

***Energy renovation and occupant behaviour:
towards a correct prediction of real energy savings in dwellings***

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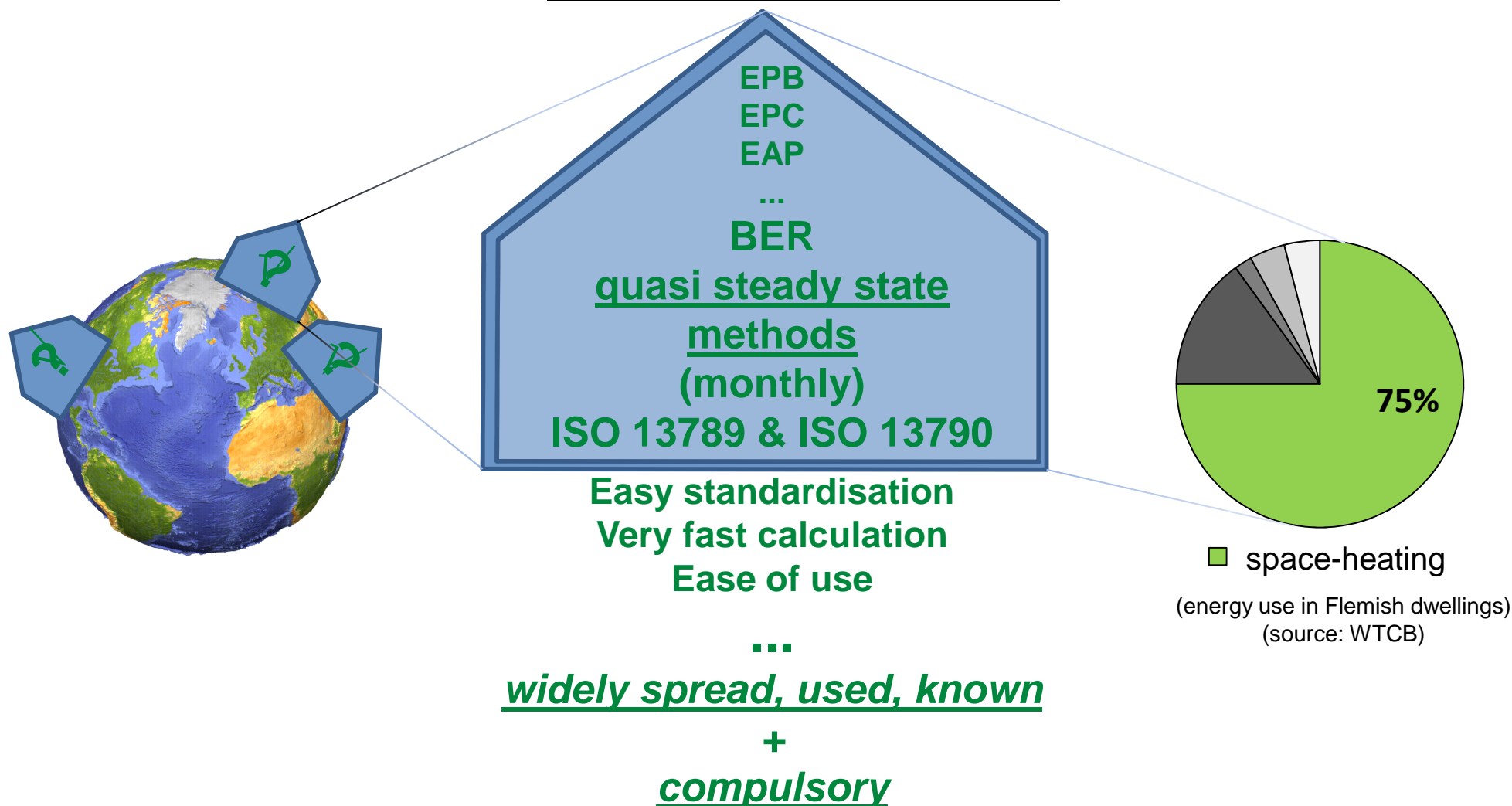
Ghent University (UGent)

Ph.D.-Fellow, FWO-VITO-scholarship

(Prof. A. Janssens [UGent], Yves Deweerdt [Vito])

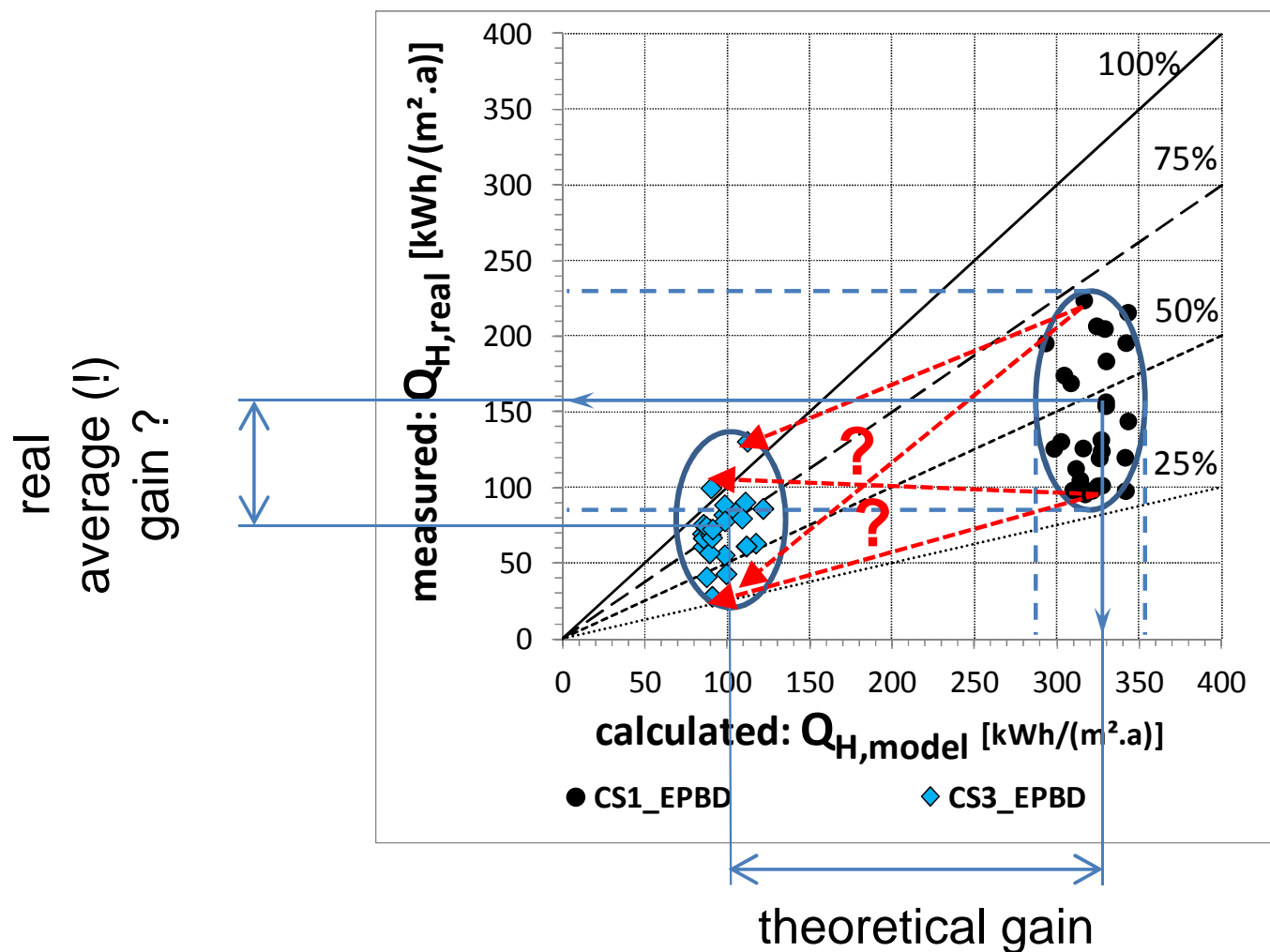
[background – problem – project]

ENERGY USE in DWELLINGS



[background – problem – project]

energy use: heating

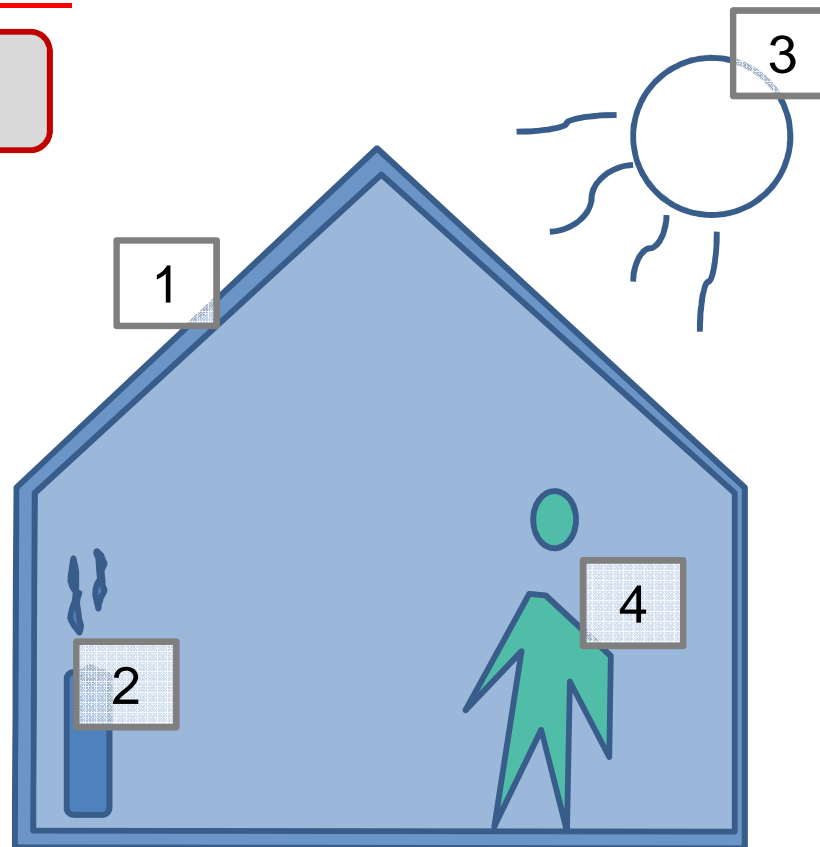


[background – problem – *project*]

