Design for Sustainable Behaviour

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Abstract. This paper explores the associated factors that lead to sustainable behaviour at home, and how design could be used to influence user behaviour in the area of pro-environmental households within China.

Keywords: Energy behaviour · Sustainable design

1 Introduction

Traditional sustainable design has a strong focus on mechanical engineering (e.g. design for disassembly, recyclability), however, sustainable technology does not automatically lead to sustainable user behaviour. Previous research that has addressed the human behaviour of energy usage and how design can contribute to the sustainability of product use is very limited [10, 19]. The behaviour component is frequently underestimated in analyses of pro-environmental households, partly because of its complexity [20, 21], and partly because it is influenced by culture, attitudes and aesthetic norms and social and economic variables [12].

Product designers shape the development of products which directly impact upon society and the environment, and the application of sustainable product design can significantly reduce lifecycle impacts [9]. Several design strategies have been identified, including Eco-feedback, which provides signs as reminders to inform users of energy consumption - (e.g. [13, 16]), behaviour steering, which encourages users to behave in sustainable ways prescribed by the designer (e.g. [7]) and persuasive technology, which applies persuasive methods to change how people think or act [5]. Little work has been done to link these strategies and techniques and to apply them in practical areas, and there is a lack of design guidelines and empirical design practices for designers briefed with influencing user behaviour [10, 19].

This study contributes by filling in the gap of lack of empirical user-centred practices to promote sustainable domestic energy consumption. It focuses on the pro-environmental domestic water use for Chinese users. This is because water scarcity is predicted to have a severe impact on the quality of life of both current and future generations, while the demand for water will outstrip supply by 25 % in 2030 in China,

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if no remedial actions are taken [3]. This study explores the associated factors that lead to sustainable domestic water use behaviour, and how design could be used to influence user behaviour in the area of pro-environmental households within China.

2 Background

Sustainable design takes into account environmental, economic and social impacts enacted throughout the product lifecycle. Generally, economic and environmental concerns are well defined and understood, whereas the social sphere of sustainable design has been less well explored [9].

2.1 Design Strategy to Promote Sustainable Behaviour K

Impacts upon society and the environment during the period of use of a product are often determined by consumer behaviour, thus designers are in a position to reduce use impacts by purposefully shaping behaviour towards more sustainable practices [1, 10, 19].

Early research has identified three design interventions: (1) Eco-feedback [13]; (2) Behaviour Steering [7]; and (3) Persuasive Technology [5] as potential strategies which could be integrated into product design to influence user behaviour [9].

Eco-feedback provides information and reminders to the user concerning his or her own impacts, and aims to guide the user toward pro-environmental behaviour. In the field of psychology, it has been acknowledged that outcome feedback, and the knowledge of results, can have a positive effect on performance. Goals and feedback are intertwined, and to optimise feedback effectiveness, goal-setting can provide a standard by which the user can judge if the feedback represents good or poor performance. The energy conservation is dependent on having a goal to save energy as the primary goal of the user, while the success of goal-setting is dependent on whether the user is anticipating large monetary savings, as the amounts of possible energy and, thus monetary savings, are very small [13].

Behaviour Steering encourages users to behave in ways prescribed by the designer through constraints integrated in the product, and it has been found that this approach helps to sustain behavioural changes. For instance, Jelsma and Knot [7] applied the idea of 'scripting' to sustainable product design. Scripting was defined as the design of a product-layout guiding the behaviour of the user, in a more or less forceful way, to comply with values and intentions inscribed into the product by the designer. If it would be the designer's intention to inscribe increased likelihood of sustainable usage into the product, this would mean designing products in such a way that unsustainable behaviour is made difficult or impossible, while sustainable behaviour is made easier, or even automatic [7].

Persuasive Technology employs persuasive methods to ensure changes in how people think or act. Fogg [5] explored the role of computing products as persuasive social actors that work on five primary types of social cues: physical, psychological, language, social dynamics, and social roles. Fogg also highlighted the impact

of physical attractiveness, where a computing technology that is visually attractive to target users is also likely to be more persuasive. In addition, people are also more readily persuaded by computing technology products that are similar familiar to themselves in some way. Also, computing technology that assumes roles of authority will have enhanced powers of persuasion [5].

Wood and Newborough [21] argued that the most effective energy intervention is that which captures the attention of the audience, gains involvement and is credible and useful in the users' situation. It is not simply the informational content given that is important, but the way in which the information motivates the consumer into action [21].

