# Design of adaptive opportunities for people in buildings

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Besides her interdisciplinary research profile connecting carbon neutral building design and operation with how people perceive and interact with indoor environments, her current research focusses especially on resilience of buildings and people, designing for personal control over the indoor environment and sufficiency concepts for the built environment. As appointed member she has been serving in the German Committee of Workplaces consulting the Federal Ministry of Labour and Social Affairs on work environment related occupational safety and health topics.

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**LHC: You are the main author of the Guidelines for Low Energy Building Design *Based on the Adaptive Thermal Comfort Concept*, which is one of the reports from IEA EBC Annex 69 [1]. What were the aims and goals for this Annex 69 (completed 2014 – 2022)?**

**RH**: The goal was to gain more insights and summarize all knowledge on how the adaptive thermal comfort approach can be used and applied in energy efficient building design and operation. Many know the adaptive thermal comfort model as evaluation method for the thermal indoor environment in periods in which buildings are non-conditioned, and the comfortable temperature range depends on the prevailing outdoor conditions of the period of interest. But what many building planners and designers are not aware of is that the adaptive comfort approach can be used for designing more sustainable buildings. To support a clear communication of the adaptive comfort approach, we summarized the most relevant points:

- WHAT the adaptive principles are,
- WHY it is beneficial to use the adaptive principles,
- HOW the adaptive principles can be translated into design and operation of buildings, and
- WHO should be addressed for enhanced implementation of the adaptive principles.

**LHC: So, what are the adaptive principles?**

**RH**: First of all, it is the physical factors of the thermal environment that is forming our daily experience to which people adapt in a physiological way by thermoregulation and by acclimatization. The two other adaptive principles concern behavioural and psychological adaptation. Examples of behavioural

adaptation actions are show in **Table 1**. Psychological adaptation includes among others the perceived level of personal control, expectations or attitudes. It means that some important factors for thermal comfort perception are difficult to quantify. Those qualitative factors normally receive less attention in design and operation then they would require. Better guidance beyond operable windows and freely adjustable clothing as mentioned in EN 16798-1 [2] could improve awareness of these factors. Overall, we need to approach thermal perception in a more comprehensive way (**Figure 1**).

***Table 1.*** *Examples of behavioural adaptation actions, adapted from [1].*

| Mechanism | Adaptive actions |
|---|---|
| **Regulating the rate of internal heat generation** | Increasing/ reducing the level of activity (e.g. standing/sitting at the desk); Drinking a warm/cool beverage; Eating more/less or low/high caloric food; Adopting siesta-routine; … |
| **Regulating the rate of body heat loss** | Adjusting clothing / choose different clothing material; Assuming wide/closed posture; adjusting air velocity (fans, open/close windows, doors); Sitting closer/ increase distance to heat sources; Sitting on material with varied thermal effusivity (low/ high resulting contact temperature); … |
| **Regulating the thermal environment** | Open/close windows, doors; Switching off heat emitting equipment; Activating/ deactivating shading; Using night time ventilation; Switching on/off a fan; Switching off/on heat/cooling source; Notifying the facility management; … |
| **Selecting a different thermal environment** | Finding a warmer/cooler spot in the building; Sitting under a tree; … |
| **Modifying one's psychological perception** | Letting the mind adjust; Holding a warm cup of tea; … |

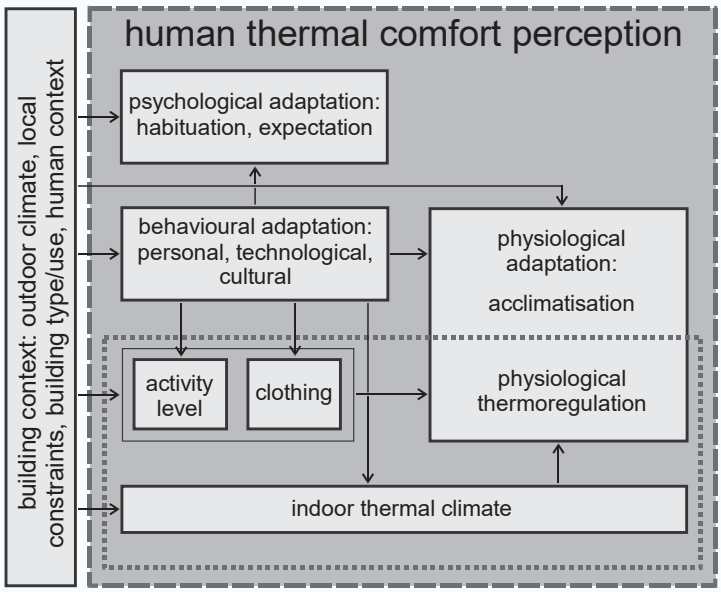


**Figure 1.** Integrated view on factors, mechanisms and main interrelations constituting human thermal comfort perception. Dotted line rectangle: Human body's heat balance and basis for thermal sensation models. Dashed line rectangle: Heat balance is accomplished by behavioural adaptation, psychological adaptation and acclimatisation processes (as part of physiological adaptation) and describe together thermal comfort perception in dynamic environments. This figure is a reprint from [2], published first at Windsor Conference 2020, Proceedings, Copyright (2020) with permission of the authors.

