Passivhaus:
How do we adapt to future climates?

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Some background..

Kranichstein, 1991 first certified Passivhaus

Saskatchewan Conservation House 1979,
Pioneer Award 2015, *www.**passivehouse**.ca*

RMI's original headquarters,
1984, Pioneer Award 2011

A long standing concept ... but will it still be robust and viable in the future?

What contributes to robustness?

Sky walk in China ©Sueddeutsche.de

Uncertainties

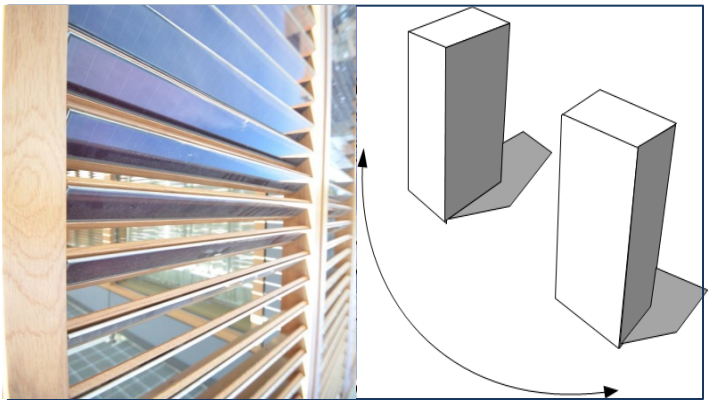
Three types of uncertainties..

1. Physical: material properties (thickness, conductivity, density etc.)

>> related to quality assurance

2. Design: building mass, orientation, type of glazing

>> related to design decision support

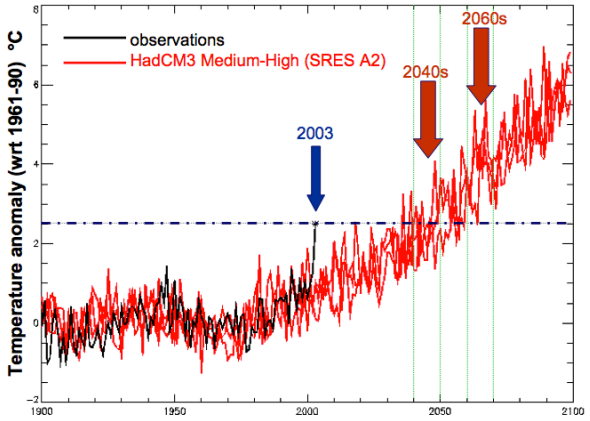


and 3. …

Uncertainties cont.

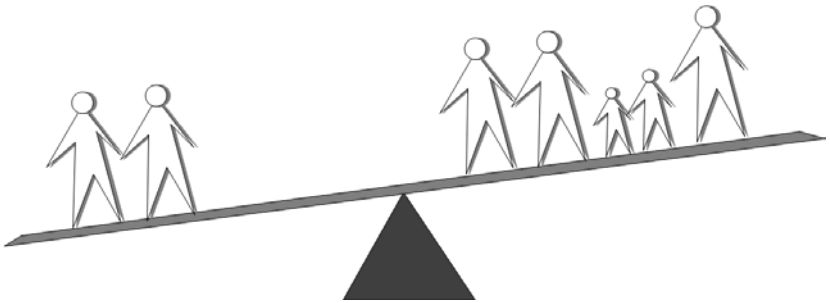
3. Scenario:

- Uncertainties in boundary conditions/ scenario uncertainties (gains, infiltration rate, climate files etc.)
- can change during the building's life time
- wide range in the possible usage of a building typically referred to as usage scenarios
- encompass the influence of ventilation (the operation of window openings), climate change, lighting control schemes, and other occupant related influences



McLeod et al 2013 (Crown copyright)

>>related to design decision support, in particular when considering design robustness and (future) adaptability of a building



How do we handle them?

- Rules of thumb
- What-if scenarios
- Parametric design
- Uncertainty analysis
- Sensitivity analysis
- Stochastic modelling
- Computational optimization
- We ignore them

Is that really necessary when designing a Passivhaus?

