NTNU – Trondheim
Norwegian University of
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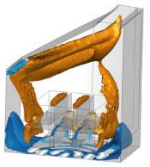
WoodCFD

Clean and efficient wood stoves through improved batch combustion models and CFD modelling approaches



Simulation of indoor thermal environment of well-insulated buildings heated by wood stoves

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BuildSim-Nordic seminar
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Lund, Sweden

ZEB The Research Centre on Zero Emission Buildings

FME CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH

Background

- Super-insulated buildings have low heat losses compared to the power of wood stoves > 3 kW
- Potential problems with overheating and local thermal discomfort (e.g. thermal stratification)
- Modelling the thermal environment of buildings with wood stoves is a complex task
- A good candidate for modelling – new zonal model based on „flow-elements“ under development by EQUA

Modeling approaches

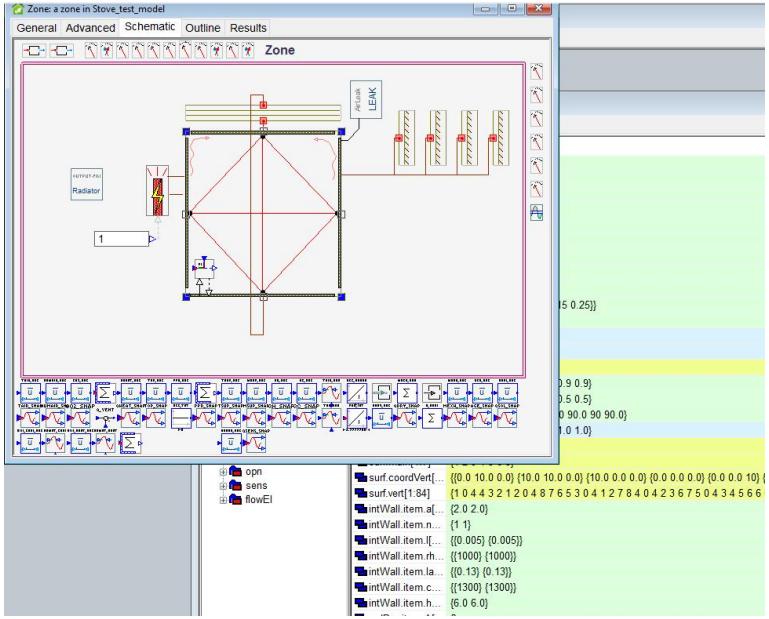
- +/- of the main modeling approaches/tools
  1. Thermal dynamic simulation (TDS)
  2. TDS + zonal model in rooms
  3. Computational fluid dynamics (CFD)
  4. CFD + TDS

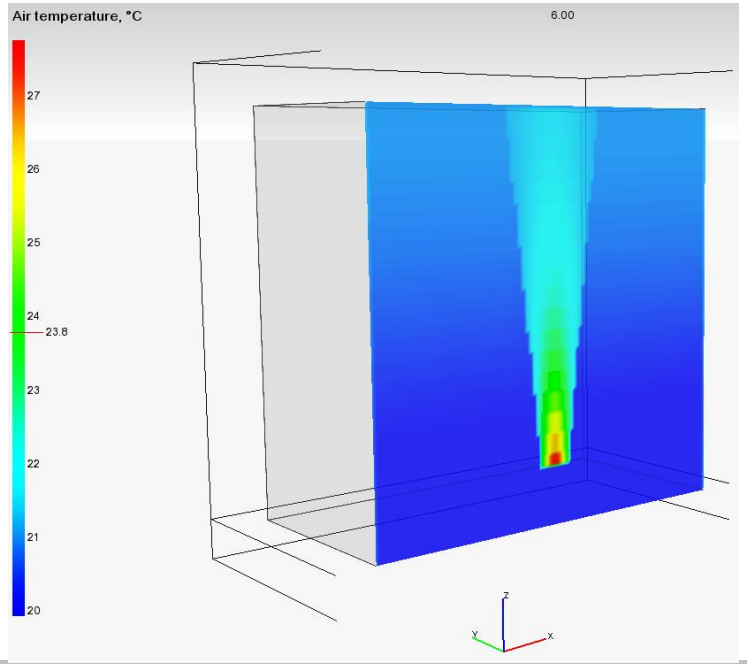
Method	Δt imposed by	Tmin	Tmax	CPU time	Convection doors	Consistent BCS	Top	Stratifi-cation	Radiation asymmetry	Air velocity
TDS	Control/Flow	1-cycle	1-year	Low-Medium	Simple	Yes	Yes	No	Yes	No
Zonal TDS	Control/Flow	1-cycle	1-year	Low-Medium	Simple	Yes	Yes	*Maybe*	Yes	*Maybe*
CFD	Flow	1-cycle	Few cycles	High	Accurate	No	Yes	Yes	Yes	Yes
TDS+CFD	Flow	1-cycle	Few cycles	High	Accurate	Yes	Yes	Yes	Yes	Yes

