Exploring Practices of Thermal Comfort for Sustainable Design

Abstract
Approaching energy consumption as something that happens as a consequence of socially shared practices, rather than as a consequence of individual decision making has consequences for sustainable design. This paper describes an exploration of practices of thermal comfort from a sustainable product design perspective. The exploration covered current practices, historic developments and cultural variation. Resulting opportunities included person heating practices, which were tested in a short observational study. The paper concludes with possible implications for HCI of taking a practices-oriented approach.

Keywords
Practices, thermal comfort, sustainability, design

ACM Classification Keywords
Design, Human Factors, Sustainability

Introduction
Is energy consumption primarily about decision making, as suggested by Azam Khan, the CHI Sustainable Community chair [1]? Or is it something that happens in the course of daily life, like argued by for example sociologist Elizabeth Shove? The first stance leads to designs that support “good” consumer
decision making, for example products like smart-meters. But what does the second stance mean for sustainable human-computer interaction (HCI)? Approaching energy consumption as a consequence of mundane daily activities like cooking, bathing or cleaning, shifts the focus of analysis and design to these daily routines, or practices.

Research in sociology teaches us that these practices are both socially shared and have a dynamic of their own. To illustrate this with an example of cooking: within a cultural group, there is a collective understanding of what cooking is for, how it is done, what is used for it and so on. Moreover, cooking has existed as a practice long before our current generations were born. In other words, the actions of individuals are related to the actions of others and practices change over time. To understand changes in practices and thus in their energy consumption, it is insightful to see them as constitutions of elements. These elements can be grouped in different ways, but one often used by Shove is conventions, competences and material artifacts [2]. That the constitution of these elements changes over time and differs between different cultural groups will be illustrated in this paper. Beyond understanding the practice, sustainable designers aim to identify opportunities for interventions in the practice that enable transitions towards less energy intensive future constitutions.

This paper offers an example from the product design area of a Dutch study on thermal comfort. It illustrates how an approach drawing on theories of practice was employed in sustainable design. The paper first elaborates on the topic and approach of the project, then describes its methods and results and closes with a reflection on the implications of this practice based approach for sustainable HCI.

**Thermal comfort**

Achieving thermal comfort takes up a large share of household’s energy consumption. When looking at energy consumption for heating in the Netherlands in the past century, there was a strong rise between 1950 and 1980 followed by a slow decline until the 1990s. When calculated per capita (household size decreased from 3.6 to 2.3 in the past 50 years), energy consumption for heating first increased from 14 GJ per person per year in 1950, to 37 GJ in 1980. It then decreased, because of improved insulation and efficiency of heating boilers, to a level of approximately 26 GJ today. The decline stagnated around 2007 and according to some sources, energy use started to slowly rise again. Heating nowadays accounts for 51% of energy use in Dutch households [3].

A dominant approach in design for thermal comfort has been to make surroundings that offer ‘optimal’ thermal comfort. These optimal conditions have been defined through laboratory studies [4] and are laid down in for example the International Standards Organization’s ISO 7730 and American Society of Heating, Refrigeration and Air-Conditioning Engineer’s (ASRAE) Standard 55 that are used as guidelines by designers and architects. Through these standards, narrowly defined conditions of comfort are materialized in our built environment and in products that “provide” comfort such as air conditioners, (de)humidifiers and heaters. Not only have these standards of maintained indoor temperatures of around 22°C had a great influence on (building) design – some buildings don’t even have possibilities for natural ventilation anymore. They have
also created conditions of inherently mechanized comfort that people have come to expect. Research by Brager and De Dear [5] showed that occupants of air-conditioned buildings – as opposed to naturally ventilated buildings – have developed higher expectations for thermal consistency; they were twice as sensitive to thermal conditions deviating from the ‘optimum’. Rather than offering comfort, these technologies strongly influence what is considered comfortable, thus creating a ‘need’ for mechanized heating and cooling. In short, the idea of offering comfort to passive receptors (i.e. people) is problematic for energy consumption on the long term, leading to lock-in infrastructures and shifting expectations of comfort conditions.

