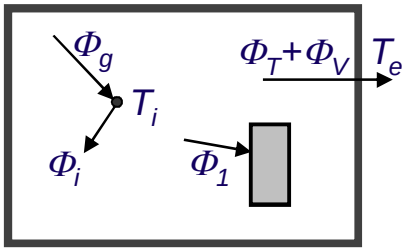
Experimental validation of two simplified thermal zone models



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Motivation

- Why to deal with simplified models?
- The more complex a system the less effective the model? (*Lofti Zadeh: „As the complexity of a system increases, our ability to make precise and yet significant statements about its behavior diminishes until a threshold is reached beyond which precision and significance (or relevance) become almost mutually exclusive characteristics“).*
- Education: ability to explain main features of the problem (target audience – students of architecture)
- EN ISO 13790 – simple hourly method

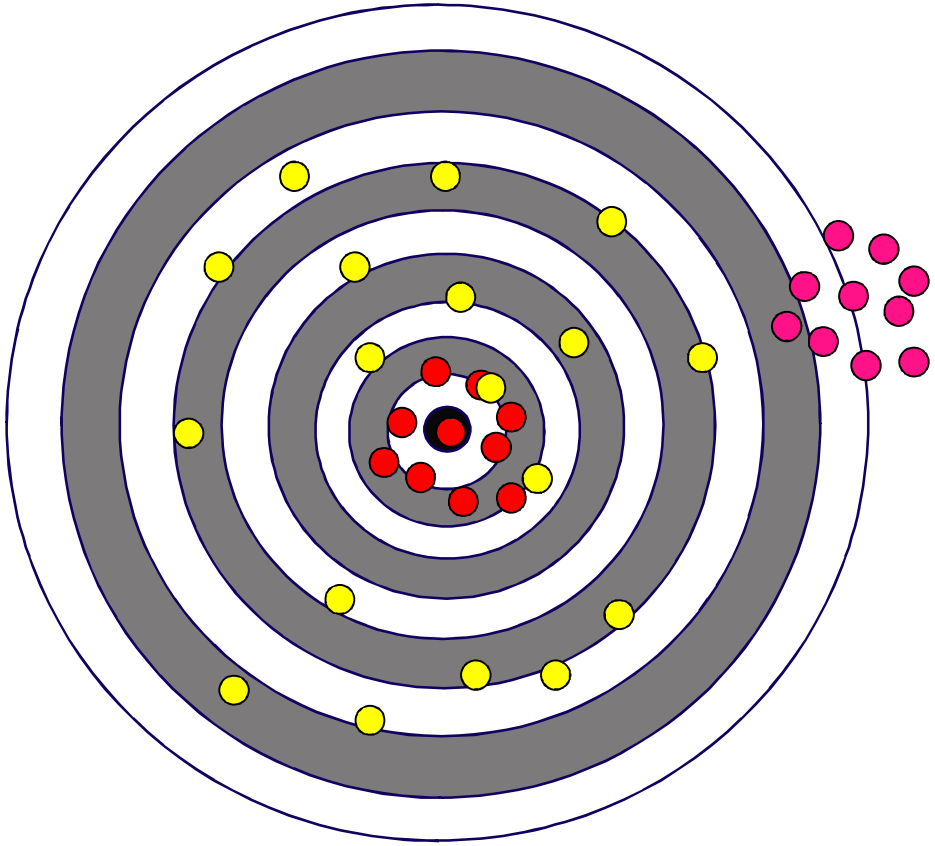
Scope

- To research suitable simplified description of heat transfer in ventilated zone
- To test if simplified models are capable to produce reliable results

- Simplified models should:
  - Exclude all factors with negligible influence (i.e. limit number of inputs)
  - Provide reasonable accuracy
  - Work with short time step
  - Be comprehensible for standard users
  - Be practical for design process

