Verification of occupants' behaviour models in residential buildings

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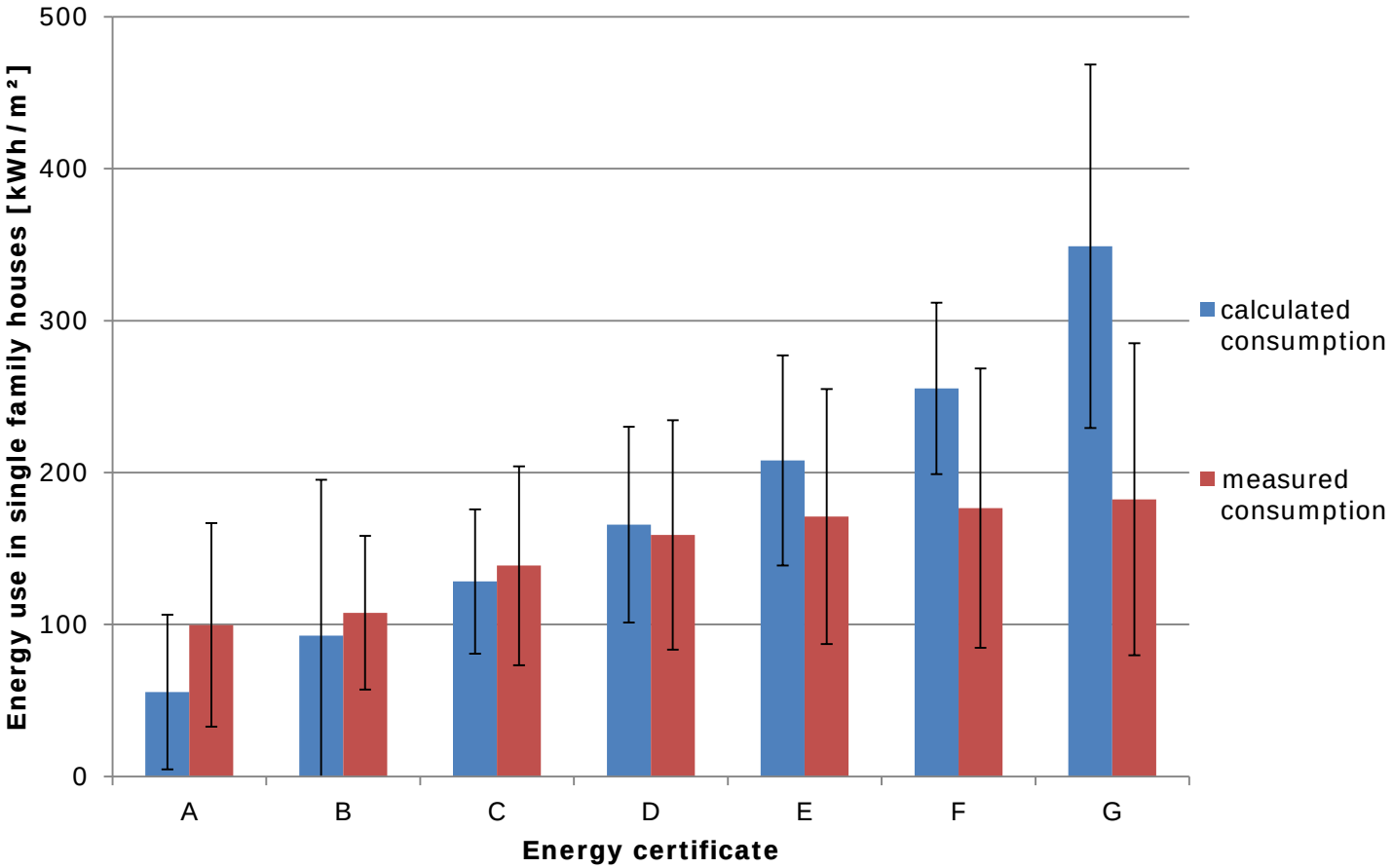
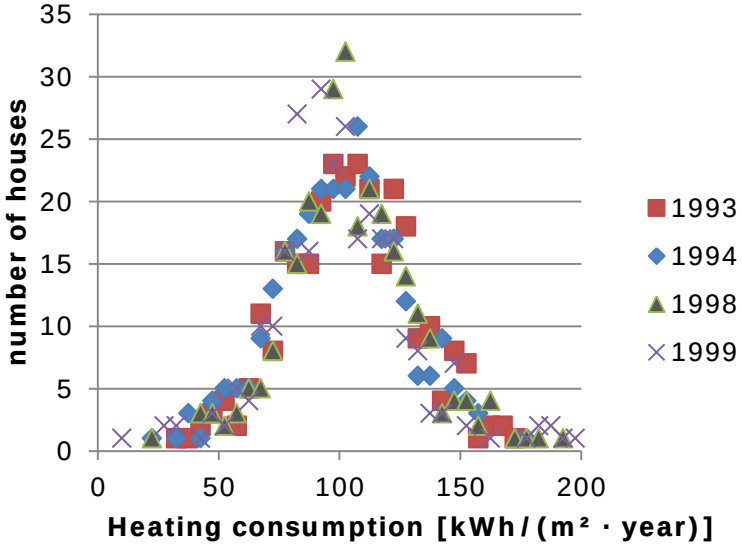
Calculated and measured energy use in 135.311 houses*