Tmin = minimal simulation time; Tmax = maximal simulation time

Zonal TDS

- Initial models show promise → validation against experiments
- Possibility of running yearly simulations with reasonable time
- Expert users needed
- Established communication with IDA ICE developers

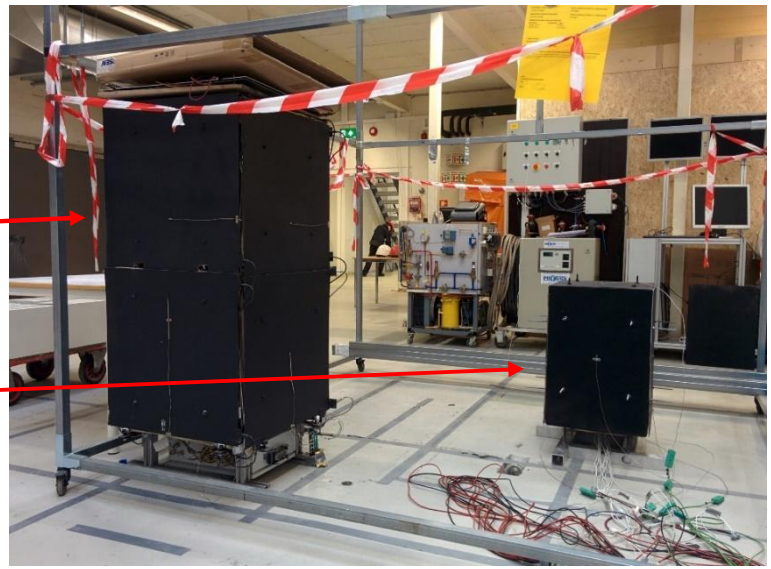




Objectives of PostDoc project (1)

- Main purpose is to establish simulation procedures to capture the complex thermal environment caused by wood stoves
  - Experiments with an electric wood stove mock-up in:
    - Large open space
    - 2.5x4.4x3.4 meter test cell
    - Well-insulated single-family building (ZEB Living Lab at NTNU)
  - Validation of zonal and CFD models

- Large stove:
  - Maximum power 15.5 kW
  - Dimensions 600x600x1200 mm
- Small stove:
  - Maximum power 4 kW
  - Dimensions 400x400x600 mm