An alternative approach is to consider comfort as a highly variable social construct that can be achieved rather than offered. ‘Comfortable’ then means an environment that offers sufficient possibilities for adjustment and adaptation in which people can make themselves comfortable [6]. This directly leads us to the role of design. To avoid lock-in and energy demanding expectations, design should offer a wide variety of opportunities to people to create their own comfort. Where these opportunities may lie and what they might entail was explored in an empirical study into practices of thermal comfort.

**Practice exploration**
The practice exploration consisted of three main elements: (1) an exploration of current practices of thermal comfort in 60 Dutch households. Participants received a workbook in which they answered questions about their indoor climate, situations in which they felt (un)comfortable and current ways of staying warm. The workbooks were used as a basis for semi-structured interviews in the participant’s homes a couple of days later. (2) A study into the history of thermal comfort in the Netherlands, covering the past century. Methods used were literature study and interviews with two elderly couples about their ways of staying warm, covering the past 70 years. (3) A study into practices of thermal comfort that focused on Japan; a culture relatively far from the Dutch culture but with a similar climate. Methods used were literature study and an observational and interview study in four households in Japan. All studies were conducted in winter. Results of these three elements of the practice exploration are summarized below.

**Getting cold**
From the workbook and interview study, we learned that a central heating system, in combination with insulation can offer a rather constant indoor temperature. However, this does not mean that people do not get cold indoors. When sitting still in front of the TV or when working behind a computer, one gets cold easily. While during activities like cooking or cleaning, little need for extra heat is felt. Furthermore, moments of getting in or out of bed show peaks in heat requirements, as does getting out of the shower. Finally, some parts of the body get cold more easily than others. Extremities, like feet and hands are most vulnerable for cold. Hands are not clothed and feet are in direct touch with the floor that can abstract heat and are closest to the coldest air flows in the room.

In short, central heating offers constant temperatures, but heat requirements differ for different times of the day, different people and different activities.
Shifts in thermal practices
In the past century, major changes have occurred in practices of thermal comfort in Dutch homes. A determining moment in the history of heating has been the discovery of large amounts of natural gas on Dutch territory in 1962. Accompanying changes can be summarized into three shifts that had consequences for the constitution of elements in the practices.

The first is a shift from solid fuels to liquid fuels. It took place between the 30s and 50s [7] and meant changes both in material things (coal-sheds and scuttles were replaced by pipes, coalmen had to find new jobs, coal carriers new functions) and in division of competences (carrying fuel to the stove was now done by pipes, skills of making and maintaining a good coal fire were no longer needed and with that, fuel and temperature management were delegated to gas meters and knobs). Together with all this, conventions for the amount of work and hassle (coal dust, cleaning the stove) involved in ones indoor climate decreased strongly.

The second is a shift from one heated (living) room to heating of the entire dwelling, which started slowly in the 30s but really took hold after the introduction of natural gas in the 60s. This shift was strongly fueled by government campaigns, aimed to sell the natural gas. Around that time, workers free time increased which left time for hobbies and study at home. While family members would first gather in the living room on winter evenings, they now spread over the house with own activities. Small additional heaters or hot water bottles that were first used for additional heating outside the living room started to disappear and expectations of normal bedroom, bathroom (if the house had one) and study room temperatures changed.

Finally, we want to elaborate on the shift from insulation by clothes to insulation by the building envelope. The introduction of central heating has already made warm clothes for bedrooms less necessary. Improved insulation especially introduced in the 80s, has strongly reduced cold draughts, further allowing for lighter clothing indoors, plus thermostats now make sure the home is heated before getting up in the morning or before getting home from work. With this shift, not only warm clothes like the ‘borstrok’ (under vest) went out of sale. Routines of dressing changed, and skills of how to dress warm disappeared. Lighter ways of dressing in turn, assume – expect as normal – certain indoor climate conditions.

Much can be learned from these shifts, but what we were looking for in particular is examples of less resource intensive practices of thermal comfort. It is clear that we cannot go back in time. What our observations can teach us is that some of the elements that were present in less resource intensive practices of the past may be re-introduced. Examples are the more direct relation of people with fuel supply, centralized family activities and the use of warm clothes. What we also learn is that we cannot simply ask people to turn down the thermostat when not offering warmer indoor clothing, re-introducing skills of dressing warm and supporting changing expectations of indoor climates.

