Heated External Insulation Composite Systems to avoid Biological Defacement

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Outline

- Background
- Research Design
  - Free weathering test of electrically heated samples
  - Concept for a regenerative heating system
  - Set-up of a test façade
- Results
- Conclusions

Background – Building Physics

Partially insulated house in the historic city of Stralsund

Thin redering layer of ETICS

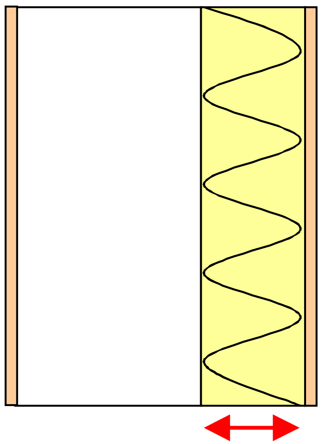
- thermally decoupled by insulation material
- small heat capacity

→ high disposition to undercooling
→ low drying capacity

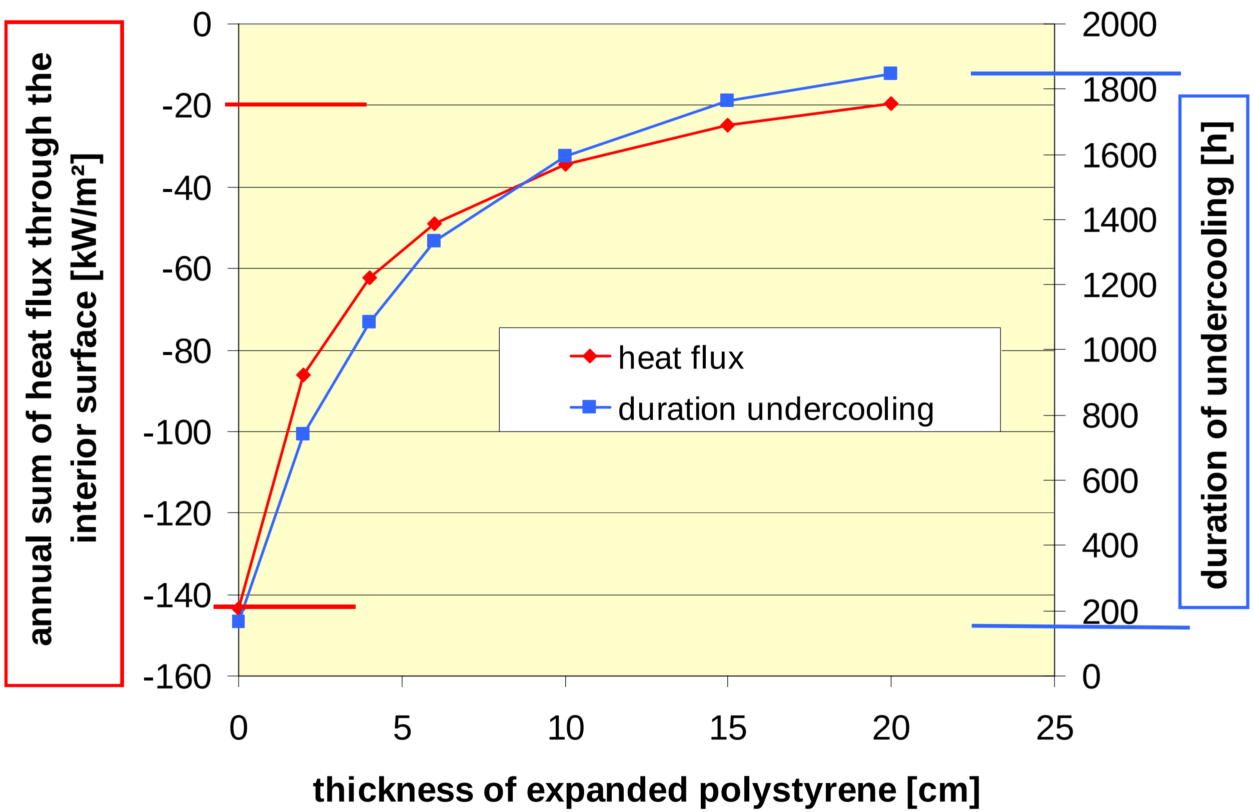
System set-up leads to

→ long lasting humidty films
→ algal growth

Background – Building Physics



Layer	Thickness [m]
External rendering (2 layers)	0,015
EPS	0 – 0,2
Brickwork	0,36
Internal rendering	0,01



Maximum reduction of heat flux in %: 85

Maximum increase of undercooling-duration in %: 1100

Strategies to prevent algal growth

- Thermal strategy:
  - Phase Change Materials
  - low emitting paints
  - **sensor controlled heating**
- Hygric strategy:
  - plaster systems controlling the humidity profil
  - microstructured surfaces (copying the Lotus-leaf)

