On the relation of thermal comfort practice and the energy performance gap

Runa T. Hellwig

Professor of Building Climatology

CREATE

Aalborg University

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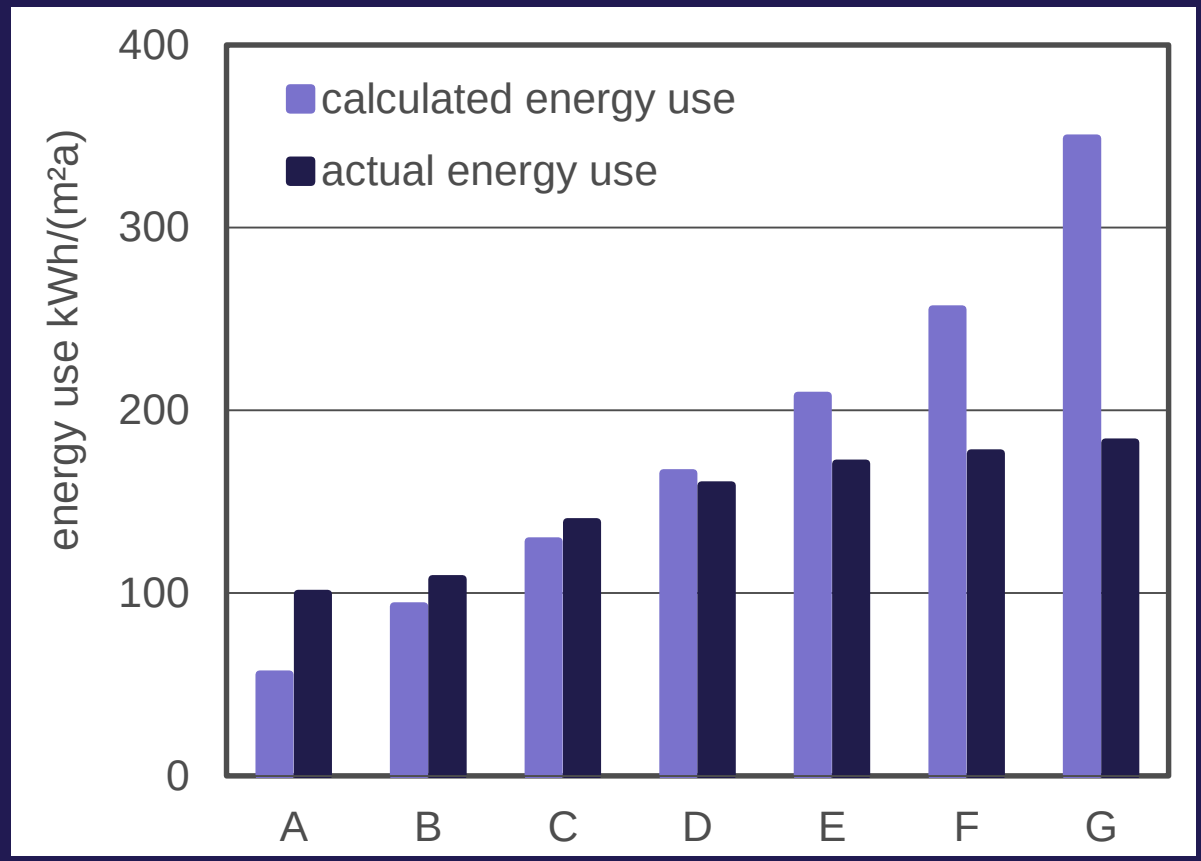
Overview

- Energy performance gap
- New technology as driver for changes
- Thermal comfort practice
- Example: attitude
- Concepts of thermal comfort
- Conclusions

Energy performance gap – Example Danish data

- Actual and calculated energy use per m² of detached houses, grouped by energy label, mean values, variance not shown (N=135.311)
- Users adjust behaviour according to level of energy-efficiency



Data used in graph:
Gram-Hanssen, K.; Hansen, A.R. (2016): Forskellen mellem målt og beregnet energiforbrug til opvarming af parcelhuse. SBI forlag. https://sbi.dk/Assets/Forskellen-mellem-maalt-og-beregnet-energiforbrug-til-opvarmning-af-parcelhuse/sbi-2016-09-1.pdf

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Technology as driver of thermal comfort practice e.g. central heating systems

- Central heating systems required instructions how to operate them
- 1916: In a classroom, more than 20°C impairs the children's learning performance (Rothfeld 1916)
- 1925: how to operate a heating system in a German Ministry's building: with permanent heating 18°C should not be exceeded because 19°C would be too warm for many persons (Bradke/Liese 1952)
- 1935: German Health Authority: a room with 21°C is overheated by the heating system (Bradke/Liese 1952)
- Yesterday's presentation by Simon P.A.K. Larsen, AAU (6/11/19):
  comfort at 23-26°C: "must be able to walk around in T-shirt and bare feet year round"
- Central heating systems → development of more freely arranged layouts of the floor plans (Grytli, Støa 1998)