**LHC: What are the benefits of using adaptive principles?**

**RH**: There are four major benefits (textbox). Energy saving potential emerges due to wider comfort temperature bands that follow the prevailing local climate. Better usability of the building and improved occupant satisfaction can be reached through personal control with occupant-centric controls (adaptive opportunities). They are central to the adaptive approach. Research evidence shows that indoor temperature fluctuations benefit occupants' health, well-being and resilience. Your earlier interview with Wouter van Marken Lichtenbelt was about those benefits (see previous interview in REHVA Journal 2/2024 [3]).

**Benefits of applying the adaptive principles in building design [1]**

- Low energy occupancy
- Usable occupancy
- Healthy occupancy
- Resilient occupancy

**LHC: What are the main adaptive design principles?**

**RH**: Taking the adaptive responses and behaviours of occupants as the point of departure for design instead of designing for certain thermal conditions only, is central to the proposal we made. We know that if occupants have opportunities to act, they can relax their mind and accept a wider range of temperatures, both daily but also seasonally. The developed design process for adaptive opportunities is shown in **Table 2**. The outcome of the process is a set of adaptive opportunities for building design.

**LHC: Are these design principles influenced by climate change?**

**RH**: Of course. Because of climate change, adaptive opportunities previously used in certain locations might not be suitable anymore and people need to change their habits and routines. So, they need to learn new habits which may come with new adaptive opportunities. We need to combine them with those adaptive opportunities they know otherwise it could be that the occupants do not feel in control enough. Besides this, the passive design of buildings will have to change in a changed climate.

***Table 2.*** *Adaptive opportunities design process to develop a design portfolio suitable for a room or building in a specific context, adopted from [4].*

| | Step | Process |
|---|---|---|
| 1 | Conceivable adaptive opportunities | Review conceivable adaptive actions as exemplified in Table 1 |
| 2 | Contextually common adaptive opportunities | Consider contextual factors that drive design:<br>- Local climate (typical climate, seasonal characteristics etc.)<br>- Building type/use (Task, building use, user group etc.)<br>- Human context (social norms, previous indoor climate experience, common practice, assumed knowledge)<br>- Local constraints (pollution, noise, urban heat island effect, security, etc.)<br>For related design questions, actions and responsible stakeholder see [1, 4] |
| 3 | Contextually new adaptive opportunities | Consider recent and expected developments:<br>- Climate change mitigation<br>- Climate change adaptation<br>- Increasing urbanisation<br>- New technologies (e.g. personal environmental control systems, IoT technology)<br>- New research results (e.g. on health effects of solutions) |
| 4 | Design portfolio of adaptive opportunities | Establish a good mixture of contextually common (step 2) and new (step 3) adaptive opportunities, considering:<br>- certain degree of redundance to serve diversity in occupants<br>- that most preferred adaptive opportunities are part of the portfolio<br>More guiding questions to be found in [1,4] |

**LHC: This brings us to the last of four basic findings. Who are the stakeholders in adaptive design and operation of buildings? And how can they contribute?**

**RH**: Our report recognizes operational planning and operation as equally – if not more – important than the design phase. We have put quite some emphasis on the design of adaptive opportunities and therefore we also thought about how they can be enabled in practice. The integrated design team, the organizational management of a company, the building operator and the occupants have all their role in this and need to interact, information flow is important (**Table 3**).

**LHC: We spoke about design principles but you are also the main author of the paper *Guidelines to bridge the gap between adaptive thermal comfort theory and building design and operational practice* [4]. What can bridge the gap?**

**RH**: First of all, a more comprehensive understanding of how a thermal comfort feeling develops in people is important. Therefore, we wrote the report. It can be used in professional trainings or in teaching at universities in building services, building physics and architecture. An important point would be to teach not only the quantifiable factors, such as thermal conditions in a space but also the human factor, for example diversity in people or psychological factors such as personal control. Integrated design and operation in cross-disciplinary teams would also help to bridge the gap. And then, some advancements in the standards, such as the integration of design principles for personal control, would also be good.