- Chemical strategy
  - photocatlysis
  - **biocides**

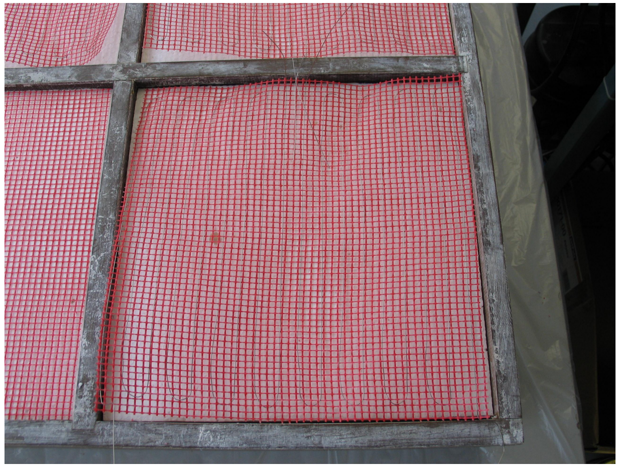
→ only reliable protection so far

→ water solubility leads to

- limited action and
- contamination of water bodies
- Periodic maintenance consumes money and energy !

Research Design - Free weathering test

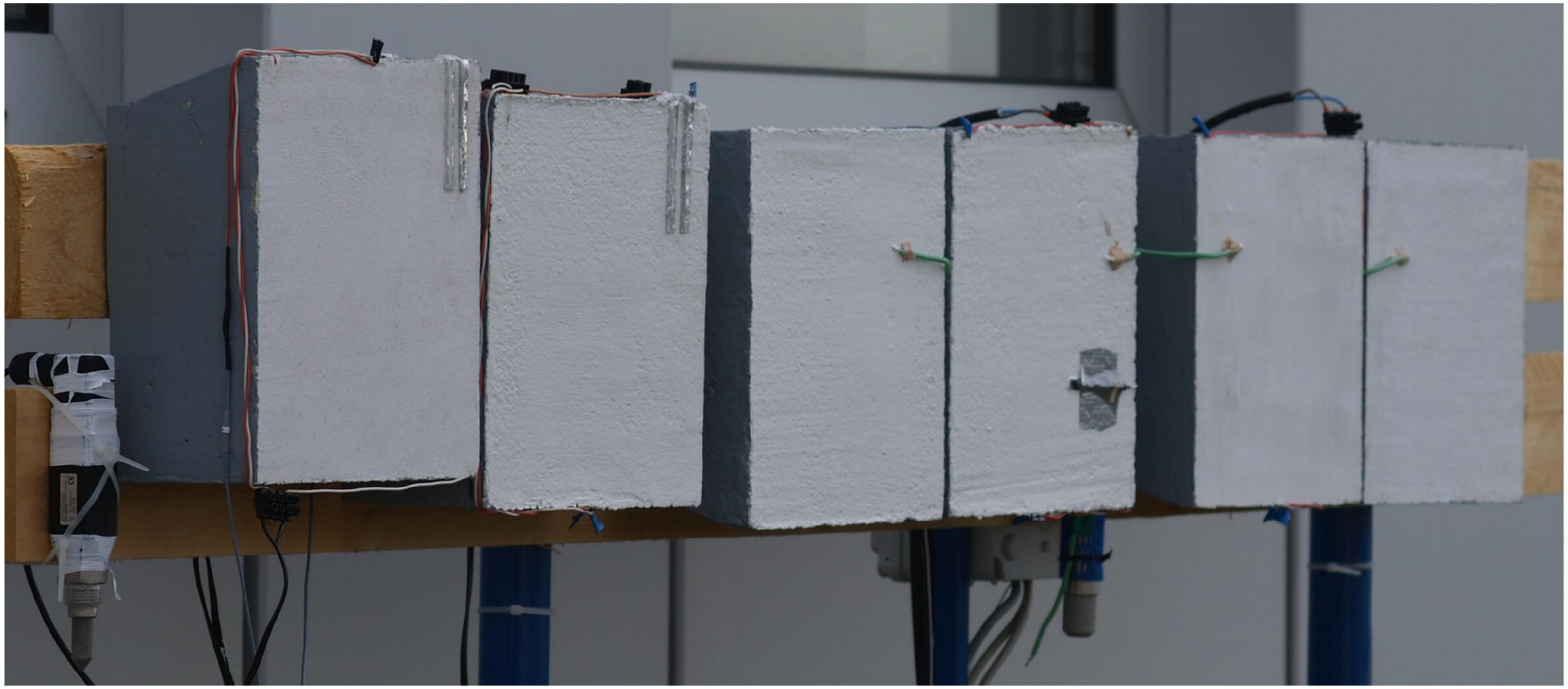
absorbing (hydrophilic system)	**low absorbing (hydrophobic) system**
mineralic under coat t = 5 mm w = 1,55 kg/(m²√h) μ = 14	**organic under coat** t = 5 mm w ≤ 0,03 kg/(m²√h) μ = 300
electrical heating system integrated into the reinforcement fabric Resistance wire ISA-Chrom 60 diameter: 0,8 mm spacing: 1,5 cm	
lime cement plaster t= 3 mm w = 1,55 kg/(m²√h) μ = 13	**silicon plaster** Schichtdicke: 3 mm w ≤ 0,06 kg/(m²√h) μ = 75
	silicon paint w ≤ 0,1 kg/(m²√h) μ = 500