2.2 Sustainable Energy Behaviour Research in China

China is a typical binary economy and a socially diverse country; there is a significant difference between urban and rural regions in many respects. Therefore, it is critical to analyse the impact on energy use for the lifestyles of both urban and rural residents. It is widely recognised that China is currently a transition economy. There is a great difference between the levels of energy consumption by rural and urban populations. Rapid urbanisation, however, will bring more and more rural residents into urban areas, as a result of which there will be changes in their energy consuming behaviour and increases in the requirement for water energy resources, such as water. Subsequently, the differences in the lifestyles of rural and urban residents will gradually reduce. Meanwhile, the increased income of rural residents will lead to a greater demand for commodities and will increase their living expenditure on fast-moving-consumer goods, thus leading to greater requirements for energy. Given all the above, however, Murata, et al., 2008 argue that a '28 % reduction [of 14] in China could be achieved by the year 2020 by means of improving citizens' energy efficiency in household appliance use'. Since households can make significant contributions to energy conservation, to effectively encourage household energy-saving behaviour, first it is necessary to identify the key behavioural antecedents [17].

Energy use is influenced by technology efficiency and by personal lifestyles. Wei, et al. [18] argue that residents' lifestyles can have an important and significant impact on energy use. Wei also suggested that one of the most efficient measures for energy conservation is a change of lifestyle, which may include the transition from luxurious consumption to frugal consumption.

Based on the research conducted in Beijing by [17], the results indicate that there is significant potential to reduce unnecessary energy use from the household perspective. This, however, is not supported by the ineffective energy-saving behaviour being encouraged in Beijing. Furthermore, it is noted that economic benefits, comfort and convenience, and information are important determinants to predicting household energy-saving behaviour. Also, the study illustrates how social norms attach great importance to the reduction of unnecessary daily electricity use, while the implementation of design strategies should depend largely on these determinants. Environmental awareness, however, has been shown to have no significant influence

on residents' energy-saving actions. It should also be noted that similar results were also obtained in Hangzhou, supporting the above findings in Beijing [2].

Moreover, Feng, et al. [4] concluded in their study that total indirect energy consumption differs by region in China, and household income also affects energy consumption, with higher levels for high-income compared to low-income households. The higher the income, the more diverse is the energy consumption. However, it is worth noting that, in contrast to findings in some Western countries, income is not a good indicator of environmental attitudes in China, as it mostly influences energy consumption through product purchase. Also, those with low incomes from both rural and urban samples in China showed environmental concern similar to members of higher-income groups [23].

While Chinese residents are able to conserve energy, many residents feel that when energy conservation is contradictory to the comfort and convenience of life, they will neglect or abandon conservation behaviour [22]. The importance of improving occupants' behaviour for reducing household energy consumption is often overlooked as many people are extremely addicted to advanced technologies on energy savings [15].

2.3 Cultural Impact in Energy Behavior

Culture has a profound influence on human behaviour [12]. In a cross cultural study, China was found to have lower energy consumption levels than developed countries. The study surveyed the energy consumption in Chinese households in 2012 and found that it represents approximately 44 % of that in the United States in 2009, and 38 % of that in the EU-27 in 2008 [24]. To further reduce energy consumption, it has been suggested that China could apply more advanced technologies, such as automatic control technology and heat recovery technology, which are in common use in the United States [8].

More existing research projects have found that people's age has a positive correlation with residential energy consumption, in countries such as Canada, Australia, Brazil, Denmark, India and the Netherlands. However, research analysis in China has revealed a negative correlation between occupant age and heating/cooling energy consumption [2].

3 User Studies

A series of empirical user studies has been planned to take place in different regions within China to investigate people's behaviour in household energy consumption. This paper reports a user study which was conducted in Southwest China.

3.1 Generating Concepts

Design concepts were generated based on the literature review to serve as seeds in user studies. As previous study indicates, Chinese urban household water usage can be classified into 5 categories including laundry (39 %), showering/bathing (27 %),

kitchen usage (19 %), house cleaning (13 %), drinking (2 %). Clearly, the water for drinking is a fixed demand of human beings, so, the remaining four categories are the main starting points of our concepts. Furthermore, laundry and showering/bathing accounts for 66 % of the total domestic water consumption in Chinese urban areas, which makes these two aspects much more important than the remaining two. Six design concepts were derived, as illustrated in Table 1.

3.2 Participants

A total of four families took part in the study (four males and three females). The four selected families represented four typical types of family in China: (1) a couple with a child; (2) a young couple; (3) a couple with senior parents; (4) a single person (See Table 2).

3.3 Procedure

Four user workshops were conducted with a series of co-design activities at four participants' homes. In the workshop, the participants were asked to describe the ways in which their energy use relates to their behaviour, and their requirements and preferences for reducing energy usage at home. All participants were also given the six design concepts described above and were asked to decide on the contexts in which they might be most useful and how they might best be changed to be useful at home.

3.4 Analysis and Results

An emergent themes analysis was applied to gain an understanding of the collected data.

The single participant did not care about the amount of detergent used for washing, whereas the household that consists of a family living with their parents used low foam detergent and a small stream of running water to wash and rinse. Furthermore, they cleaned their tableware by using hot water and without detergent, and used paper kitchen towels to remove any oil from the tableware beforehand. This may demonstrate that elderly occupants are more familiar with, and more aware of the need for energy conservation.