*Data from: SBI 2016:09, Forskellen mellem målt og beregnet energiforbrug til opvarmning af parcelhuse

Investigation of heat consumption in 290 identical houses*

- Correction for differences in outer wall area
  - End houses vs. Middle houses
- Highest consumption up to 20 times higher than lowest
- Stable consumption distribution over time

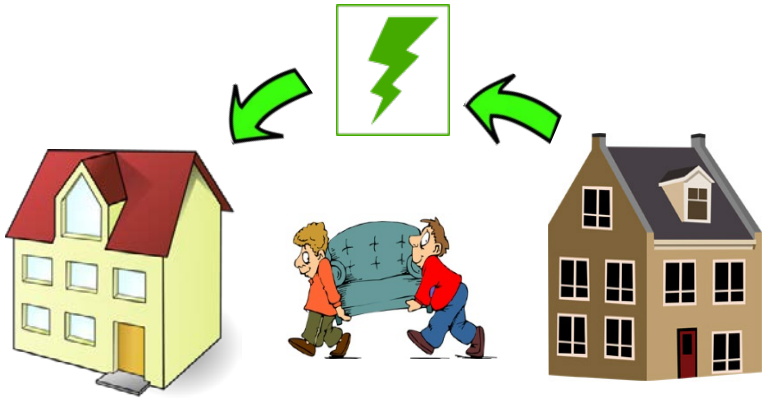


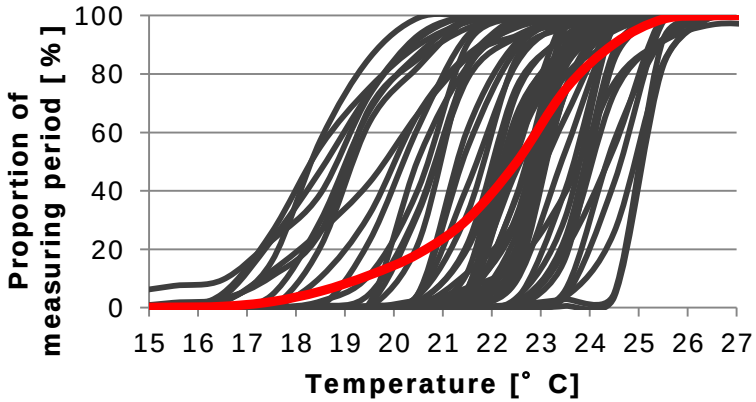
*Andersen R, Proceedings of Healthy Buildings 2012, Brisbane, Australia

Behaviour – random or patterns?