CALCULATED ENERGY USE

Default values + detailed overrides

1. building envelope
2. building techniques



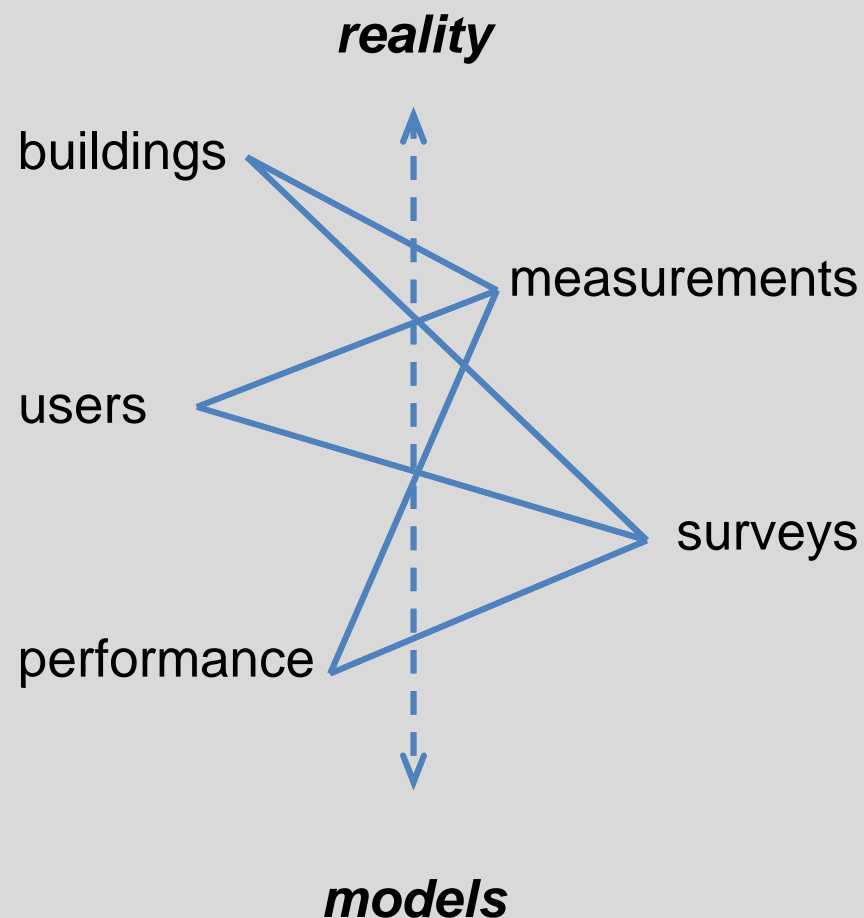
Standardized average

3. exterior boundary conditions
4. interior boundary condition

!
**interacting
user behaviour**
!

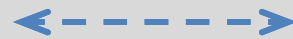
- OK for **qualitative** values of the building itself,
- NOT for **quantitative** values of resulting energy use

a comprehensive approach *on complementary case-studies*



a comprehensive approach on complementary case-studies

buildings



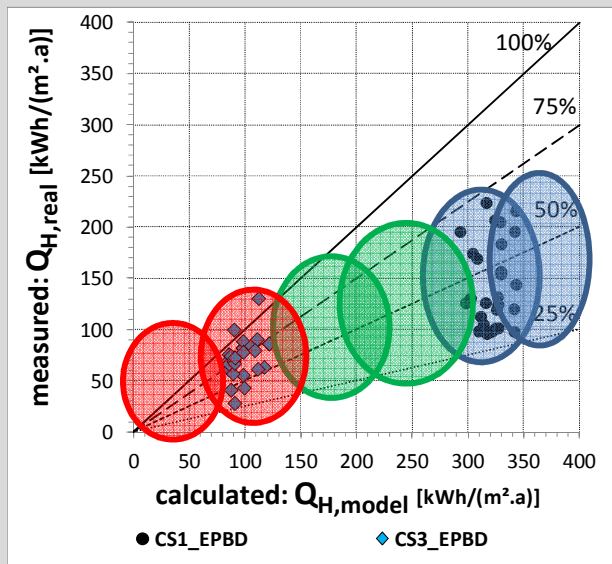
users

Different neighbourhoods:

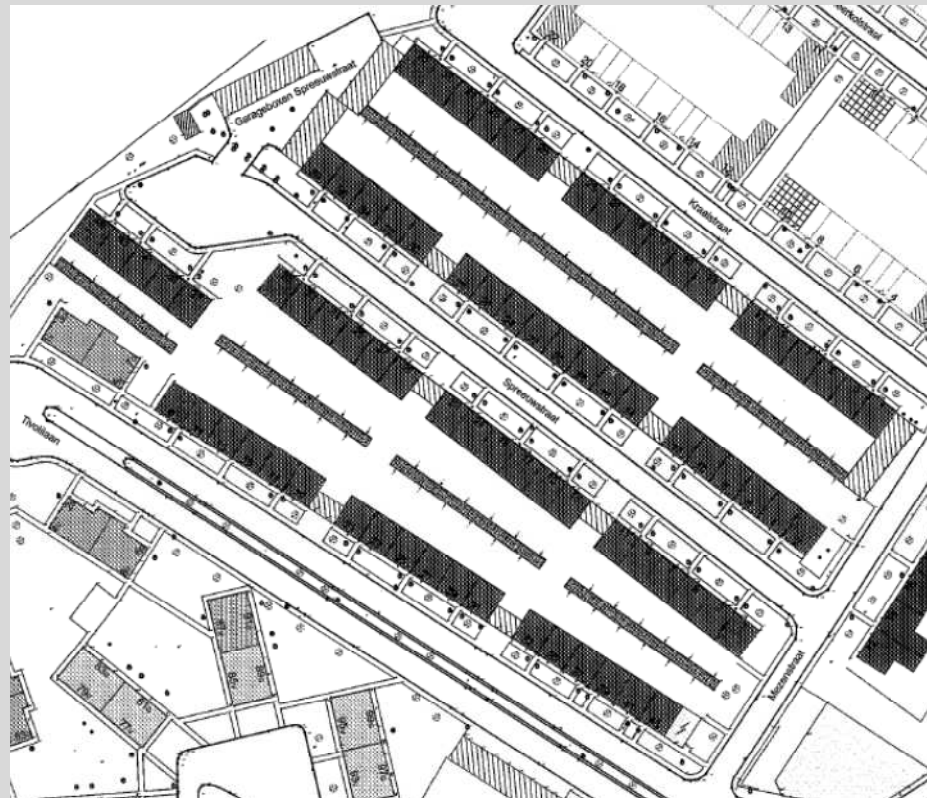
- nearly identical houses
- different performance levels

Different households

- within a neighbourhood
- between neighbourhoods

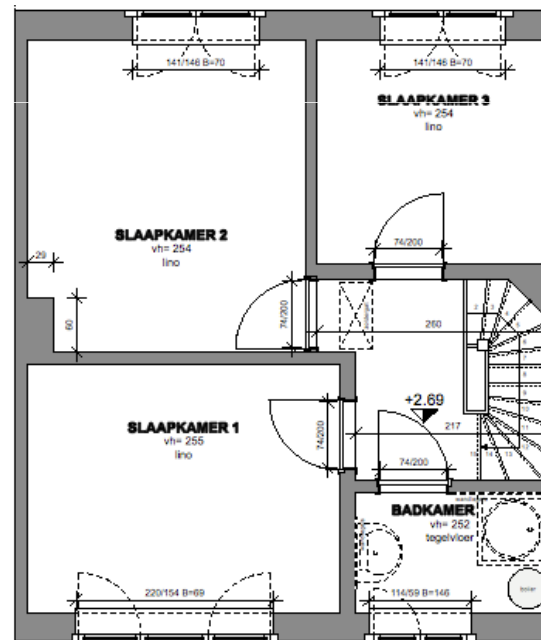
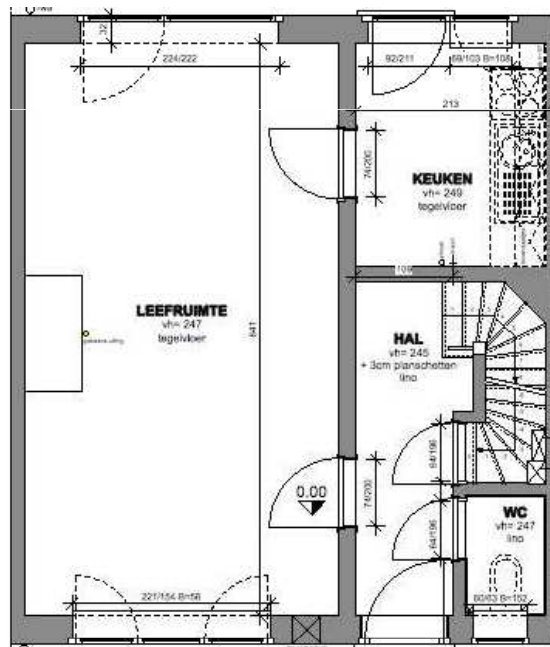


a comprehensive approach *[case-study]*



old social housing neighbourhood

[building – user – performance]