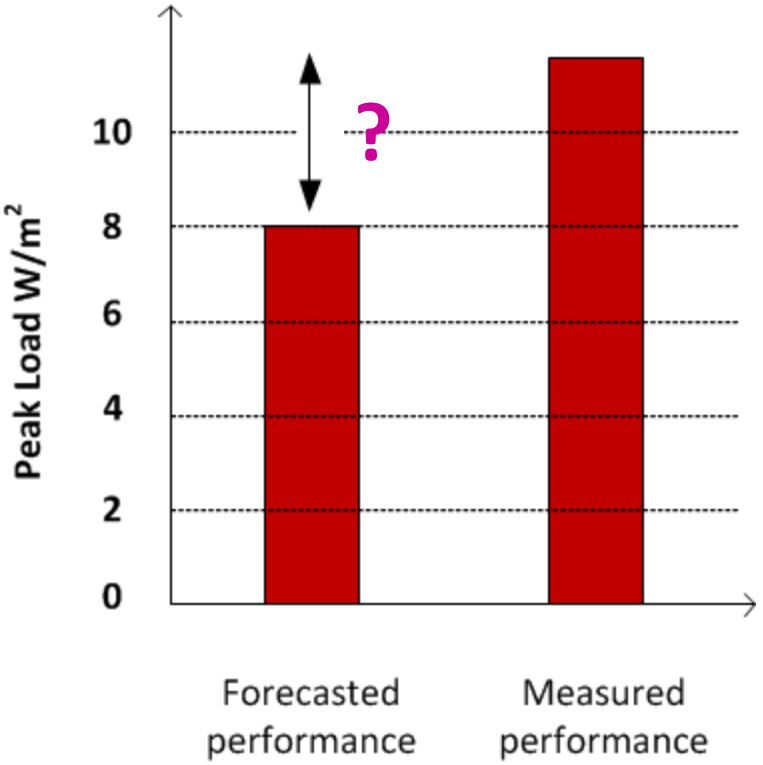
*__German__: “I thought it was perfect already“

Performance gap?

- In Passivhaus: if reality matches well with our assumptions or simulation, then we think that we have only little uncertainty
- That may well be possible because PH gives strict guidance and only little leeway or you may have just got lucky with the weather that year

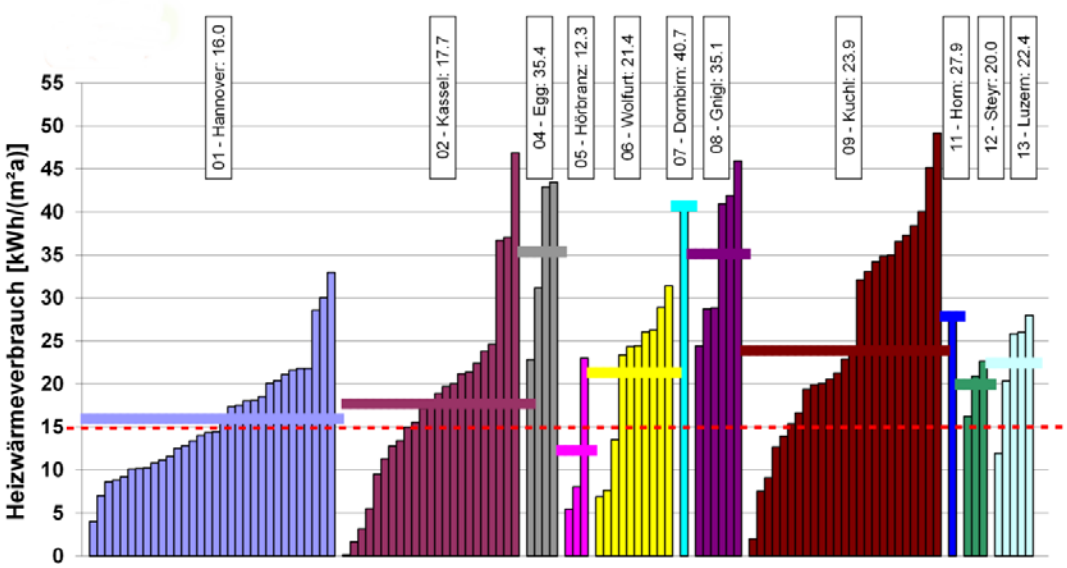
>> HAPPY DAYS!