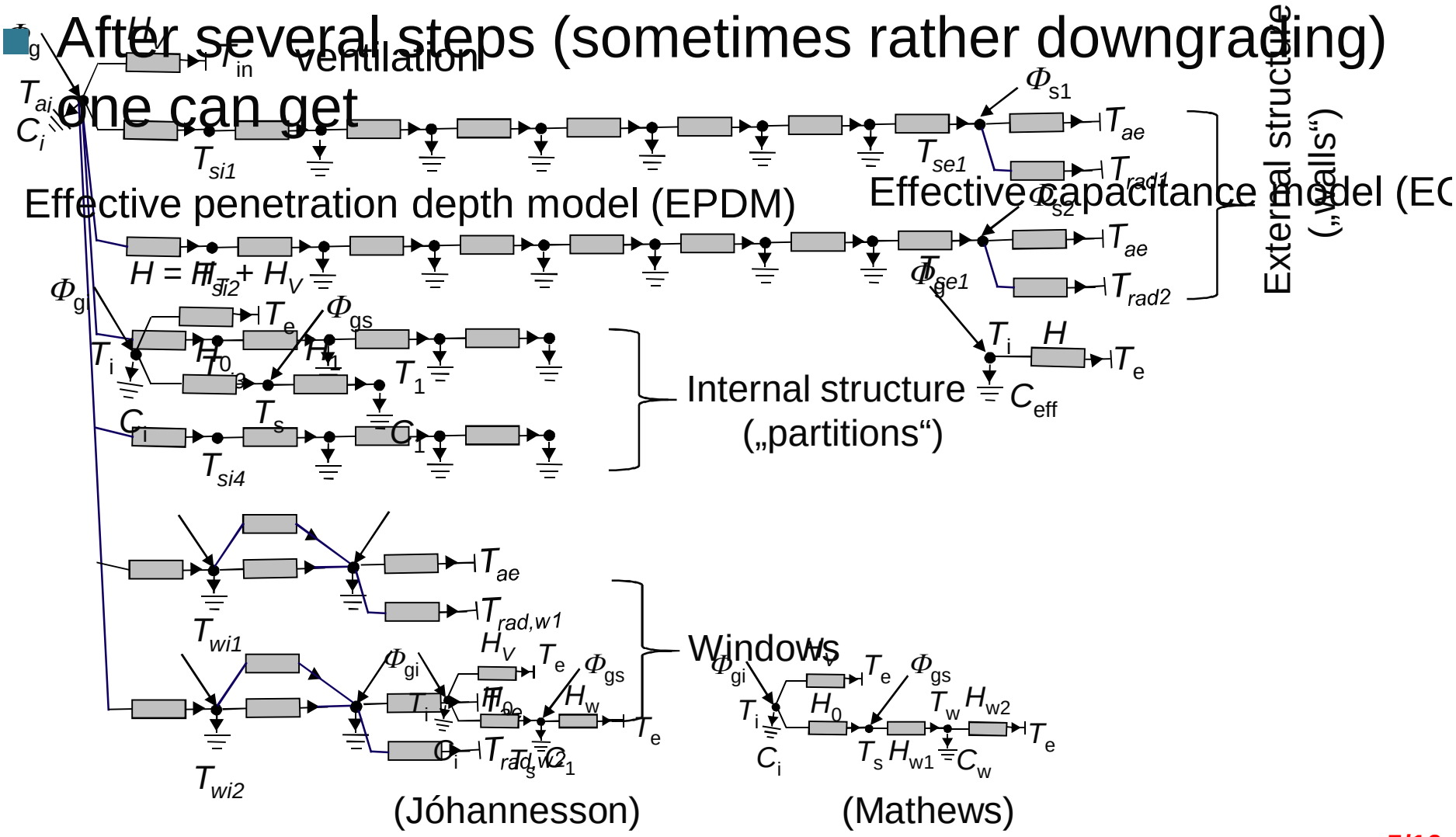
Problem of accuracy

- Model uncertainty x deterministic criteria?



