Trends and challenges in Building Physics during the last 30 years
In a very Swedish and personal perspective

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Sweden

Keynote speech at the Building XIII conference, Clear Water Beach, 2016

Outline of presentation

- A short background of my research career
  - mirroring trends in Sweden since the 80´s
- Sustainable development - the role of Building Physics
- Trends in the research (papers at NSB), Swedish Ph.D. theses and funding
- When it goes wrong and right –Why?
- What drives the development in the building industry?
- Challenges for the future

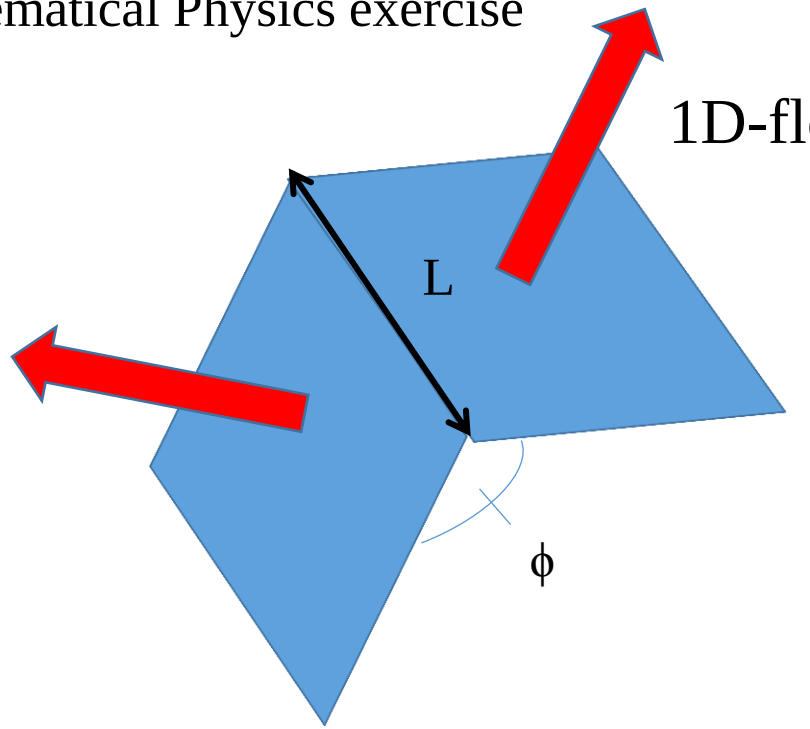
Micro CV

Engineering Physics, graduated 1983, Ph.D. 1988 Lund University
1992-93 CSIRO Melbourne
Full professor in Building Physics 1993, Moved to Chalmers, Gothenburg

My start:

Master thesis: Corner effects- Heat loss from a ground storage.
Mathematical Physics exercise

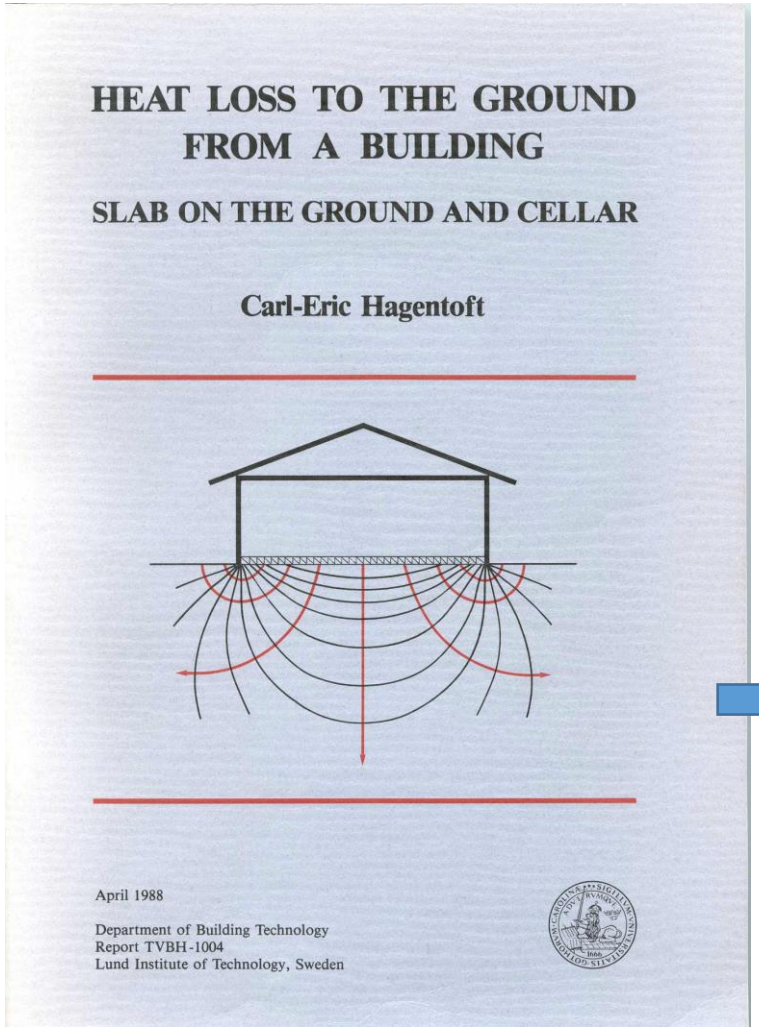
Year 1983



1D-flow
+
an extra constant heat loss
proportional
to L and determined by the angle

Oil crisis in the 70's – Lots of funding available by
the Swedish Building Research Council

Stumbled in to a research position … and a kind of PhD-project at Lund University.



More mathematical analyses, both analytical and numerical ones.

EN-ISO Standards
(Started as an EU-initiated project)

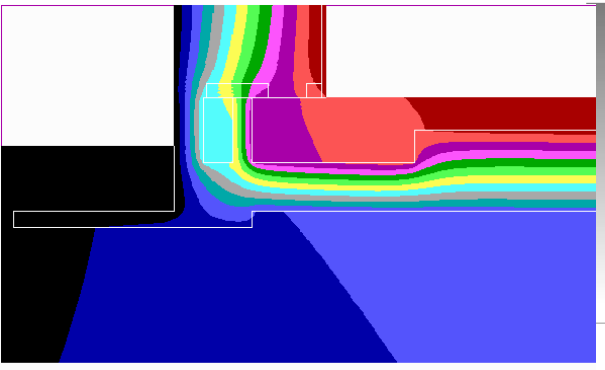
Ground:
District heating pipes
Foundations - Crawl-spaces
Hygro-thermal processes
Frost protection

Research question: Thicker insulations, Degradation by air flows?

More mathematical analyses-both analytical and numerical ones.

Software development:
Mathematical Physics – heat storage – heat extraction
Lund Computational Group in Building Physics, (Johan C, PC-applications)

HConP, ANHConp, AHConp, CRAWL, SLAB, CELLAR, 1D-HAM,….



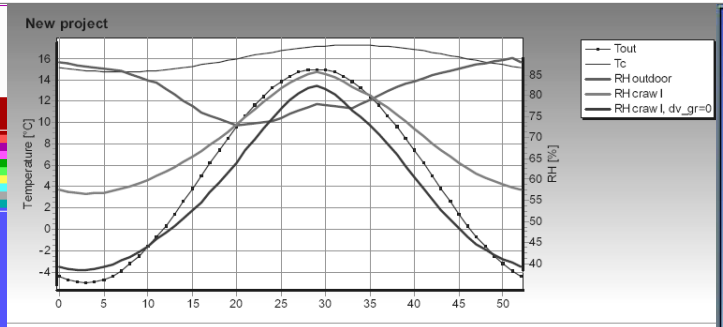
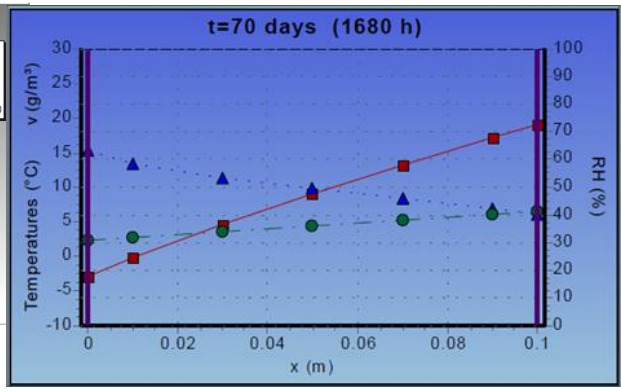


Figure 5: Menu showing a crawl-space temperature and relative humidity.



1992-93 CSIRO Melbourne, Australia
Foundations/Attics
Dr. Angelo Delsante

Gothenburg

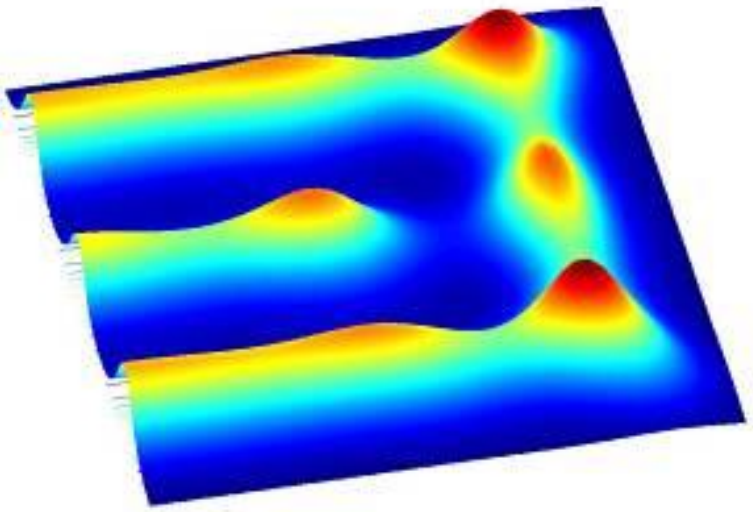
Chalmers University of Technology, Sweden

Highly insulated envelope components – Air movements-Loose fill insulation

Years 1993-2000

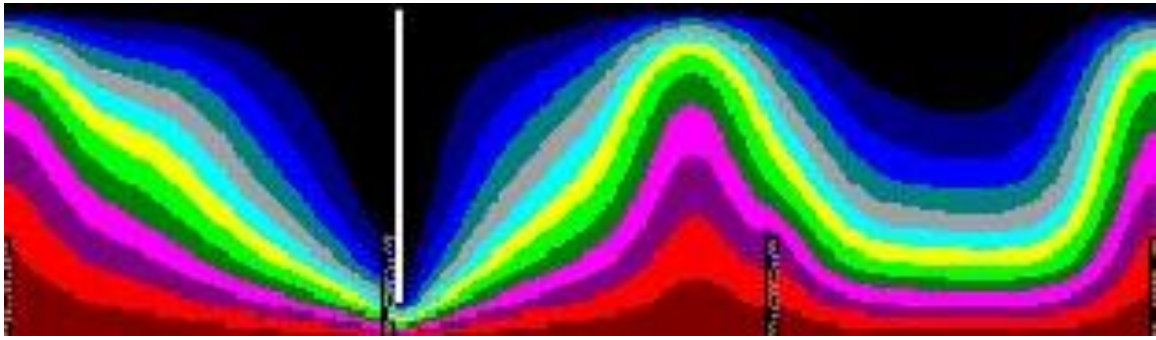
Windbox – Guarded heat box for loose fill insulation