...if there would be no variability and changing climate



Recent post occupancy studies

1. Original CEPHEUS projects



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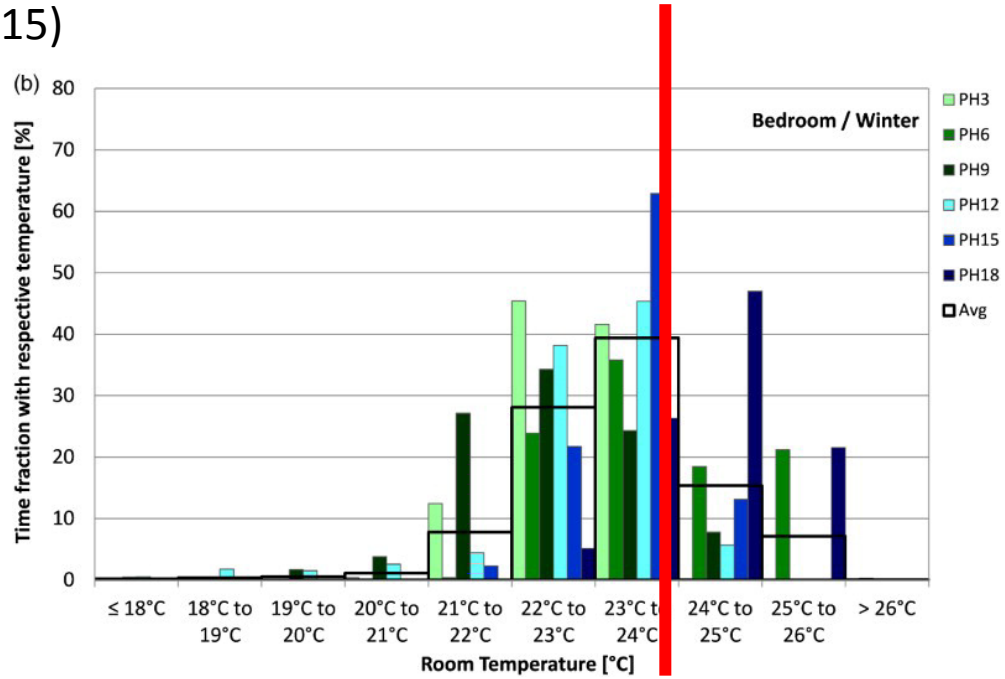
2. Opposed to Love's (2014) research of retrofit in social housing: "although indoor temperatures increased because of improved building fabric, the householders acted to reduce their heating demand"

Recent post occupancy examples

3. Ebbw Vale: exceeding of comfortable temperature in bedroom -> spiders (www.bere.co.uk)
4. Social housing in Lodenareal: room temperatures in winter exceeded 26°C: “18% prefer it warmer “(Rojas et al., 2015)



=> There is no easy way: we need to understand that future performance involves many different aspects

