Business from technology

Effect of energy renovation on thermal sensation and comfort

9th Nordic Symposium on Building Physics
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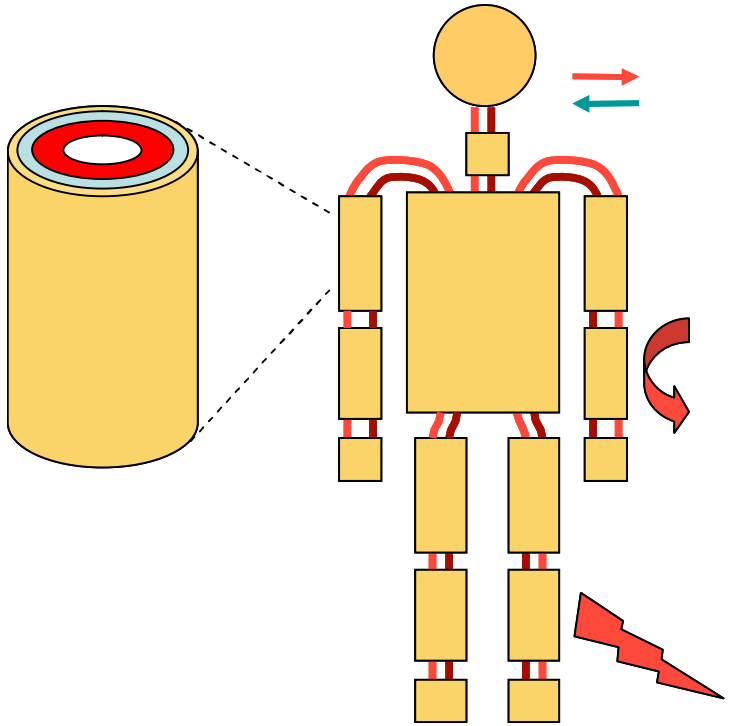
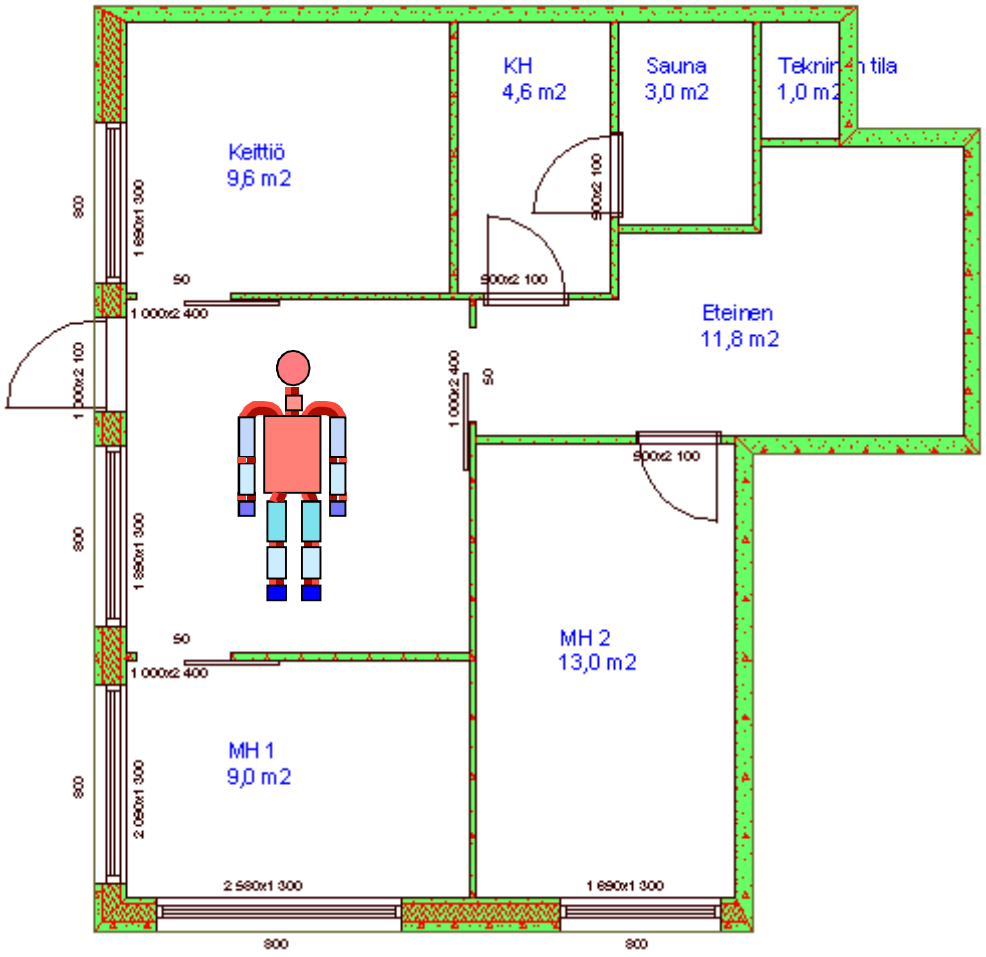
Human Thermal Model (HTM)