Years 1993-2000



Thick loose fill insulation

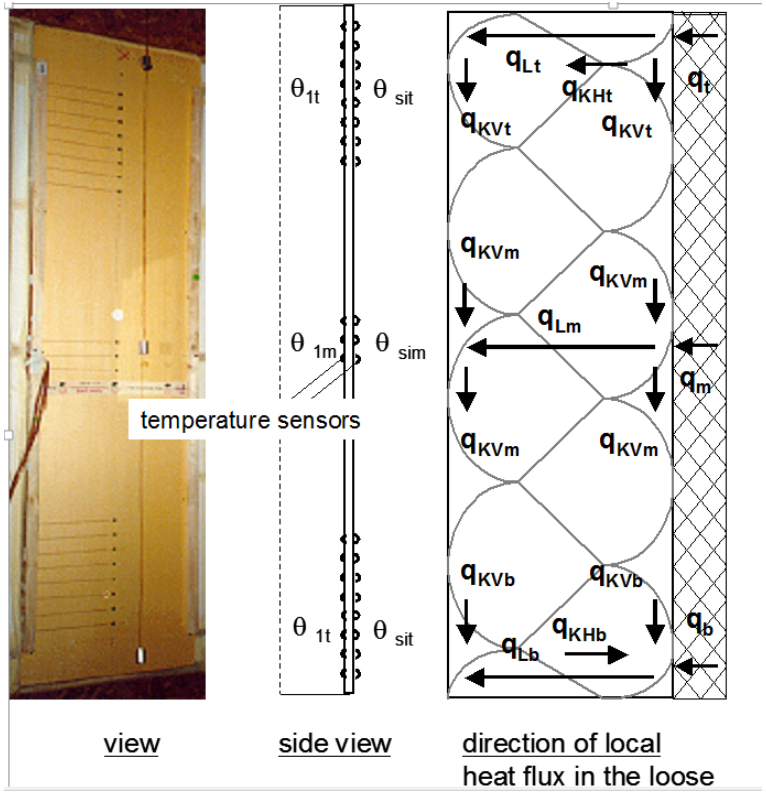
Simulations and experiments

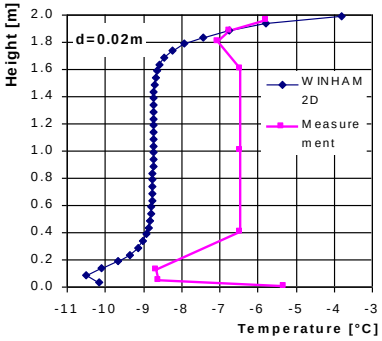


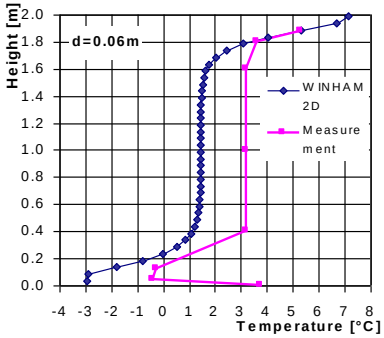
Microclimate – Driving rain – Rain penetration

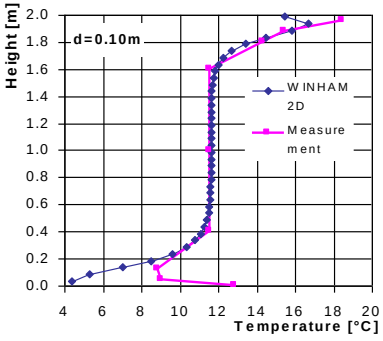
Computer and analytical simulation of HAM-processes IEA – Annex 24, 41

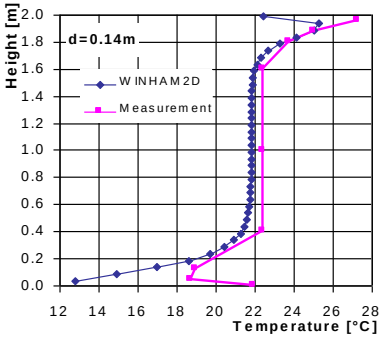
Validation test Wismar/Rostock and Chalmers

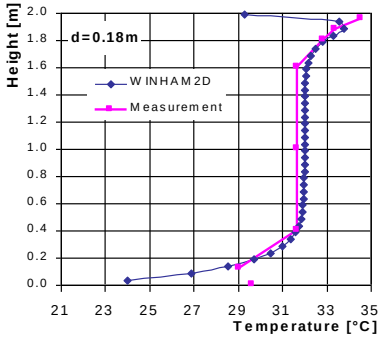




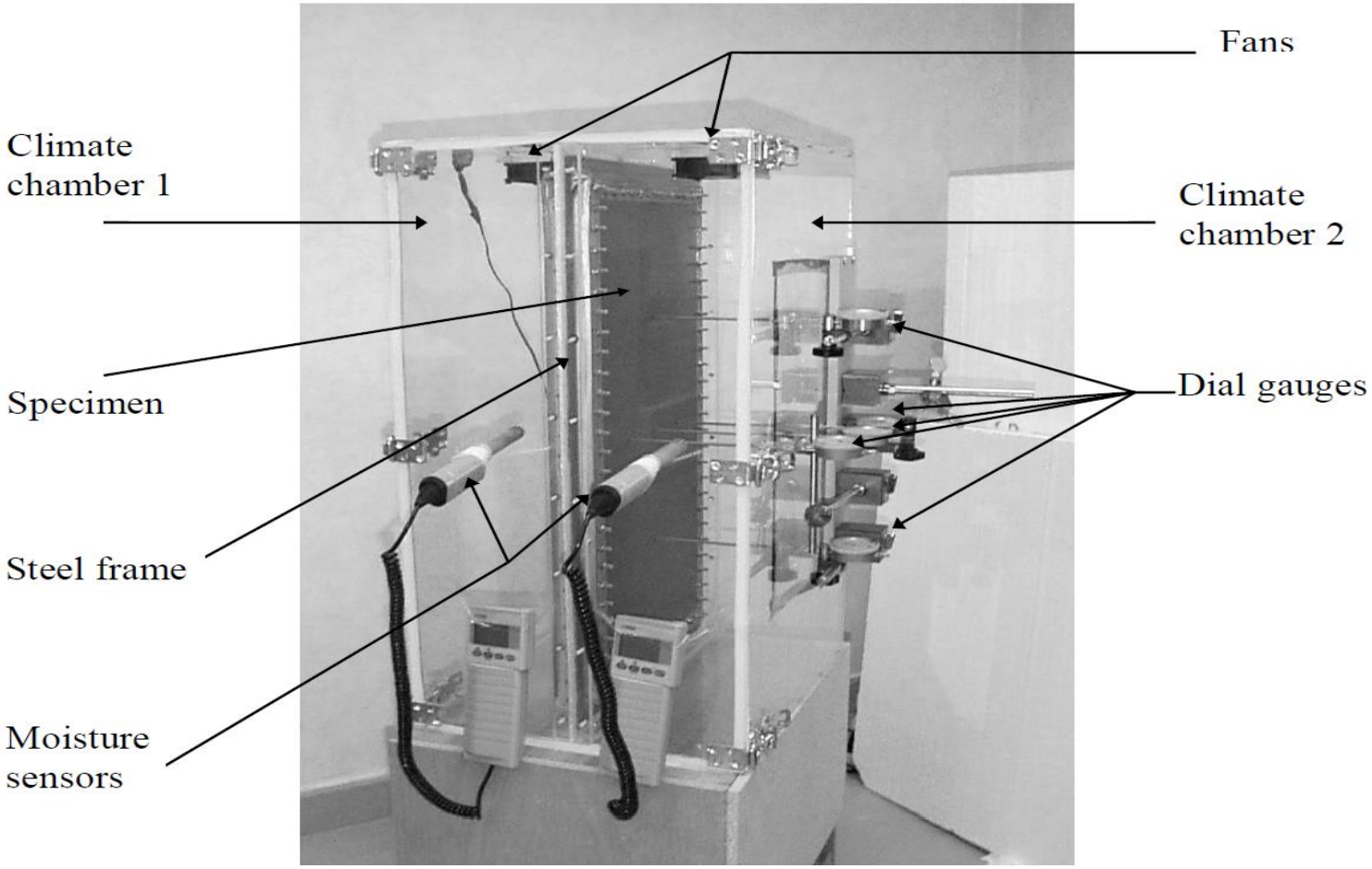








Hygro-elastic deformation of high pressure laminates



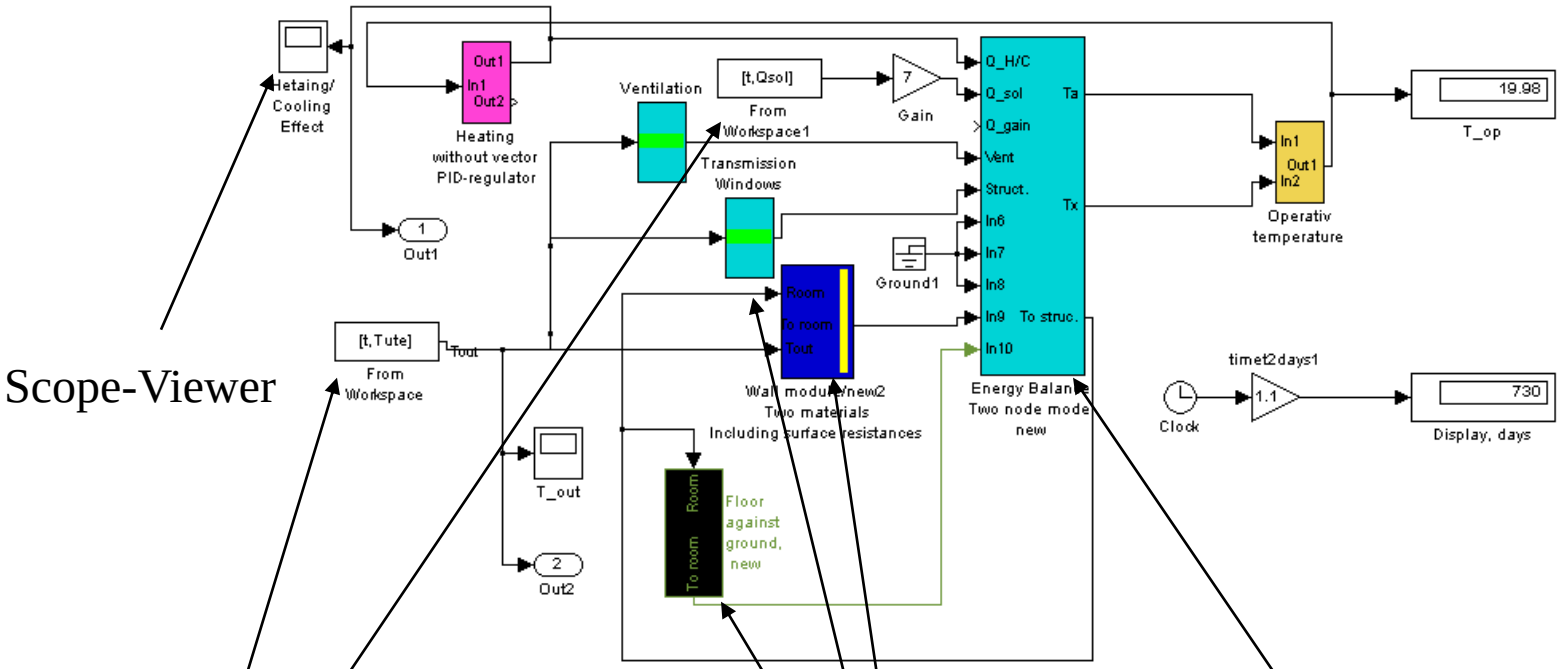
Visit to K.U.Leuven in spring 2000, Hugo H.

