LUNDS UNIVERSITET

Moisture damages and preventive actions in Sweden

- **RAKENNUSFYSIIKKA 2019**

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ANDERS KUMLIN AB
Moisturesafe and thereby sustainable buildings

Short background

I have been working as a consultant dealing with moisture problems in buildings and constructions since the 1980s.

Since 2009; chairman of the board at The Moisture Research Centre (FuktCentrum) in Lund.

Founder and owner of AK-konsult in 1990, sold to Polygon in 2012 and self employed in Anders Kumlin AB since 2015.

The main focuses have been:

- **Moisture damage investigations**
- **Expert assignments regarding moisture problems**
- **Moisture calculations**
- **Moisture safety**
- **Education within the moisture field**

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Moisturesafe and thereby sustainable buildings

Bullet Points

- Sustainable Building – Moisture
- Economical cost of moisture damages
- Typical Swedish damages
- Common measures
- Preventive actions
- Future and today´s climate

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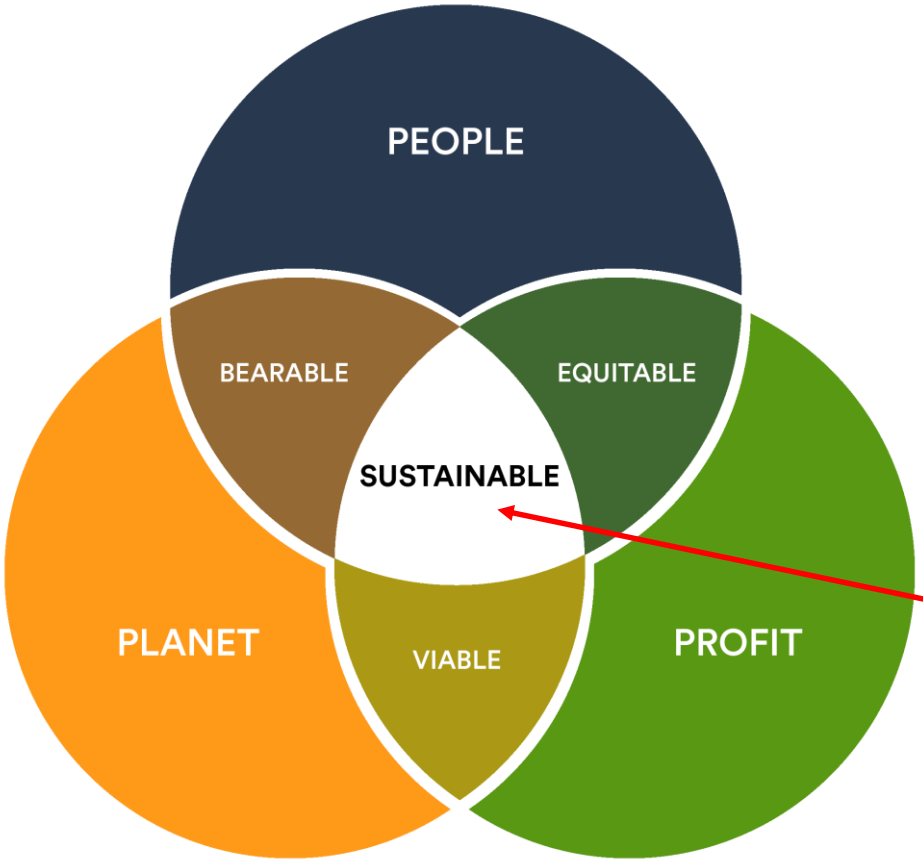
Sustainable Development, Triple Bottom Line (TBL)



Sustainable development is not based on one factor.

All factors must be taken into account simultaneously: People, Planet and Profit.

Sustainable development

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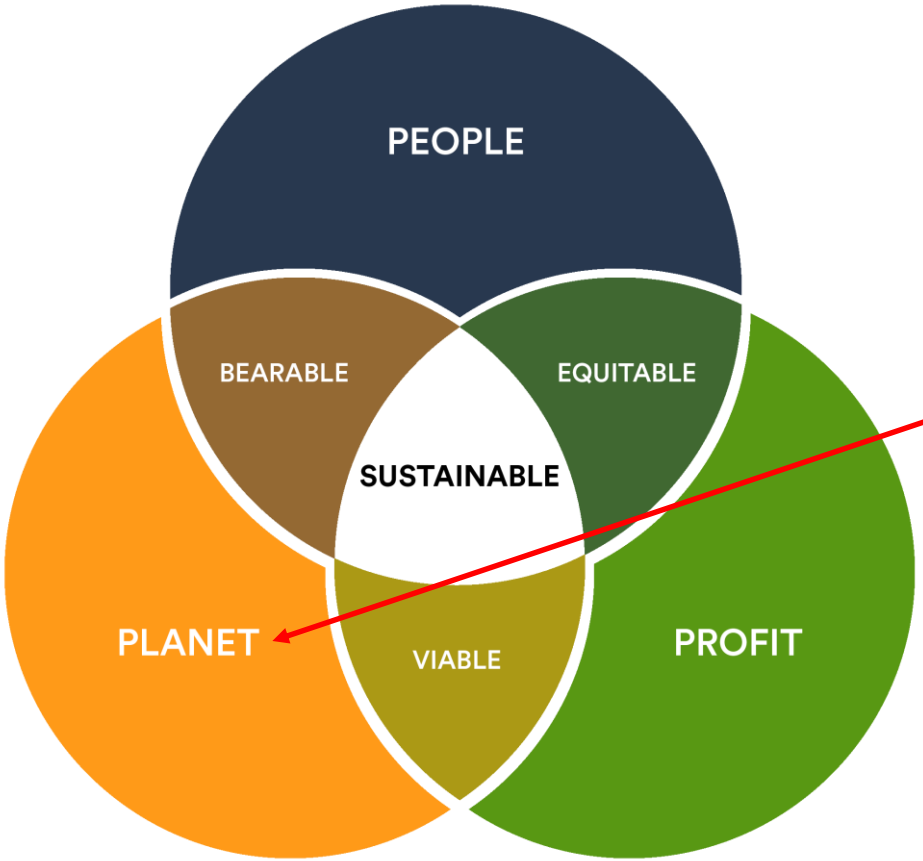
Sustainable Development, Triple Bottom Line (TBL)



Environmental benefits

- **Protect and preserve eco-systems and biodiversity**
- **Cleaner air and water**
- **Reduced impact on the climate**
- **Reduced waste**
- **Reduced use of nature's resources**

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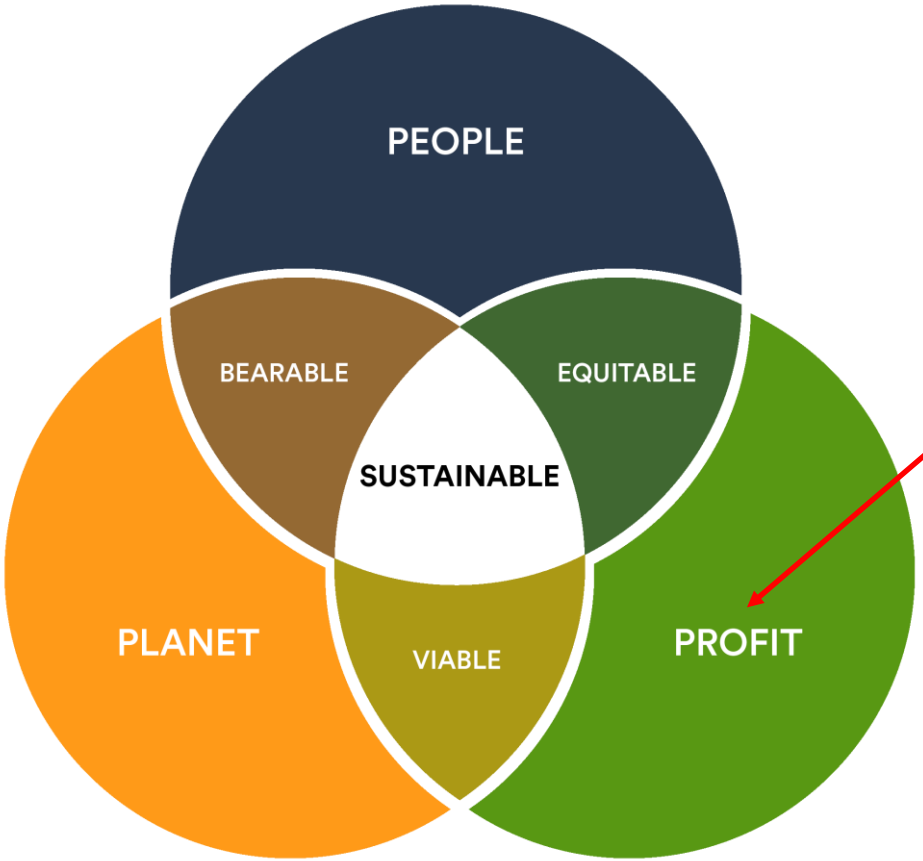
Sustainable Development, Triple Bottom Line (TBL)



Financial gains

- **Reduced operating costs**
- **Increased property value and profits**
- **Increased productivity and satisfaction among employees**
- **Optimized financial performance over the lifespan of the building**
- **Increased resistance to unstable energy prices**