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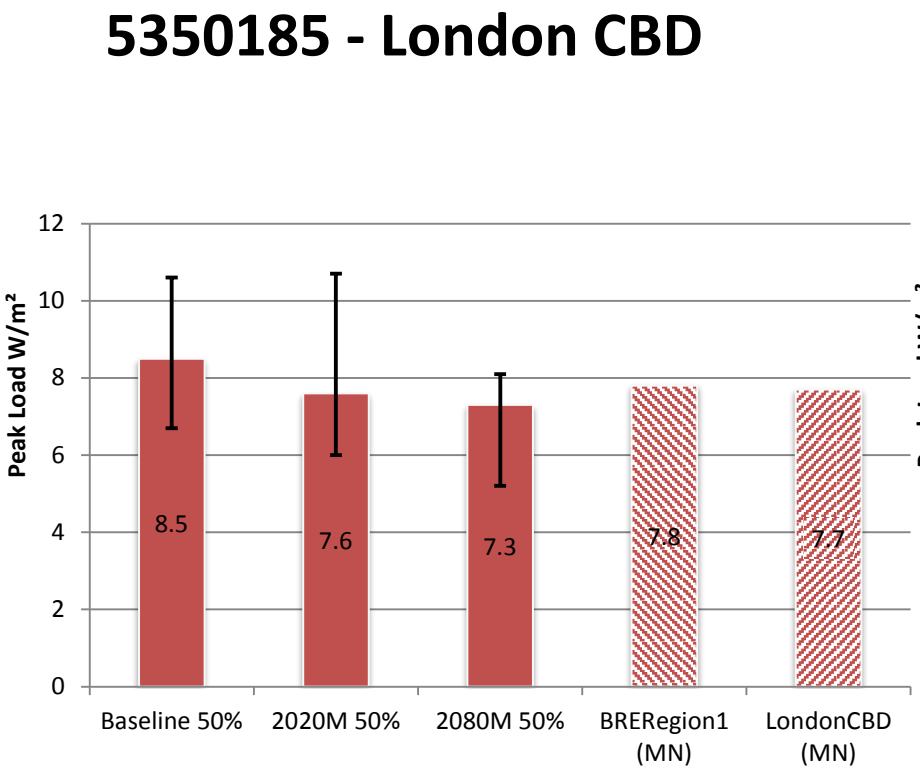
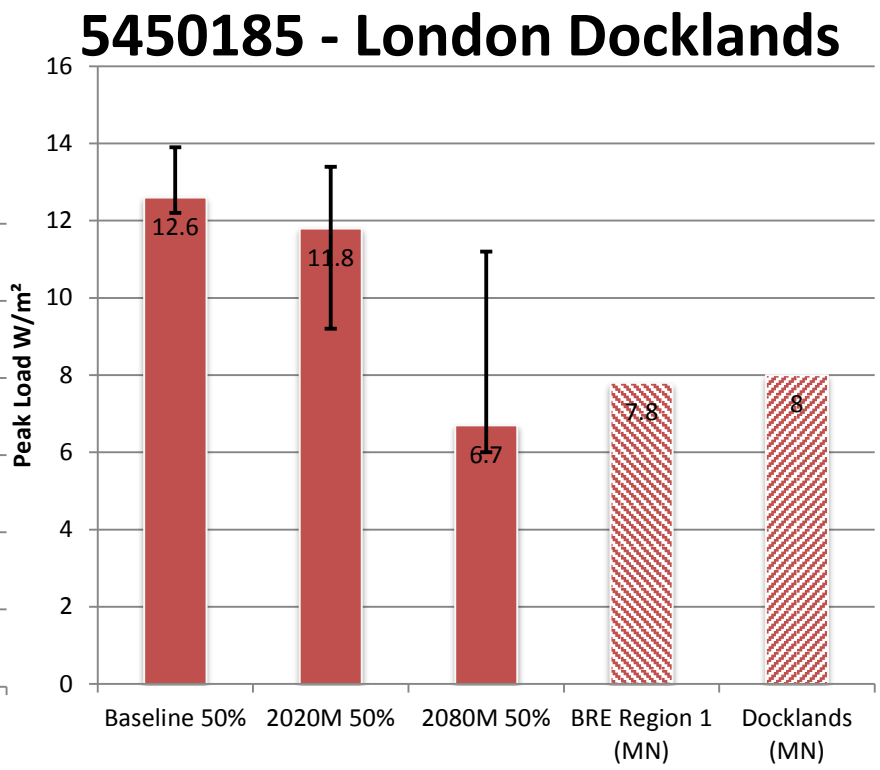
Some examples…

How do we handle the scenario uncertainties?