36 single family houses

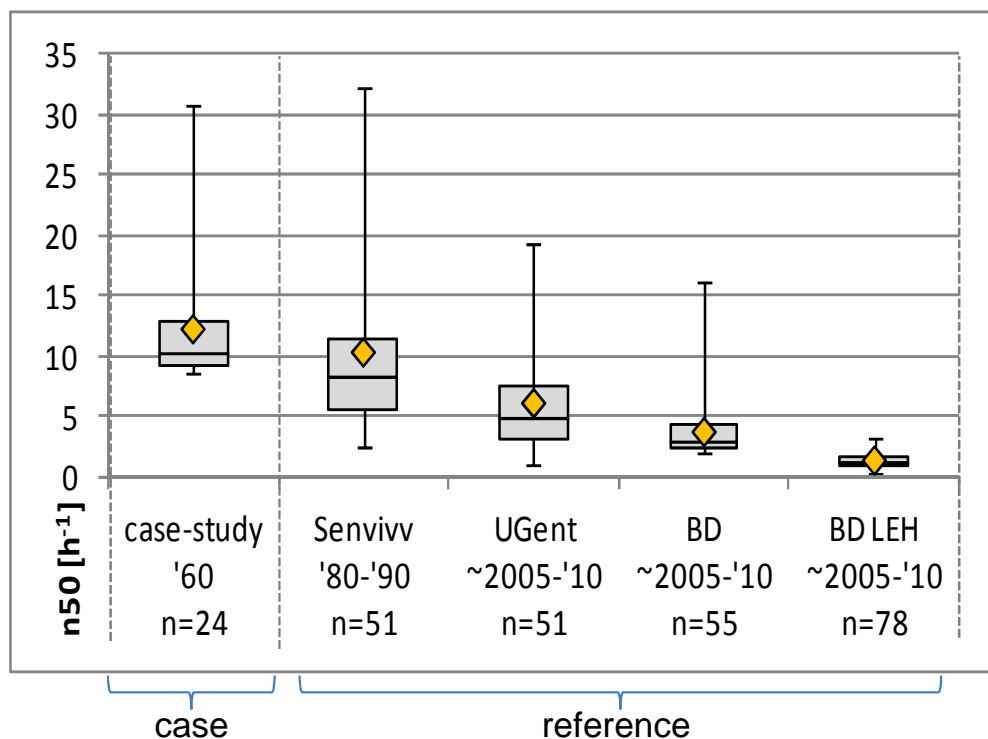
- Nearly (!) identical
 - = volume, floor area, heating system, walls, ...
 - ~ air tightness, orientations (~symmetry), windows (some replacements)
- Before any energy renovation (1960's!)
- => uniform sample of houses

$$Q_{h,EPB} = [90 ; 125] \text{ kWh}/(\text{m}^2.\text{a})$$

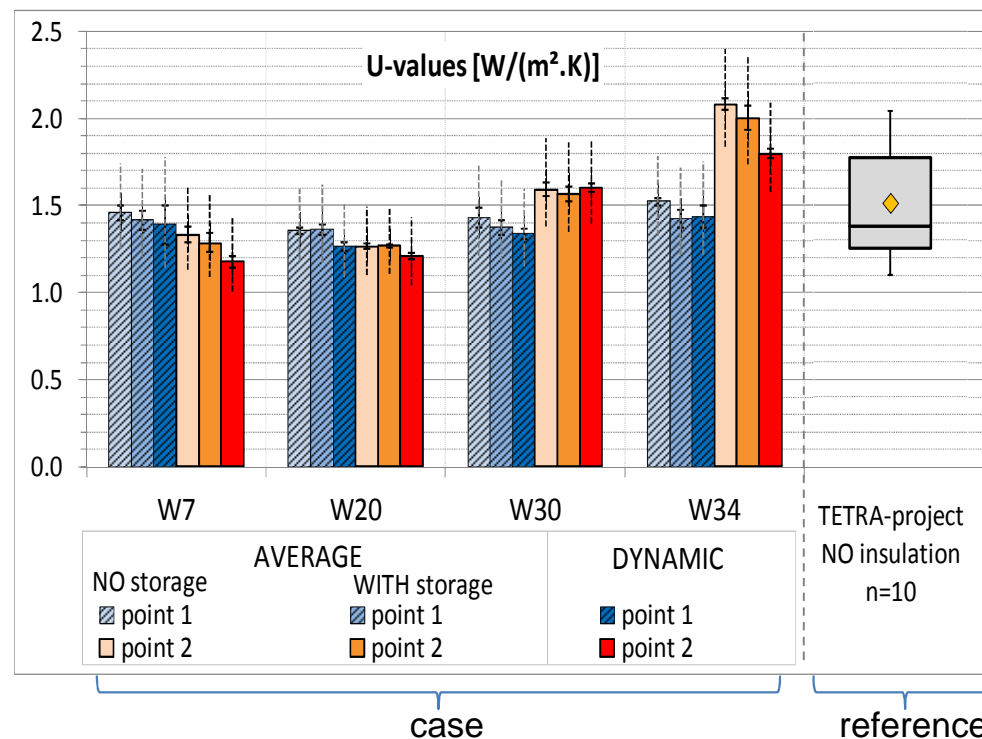
[building – user – performance]

in-situ measurements

real values & spread



Air tightness (n_{50} [m³/(h.m³)])



Heat-flux (U-value, [W/(m².K)])

*[building – **user** – performance]*

33 houses = 33 households = 97 inhabitants
Different ways of living and thinking.

survey

Who?

households & individuals

How?

use & interaction

Happy?

appreciation & aspirations

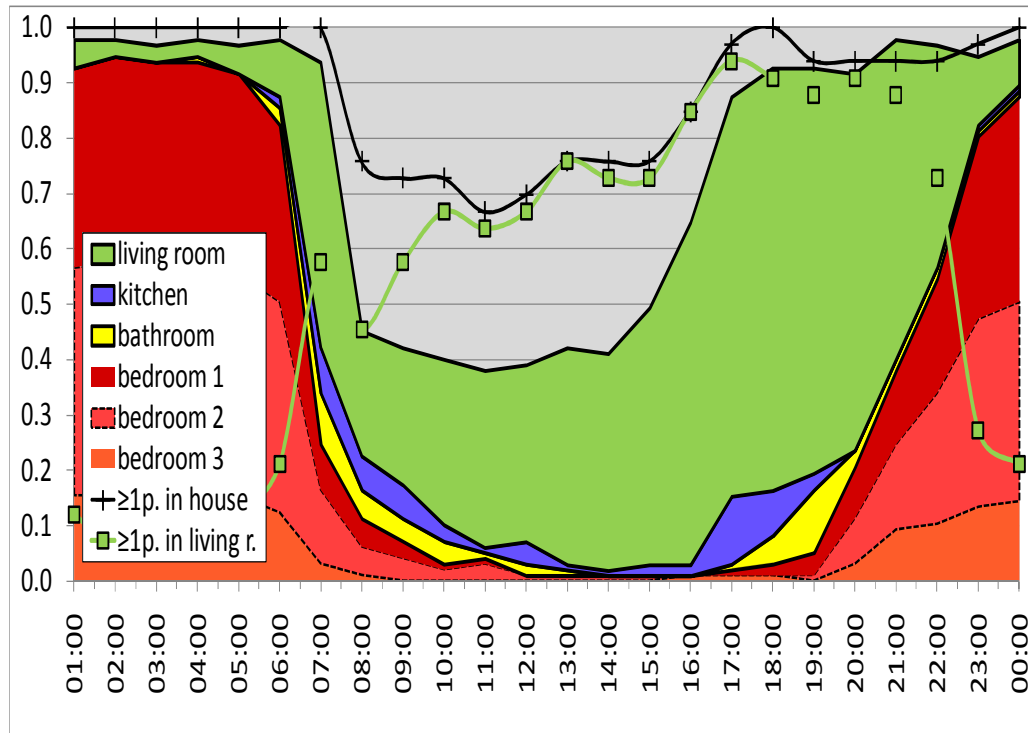
Do they know?

...

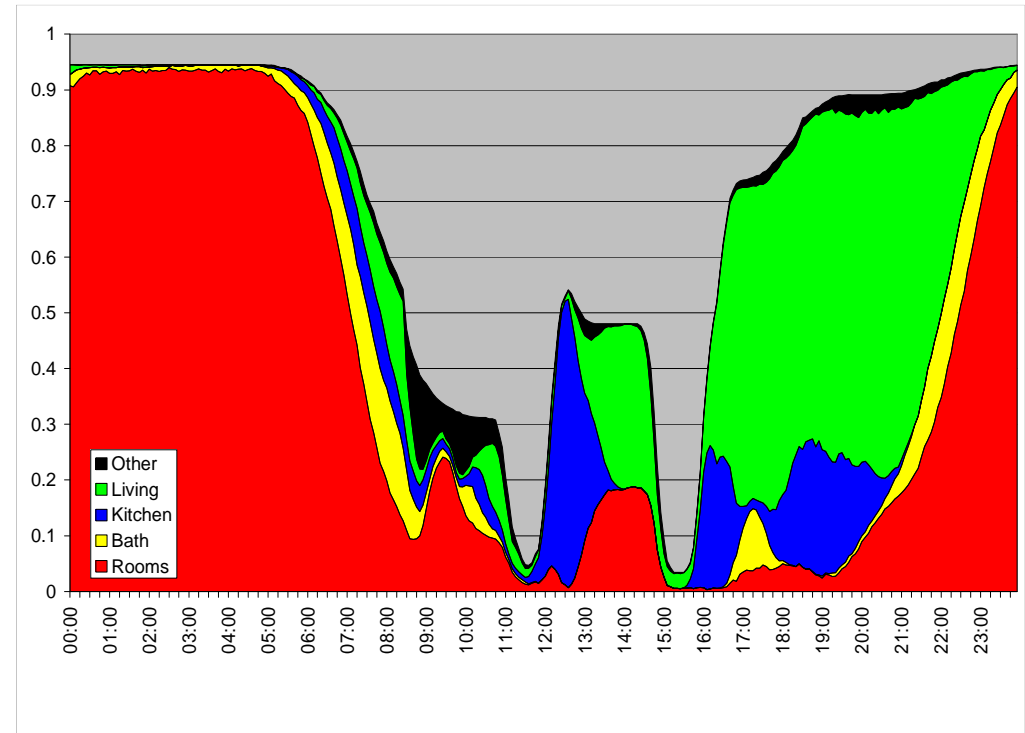
What if?