	C tv	C TH	B tv	B th	A tv	A th
5	61	45	32	57	40	55
4	39	35	30	13	27	52
3	76	70	19	48	36	15
2	78	63	34	65	25	40
1	45	43	5	28	6	88

- Large differences in temperature between 56 apartments*
  - None of the apartments cover the entire temperature range
- Energy consumption follows residents, when they move**
- Patterns can be modelled
  - and simulated



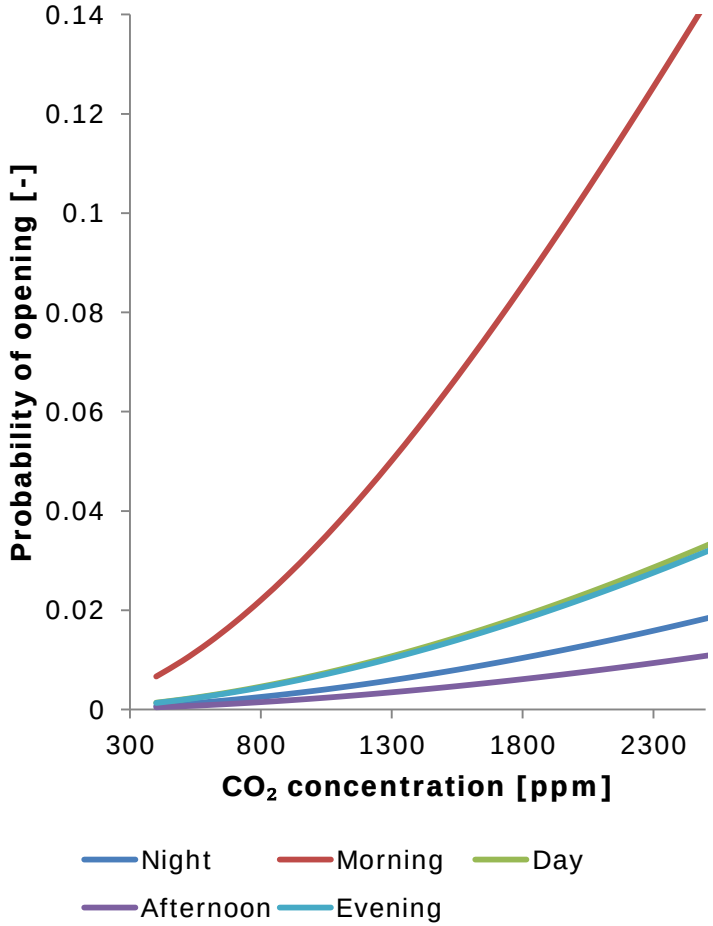


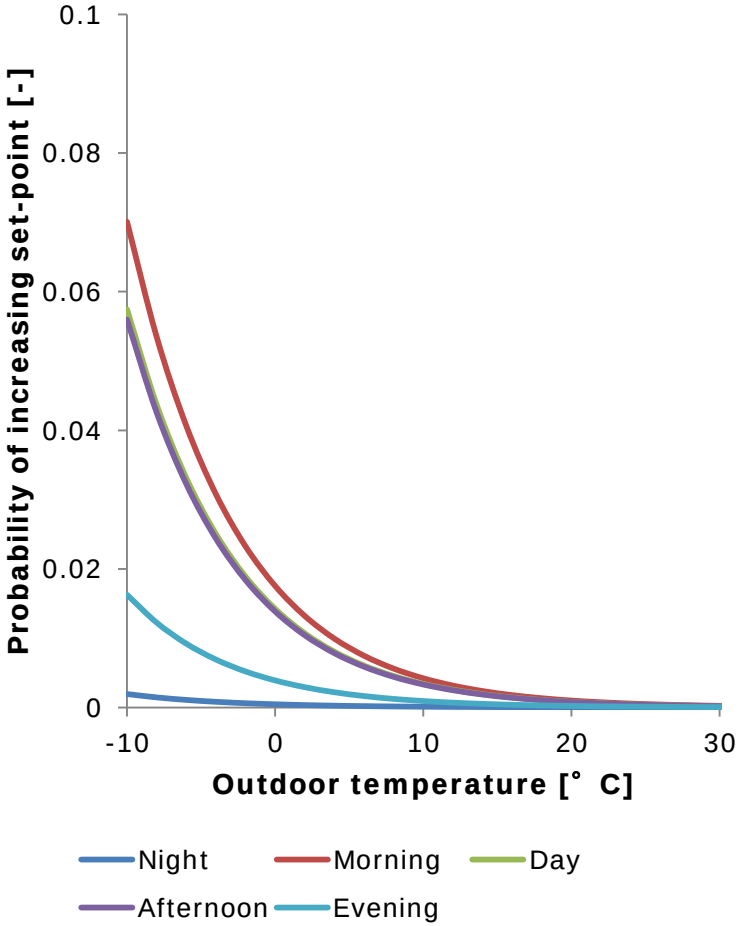
* S. Andersen et al. / Building and Environment 101 (2016) 1-8
** R. Andersen, Proceedings of Healthy Buildings 2012, Brisbane, Australia