**LHC: Are you in favour of considering adaptive principles for all conditioned modes of buildings?**

**RH**: Yes. I think we need a comprehensive approach to thermal comfort for all buildings and all year round (**Figure 1**). The adaptive approach could also be used for operating heating or cooling systems in conditioned buildings. The adaptive principles can help to design both periods of building operation, conditioned and unconditioned. For this, the opportunity for behaviours that help us to overcome moments of slight discomfort, meaning appropriate personal control, is important in all buildings as available personal control relaxes our expectation towards temperature requirements.

**LHC: Should we change the actual standards which divide rooms in categories A, B, C, where the highest category is the narrowest, which is contrary to the adaptive approach thinking?**

**RH**: One major misunderstanding is that in Green Building rating systems buildings get more points when they are designed for the highest category (A or I) with the narrowest temperature band. Originally, this category was described as to be used for high expectations and should therefore be used for vulnerable people with special needs, who might for example not be able to adjust their clothes or with impaired thermoregulation. Following the rating systems, should we treat the whole working force as people with special needs? I don't think so. Research where the performance of the thermal indoor environment was categorized using A, B, C (or I, II, III) shows that A-buildings were not better rated by occupants than C buildings. Therefore, yes, there is a need for redefining those categories.

**LHC: It is 30 years ago that the 1st Windsor Conference 'Standards for thermal comfort' was organized by Sue Roaf and Fergus Nicol in 1994 as *'the beginning of the end of dominance of simplistic steady state calculation methods'*. Where do you think we are now?**

**RH**: I wish we would have reached further in practical understanding and application. The basal information and argumentation have in principle been there for a

***Table 3.*** *Stakeholder and stakeholder action required to enable adaptive opportunities for occupants [1,4].*

| Stakeholder: | Integrated design team | Organisational management | Operator | Occupant |
|---|---|---|---|---|
| Stakeholder action: | - Design context adjusted adaptive opportunities<br>- Inform operation | - Inform the design team<br>- Facilitate use<br>- Inform the occupants | - Inform design team<br>- Maintain context adjusted adaptive opportunities<br>- Prepare user and operator manual | - Take information up<br>- Use adaptive opportunities |

long time, and meanwhile many research studies have added really good insights - only now it has reached a broader audience in research. How we describe and discuss the adaptive thermal comfort approach today has become more comprehensive and deeper. But we still should enhance the application in building design and operation.

**LHC: Recently, there was the third update of EPBD, where a SRI (Smart Readiness indicator) of buildings is introduced. Could this help to use an adaptive approach in operation of buildings?**

**RH**: I think that there is a chance to use such kind of approaches in a positive way for the adaptive approach. But we certainly also need to think about the amount of this smartness and the number of sensors installed, because all this needs energy and resources …

**LHC: ...and people want to be in control…**

**RH**: Yes, exactly. The SRI describes user-friendliness as how much the smart service simplifies the use of the building. They say, that increased automation would save manual interactions with the building technology. But do users want this? As we know from many field studies, occupants want control. Automation on room level decreases the personal control of occupants. Also, a lot of smart control interfaces does not necessarily mean that we as users have the perception of being in control. Technology needs to be easy to use because we have a diverse population that should be offered suitable controls [1], [4]. I therefore think, it can be questioned whether the current approach of the SRI responds appropriately to the adaptive principles.

I have recently heard about an interesting example in Luxembourg. It is a school building under retrofitting and they actually request to get thermostats that pupils can adjust themselves. It's the opposite of what normally would be recommended. I think this is a very interesting approach because they make it part of their teaching. I think it's quite interesting to try those paths and to build on people's ability to contribute and also their willingness to contribute and learn good daily routines.

## Cited report and articles:

[1] R. Hellwig *et al.*, *Guidelines for low energy building design based on the adaptive thermal comfort concept - Technical report: IEA EBC Annex 69: Strategy and Practice of Adaptive Thermal Comfort in Low Energy Buildings.* 2022.

[2] EN 16798-1: Energy performance of buildings - Part 1: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics.CEN

[3] W. D. van Marken Lichtenbelt, "The Concept of Comfort and Health May Be Related but Are Not Synonyms," *REHVA J.*, vol. 61, no. 2, pp. 52–54, 2024, [Online]. Available: https://www.rehva.eu/rehva-journal/chapter/new-series-of-interviews-the-concepts-of-comfort-and-health-may-be-related-but-are-not-synonyms.

[4] R. T. Hellwig *et al.*, "Guidelines to bridge the gap between adaptive thermal comfort theory and building design and operation practice," in *11th Windsor Conference - resilient Comfort, Proceedings*, 2020, pp. 529–545.

[5] R. T. Hellwig and A. C. Boerstra, "Personal control over indoor climate disentangled, Part 1, 2," *REHVA J.*, vol. 54, 55, no. 3, 4, pp. 23–26, 20–23, [Online]. Available: https://www.rehva.eu/rehva-journal/chapter/personal-control-over-indoor-climate-disentangled-part-1. ■