[building – user – performance]

survey



Probability of presence

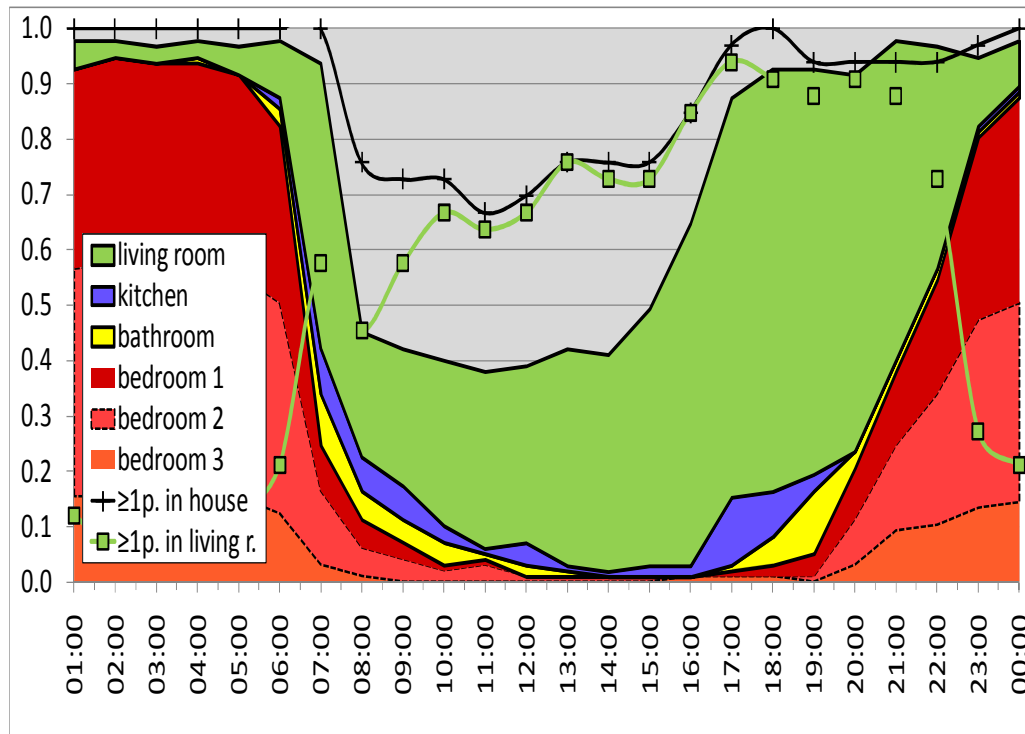


Reference: Belgian data (NIS)

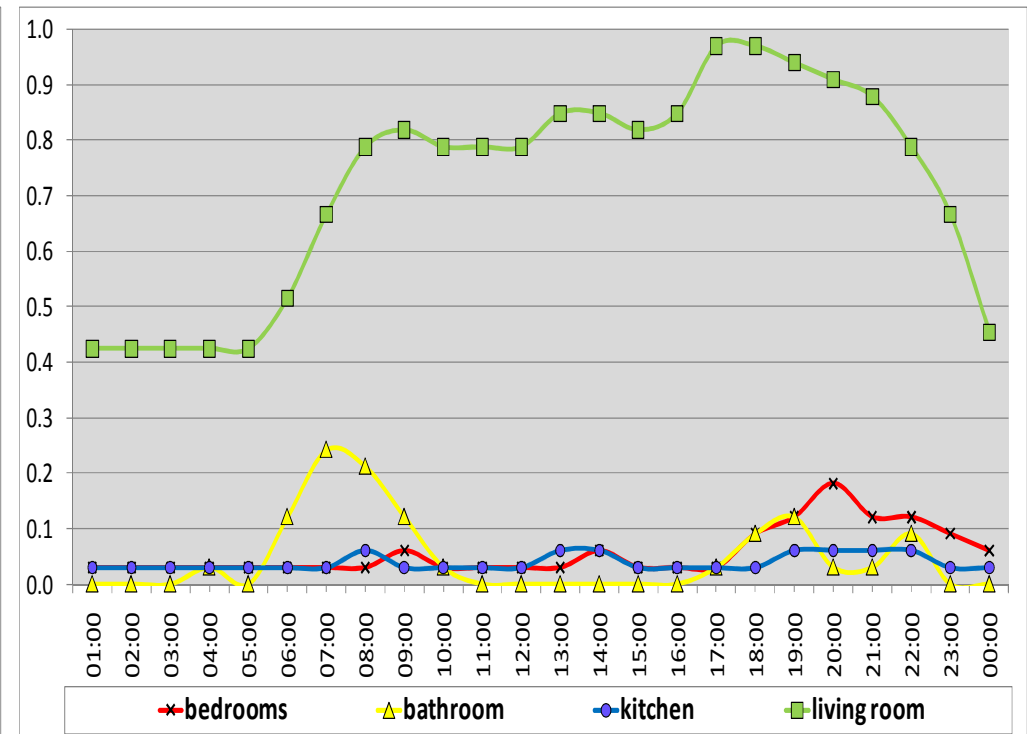
Probability of Presence of a certain person in a room

[building – user – performance]

survey



Probability of presence

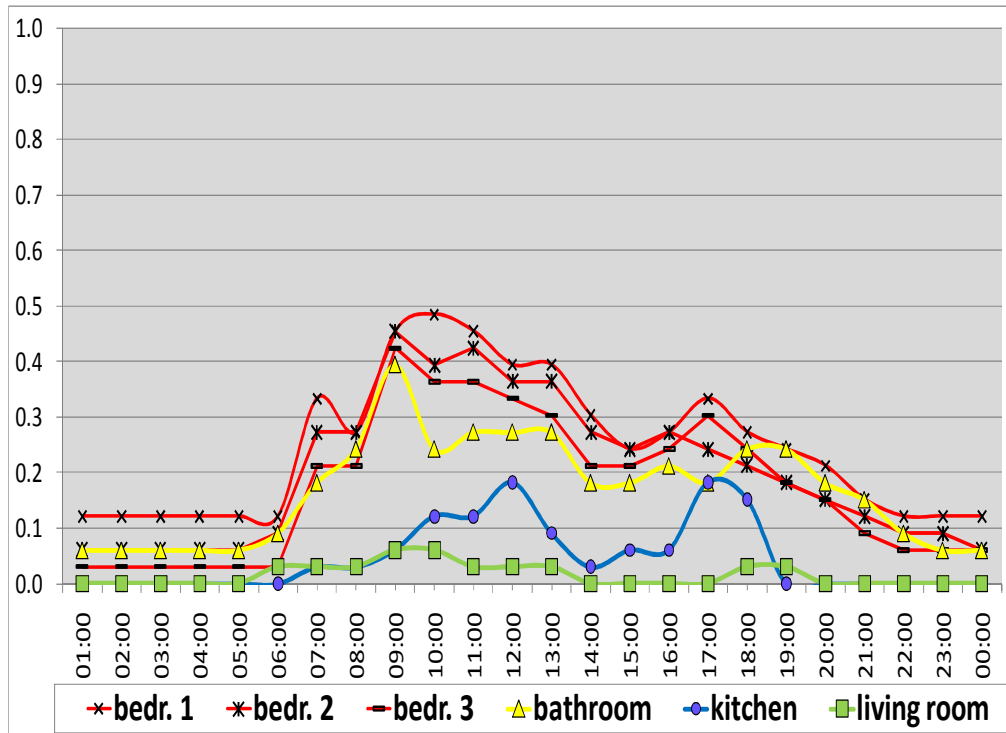


Probability of heating

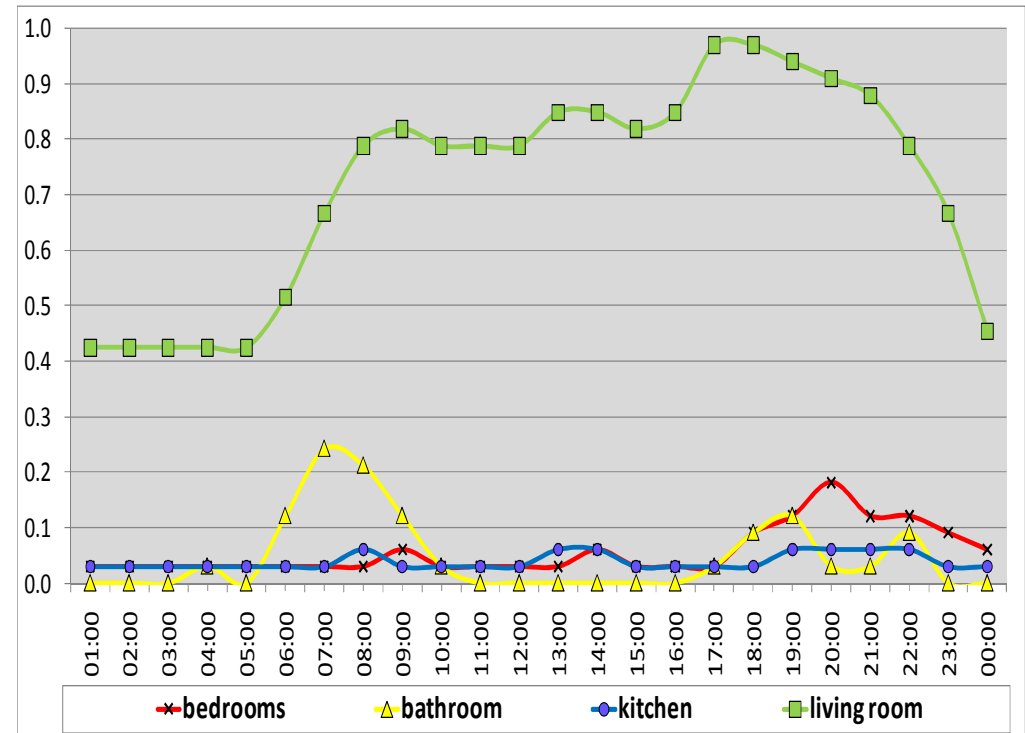
Probability of Presence of a certain person in a room