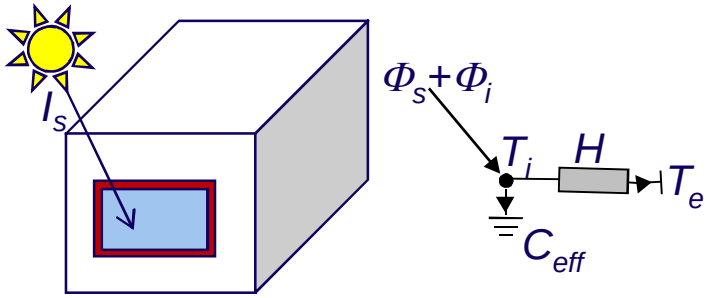
Process of simplification

- How to change complex structures to simple?
- After several steps (sometimes rather downgrading) one can get



Effective capacitance model

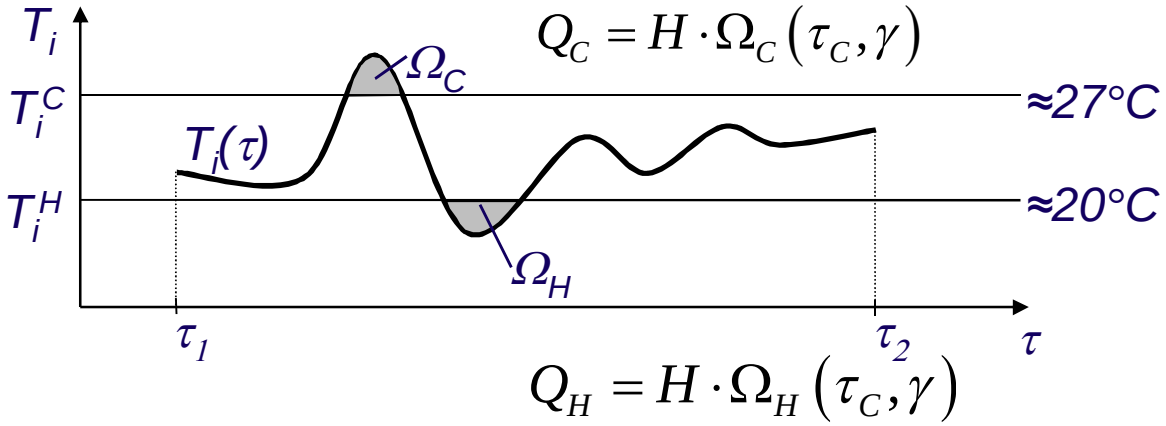
- Very helpful for education
- „Climate surfaces“ – Keller, Burmeister



$$C_{eff}\frac{dT_i}{d\tau}=\Phi_s+\Phi_i-H\left(T_i-T_e\right)$$

$$\tau_C\frac{dT_i}{d\tau}=\gamma I_s+\frac{\Phi_i}{H}-\left(T_i-T_e\right)$$,where $$\tau_C=\frac{C_{eff}}{H}$$