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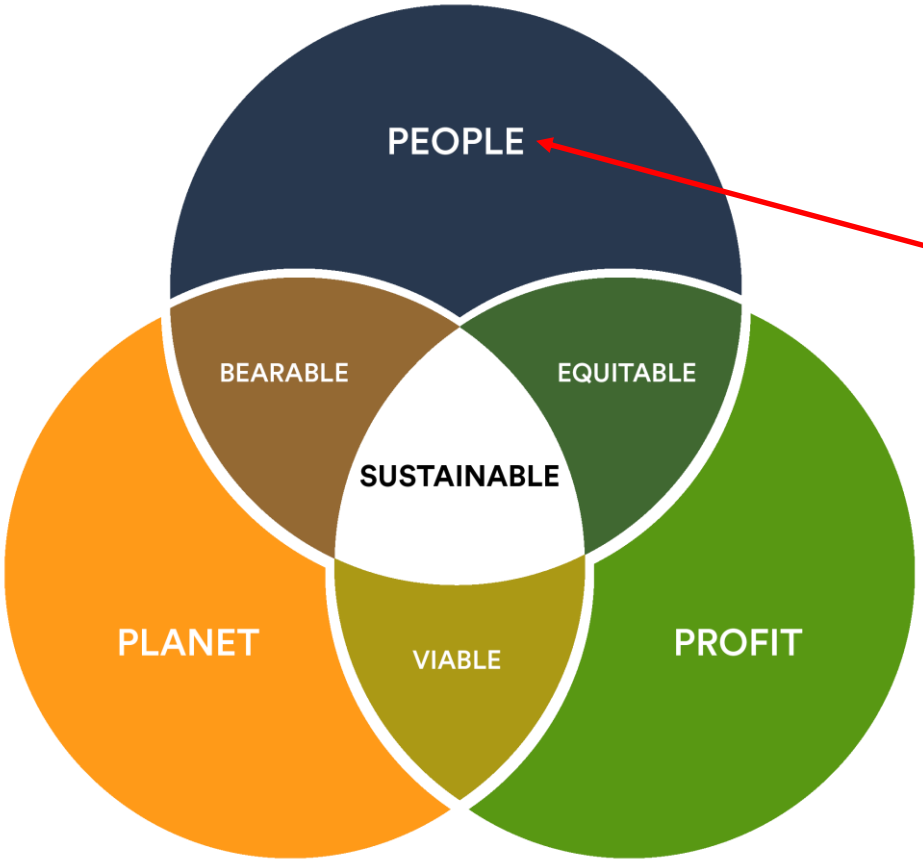
Sustainable Development, Triple Bottom Line (TBL)



People

- **Cleaner indoor air, increased thermal comfort and better acoustic environment**
- **Increased comfort and health for users of the building**
- **Reduced pressure on local infrastructure**
- **Contribution to general quality of life**

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Effects of moisture damages

The measures required to remedy moisture damages in a building can vary greatly. In some cases, simpler measures may be sufficient, while in other cases it can be necessary to demolish part of the building and build up a new moisture-proof construction.

Of course, moisture damages result both in financial issues and environmental impact. However, it should also be noticed that the risk for various types of health problems / indoor environmental problems increase in a "damp building".

In summary: Moisture damage affects all three parts in the TBL-model: Planet, Profit and People.

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Sustainable Buildings

From a sustainable perspective it is therefore crucial that a building is moisture-proof.

Or, in other words, a sustainable building must be moisture-proof.

Therefore, the conclusion must be that moisture safety have to be implemented in all aspects of the TBL-model.

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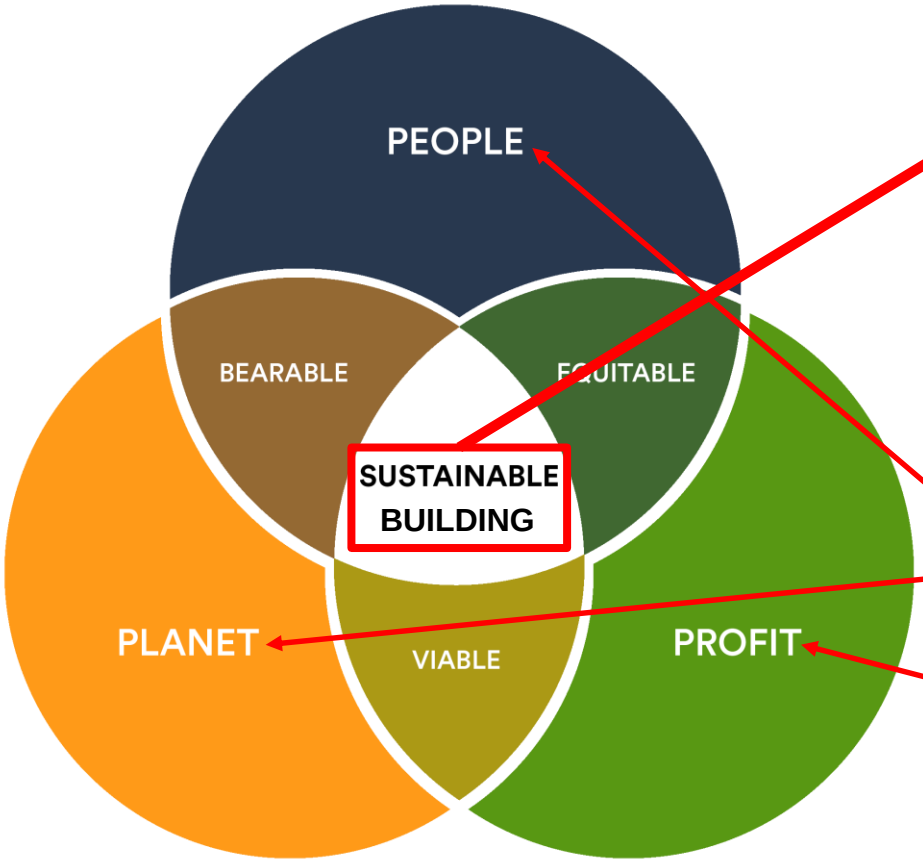
Sustainable buildings must be moisture-proof



Requires that the building is moisture-proof

Consequences of moisture damages:

- **Increased risk of health problems**
- **Early exchange of building materials**
- **Economic losses**

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The cost of moisture damages

Moisture status in Swedish Buildings, BETSI 2009

(Building´s Energy, Technical Status and Indoor Environment)

In total, approximately 1/3 of the Swedish building stock have moisture damage resulting in mould growth or bad odour with the risk to affect the indoor environment. Moisture and mould are most common in single family houses.

In comparison with a similar investigation 17 years ago shows that moisture damage in Swedish buildings has increased.

The cost to fix moisture damages in Swedish buildings was estimated to about 100 billion SEK (≈9,3 billion euro).

Slide from key lecture, NSB 2014

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The cost of moisture damages Report from Boverket 2018

BOVERKET
National Board of Housing, Building and Planning

Survey of faults, defects and damages within the construction sector

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The cost of moisture damages Conclusions from Boverket 2018

Water and moisture problems are most common.

- **The presence of the most common faults, defects and damages is judged to be relatively unchanged during the past ten-year period.**
- **However, there are companies who have taken systematic measures to minimize the presence of faults, defects and damages and claim that they have achieved good results.**

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The cost of moisture damages Conclusions from Boverket 2018

High costs for errors, defects and damages.

- **The costs are very difficult to estimate, but the estimation is intended to show the order of the costs.**
- **The total real estate costs for internal and external action costs and costs related to ineffective resource use are estimated to about 59–73 billion SEK per year (≈5,5 to 6,8 billion euro).**
- **In addition, if indirect consequential effects are taken into account, the total assessed real estate costs can amount to as much as 83-111 billion SEK per year (≈7,7 to 10,3 billion euro).**
- ***The cost to remediate moisture damages in Swedish buildings was estimated to a total sum of about 100 billion SEK (≈9,3 billion euro) in 2009……***

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The cost of moisture damages Conclusions from Boverket 2018

High costs for errors, defects and damages.

- **If the assessment is expanded to include the socio-economic consequences, where the property-economic consequences are included as a subset, there will be a number of side effects with associated costs.**

In other words, it is time to take faults, defects and damages within the building sector very serious.

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Damp Buildings from a technical point of view

- **High relative humidity (RH) in the indoor air.**
  - **High moisture production in relation to ventilation flow, additional moisture ($\Delta v = v_i - v_e$) is higher than 3 g/m³.**
  - **Can lead to moisture problems within the building construction/envelope, especially if the building envelope is not air-tight or / and have severe thermal bridges**

- **Improper, not moisture safe, design, "risk construction"**
  - **Expected moisture levels are higher than critical levels. It is assumed that moisture damage will occur.**

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Damp Buildings from a technical point of view

- **Water leakage**
  - **Can occur both during construction and management**
  - **The moisture must be handled correctly to prevent the leakage from causing damage.**

- **Construction moisture**
  - **Many building materials contain a lot of water that has to be dried out.**
  - **If the moisture level in a building material is too high for too long, due to construction moisture, it can lead to microbial growth, "chemical" damage etc.**

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Damp Buildings from a technical point of view

Example of other unwanted side-effects from moisture

- **The thermal conductivity (λ-value) increase for many hygroscopic material when the water content increase.**
- **Drying out of construction water can be very energy consuming.**

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Moisture damage in cold climate

Typical Swedish moisture damage

Mould on internal surface, unusual in Sweden

Conclusion 1: to identify a moisture damage you need to examine the entire structure.

Conclusion 2: to be able to take correct actions to solve the moisture problem, if the problem be caused by a "bad construction", you need to identify in detail how the building was designed and built.