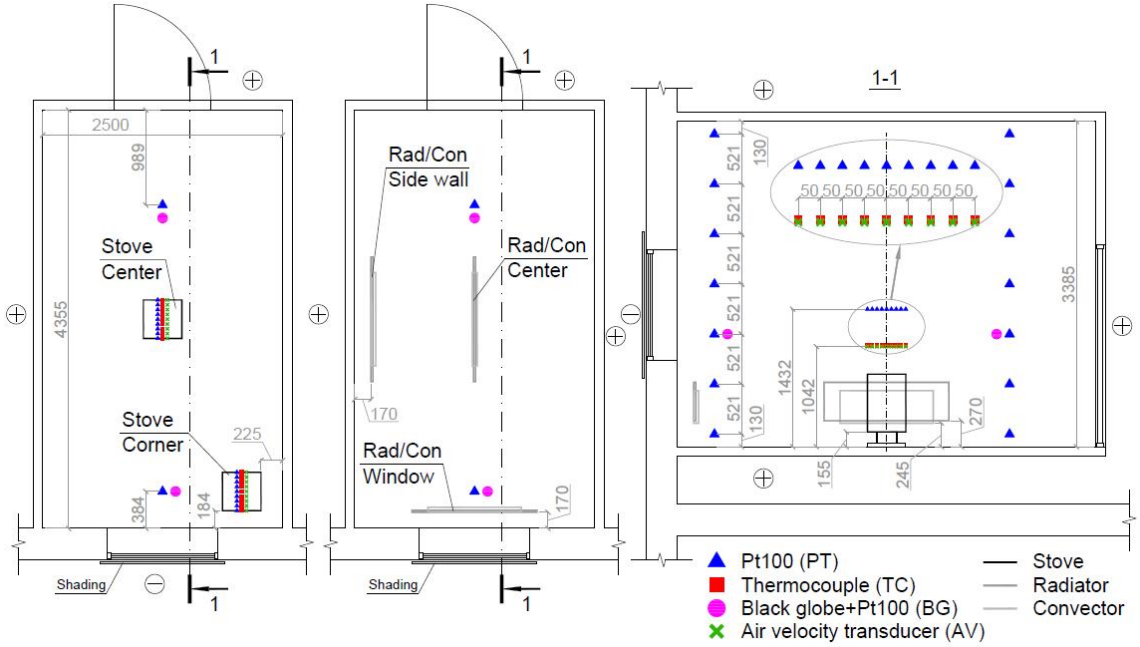


Objectives of PostDoc project (2)

- Derive guidelines for the proper integration of wood stoves from an indoor thermal environment perspective
  - Investigation of user behavior (when do people heat stoves?)
  - Defining building model with various architectonic parameters in different climates
  - Modelling the thermal indoor environment and energy use of the cases with various architectonic parameters and climates
  - Identifying the cases that meet acceptable thermal indoor environment according to EN ISO 7730 and low energy use

Experiments in ZEB Test Cell (1)

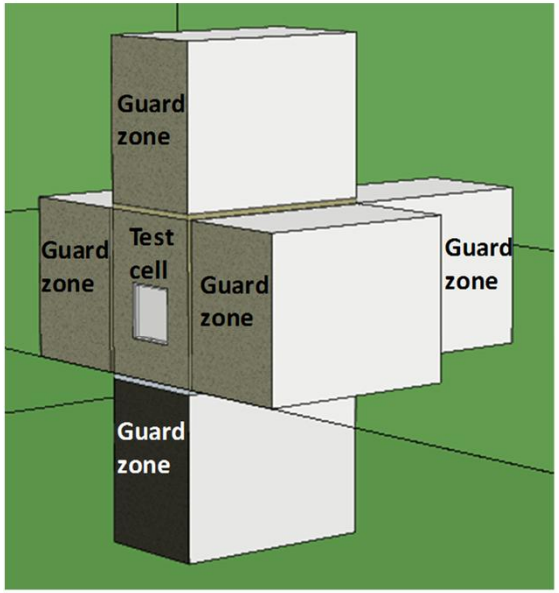
- Total 24 experiments:
  - 12x stove without rad. shields (8 center, 4 corner)
  - 5x stove with rad. shields (3 center, 2 corner)
  - 3x plate radiator (3 positions)
  - 3x “convector” (3 positions)
  - 1x free-floating cell with solar gains