- Power supply over transformer rectifier electric potential: 9 Volt
- Resistance of wire: 26 Ω
- Sample area: 0,0625 m²
- Areic heating power $P = U^2 / (R*A)$

~ 50 Watt/m²

Research Design - Free weathering test


Heated and reference samples with different sensors

Concepts tested to control the heating:

- Comparison of surface and dewpoint temperature
- Comparison of surface humidity with a predefined critical limit

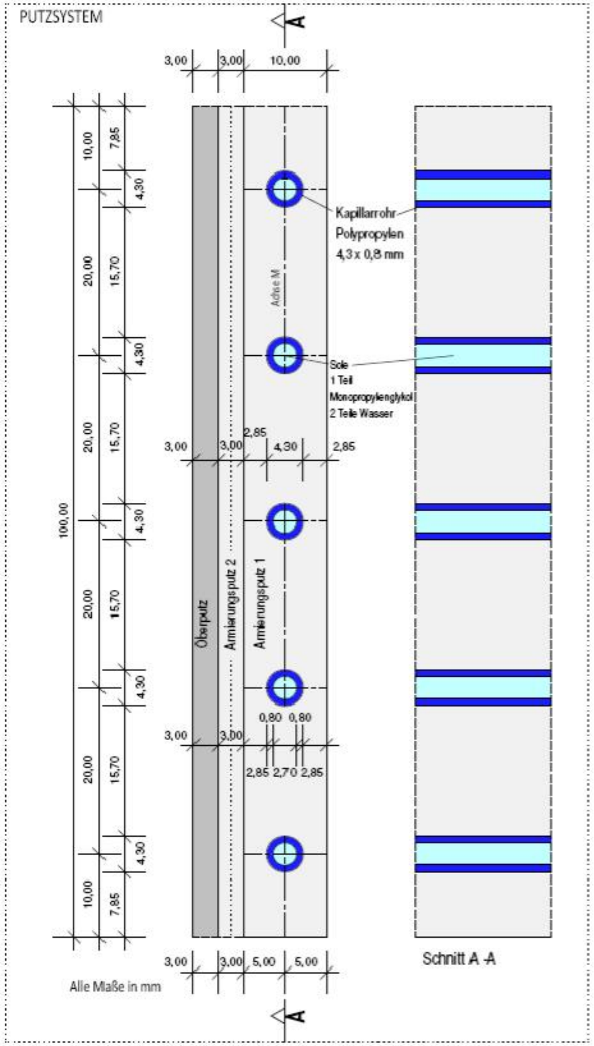
Research Design - Data evaluation

- absolute heating time (t_H) to prevent undercooling [h]
- heating time to prevent undercooling as a percentage of the period under consideration (t_{HP}) [%]
- heating time
  - reduced to the time span relevant for active growth of algae and
  - reduced to the time span without precipitation [h or %]
- (C1 + C2 + C3)
- Condition 1: $T_S \leq T_T$
  Condition 2: $\vartheta_L > 5°C$
  Condition 3: $m_P = 0$
- energy consumption per unit area W_A [kWh/m²]

