ir. E.E. (Noortje) Alders; PhD Candidate; Delft University of Technology; Climate Design Group

Comfort Delivery on Demand

Adaptive Approach to Sustainable Comfort Systems in Dwellings

PhD research description 4th September 2009

Objective

To develop concepts for adaptive comfort amenities and systems in dwellings, which optimize flexibility and responsiveness to the user, weather and renewable energy.

Research Question

What aspects of adaptivity of amenities in a residential comfort system, to user, climate and availability of renewable energy can provide the increasing demand for quality of thermal comfort with reduced fossil fuel use?

Illustration: B. Rudofsky; Architecture without Architects; 1965

Figure 1: Before being able to create its own shelter, man would use natural elements

illustration: Andy Davey

Figure 2: Fangers climate chamber studies

Figure 3: Factors to predict thermal comfort experience according to Fangers model.

Figure 4: Changing preferences and options to adapt to the environment or to adapt the environment itself.

Source: SBR, Netherlands

Figure 5: People can have different preferences

THERMAL COMFORT

In former times, man would cope with the ever changing weather conditions by its adaptive skills and would use the things nature provided to find the most appropriate environment for its activities (figure 1). Later on in the evolution of mankind he would create his own shelter, though merely to mitigate the swings of outdoor conditions. Only recently people started to create their own microclimate. First by heating the occupied space during the winter and even more recently cooling when too hot. By the 2nd half of the 20th century man could bend indoor climate to its will, although at high (energy) cost. It was only then when people would talk about comfort in the current meaning, instead of shelter from extremes [1, 2].

THERMAL COMFORT AND ENERGY

Being able to control indoor climate, people became interested in defining optimal climate conditions as a setpoint for the thermal comfort amenities. In 1970 Fanger published his human heat balance model [3], in which he states that thermal sensation can be predicted by calculating the thermal heat balance of the body and the environment, with a physical thermodynamic model (Figure 3).This model is based on climate chamber experiments (Figure 2) and it is static. Nevertheless, it would become the standard for determining design guidelines and even regulations for thermal comfort in buildings all over the world in whatever climate zone or culture. Describing ánd creating this "ideal" situation to be implemented all over the world, regardless climatic and cultural differences, leads to excessive energy use [2]. Partly due to this, mankind is becoming more and more dependent on energy. Most of this energy is generated from fossil fuels. Our increasing consumption of these fossil fuels causes a growing exhaust of greenhouse gases leading to what we call Global Warming [4]. Therefore, we can no longer afford this situation of excessive energy consumption.

DIVERSITY

Apart from the fact that we cannot continue to condition our indoor space to this universal ideal, such a universal optimum in climate conditions does not exist. This theoretical "neutral temperature" at which people feel neither cold nor warm varies from person to person and is also dependent on the overall circumstances. The tolerance of the (thermal) environment has proven to increase if people feel in control of their own environment. People adapt their clothing, activity or posture, as well as their environment by turning down or up the heat, opening a window or turning on fans (Figure 4). Unconsciously they can adapt their physiology, like shivering or adapting metabolism. Besides physical actions of adaptation, people also have psychological abilities for adaptation, such as expectation (like seasonal or daily variance), habituation (getting accustomed to a certain climate) and tolerance. All these reactions highly depend on the individual as well as the circumstances. A feeling of discomfort increases if one does not know what or how things are happening, which supports the fact that it is favourable to let the people be in contact with the outdoor climate to see the seasonal and daily changes in climate to be able to anticipate to their expectations[5-10]. These psychological aspects are not incorporated in Fangers model.

ADAPTIVE COMFORT MODEL (Figure 6)

The aspects stated in the former paragraphs, together with the changing outdoor conditions, imply that the indoor thermal environment changes (opening a window changes air velocity and the air temperature) as are the physiological parameters (like changing metabolic rate and clothing) ánd the psychological parameters (expectation, habituation) [11]. This makes predicting the comfort setpoints difficult; However, the tolerance of people, makes that there is no need for a very sensitive prediction of the prefered temperature. More important is to provide people with control possibilities on the indoor environment and awareness of their outdoor environment. Providing the comfort only when and where needed, according to above mentioned, can lead to significant energy savings.

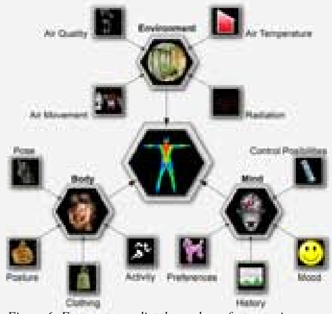

Figure 6: Factors to predict thermal comfort experience according to the adaptive model

Figure 7: An adaptive dwelling, reacting to the occupant, the weather and energy availability

Figure 8: Example of a presence schedule and floor plan for simulations

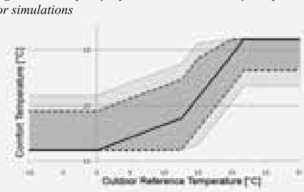

Figure 9: Example of thermal comfort area for bedrooms

After: Peeters (2008) [13]

THE ADAPTIVE DWELLING

An adaptive dwelling (figure 7) with regard to comfort is a dwelling in which the comfort delivery system (whole of passive and active comfort components) adapts its settings to the dynamics of the occupants comfort demands and the weather conditions - seasonal, diurnal and hourly (depending on the aspects adapted) - thus providing comfort only where, when and at the level needed by the user, while harvesting the naturally delivered energy when available and storing it when abundant (after DEPW, 2006 [12]). Components of such an adaptive dwelling can vary from adaptable shading and insulation to a sophisticated demand driven ventilation system.

ESTIMATING DEMAND

For being able to fit building services for residential buildings it is needed to set lower and upper temperature limits, to be able to provide the instantaneous demand. Also important for adaptive comfort systems, is to know the probability of a demand at a certain moment and the frequency of occurrence, determined mainly by weather conditions and presence of occupants. The level of demand is determined by numerous factors varying in time and space, visualised in the scheme on the left. First step in determining demand for comfort is to indicate peoples presence in the various rooms to be able to identify the time and frequency of comfort demand. In simulations a schedule can be formulated based on statistical information mimicing reality (Example: Figure 8) to study possible technical solutions for providing adaptive comfort while profiting from the energy saving potential. To further specify the demand, levels of demand can be estimated. As stated before, this level of demand, like setpoint temperature, depends on environmental factors, physiological factors and psychological factors. Literature stud ies will be performed to map and relate these factors. Figure 9 shows a visualisation of a comfort temperature algorithm for bedrooms, created by the university of Leuven [13].

CONFLICTS

Certain conflicts are expected to occur in flexibility between the various constraints. The object of this research is to identify these conflicts and find optimal solutions for various conditions. Furthermore, the optimal change rate of the various building settings will be sought.

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