Example future high resolution climate data





- Significantly higher peak loads are predicted just outside the CBD
- London Regional data extrapolated from a location within the UHI - appears to substantially underestimate peak loads outside the CBD

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How do we handle the scenario uncertainties?

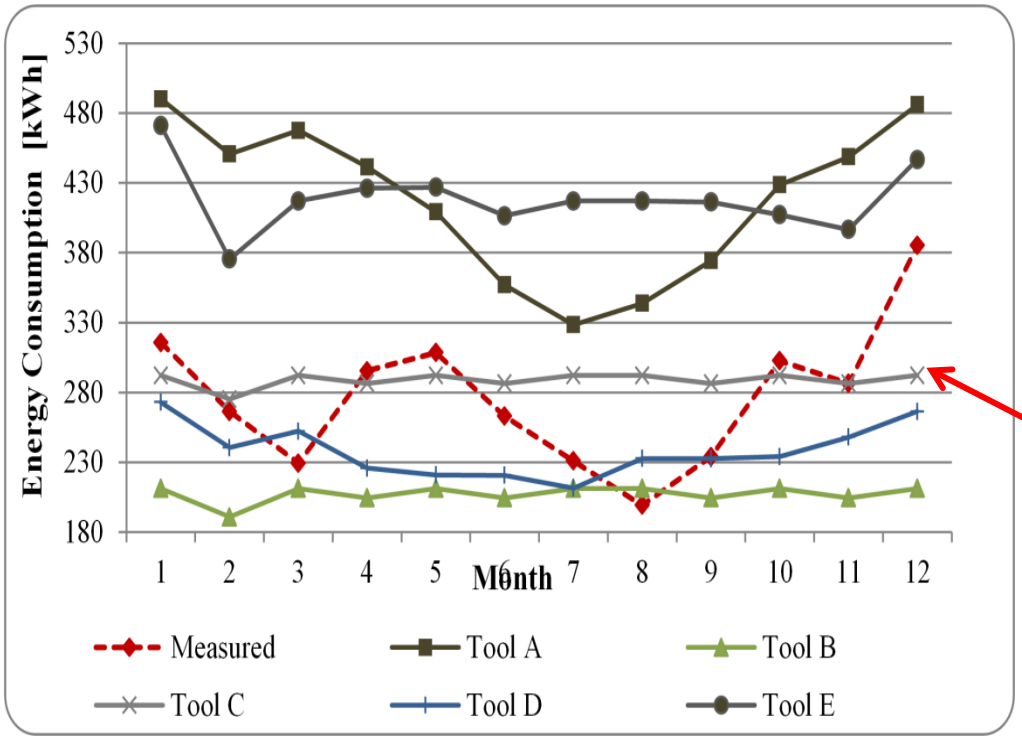
Example high resolution climate data cont.

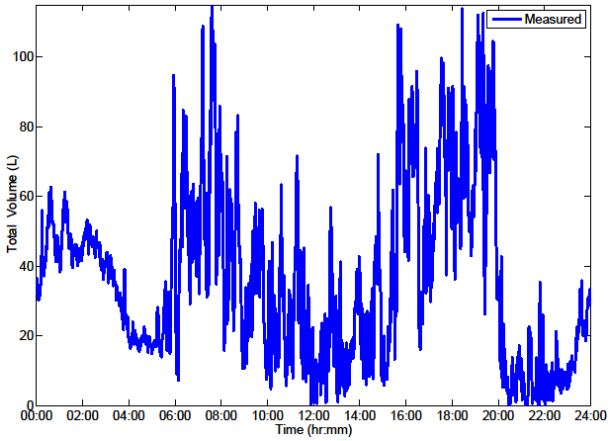
- Adapting or optimising for a future climate predictions (i.e. designing in resilience to extreme long term variability hot and cold variance, high winds, extremes of heat, wet and cold...)...
- Improving our understanding of future performance bands by using probabilistic ranges (shown earlier by error bars at 10th and 90th percentile)
- Finding more robust solutions e.g. optimising for peak loads rather than "annual space heating" ; i.e. optimising for multiple beneficial design outcomes (rather than creating a "heat fest" or one-trick pony)
- Considering good daylighting in conjunction with other factors

>> not just chasing down absolute heating energy demand, e.g. reducing demand on electricity grid and other major infrastructure (water, waste etc.).