- developed for predicting thermal behaviour of the human body under both steady-state and more realistic dynamic indoor environment boundary conditions
- realistic tissue distribution
- blood circulation system
- metabolism, respiration
- thermoregulatory system: control of skin blood flow, sweating, shivering
- interaction with the space by conduction, convection, radiation and evaporative heat transfer

HTM as a module of the VTT House building simulation tool



- adaptive thermal comfort approach: effect of human thermoregulation connected on thermal sensation and comfort
- estimates e.g. effects of alternative building structures and building service systems on thermal comfort
- thermal sensation can be used as a design parameter resulting in better thermal environments of new or renovated buildings

Renovation case

- typical Finnish apartment building from 1970
  - wall structure 0.085 m concrete + 0.140 m mineral wool + 0.100 m concrete, U-value **0.36 W/m²K**
  - double glazed windows, U-value **2.4 W/m²K**, g-value 0.75.
- mechanical exhaust ventilation system, radiator heating
- indoor set point temperature 21 °C
- retrofitting solutions with U-values on Finnish very low-energy house level
  - wall structure 0.085 m concrete + 0.360 m polyurethane (PUR) + 0.100 m concrete, U-value **0,10 W/m²K**
  - triple glazed windows, U-value **0.67 W/m²K**, g-value 0.35

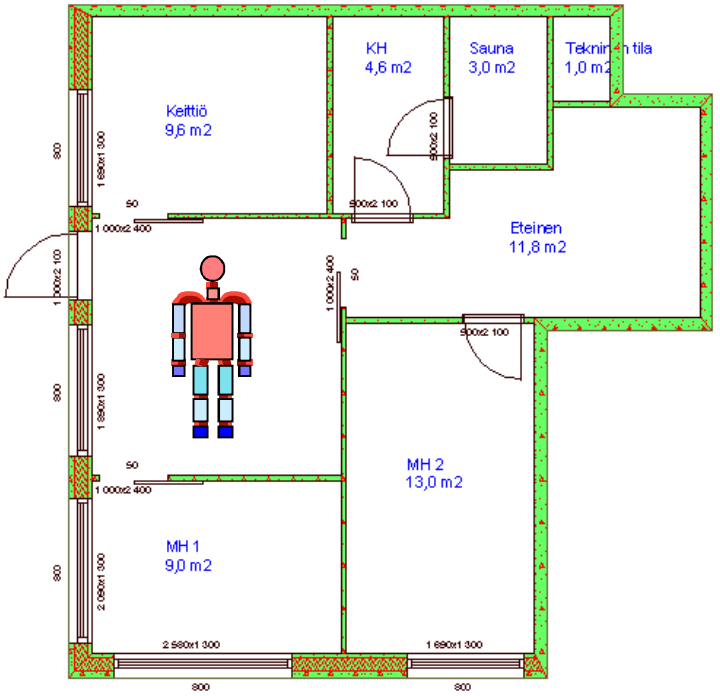
Simulation cases:

1. original walls and windows
2. original walls and new windows
3. retrofitted walls and original windows
4. retrofitted walls and new windows