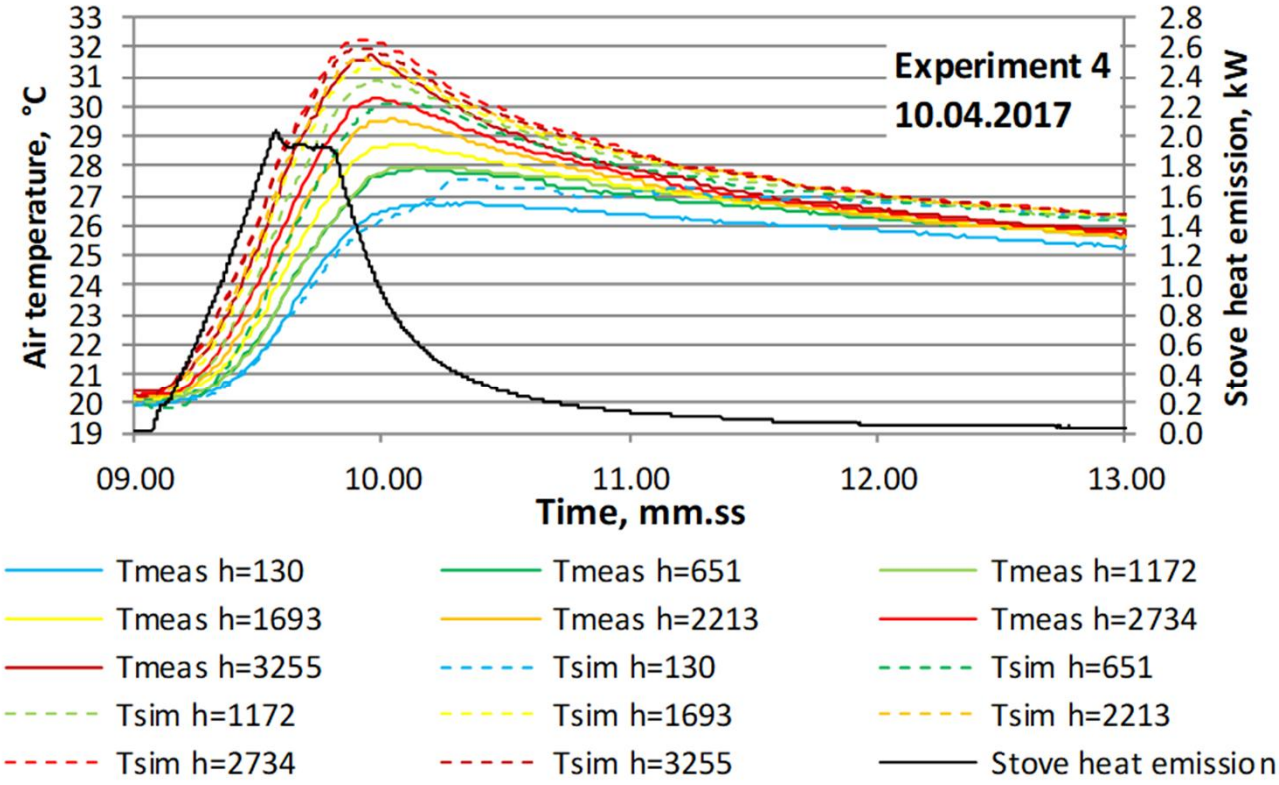


Experiments in ZEB Test Cell (2)

ZEB Test Cell experiment results

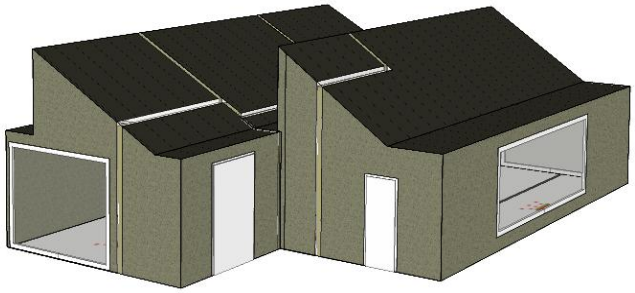
- Thermal stratification in experiments 0.7-3.1 K/m
- Lowest and top level temperature prediction good, otherwise not really
- Nevertheless, results are encouraging and work is ongoing