Thermal comfort related changed practice in using, operating and designing buildings

- Changed conditioning schedule (temporal: intermittent/ night set back/ permanent)
- Extended availability of conditioning systems to more rooms (spatial: more rooms)
- Changed occupant behaviour (behavioural: e.g. less clothing)
- Changed temperature regime (extent, "*indoor exposure rebound*")

Thermal comfort practice

- Concept of what thermal comfort is
- Attitudes, expectations
- Role of player, contribution
- Strategy of how to reach thermal comfort
- Behaviour

- Phases: Design/planning, operation, use, standardisation, certification
- Players: researchers, authorities, building professionals, legislation, component manufacturers, occupants
- Contribution: Design, plan layout, complaints, litigation issues, requirements, guidance, advice, information, education…

Attitudes, expectations

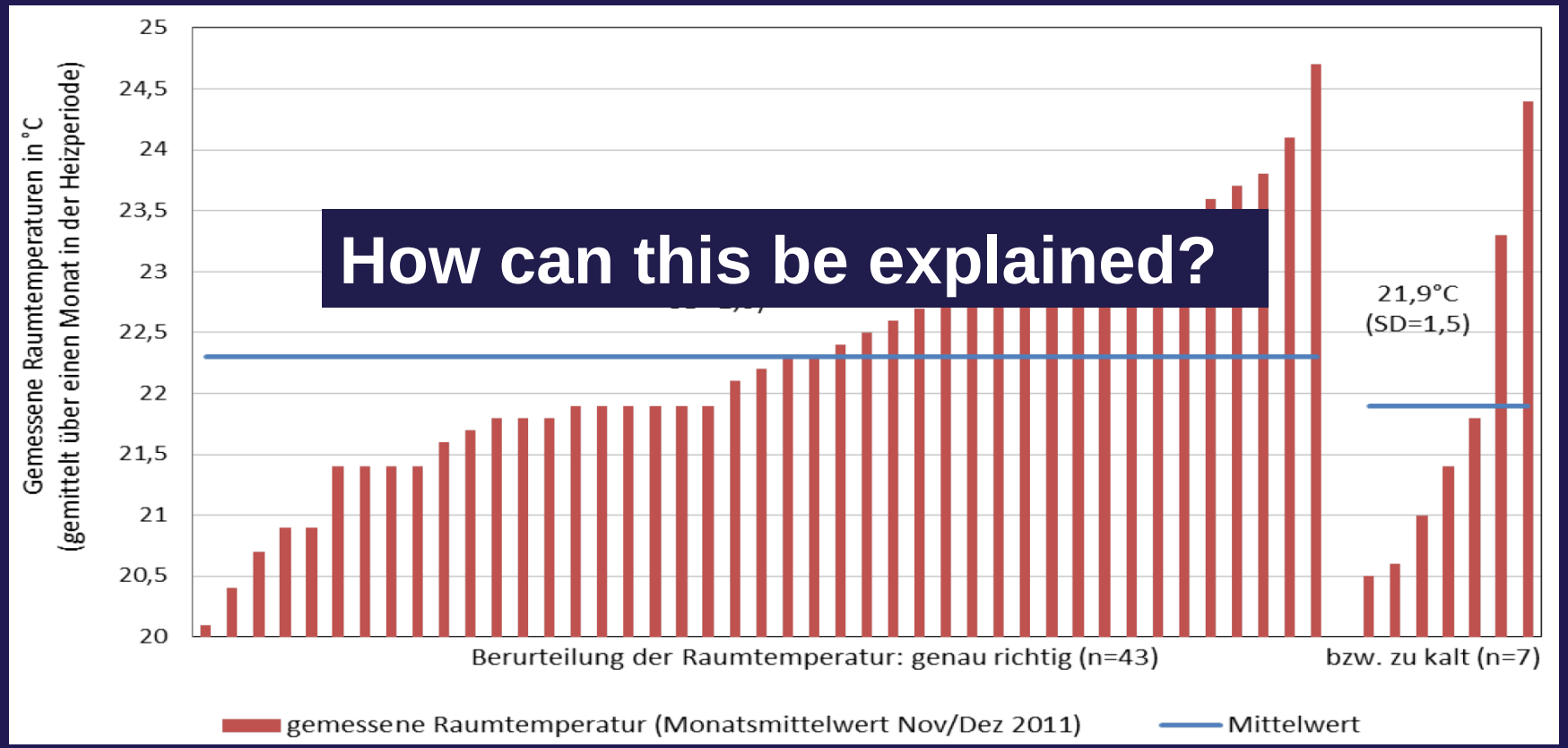
- In the 70ies: Thermal comfort is a product which can be sold (Fanger).
- Selling a fantastic building knowing about the needs of the occupants shapes expectations
- Building professionals are seen as providers of comfort
- Occupants are seen as passive recipients [consumers] of comfort (de Dear et al. 1997, p3)
- Widespread opinion among professionals: Occupants exert ‘unsuitable’ behaviour
- Occupants may get the impression that they are unable to do anything about the indoor climate
- They would then demand changes from the comfort provider (e.g. complaint rate)