Measurements in 16 dwellings

- Behaviour
  - Window opening
  - Heating set-point
- Indoor environment
  - Temperature
  - Relative humidity
  - CO_2 concentration
- Weather
  - Temperature
  - Wind speed
  - Solar radiation
  - Relative humidity

Models of occupant behaviour*





*R. Andersen et al. Building and Environment 2013

S. D'oca et al. HAVC&R 2013

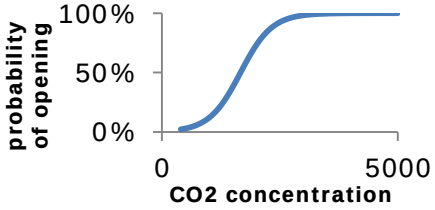
From deterministic to stochastic modelling

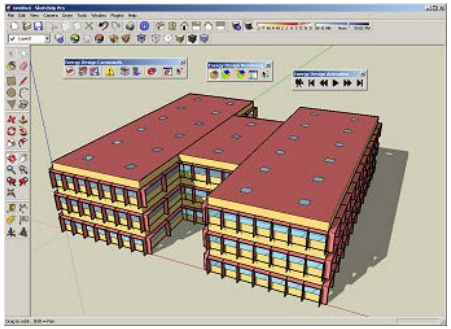
Stochastic models

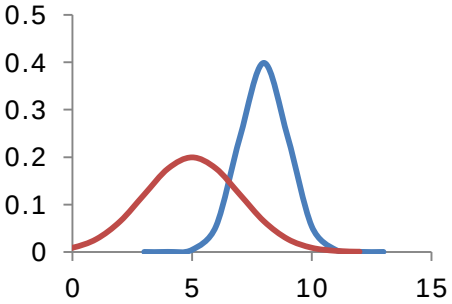
- Window opening
- Heating set-points
- Cooling set-points
- lighting
- ...