Space: living room 13.3 m2

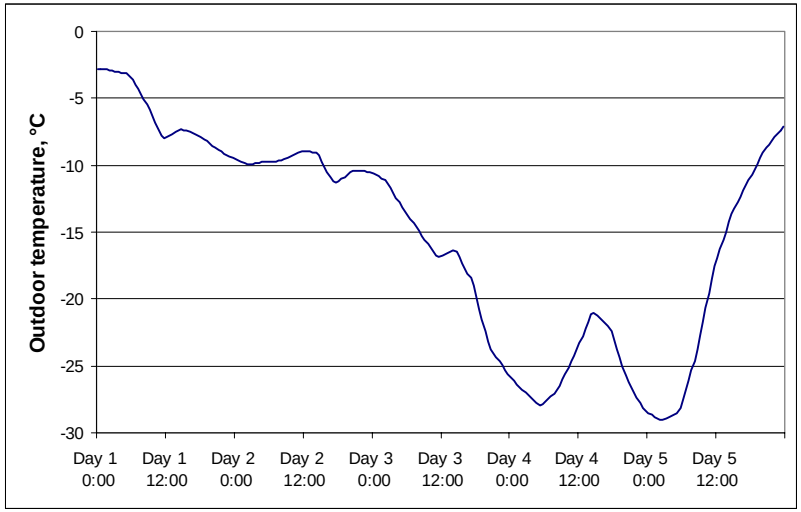
Outer wall area: 5.4 m^2

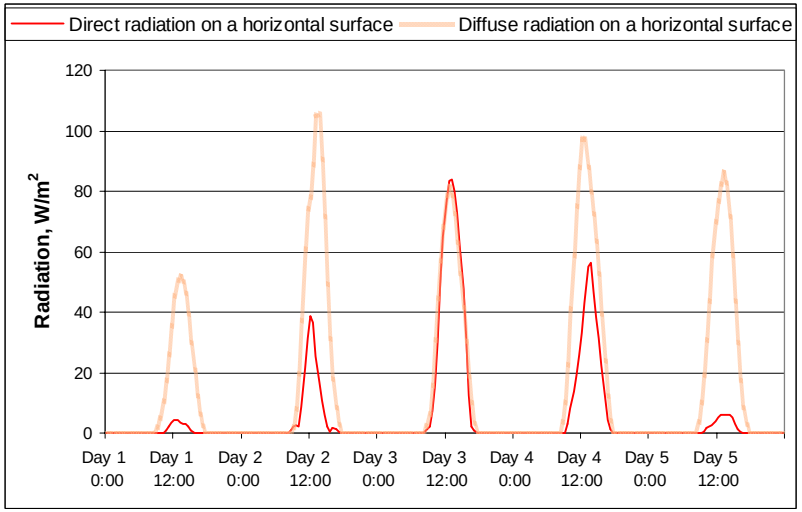
Window area: 2.5 m^2



Weather data during simulation time

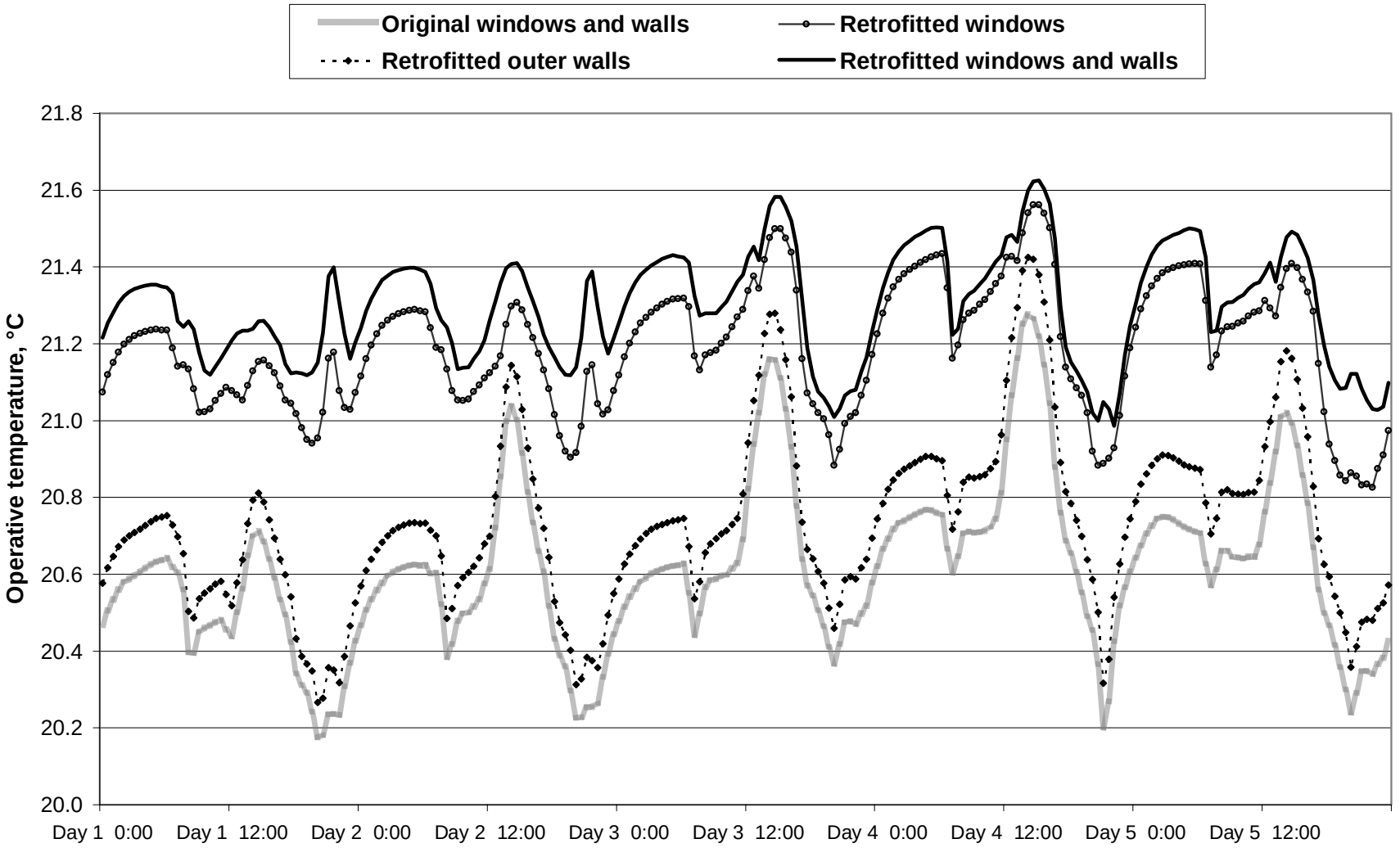
- typical 5-day* cold weather period in middle-Finland
- outdoor temperature between -3 °C and -39 °C
- direct solar radiation on horizontal surface max 83 W/m^2
- diffuse solar radiation on horizontal surface max 105 W/m^2