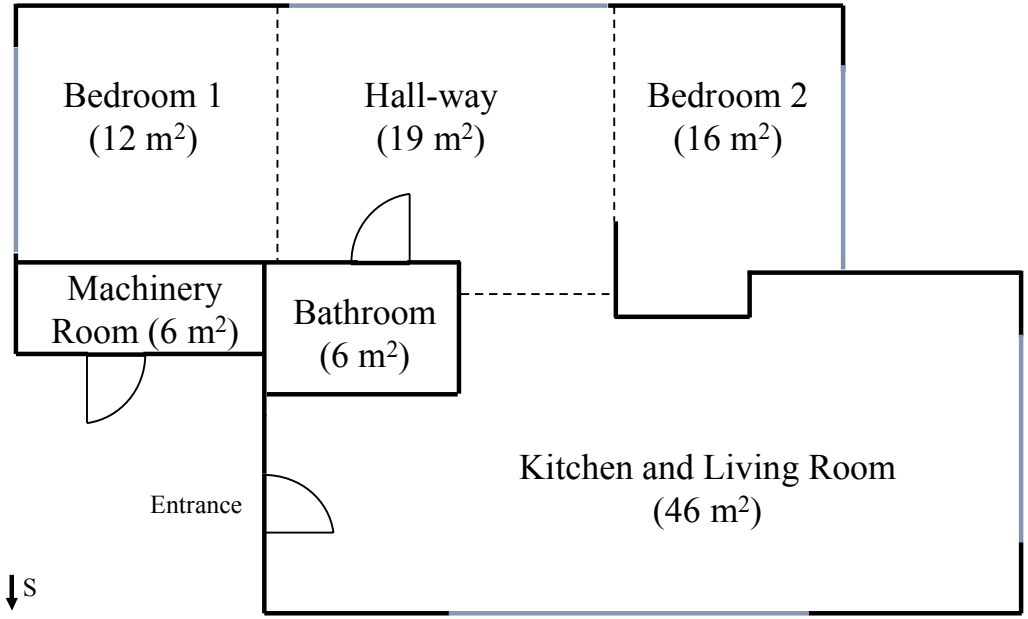




ZEB Living Laboratory

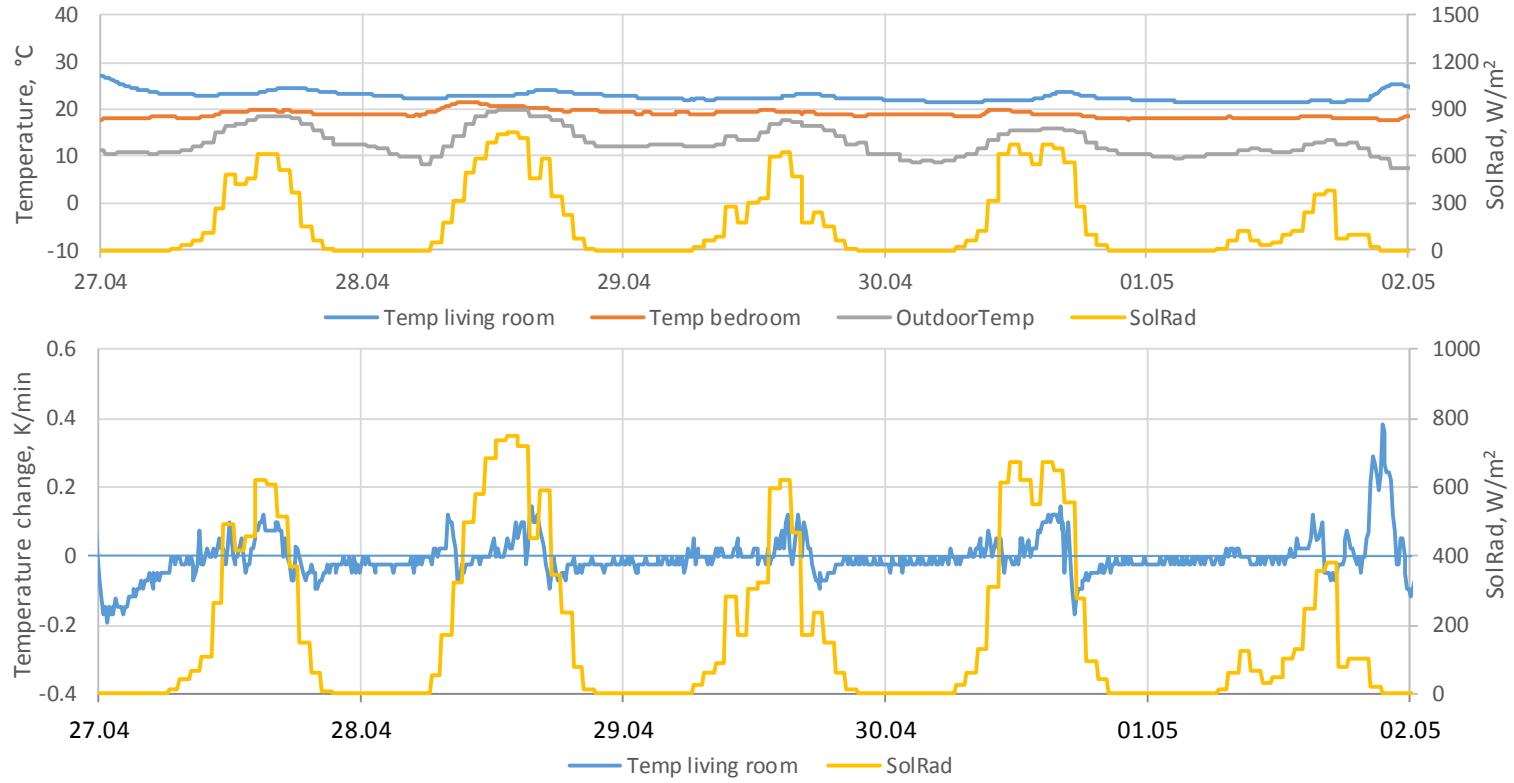
- Experiments in a super-insulated building
- Investigation of heat flow between zones