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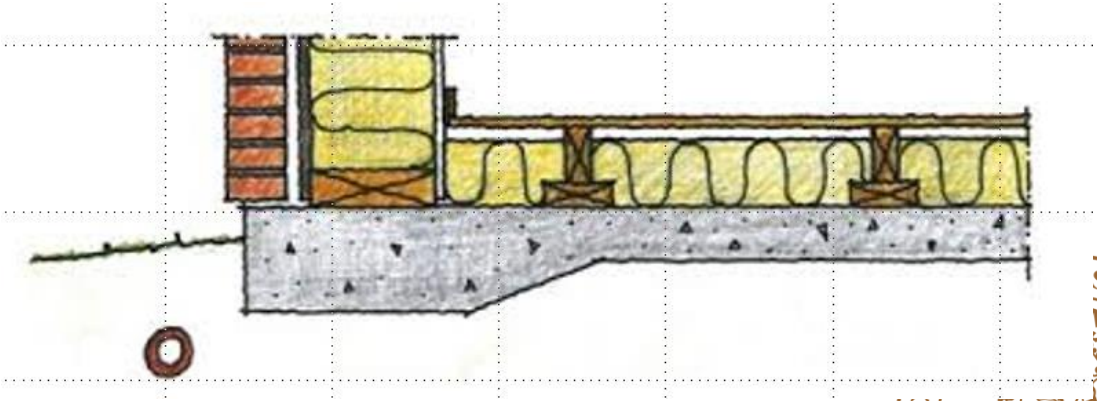
Typical moisture damage

Concrete slabs on ground, with joist floor

Typical “risk construction”



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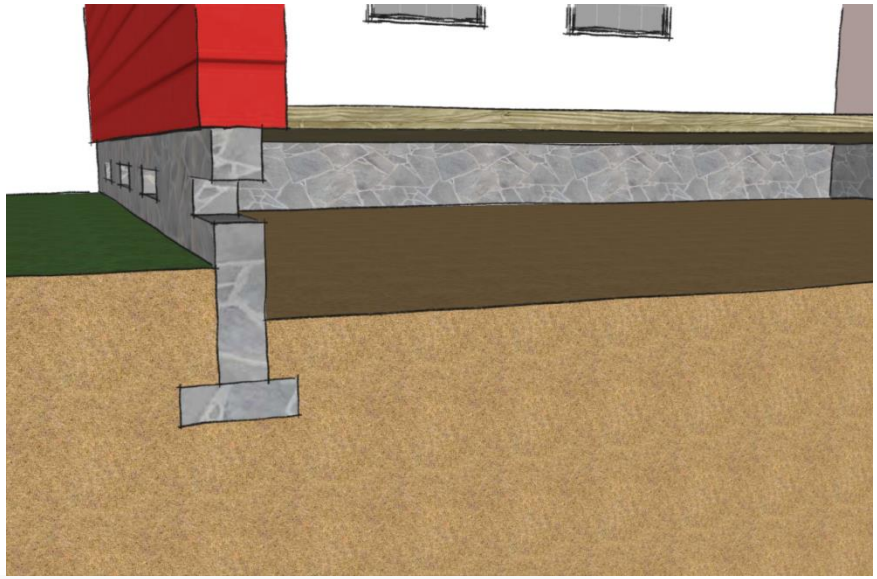
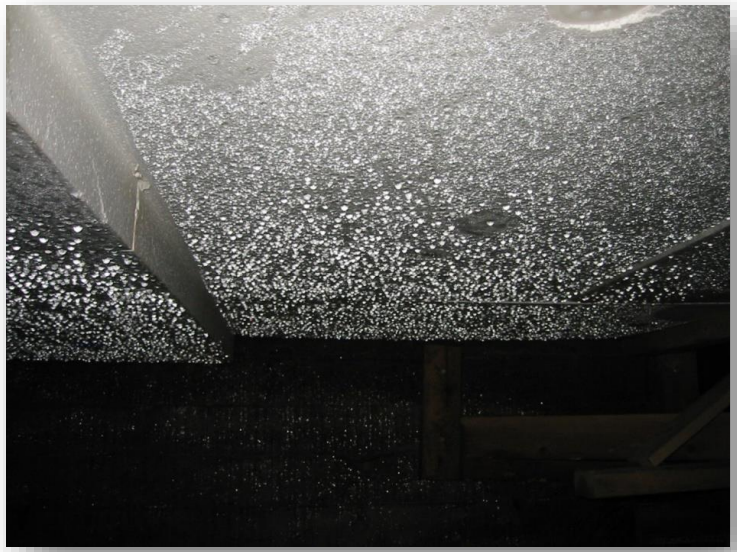
Typical moisture damage

Outdoor ventilated crawl space foundation

Typical “risk construction”





Typical moisture damage

Problems with bad odour from impregnated wood exposed to moisture.

Chloroanisoles, that are known to emit strong odours, can be formed when wood treated with preservatives containing chlorophenols (PCP), is exposed to a combination of moisture and microorganisms.

Although the usage of PCP-treated wood was phased out approximately 40 years ago, problems with poor IAQ and bad/strong odour in buildings containing PCP impregnated wood exposed to moisture, still occurs frequently today.

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Typical moisture damage

Attic

Moisture problems often occur due to high vapour content in the indoor air, in combination with air-leakage to the attic from the building. Other influencing factors are thicker thermal insulation, lack of chimney and long wave radiation from the building during clear sky conditions.

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Typical moisture damage

Damage due to construction moisture

A material such as aerated concrete contains approximately 30 % water when delivered. If the moisture level is too high, and the material is not dried out in an appropriate way it can lead to moisture damage and initially a higher energy demand for heating.

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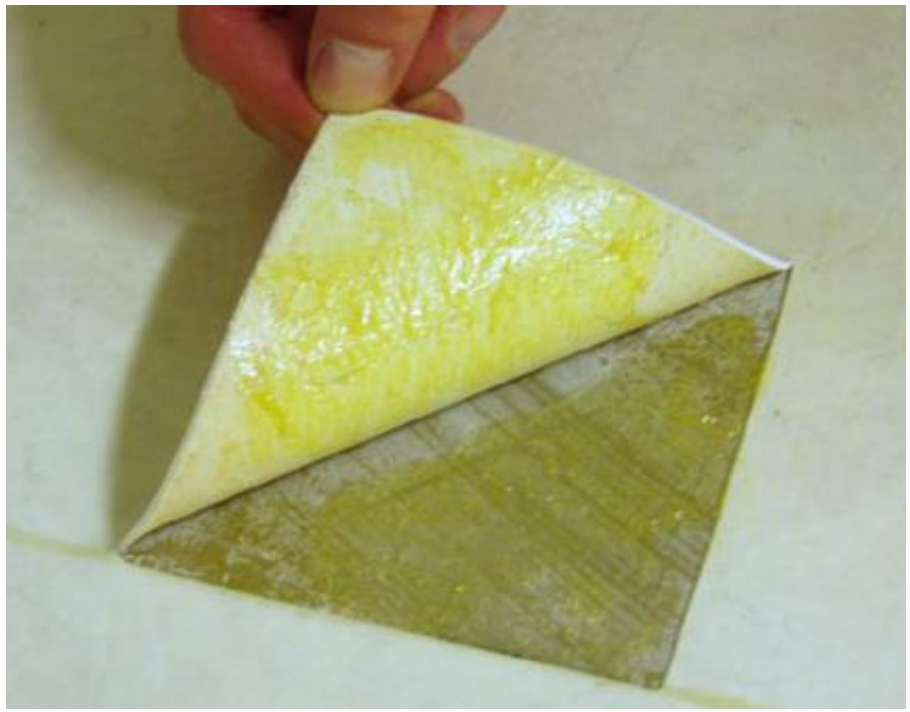
Typical moisture damage

Degradation of water based adhesive and/or high chemical emissions.

To avoid chemical degradation of the water based adhesive, and high chemical emissions, the RH in concrete must be below 85 % before flooring materials with high moisture resistance can be applied.



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Typical moisture damage

External thermal insulated composite system (ETICS) wall on wooden frame

If the wall is unventilated and undrained moisture damage can occur on the plasterboard, wind-barrier, and in wooden parts. Damage is more common in locations with high moisture load in the form of driving rain.

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Measures

- **Water damage**
  - **Caused by a leakage**
  - **Normally fixed by exchanging damaged materials and drying**

- **Moisture damage**
  - **Often caused by a, from a moisture point of view, bad design – often a “risk construction”.**
  - **To be able to design a refurbishment plan that solves the moisture related problems the cause of the damage must be understood.**
  - **If the damage is due to failure from the design process, it is, in most cases, necessary to modify the construction to achieve a long-term moisture-proof solution.**

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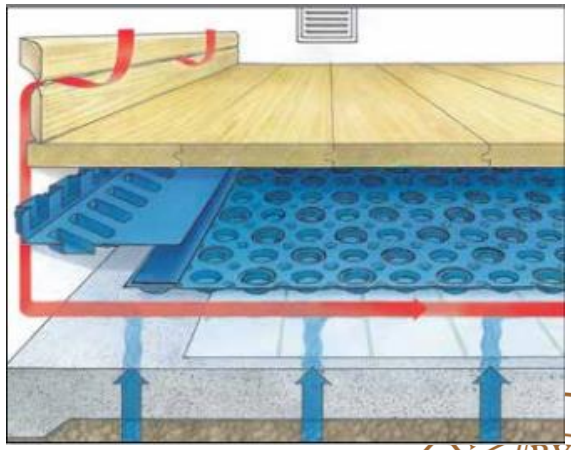
Measures

- Sink-effect - odour contamination
  - In many cases materials that are not directly damaged by moisture have been contaminated by odour/emissions from moisture damaged nearby materials.
  - For instance contaminated concrete or insulation material.

  - If the contaminated material is not replaceable, for example a concrete slab, measures to prevent emissions to reach the indoor environment must be taken. Such as:
    - Mechanical ventilated floor systems
    - Emission barriers

Contaminated concrete

Sjöberg (1998)



Mechanical ventilated floor construction

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Moisture in the building process

Moisture and environmental questions must be taken into consideration during the entire building process. From planning, design, construction, and management to demolition.