$$\gamma=\frac{\bar{g}A_wF_g}{H}$$



$$Q_C=H\cdot\Omega_C\left(\tau_C,\gamma\right)$$

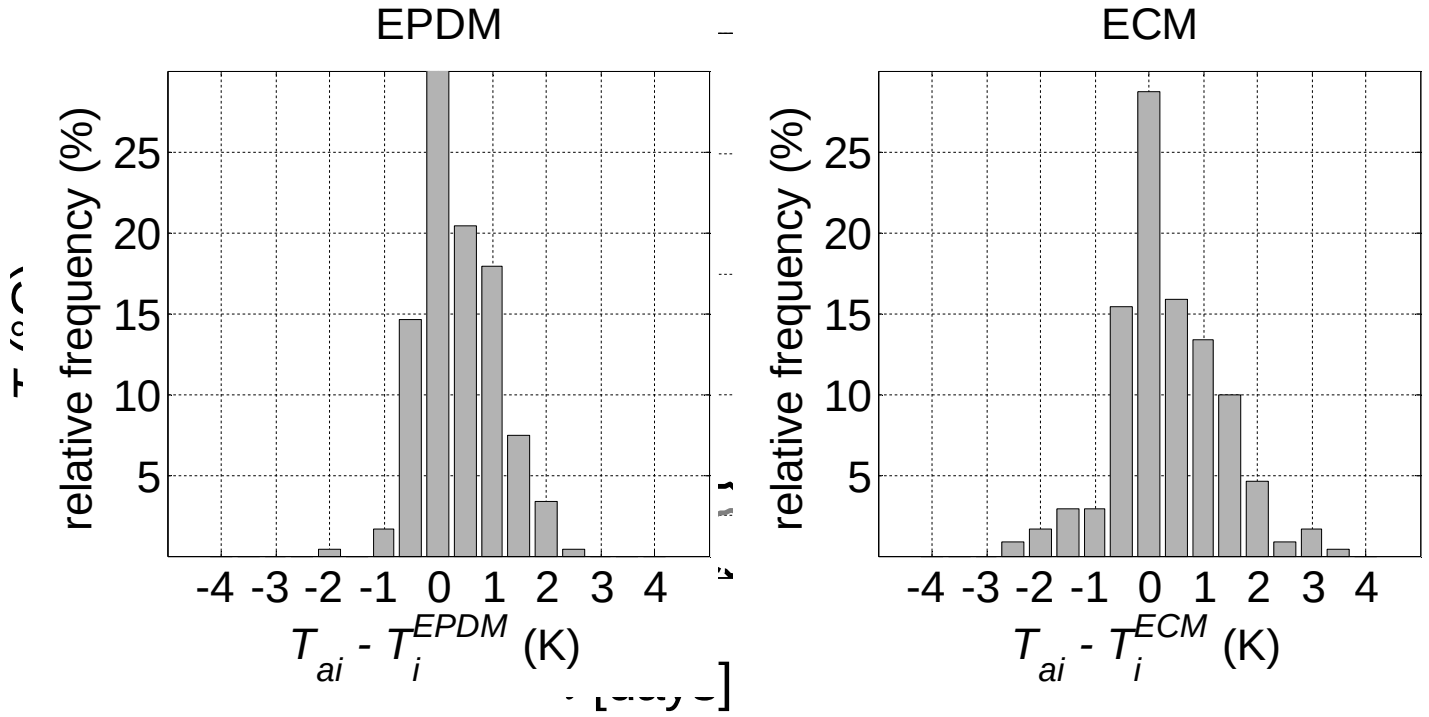
$$Q_H=H\cdot\Omega_H\left(\tau_C,\gamma\right)$$

Examination of models

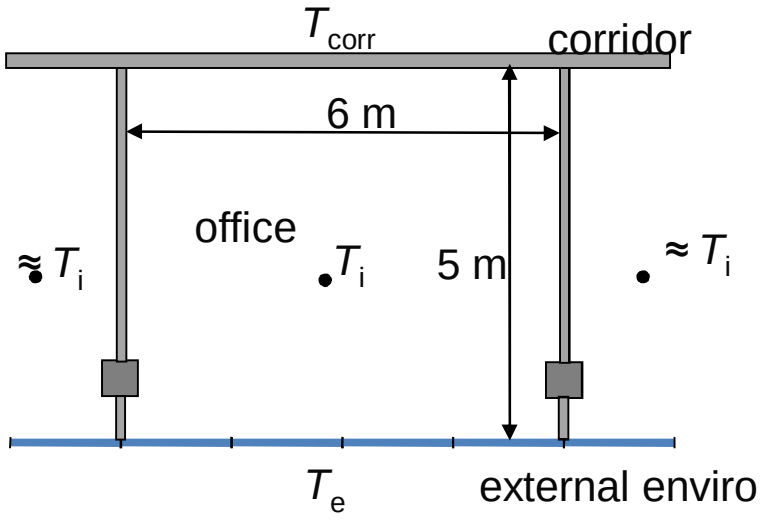
- Goal: to confront EPDM and ECM with measurement
- Comparison with other models (Bestest)
- Comparison with measured data
  - Box on the university roof
  - Real occupied office

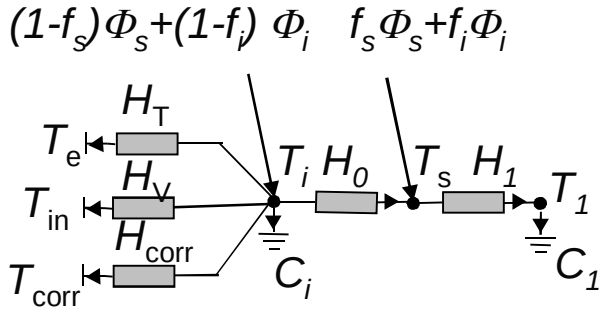
Box on the roof

- Room model (1:3)
- Very light structure
- Very good data about solar gains
- Comparison based on ten-day period