[building – user – performance]

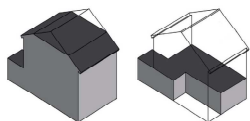
survey



Probability of opening a window



Probability of heating

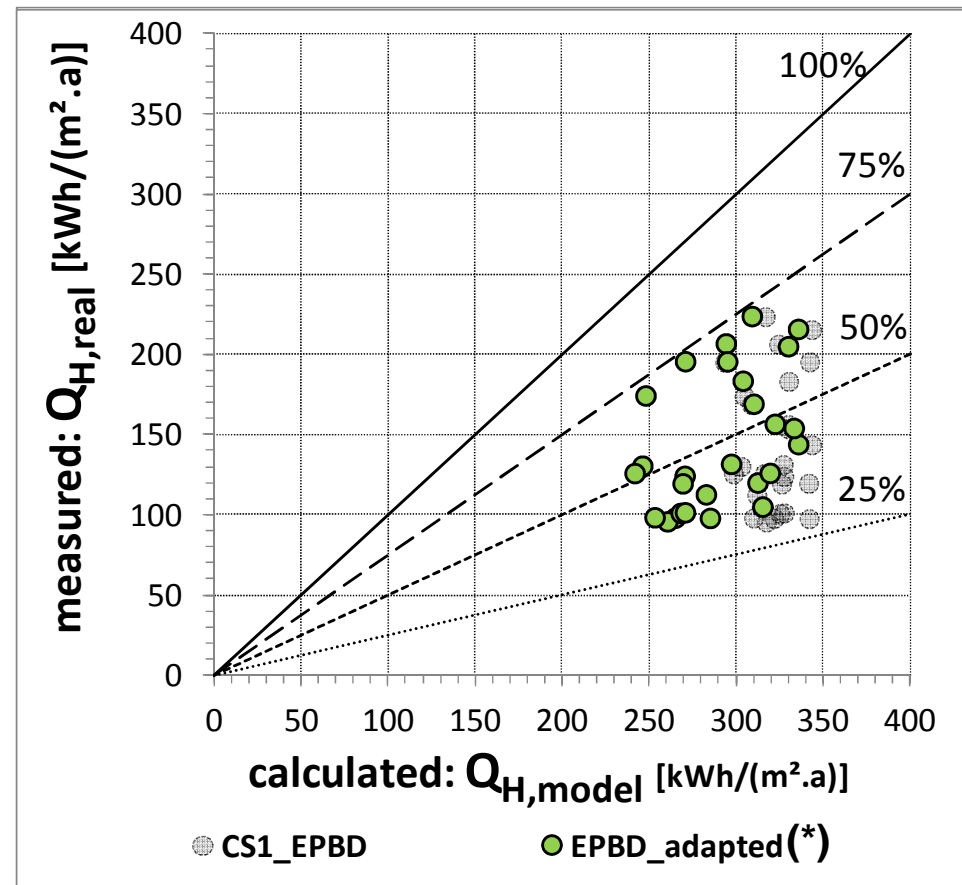


!! user + building = interaction !!
in space & time



[building – user – performance]

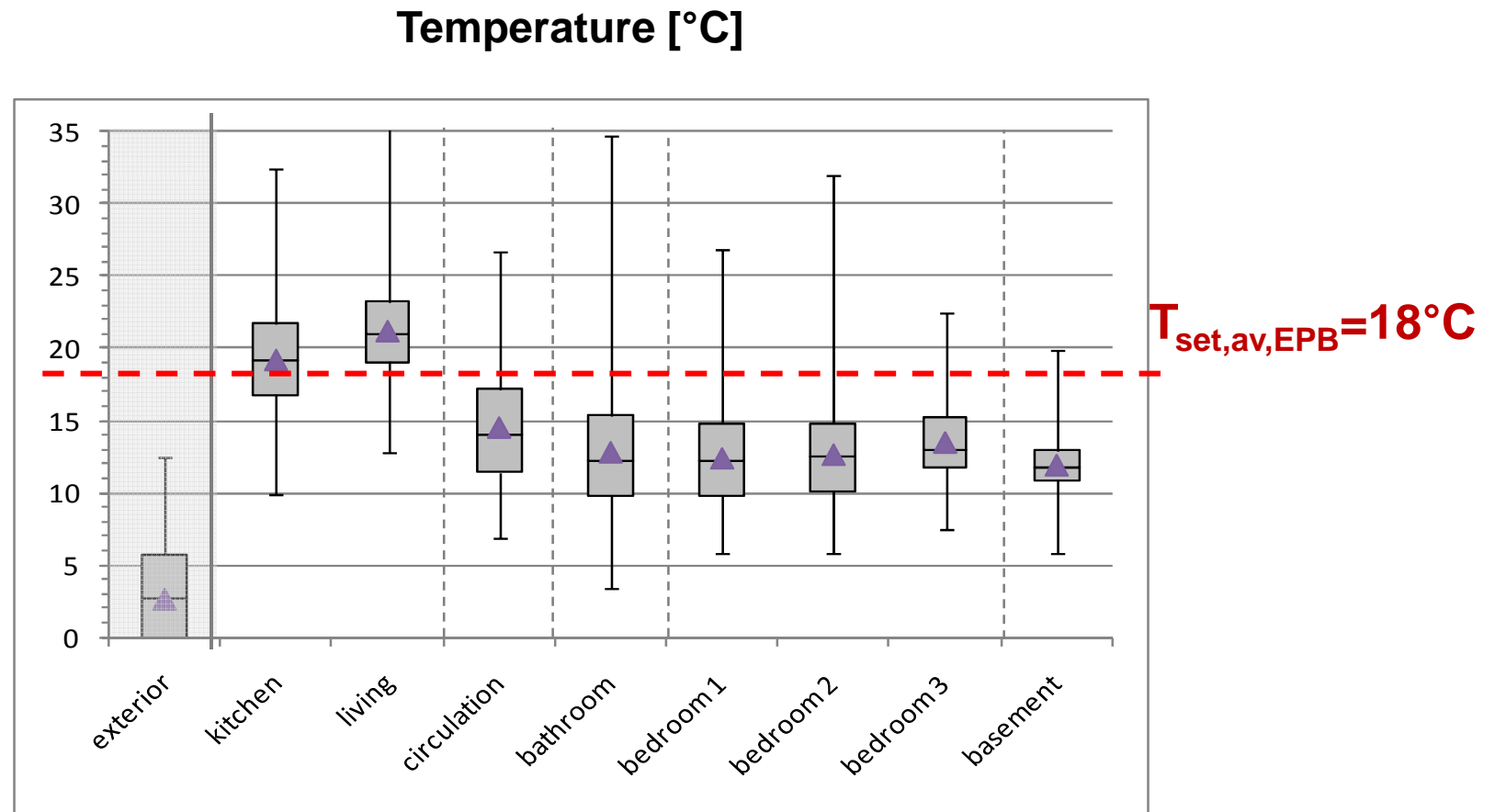
energy use: heating



(*) First adaptations: general findings and real surroundings

- negligible ventilation
- uninhabited houses as adjacent unconditioned spaces

[building – user – performance]