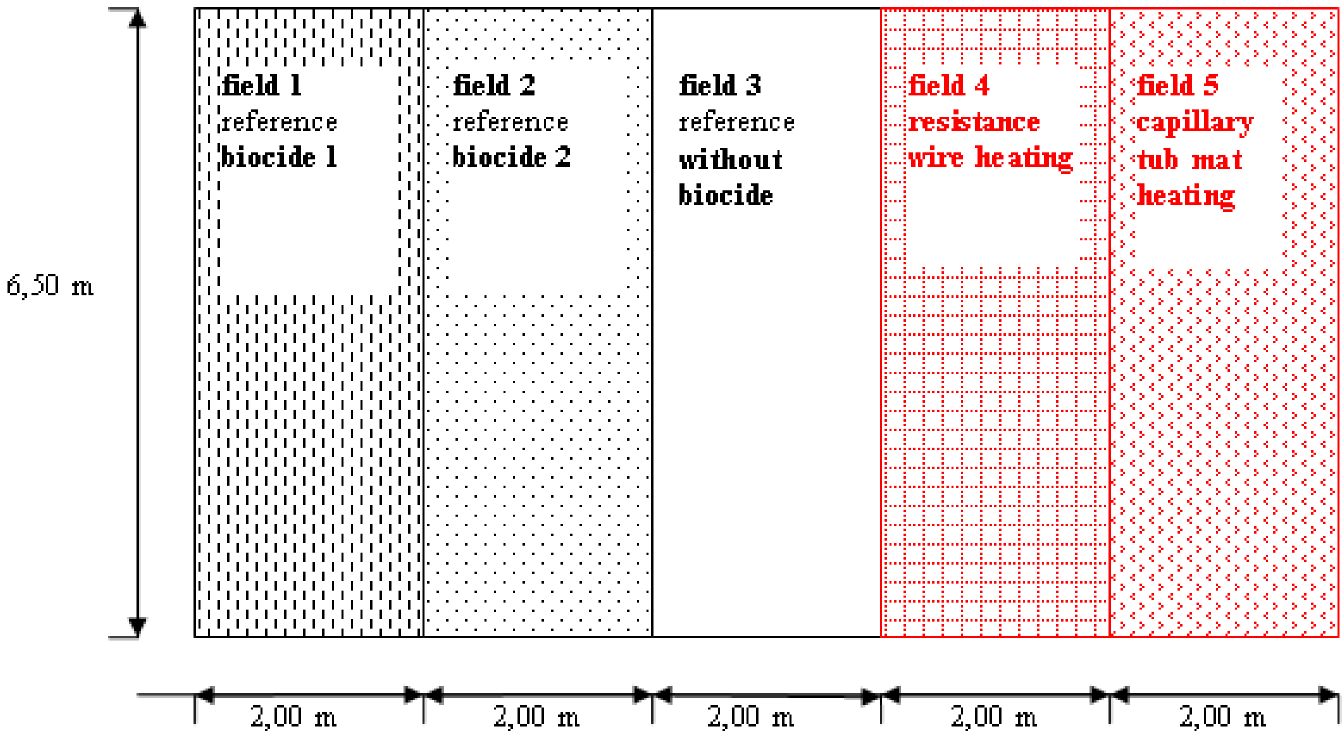
Research design - Concept for the gain and storage of regenerative energy

- integration of a capillary tube mat into the plaster system of the ETICS working as a solar absorber / collector
- Bidirectional use of the capillary mat for the absorption and dissipation of heat
- Heat storage in sensible short term storage tank
- Control of the circulation pump by the comparison of surface (T_S), dewpoint (T_T) and storage tank temperature (T_{ST})
- $T_S > T_{TS} \rightarrow$ heat extracted from the façade
- $T_S < T_{TS} \rightarrow$ heat supplied to the façade

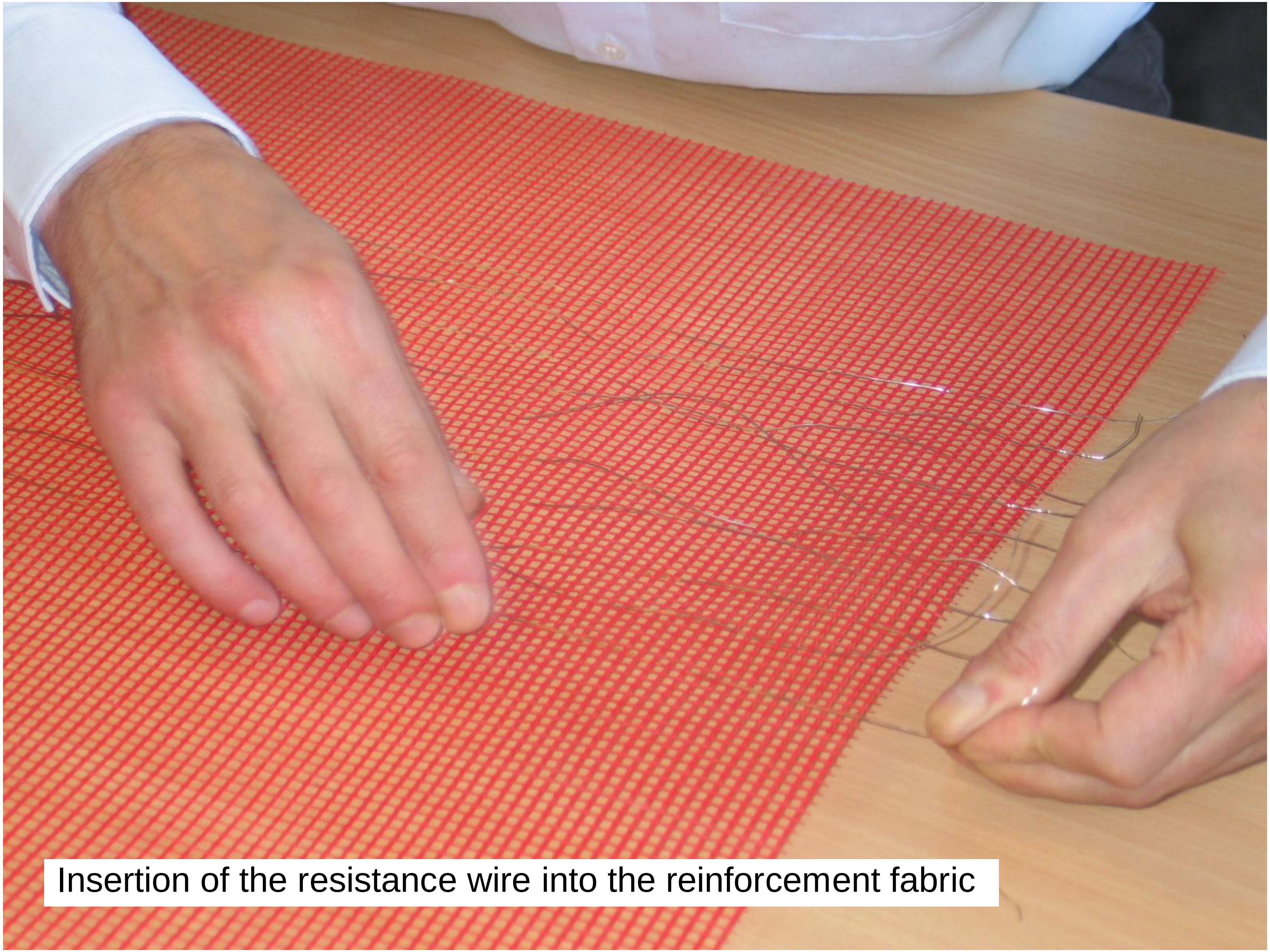
Research design – capillary tube mat heating