New inspiration:
Simulink models – HAM
Thermal mass
Cold attics
Floor Heating/TABS

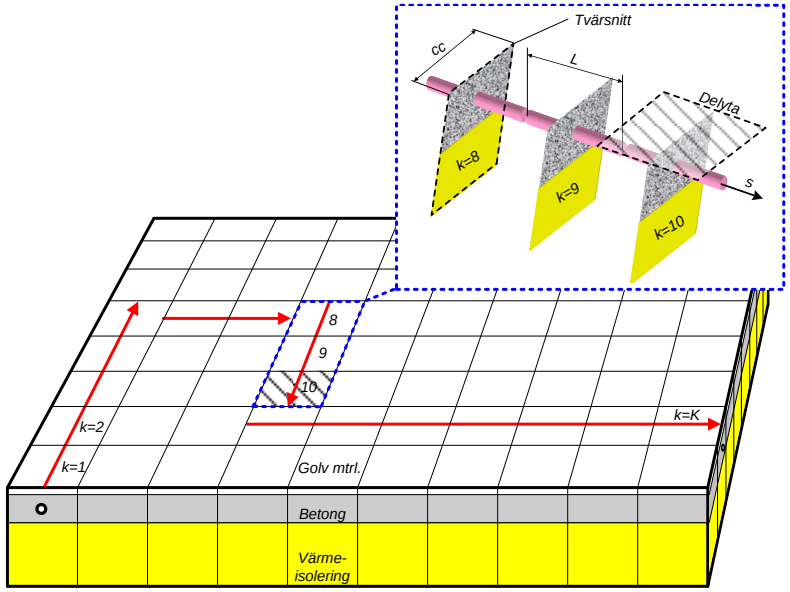
Years 1993-2000

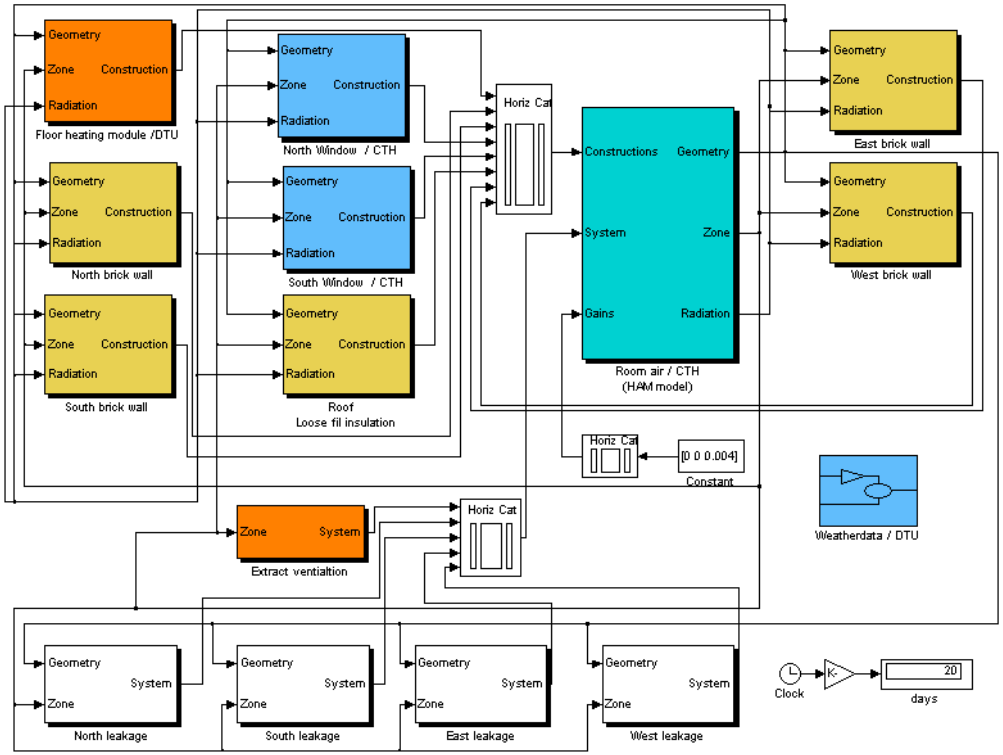
Building Physics Toolbox in MATLAB/Simulink
Further developed in HAM-Tools

Example with a ventilated room:



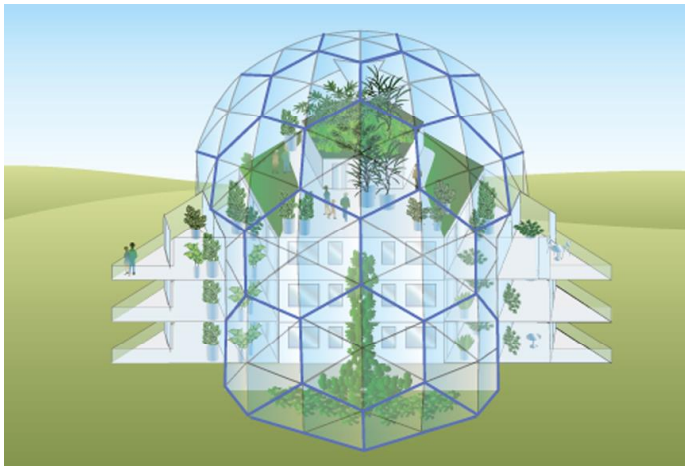
Floor heating simulations by Simulink- Matlab



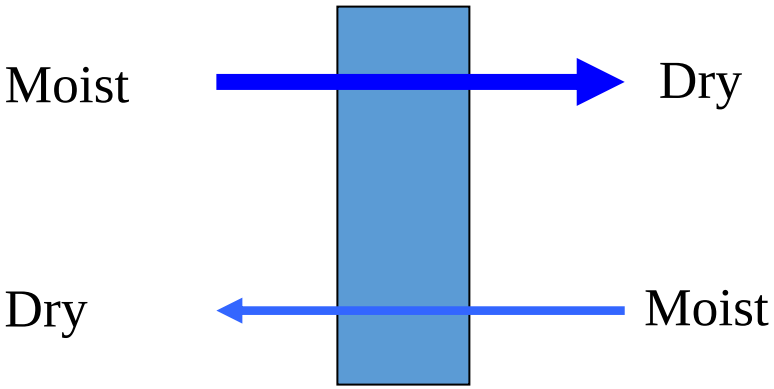


Experimental validations – Paper at this conference on Tuesday afternoon

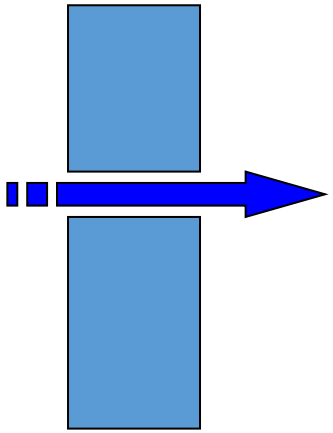
Homes for Tomorrow - Innovative technical solutions
Novel insulation materials and Envelope solutions



Moisture diode



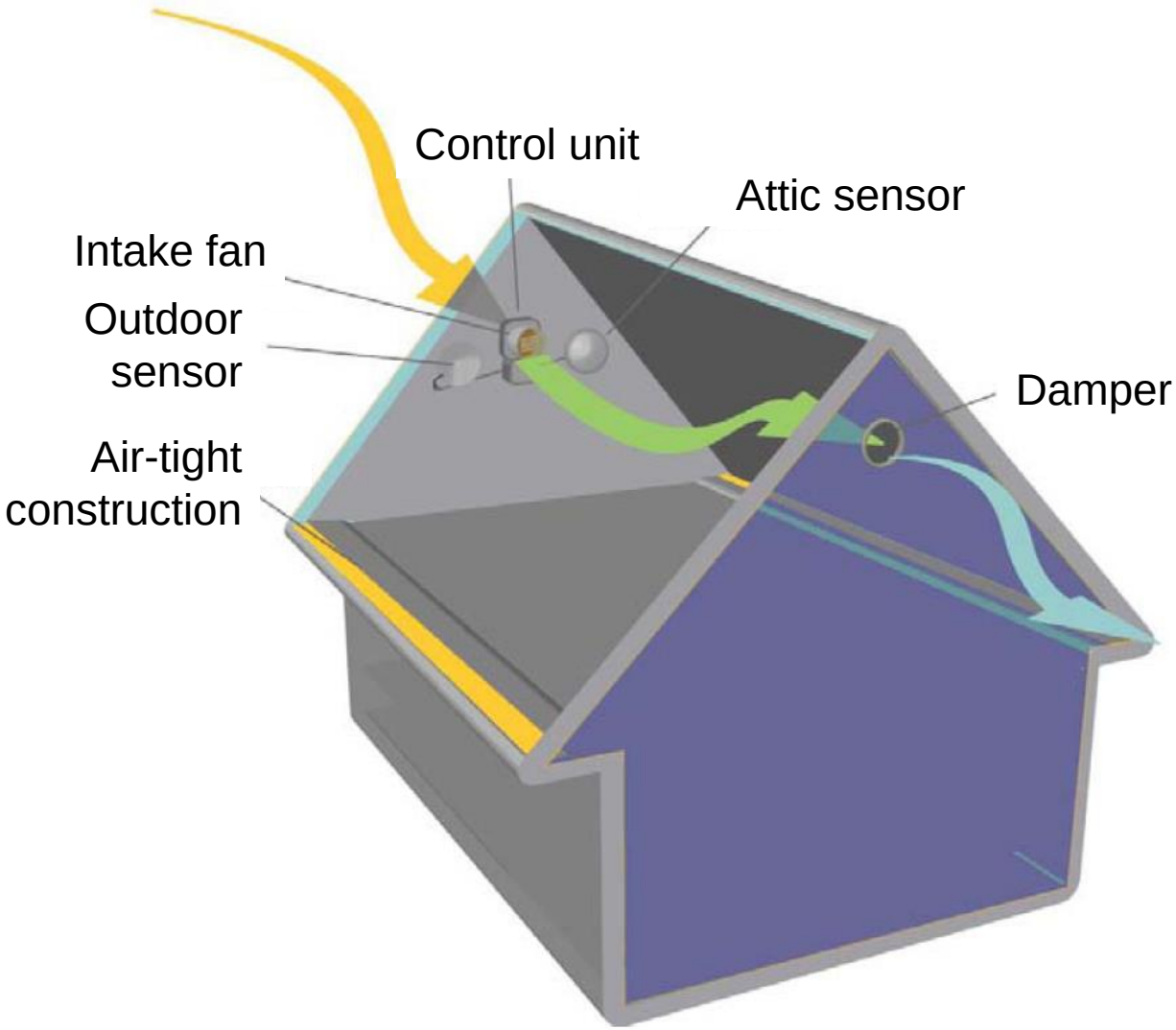
Smart envelope components



Sensor/prognosis driven
for ventilation, daylight heat/cooling control,…

Controlled ventilation of cold attics

Years 2008-Today



Retrofitting of old buildings - A real challenge!
Example: using VIP

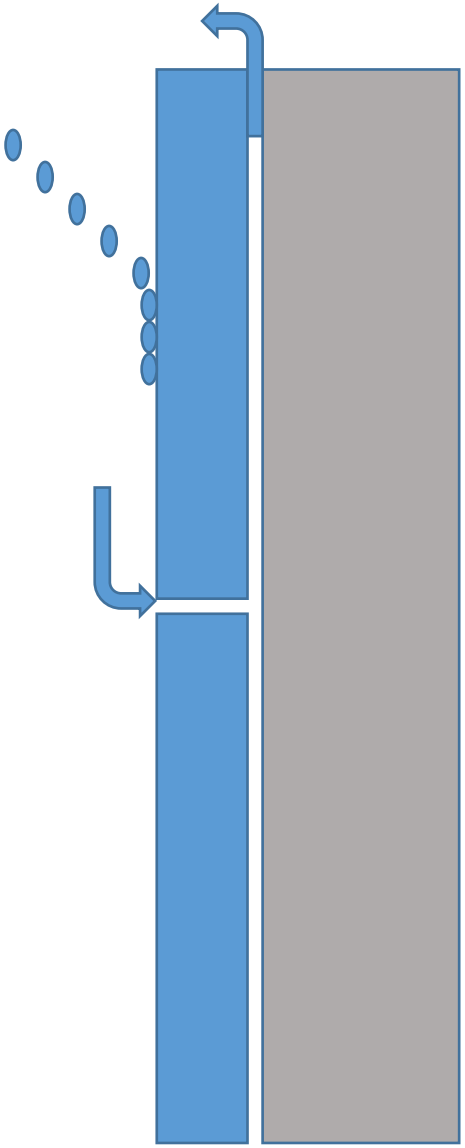
Kvarteret Malörten

Buildings from the 30´s

Retrofitting of buildings from the 60´s and 70´s

Years 2008-Today

Risk assessment – rain intrusion



a)

b)