Temperatures in Passivhouses – Example Germany, Winter, Data Institut für Wohnen und Umwelt

Source:

Ulrike Hacke,
Institut Wohnen und Umwelt:
Sozial – Menschen wohnen in neuesten Standards: Erfahrungen aus Nutzersicht

Deutscher Thementag „Nachhaltige Lösungen für die Wohnungswirtschaft“ im Rahmen der Sustainable Built Environment Conference 2016 in Hamburg



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Concepts of thermal comfort

- Human thermoregulation and the physical principles of heat exchange between humans and their environment

…form *one* basis of thermal comfort - the *complete set of variables* comprises more variables:

- There are three non-quantifiable principles in the adaptive thermal comfort concept*:
- *Behavioural adaptation* – actively contributing to own satisfaction
  by changing posture or activity, clothing insulation or “exercise control”/ changing the environment
- *Physiological adaptation*
  thermoregulatory adjustments, acclimatisation processes, exposure
- *Psychological adaptation*
  previous experience, expectation, preferences, availability of personal control (*back-up*), social factors and constraints

→ Furthermore: thermal comfort has a transient character

Hellwig, RT; Teli, D; Schweiker, M; Choi, JH; Lee, MCJ; Mora, R; Rawal, R; Wang, Z; Al-Atrash, F (2019): A Framework for Adopting Adaptive Thermal Comfort Principles in Design and Operation of Buildings, Energy and Buildings, Vol 250, https://doi.org/10.1016/j.enbuild.2019.109476

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Photos: Hellwig 2005

Attitudes, Expectations assign roles which impact behaviour

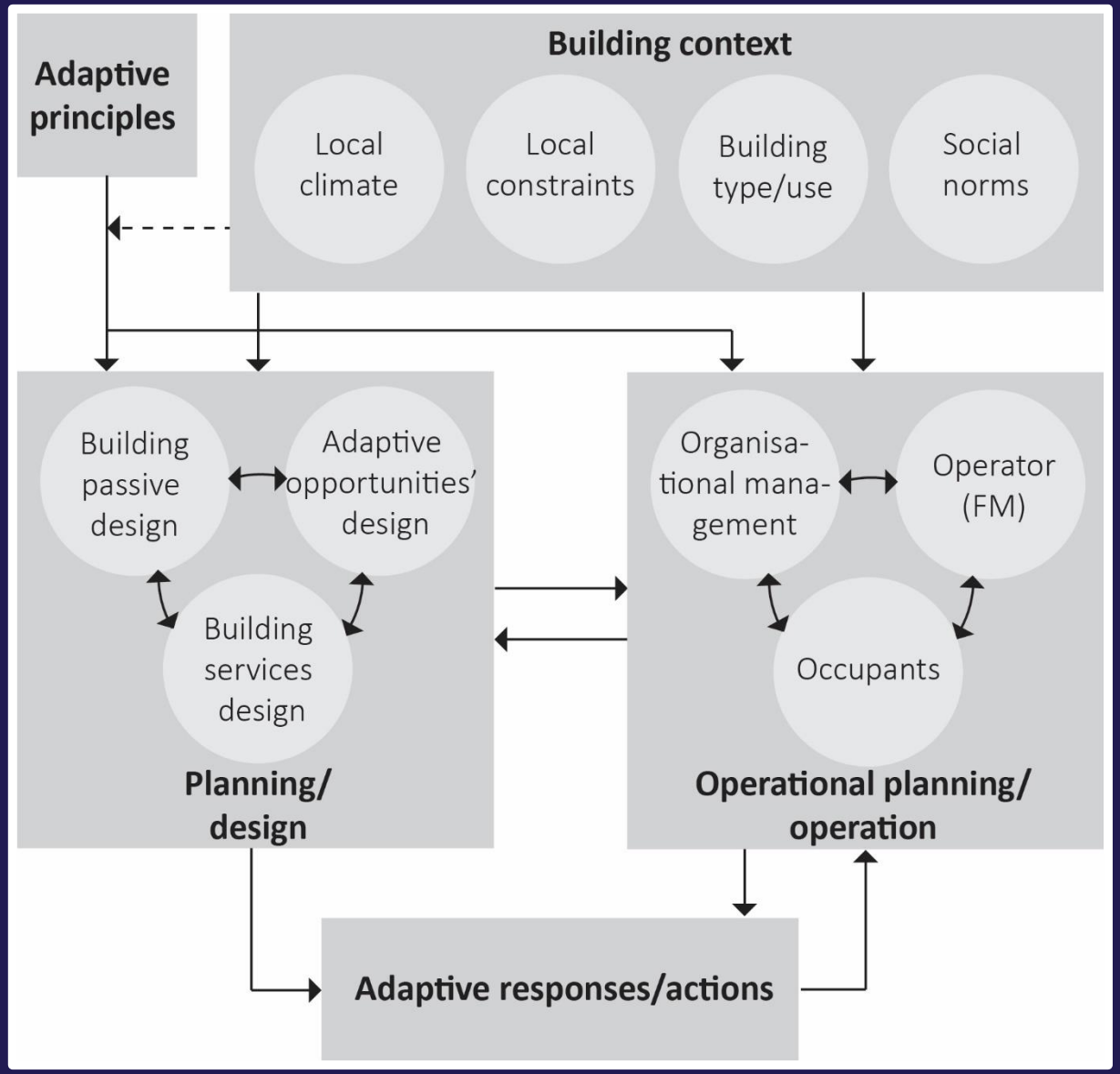
- The adaptive thermal comfort approach is based on the assumption of an occupant actively using adaptive opportunities, *seeking comfort*
- The pronunciation on *comfort provision* as a service of building professionals "…may deny occupants simple facilities for discomfort alleviation…" (Bordass&Leaman 1997, p192)
- Occupants who are concerned about environmental issues react more relaxed when in a green building the thermal comfort conditions are somewhat outside the normally experienced ranges (Leaman&Bordass 2007, Deuble&deDear 2012)