Research design - test façade



External insulation composite system applied to a newly errected concrete facade facing north


Insertion of the resistance wire into the reinforcement fabric

Research design - test façade

Integration of the resistance wire into the organic undercoat

Connection of the resistance wire loops to the power supply

Cutting out of the insulation board for the integration of the collecting pipes

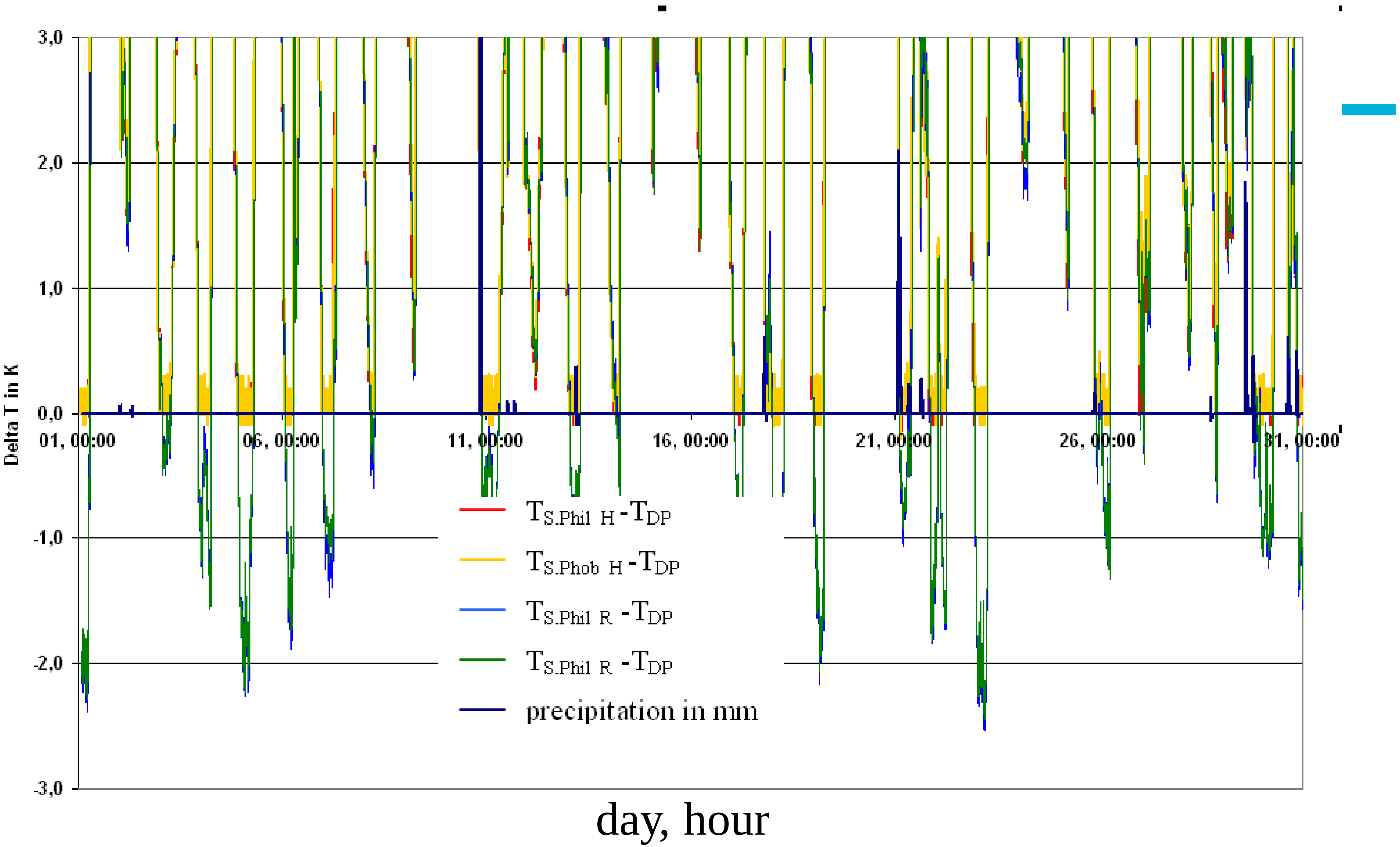
Connection of the flow and the return with the collecting pipes of the mats