Planning

Design

Construction

Management

Demolition

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The Swedish Building Code

Moisture is regulated in chapter 6: Hygiene, health and environment

- **6:5 Moisture**
  - **6:51 Generally**
  - **Buildings should be designed so that moisture does not cause damage, odour or microbial growth that can affect hygiene or health.**

    General advice
    - **The requirements in section 6: 5 should be verified at the design stage by means of moisture safety design. Measures at other stages in the building process also affect moisture safety.**
    - **During planning, design, construction and control of moisture safety the Industry Standard ByggaF, method for moisture safety of the building process, can be used as a guide.**

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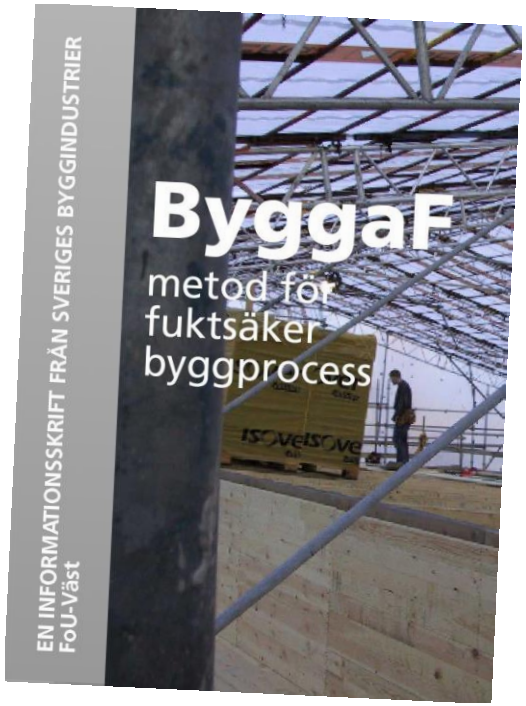
Background - ByggaF

- 2007 first report ByggaF
- 2008 launch of ByggaF
- 2012 - 2013 ByggaF was transformed into Swedish industry standard
- Some changes have been made over time
- Cooperation/input/development from the building industry and moisture experts
- Today there are 145 moisture experts with a diploma who has been educated by Fuktcentrum
- The industry standard ByggaF is available on Fuktcentrums website, www.fuktcentrum.se



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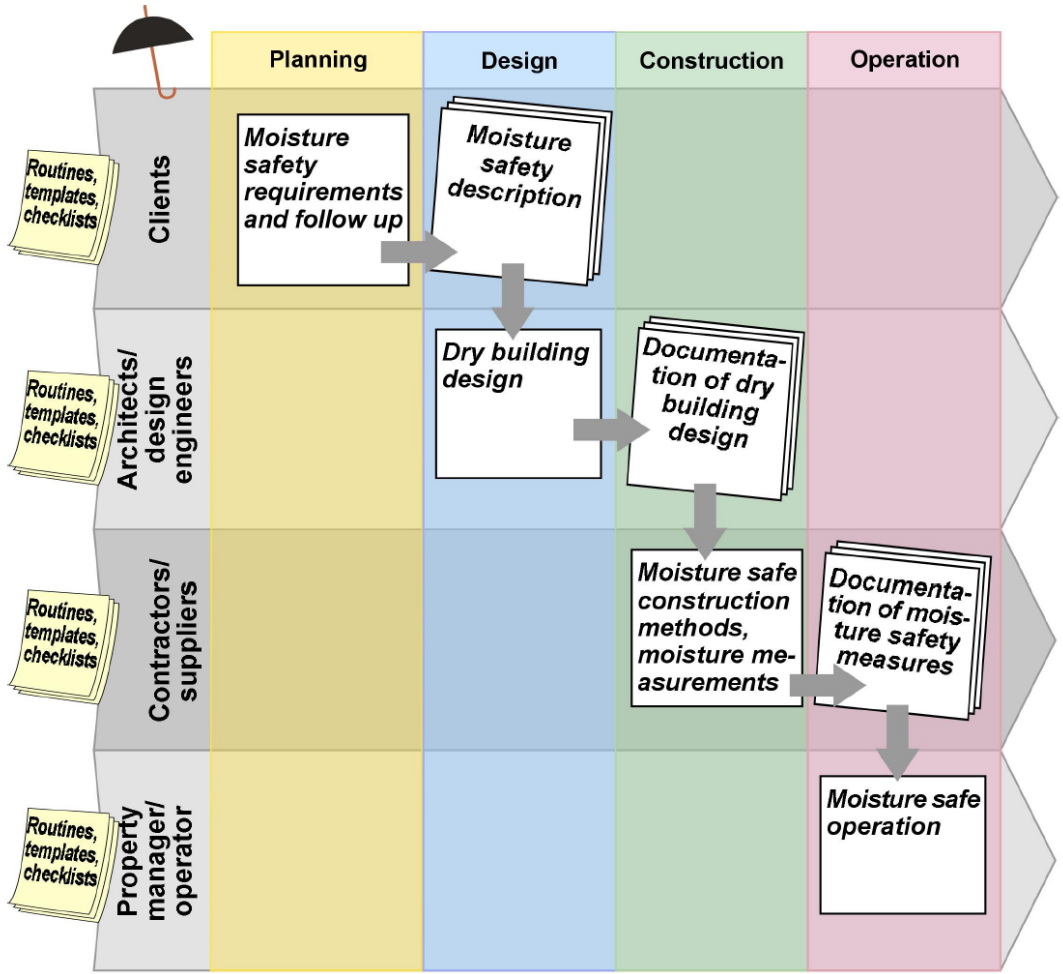
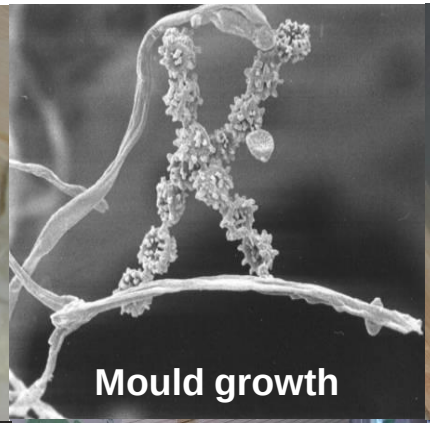
ByggaF

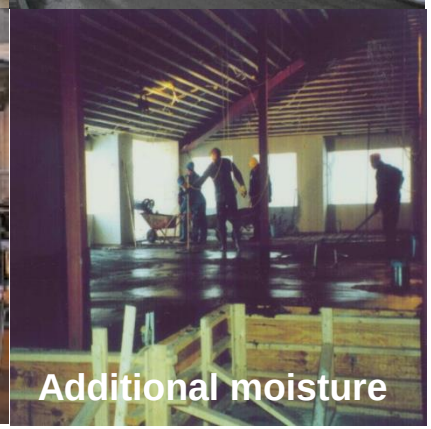
The Industry Standard ByggaF, method for moisture proof construction process, is administered by the Moisture Research Centre (FuktCentrum).



ByggaF – example planning phase

Decide on moisture requirements (examples)





Also decide on:

- **Consequences if requirements are not fulfilled**
- **Method for verification**
- **Who is responsible?**