Deterministic model of physical aspects

Probability distribution of performance indicators

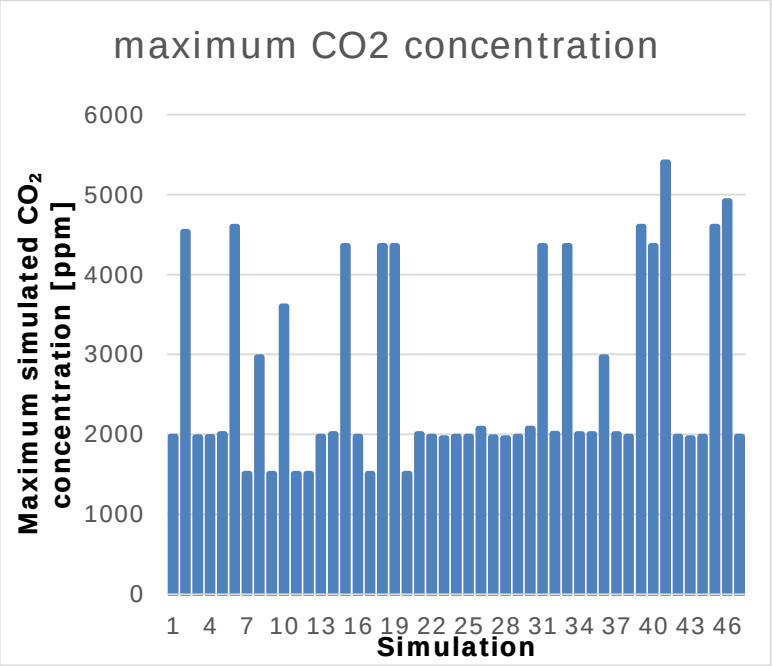


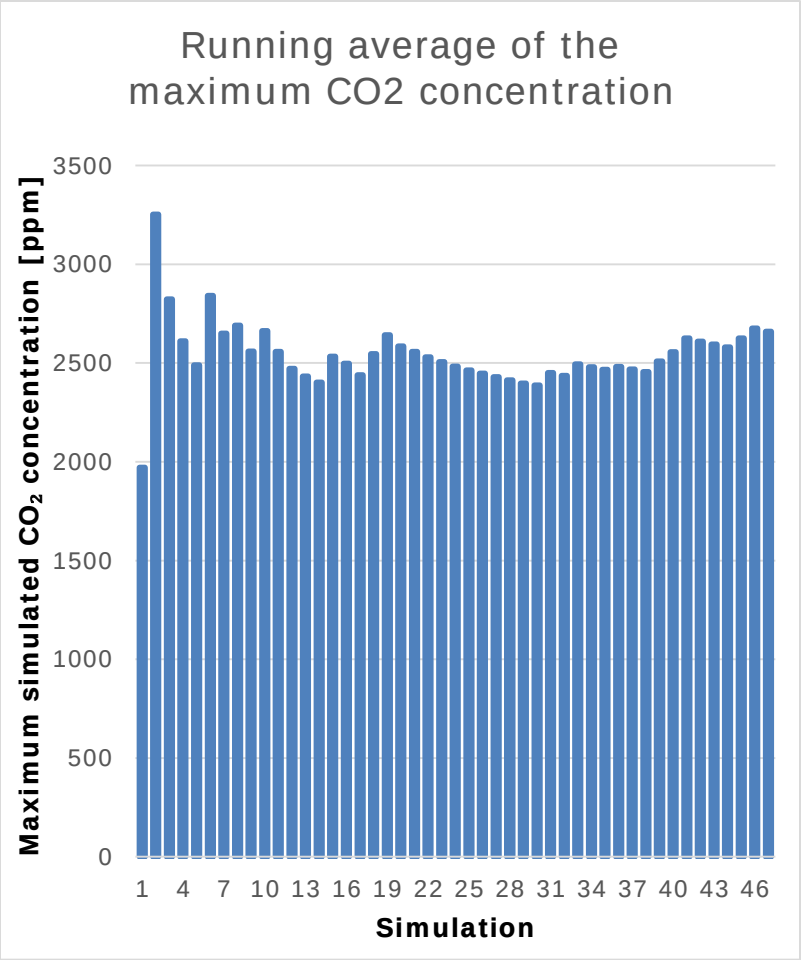




How many simulations are necessary?