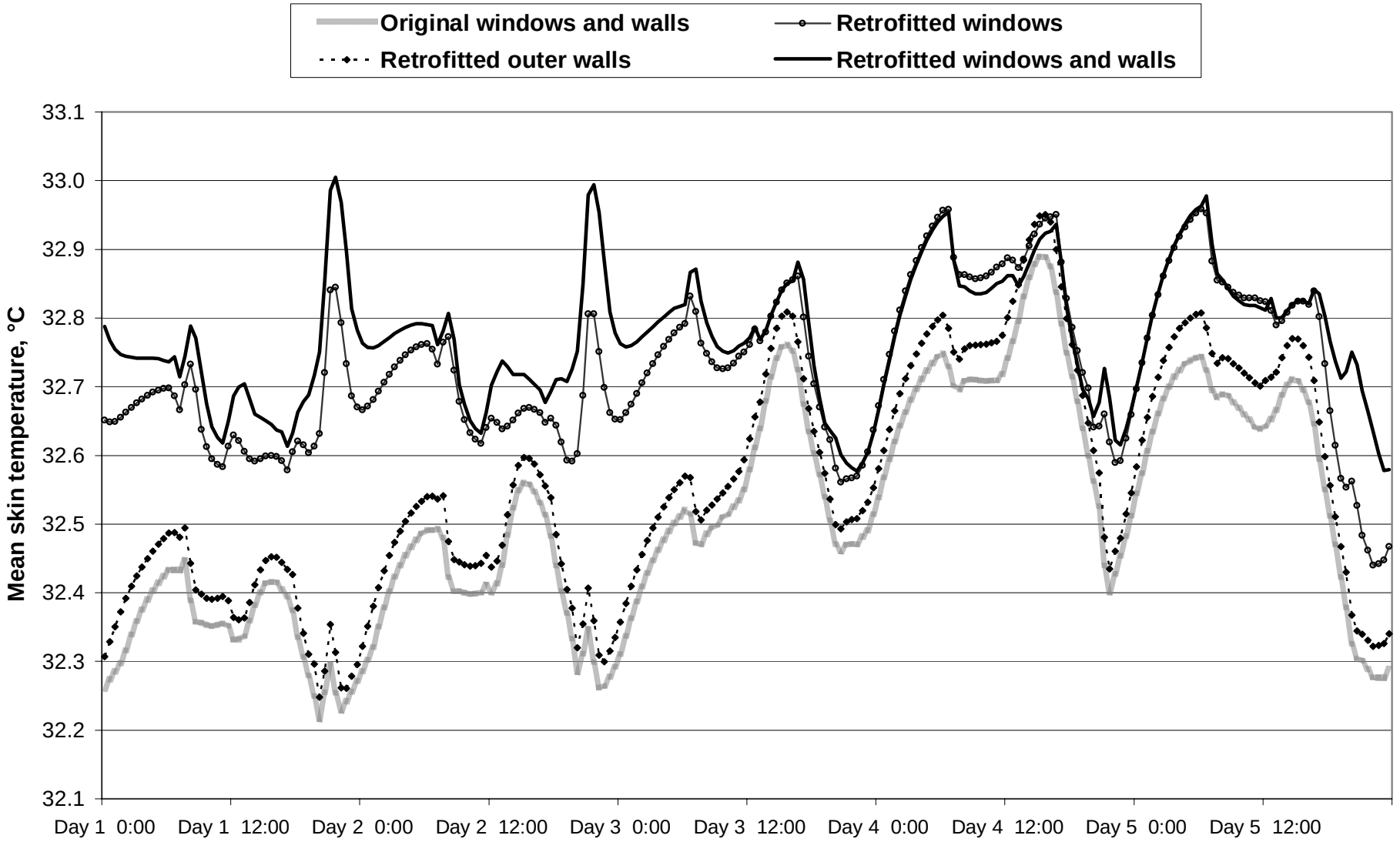


* 3.2. – 7.2. Jyväskylä test year 1979

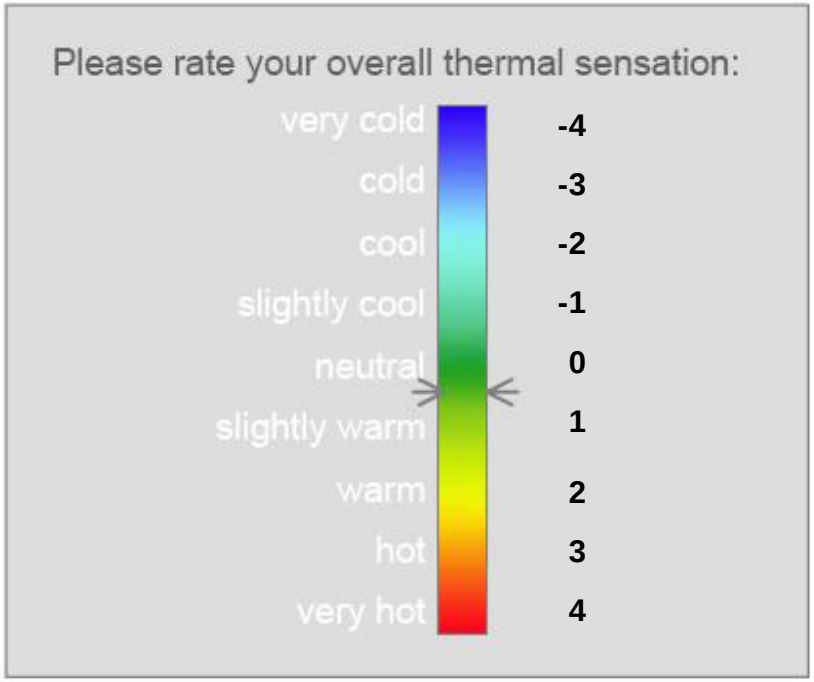