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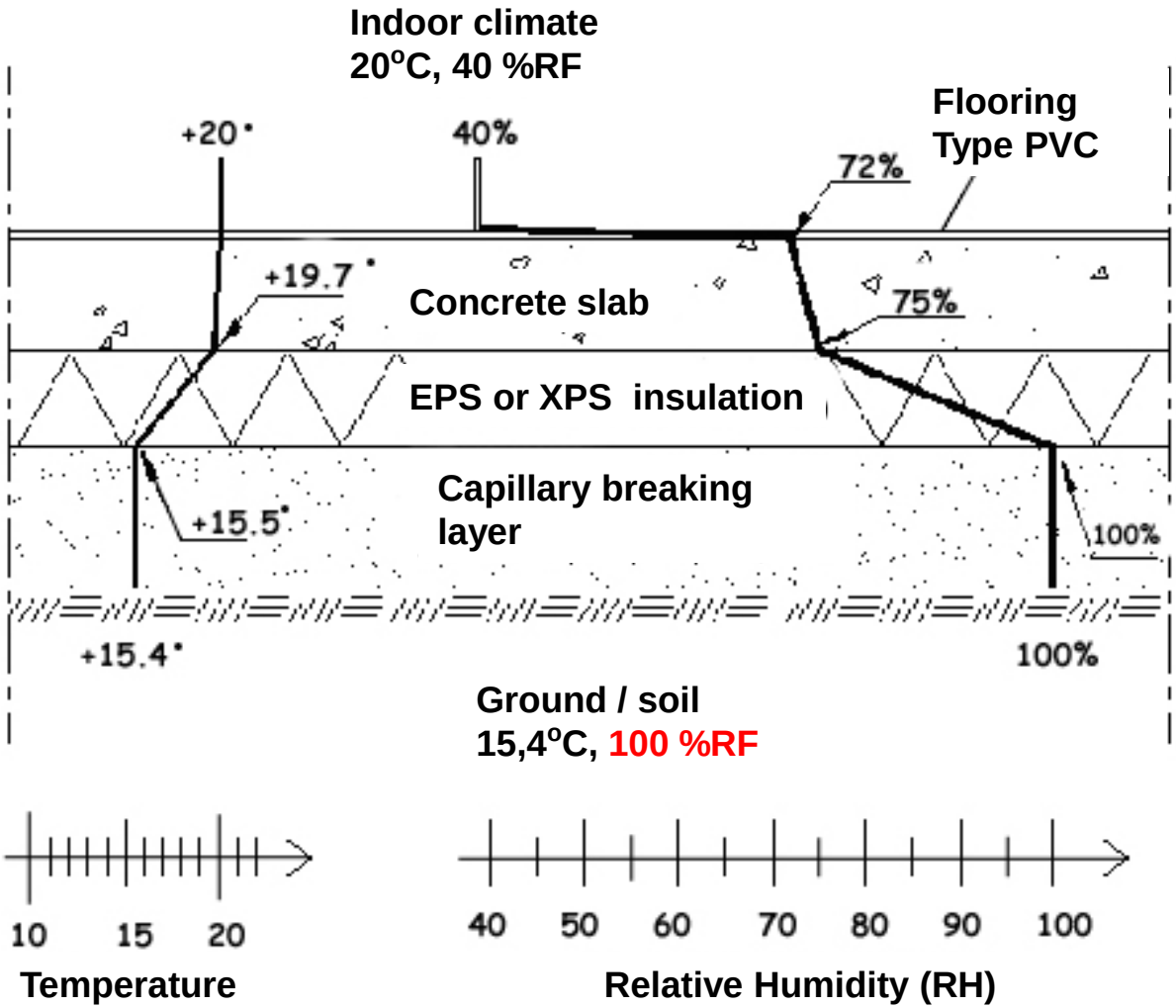
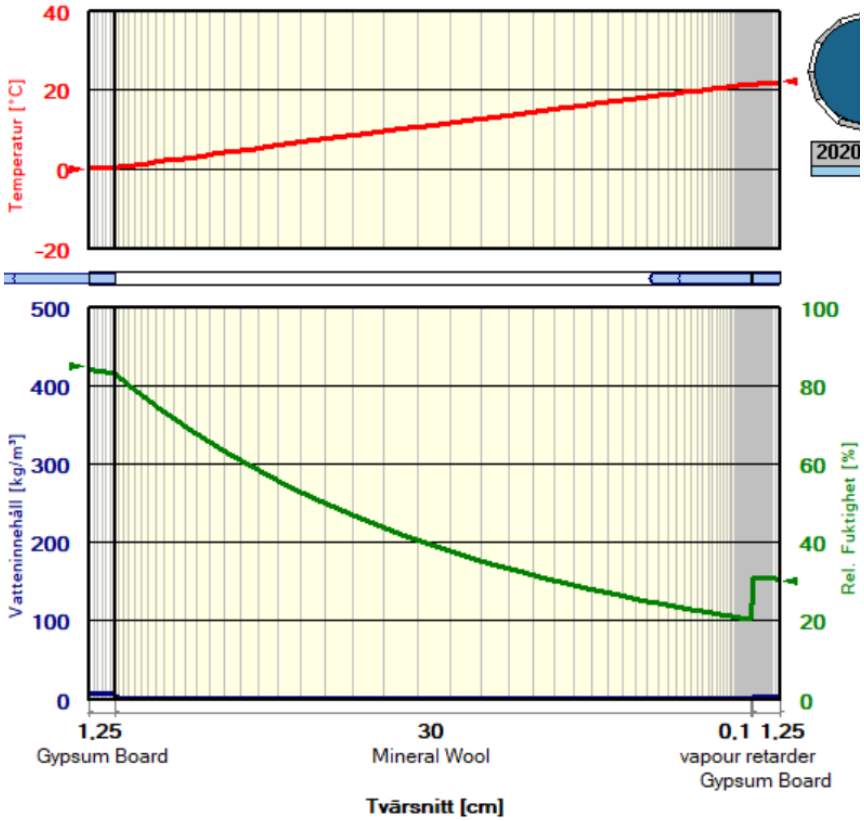
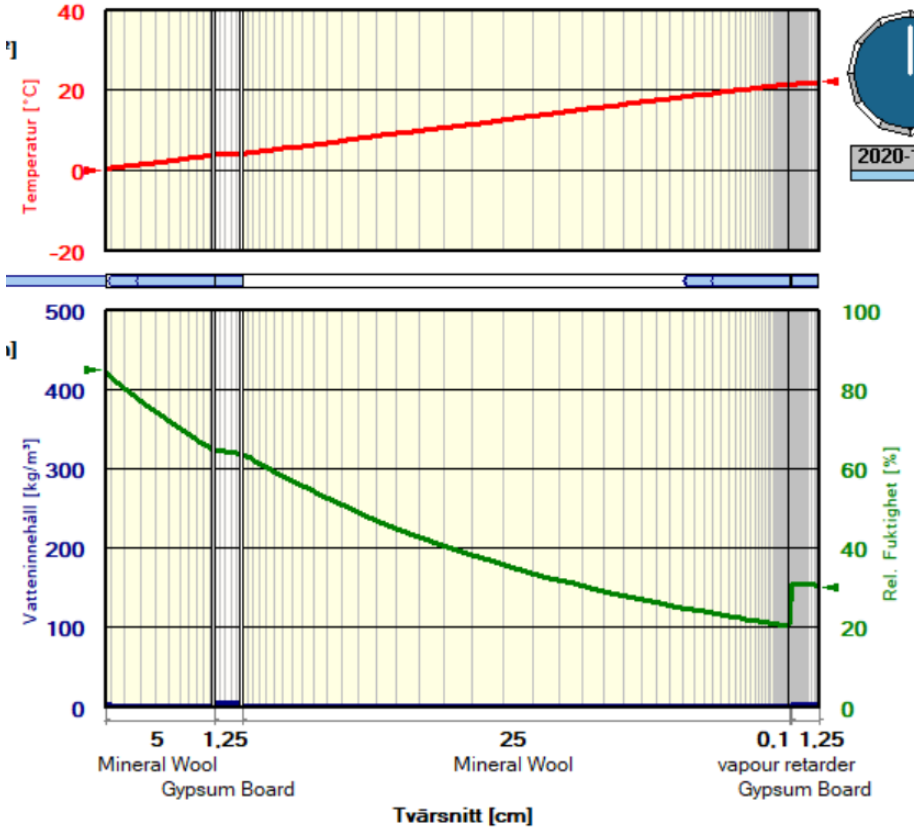
Insulation under a concrete slab



Insulation - moisture



No outer insulation
RH outer part of sill/stud 83 %



50 mm outer insulation
RH outer part of sill/stud 64 %

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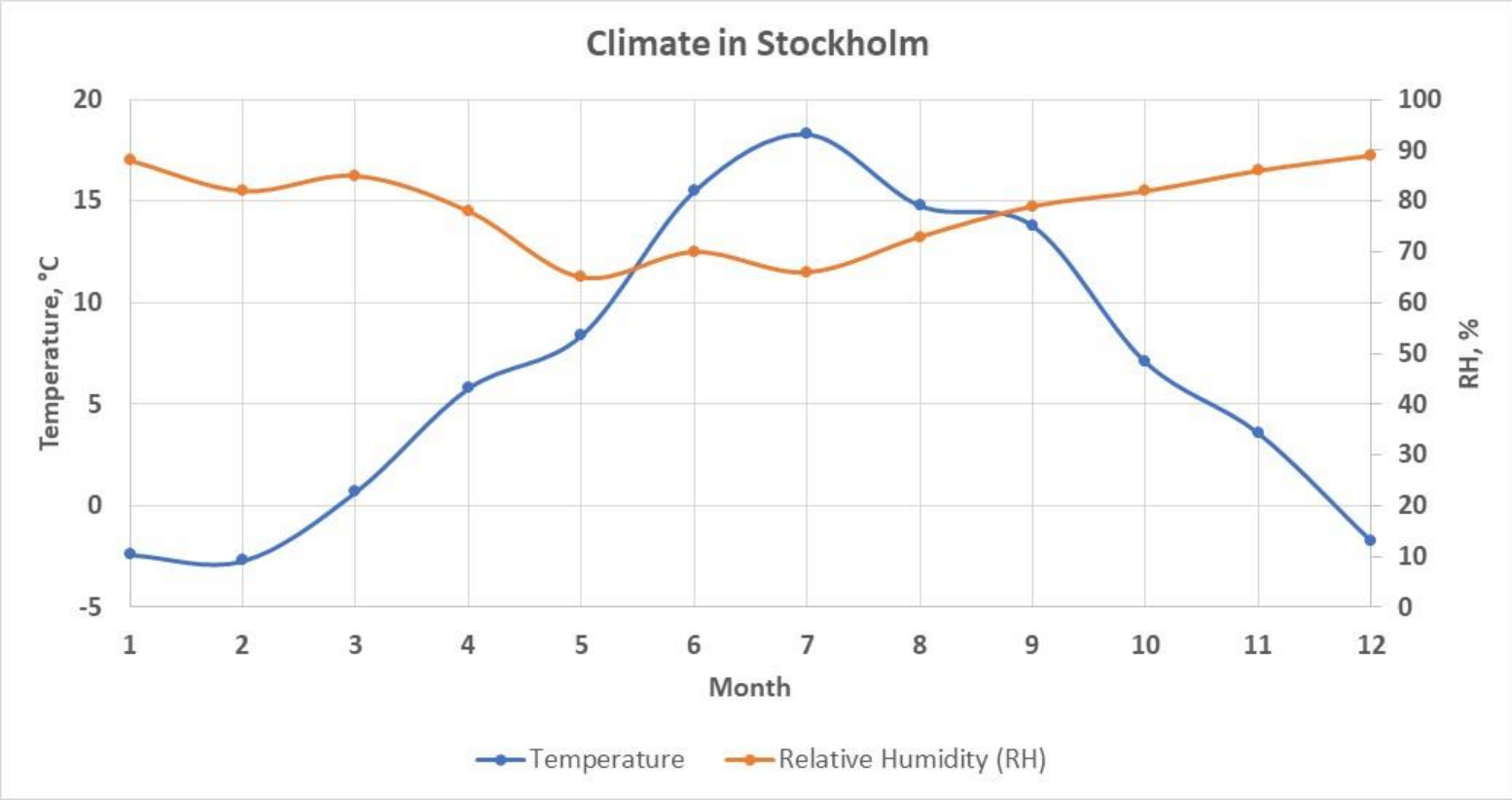
Future and today's, climate



Based on processed data 1995 – 2005 presented in the Swedish Moisture Handbook (Fukthandboken).