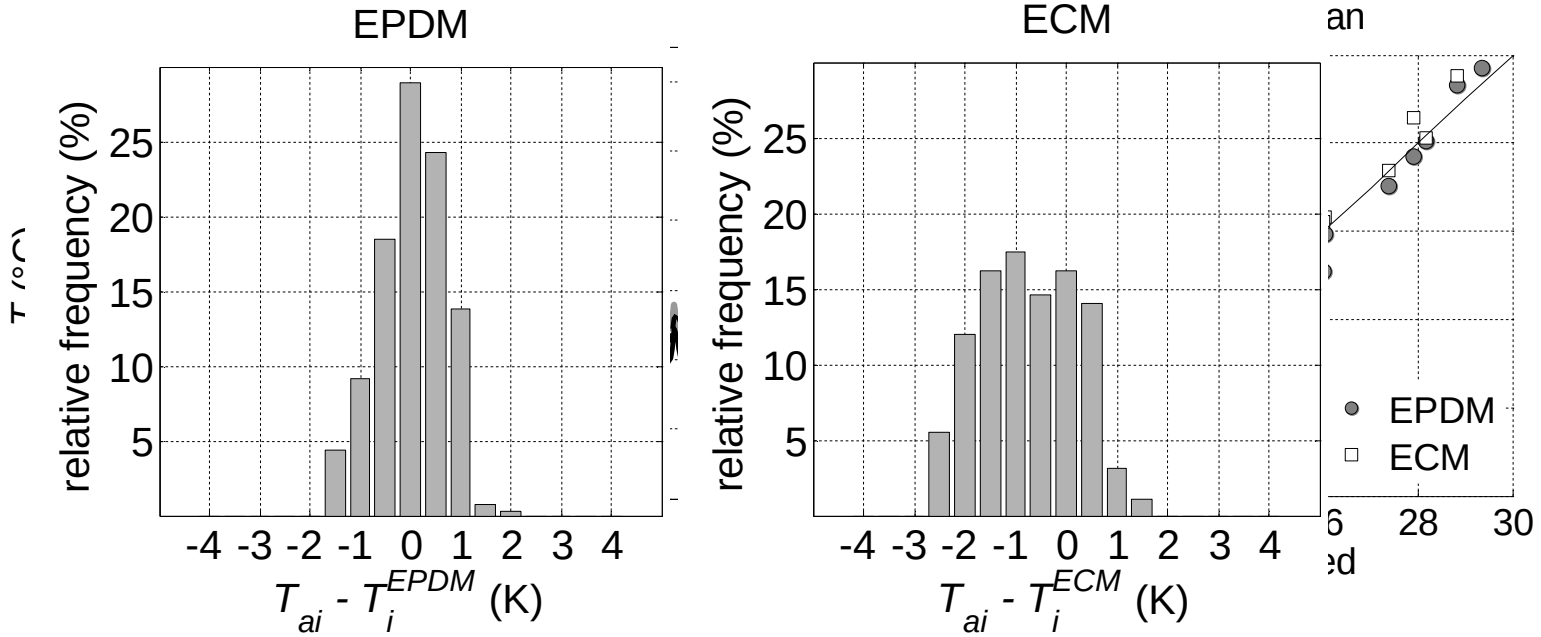


Office



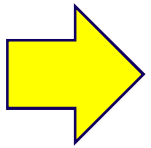


- Heavy structure with light envelope



Conclusions

- Two simplified thermal models of ventilated zone were comparable with measurement
- It seems they could be capable to predict
  - Heating need and cooling need
  - Thermal comfort



- Problems
  - How to upscale from one-zone analysis to whole building not to lose information about thermal comfort?
  - Dynamics based on longer (ground heat transfer, or castle) or much shorter fluctuation than one day (e.g. technical systems)

Thank you for your attention