Presentation by Lars Olsson on Wednesday morning

- 50% of my time at Chalmers University of Technology
- Board member Swedish Research Council FORMAS
- Chairman Scientific Council Volvo Research Foundations (VREF)
- Executive Board member of the Stena Foundation

Today-

…and hotel director, small B&B:

Trends in papers at the
Nordic Building Physics Symposium

Swedish PhD theses

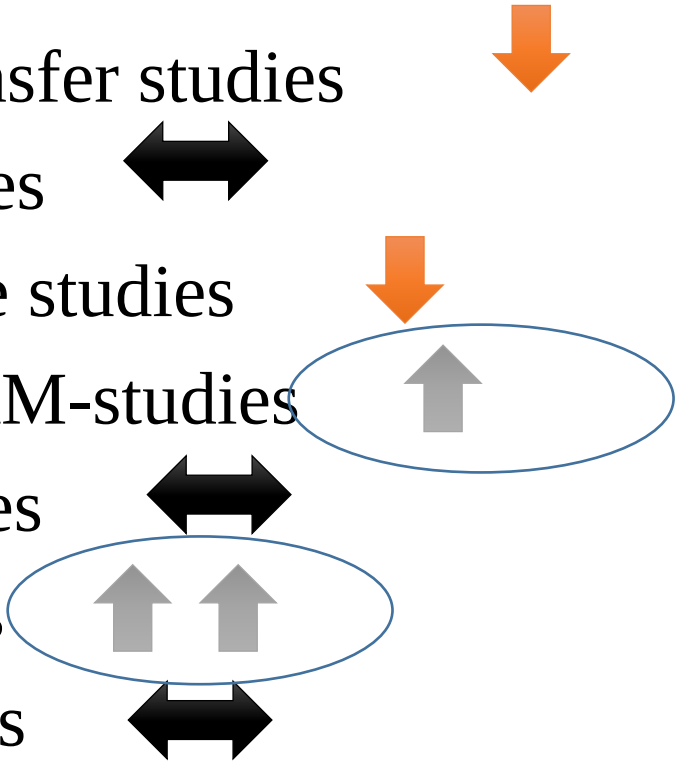
and

Funding

Evolutionary indications 1987-2014

Context:

- Basic heat transfer studies
- Air flow studies
- Basic moisture studies
- Combined HAM-studies
- Material studies
- Energy studies
- Climate studies

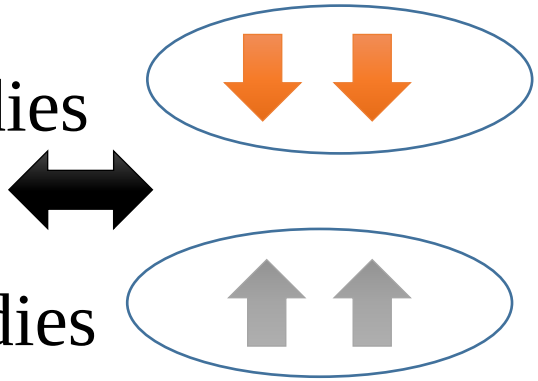


Analyses done by Johnny Kronvall

Evolutionary indications 1987-2014

Nature of study

- Laboratory studies
- Field studies
- Theoretical studies

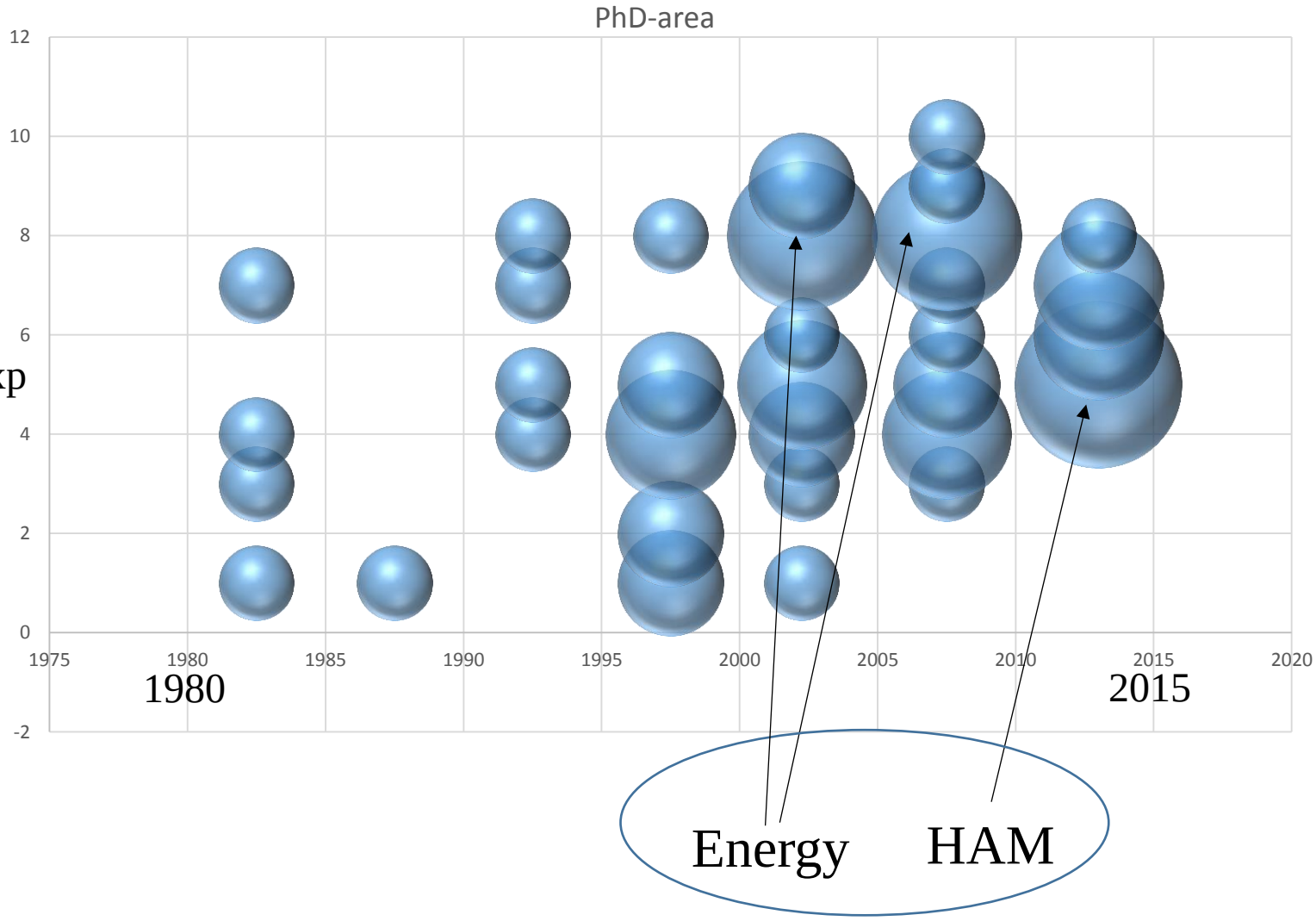


Possible reasons:

- Good and well equipped labs more and more rare at the universities?
- Reductions in technicians´ staff limit the possibility for time- and resource-intensive field studies?
- The general ”computerization” of research?

Swedish Ph.D.-theses since 1980 – in the Building physics area

LCC/LCA
IAQ
Energy
Materials
Durability
HAM-Theory/exp
Basic moisture
Air flow
Heat and Air
Basic Heat



Funding

Good times for the building sector
More money again in the new government budget

and EU-money as well.

Focus on cross-disciplinary and trans-disciplinary approaches
Co-funding often required

Quite applied –
sometimes difficult to see that our core science area is moving forward!

Challenges for the future

Importance to Sustainable development, the role of Building Physics

Building sector:
uses 40% of all resources:

- Energy
- Material

Development

Sustainable society-
Sustainable buildings

?

Resources

Resources

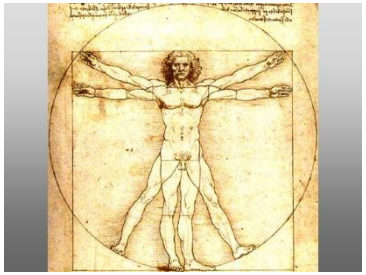
Resources

Advanced technology

Time

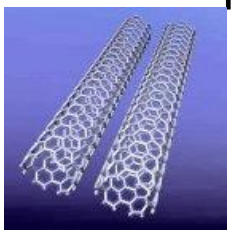
Innovative concepts important!

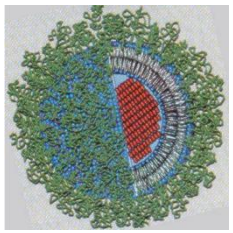
Top down



a) Building as a system. Requirements due to performance criteria. Potential of novel systems and their limitations.

b) Building component. Requirements for satisfying system demands. Potential of novel components and their limitations.





Bottom up

c) Building material. Requirements for satisfying component demands. Potential of novel materials and their limitations.

A few brief examples of when it has gone wrong:

- Slab on grade
- Crawl-space
- ETICS
- Floor heating

and also some good examples!

Frågan är vad som ska hända med Trulsagården i Killeberg. Dålig ventilation, buller samt fukt- och mögelskador kräver åtgärder snarast.