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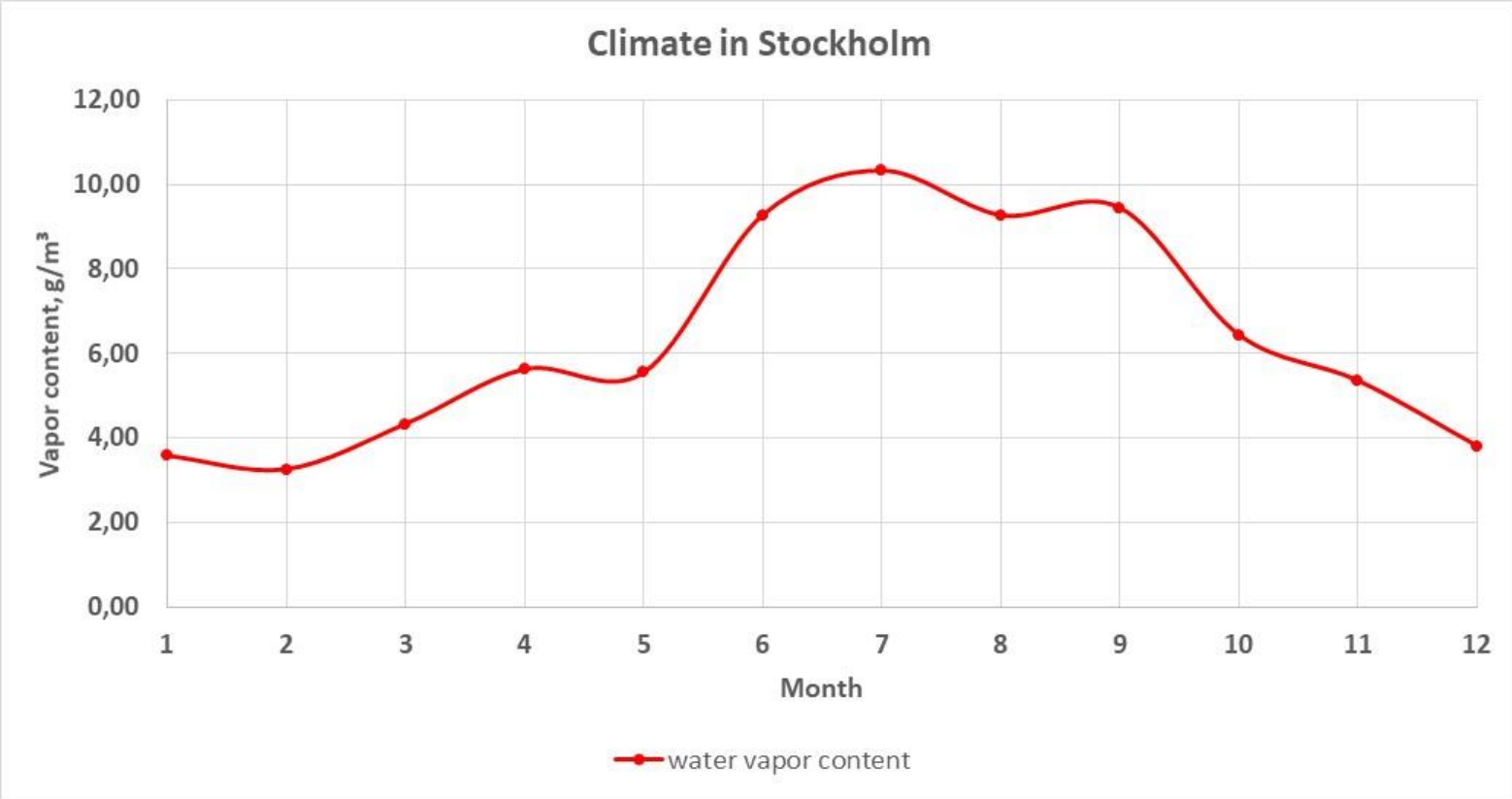
Future and today's, climate



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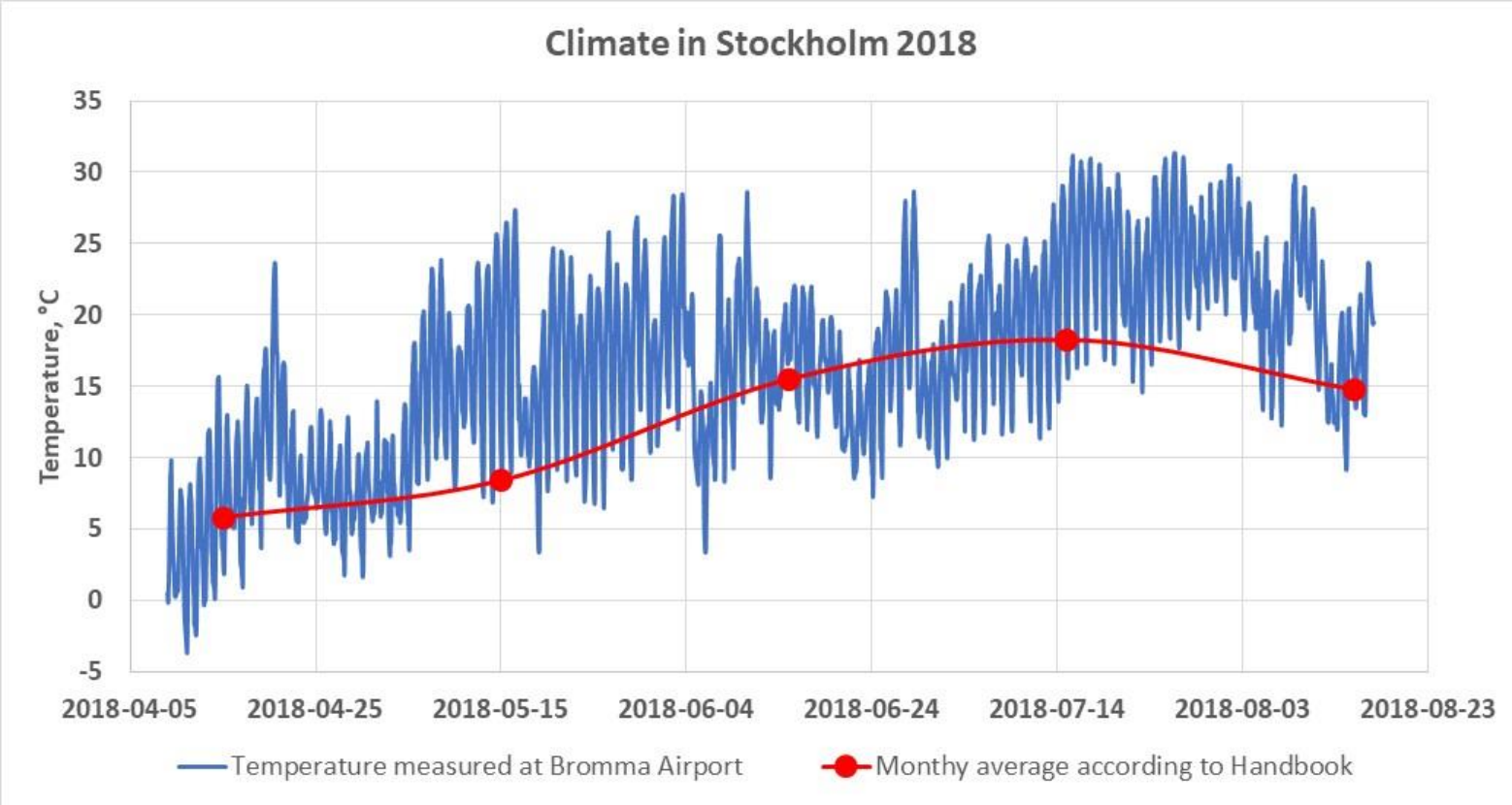
Climate during 2018