- To estimate
  - Mean
  - Standard deviation



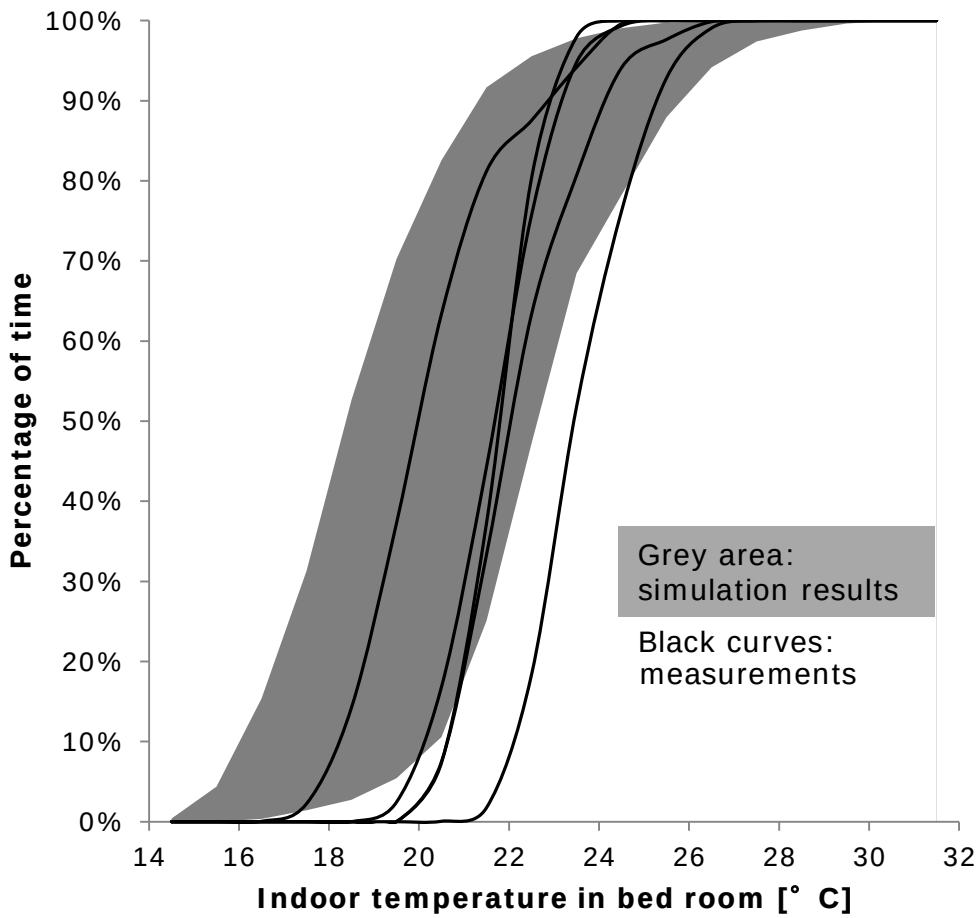


Verification of behaviour models

- Measurements in five apartments
  - temperature
  - CO_2 concentration
  - Relative humidity
- Simulations based on questionnaire and observations
- Stochastic models
  - Window opening
  - Thermostat adjustments
  - Inferred from detailed measurements in apartments