Filling of the area cut out for the piping with foam

Application of the organic under coat and integration of the reinforcement fabric

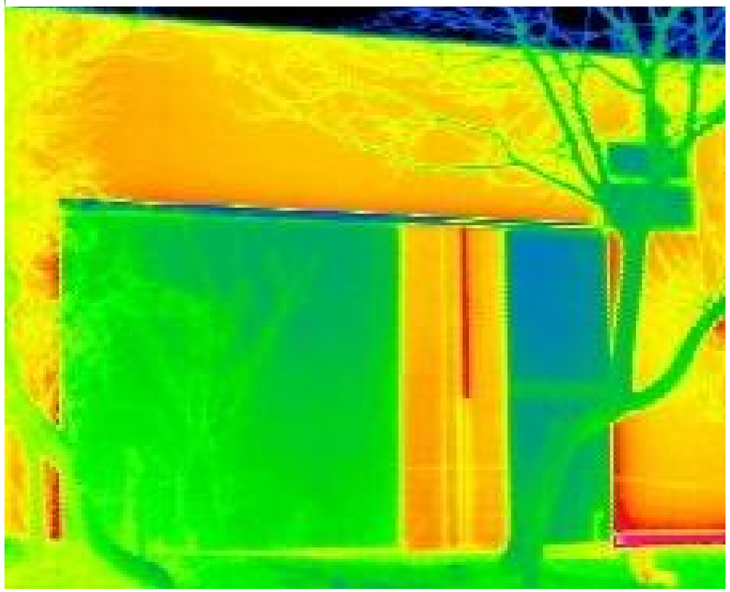
Results- Resistance wire heating

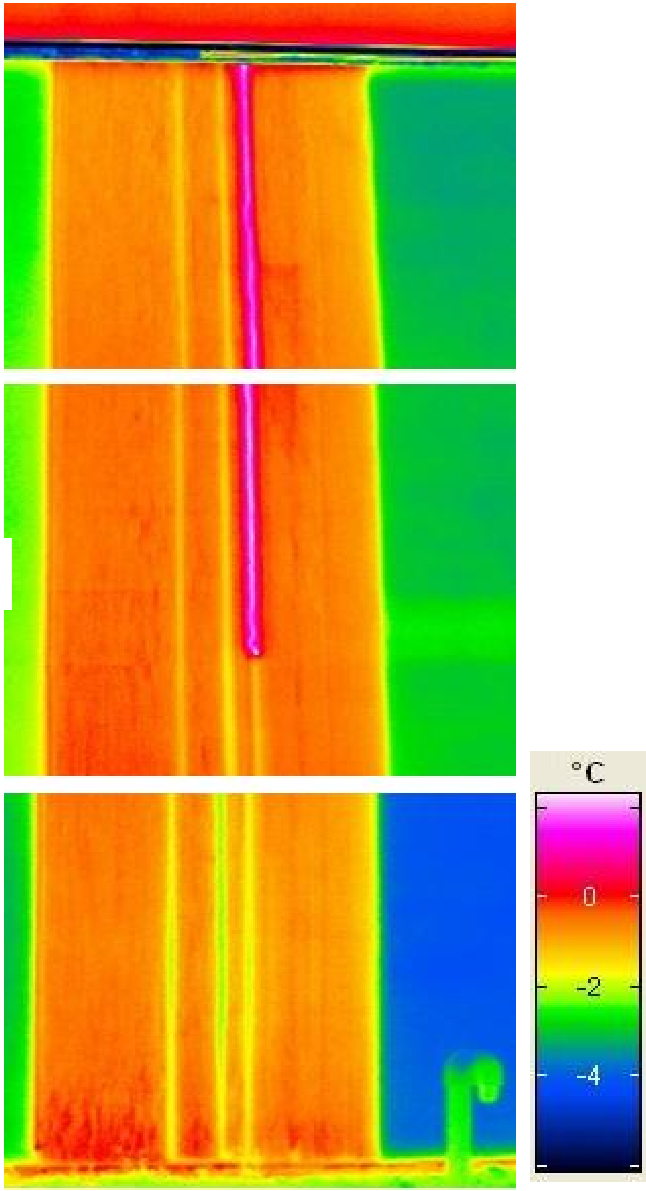
- system set-up simple and cost efficient
- Prevention of dewpoint deficits over the whole year
- additional costs compared to a standard system about 20 Euro /m²
- spacing of the resistance wire of 2 cm allows uniform heating
- Hydrophobic surface more efficient
- **anual heating demand to avoid undercooling (time span relevant for microorganisms without precipitation): 25 kWh/m² → to high!**
- Anual electricity costs per m²: 6,25 (0,25 Euro /kWh) exceed costs for maintanance (27 Euro /m², maintanance interval: 10 years)
- System can be only efficient if algal growth can be already prevented by a reduction of undercooling!