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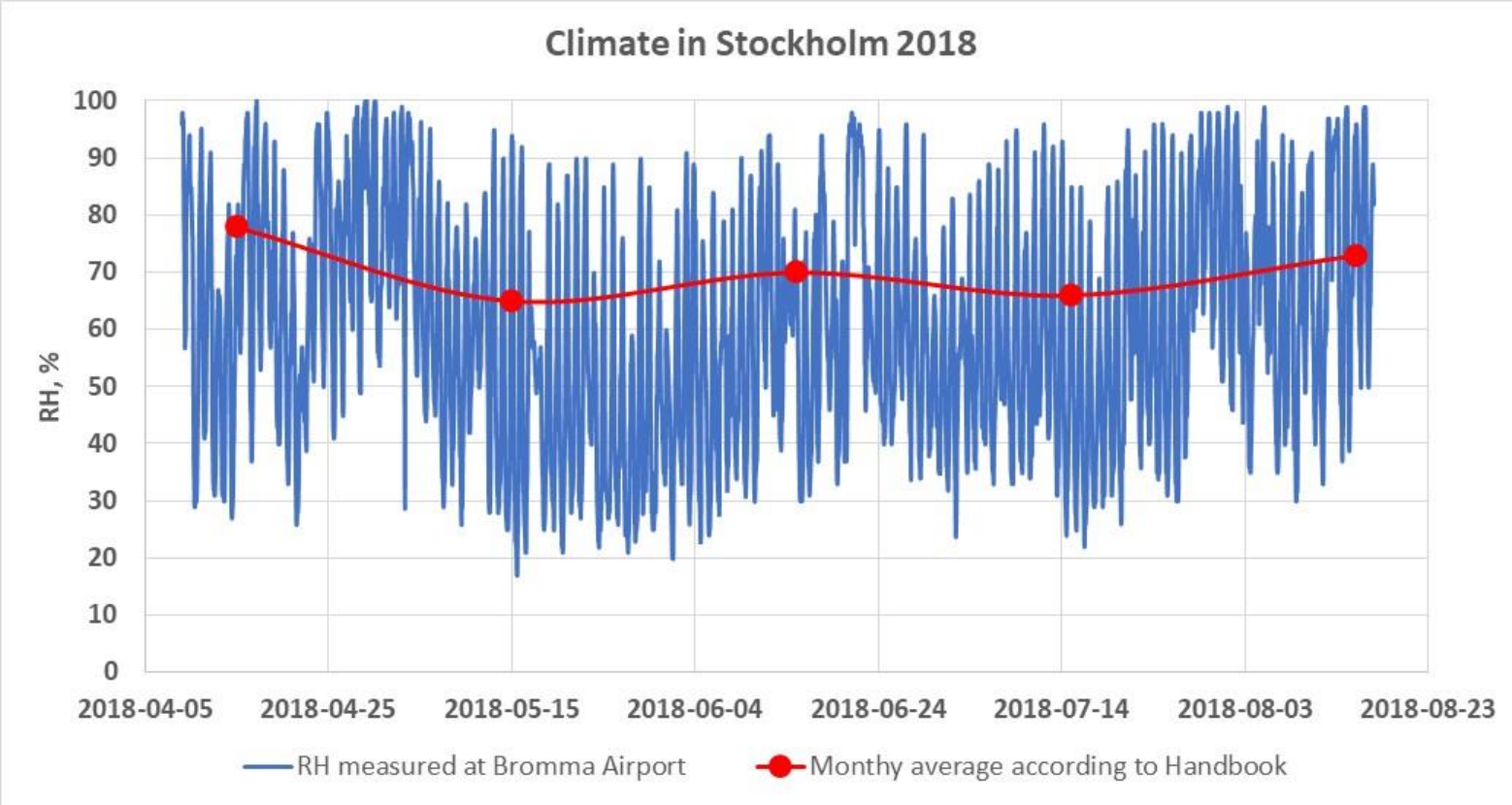

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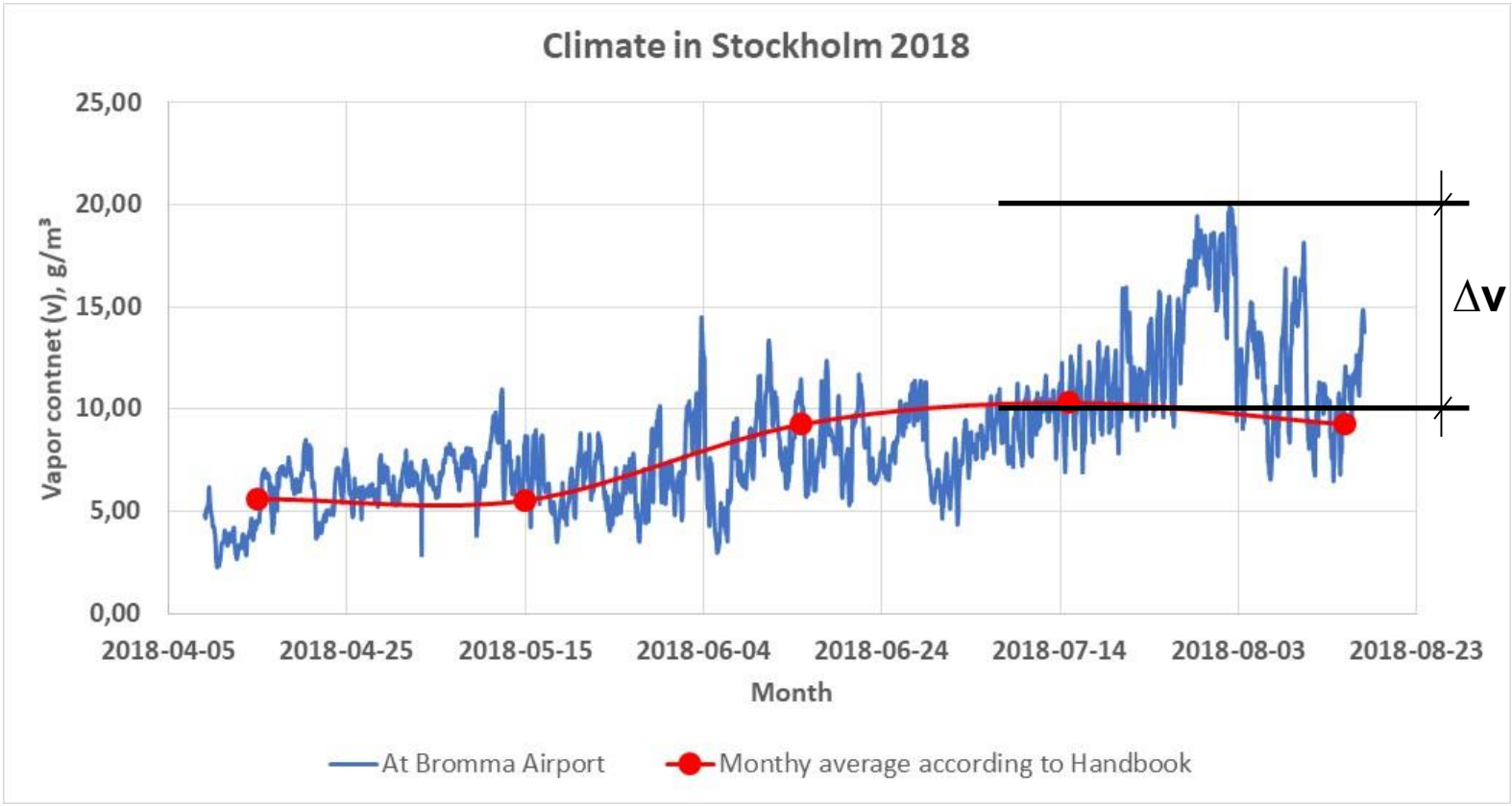
Climate during 2018



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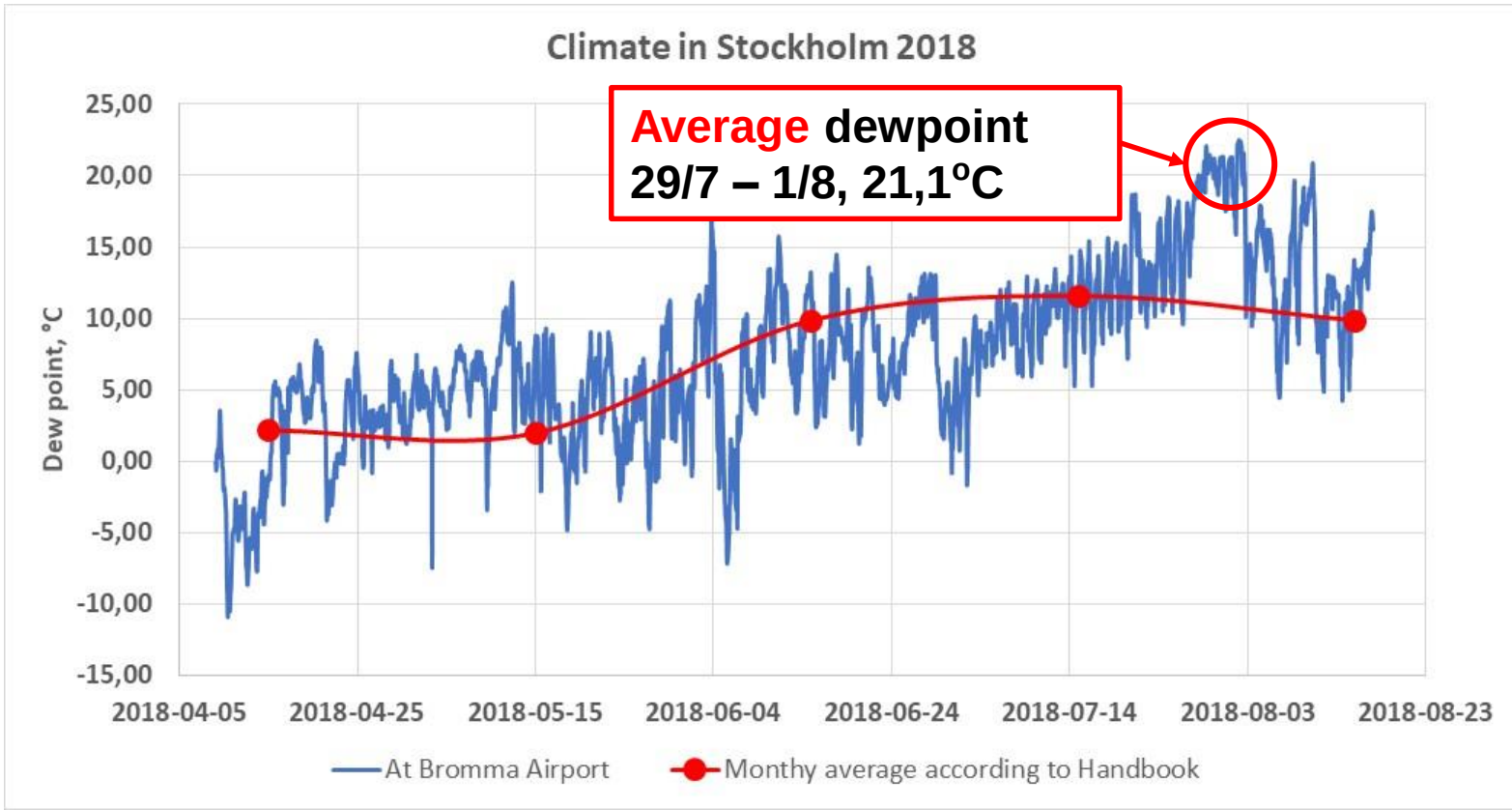
Climate during 2018