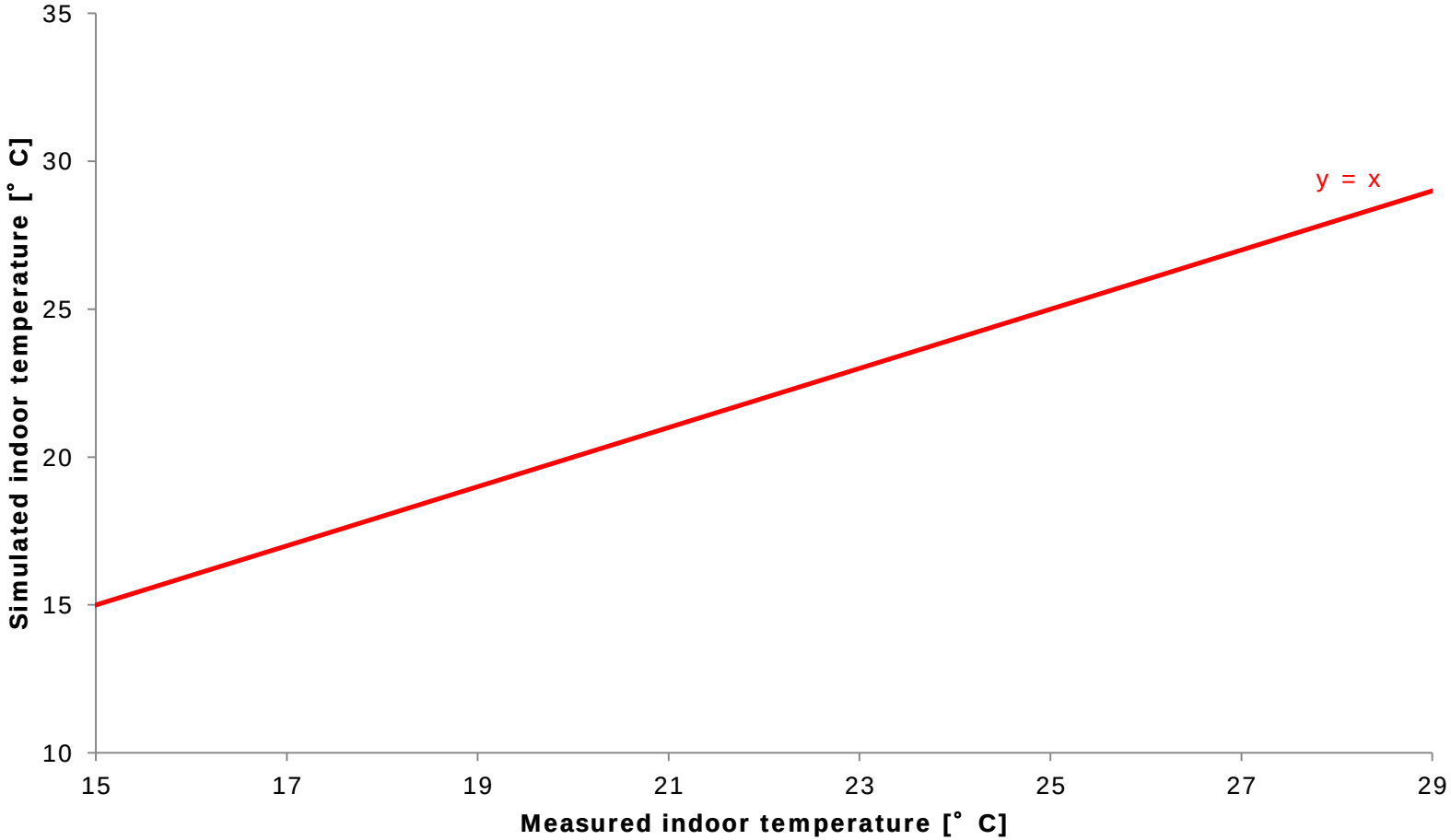
Measurements vs. simulation - overall*

- Stochastic simulations
  - temperature ranges rather than fixed figures
- Simulated temperatures in the same range as measurements