Staying warm in Japan
Our study into heating practices in Japan revealed a very basic difference between Japanese and Dutch heating practices. Although the practice of space
heating is increasing, Japanese generally show more person-oriented heating practices. They tend to heat only one room in the house or even just the part of the room they occupy [8]. Traditionally, this is done by means of a "kotatsu"; a low table covered by a comforter that is wrapped around the waist area and captures the heat of the heating unit placed under the table. Other local heat sources are electric carpets or the "yuuutampo", a type of hot water bottle. Person heating practices do not only encompass different things, they also mean different routines of turning on and off heating and different expectations; Japanese are used to entering a cold room.

The study of thermal practices in Japan revealed ways of staying warm that were not encountered in current and historic practices in the Netherlands. The option of person heating revealed a scale of variety from space to person heating (illustrated in figure 1) that was not thought of before. This insight formed the basis for the design direction taken from the study.

**Design direction**

The goal of the practice exploration was to gain understanding of current heating practices and to elicit opportunities for design to offer a wider variety in ways of achieving comfort. Dutch ways of staying warm at home are increasingly based on paradigms of space heating, embedded in the architectural design of the building. Gas fuelled central heating has become normal since the 60s and floor heating is on the rise [8]. However, this does not mean that people don’t feel cold; inter- and intra personal heat requirements turn out to vary widely. There is no one type of simply “being at home” that typical thermostats cater to with constant temperatures. When variety is the goal, offering opportunities towards the "person heating" side of the spectrum seems like a promising direction for sustainable design.

**Piloting person heating**

To gain insight into the potential of “person heating” practices in current Dutch households, a study was conducted to pilot this type of achieving thermal comfort in a daily life setting. Participants of the same 60 households used the practice exploration were given a small heat source and asked to creatively integrate it into their daily life for two days. Results were documented in workbooks and video interviews in the participants’ homes.

However, the two days turned out to be too short to test the possible emergence of novel practices. In addition, practices are socially shared and cannot develop in isolation. Therefore such a study should facilitate interaction between participants.

**Discussion**

From the study it can be concluded that person heating practices could complement space heating to cover for those situations in which a bit of extra heat is desired. In terms of energy consumption, this type of heating is preferred over heating the entire home. Person heating is instant, more focused and prevents people getting used to higher room temperatures. Moreover, such practices facilitate a broad temperature range in the home, such as advocated in the adaptive model proposed by Brager and De Dear [5], which requires less heating in winter and less cooling in summer.

However, desired changes in heating practices – those that will lead to overall lower resource consumption –
will not occur through the introduction of person-heating devices alone. Changes in building design and climatic system engineering are required and there are clear opportunities in the area of clothing design. Moreover, it is not just material elements that matter. Together, designers, architects and policy makers should cater for a coherent set of elements that could form the ingredients for less resource intensive heating practices.

In the end, however, it is the practitioner – the performer of the practice – who integrates the elements and thereby reproduces and transforms the practice. Designing less resource intensive practices is therefore not a one time effort, but an ongoing process of evaluation and adjustment. Further study is required in this evaluative side of the practice-oriented design approach.

**Conclusion**

Sustainability is about much more than individual decision making or about choices between the ‘sustainable’ and ‘unsustainable’ option alone. A focus on everyday contexts and practices reveals that people’s routine activities like bathing, cooking or maintaining a comfortable temperature, which take up a large share of energy consumption, are made up of closely related elements; materials, competences and conventions. Making changes in energy consumption first requires an understanding of the constitution of these energy consuming practices. Only then it becomes possible to make interventions that may shift practices in desirable directions. However, practices are only likely to shift when a coherent alternative is offered, which requires the involvement of other stakeholders than designers alone. Inspiration for alternative compositions of elements can be found in history and other cultures. Finally, a practice only emerges when different elements are recombined in practice and when these elements become shared within a group of practitioners. Therefore, to study the actual effects of product interventions, it is essential to pilot the envisioned practice on a small scale and make adjustments to the design before making a larger scale introduction.

**References**