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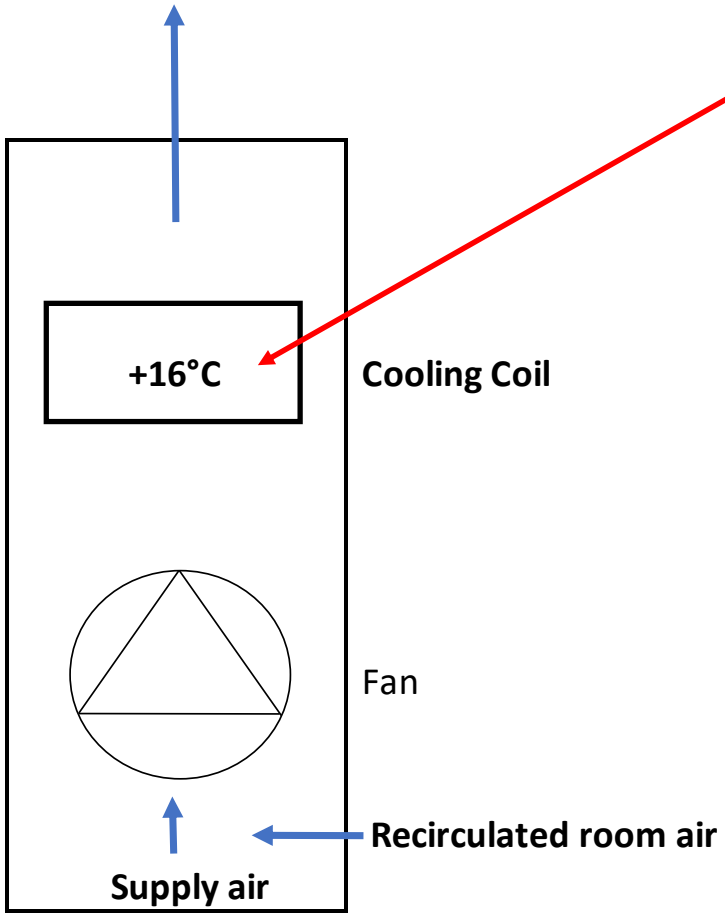
Climate during 2108 - Consequence



Condensation in the cooling element led to extensive water damages in the floor construction.

No previous moisture problems had been reported from the building that was erected in 1974.

Conclusion: The "warm and dry" summer of 2018 resulted in a water damage.

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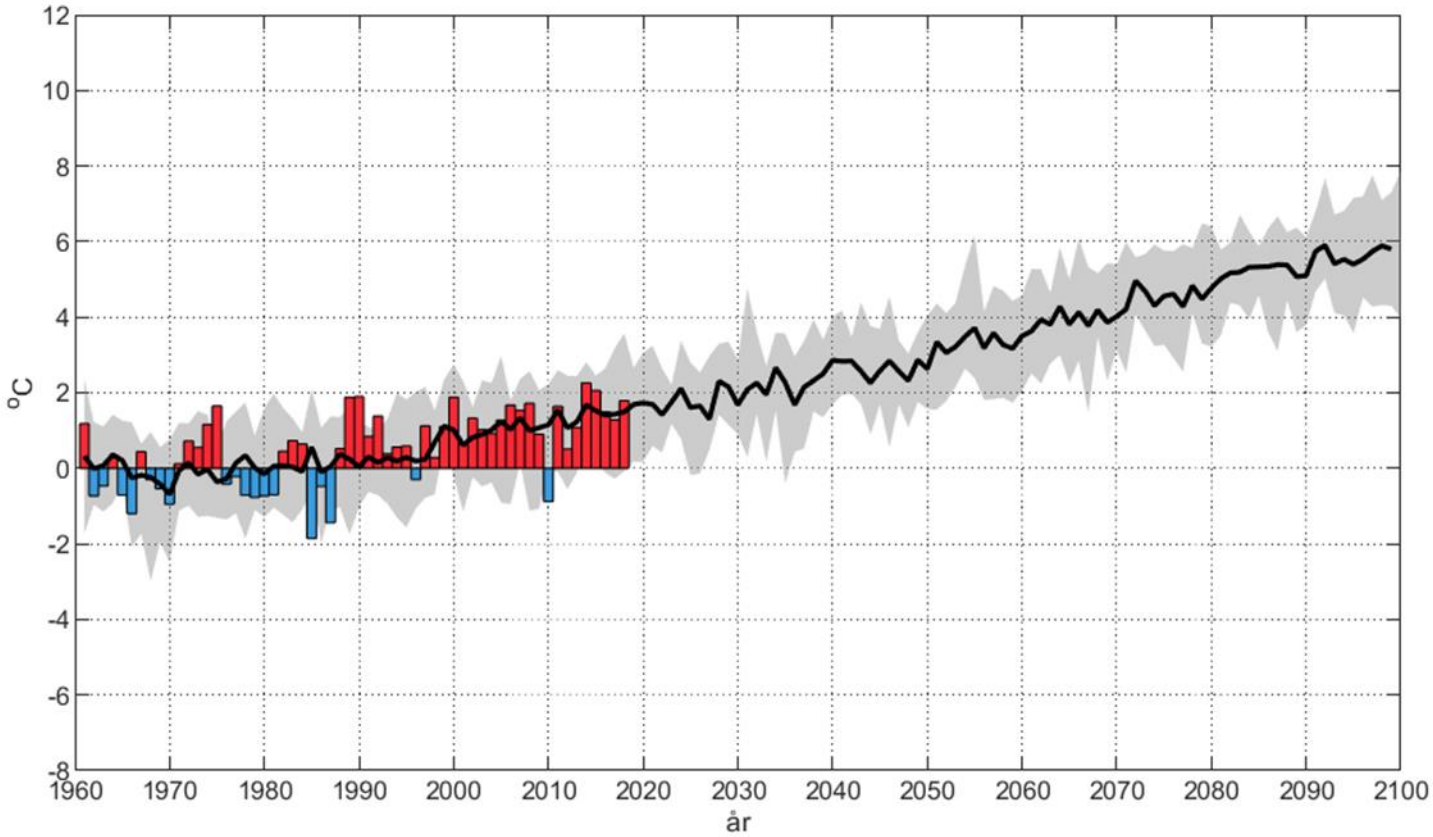
Future and today's, climate

Question: Which climate should be used during moisture safety planning? Historical data or?

Sweden's future climate

Estimated change in annual temperature in Sweden compared with 1961-90. Scenario RCP 8.5



https://www.smhi.se/pd/klimat/rcp_scenario/climate_scenarios/swe/rcp85/dia_big/t_ar_swe_rcp85_y.png?v=4.0

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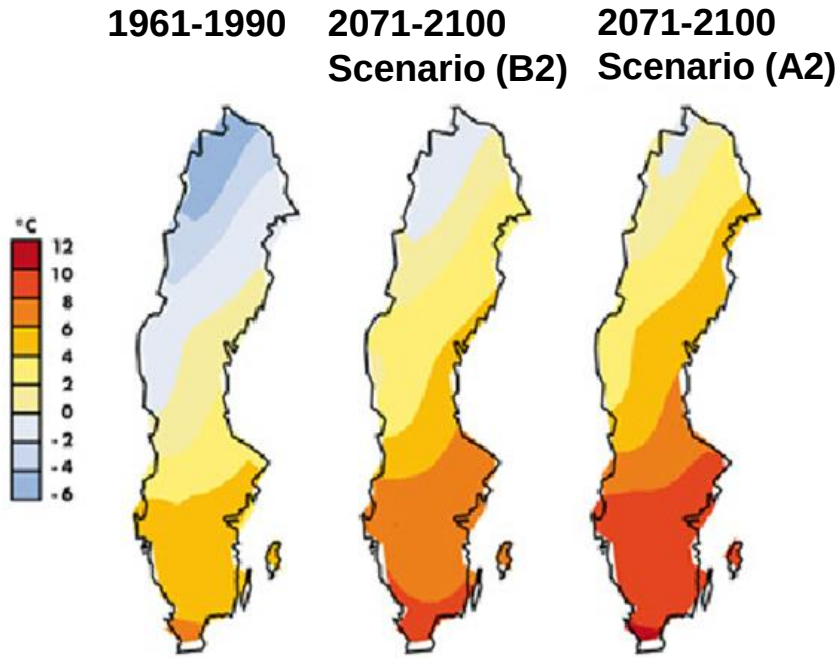
Sweden's future climate
Temperature

At the end of the century Mälardalen's temperature climate will be similar to that found in northern France today. The greatest temperature increase is seen in the calculations in Norrland during wintertime with up to 6-7 degrees higher average temperature towards the end of the century. This is mainly due to a decrease in snow cover.

Average temperature



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Sweden's future climate

Precipitation

Generally, more precipitation is expected in the future. Annual precipitation is expected to increase by 10% in the south to about 30% in the north. In southern Sweden, however, is summer precipitation more uncertain when estimates show both increases and decreases. A greater proportion of winter precipitation comes as rain because temperature increases.

- Drainage system
- Dewatering from roofs
- Sewage system
- Height of skirting
- Slope from the building

- Moisture levels in materials
- Driving rain?
- Driving snow

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http://www.smhi.se/tema/Klimat-i-forandring

Sweden's future climate

Wind climate

Concerning the wind climate in Sweden in the future, it is uncertain if it will be changed and if so, to what extent.

The same road before and after the storm Erwin (Gudrun in Sweden) in 2005. *Foto: Anders Gerestrand*.

- **Driving rain?**

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The overriding challenge for the future

- **Sustainable Buildings**
  - **That are moisture safe in today´s and tomorrows climate**

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