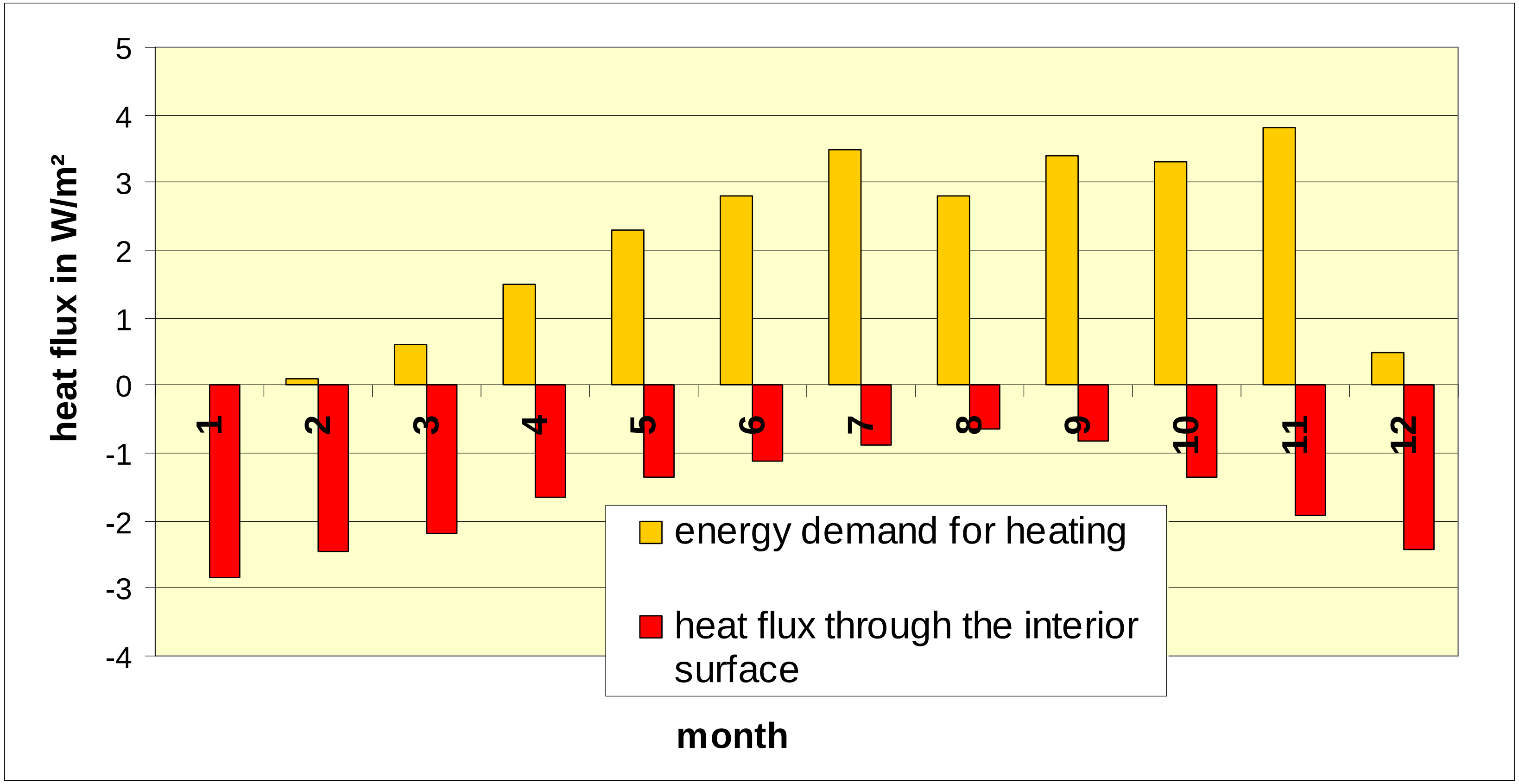
Chronological sequence of the differences between the surface and dewpoint temperature of the different sample setups for the time span 01.- 31. August 2009