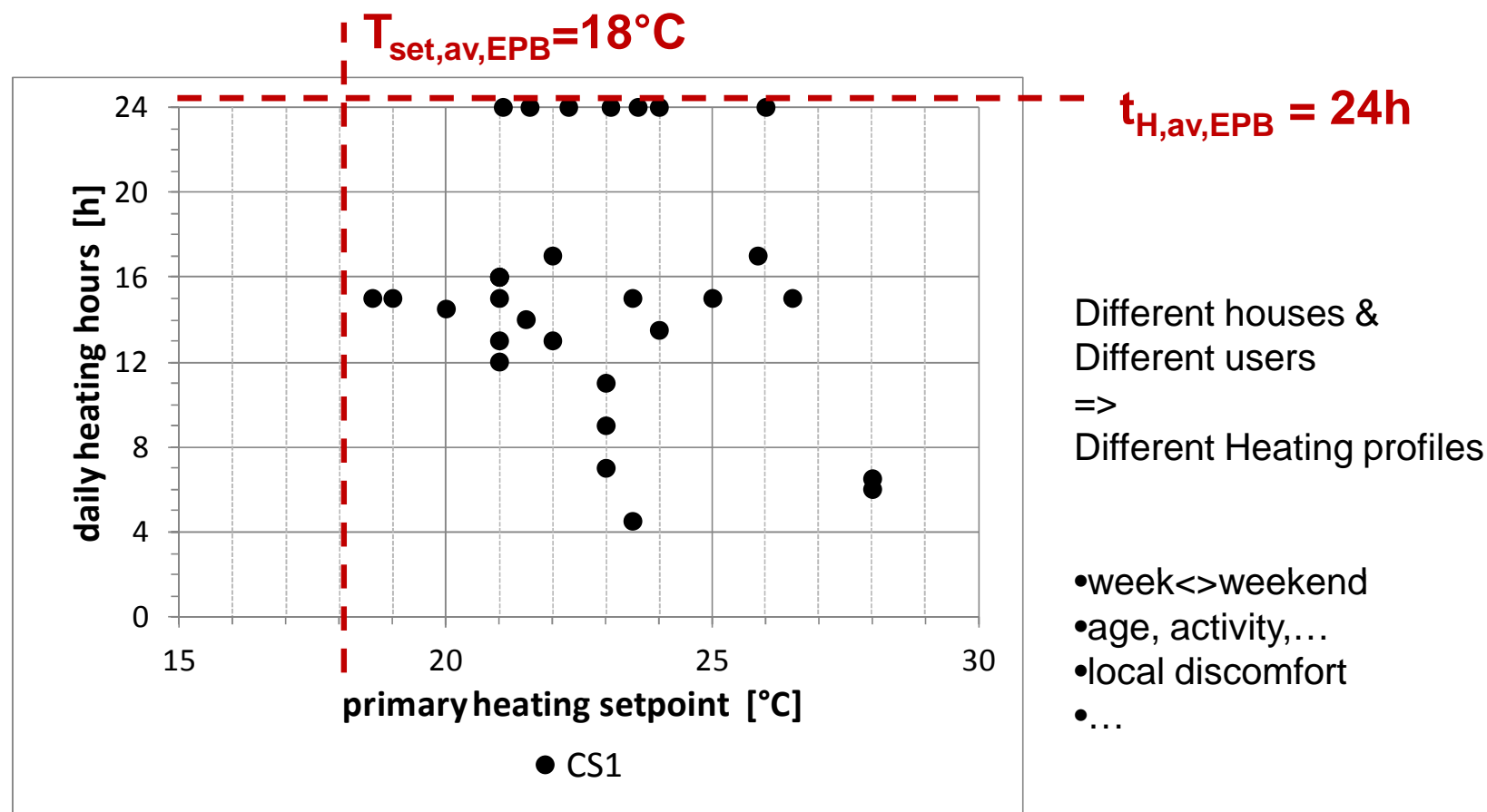


- seasonal: ~outdoor climate & adaptation
- daily profiles: ~outdoor climate & use

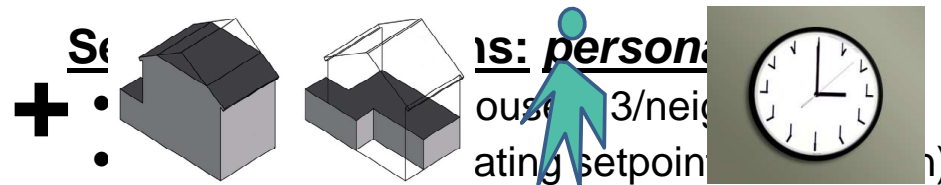
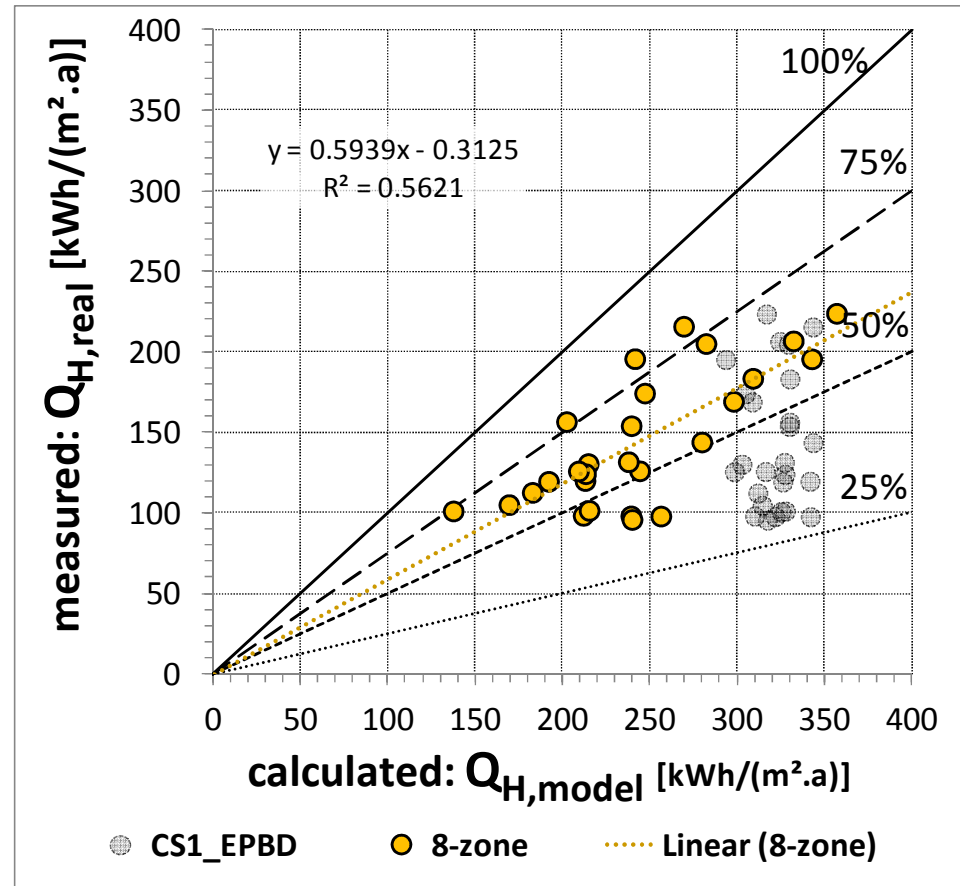
[building + user = performance]

Heating behaviour (living room!)

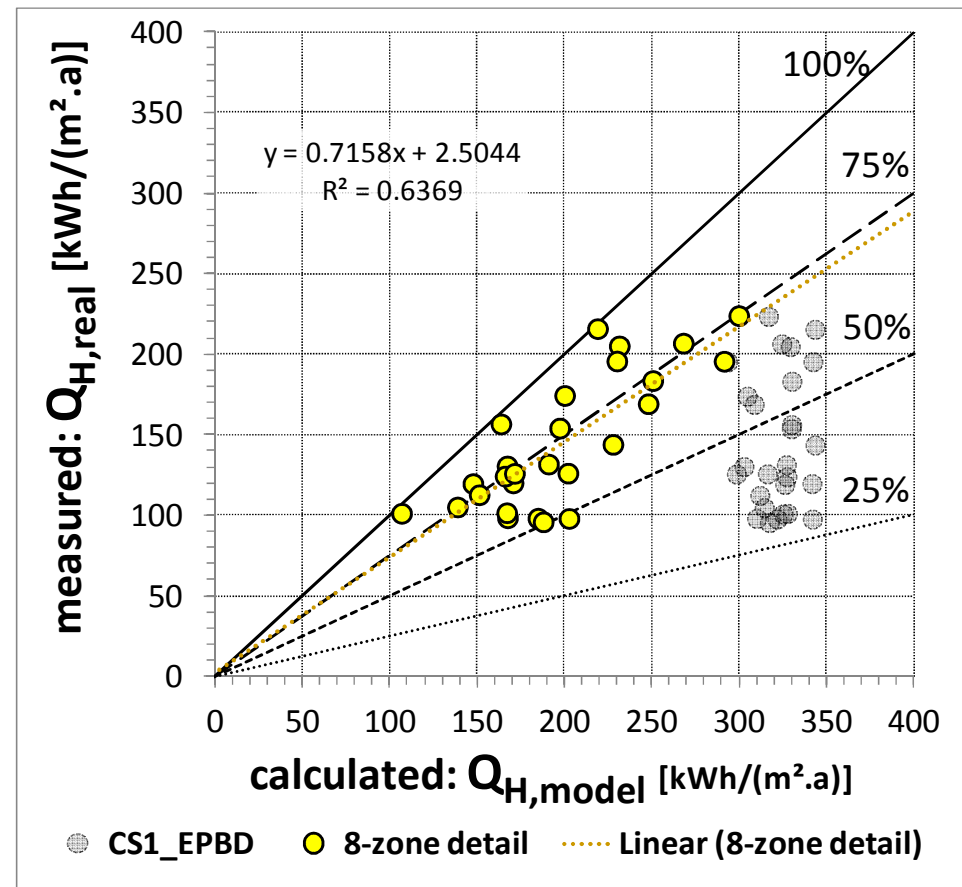
survey + measurements



[model adaptation & user-differentiation]



