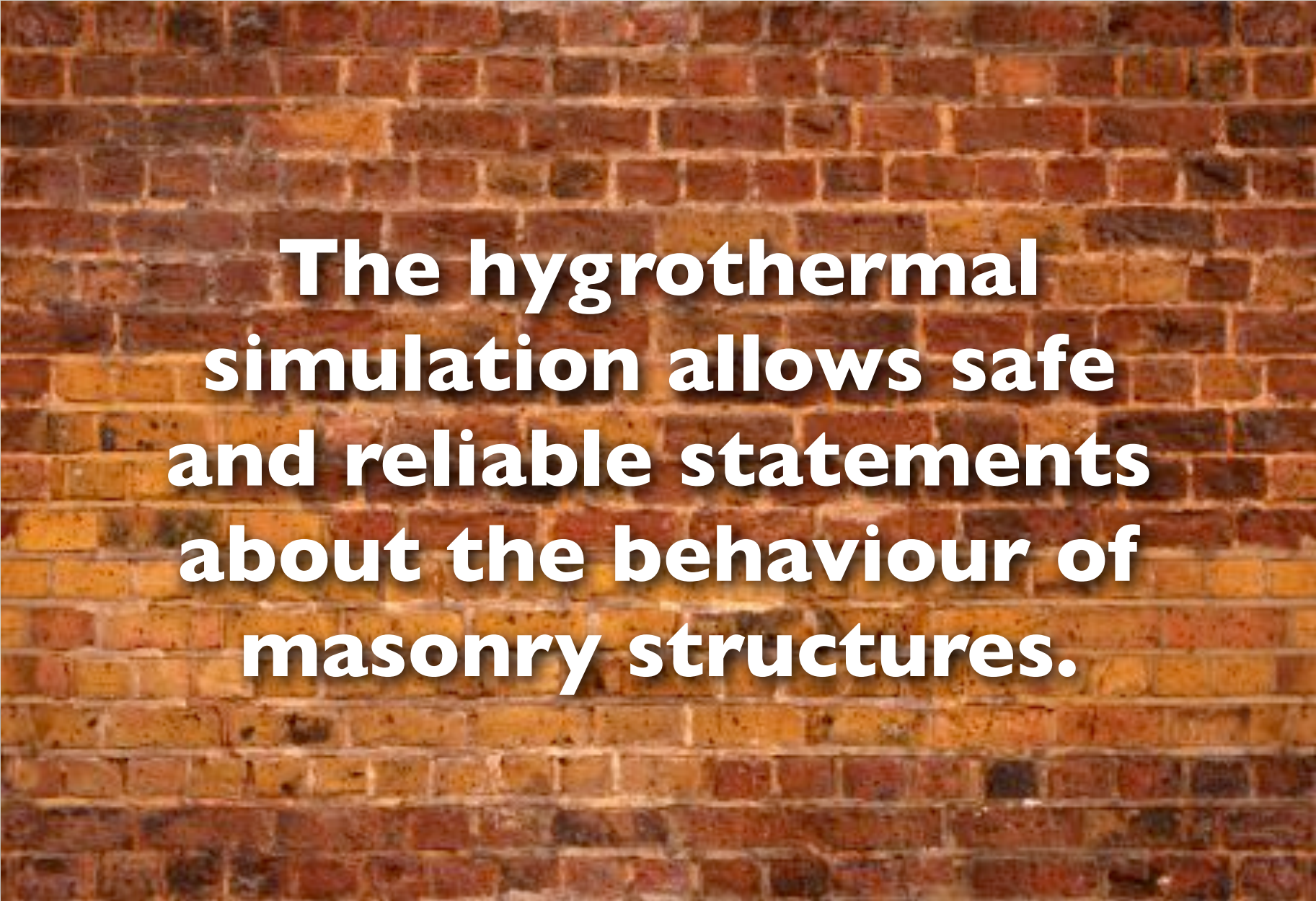
...