*R. Andersen et al. Energy and Buildings 2016

Measurements vs. simulation – in each time step *



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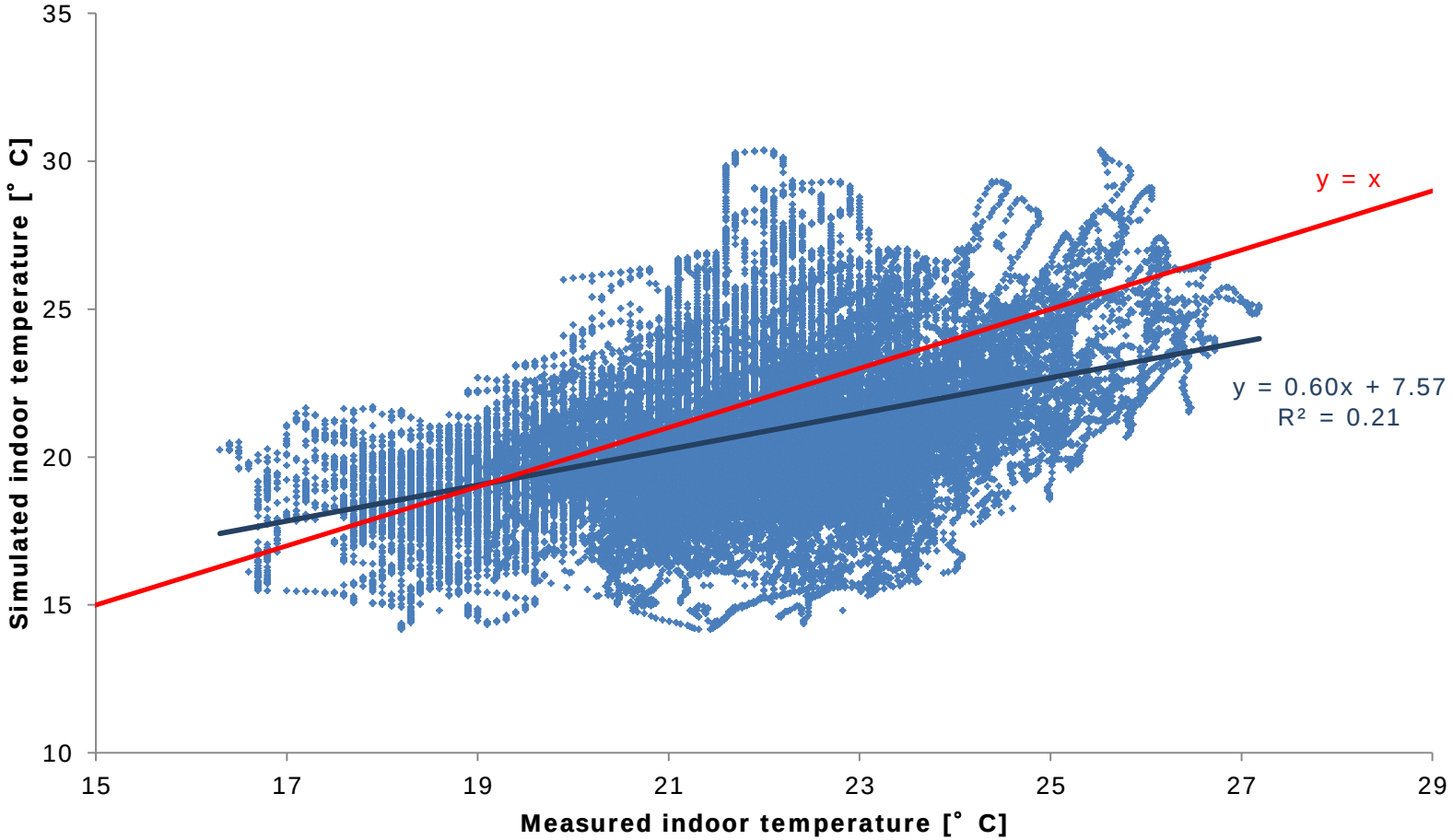

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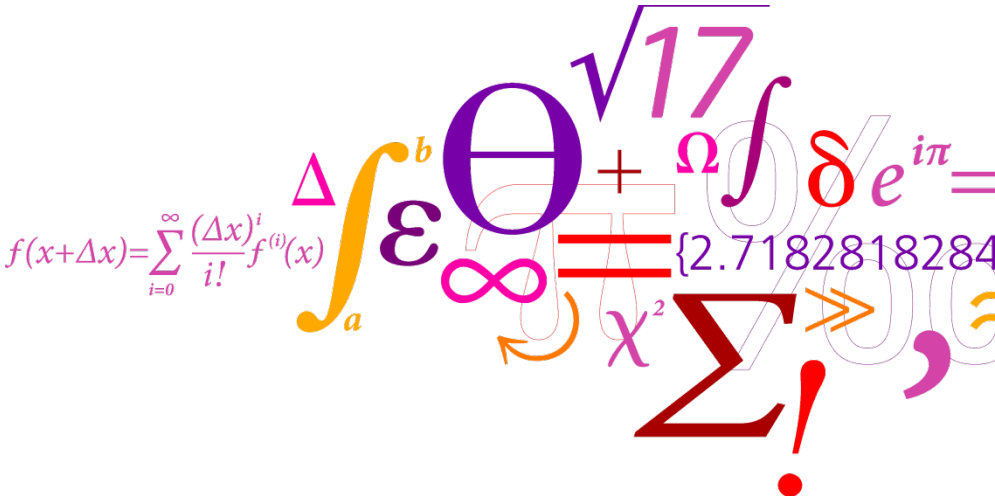
Thank you for your attention!

Questions?



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