thermography 3.12.2009





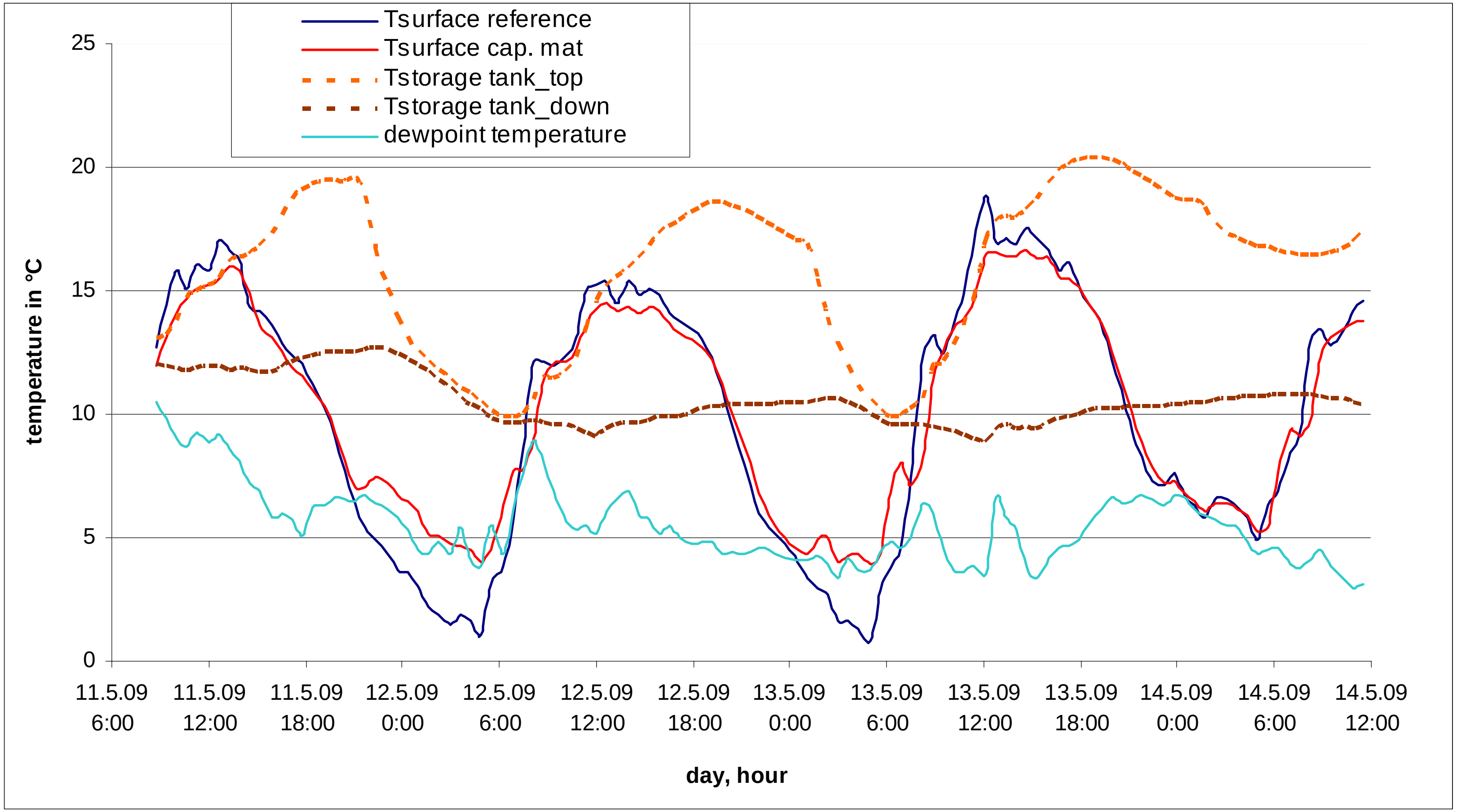
Results- monthly energy demand of the resistance wire heating



Highest energy demand in summer and fall months

Research results- capillary tube mat

- The integration of a capillary tube mat into an external insulation system is more costly than the integration of a resistance wire
- Additional costs including storage tank are approx. 45 Euro /m²
- The abstraction capacity of the facade absorber measured is approx. 12 W/m²K.
- Because of the low energy input during the fall and winter months undercooling can only be reduced by a percentage of 10-20 %
- The energy costs for the service of the pump are maximum 1kWh/m²
- If a reduction of undercooling is sufficient to prevent algal growth the system could be economical



Measuring data 11.-14.05.2009