From newspaper:

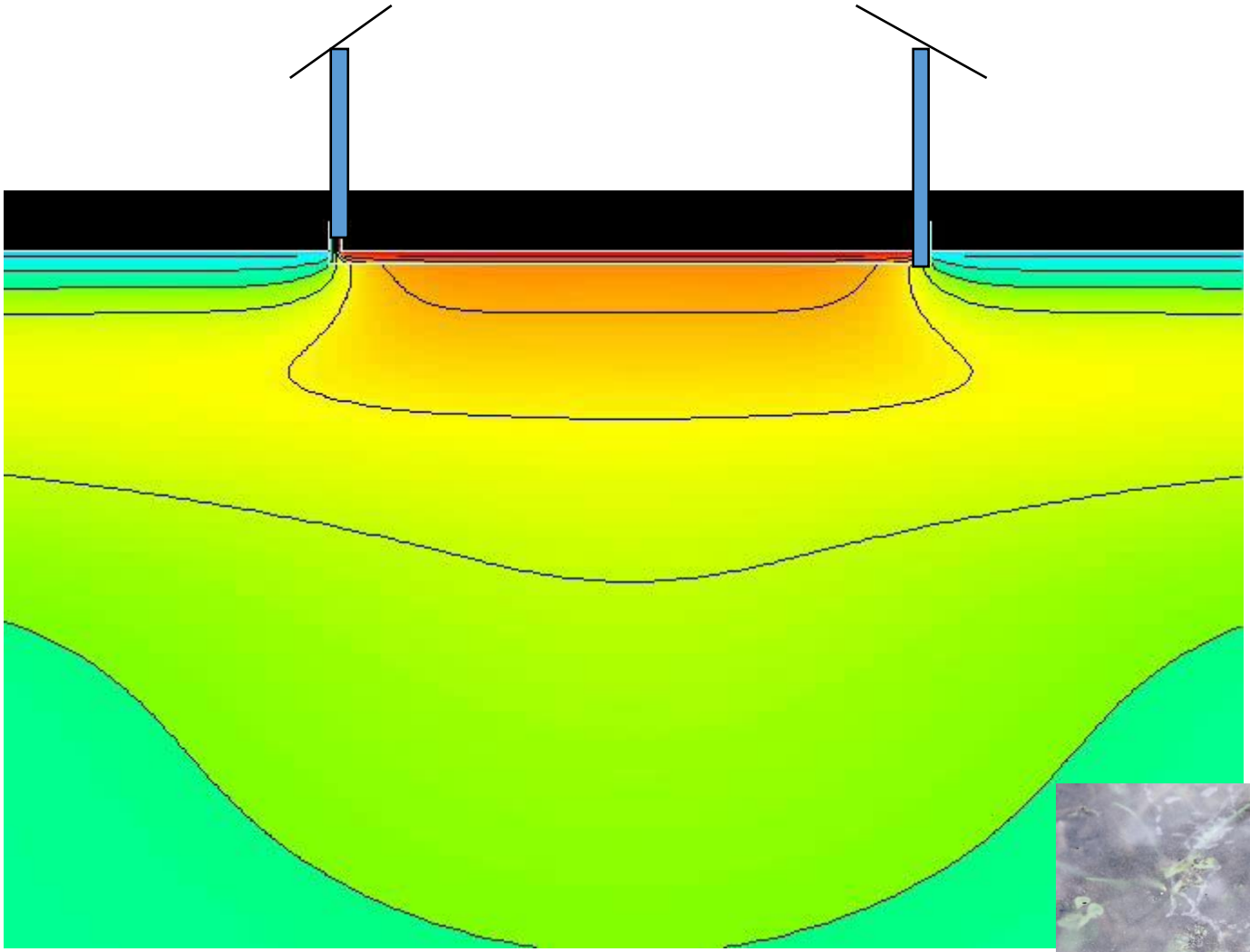
”Mould growth found in further one pre-school!”

Publicerad 27/1 07:00 · Uppdaterad 27/1 07:11

Mögel upptäckt på ännu en förskola

Slab on grade

Ground temperature below building

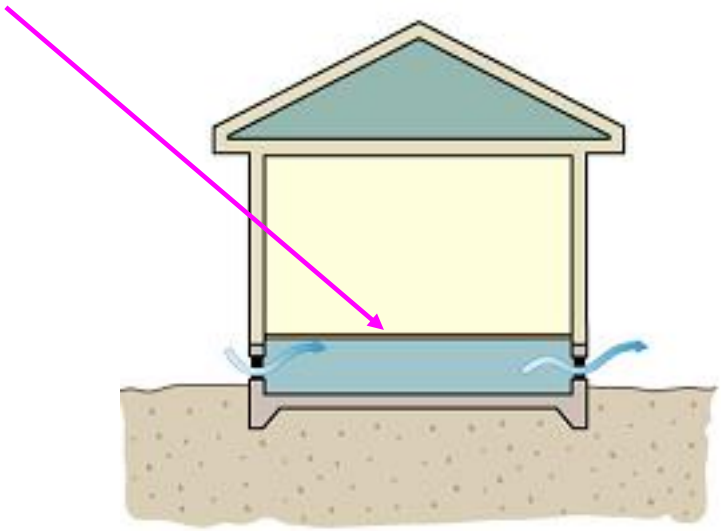


RH 100% in soil

High temperature –
High water vapor concentrations!

Crawl-space

Thermally insulated floor
No heat sources

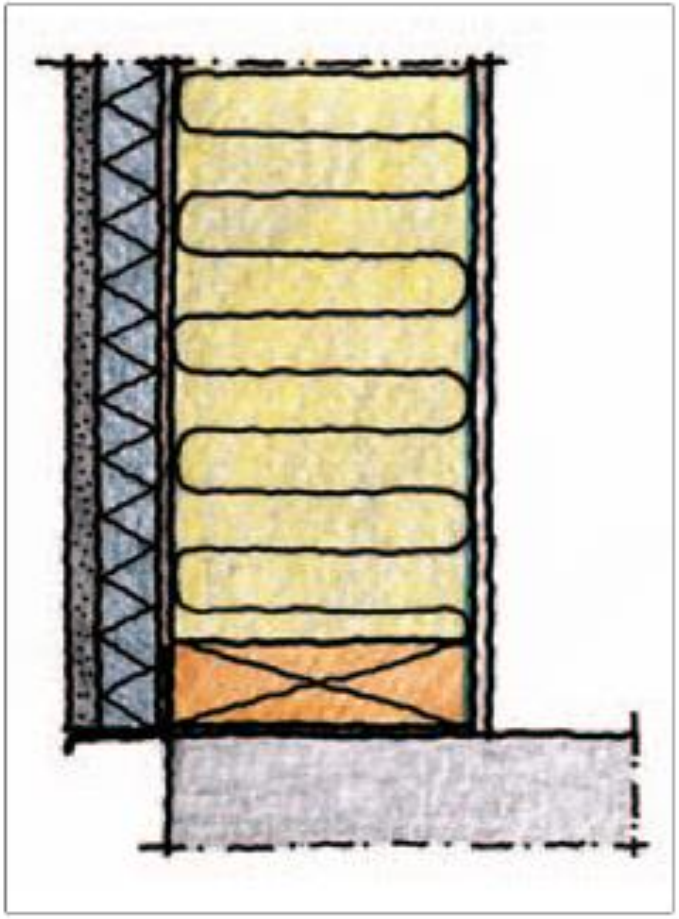


Old building technology

Crawl-spaces
Mould growth and rot

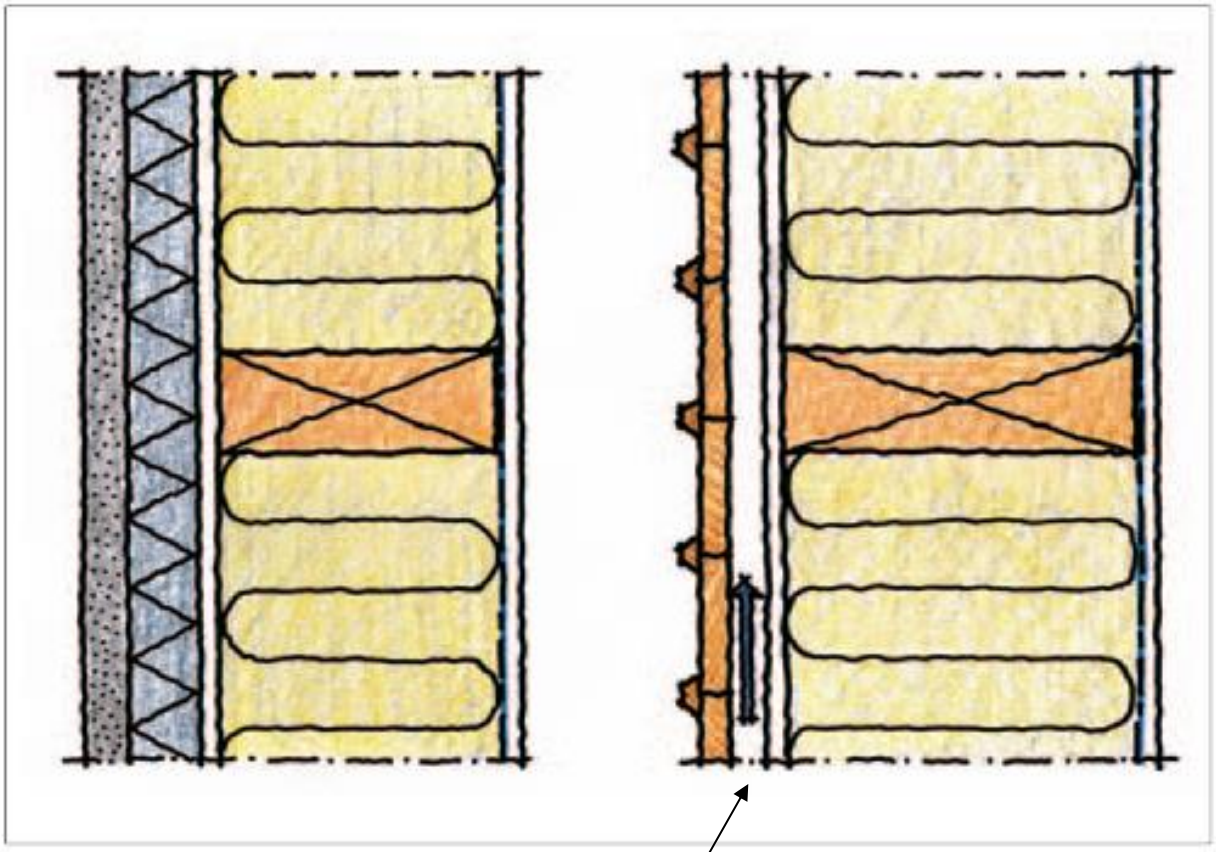
Problems with facades in Sweden

ETICS



Exterior surface of gypsum board

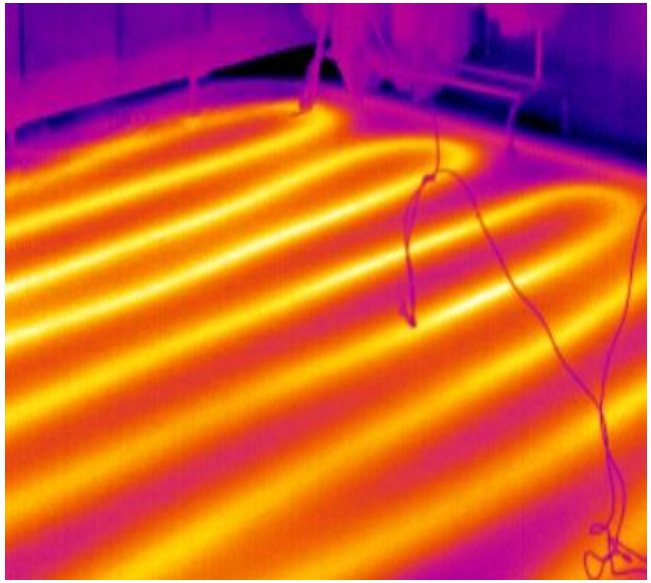
German experiences are positive –
Stone houses/mineral based walls