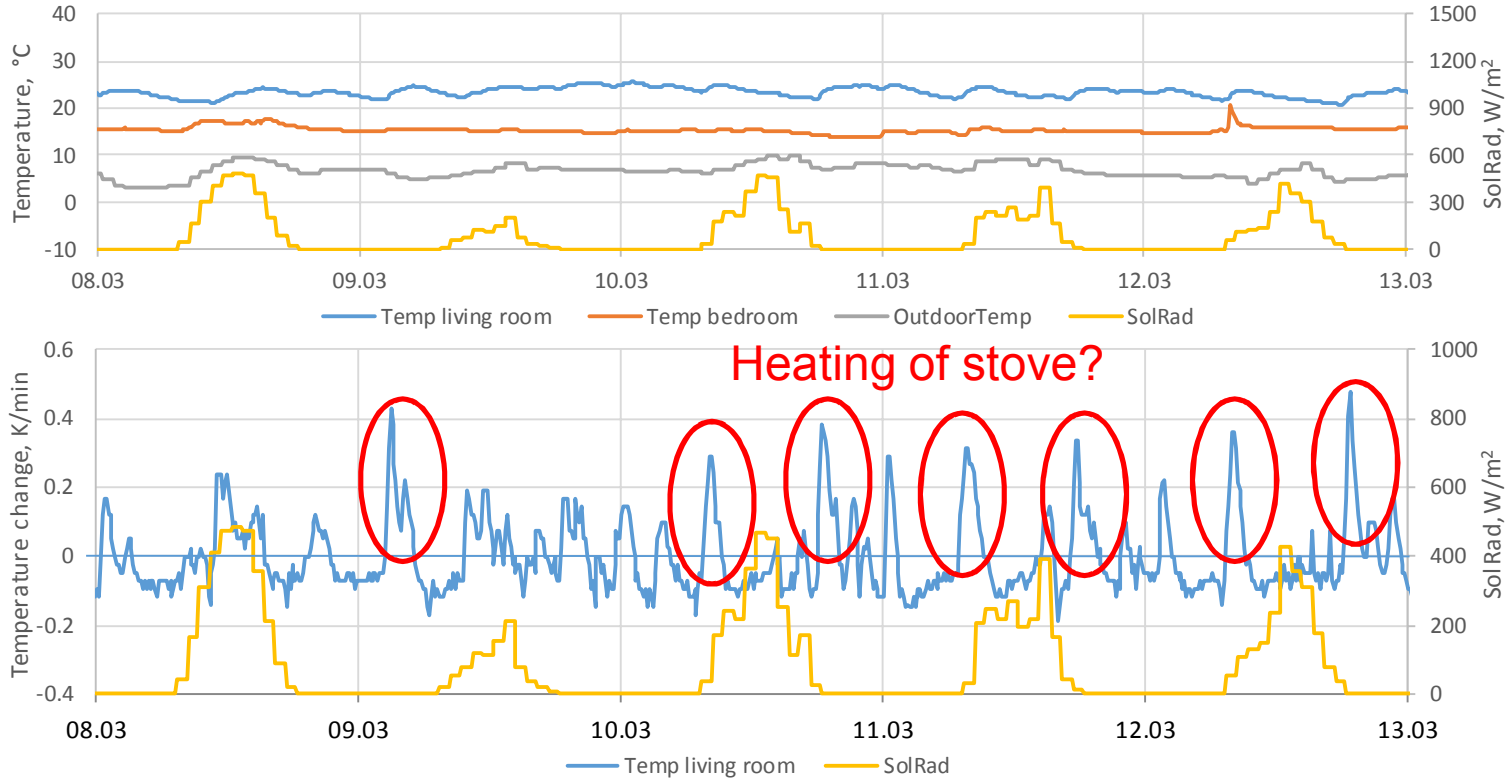
Investigation of user behavior

- Analysis based on measurement data from other projects

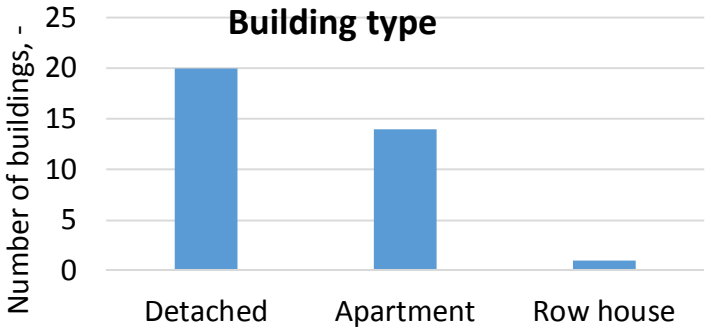


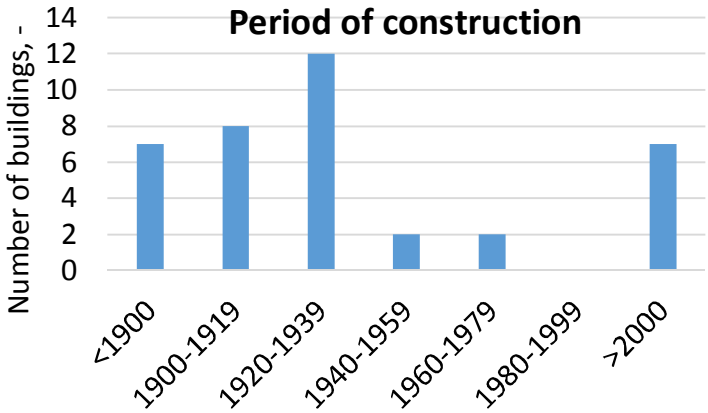
Investigation of user behavior

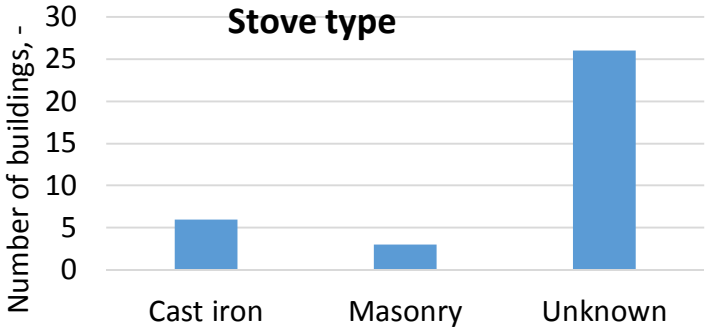
- Validation of methodology based on measurements next heating period

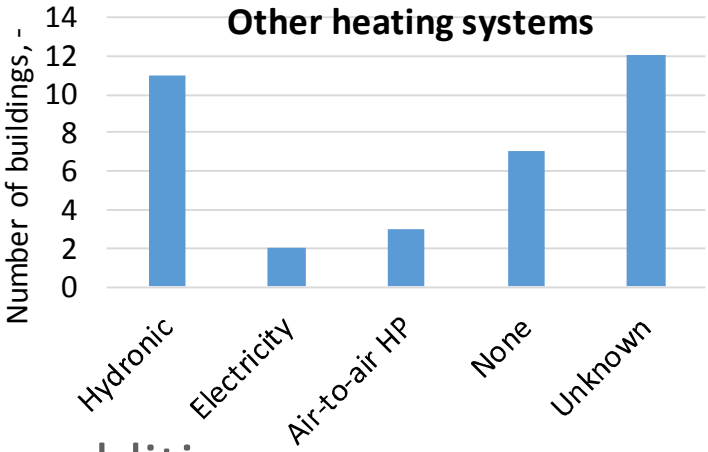


Gathered data (total 35 buildings)









- A few buildings in Trondheim in addition

Conclusions

- Work is done to answer the question:
  How to integrate wood stoves in super-insulated buildings?
- Annual simulations needed to answer the questions:
  Main focus has shifted towards zonal BPS models
- Validation of models at different levels:
  Plume → Room → Dwelling
- Initial results look promising, but development and experiments are ongoing
- Investigation of user behaviour to be done

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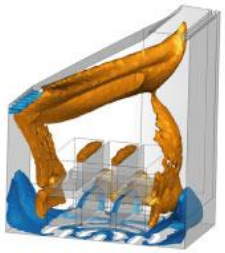

Questions?

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