Diffusion resistance factor

Water vapour permeability

Water absorption coefficient

Moisture storage functions / Sorption isotherm



**The hygrothermal
simulation allows safe
and reliable statements
about the behaviour of
masonry structures.**

Source: Mayang's Free Textures - <http://www.mayang.com/textures/>

An Example:

Double layer masonry wall

Case I: No Insulation

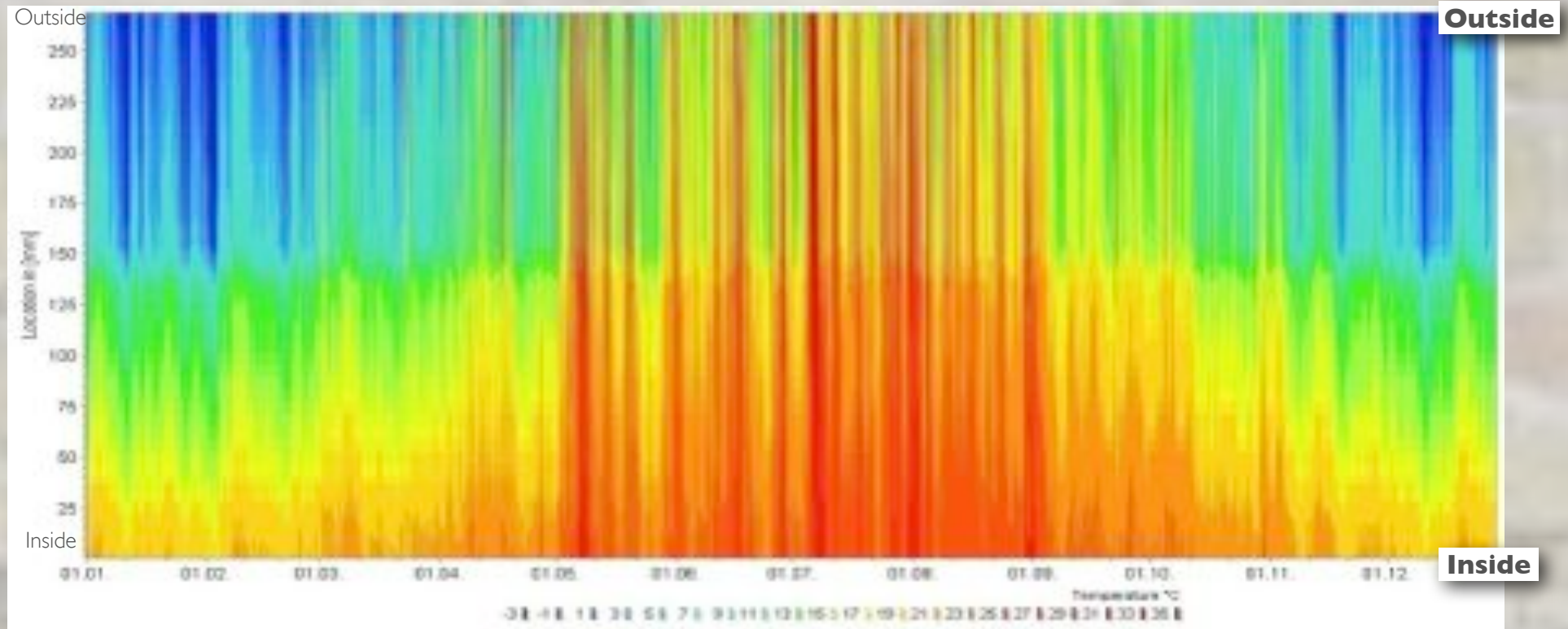
Case II: Inside Insulation, Material I

Case III: Inside Insulation, Material II,
(Calciumsilicate based)

Investigation of Temperatures

EXAMPLE:

DOUBLE-SHELL MASONRY WALL



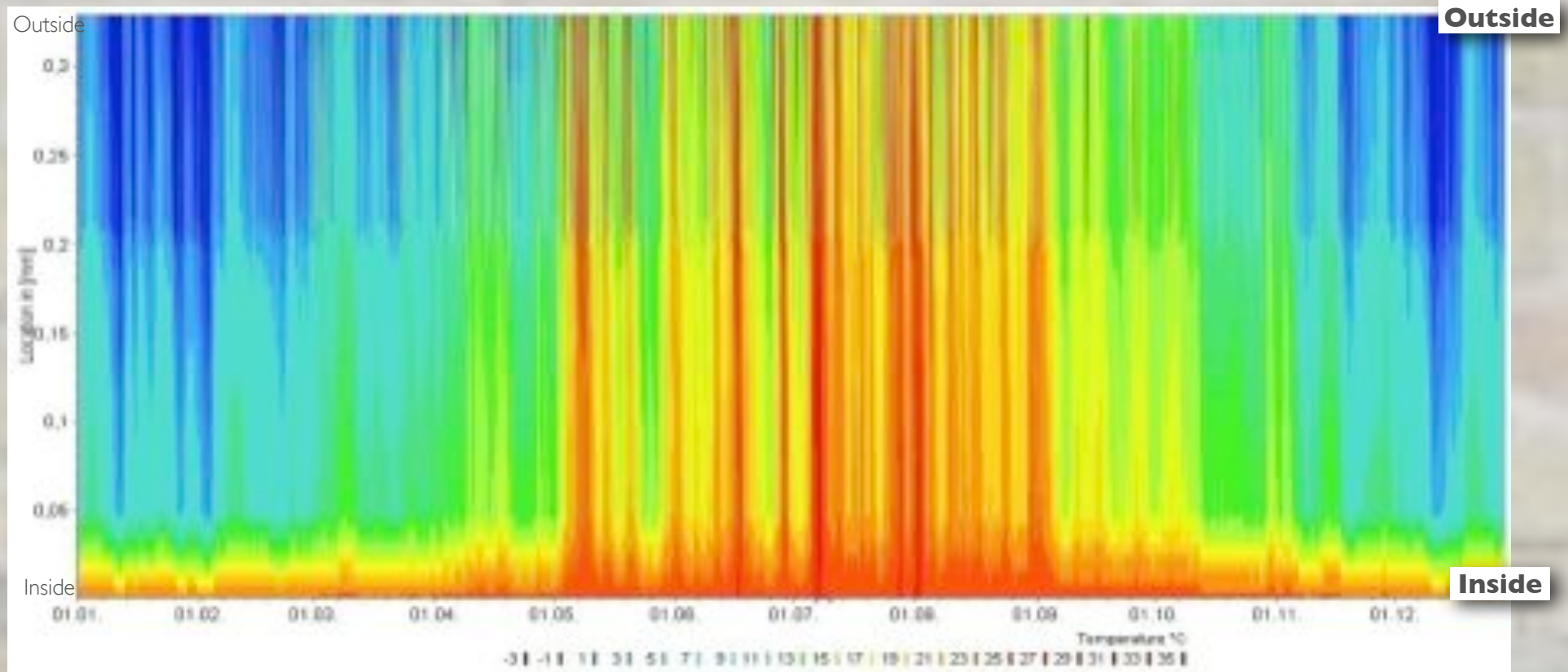
Source: Werner Kaul/ABT TUHH 2012

Parameter: Temperature

State: No insulation

EXAMPLE:

DOUBLE-SHELL MASONRY WALL



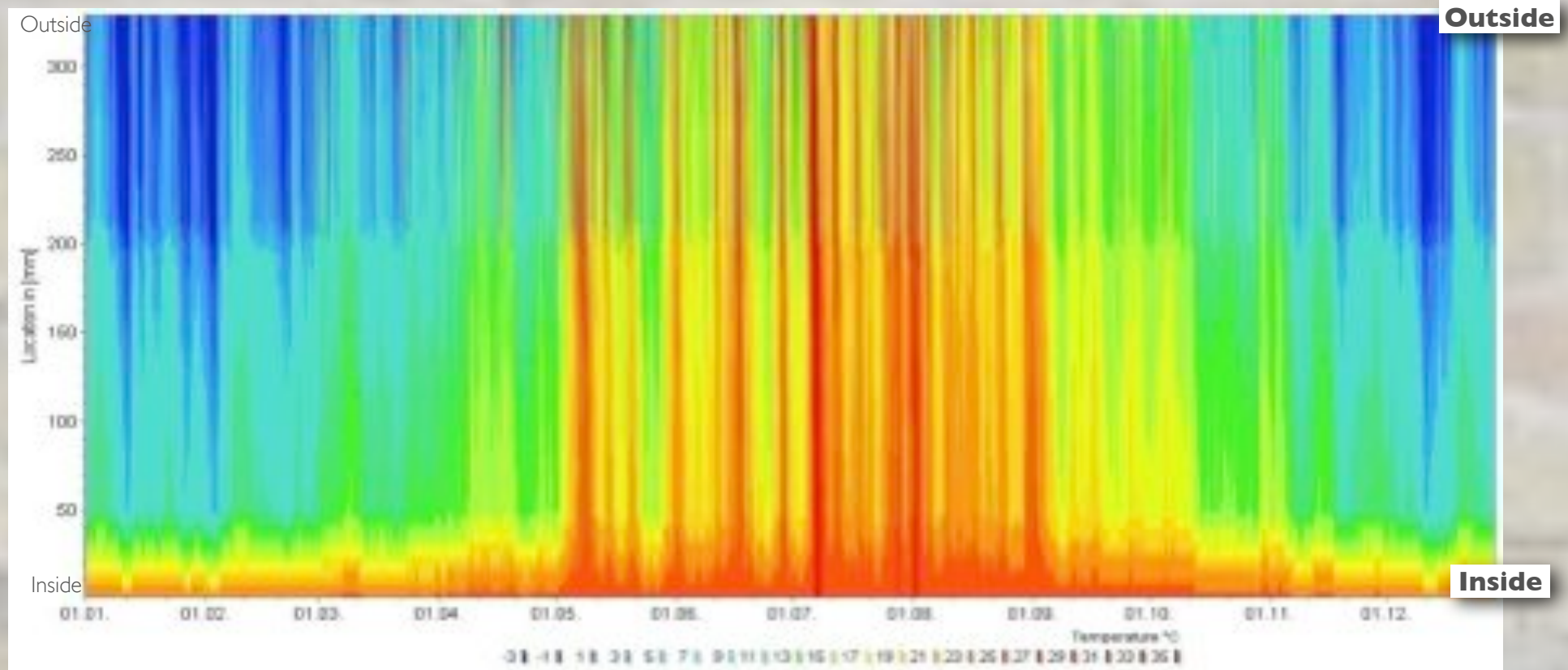
Parameter: Temperature

Source: Werner Kaul/ABT TUHH 2012

State: Inside insulation, Material I

EXAMPLE:

DOUBLE-SHELL MASONRY WALL



Parameter: Temperature

Source: Werner Kaul/ABTTUHH 2012

State: Inside insulation, Material II (Calciumsilicate based)

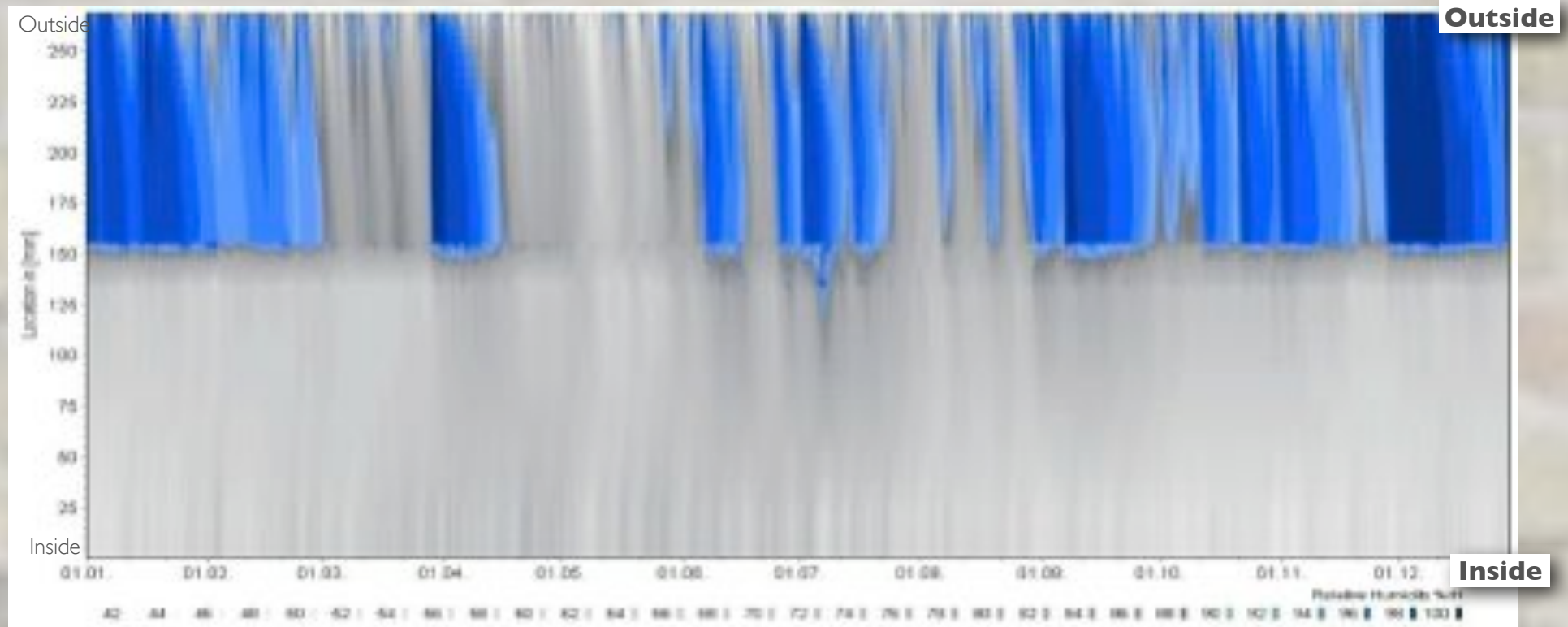
Result:

Case II and Case III both show up higher inside surface temperatures, which is essential for a comfortable indoor climate without the need of high indoor air temperatures.

Investigation of Relative Humidity

EXAMPLE:

DOUBLE-SHELL MASONRY WALL



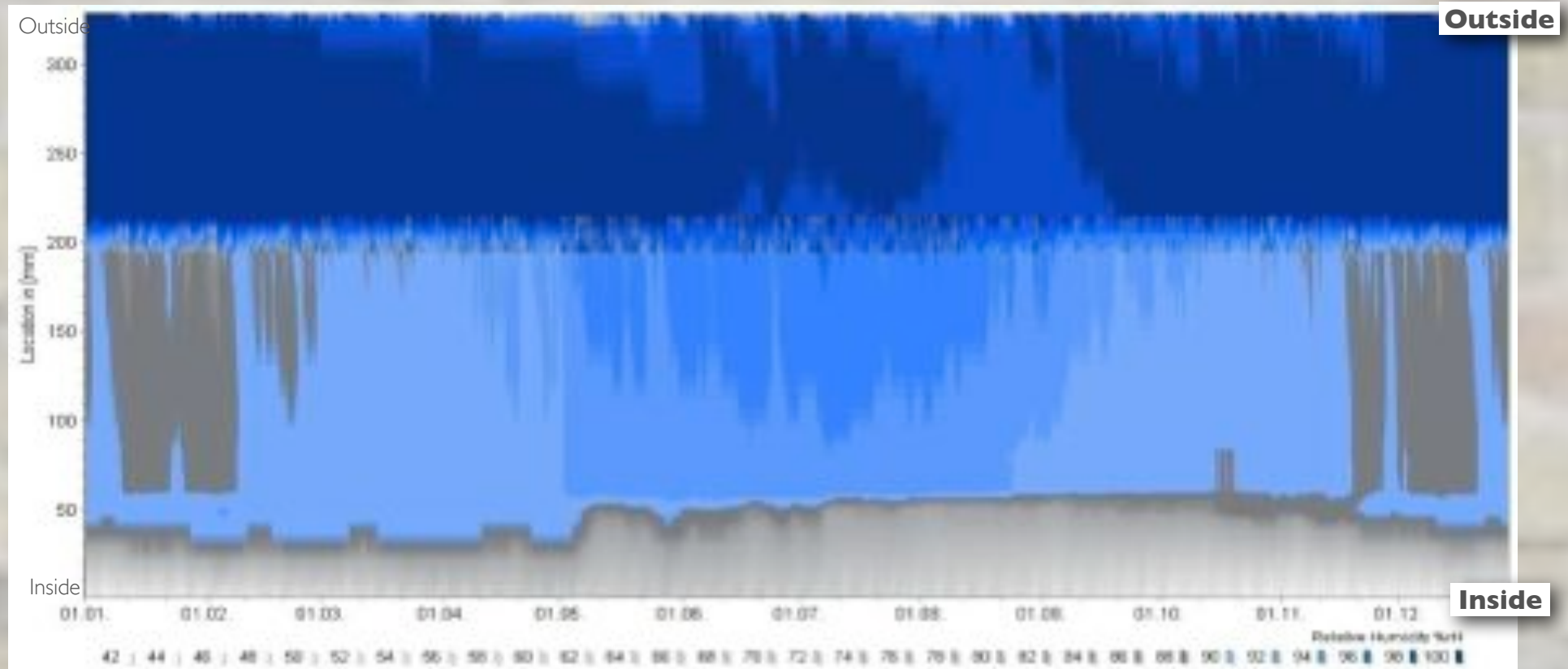
Source: Werner Kaul/ABT TUHH 2012

Parameter: Relative Humidity

State: No insulation

EXAMPLE:

DOUBLE-SHELL MASONRY WALL



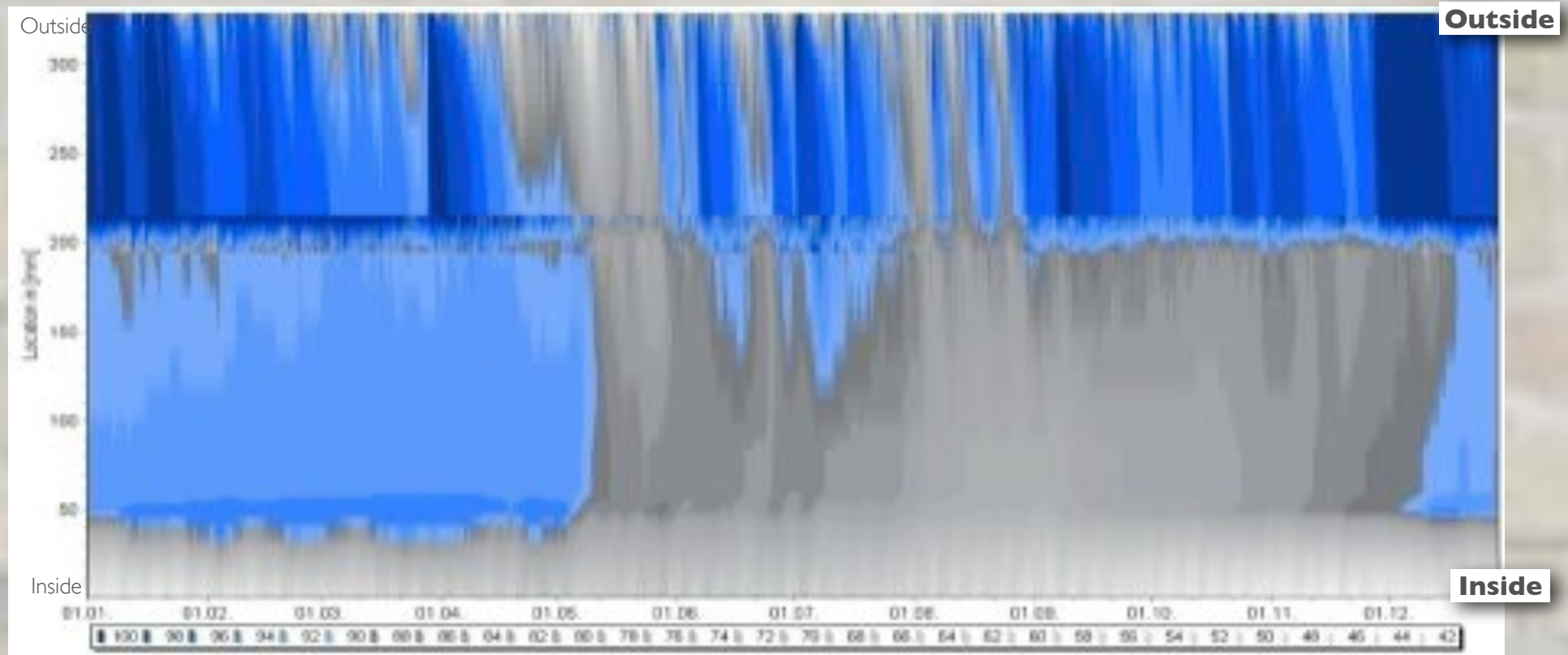
Parameter: Relative Humidity

Source: Werner Kaul/ABT TUHH 2012

State: Inside insulation, Material I

EXAMPLE:

DOUBLE-SHELL MASONRY WALL



Source: Werner Kaul/ABTTUHH 2012

Parameter: Relative Humidity

State: Inside insulation, Material II (Calciumsilicate based)

Result:

Case II shows up a dramatically higher risk of condensation than case III.

This is why material II has to be chosen for this specific structure.

**Hygrothermal
simulation is the perfect
tool to investigate the
options for energetic
improvement of a
building's envelope
components.**

Source: Mayang's Free Textures - <http://www.mayang.com/textures/>

THANK YOU FOR YOUR ATTENTION.

Dipl.-Ing. Werner Kaul

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