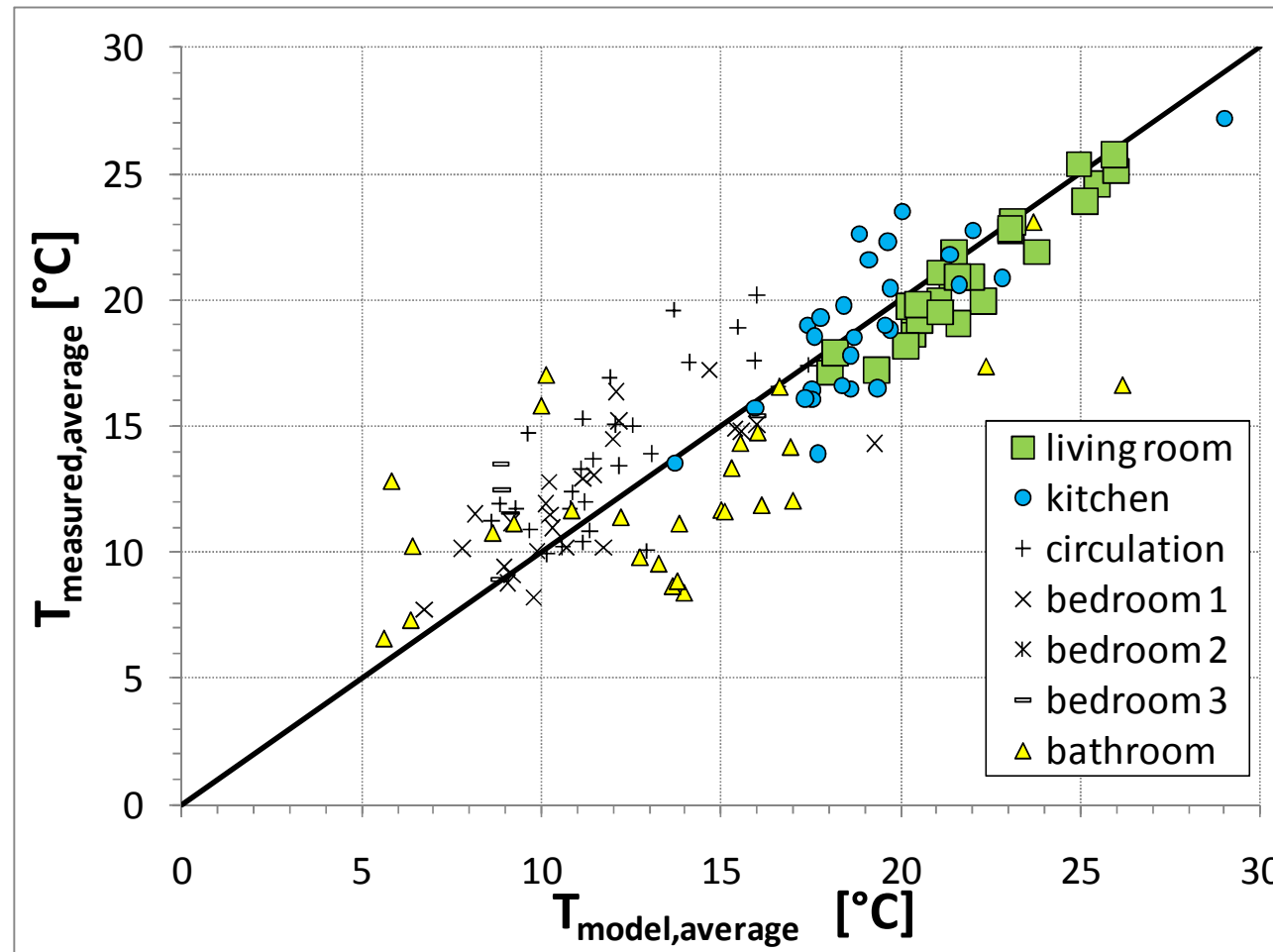
[model adaptation & user-differentiation]



Going further: sensitivity & robustness analyses

- **Default values** (U_g single glazing, η_{sys} , ...)
- **Simplified calculations** (U_{floor} , ...)

[model adaptation & user-differentiation]



Limitations of quasi-steady state models...

complementary case-studies

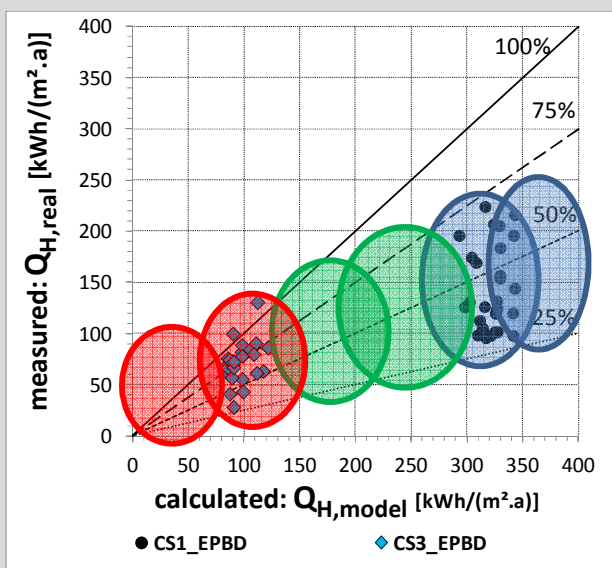
buildings

different performance levels



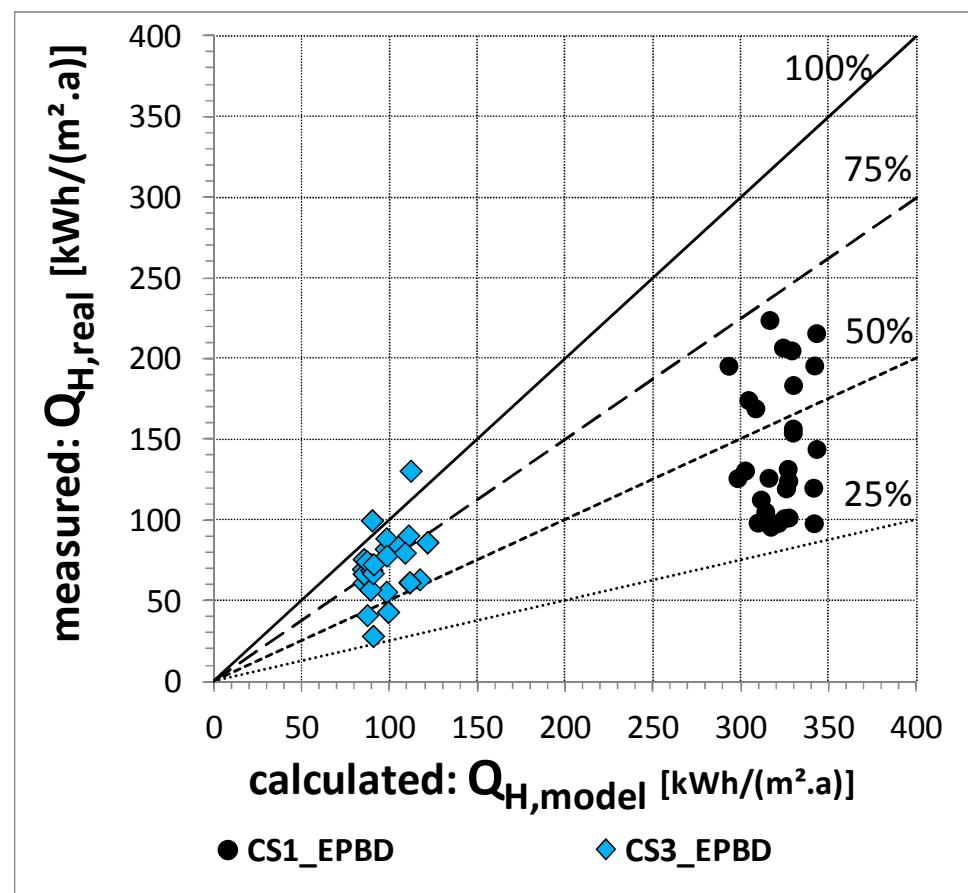
users

different households



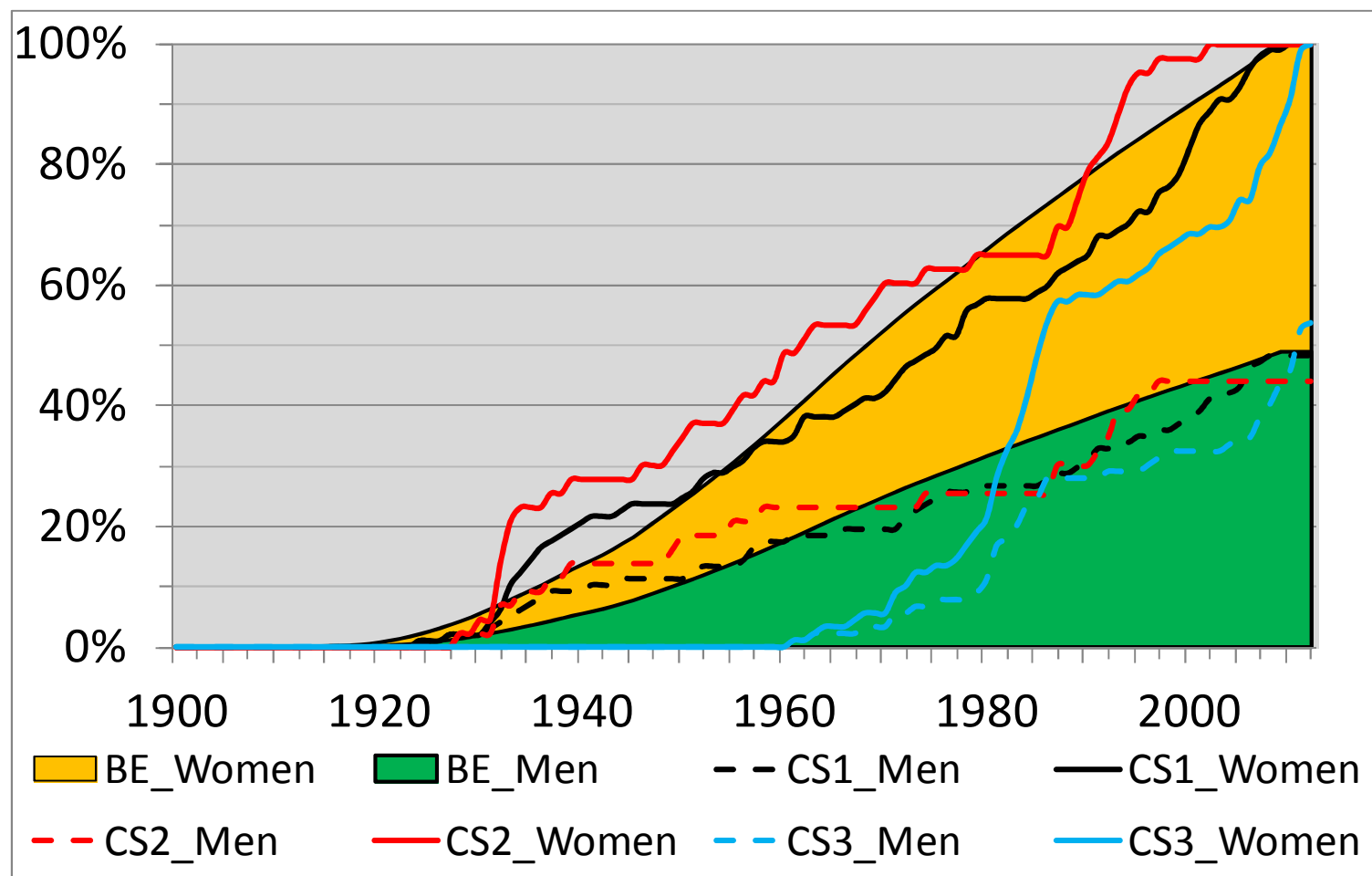
[building]