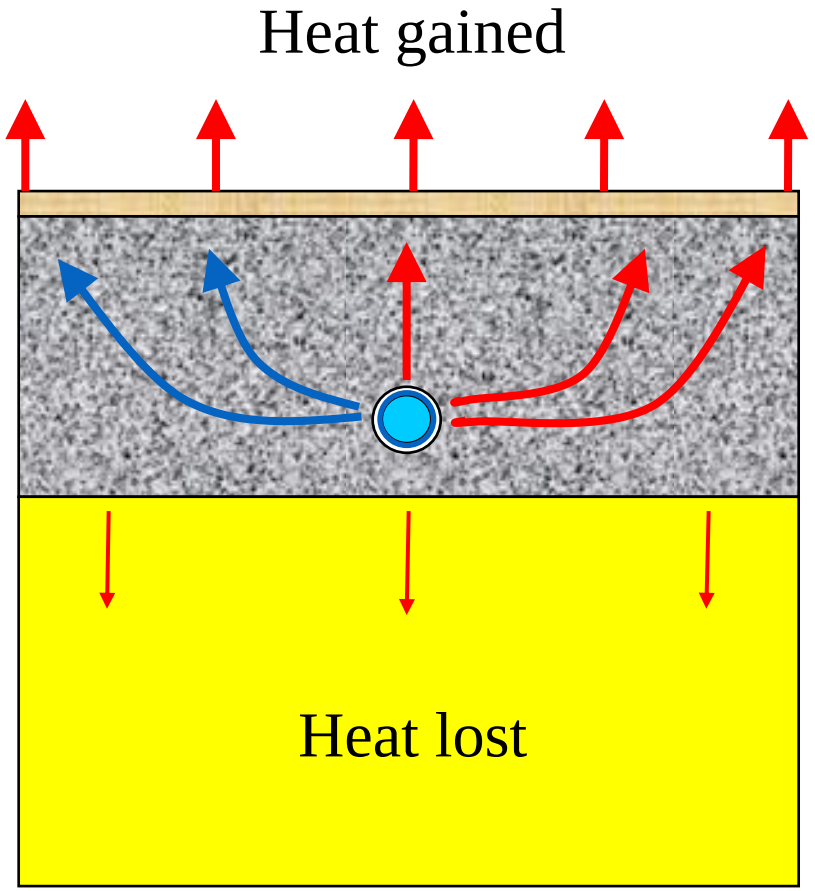


Traditional ventilated cavity –
more robust for timber-framed constructions!

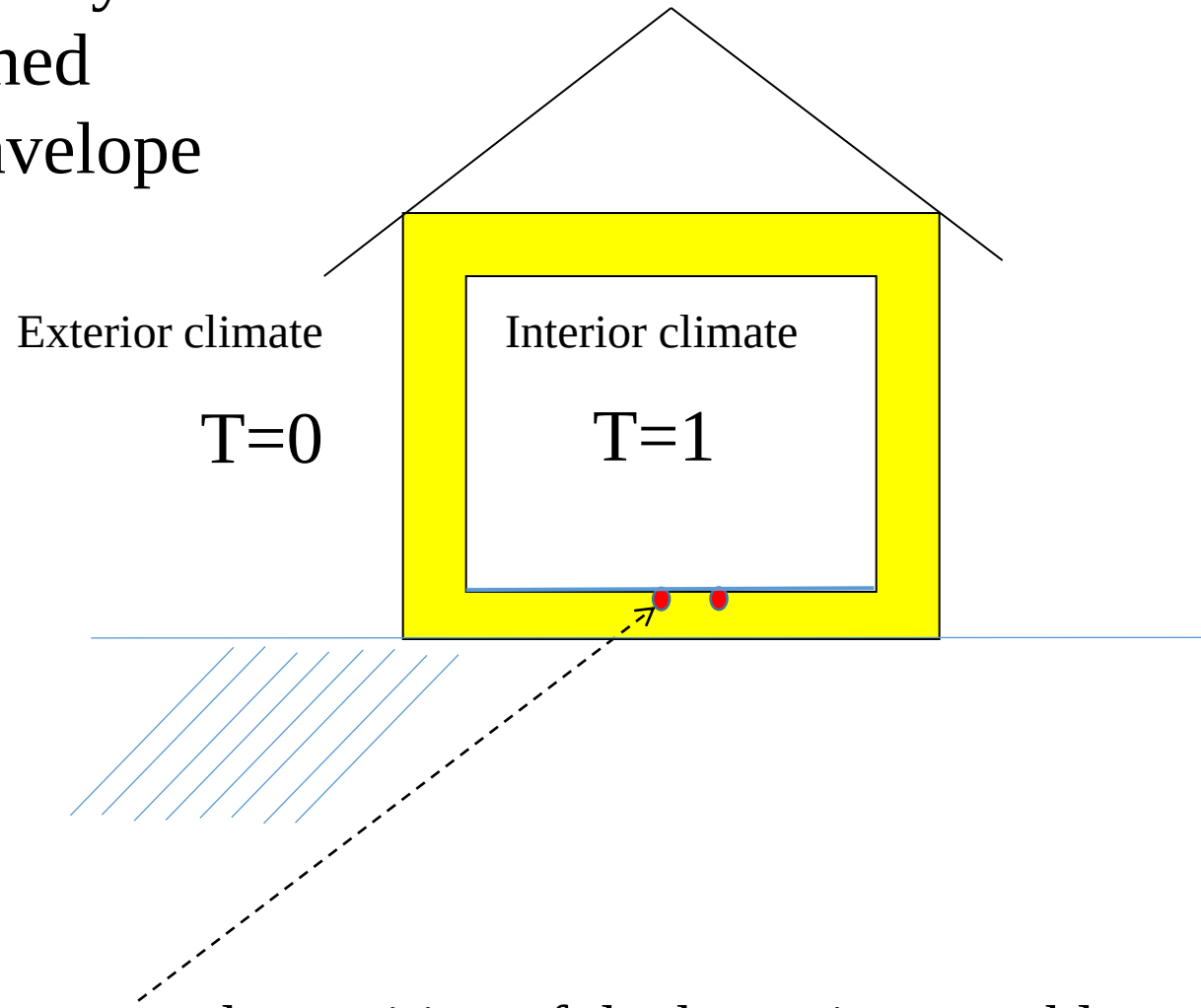
Floor heating

Claiming better energy efficiency and comfort!





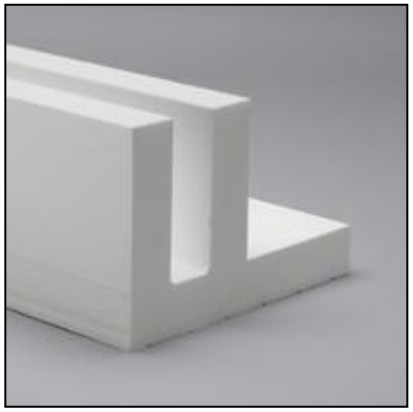
Simple rule for efficiency!
Floor heating positioned
inside the building envelope



Temperature at the position of the heat pipe or cable
=
Part of the heat that is gained (not lost)

Research efforts resulted in change!

Thermal insulation levels changed from
2-3 inches to up to 16 inches!
Good edge solutions without thermal bridges.



Construction moisture

Weather protection

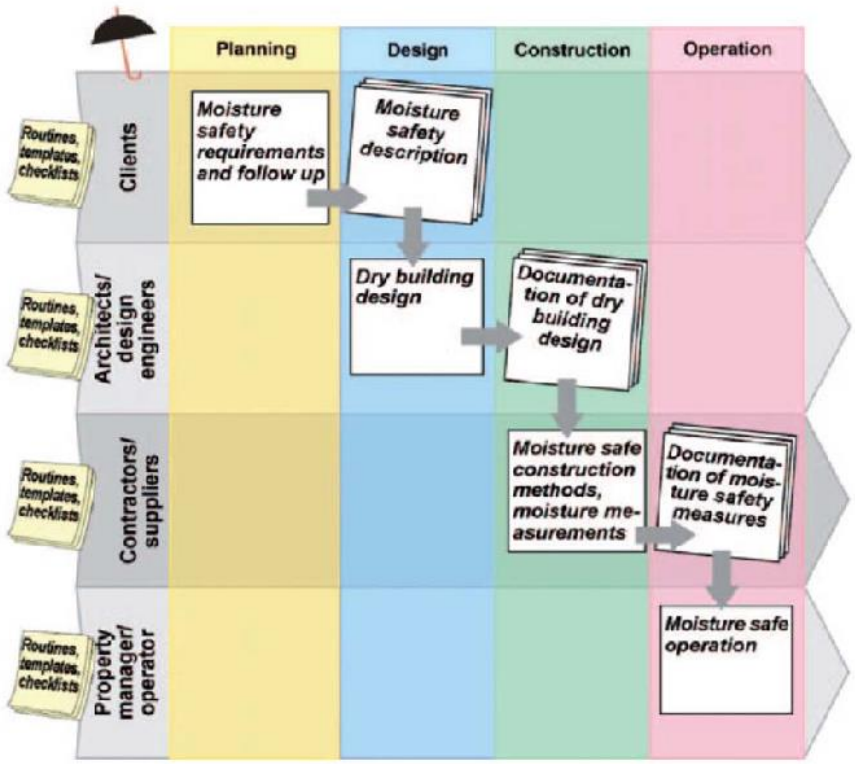
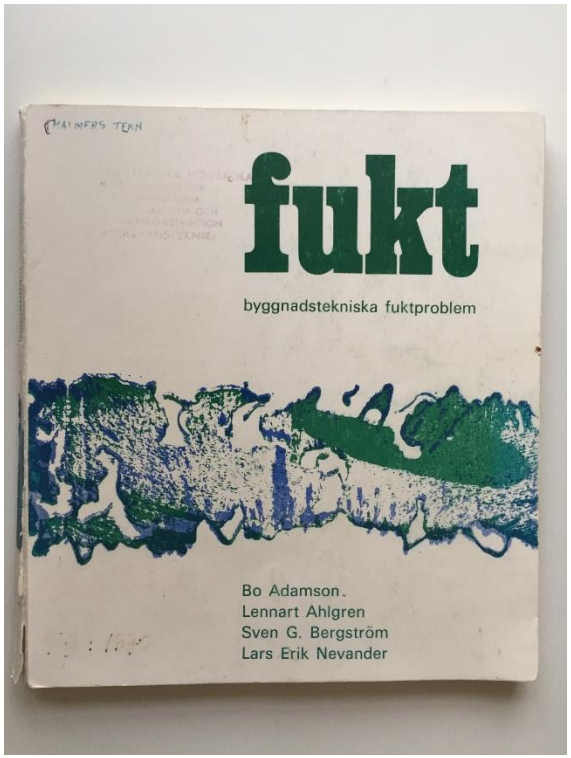


Figure 3 Conceptual outline of the ByggaF method (from Mjörnell et al. 2012).

Moisture safe design and operation
Procedure in national rules!



Lund University Moisture Research Group program 1970-
Now also a national resource!

Situation today

- A rather solid base of knowledge exists
- Extensive dissemination – handbooks etc.
- **Still – building physics related failures in buildings occur with an intensity quite exceptional compared to e g structural failures**

What is the problem with the building sector?

- Parts of the building sector tend to **ignore** (at least) written **research information**.
- Parts of the building sector are suffering from apparent **problems with learning** – the sector repeatedly replaces old technical mistakes with new and more elaborated ones, forever and ever…
- Most learning in the building sector seems to be associated with **oral communication – rumors**!
- Better **stick to the common practice** – even if wrong

What drives the sector?