Operative temperature

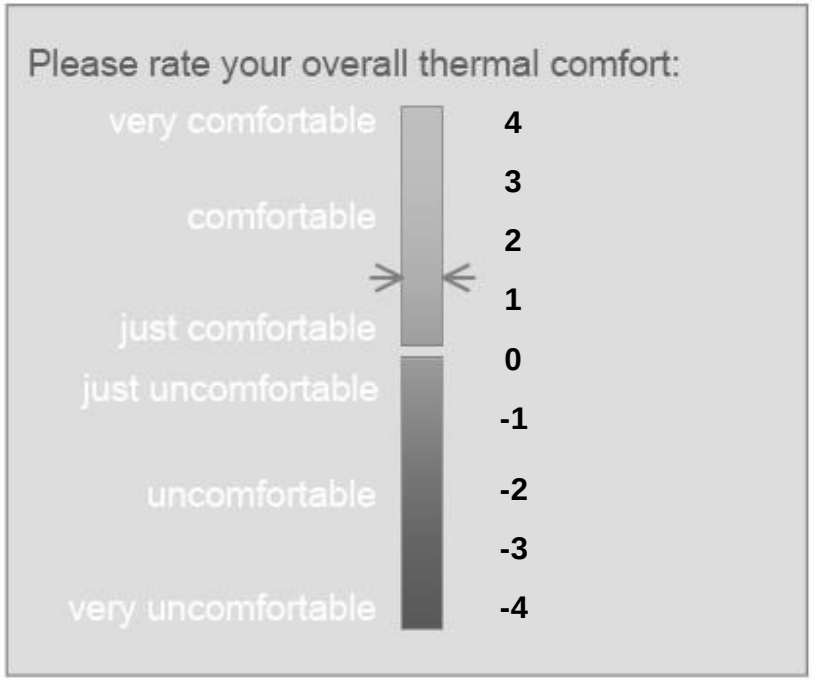


Mean skin temperature of the Human Thermal Model (HTM)