How do we handle the scenario uncertainties?

Example hot water consumption





Measured total hot water consumption profile normalised on minutely time step.

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How do we handle the scenario uncertainties?

Example People

- Static user profiles of work week and weekend
- Occupancy schedules based on ASHRAE 90.1
- Stochastic profiles
- Observation based data
- Time series

Reality?

>> Question: what is the minimum user model resolution required with regards to Passivhaus design?

Conclusions

Don’t design just for today (or yester year)

- Our climate is changing, our population is aging and we are spending more time inside buildings – these factors *increase the magnitude of risks*
- Designers need to consider *a range* of probabilistic performance predictions to better understand *whole-life design performance* - rather than focusing on a single deterministic ‘*result*’
- Designers need to be aware of the impact future scenarios or real-world scenarios have on the design and consider means (such as uncertainty analysis) to address these
- Behavioural studies remain a challenge but should play part of the decision making process
- We must consider health and wellbeing impacts and not just short "thermal comfort" when agreeing acceptable design parameters

References and resources

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- McLeod, R., Hopfe, CJ, Kwan, A., 2013. *An Investigation Into Future Performance And Overheating Risks In Passivhaus Dwellings.* Building and Environment 70 (2013) 189-209. Available: http://dx.doi.org/10.1016/j.buildenv.2013.08.024
- McLeod R., Hopfe, CJ, 2012. A proposed method for generating high resolution current and future climate data for Passivhaus design. Energy and Buildings, 55 (2012) 481–493 . Available: http://dx.doi.org/10.1016/j.enbuild.2012.08.045
- NHBC, 2012. *Overheating in new homes.* (Dengel, A., and Swainson, M.,) NHBC Foundation

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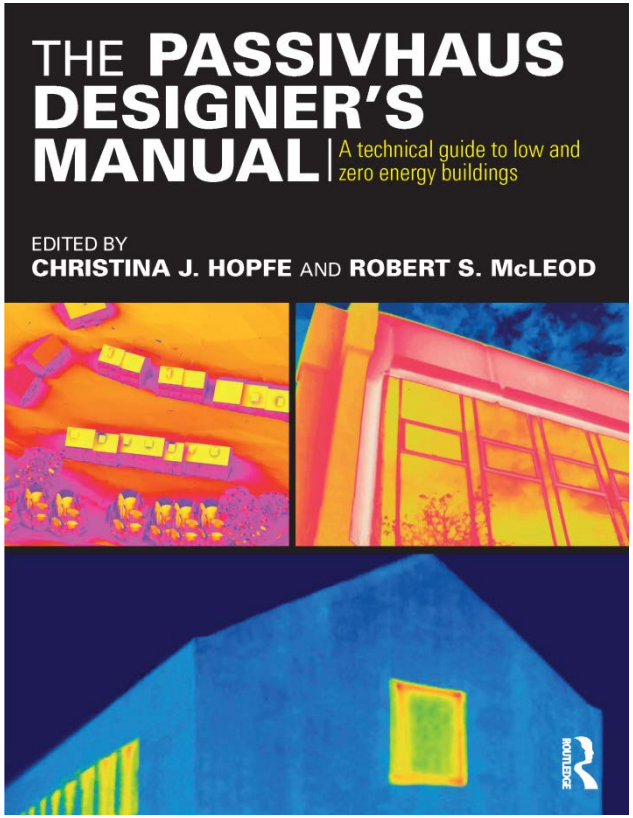
“The Passivhaus Designer’s Manual” – out now!



The Passivhaus Designers Manual is the most comprehensive technical guide available to those wishing to design and build Passivhaus and Zero Energy Buildings.

State of the art guidance for anyone designing or working on a Passivhaus project. Expert advice from 20 world-renowned Passivhaus designers, architects, building physicists and engineers.

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Thank you!