- Cost and time savings - efficiency
- Customer satisfaction
- Well educated staff (+PhDs…)

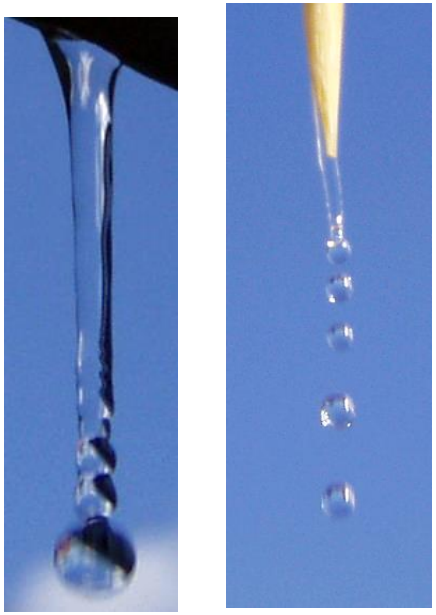
- Laws, standards and external inspection
- Skilled and demanding clients

Are we as researcher a part of the problem?

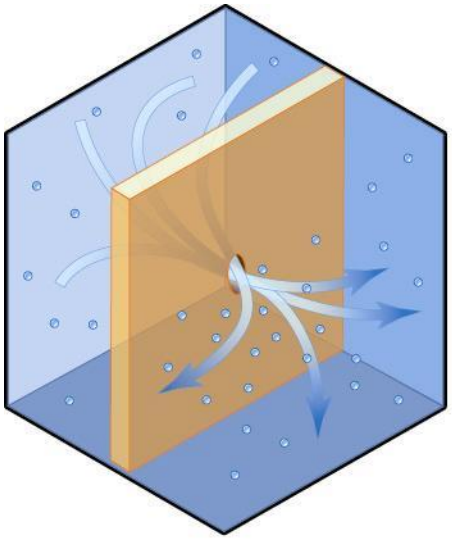
- We **cannot give a simple answer**!
  - Yes but…it depends…
- We must be **better** in our **communication** with the sector!
- How to **challenge long-existing practise**.