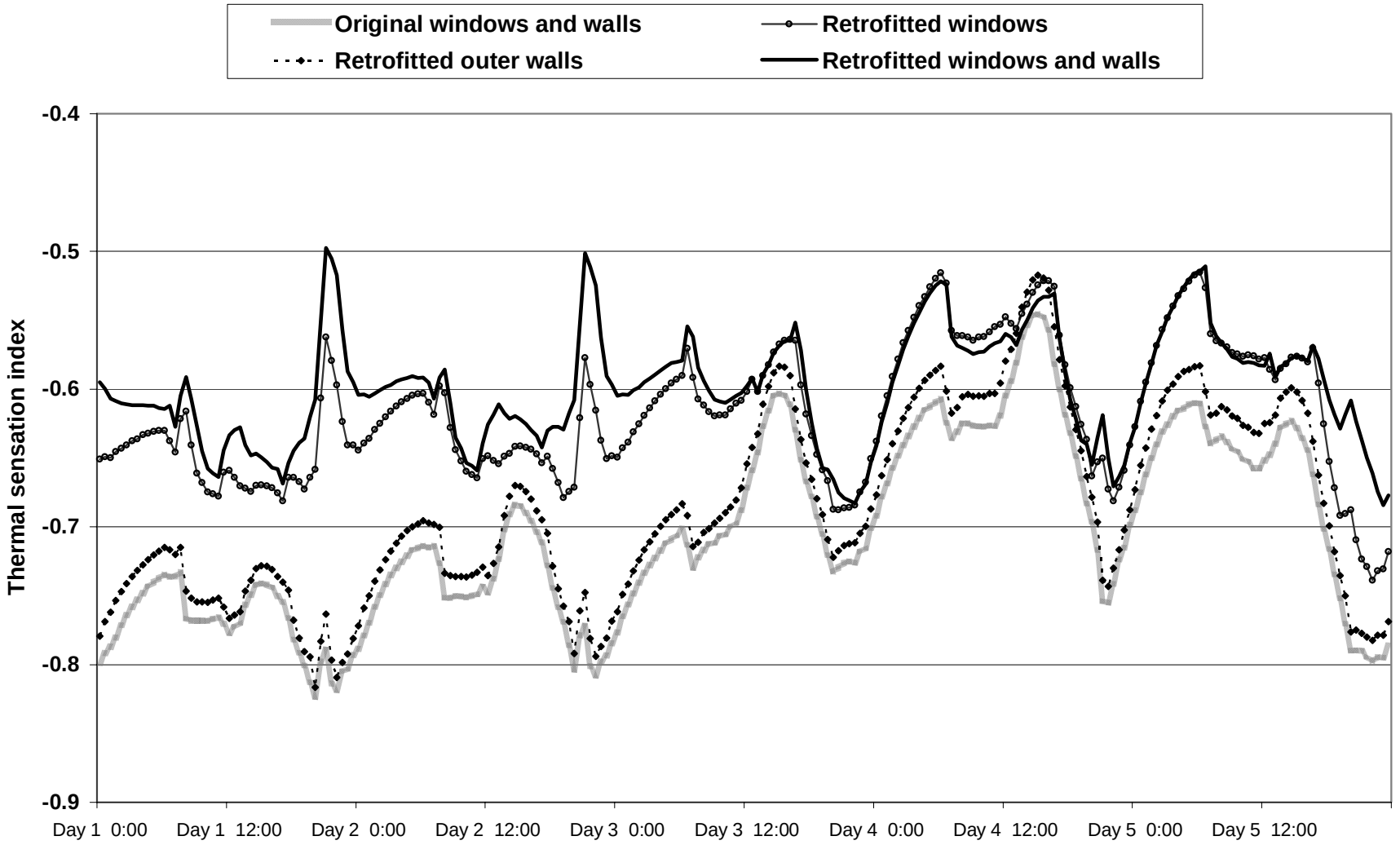


Thermal sensation and thermal comfort scales

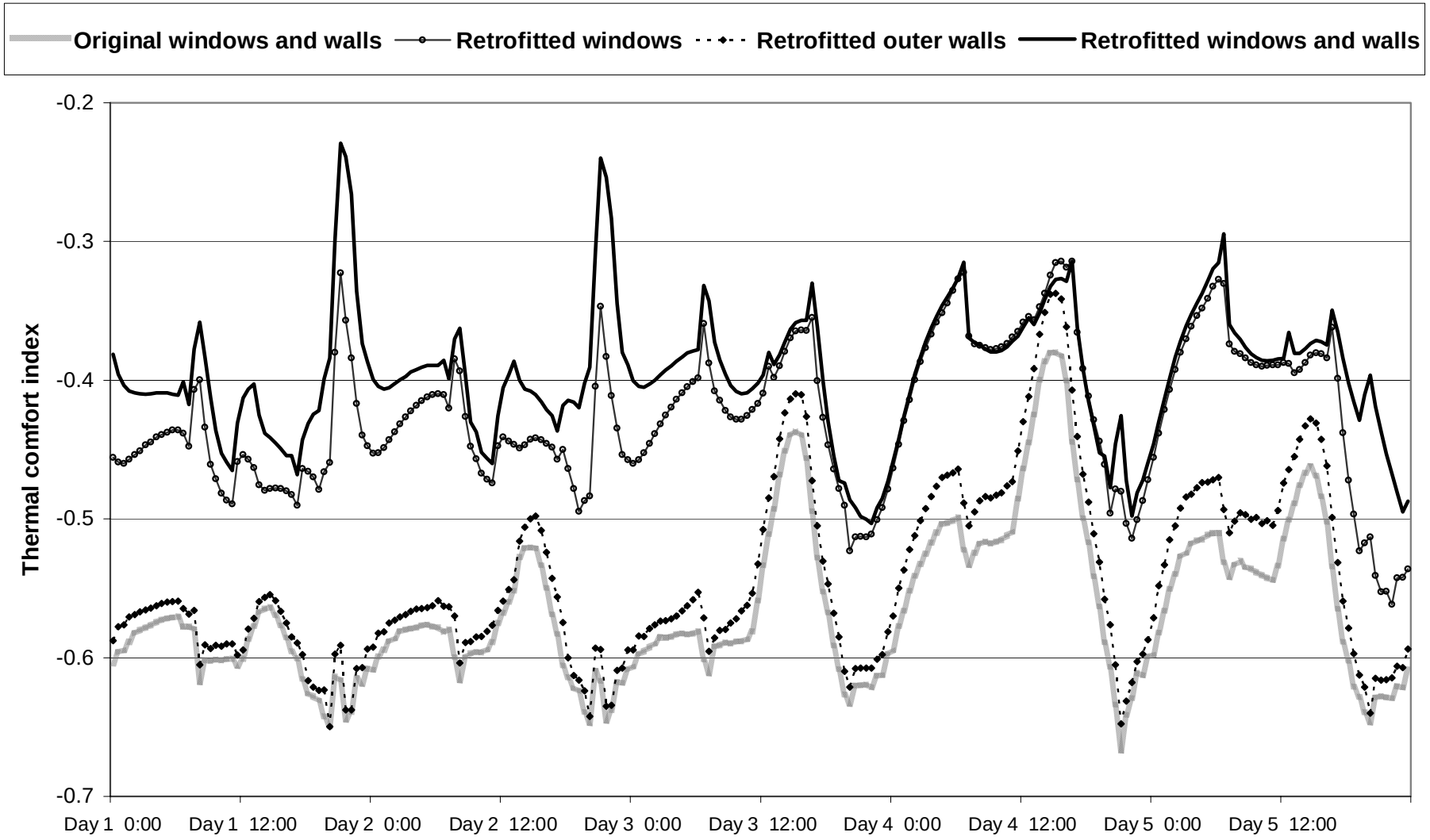




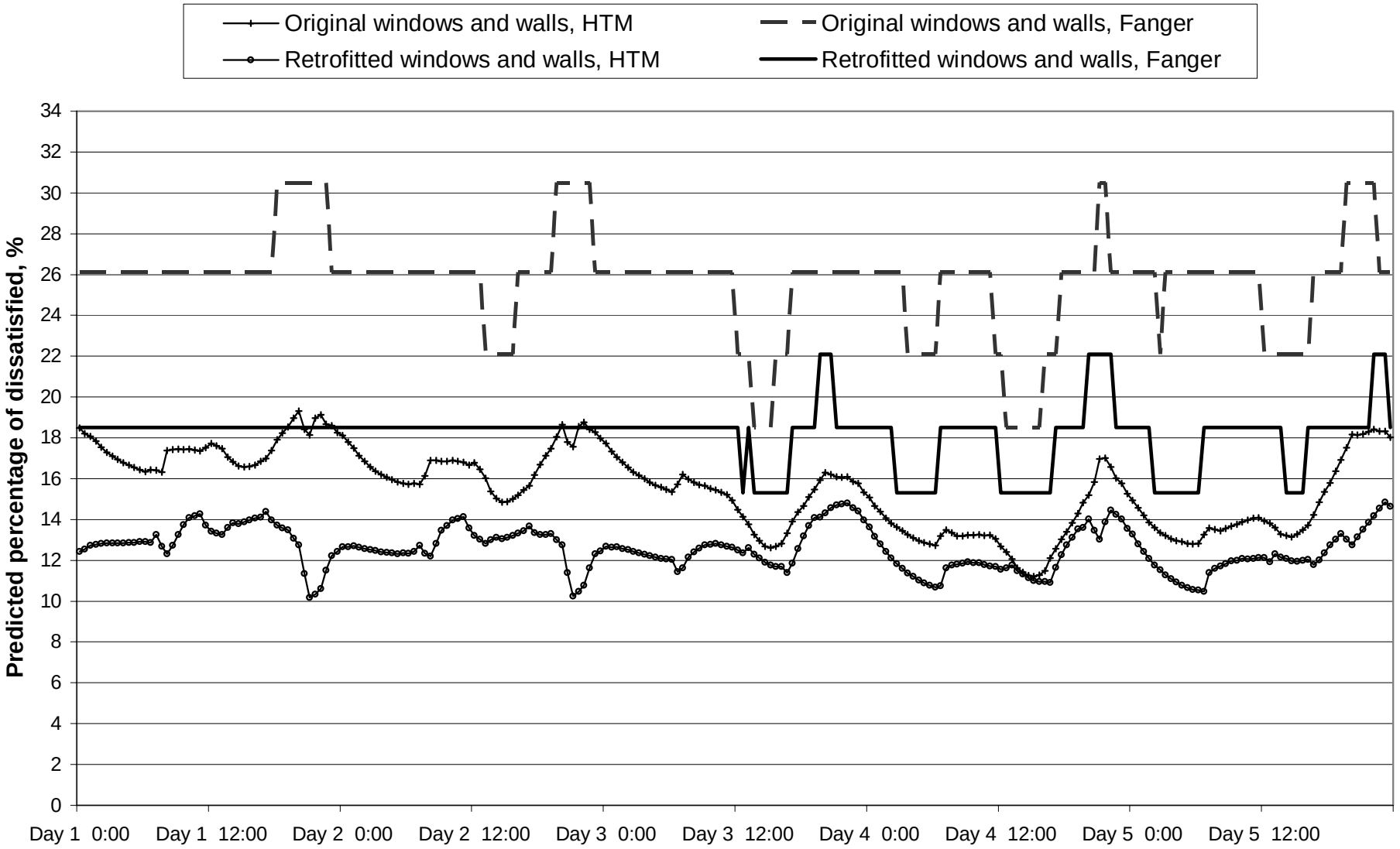
Overall thermal sensation



Overall thermal comfort



Predicted percentage of dissatisfied



Conclusions

- improving the thermal resistance of the building structure increases thermal comfort during the heating season
  - higher inner surface temperatures of retrofitted structures increase the operative indoor temperature and mean skin temperatures -> lower variation of temperature levels -> higher thermal comfort index
- new windows increased thermal comfort more than retrofitted walls (result depends on surface areas)
- total energy renovation decreased the annual heating demand of the test flat by 38 %
- increased indoor surface temperature levels decrease the radiation of cold surfaces -> lower indoor temperature demand -> further savings in energy cost

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