Most households were aware of the water problem but were not aware of how much water they used for daily activities. The household with a family and their child paid for water every six months and only notified when the water quota is almost over. Furthermore, the household consisting of the young couple located in a water abundant area were more likely to ignore water conservation even if they were aware of water scarcity. These results are consistent with the research findings by [2] in which environmental awareness may not result in a significant influence on residents' energy-saving actions.

All of the household members interviewed thought that different utility pricing at different hours of the day would not make much difference to levels of water

Table 1. Sustainable design concepts

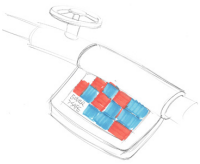
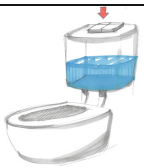
Concepts	Descriptions
	**Concept 1:** *Water saving washing machine* With a built-in laundry detergent tank, the washing machine can add just the right amount of detergent during the washing process. This method can minimise the water used for washing and rinsing and limits the amount of detergent residue. In addition, the washing machine can show the overall water consumption in a direct way to increase the water saving awareness of the user.
	**Concept 2:** *An electrical calendar providing information on daily water consumption* Normally, people are informed of the water consumption of their household when they pay their bill, either monthly or quarterly. Such frequency of information is insufficient to build awareness of sustainable water use. This concept divides a monthly check into a daily check to increase awareness of the water consumption.
	**Concept 3:** *Warning of shower time* By providing an unstable water pressure for a shower, this concept warns people who take a long time to wash. In such way, the concept can encourage direct water savings, although it may annoy people.
	**Concept 4:** *Collecting cold water before the shower water has heated up* This concept is based on the problem whereby shower water heats up slowly. The cold water which comes before the water heats up is often wasted. This concept promotes the collection of the cold water for other uses.
	**Concept 5:** *Transparent cistern for a flush toilet* Flush toilets waste a lot water because they use a whole tank or perhaps a half tank of water for each flush. This concept adapts the flush button so that it requires a continuous press, which allows users to stop the water at any moment. The transparent cistern can increase the awareness of saving water under the same method as Concept 1.
	**Concept 6:** *Induction area to stop the area* This concept solves the problem whereby people keep the shower water running when they are applying soap. By setting an induction area under the shower head, the shower head can stop the water when people leave this area to apply soap. This concept promotes the idea of saving water directly.

Table 2. Participants' demographic profile

Demographic profile	Number
Gender	
Male	4
Female	3
Age	
20 years and less	1
21 to 29 years	3
40 to 49 years	2
50 years and above	1
Profession	
Manager	1
Teacher	1
Student	1
Contractor	1
Government officer	1
Engineer	1
Retiree	1

conservation. This is very likely due to the fact that water is relatively cheap in China, and thus does not directly affect people's behaviour in relation to their energy consumption.

All of the household members interviewed also thought culture (i.e. social relationships) plays a role in changing user energy behaviour, as participants reflected on a community sharing concept in which data is shared amongst all members of their community; they would not want to be the household that uses/wastes the most water in the community. This indicates a change in user behaviour by providing competition in their local community.

One particular comment was made in terms of privacy concerns, whereby the user was unwilling to, and would be uncomfortable about revealing the amount of their water usage to the public.

Of the six concepts presented to the interviewees, they gave high ratings to the concepts that are related to water conservation during showering (Concepts 3 and 6).

4 Conclusion

The results have identified four areas which should be further explored in the design of sustainable energy behaviour, including people's age, the area in which they live, their perceptions of water usage and any relevant cultural factors.

Age. The study indicates a positive relationship between the participants' age and household energy conservation. Generally, households with older members tend to consume less water for both personal hygiene and cleaning purposes, as older

occupants are more experienced and are more concerned about the environment than younger people.

Living area. In this study, the participants' families all live in Sichuan province, which is in the southwest of China. This is a water rich area of China, especially Luzhou city which is located at the intersection of the Yangtze River and the Tuojiang River. Such geographic characteristics seem to encourage residents to neglect water conservation in their daily activities, with the exception of the older occupants.

Awareness of water consumption (e.g. water pricing policy). Members of the participating households were aware of approximately how much water they consumed each month, and they were aware of the pricing policy for water usage in their neighbourhood. They were of the opinion that different pricing for different hours of the day would not affect their water usage behaviour, probably due to the fact that water is relatively cheap in China. The professions of the participants may also have an impact on their perception of water pricing relative to their level of income or spending.

Finally *culture* can play a role in changing user behaviour. Individuals understand their everyday practices with regards to social norms. The research identified a need for the inclusion of social context and cultural considerations in the field of energy consumption research and design.

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