Temperatures - Indoor exposure adaptation

- Observed increasing temperatures for heating set-points (and decreasing temperatures for cooling) leading higher use of energy
- Theory of adaptation in thermal comfort: We get adapted to what we are exposed to – outdoors or indoors

How to use the adaptive principles in design

- Framework done in Annex 69, Activity B2
- Planned design of adaptive opportunities and actions



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Repository: Conceivable adaptive actions in response to warmer or cooler than previously experienced environments

categories of adaptive actions	response to cooler than previously experienced	response to warmer than previously experienced
regulating the rate of internal heat generation	– increasing the level of activity – eating a meal – ….	– adopting siesta-routine – reducing the level of activity – eating less
regulating the rate of body heat loss	– adding clothing or blankets – curling up or cuddling up – ….	– taking off some clothing – opening a window for getting a breeze – …
regulating the thermal environment	– insulating the loft or wall cavities …. – adjusting or turning down the thermostat – notifying the management – …	– opening a window – switching off heat emitting equipment not needed – adjusting thermostat or turning down the air conditioner ….
selecting a different thermal environment	– finding a warmer spot in the house building a better house …	– going for a swim – visiting a friend (hoping for a cooler temperature)
modifying the body physiological conditions	– acclimatising: letting the body become more resistant to cooler environments – emigrating	– acclimatising: letting the body adjust so that they become used to warmth – emigrating
modifying expectation	- letting the mind become more relaxed - …	- letting the mind adjust - …

adopted from Humphreys and Nicol, 1998 and Nicol and Humphreys, 2018 and slightly adjusted and amended

Hellwig, RT; Teli, D.; Schweiker, M; Choi, JH; Lee, MCJ; Mora, R; Rawal, R; Wang, Z; Al-Atrash, A (2019): A Framework for Adopting Adaptive Thermal Comfort Principles in Design and Operation of Buildings, Energy and Buildings, 2019, https://doi.org/10.1016/j.enbuild.2019.109476.

Conclusions

- Thermal comfort practice contributes to the energy performance gap
- Thermal comfort practice is influenced by prevalent concepts of what thermal comfort is.
- How much temperature is sufficient?
- How can we determine what is (good) enough in a self-adapting system?
- Taking into account that people are getting used to conditions there are exposed to for long periods
- Attitudes: Offering the users a more active responsible role in *seeking* comfort
- Expectations: Raising realistic expectations
- Approaching thermal comfort more comprehensively: taking into account also non-quantifiable factors
- Design and plan buildings taking into account typical behaviour

THANK YOU!

Contact: rthe@create.aau.dk

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