Learning – Text books – Popular scientific books

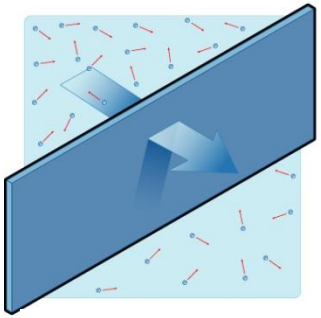
Moisture transfer illustrations



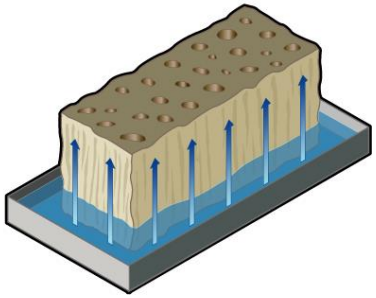
Gravitation



Convection

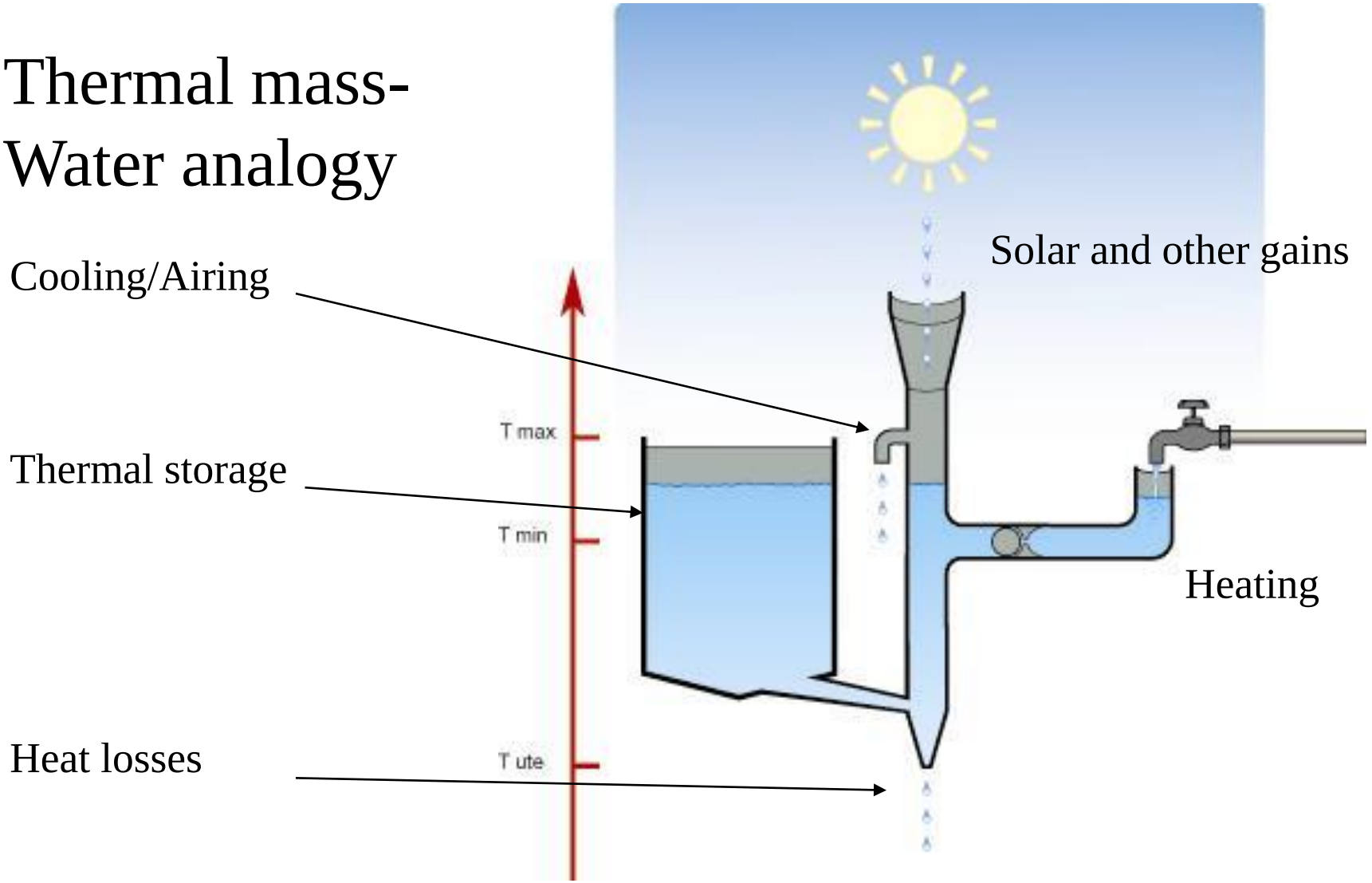


Diffusion



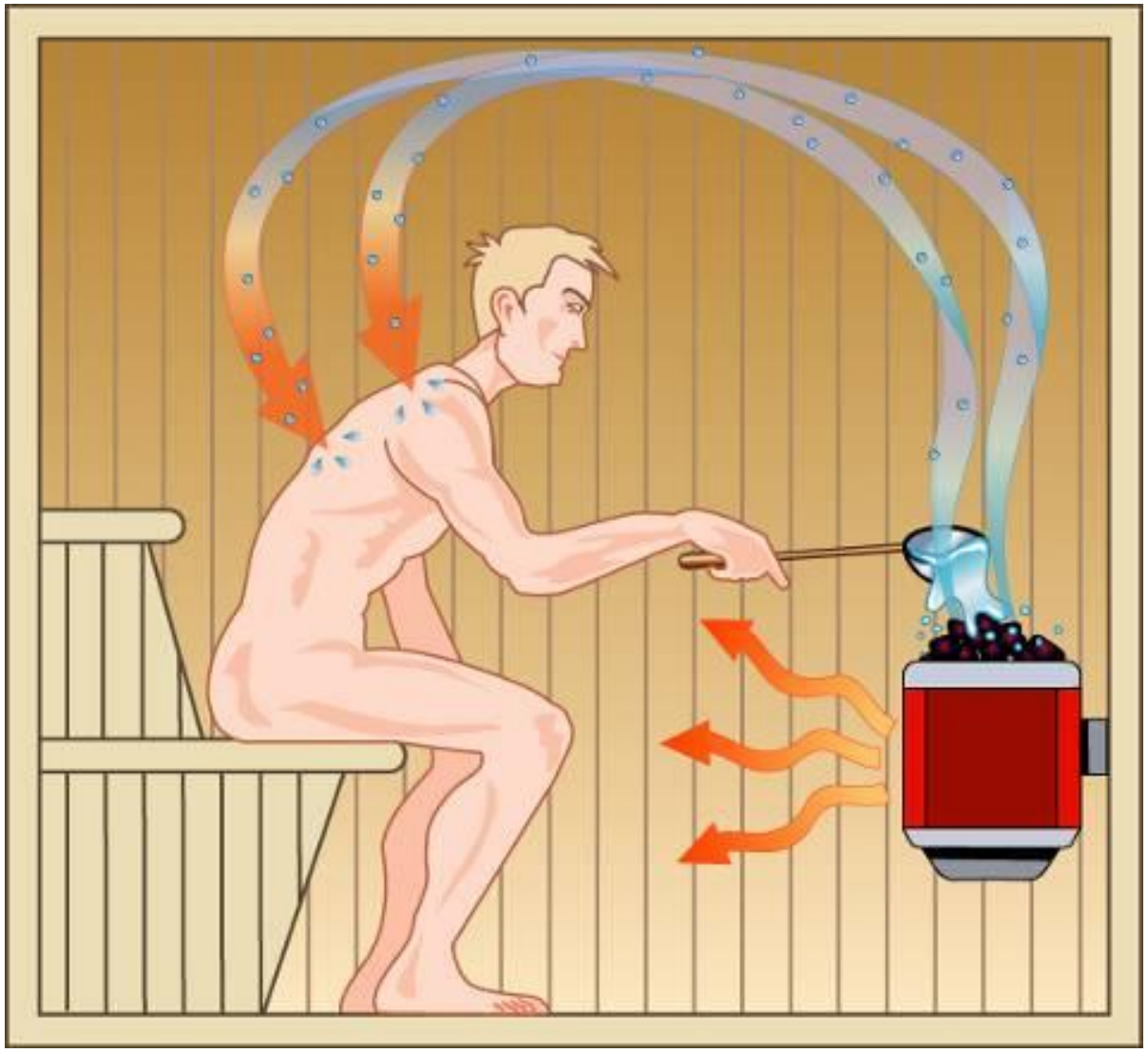
Capillary suction

Thermal mass-
Water analogy

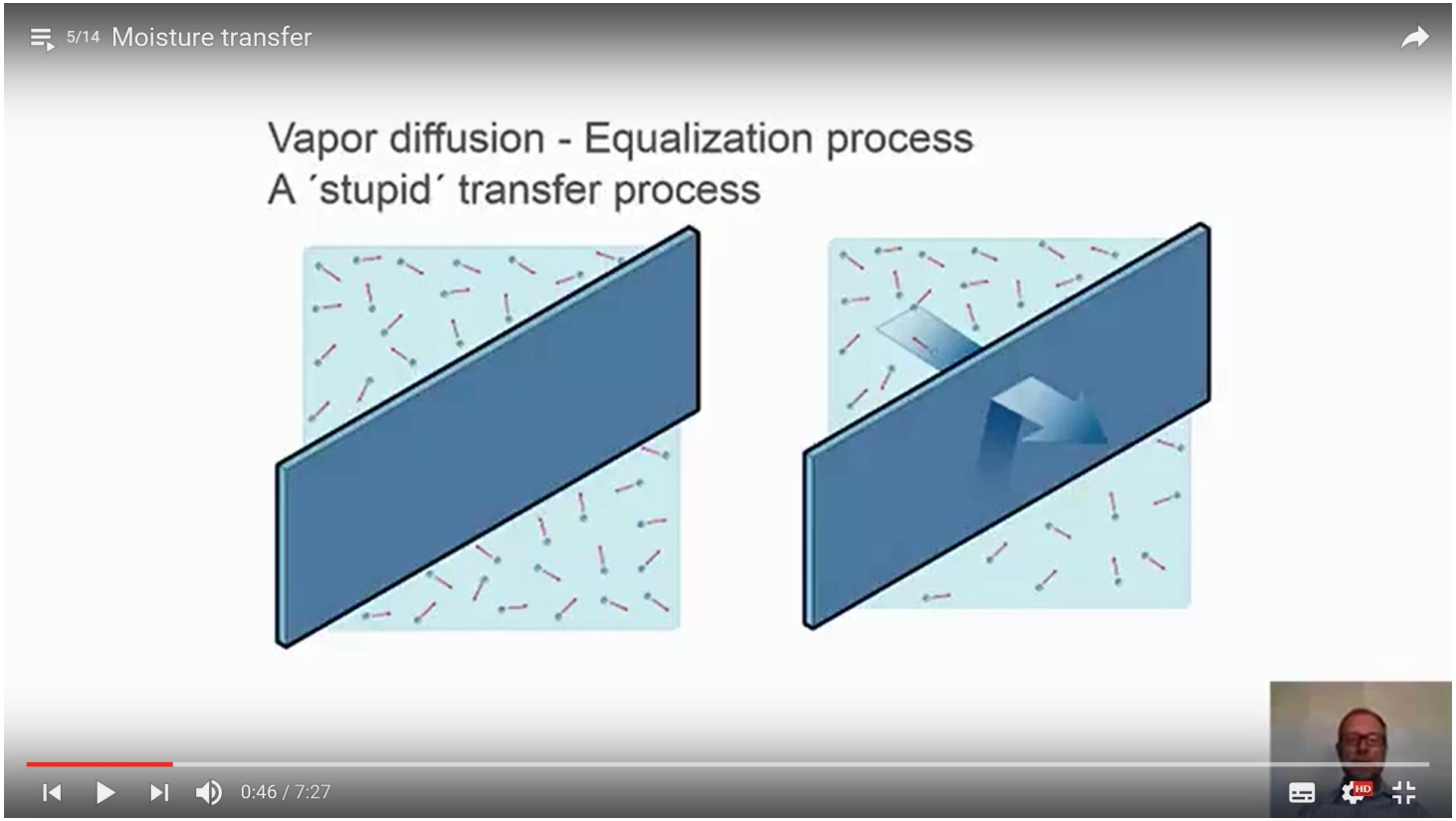


Benefits when not wasting heat by unnecessary cooling and airing!
Mean heat losses by transmission and ventilation depends only on the mean temperature difference! (Swedish climate perspective)

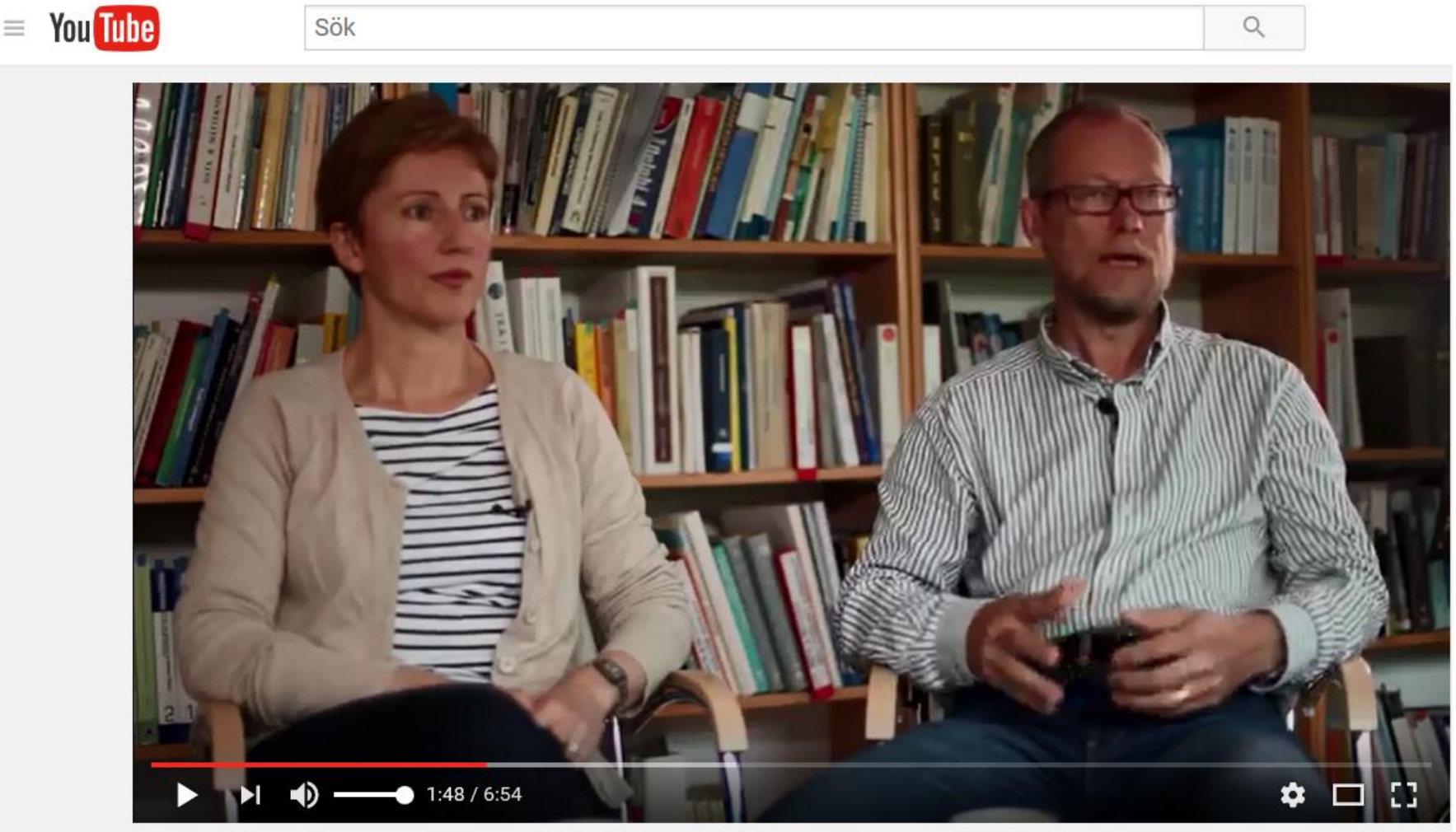
Building physics and Sauna!



Learning –YouTube-videos



Search in YouTube: **Building Physics Introduction lectures** **by Hagentoft**


YouTube
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Challenges for the future

How to get a better
building process?

How to do things better!

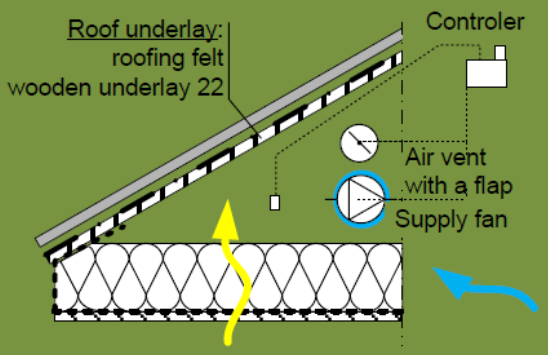
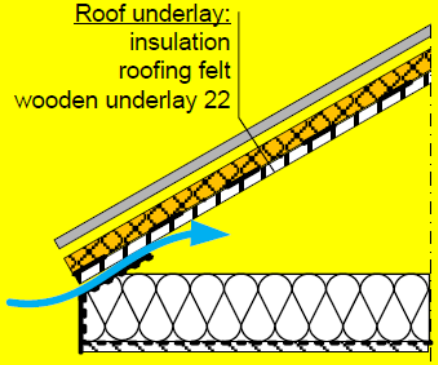
One possible way forward
might be a proper:

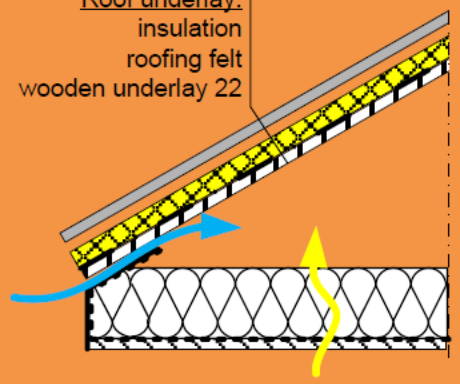
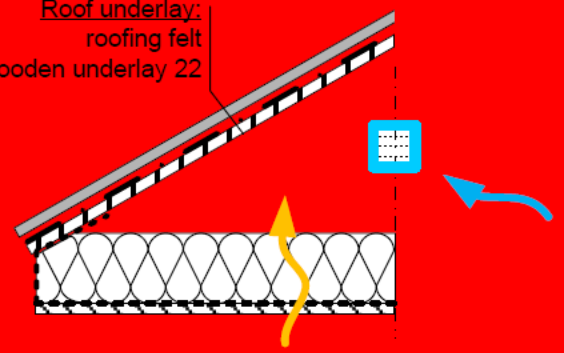
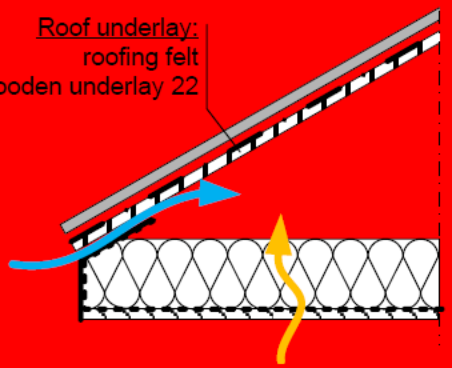
Risk assessment!

We can not talk about RH and temperatures…bottom line is needed!

Risk free (green)
Low risk (yellow)
Semi high risk (orange)
High risk (red)

Challenge!
Better communication of risk!

	Cold attic construction	Requirements and sensitivity
Risk free	 Controlled mechanical ventilation	• The airtightness of the attic should be at least 10 1/h@50Pa • Ventilation should start directly after completeness of attic construction • Requires alarm function for failure of mechanical devices • Lowest total life cycle cost
Low risk	 Insulated roof, good air tightness of the attic floor	• Requires durable solution for the airtightness of the attic floor. • Works better at low moisture excess in the building (well ventilated housing - preferably exhaust only mechanical ventilation system). • Sensitive to the building orientation. • Some sensitivity to the local and future climate. • Should be supplemented with dehumidifiers in the construction phase to eliminate built-in moisture.

Semi-high risk	 Insulated roof, some air leakage in the attic floor	• Works better at low moisture excess in the building (well ventilated housing - preferably exhaust only mechanical ventilation system). • Sensitive to the local and future climate. • Should be supplemented with dehumidifiers in the construction phase to eliminate built-in moisture.
High risk	 Reduced ventilation – only through gable vents; air tight roof eaves.	• Extra sensitive to the lack of air-tightness in the attic floor and high moisture excess in the home. • Should be supplemented with dehumidifiers in the construction phase to eliminate built-in moisture. • Sensitive to future climate.
High risk		• Extra sensitive to the lack of air-tightness in the attic floor and high moisture excess in the home. • Sensitive to future climate. • The most expensive technical solution when lifecycle cost is assessed. • Should be supplemented with dehumidifiers in the construction phase to eliminate built-in moisture.

Thanks!

Ecological building facts and myths