(theoretical) energy performance



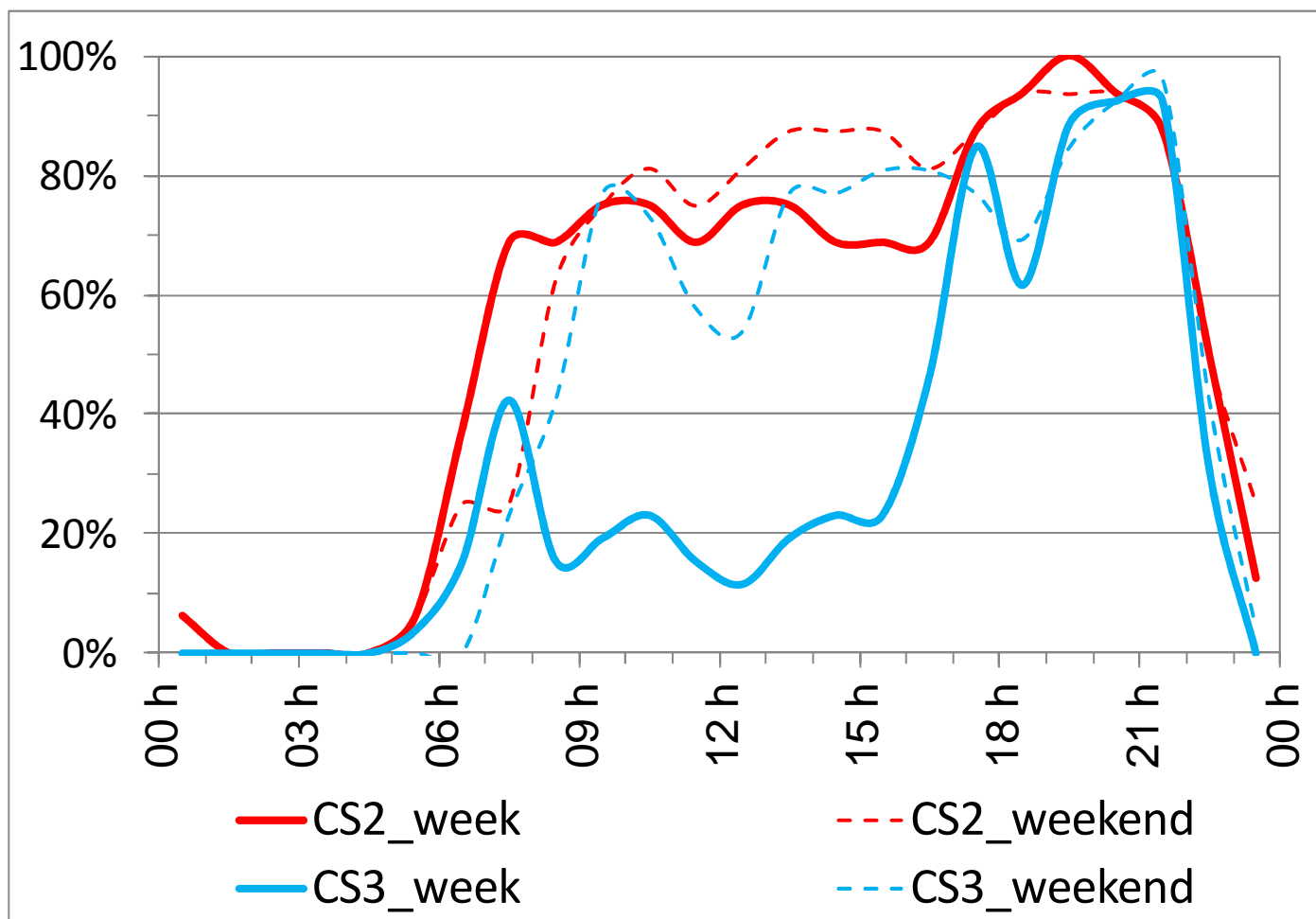
[user]

age



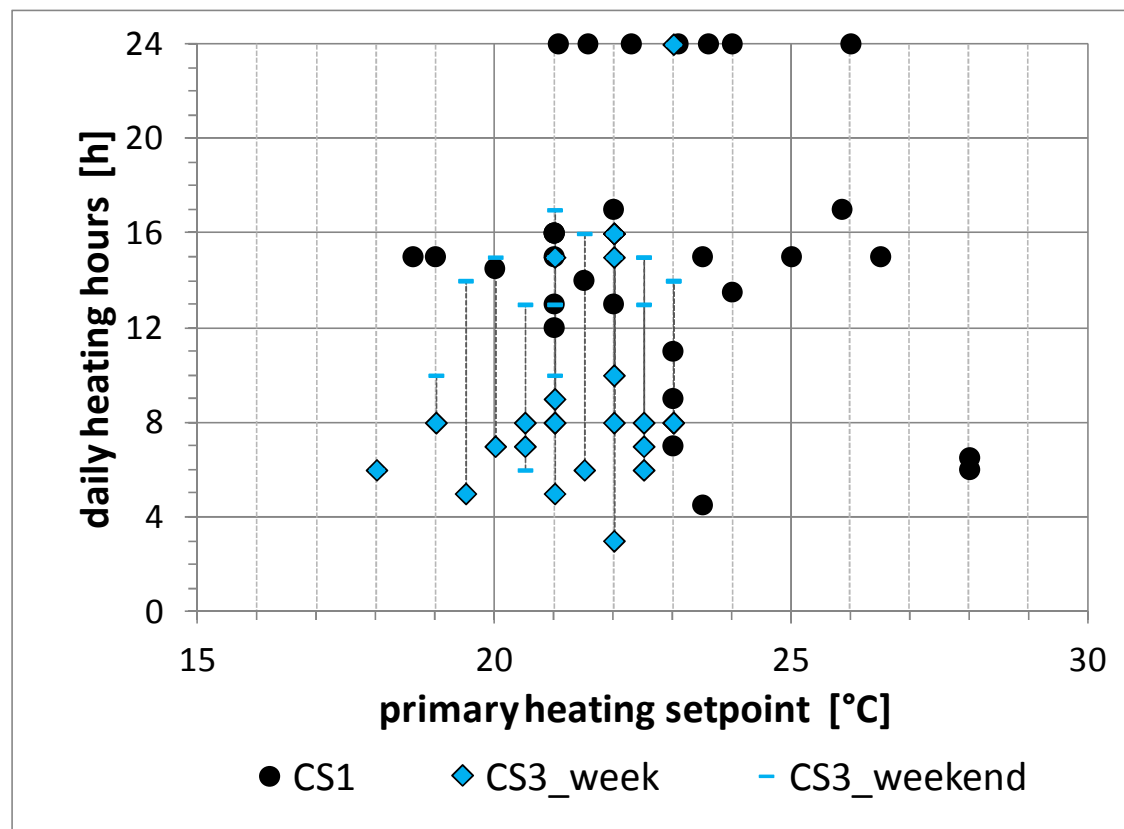
[user]

probability of presence (living room)



[building + user => energy use]

heating behaviour (living room)



Different houses &
Different users
=>
Different Heating profiles

- week<>weekend
- age, activity,...
- local discomfort
- ...

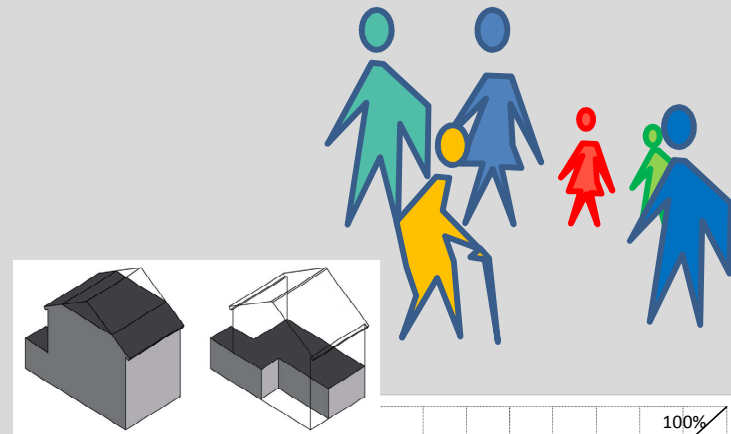
[conclusions & challenges]

importance of user behaviour

...but don't blame the user for everything

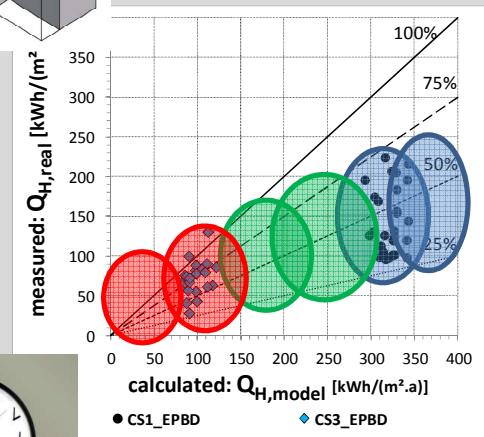
- **complex human beings**

- comfort sensation
- living interaction
- changing reality
- ...



- **models:**

- uncertainties: due to model & input
- applicability: labelling \leftrightarrow real energy use
- practicality: work & calculation time
- model validation: different building typologies & performances



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